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# THE SYNERGISTIC EFFECTS OF COMBINED BLAST AND FRAGMENT LOADINGS

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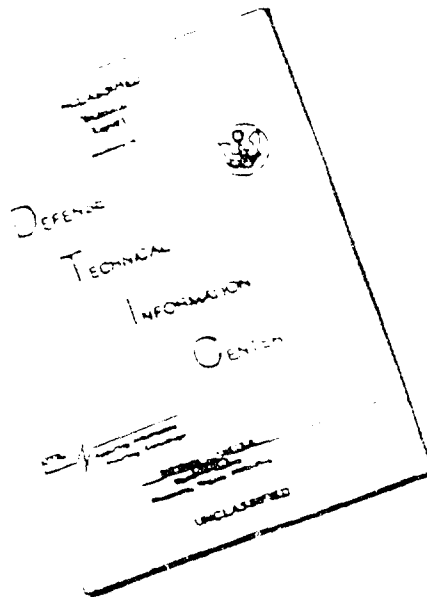
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|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |       |                                                                                       |                                                                                                   |                                                                                  |                                     |
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| 19. ABSTRACT (Continue on reverse if necessary and identify by block number)<br>The objective of this program was to determine the synergistic effects of blast and fragments on construction materials. This required the conduct of a test series to determine the structural loads and the actual failure mechanisms induced by blast loads, fragment loads and the combinations of both. The first series of tests was conducted to quantify the loads generated by the cased weapon and to establish an equivalent bare explosive charge with the same impulse distribution as the cased weapon. The second series of tests was performed in conjunction with analyses efforts to determine and compare the response modes of structural components loaded with both cased and uncased scale model weapons and to supplement future analytical developments. These tests involved scale model panels. Finally, the data was evaluated and the observed synergism was quantified. A factor of four enhancement of stress due to the synergistic effects of the blast and fragments in the concrete and fibrous concrete slabs was observed. |       |                                                                                       |                                                                                                   |                                                                                  |                                     |
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## EXECUTIVE SUMMARY

### A. OBJECTIVE

The objective of this program was to determine the synergistic effects of blast and fragments on construction materials. This required the conduct of a test series to determine the structural loads and the actual failure mechanisms induced by blast loads, fragment loads and the combinations of both.

### B. BACKGROUND

Simultaneous impact and blast loads applied to a structure can cause responses that in some cases are more severe than the sum of the damage generated in the structure through the independent application of the loads. Hence, this simultaneous loading is considered to be *synergistic* in the sense that the simultaneous damage is greater than the sum of the impact and non-impact loadings.

### C. SCOPE

Tests and analysis were conducted to define this synergism. The first series of tests was conducted to quantify the loads generated by the cased weapon and to establish an equivalent bare explosive charge with the same impulse distribution as the cased weapon. The second series of tests was performed in conjunction with analyses efforts to determine and compare the response modes of structural components loaded with both cased and uncased scale model weapons and to supplement future analytical developments. These tests involved scale model panels.

### D. CONCLUSIONS

The important comparison that was made is between the measured stresses generated by the lightly cased, heavily cased and bare equivalent charges. It is important to note that these comparisons are being made for charges of *equivalent impulse*, not simply equivalent explosive weight. The fragment impulse is being accounted for in the bare charge equivalent weight.

1) The heavily cased charges (2.4 lb. cased) in tests 15 and 19 produced significantly higher interior stresses than the lightly cased test (2.7 lb. cased, test 13) by a factor of 1.7 in the Type B panel.

2) The heavily cased charge produced stresses 4 times higher than the equivalent bare charge for the Type B panel.

3) In the SIFCON panels (Type C) the stresses are much higher due to the increased density and impedance.

#### E. RECOMMENDATIONS

Future work in the definition of the synergism in blast and fragment loadings should include a second phase of laboratory testing and some additional analysis as well as some effort to integrate the information derived from research and testing into design guidance for protective construction. These phases could be conducted as follows:

##### PHASE II:

- (1) *Laboratory tests and numerical analysis to define fragment and blast shock front interaction and material failure in a loaded specimen.*
- (2) *Characterization of response mode change with respect to standoff based on fragment density and shock intensity calculations.*

##### PHASE III:

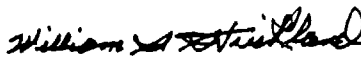
- (1) *Analytic model development/refinement*
- (2) *Selection of optimum materials and structural configurations*

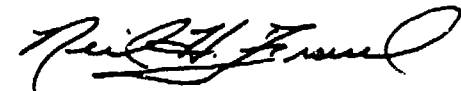
## PREFACE

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## SECTION I

### INTRODUCTION

#### A. OBJECTIVE

The objective of this program was to determine the synergistic effects of blast and fragments on construction materials. This required the conduct of a test series to determine the structural loads and the actual failure mechanisms induced by blast loads, fragment loads and the combinations of both. The first series of tests was conducted to quantify the loads generated by the cased weapon and to establish an equivalent bare explosive charge with the same impulse distribution as the cased weapon. The second series of tests was performed in conjunction with analyses efforts to determine and compare the response modes of structural components loaded with both cased and uncased scale model weapons and to supplement future analytical developments. These tests involved scale model panels. Finally, the data were evaluated and the observed synergism was quantified.

#### B. BACKGROUND

In the design and analysis of protective structures designed to resist the attack of modern conventional weaponry, many methods are available for the prediction of dynamic response of the structure of concern (References 1-4). Additionally, several methods for the prediction of projectile and fragment penetration are available for these same structural varieties. What is missing, and is typically not addressed in a design or simplified analysis reference, is the effect of combined load types such as simultaneously applied impact and non-impact, yet impulsive, loadings.

The effect of simultaneous loadings has been observed, however, and the differences in structure responses as compared to separately applied loads of the same type are severe. In some early Waterways Experiment Station work (Reference 5) concerning the testing of field fortifications used in the Vietnam War years, it was noted that the integrity of reinforced concrete walls loaded with artillery shells detonated in close proximity to the fortifications (5-15 feet) was dependent on the use of sandbags placed in front of the walls. The sandbags in these tests provided a measure of protection from the impact loading generated by the fragments. Recent work at Southwest Research Institute (SwRI) (Reference 6) has shown that the damage caused by the combined impact and blast loading of a steel flyer plate is significantly more damaging to concrete barrier panels than the loading generated by approximately three times the weight of uncased explosive. Other work reported by Coltharp, et al. (Reference 7) has provided additional information concerning the necessity of fragment protection.

It can be shown, then, that simultaneous impact and blast loads applied to a structure can cause responses that in some cases are more severe than the sum of the damage generated in the structure through the independent application of the loads. Hence, this simultaneous loading is considered to be synergistic in the sense that the simultaneous damage is greater than the sum of the impact and non-impact loadings.

A rationale, both analytically and empirically supported, is needed by the hardened structure designer and vulnerability analyst to define the response modes and degree of response expected from synergistic blast and fragment loadings. Significant test data and applicable analytic tools are available which could allow design or analysis information to be generated which would adequately predict and account for these kinds of structural responses.

Southwest Research Institute (SwRI) is currently conducting a study to consider and define the synergism of blast and fragment impact on structures, and the resulting structural damage modes and response. This work is being performed in the form of a combined structural test series and analysis program.

#### C. PURPOSE AND SCOPE

The effort described above is being performed in three phases. This interim technical report documents Phase I testing and existing analytic model evaluation. This Phase I Literature Search is complete and has been provided under separate cover (Reference 8). Phases II and III are discussed in limited detail below. The three Phases will include the following activities as a minimum:

##### PHASE I:

- (1) Comprehensive literature search
- (2) Testing of threats and materials to quantify the synergistic effects as they vary with material type, threat type, and munition proximity
- (3) Evaluation of available response models concurrent with testing

##### PHASE II:

- (1) Laboratory tests and numerical analysis to define fragment and blast shock front interaction and material failure in a loaded specimen
- (2) Characterization of response mode change with respect to standoff based on fragment density and shock intensity calculations

**PHASE III:**

- (1) Analytic model development/refinement to allow the prediction and definition of synergistic effects, response modes, and response magnitude**
- (2) Selection of optimum materials and structural configurations for combined blast and fragment loading scenarios**

This interim report describes work partially satisfying the requirements of Phase I. A detailed final report will subsequently be prepared which will include completed data reduction and detailed data analysis.

## SECTION II

### TEST PLAN, SETUP AND INSTRUMENTATION

The objective of the program was to determine the synergistic effects of blast and fragments on construction materials. This required the conduct of a test series to determine the structural loads and the actual failure mechanisms induced by blast loads, fragment loads and the combinations of both. The first series of tests was conducted to quantify the loads generated by the cased weapon and to establish an equivalent bare explosive charge with the same impulse distribution as the cased weapon. The second series of tests was performed in conjunction with analyses efforts to determine and compare the response modes of structural components loaded with both cased and uncased scale model weapons and to supplement future analytical developments. These tests involved scale model panels.

All tests described in the following paragraphs were conducted at the SwRI ballistics range on the SwRI campus. The complete test matrix is shown in TABLE 1.

#### A. DESIGN OF SCALED BARE AND CASSED EXPLOSIVE CHARGES

The bare and cased charge tests were conducted using two types of simulated bombs, the U.S. Mk 82, GP 500 bomb which is a lightly cased bomb; and the U.S. AN-Mk 1, AP 1600 bomb which is a heavily cased bomb. Physical characteristics and other details on both the Mk 82 and the AN-Mk 1 are provided in TABLE 2 and in Figure 1 of this report. Since SwRI's on-site test facility has a 3-pound aboveground TNT explosive limit, the scale model size selected for these tests was a 1:4.3 scale which allowed for the conduct of the tests on-site. Physical dimensions for the scaled munitions are also included in TABLE 2. Fabrication details for each simulated bomb are provided in the following paragraphs:

Mk 82 GP 500 Bomb - The scaled model Mk 82 was fabricated using commercially available 2.5 inch O.D. round carbon steel tubing. The scaled wall thickness used was 0.065 inch which scales within 6 percent of the full scale bomb casing thickness which is 0.3 inches (Reference 1). As shown in TABLE 2, the Mk 82 contains 192 pounds of B-6 explosive (Reference 1) which converts to an equivalent weight of TNT of 243 pounds. Using a 1:4.3 scale, the charge weight scales down to 3 pounds of TNT (charge weight scales down by the scale factor cubed). SwRI used composition C4 explosive to simulate the TNT. Since C4 has a TNT equivalency of 1.129, the simulated cased charge explosive weight was 2.707 pounds of C4. The scaled bomb length was sized to be the exact length of a cylinder of C4 explosive having a diameter of 2.372 inches and weighing 2.707

pounds. This explosive cylinder length was calculated to be 10.7 inches using a density of C4 of .0574 pounds/cubic inch. Figure 1 shows the modeled Mk 82 bomb.

AN-Mk 1 AP 1600 Bomb - The scaled model AN-Mk 1 was also fabricated using commercially available carbon steel round tubing. The tubing selected had a 3.25-inch O.D. with a wall thickness of 0.375. The desired scaled wall thickness as shown in TABLE 2 is 0.302 inches and the tubing wall was machined down to the correct thickness from the inside of the tube thereby increasing the inner diameter. The full-scale bomb case thickness given in Reference 12 is 1.3 inches. The AN-Mk 1 bomb has 215 pounds of TNT (Reference 12) which scales down to 2.7 pounds of TNT for the scaled bomb. SwRI used C4 on these tests. The comparable C4 explosive charge was 2.39 pounds. The scaled bomb length for this bomb was also calculated by determining the corresponding length of a C4 explosive cylinder with a diameter of 2.65 inches and weighing 2.39 pounds. The length was 7.54 inches. Figure 1 shows the modeled AN-Mk 1 bomb.

## B. TASK 1 - LOADS TESTS

### 1. Task 1A - Bare Charge Tests

Bare explosive charge tests were conducted first to validate an instrumentation and reaction structure designed for close-in, nonuniform (nonspherical) explosive charge loads determination. Five of these tests were conducted. Although the fixture was somewhat damaged in later cased charge tests, and was not used further in the program, it proved to be effective in loads determination for bare explosive charges.

#### a. Test Description

The scaled bare charge tests were conducted in a reaction structure consisting of a 6 foot x 8 foot x 8 foot reinforced concrete culvert. The concrete culvert was reinforced using 0.5-inch steel plates which were attached to the sides and floor of the culvert as shown in Figure 2. An impulse plug fixture used to measure the specific impulse at various radii from the center point of the charge was located at the east end of the concrete culvert as shown in Figure 3. The bare C4 charge was centered vertically in the reaction structure and was initiated remotely using an RP-83 detonator. The pulse to initiate the detonator originated from the high-speed camera used to document the test.

The impulse plug fixture was fabricated out of 6-inch thick steel plate. A number of holes were drilled into the plate for positioning the impulse plugs (I1-I8) and for positioning the

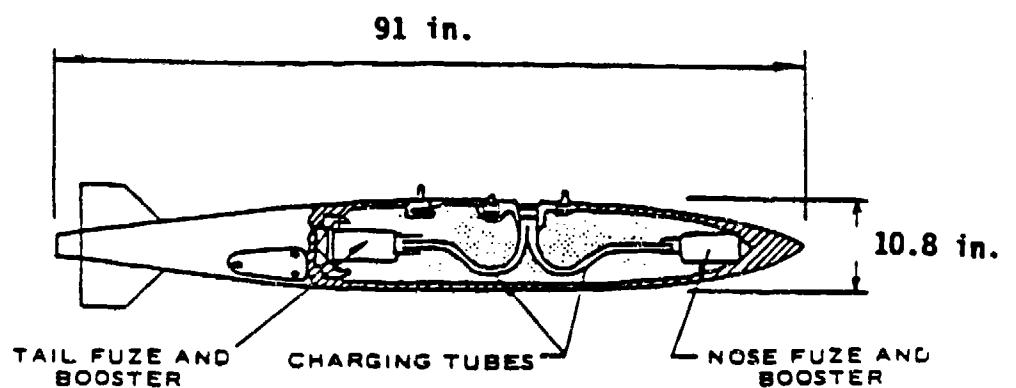
TABLE 1. TEST MATRIX FOR PHASE I TESTS.

| Test No. | Charge     | Panel Type    | Standoff | Instrumentation*    | Date Complete |
|----------|------------|---------------|----------|---------------------|---------------|
| 1        | 2.4 bare   | Impulse Plate | 18"      | RP( ), IP(8), SP(4) | 11/2/89       |
| 2        | 2.7 bare   | "             | "        | RP( ), IP(8), SP(4) | 11/7/89       |
| 3        | 2.4 bare   | "             | "        | RP( ), IP(8), SP(4) | 11/13/89      |
| 4        | 2.7 bare   | "             | "        | RP( ), IP(8), SP(4) | 11/27/89      |
| 5        | 2.4 bare   | "             | "        | RP( ), IP(8), SP(2) | 12/13/89      |
| 6        | 2.7 cased  | "             | "        | SP(2), VS(4), F     | 12/13/89      |
| 7        | 2.4 cased  | "             | "        | SP(2), VS(4), F     | 1/8/90        |
| 8        | 2.4 cased  | "             | "        | SP(2), VS(4), F     | 1/12/90       |
| 9        | 2.7 cased  | Type A        | 6"       | V, HS               | 3/30/90       |
| 10       | 2.4 equiv. | "             | 6"       | V, HS               | 4/4/90        |
| 11       | 2.4 cased  | "             | 6"       | V, HS               | 4/25/90       |
| 12       | 2.8 equiv. | "             | 7"       | V, HS               | 4/27/90       |
| 13       | 2.7 cased  | Type B        | 6"       | V, HS, ES(4), PC(8) | 4/5/90        |
| 14       | 2.4 equiv. | "             | 6"       | V, HS, ES(4), PC(8) | 4/19/90       |
| 15       | 2.4 cased  | "             | 6"       | V, HS, ES(4), PC(8) | 5/1/90        |
| 16       | 2.8 equiv. | "             | 7"       | V, HS, ES(4), PC(8) | 5/4/90        |
| 17       | 2.7 cased  | Type C        | 6"       | V, HS               | 4/30/90       |
| 18       | 2.4 equiv. | "             | 6"       | V, HS               | 4/30/90       |
| 19       | 2.4 cased  | "             | 6"       | V, HS, ES(4), PC(8) | 5/3/90        |
| 20       | 2.8 equiv. | "             | 7"       | V, HS, ES(4), PC(8) | 5/4/90        |

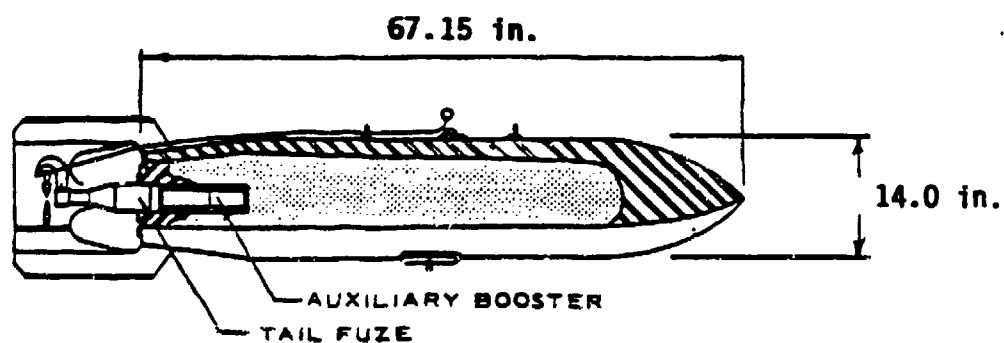
\* IP = impulse plugs  
 RP = reflected pressure  
 ES = embedded stress (carbon film gage)

SP = side-on pressure  
 VS = velocity screens  
 F = fiberboard frag trap

V = video  
 HS = high-speed film  
 PC = piezocrystal (TOA)



GENERAL-PURPOSE  
(HIGH STANDARD RATIO)



ARMOR PIERCING

Figure 1. Physical Descriptions of Mk 82 and AN-Mk 1 Bombs.





Figure 2. Reaction Structure for Testing.

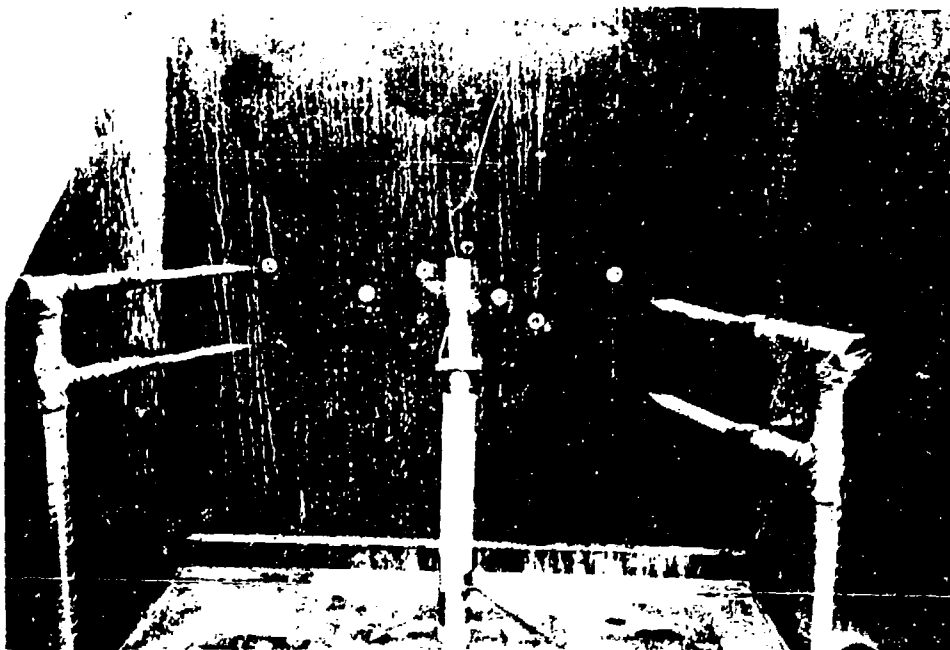


Figure 3. Charge and Impulse Plate Location for Loads Tests.

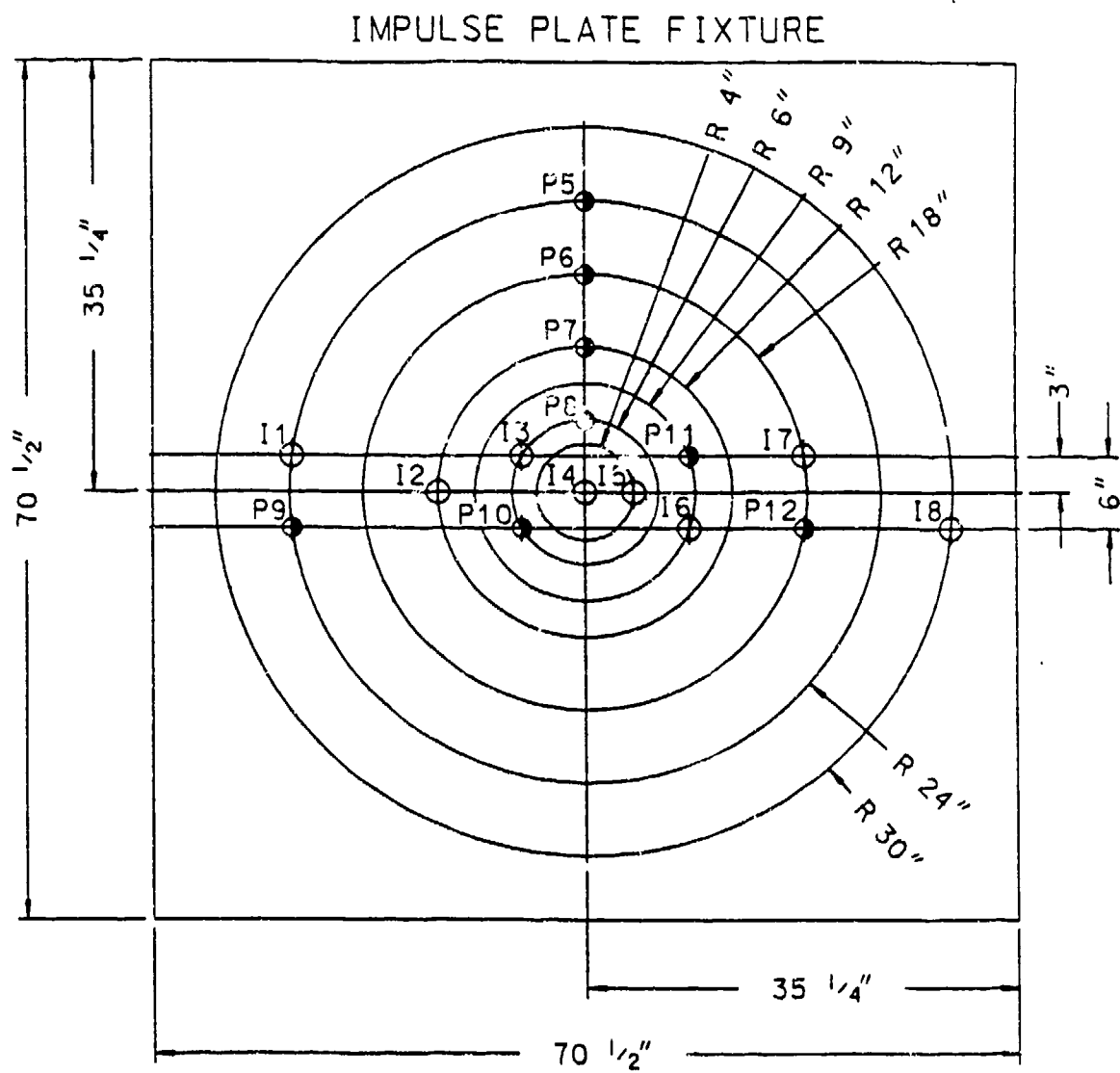


Figure 4. Schematic of the Impulse Plate.



Figure 5. Impulse Plugs.

reflected pressure gages (P5-P12). A schematic of the impulse plug fixture is provided here as Figure 4. The impulse plugs used in the test fixture are shown in Figure 5; 2-inch diameter plugs were used and consisted of a thin steel tube 6 inches long with either a 0.188-inch thick steel cap or with a 0.188-inch thick aluminum cap. The heavier steel cap was selected for use in those tests where the expected impulse would be large, resulting in a relatively high plug velocity. The heavier cap would slow the plug to allow for accurate recording with the high-speed cameras. The aluminum cap was selected for those tests where the expected impulse would be low, resulting in a low plug velocity where the lighter cap would enable the plug to exit at a high enough velocity where it could be captured on high-speed film. The actual velocities of the plugs were initially measured using fiber-optic break cables and switching circuitry located on the back of the impulse plug fixture which would emit an electrical signal when broken. This approach performed very well; however, the higher cost of the fiber-optic cable made it desirable to replace the cables with Dynasen position transducers or shorting pins (Reference 9). These position transducers produce an electrical signal when the tip of the transducer is impacted by a rapidly moving object, such as a shock front or an ionization front. Each set of shorting pins consisted of a 7-inch pin and a 1-inch pin and both were mounted on an assembly which was positioned on the back of the impulse plug fixture (Figure 6). This configuration enabled each set of pins to be located inside of each of the impulse plug tubes such that the longer pin was 0.5 inches from the back of the plug cap. Once the explosive charge was detonated, the plugs were driven out of the plate, and the base of the cap impacted the pins which in turn gave an output which was recorded on magnetic tape. The time that each pin shorted and the distance between pins was used to calculate the individual plug velocities. The velocity and plug mass and area were then used to determine the momentum and specific impulse imparted to the plugs.

Both side-on and reflected pressure gages were used in the bare charge tests. The side-on pressures were measured at two different standoffs using two gages at each standoff. The two gages were located six inches apart as shown in Figure 7. Six reflected pressure measurements were made using gages mounted in the impulse plug fixture. Measurements of the impulse distribution for the bare charge tests were made at various radii from the center point adjacent to the charge using the impulse plug test fixture. Figure 4 shows the gage layout and numbering scheme.

A total of five bare charge tests were conducted. Three tests were conducted using the 2.4-pound bare charge and two tests were conducted using the 2.7-pound bare charge. For each of the tests, the center of the charge was positioned 36 inches above the



Figure 6. Shorting Pin Setup for Plug Velocity Measurement.

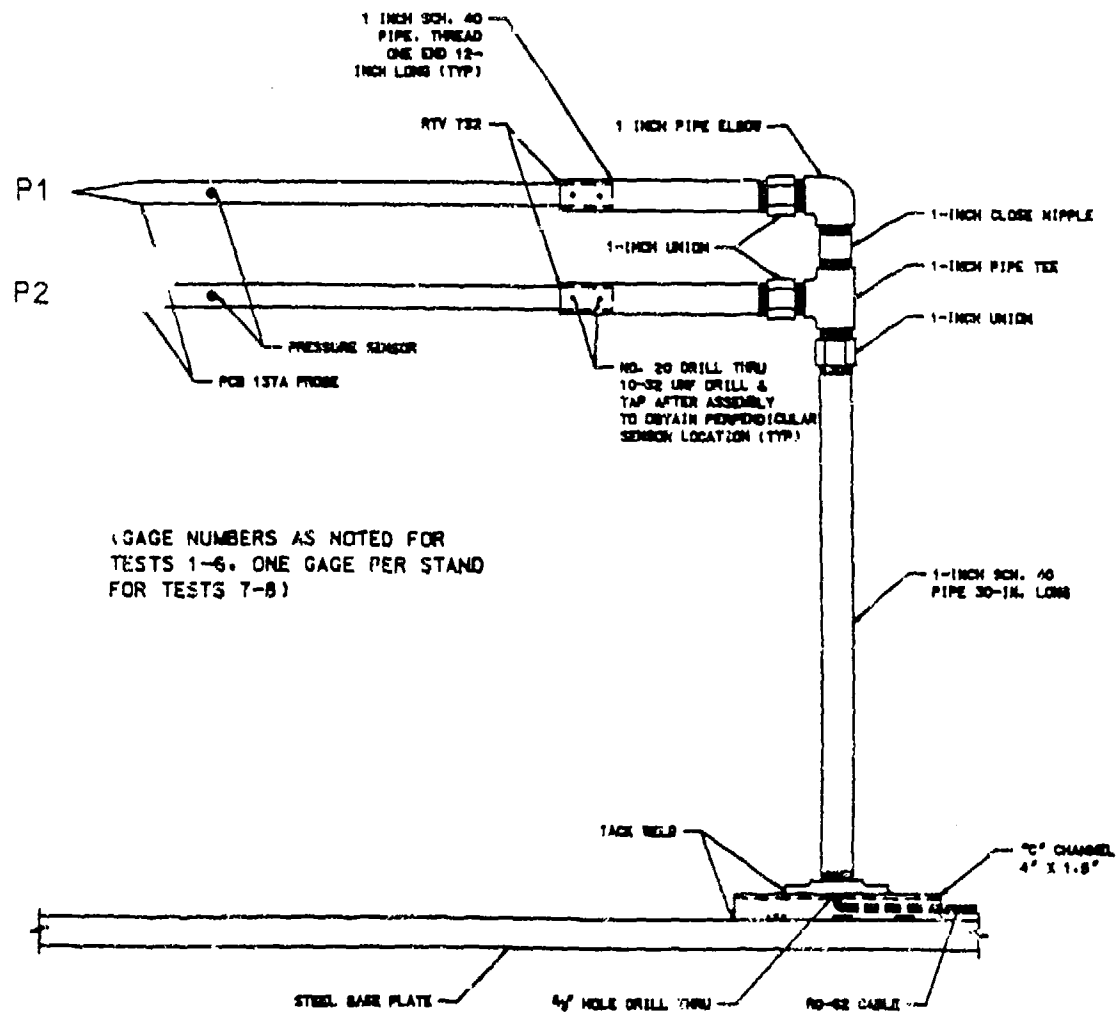


Figure 7. Side-on Pressure Gage Setup.

floor and at a standoff of 18 inches from the impulse plug fixture. Detailed descriptions of the results of each of the tests are provided in Section III of this report.

b. Instrumentation

The bare charge tests were performed, using a full complement of instrumentation, including Dynasen position transducers for measuring the impulse plug velocities (eight sets of two position transducers), PCB 137A side-on pressure gages (Reference 10) (two each at two standoffs), PCB 109A and Kulite HKS-375 reflected pressure gages (Reference 11) (six gages mounted on the impulse plug fixture adjacent to the plugs), and high-speed camera coverage. A Honeywell 24-channel analog tape recorder was used to record the data which were then digitized and processed using the computer resident at the range. Pressure-time histories were generated for each of the pressure transducers. Figure 8 shows a sample pressure-time history. Pressure-time histories and impulse plug velocities for each of the tests are included in Appendix A.

2. Task 1B - Tests To Establish Impulse and Peak Pressure Distributions for a Simulated Cased Charge

Loads tests with simulated cased charges were conducted for two reasons. First, it was necessary to determine the casing effect on the airblast produced by each charge, that is, the airblast reduction from energy loss in case fracture and launch. Second, that the casing fragments had to be quantified in terms of geometry, weight and velocity such that a determination of fragment impulse and impulse distribution could be made. These tests were conducted using charges simulating a heavily cased weapon and a lightly cased weapon as described in TABLE 2.

TABLE 2. PHYSICAL CHARACTERISTICS OF FULL-SCALE AND MODEL BOMBS.

|                            | Mk 82 (Reference 1)<br>GP 500 pound Bomb |        | AN-Mk 1<br>AP 1600 pound |       |
|----------------------------|------------------------------------------|--------|--------------------------|-------|
| Scale                      | Full                                     | 1:4.3  | Full                     | 1:4.3 |
| Explosive Type             | H-6                                      | C4     | TNT                      | C4    |
| Explosive Wt.<br>(pounds)  | 192.0                                    | 2.707  | 215.0                    | 2.395 |
| Equivalent Wt. TNT         | 243.0                                    | 3.0    | 215.0                    | 2.7   |
| Case Diameter<br>(inches)  | 10.8                                     | 2.51   | 14.0                     | 3.256 |
| Case Thickness<br>(inches) | 0.3                                      | 0.0697 | 1.3                      | 0.302 |

# TEST 2 LOC 3

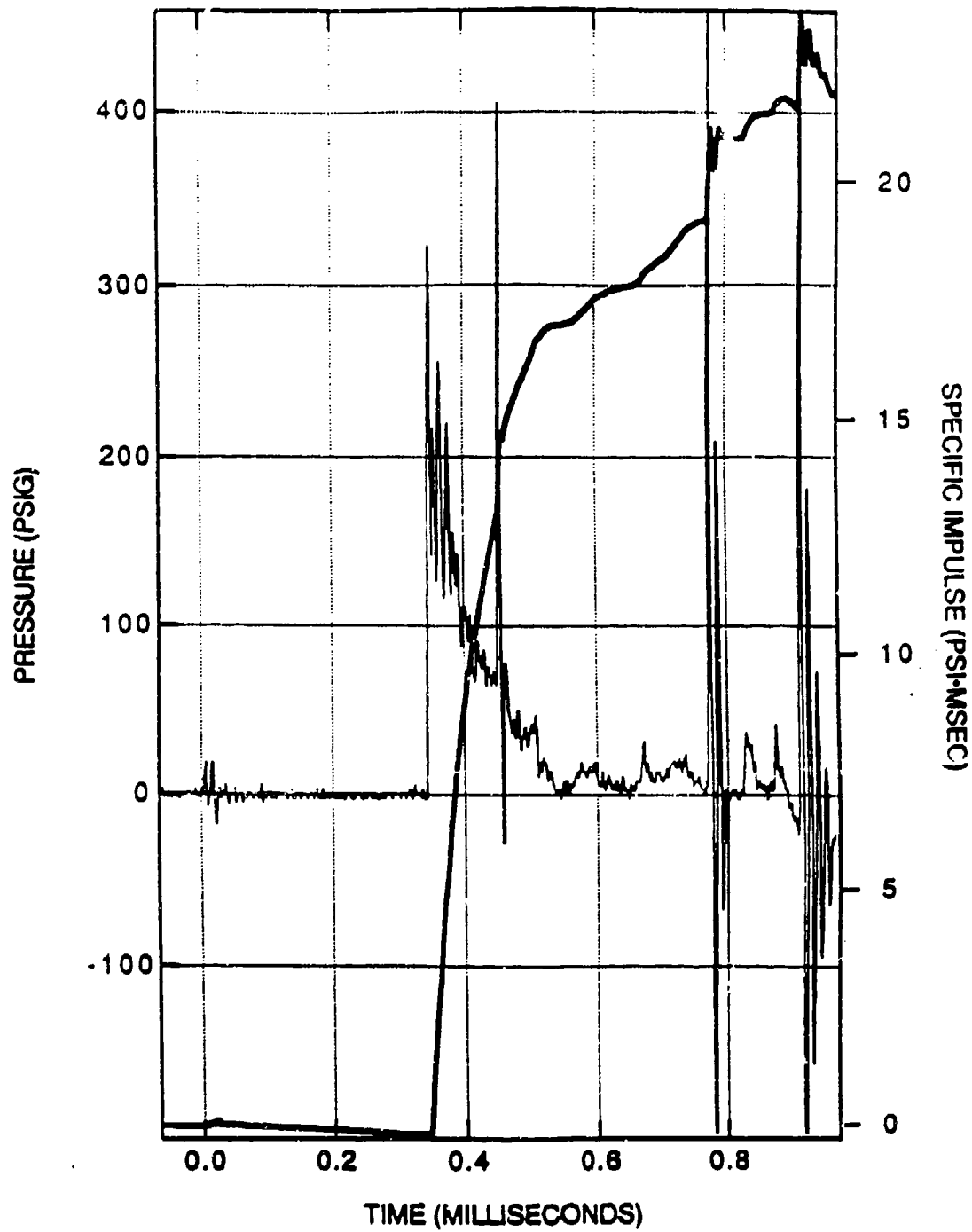


Figure 8. Sample Pressure - Time History Recorded During Testing.



#### a. Test Description

The scaled cased charge tests were also conducted in the reinforced concrete culvert. A total of three tests were conducted. Two tests were conducted using the 2.4-pound cased charge and one test used the 2.7-pound cased charge. All three tests were conducted with the center of the cased charge positioned 36 inches above the floor and at a standoff of 18 inches from the impulse plug fixture. Detailed descriptions of each test are provided in Section III of this report.

A network of velocity break screens was located outside of the west end of the culvert (Figure 9) to measure maximum casing fragment velocities. Fiberboard bundles were placed behind the velocity screens to capture the actual fragments thereby providing data on fragment size and depth of penetration. The velocity data and the measured fragment mass data were used to determine impact energy.

Pressure measurements were recorded for each of the cased tests. Side-on pressure measurements were made at two standoffs from the charge with two gages located at each standoff. The first cased tests were conducted with the side-on pressure gages located at 24 inches and 36 inches. The gages were severely damaged by the fragments in this test. It was then decided to move them further back for the remaining tests. As previously mentioned, six reflected pressure gages were located on the impulse plug fixture and measurements were made at each of these locations.

#### b. Instrumentation

The cased charge tests were conducted using a considerable amount of instrumentation including Dynasen position transducers for measuring the impulse plug velocities (eight sets of two position transducers), fragment break screens (eight sets of two screens), side-on pressure gages (two each at two standoffs), PCB and Kulite reflected pressure gages (six gages mounted adjacent to the impulse plugs), and high-speed camera coverage. SwRI utilized a 24-channel Honeywell analog tape recorder to record the impulse plug velocity data and the pressure data. The fragment break screen data were recorded using eight sets of counters. The analog data were digitized and processed and pressure-time histories were generated for each pressure transducer. Pressure-time histories as well as individual impulse plug velocities are provided for each test in Appendix B.

#### C. TASK 2 - TESTS FOR PANEL RESPONSE MODE INITIATION STANDOFF - CASED AND BARE CHARGE TESTS

Tests of the three types of walls were conducted to evaluate the effectiveness of the lightly cased, heavily cased and

corresponding equivalent bare explosive charges. The tests were designed to produce breach or near breach responses in each of the panels. The result of these tests allowed comparisons with existing predictive models to be made. Additionally, the results provide quantification of the synergism or nonimpulse-related local material failure effects for cased charges.

A unique aspect of these tests was the use of the Dynasen carbon stress gages to measure internal stresses in each of the panel types subjected to all three charge types (lightly cased, heavily cased and bare equivalent). Use of the gages proved successful.

#### 1. Panel Fabrication

Three types of panels were tested using the cased and the equivalent bare charges. Equivalent bare charges were developed based on the analysis of data generated from the tests described in the previous section. Description of that analysis is provided in Section III. Two of the panel types were reinforced concrete panels and the third panel was a Slurry Infiltrated Fiber CONcrete panel (SIFCON) with a centerline steel reinforcement mat. Standard concrete batch designs were used in the R/C panel fabrication with the maximum size aggregate used being 1/4 inch. Compressive cylinder or cube tests were performed on all cement materials. TABLE 3 presents slurry strength data (SIFCON panels), mortar cube strength data (mortar used in carbon gage placement), and cylinder strength data. The steel selected for use in all three panel designs had a yield strength of 65 KSI, an ultimate strength of 95 KSI and was supplied in the form of mats welded at each intersection. Four panels were fabricated for each panel type and all fabrication was done at SwRI. The following paragraphs describe the fabrication procedures for the three wall types.

The first type of panel, Type A (Figure 10), was a standard reinforced concrete panel 50 inches high by 68 inches wide by 4 inches thick. The reinforcement used consisted of two 8 gage steel mats having a 3-inch by 3-inch spacing resulting in a reinforcement ratio of 0.20 percent. The steel mats were spaced 3 inches apart using 17-gage wire stirrups as shown in Figure 11, allowing for a 0.5-inch cover on both faces. Twelve mounting holes (six per side) were provided for attaching the wall to the test structure. A schematic identifying the pertinent construction details is provided here as Figure 11.

The second type of panel, Type B, was also a standard reinforced concrete panel 50 inches high by 68 inches wide by 4 inches. This design, however, had a percentage of steel of 0.91 percent steel each face each way. The type B wall used two three gage mats having a 1.5-inch by 1.5-inch spacing. The mats were

also spaced 3 inches apart, using the 17-gage stirrups as shown in Figure 12, giving the wall a 0.5-inch cover on each face. Construction details for this wall type are given in Figure 13.

The third type of panel, Type C, was a reinforced SIFCON panel. This design was also 50 inches high and 68 inches wide and 4 inches thick. The type C wall consisted of a slurry mix with Dramix 30/.050 fibers at a volume percentage of 10 percent with a single 13 gage mat with 3 inch by 3 inch spacing centered in the middle of the wall (0.1 percent reinforcement ratio) as shown in Figure 14. The fabrication of the SIFCON panels required that the fibers be freely dispersed into the form to prevent balling, thereby allowing a maximum percentage of fibers to be added to the form. From past experience, it was found that any attempt to increase the percentage of fibers by vibrating the fibers or by trying to pack the fibers down resulted in some of the fibers being oriented in a vertical position creating small pockets of fibers. These pockets occupied a much larger volume of the form and resulted in an actual reduction in the percentage of fibers that could be cast into the panel. Once the fibers and reinforcement were in place, the slurry was slowly poured into the form and lightly tamped to insure a uniform fill. This is shown in Figure 16. Details of Panel-Type C are shown in Figure 15. Slurry placement is shown in Figure 16.

## 2. Test Description

The panel-response mode tests were performed inside of the reinforced concrete containment structure. Two steel angles having the same hole pattern as the test panels were welded to the containment structure walls. Two channel sections also having the same hole pattern were used to clamp the wall panels to the containment structure as shown in Figure 17. The cased and the equivalent bare charges were centered vertically in front of the test wall at a height of 25 inches from the floor of the containment structure and at a specified standoff. The cased charge tests and the 2.4-pound equivalent charge tests were conducted at a standoff of 6 inches from the test panels. The 2.8-pound equivalent tests were conducted at a standoff of 7 inches from the test panels. All of the cased charge tests utilized casings fabricated identical to the casings tested in Task 1B.

## 3. Instrumentation

All four of the Type B panels and two of the Type C panels were instrumented with Dynasen piezoresistive shock pressure carbon gages (References 9, 13, 14) and with piezocrystals for measuring the time-of-arrival of the shock wave as it moved through the wall panel. Four of the carbon shock pressure gages were installed in each of the test walls at two different depths, 0.5 inches and 3.5 inches from the surface of the panel exposed to the charge. The

TABLE 3. CONCRETE AND SLURRY STRENGTH DATA.

| <b>SIFCON<br/>2 inch x 2 inch<br/>Slurry Cubes</b> | <b>Age<br/>(Days)</b> | <b>Compressive<br/>Strength<br/>(psi)</b> | <b>Average<br/>Compressive<br/>Strength<br/>(psi)</b> |
|----------------------------------------------------|-----------------------|-------------------------------------------|-------------------------------------------------------|
| 1A                                                 | 7                     | 8,965                                     |                                                       |
| 2A                                                 | 7                     | 7,335                                     | 8,560                                                 |
| 3A                                                 | 7                     | 9,380                                     |                                                       |
| 1B                                                 | 14                    | 8,700                                     |                                                       |
| 2B                                                 | 14                    | 9,270                                     | 9,100                                                 |
| 3B                                                 | 14                    | 9,335                                     |                                                       |
| 1C                                                 | 28                    | 9,450                                     |                                                       |
| 2C                                                 | 28                    | 8,920                                     | 9,090                                                 |
| 3C                                                 | 28                    | 8,905                                     |                                                       |
| <b>4 inch x 8 inch<br/>Concrete<br/>Cylinders</b>  |                       |                                           |                                                       |
| 1A                                                 | 7                     | 4,935                                     |                                                       |
| 2A                                                 | 7                     | 4,775                                     | 4,930                                                 |
| 3A                                                 | 7                     | 5,090                                     |                                                       |
| 1B                                                 | 14                    | 5,490                                     |                                                       |
| 2B                                                 | 14                    | 5,330                                     | 5,490                                                 |
| 3B                                                 | 14                    | 5,650                                     |                                                       |
| 1C                                                 | 28                    | 5,965                                     |                                                       |
| 2C                                                 | 28                    | 5,810                                     | 5,965                                                 |
| 3C                                                 | 28                    | 6,125                                     |                                                       |
| 4A                                                 | 60                    | 5,650                                     |                                                       |
| 4B                                                 | 60                    | 6,050                                     | 5,890                                                 |
| 4C                                                 | 60                    | 5,970                                     |                                                       |
| <b>Gage Placement<br/>Mortar Cubes</b>             |                       |                                           |                                                       |
| 1M                                                 | 14                    | 4,800                                     |                                                       |
| 2M                                                 | 14                    | 4,700                                     | 4,797                                                 |
| 3M                                                 | 14                    | 4,890                                     |                                                       |

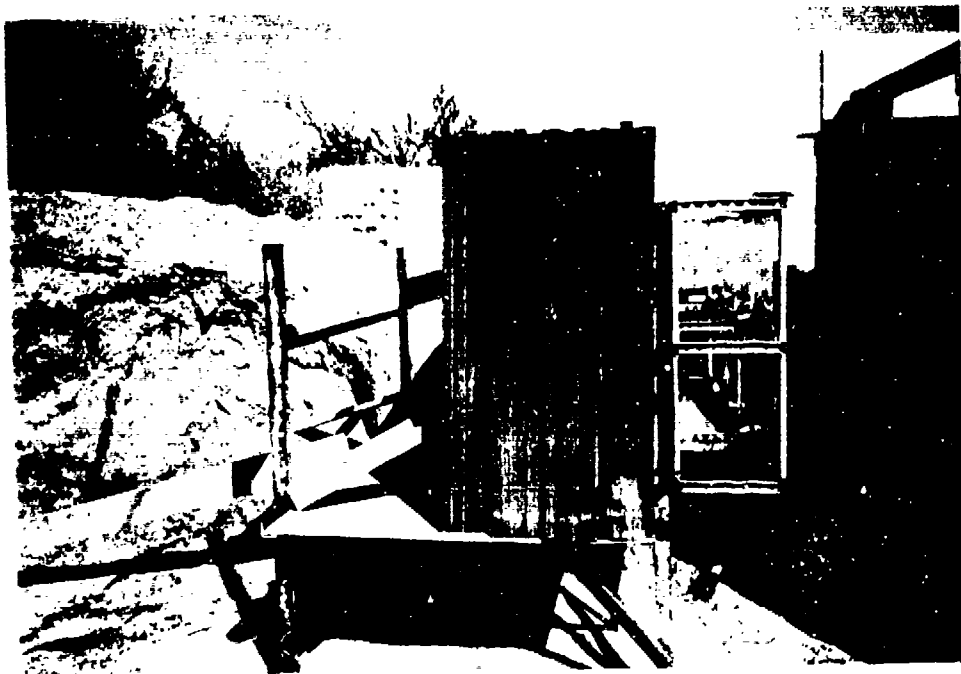


Figure 9. Velocity Screen and Fiberboard Bundle Setup for Cased Charge Tests.

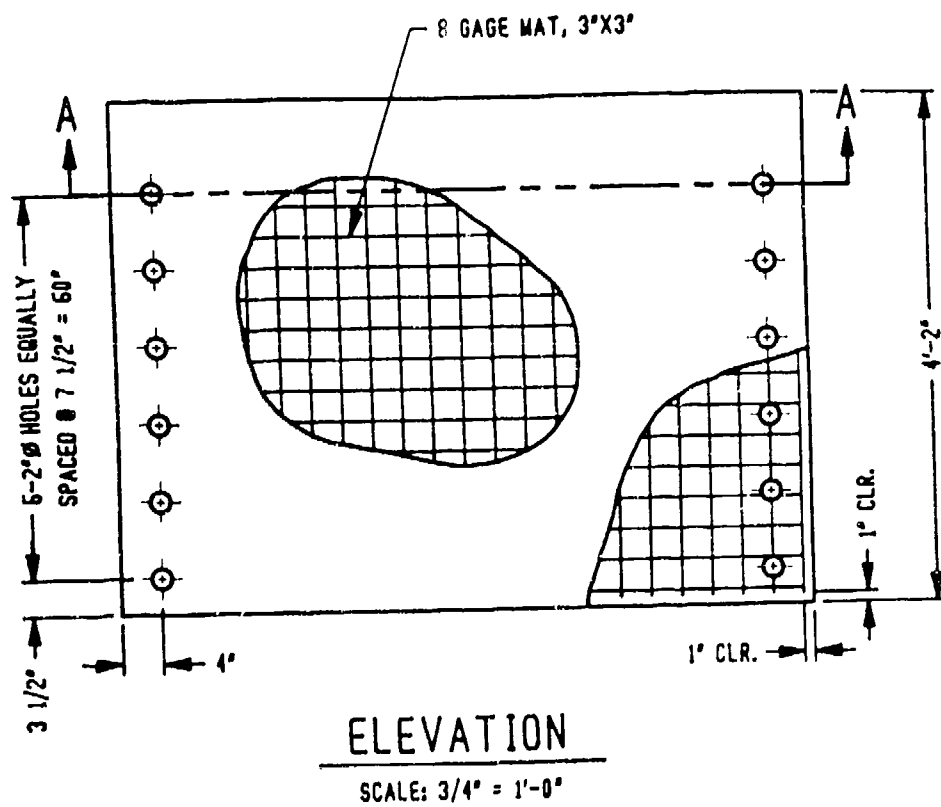
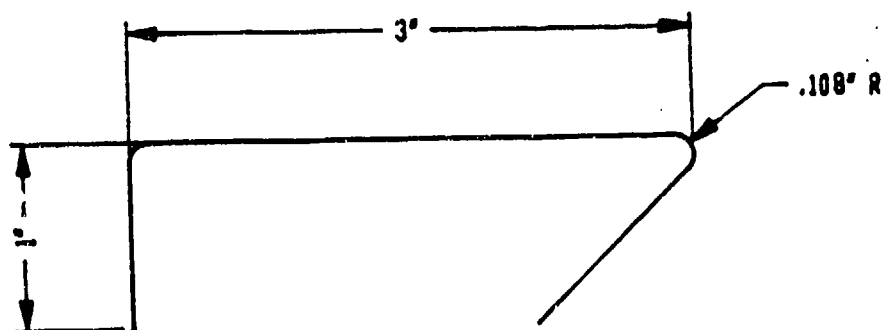
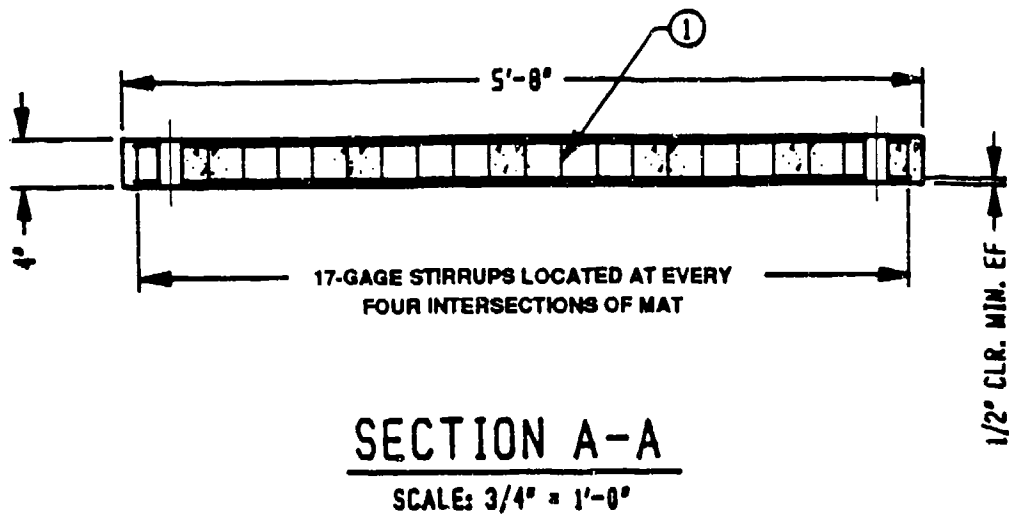


Figure 10. Panel-Type A Layout.



NOTE: 135° HOOK STIRRUP, 17 GAGE WIRE

**DETAIL ①**

SCALE: 12" = 12"

Figure 11. Panel-Type A Details.

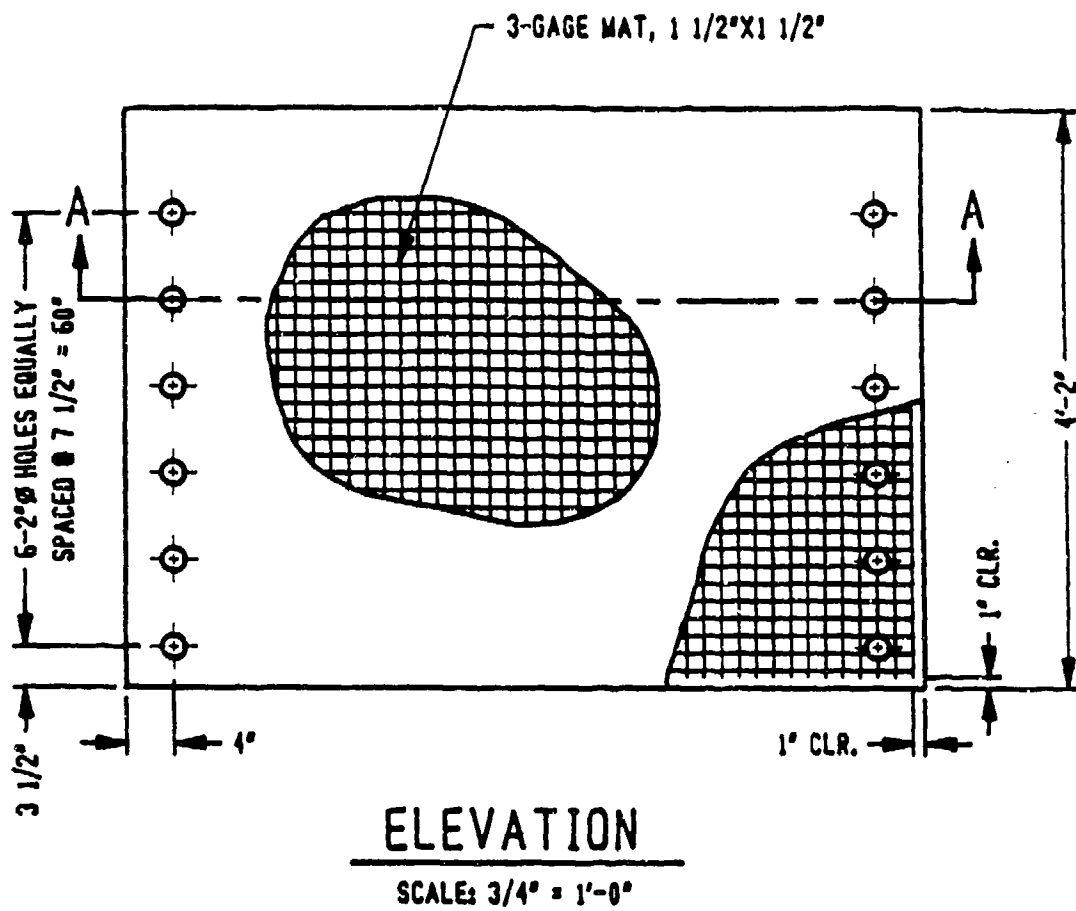


Figure 12. Panel-Type B Layout.

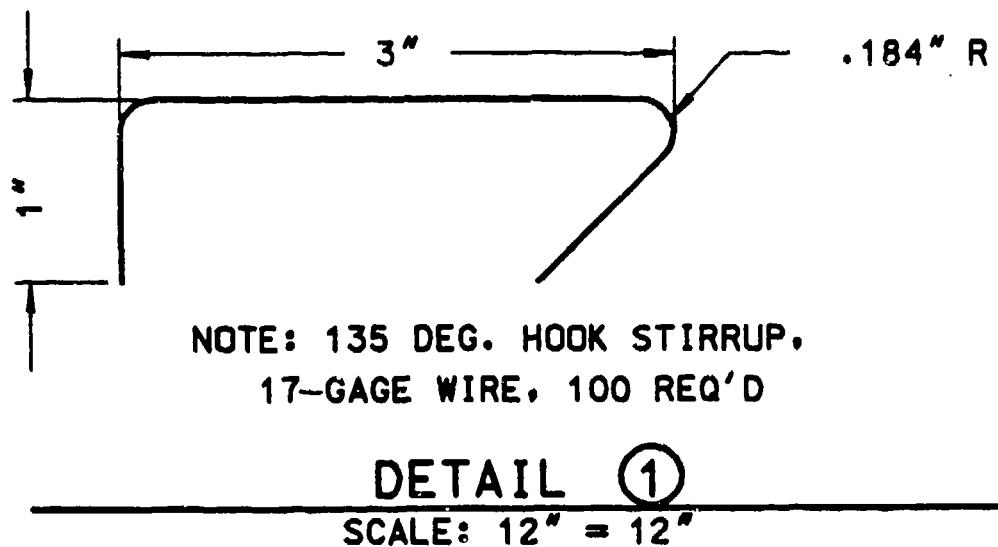
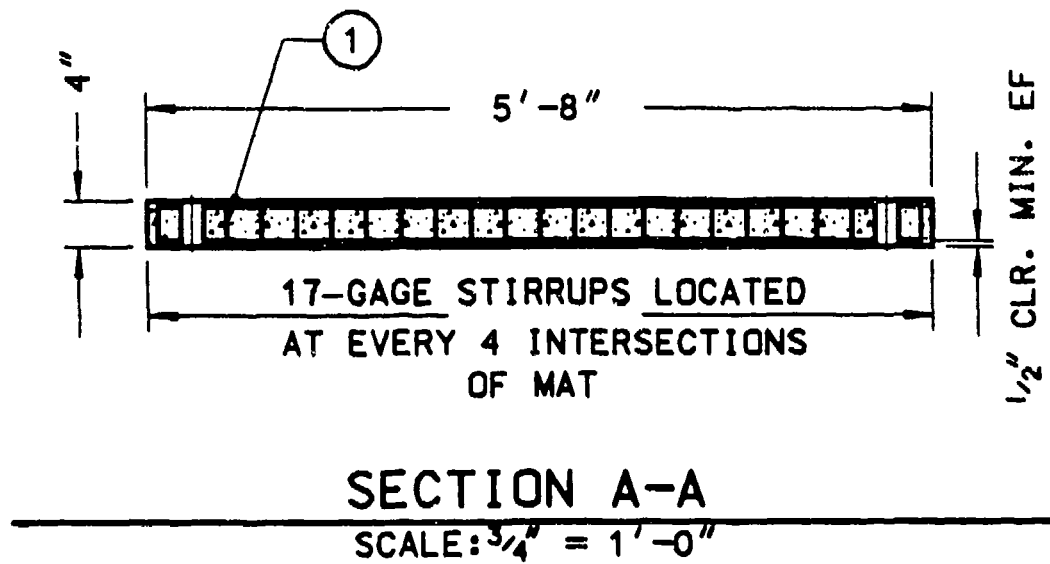
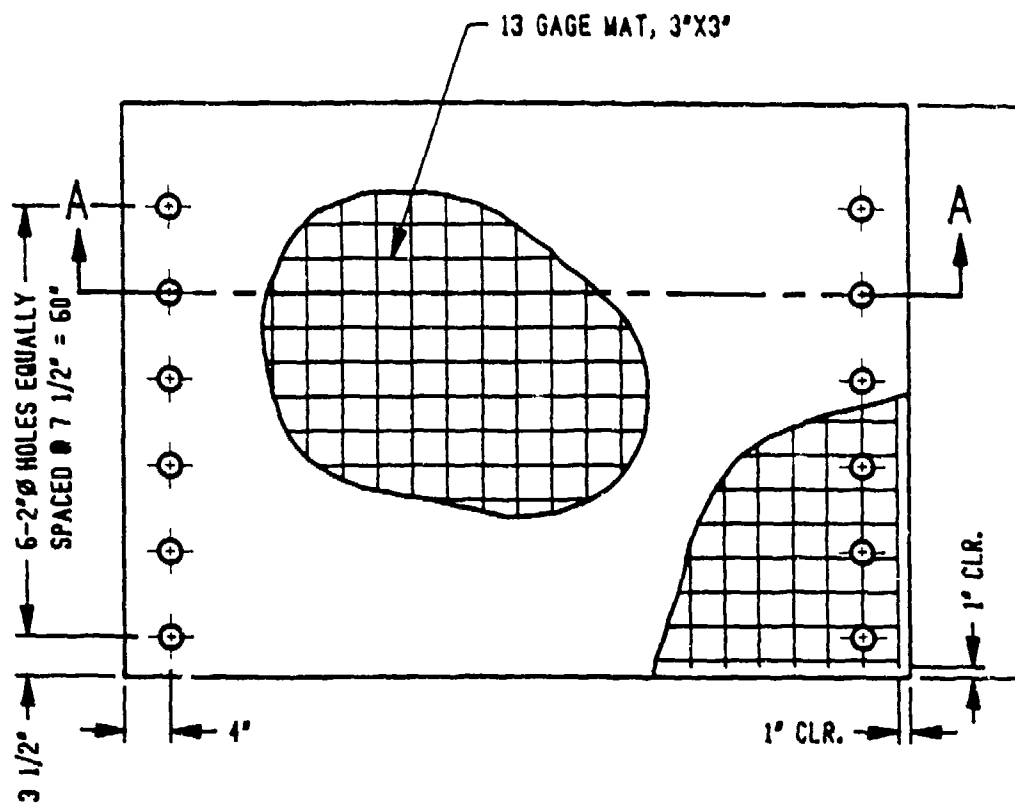


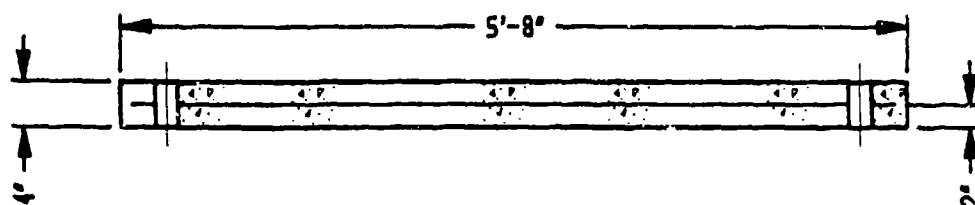
Figure 13. Panel-Type B Details.





## ELEVATION

SCALE: 3/4" = 1'-0"



## SECTION A-A

SCALE: 3/4" = 1'-0"

Figure 14. Panel-Type C Layout.

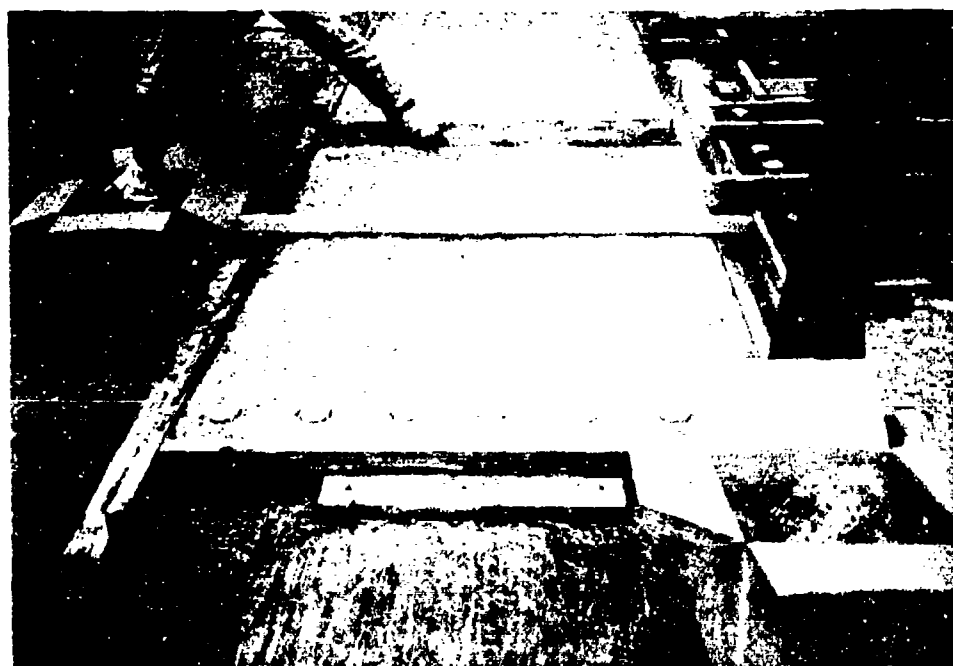
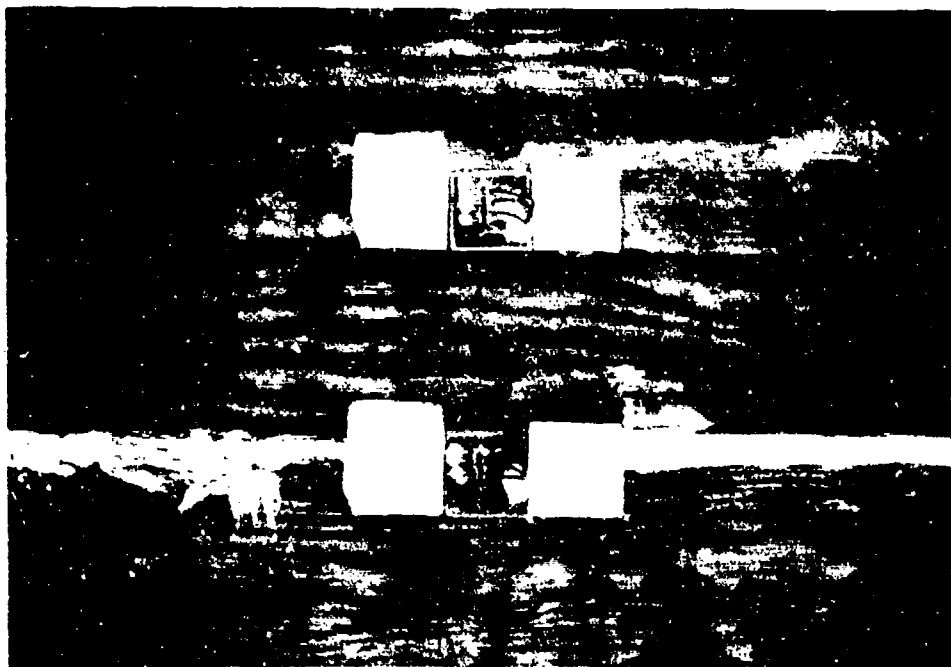


Figure 15. Panel-Type C Details.

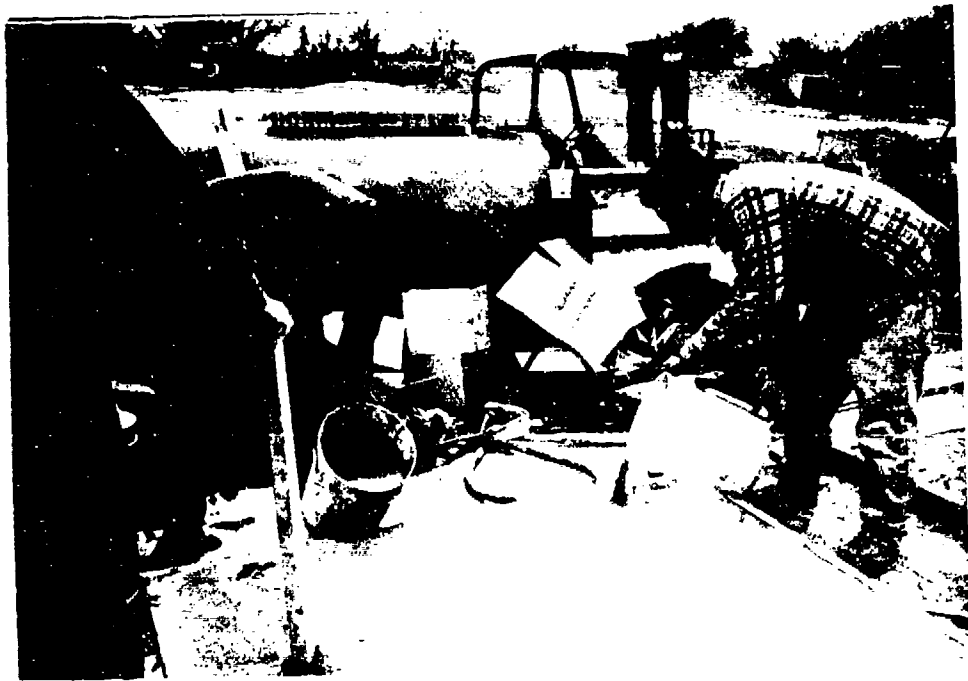


Figure 16. Panel Fabrication.

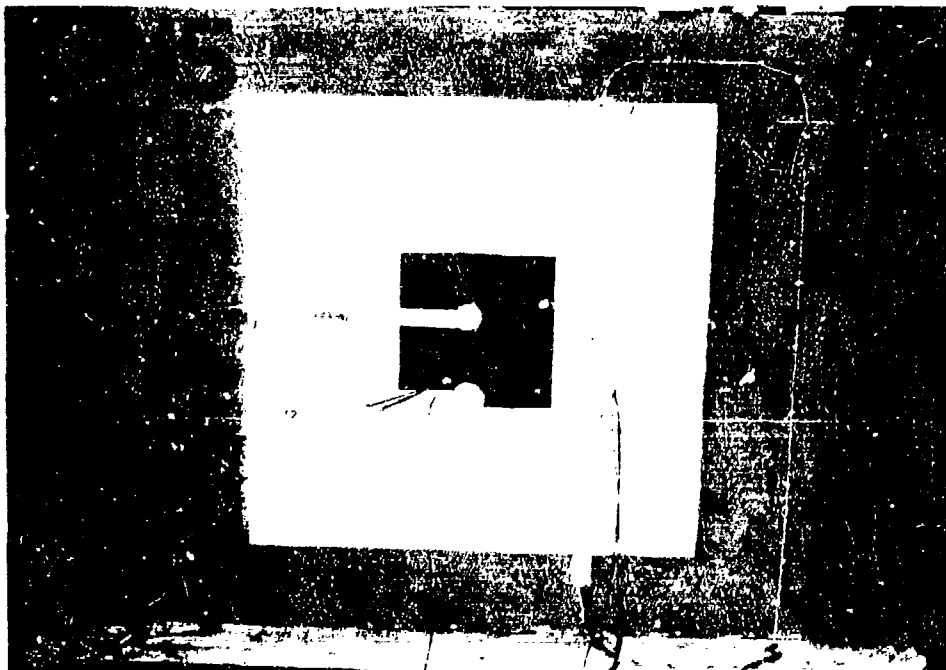


Figure 17. Panel Support.

piezocrystals were installed in the test panels in two arrays of four crystals per array. The crystals in each array were 0.5 inches apart with the crystal being located 0.5 inches below the surface of the test panel closest to the charge. The exact locations of the gages are shown in Figure 18 for the Type B panels and in Figure 19 for the Type C panels. Details of the gage placement are shown in Figure 20. The outputs of the carbon shock pressure gages and of the crystals were recorded on magnetic tape and were subsequently analyzed. Computer-generated plots of these outputs were made and are included in Appendix C of this report.

Calibration of the Dynasen carbon pressure gage was accomplished through a simulation of the behavior of the gage under pressure. Since the percentage change in resistance of the carbon element under pressure is known, we can simply insert that calculated resistance can be used to obtain the voltage output for that pressure.

The Dynasen pulse power supply provides a relatively short-duration excitation voltage to the gage and the associated bridge arrangement. The voltage can be adjusted from 30-300 VDC and the duration can be adjusted from 5 microseconds to hundreds of microseconds. It was determined that a duration of about 500 microseconds was needed to allow ample time for data recording. The power supply schematic is shown in Figure 21.

To select a suitable excitation voltage, an actual carbon gage with its connecting cable was connected to the power supply after the pulse duration was set to 500 microseconds. Beginning at 30 volts, the gage was pulsed and the output monitored to check for both gage heating and for an appropriate output level to allow recording throughout the 2 - 7-kilobar region. Voltage levels above 50 volts caused gage heating due to the relatively long pulse time (500 microseconds), thus a 50-volt level was selected.

Next, a standardized bridge output attenuation setting was needed in order to ensure that the calibrations remained accurate when gages were replaced between tests and different pressure levels were expected. By simulating both extremes of pressure, a 0 attenuation was found to be both suitable and convenient because the potentiometer is simply turned against its stop and the bridge output would not be high enough to saturate the buffer/follower output stage.

To perform the actual calibration, the gage resistance was added to the cable resistance and the negative change in gage resistance corresponding to the pressure level ( $\Delta R/R$ ) was calculated and subtracted from the total. The  $\Delta R/R$  as provided by Dynasen is shown in Figure 22. A decade resistor with .01 ohm resolution was used to provide this calculated resistance. The power supply was then pulsed and a Nicolet digital oscilloscope was used to measure the voltage output over the 500 microsecond pulse. Sixteen pressure

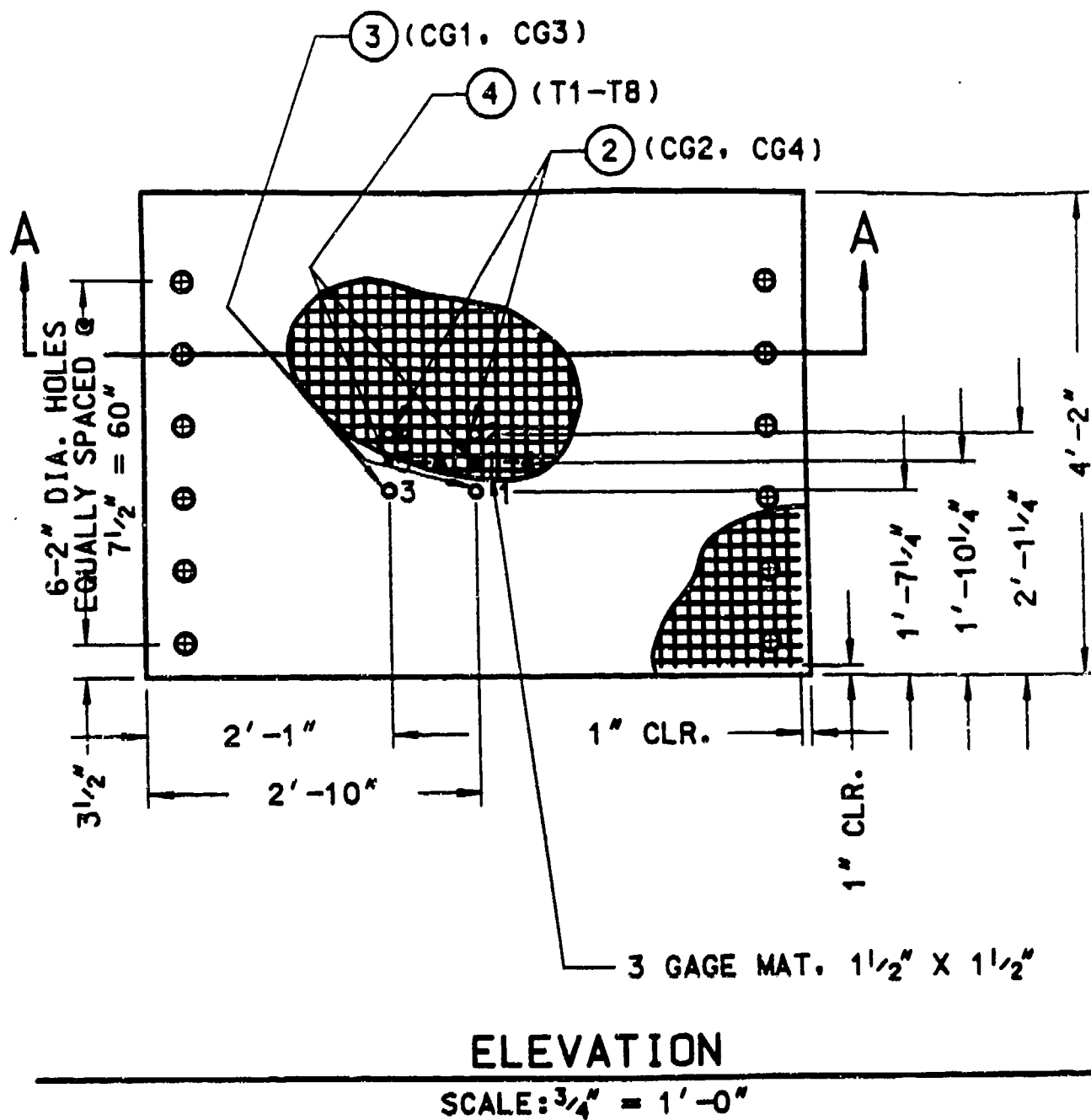
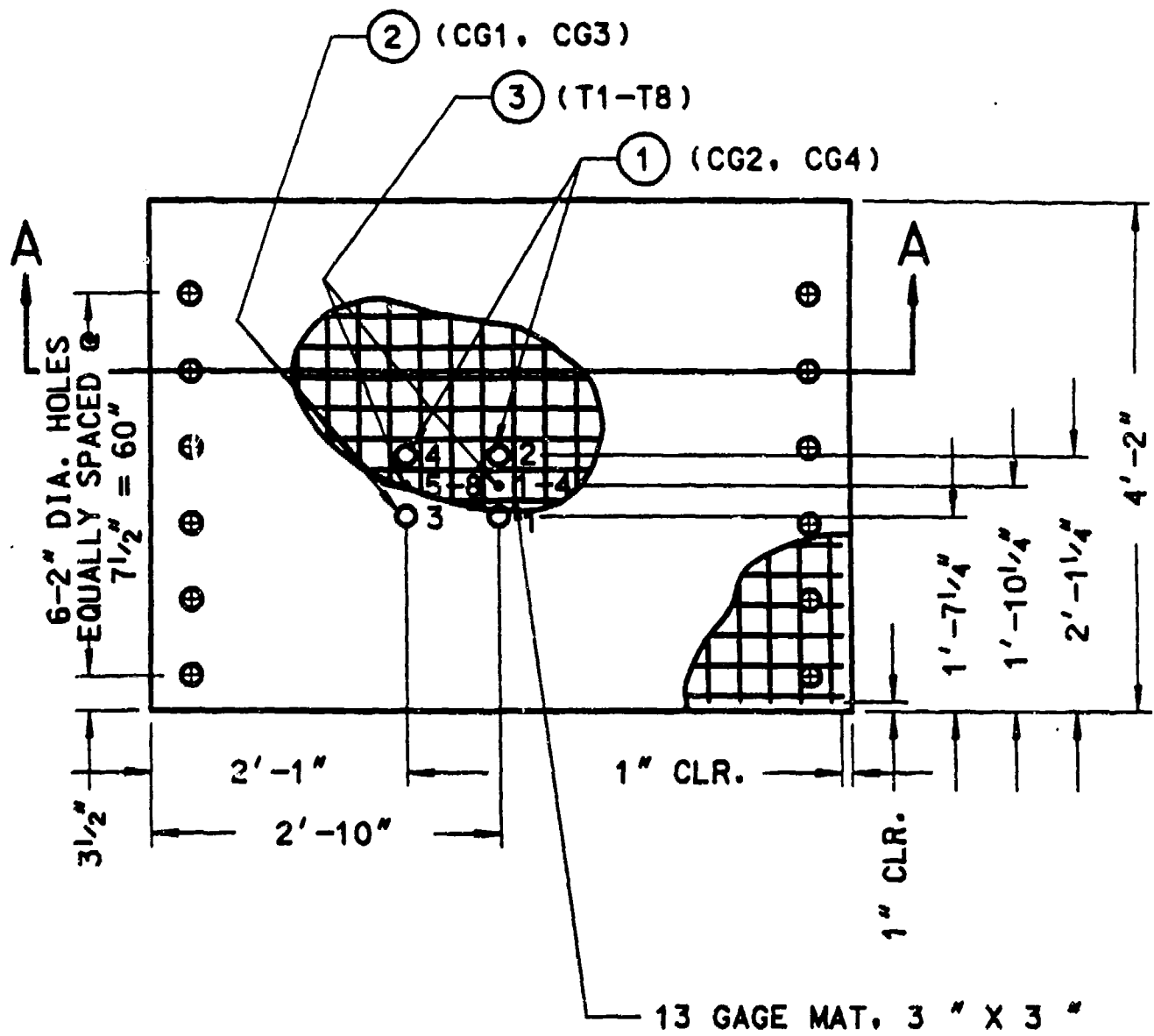


Figure 18. Panel-Type B Carbon Gage and Piezocrystal Locations.



## ELEVATION

SCALE:  $\frac{3}{4}" = 1'-0"$

Figure 19. Panel-Type C Carbon Gage and Piezocrystal Layout.

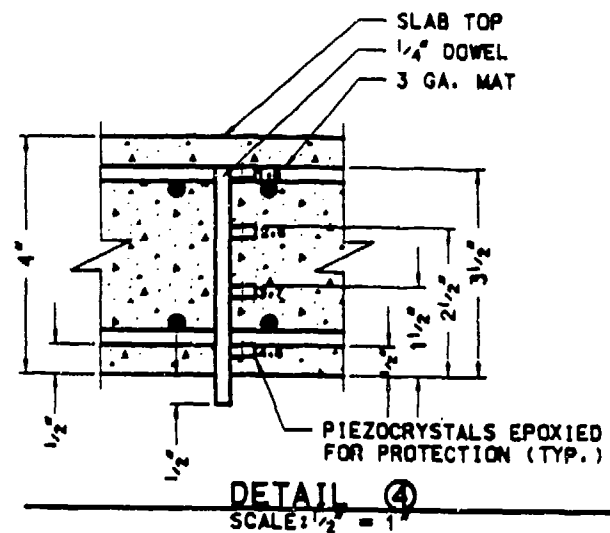
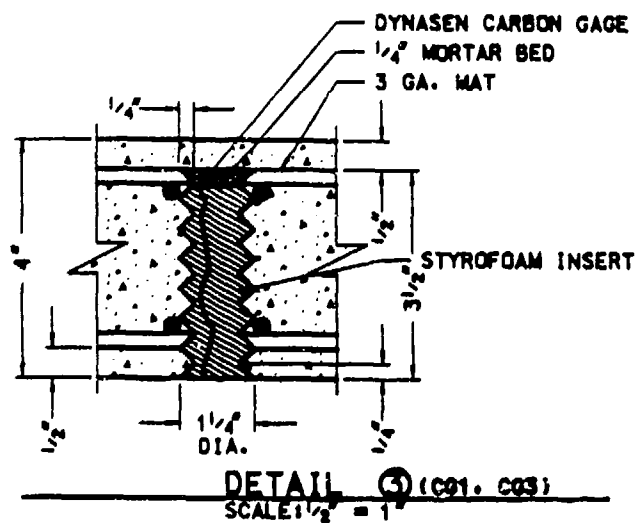
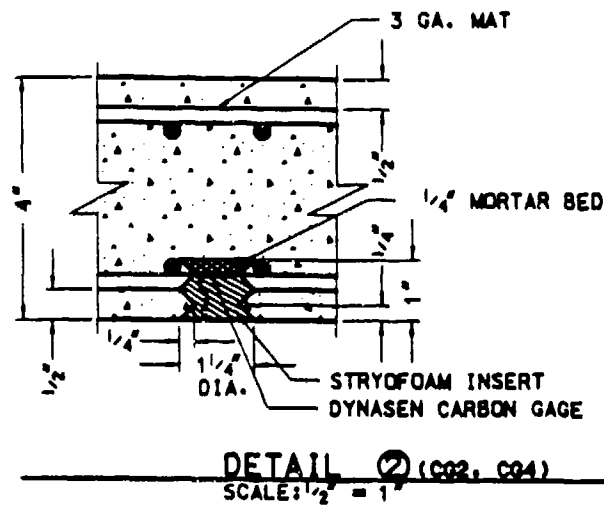


Figure 20. Details of Gage Placement for Panel-Types B & C.





points from 0 - 7.5-kilobars were then read in the same manner. A typical calibration curve is shown in Figure 23. All calibrations are included in Appendix D.

Since the carbon gages provided by Dynasen ranged in resistance from 48-55 ohms, calibrations were performed in four resistance ranges; 48, 50, 52, and 54 ohms. Also, all four gage resistance range calibrations were performed on each of the four channels of pulse power supplies used so that any gage could be connected to any power supply and an accurate calibration would exist.

High-speed cameras were also used to document the tests. One camera was positioned so that it viewed the back side of the panel to observe the wall failure mechanism. The back sides of the walls were painted to aid in viewing the failure mechanism. A second high-speed camera was positioned perpendicular to the side of the reaction structure, that is, perpendicular to the trajectory of the resultant wall back face fragments. A grid background was positioned next to the far side of the reaction structure as shown in Figure 24 and was used to determine the velocity of the fragments.

GAGE J, 50 OHMS, CHAN 3

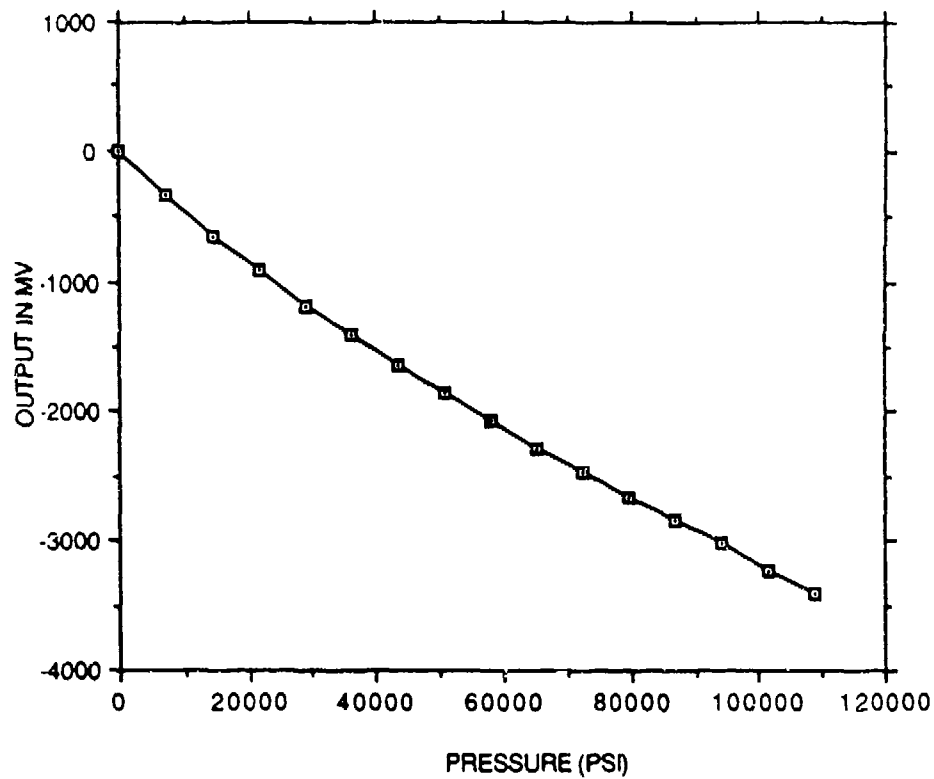


Figure 23. A Typical Carbon Gage Calibration Curve.

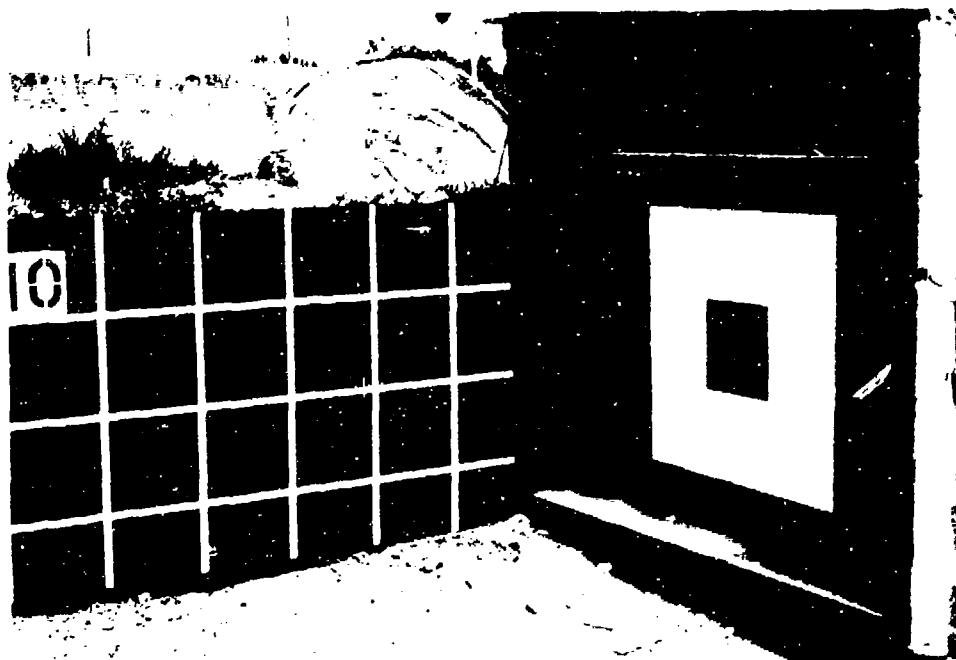


Figure 24. High-speed Camera Grid.

### SECTION III. TEST RESULTS

#### A. LOADS TESTS

##### 1. Bare Charge Tests

The bare charge tests were conducted inside of the reinforced concrete structure as previously described. A total of 5 tests were conducted using the bare charges, three tests with the 2.4-pound charge and 2 tests with the 2.7-pound charge. The 2.4-pound charges were cylindrical in shape having a diameter of 2.65 inches and a length of 7.54 inches. The 2.7-pound charges were also cylindrical having a diameter of 2.372 inches and a length of 10.7 inches. In all of the bare charge tests, the center of the charge was located at a height of 36 inches from the bottom of the floor and at a standoff of 18 inches from the impulse plug plate. The following paragraphs describe the tests.

##### a. Test 1

The first test conducted involved a bare C4 charge weighing 2.4-pounds. This test was instrumented with five reflected pressure gages mounted at positions P6-P10 and four side-on pressure gages, P1-P4. The side-on gages were located at 24 inches and 36 inches as shown in Figure 25. Eight impulse plugs with aluminum caps were used in this test with eight sets of fiber-optic break wires to measure the plug velocities. Two fiber-optic cables spaced 6 inches apart were placed on the back face of the impulse plug fixture directly behind each of the impulse plugs. As the impulse plugs were loaded by the blast and were driven out of the fixture, the plug severed each of the two cables. A time pulse was provided by each cable when the impulse plug broke the cable. The break times and the distances between cables were used to calculate the plug velocity. Six of the eight impulse plugs were completely driven out of the fixture. Plug 7 did not exit the fixture at a high enough velocity to break the second fiber-optics cable and a velocity was not obtained for this particular plug. A velocity was also not obtained for Plug 8 due to instrumentation problems. Pressures were measured by each of the four side-on gages and by four of the five reflected pressure gages. The computer generated pressure-time history for Gage P6 showed that the gage was damaged during the test and a peak pressure was not measured. TABLE 4 summarizes the peak pressures measured by the remaining gages. TABLE 5 provides maximum impulses resulting from integration of those records. TABLE 6 presents the impulse plug velocities, and TABLE 7 presents the calculated impulses based on plug mass. Original data sheets are included in Appendix A.

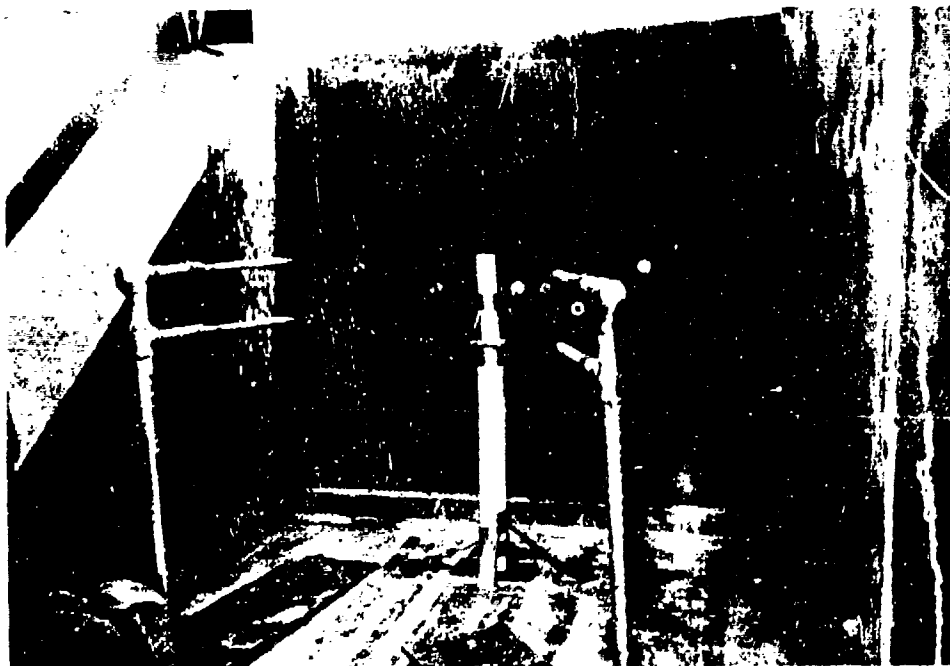


Figure 25. Side-on Gage and Charge Placement for Test 1.

TABLE 4. COMPARISON OF PRESSURES FOR BARE CHARGE TESTS.

| Gage Location | Measured Pressures (psi) |              |              |              |              |
|---------------|--------------------------|--------------|--------------|--------------|--------------|
|               | Test 1 (2.4)             | Test 2 (2.7) | Test 3 (2.4) | Test 4 (2.7) | Test 5 (2.4) |
| P1:           | 528                      | 464          | 625          | 325          | 512          |
| P2:           | 891                      | 1280         | 1100         | 660          | 950          |
| P3:           | 175                      | 324          | 600          | 315          | N/A          |
| P4:           | 575                      | 741          | 375          | 399          | N/A          |
| P5:           | N/A                      | N/A          | N/A          | N/A          | GF           |
| P6:           | GF                       | N/A          | N/A          | N/A          | GF           |
| P7:           | 800                      | N/A          | 900          | GF           | GF           |
| P8:           | 9250                     | GF           | GF           | 5586         | 7441         |
| P9:           | 2100                     | 2690         | 2400         | 2600         | 977          |
| P10:          | 24000                    | 14000        | GF           | 16296        | 21780        |
| P11:          | N/A                      | 6956         | 4500         | GF           | 7916         |
| P12:          | N/A                      | 4656         | 3000         | 3500         | 2654         |

TABLE 5. COMPARISON OF IMPULSES FOR BARE CHARGE TESTS.

| Gage Location | Integrated Impulses (psi-msec) |              |              |              |              |
|---------------|--------------------------------|--------------|--------------|--------------|--------------|
|               | Test 1 (2.4)                   | Test 2 (2.7) | Test 3 (2.4) | Test 4 (2.7) | Test 5 (2.4) |
| I1:           | 22.6                           | 16.6         | 21.4         | 20           | 27           |
| I2:           | 29                             | 30.7         | 24.4         | 46.9         | 39           |
| I3:           | 19                             | 17.8         | 43           | 25           | N/A          |
| I4:           | 35                             | 45           | 23           | 40           | N/A          |
| I5:           | N/A                            | N/A          | N/A          | N/A          | GF           |
| I6:           | GF                             | N/A          | N/A          | N/A          | GF           |
| I7:           | 200                            | N/A          | 98.8         | GF           | GF           |
| I8:           | 160                            | GF           | GF           | 126.9        | 241          |
| I9:           | 114                            | 140          | 78           | 150          | 93.5         |
| I10:          | 430                            | GF           | GF           | 336          | 290          |
| I11:          | N/A                            | 310          | 263          | GF           | 353          |
| I12:          | N/A                            | 272          | 170          | 200          | 171          |

**TABLE 6. COMPARISON OF IMPULSE PLUG VELOCITIES FOR BARE CHARGE TESTS.**

| Plug No. | Measured Velocity<br>(fps) |                 |                 |                 |                 |
|----------|----------------------------|-----------------|-----------------|-----------------|-----------------|
|          | Test 1<br>(2.4)            | Test 2<br>(2.7) | Test 3<br>(2.4) | Test 4<br>(2.7) | Test 5<br>(2.4) |
| 1:       | 28.5                       | 37.8            | 38.4            | 30.9            | 30              |
| 2:       | 53.4                       | 59.4            | 39.2            | 41.9            | N/A             |
| 3:       | 69.4                       | 43.9            | 42.6            | 47.6            | 31.7            |
| 4:       | 111.8                      | 42.8            | 53.4            | 60.5            | 42.8            |
| 5:       | 90.8                       | 38.9            | 61.2            | 56.9            | 43.8            |
| 6:       | N/A                        | 39.9            | 30.5            | 42.2            | 27.4            |
| 7:       | N/A                        | 40.5            | 38.5            | 44.1            | 42.4            |
| 8:       | N/A                        | N/A             | 38.7            | 23.9            | 32.9            |

**TABLE 7. COMPARISON OF CALCULATED PLUG IMPULSES FOR BARE CHARGE TESTS.**

| Plug No. | Calculated Impulse <sup>1</sup><br>(psi- msec) |                              |                              |                              |                              |
|----------|------------------------------------------------|------------------------------|------------------------------|------------------------------|------------------------------|
|          | Test 1 <sup>2</sup><br>(2.4)                   | Test 2 <sup>3</sup><br>(2.7) | Test 3 <sup>4</sup><br>(2.4) | Test 4 <sup>4</sup><br>(2.7) | Test 5 <sup>4</sup><br>(2.4) |
| 1:       | 147.0                                          | 195.0                        | 198.1                        | 159.4                        | 154.8                        |
| 2:       | 275.5                                          | 306.5                        | 388.9                        | 415.7                        | N/A                          |
| 3:       | 358.1                                          | 435.6                        | 422.7                        | 472.3                        | 314.5                        |
| 4:       | 576.8                                          | 424.7                        | 529.8                        | 600.3                        | 424.7                        |
| 5:       | 468.5                                          | 386.0                        | 607.2                        | 555.6                        | 434.6                        |
| 6:       | N/A                                            | 395.9                        | 302.6                        | 418.7                        | 271.9                        |
| 7:       | N/A                                            | 209.0                        | 198.6                        | 227.5                        | 218.8                        |
| 8:       | N/A                                            | N/A                          | 199.7                        | 123.3                        | 169.7                        |

**Notes:**

- 1) Plug face area = .13 inches<sup>2</sup>
- 2) All plugs were aluminum. The average plug weight was 0.52 pounds
- 3) Plugs 1,2,7 and 8 were aluminum. Plugs 3-6 were steel with a weight of 1 pound
- 4) Plugs 1,7 and 8 were aluminum. Plugs 2-6 were steel.

### b. Test 2

The second test conducted involved a bare charge weighing 2.7-pounds. This test was also instrumented with four side-on pressure gages (P1-P4) and five reflected pressure gages (P8-P12). The side-on gages were again located at 24 inches and 36 inches. Eight impulse plugs were used on this test. Five plugs had steel caps and three plugs had aluminum caps. This test also used sets of two fiber-optic break wires for each impulse plug for measuring the plug velocities. Seven of the eight impulse plugs were completely driven out of the fixture. Plug 8 did not break the second fiber-optics cable and a velocity was not obtained for this plug. Pressures were measured by each of the four side-on gages and by four of the five reflected pressure gages. These data are provided in TABLE 4. TABLE 5 presents the impulses measured and TABLES 6 and 7 include measured plug velocities and calculated specific impulse. The review of the pressure-time histories showed that gage no. P8 failed during the test and did not accurately measure the peak reflected pressure. Gage P10 was also damaged during the test, however, a peak reflected pressure was measured before the gage failed. The computer generated pressure-time histories, the impulses and the fiber-optics break times are given in Appendix A of this report.

### c. Test 3

The third test conducted involved a bare charge weighing 2.4-pounds. This test was instrumented with six reflected pressure gages located at positions P7 - P12 and with four side-on pressure gages, P1-P4. The side-on gages were located at 24 inches and 36 inches. Eight impulse plugs, five with steel caps and three with aluminum caps were used on this test. This test used the Dynasen position transducers (shorting pins) located at the back of the impulse plug fixture to measure the plug velocities. As previously mentioned, the position transducers were used in sets of two transducers, one 7 inches long and the other 6 inches long. The two transducers were located behind each of the plugs and as the plug cleared the fixture, it made contact with each transducer. All eight of the impulse plugs were completely driven out of the fixture. Velocities were calculated for each of the plugs based on the position transducer (shorting pin) data. The velocities are provided in the summary data sheet, TABLE 5. Pressures were measured by each of the four side-on gages and by four of the six reflected pressure gages. Gages P8 and P10 failed during the test, prior to measuring the peak reflected pressures. The measured pressures for the other gages are included in TABLE 4. TABLES 6 and 7 present measured plug velocity and calculated impulse. The computer generated pressure-time histories and the shorting pin times are given in Appendix A.



#### d. Test 4

This test involved a bare charge weighing 2.7-pounds. This test was also instrumented with six reflected pressure gages located at positions P7-P12 and with the four side-on pressure gages, P1-P4. For this test, however, the side-on gages were located at 36 inches and 48 inches. Eight impulse plugs, five with steel caps and three with aluminum caps were used on this test. The impulse plug velocities were calculated using the data generated by the position transducers located behind the impulse plugs. All of the impulse plugs were completely driven out of the fixture. Pressures were measured by each of the four side-on gages and by four of the six reflected pressure gages and are included in TABLE 4. The computer generated plots for the gages located at P7 and P11 indicated that the gages were damaged during the test and the pressures measured were questionable. TABLE 5 includes the measured impulses while TABLES 6 and 7 have plug velocities and impulses. The actual computer generated pressure-time histories and the position transducer break times are given in Appendix A.

#### e. Test 5

This test also involved a bare charge weighing 2.4-pounds. This test was instrumented with two of the side-on pressure gages at positions P1 and P2 and with eight of the reflected pressure gages mounted at positions P5-P12. The two side-on gages were both placed 36 inches from the charge. The eight impulse plugs were installed as were the position transducers. Velocities were measured for seven of the eight impulse plugs. The back shorting pin on Plug 2 did not respond, thus a velocity calculation was not possible for this plug. Pressures were measured by each of the side-on gages and by all of the reflected pressure gages. The actual pressures are provided in TABLE 4. Measured impulse is presented in TABLE 5. TABLES 6 and 7 include plug velocities and impulse. The computer generated plots for the gages located at P5, P6 and P7 indicated that the gages were damaged during the test and the pressures measured were questionable. These plots are provided in Appendix A of this report.

### 2. Cased Charge Tests

A total of three cased charge tests were conducted inside of the reinforced concrete structure. The first cased test conducted, Test 6, involved the 2.7-pound cased charge which simulated the Mk 82 GP 500 bomb. The remaining two tests, Tests 7 and 8, were conducted using the 2.4-pound cased charge which simulated the AN-Mk 1 AP 1600 pound bomb. Tests 6 and 7 were equipped with fragment velocity break screens for measuring the casing fragment velocities. Each set of screens consisted of a front and a rear break screen made out of aluminum foil sheets 18 inches wide by 12 inches high. The front screen and the rear screen

were spaced 12 inches apart. The corners of each of the aluminum sheets were wired to trigger boxes which produced an electrical pulse when the aluminum sheet was perforated by a fragment. The signals emitted by the front and the rear break screens were recorded on counters. Times measured were used to calculate the fragment velocity. Only velocities for the first fragment to hit the screens were recorded. Velocities for those fragments impacting the screens at a later time were not measured. The first test was conducted using one row of four sets of screens. The second test conducted used two rows of four sets of velocity screens for a total of eight velocity measurements. The screens were positioned in the expected path of the cased charge fragments with the front screen located 8-feet from the charge.

The fiberboard bundles used to capture the fragments were positioned 9-feet away from the charge and directly behind the back velocity screens as shown in Figure 26. This configuration allowed some correlation to be made between the actual fragments recovered in the fiberboard and the velocities measured by the break screens. All fragments removed from the fiberboard sheets were cleaned, sized and weighed. Initial impact positions and trajectories of the fragments were recorded for use in fragment spray distribution calculations. In the three cased charge tests conducted, the center of the cased charge was always located 36 inches from the floor and with an 18-inch standoff from the impulse plug fixture. The following paragraphs describe the three cased charge tests.

a. Test 6

Test 6 was the first cased charge test conducted. A 2.7-pound cased charge simulating the Mk 82 was tested. This test had two side-on pressure gages (P1, P2) positioned 30 inches away from the charge. A steel pipe was placed in front of the side-on gages to aid in protecting the gages from fragment impacts. This fragment stripper pipe was located sufficiently far away from the gages so as to not affect the pressure measurements. Eight reflected pressure gages were installed in the impulse plug fixture at positions P5-P12. Eight impulse plugs and corresponding position transducers were also installed in the fixture, as shown in Figure 27. Four sets of velocity screens were positioned in a row and the fiberboard was located directly behind the screens as shown in Figure 26. For this test, 96 sheets of 0.5 inch thick fiberboard were used to capture the fragments. The cased charge was initiated using an RP-83 detonator. The resulting casing fragments severely damaged four of the reflected pressure gages and only Gages P8 - P11 measured acceptable pressure levels. The two side-on pressure gages measured the pressures even though one of the gages was severely damaged. The casing fragments also impacted the impulse plugs and deformed them. The plugs were wedged in place in the fixture and only one plug (11) was able to exit the fixture and function the position transducers. The four sets of fragment

velocity screens each recorded a fragment velocity with the four velocities ranging between 6,098 fps and 6,906 fps. The fiberboard was examined and over 171 casing fragments were recovered. Coordinates for each fragment were recorded as well as the depth of penetration, that is, the number of sheets penetrated, and the size and weight. TABLE 8 presents the pressure data, the measured impulses, and the impulse plug velocity and impulse data. Appendix E contains fragment data collected in Test 6. Break screen data for Tests 6 - 7 is included in TABLE 9.

TABLE 8. DATA SUMMARY FOR CASED CHARGE TEST 6.

| Gage Location | Measured Pressure (psi) | Integrated Impulse (psi-msec) | Measured Plug Velocity (fps) | Calculated Impulse (psi-ms) |
|---------------|-------------------------|-------------------------------|------------------------------|-----------------------------|
| P1:           | 415                     | 29                            | 31.5                         | 162.5                       |
| P2:           | 483                     | 34                            | No Data                      | No Data                     |
| P8:           | 5000                    | 265                           | "                            | "                           |
| P9:           | 1400                    | 110                           | "                            | "                           |
| P10:          | 18350                   | GF                            | "                            | "                           |
| P11:          | 9200                    | 300                           | "                            | "                           |

TABLE 9. COMPARISON OF BREAK SCREEN VELOCITIES.

| Screen No. | Measured Velocity (fps) |                     |
|------------|-------------------------|---------------------|
|            | Test 6<br>2.7 Cased     | Test 7<br>2.4 Cased |
| Set 1:     | 6906                    | 6250                |
| Set 2:     | 6671                    | 4167                |
| Set 3:     | 6519                    | 4386                |
| Set 4:     | 6098                    | 2976                |
| Set 5:     | N/A                     | 6757                |
| Set 6:     | N/A                     | 4807                |
| Set 7:     | N/A                     | 5556                |
| Set 8:     | N/A                     | 6097                |



Figure 26. Fiberboard Setup for Tests 6 - 7.

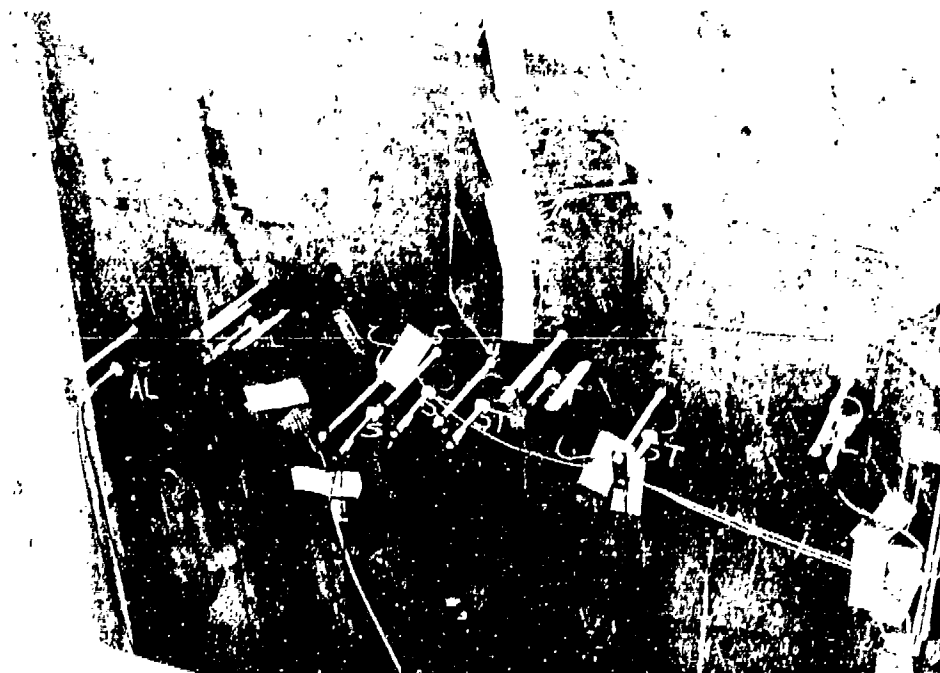


Figure 27. Position Transducer Setup for Test 6.

b. Test 7

This test was conducted with the 2.4-pound cased charge simulating the AN-Mk 1. This test also had two side-on pressure gages (P1, P2), however, for this test, the gages were placed on separate stands with one gage positioned 30 inches away from the charge and the second gage positioned 48 inches away from the charge. Fragment stripper pipes were again placed in front of the gages to try and protect them from fragment impacts. Since the reflected pressure gages were so badly damaged in the previous test and very little data were obtained, it was decided to omit the reflected pressure gages and use only the side-on pressure gages. Similarly, the use of the impulse plugs in the previous test yielded very little usable data and their use were also omitted from this test. The number of sets of velocity screens was increased to two rows of four sets of screens per row. For ease in handling, the fiberboard was bundled in groups of 12 sheets per bundle. The velocity screens and the fragment recovery fiberboard bundles were positioned as shown in Figure 28. The cased charge was initiated using an RP-83 detonator. The resulting casing fragments slightly damaged the two side-on pressure gages, however, the damage did not affect the ability of the gages to measure the side-on pressures correctly. The eight sets of fragment velocity screens each recorded a maximum fragment velocity ranging between 2,976 fps and 6,575 fps. TABLE 10 provides the side-on pressure and impulse data. The first fiberboard bundle, which consisted of 12 sheets was ignited by a hot fragment buried in the middle of the bundle and burned completely, preventing the accurate recovery of the fragments in the bundle. Since the fragment data were incomplete, it was decided to repeat this particular test.

c. Test 8

Test 8 was a repeat test of the 2.4-pound cased charge test. This test also had two side-on pressure gages (P1, P2) however, they were positioned 48 inches away from the charge, one gage centered directly in line with the charge and the other gage offset at an angle. A fragment stripper pipe was again placed in front of each of the gages to protect them from fragment impacts. Since the purpose of this test was to obtain a good fragment count, impulse plugs, reflected pressure gages and fragment velocity screens were not used. The cased charge was initiated using an RP-83 detonator. The resulting casing fragments damaged the two side-on pressure gages but the pressures were recorded. The fiberboard sheets survived this test and over 269 fragments were recovered. Coordinates for each fragment, as well as depth of penetration, size and weight, were recorded. The measured side-on pressures and impulses for this test are presented in TABLE 10. They compare favorably with the side-on pressures recorded for the previous test. Fragment data for this test are included in Appendix F.

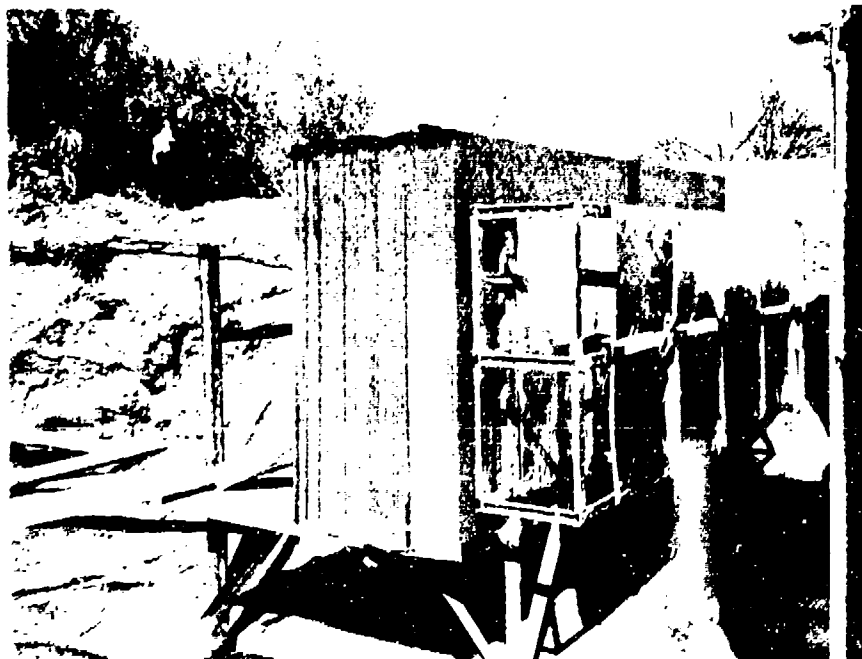


Figure 28. Velocity Screen and Fiberboard Setup for Test 7.

TABLE 10. DATA SUMMARY FOR CASED CHARGE TESTS 7 AND 8.

| Gage Location | Measured Pressure (psi) |        | Integrated Impulse (psi-msec) |         |
|---------------|-------------------------|--------|-------------------------------|---------|
|               | Test 7                  | Test 8 | Test 7                        | Test 8  |
| P1:           | 95.6                    | 70     | 10.6                          | 10.5    |
| P2:           | 87                      | 85     | 11.6                          | No Data |

## B. DETERMINATION OF EQUIVALENT BARE CHARGES

At the conclusion of the loads tests with both the cased and bare charges, an effort was undertaken to define an equivalent charge for both the scaled lightly cased charge (Mk 82) and the scaled heavily cased charge (AN-Mk 1). This equivalent charge was based on the determination of a bare explosive charge with an impulse distribution similar to that produced by both blast and fragments from a cased charge. This was done to allow panel tests to be conducted on the three panel types with both cased charges and equivalent impulse bare charges.

## 1. Cased Charge Blast Impulse

As is presented in the paragraphs above and in TABLES 8 and 10, the side-on airblast measured in the cased charge tests was reduced considerably from that produced by an equivalent amount of bare explosive. Standard tables from Reference 1 were used to determine an appropriate bare charge that would produce these blast impulses at the cited standoffs. TABLE 11 presents the charge weights determined for these impulses. This measured airblast was simply added to the fragment impulse described below to establish an equivalent charge.

TABLE 11. 2.7- AND 2.4-POUND CASED CHARGE MEASURED AIRBLAST IMPULSE AND CORRESPONDING BARE CHARGES.

| Charge (Test) | Measured Impulse (psi-ms) | Equivalent Bare Charge Weight (pounds) |
|---------------|---------------------------|----------------------------------------|
| 2.7 (6)       | 31.5                      | 2.373                                  |
| 2.4 (7,8)     | 10.6                      | 0.567                                  |

## 2. Cased Charge Fragment Impulse

As is described in the paragraphs above detailing the test procedures, fragments from Tests 6 and 8 were collected from the fiberboard panels and were weighed and measured. Impact location and depth of penetration were also documented. These measurements were used to calculate an impact velocity for each fragment using a relationship for steel fragments into Celotex fiberboard as a function of presented area, mass and depth of penetration as follows (from References 15 and 16):

$$V = 44740 (eA)^{0.75} w^{-0.75}$$

where

- e = penetration depth, inches
- A = presented area, inches<sup>2</sup>
- w = weight of fragment, grains
- V = velocity, feet/seconds

The tables in Appendices E and F include all data extracted from the fragment tests, and have columns of calculated impact velocity for each fragment. These calculated velocities, based on observed fragment penetration, mass and presented area are compared with measured maximum velocities observed in TABLE 12. The comparison presented in TABLE 12 is not conclusive. However, several qualifiers can be attached to the velocity data presented. First, the velocity screens break at the earliest arrival of very small particles. Thus, very small case fragments (those not captured by the fiberboard) could break the screens while they may not be imbedded and found for recording. Second, the smaller fragments are easy to overlook in the fiberboard. A small magnet is used to detect the fragments for recording which may miss some of the fragments weighing only a few grains. Finally, velocities close to those recorded were calculated, shown in Appendices E and F, but were not included in TABLE 11 because they were not assigned a corresponding screen number due to their estimated location. For the 2.7-pound Test 6 (light case), fragment velocities as high as 5971 fps, 9180 fps, and 5572 fps were calculated (Fragments 169, 170, and 171), but were noted as just missing the screen region (in two cases about 6 inches low, and in the third case about 2 inches high. For the 2.4-pound Test 8 (heavy case), velocities as high as 6462 fps were calculated (Fragment 108).

When a velocity for each fragment is known, momentum applied to the target can be calculated and a fragment impulse can be determined for each charge. Combining the calculated momentum with the catcher bundle size allows specific momentum or momentum per unit area (specific fragment impulse on the target) to be calculated.



**TABLE 12. COMPARISON OF CALCULATED AND BREAK SCREEN VELOCITIES.**

| Screen No. | Test 6<br>2.7 Cased     |                                   | Tests 7 and 8<br>2.4 Cased       |                                            |
|------------|-------------------------|-----------------------------------|----------------------------------|--------------------------------------------|
|            | Measured Velocity (fps) | Calculated Maximum Velocity (fps) | Measured Velocity (fps) (Test 7) | Calculated Maximum Velocity (fps) (Test 8) |
| Set 1:     | 6906                    | 1411                              | 6250                             | 2082                                       |
| Set 2:     | 6671                    | 2920                              | 4167                             | 1646                                       |
| Set 3:     | 6519                    | 2150                              | 4386                             | 3290                                       |
| Set 4:     | 6093                    | 1588                              | 2976                             | 1910                                       |
| Set 5:     | N/A                     | N/A                               | 6757                             | 2688                                       |
| Set 6:     | N/A                     | N/A                               | 4807                             | 1950                                       |
| Set 7:     | N/A                     | N/A                               | 5556                             | 4177                                       |
| Set 8:     | N/A                     | N/A                               | 6097                             | 2259                                       |

Additional fragment data is presented in Figures 29-32. These figures show the fragment dispersion as a function of height along the length of the cylindrical charge. Figures 29 and 31 show the number of fragment impacts for the 2.7 and 2.4 (lightly and heavily cased) charges respectively. Figures 30 and 32 show the calculated impulse. The fragment impacts can be seen to be skewed towards the top of the fiberboard panels slightly in the figure for Test 6 and towards the bottom for Test 8. This is logical for Test 8 since the charges were detonated at the top, and the resulting Taylor angle will drive them off at an angle greater than perpendicular due to the interaction of the detonation front with the casing material. It is unclear why Test 6 indicates a concentration of fragments opposite what the Taylor angle would suggest.

The impulse distribution to be obtained and modeled after this fragment data is a function of the standoff of the weapon. Since the charges were located at a standoff of 9 feet from the 8 foot wide fiberboard panels, the total fragment impulse is assumed to be that lying in a circular arc of 48 degrees in the horizontal dimension, spanning vertically over the charge height plus and minus 10 degrees for the 2.7-pound charge and 11 degrees for the 2.4-pound charge based on the fragment concentrations in the data of Appendices E and F. From Figures 29-32 it can also be seen that for the 2.7-pound test, the impulse is evenly distributed over the 4 foot height, while for the 2.4-pound test 93 percent of the

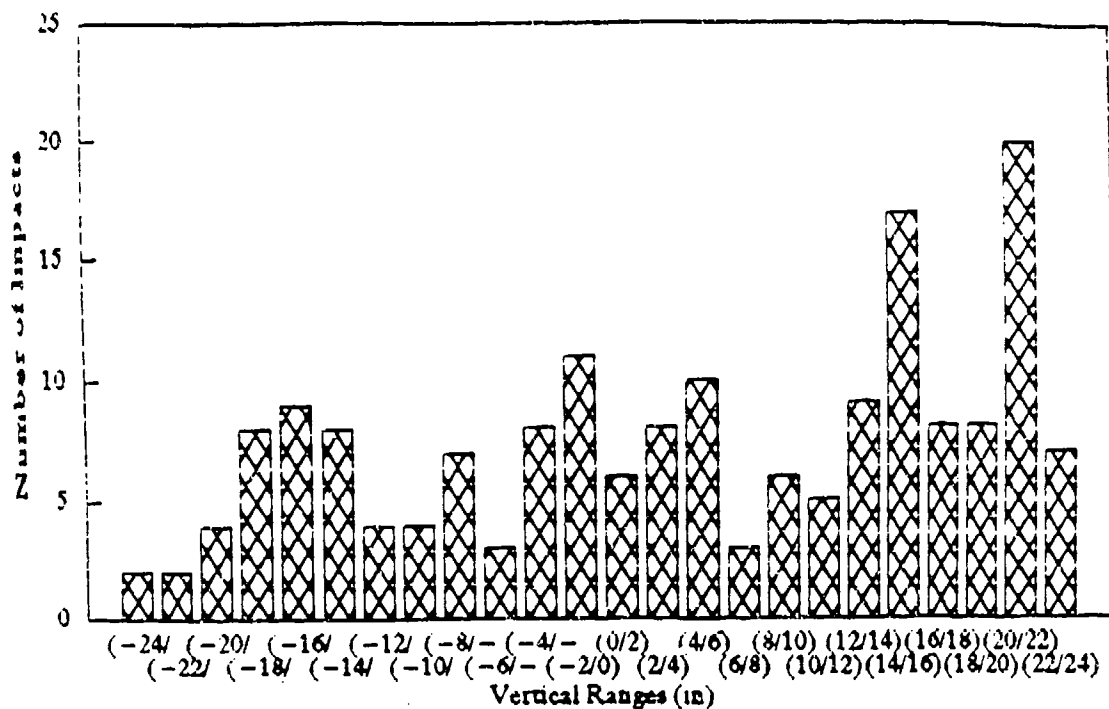


**Figure 29. Number of Fragment Impacts for the 2.7-Pound (Lightly Cased) Test.**

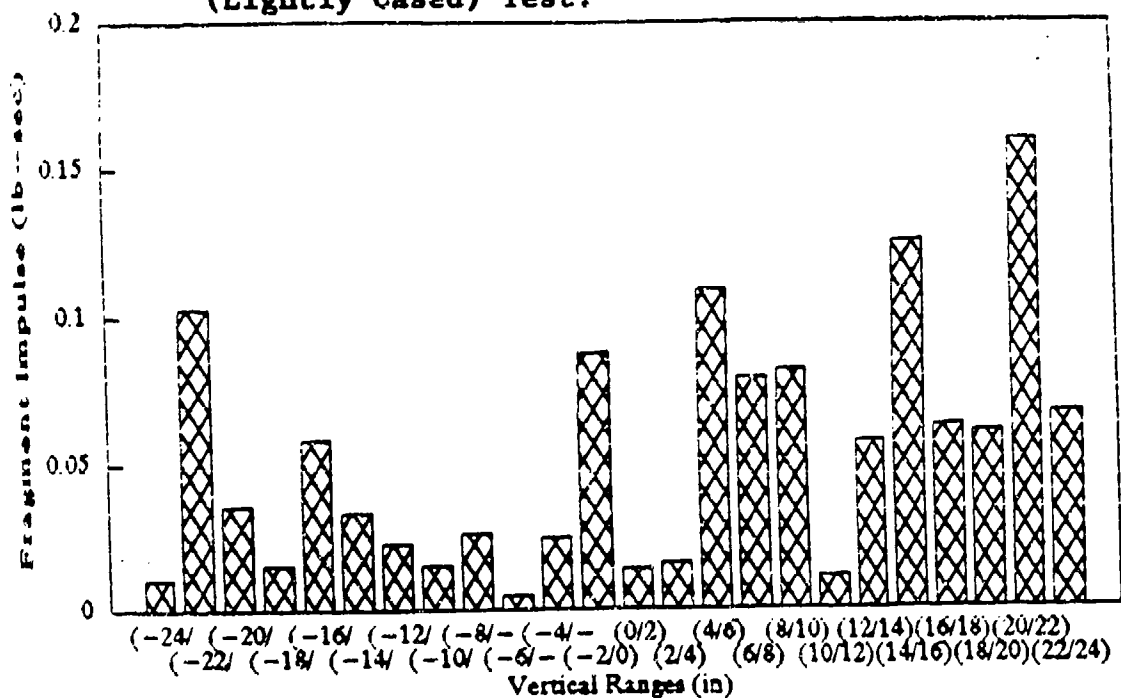


**Figure 30. Fragment Impulse Distribution for the 2.7-Pound (Lightly Cased) Test.**

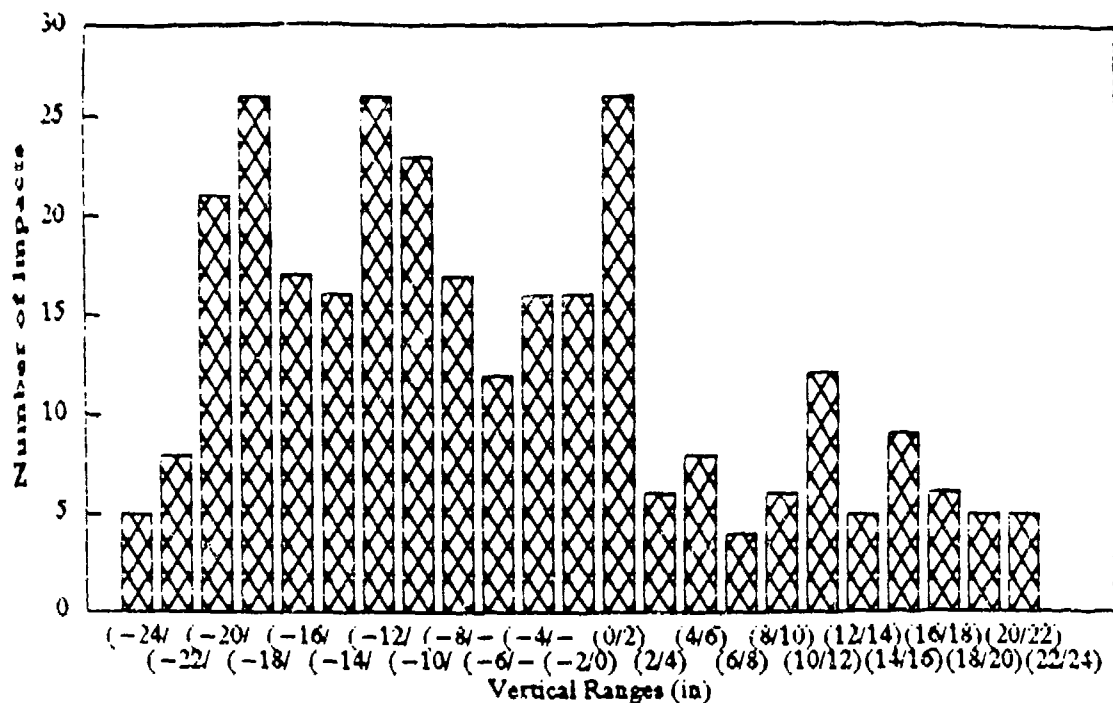


**Figure 31. Number of Fragment Impacts for the 2.4-Pound (Heavily Cased) Test.**

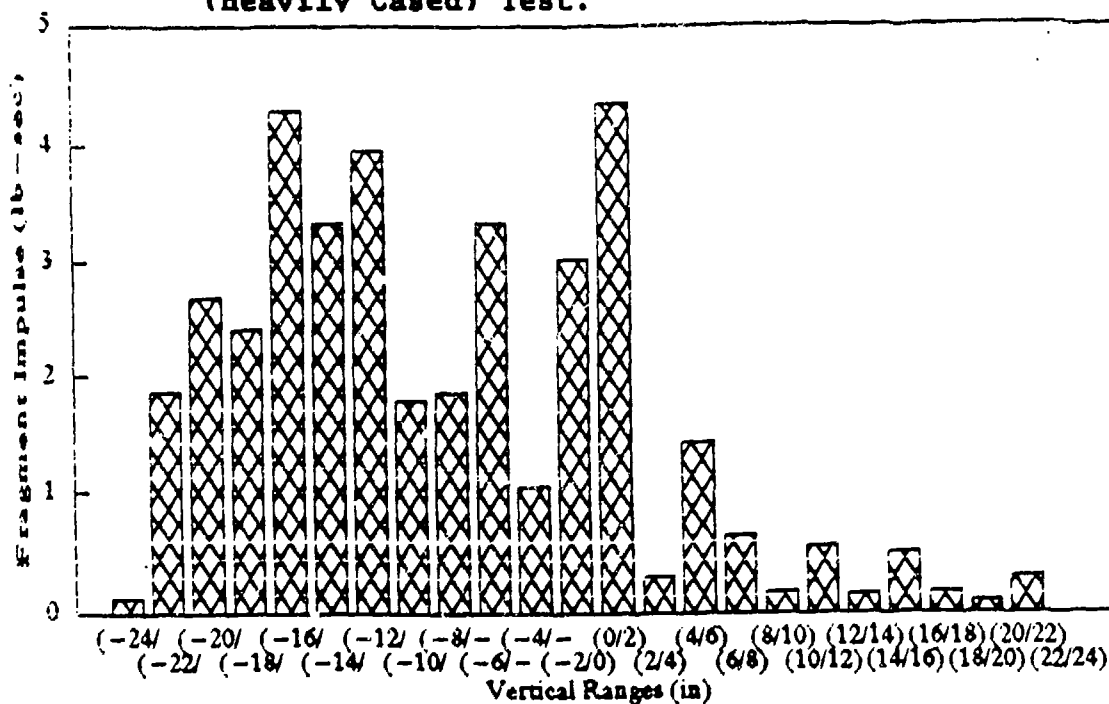


**Figure 32. Fragment Impulse Distribution for the 2.4-Pound (Heavily Cased) Test.**

for the 2.7-pound charge and 11 degrees for the 2.4-pound charge based on the fragment concentrations in the data of Appendices E and F. From Figures 29-32 it can also be seen that for the 2.7-pound test, the impulse is evenly distributed over the 4 foot height, while for the 2.4-pound test 93 percent of the impulse is distributed over 75 percent of the height. Using a relationship for the impulse at some radius from the surface center combined with the above data, specific impulses for the two charges can be defined for different standoffs.

$$i_r = i_0 R \left( \frac{\theta}{2} \right) / r$$

where

- $i_0$  = impulse at the surface center, psi-ms
- $i_r$  = impulse at the radius, r, psi-ms
- $r$  = radius from surface center, inches
- $R$  = standoff from charge to surface, inches

From the data, the 2.7-pound charge had a total impulse of 1.288 pound-second and the 2.4-pound charge had a total impulse of 36.688 pound/second. TABLE 13 shows the fragment specific impulses calculated for three standoffs. Figure 33 shows the distributions for the 2.7-pound and 2.4-pound fragment impulses at a 12-inch standoff.

TABLE 13. CALCULATED IMPULSES FOR THE CASSED CHARGES AT 6 INCH, 12 INCH AND 18 INCH STANDOFFS.

| Charge Type     | Impulse<br>(psi-ms) |                     |                     |
|-----------------|---------------------|---------------------|---------------------|
|                 | 6 inch<br>Standoff  | 12 inch<br>Standoff | 18 inch<br>Standoff |
| 2.7-pound Cased | 20.0                | 8.62                | 5.04                |
| 2.4-pound Cased | 919.7               | 373.14              | 208.54              |

### 3. Equivalent Charge Definition

To define the equivalent charges, the calculated impulse distributions for the bare charges equivalent to the measured side-on blast impulse from Tests 6 and 7 were superimposed on the fragment impulse distributions calculated and shown in Figure 33. Appendix G presents these calculations. Bare explosive charges which would produce impulse distributions very similar to the predicted blast and fragment impulses of the 2.7-pound and 2.4-pound cased charges were then determined. An equivalent charge of 2.373 pounds at

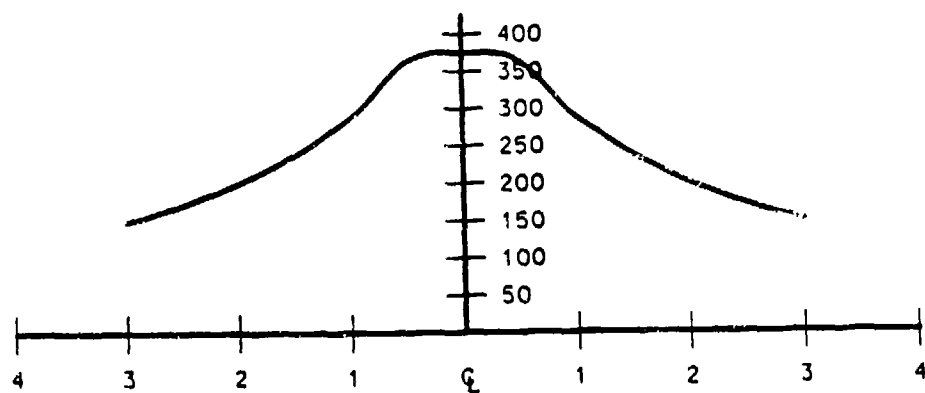
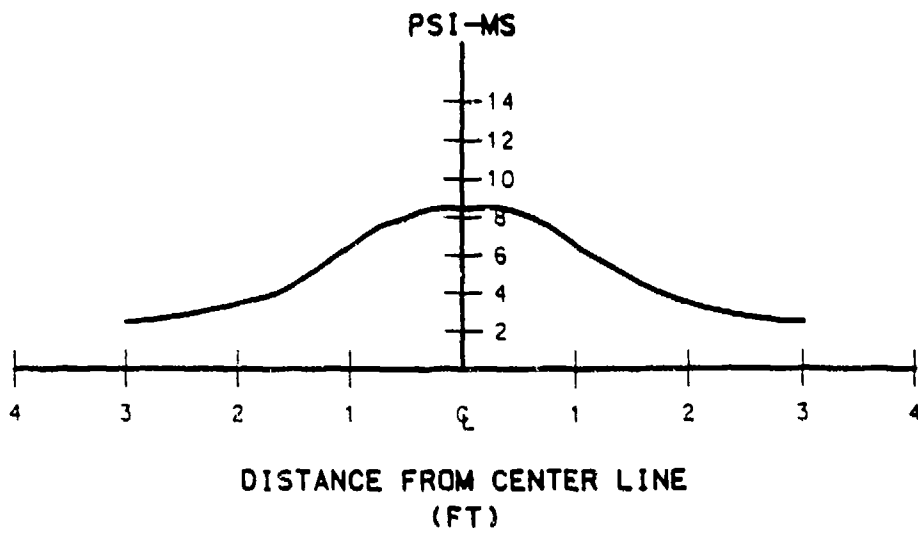


Figure 33. Impulse Distributions for the 2.7-Pound and 2.4-Pound Cased Charges at a 12 inch Standoff.

identical standoff was chosen to simulate the 2.7-pound cased charge. An equivalent charge of 2.8 pounds at slightly larger standoffs (7.2 inches, 15.6 inches, and 22.8 inches) was chosen to simulate the 2.4-pound cased charge. Figures 34 and 35 show plots of the calculated and predicted impulse distributions of the cased charges and equivalent bare charges respectively.

### C. PANEL TESTS

As previously mentioned, cased charge tests and equivalent bare charge tests were conducted on three different types of panel constructions. The three construction types tested were the following: Type A - a standard reinforced concrete panel, Type B - a heavily reinforced concrete panel and Type C - a reinforced SIFCON panel. Four panels of each type were fabricated and one of the panels was tested against each of the following threats:

- 2.7-pound cased charge at 6 inch standoff
- 2.4-pound cased charge at 6 inch standoff
- 2.4-pound equivalent bare charge (2.4 pounds of C4 at 6 inch standoff) (replicates 2.7 cased)
- 2.8-pound equivalent bare charge (2.8 pounds of C4 at 7 inch standoff) (replicates 2.4 cased)

The following paragraphs describe the panel tests.

#### 1. Type A Panel Tests

##### a. Test 9

Test 9 was conducted using the 2.7-pound cased charge. The test panel was mounted in the concrete reaction structure as shown in Figure 36 and the cased charge was positioned at the 6 inch standoff (Figure 37). This test utilized one high-speed camera positioned to record the reinforced concrete wall failure pattern. The back side of the wall was painted to aid in viewing the failure. The cased charge was detonated using an RP-83 detonator located approximately 1 inch from the top of the cased charge. The high-speed camera was used to provide the pulse that initiated the detonator. Post-test inspection of the wall showed that the cased charge had created a breach 20 inches wide by 14 inches high as shown in Figure 38. The wall also had a back face spall area of approximately 32 inches wide by 25 inches high. The wall had a major vertical failure about midway across the face, and had rotated approximately 5.75 inches at the center as shown in Figure 39. The charge side of the wall also exhibited major damage as shown in Figure 40. The wall damage was documented and the wall was removed. A schematic of the back face damage is shown in Figure 41. TABLE 14 presents a tabulation of debris velocity for Tests 9-20. TABLE 15 is a

## Light Cased Charge Comparisons

Bare Equivalent to Cased Incident Airblast (2.373 lb.)

Bare Equivalent to Cased Incident Airblast with Fragment Impulse

Bare Equivalent to Airblast and Fragment Impulse of Lightly Cased Charge

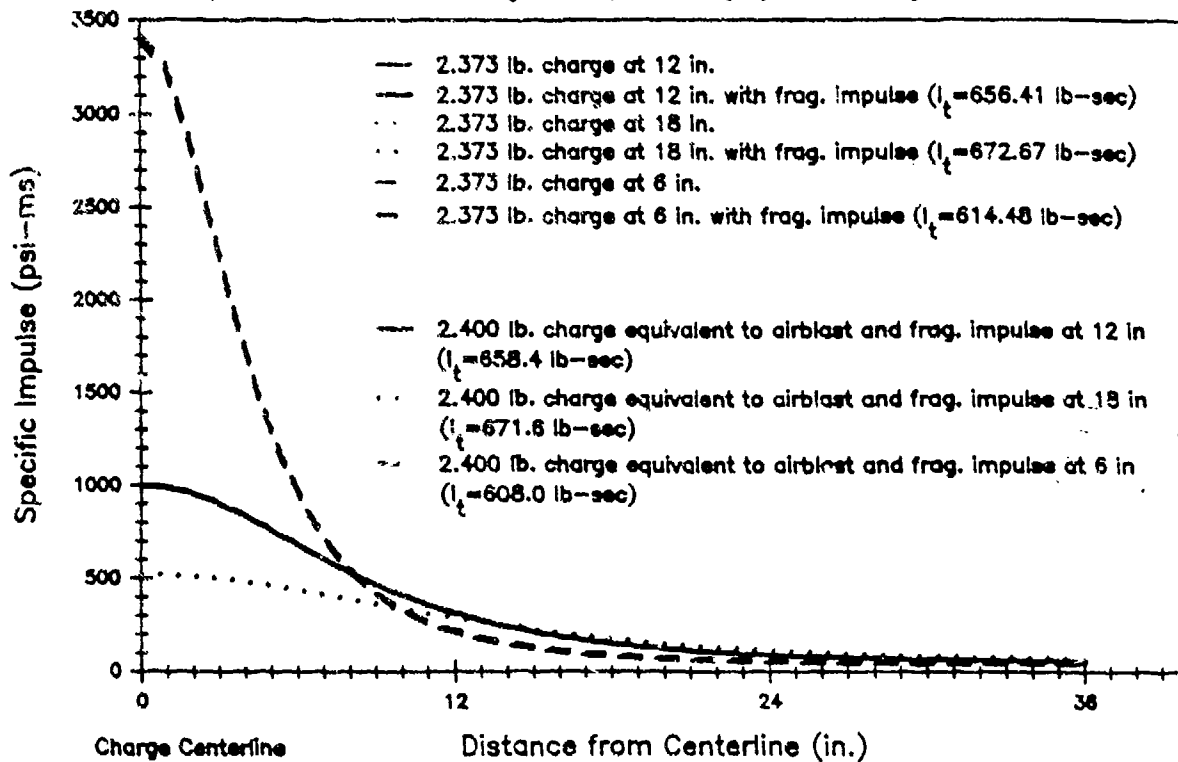


**Figure 34.** Comparison of the Predicted Blast and Fragment Impulse with the Equivalent Bare Explosive Charge for the 2.7-Pound Cased Charge.

# Heavy Cased Charge Comparisons (Over 18.0 in. Charge Radius)

Bare Equivalent to Cased Incident Airblast with Fragment Impulse

Bare Equivalent to Airblast and Fragment Impulse of Heavily Cased Charge

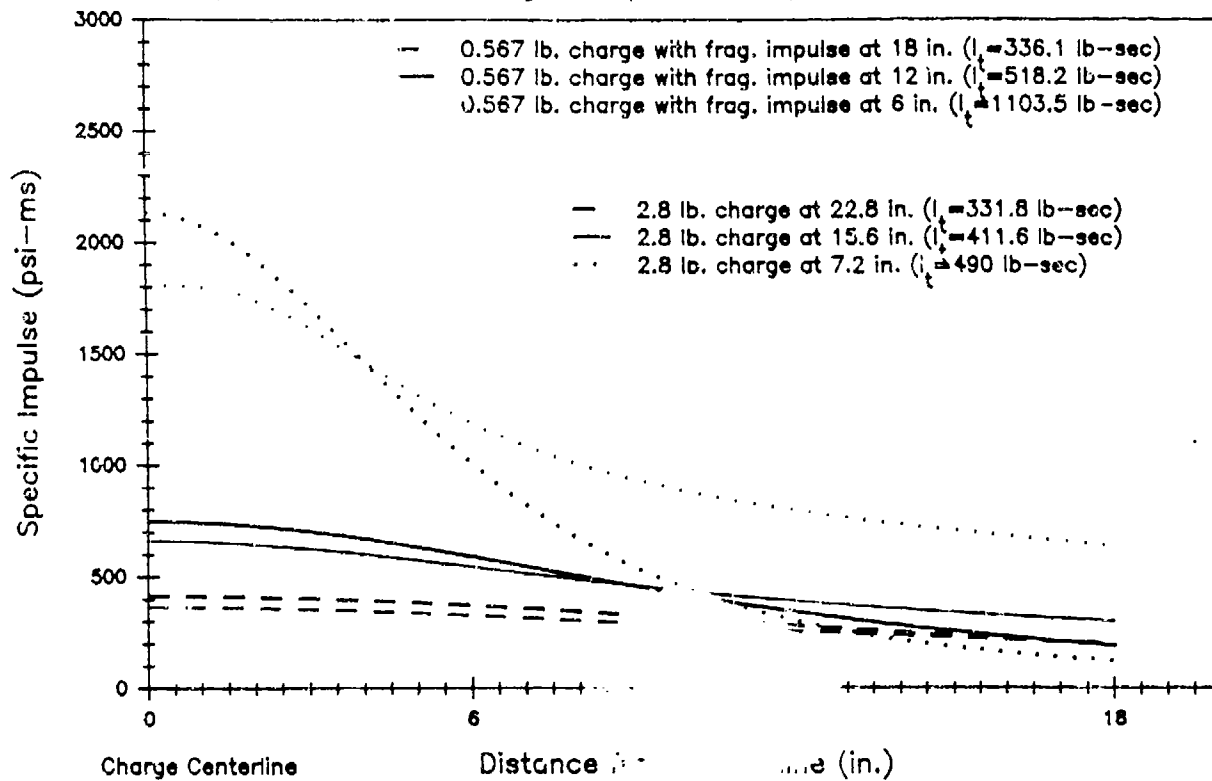


Figure 35. Comparison of the Predicted Blast and Fragment Impulse with the Equivalent Bare Explosive Charge for the 2.4-Pound Cased Charge.



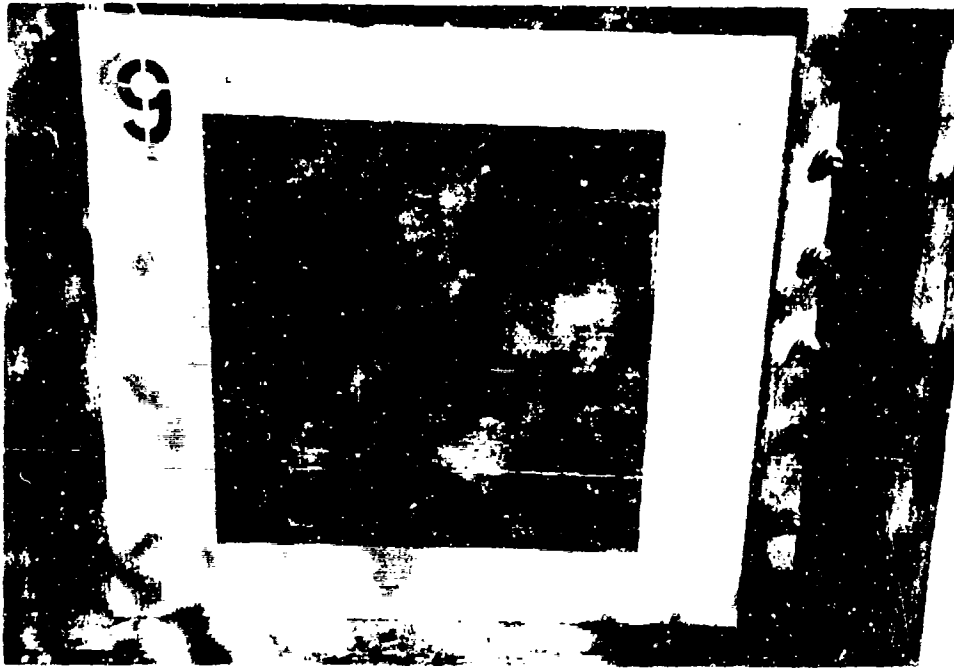


Figure 36. Panel-Type A Mounted in Reaction Structure Support Frame.



Figure 37. Charge Setup for Test 9.

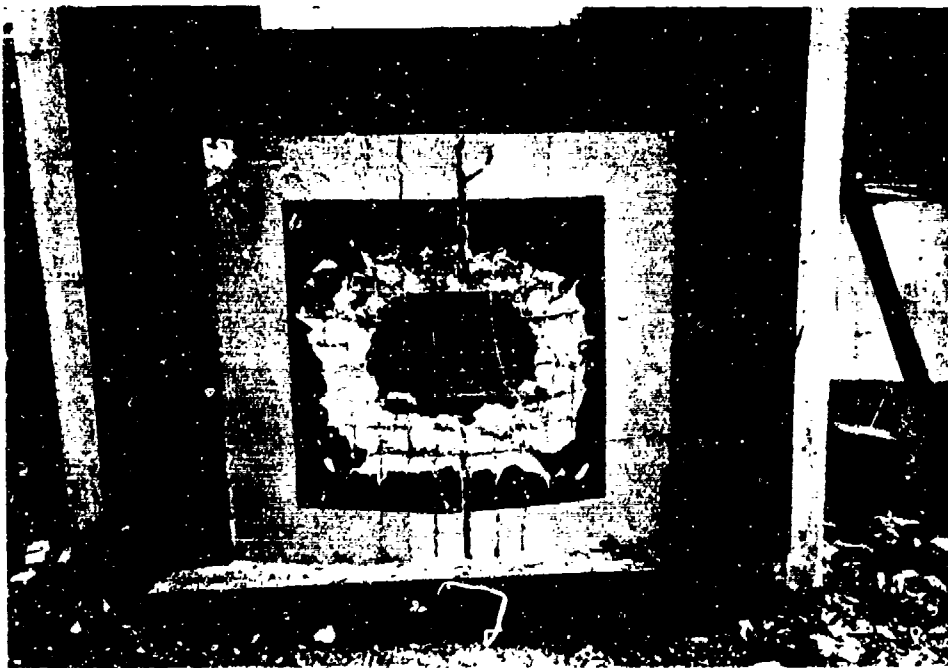


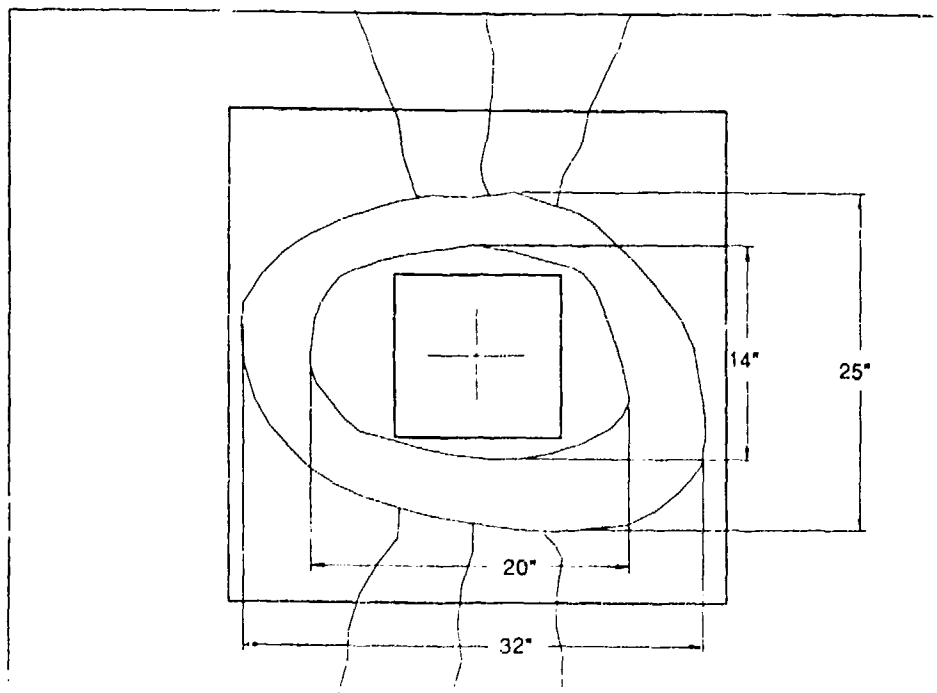
Figure 38. Test 9 Wall Damage (Type A, 2.7-Pound Cased Charge).



Figure 39. Test 9 Wall Rotation (Type A, 2.7-Pound Cased Charge).



Figure 40. Test 9 Charge Side Wall Damage (Type A, 2.7-Pound Cased Charge).



5 3/4" DEFORMATION

Figure 41. A Schematic of Test 9 Wall Damage (Type A, 2.7-Pound Cased Charge).

TABLE 14. PANEL DEBRIS VELOCITY.

| Test | Charge Type    | Wall Type | Max. Debris Velocity (fps) | Avg. Debris Velocity (fps) |
|------|----------------|-----------|----------------------------|----------------------------|
| 9    | 2.7 Cased      | A         | N/A                        | N/A                        |
| 10   | 2.7 Equivalent | A         | 168                        | 70                         |
| 11   | 2.4 Cased      | A         | 336                        | 76                         |
| 12   | 2.4 Equivalent | A         | 140                        | 70                         |
| 13   | 2.7 Cased      | B         | 210                        | 60                         |
| 14   | 2.7 Equivalent | B         | 140                        | 52                         |
| 15   | 2.4 Cased      | B         | 291                        | 76                         |
| 16   | 2.4 Equivalent | B         | 120                        | 31                         |
| 17   | 2.7 Cased      | C         | ---                        | ---                        |
| 18   | 2.7 Equivalent | C         | ---                        | ---                        |
| 19   | 2.4 Cased      | C         | 288                        | 70                         |
| 20   | 2.4 Equivalent | C         | 105                        | ---                        |

TABLE 15. PANEL DAMAGE.

| Test | Charge Type    | Wall Type | Breach<br>(Width x Height) | Spall<br>(Width x Height) | Rotation<br>(inches) |
|------|----------------|-----------|----------------------------|---------------------------|----------------------|
| 9    | 2.7 Cased      | A         | 20 x 14                    | 32 x 25                   | 5.75                 |
| 10   | 2.7 Equivalent | A         | 14 x 7                     | 38 x 24                   | 8.00                 |
| 11   | 2.4 Cased      | A         | 28 x 12                    | 32 x 21                   | 5.25                 |
| 12   | 2.4 Equivalent | A         | 14 x 8                     | 36 x 34                   | 14.00                |
| 13   | 2.7 Cased      | B         | 21 x 18                    | 30 x 35                   | 1.75                 |
| 14   | 2.7 Equivalent | B         | 14 x 10 <sup>1</sup>       | 22 x 37                   | 2.00                 |
| 15   | 2.4 Cased      | B         | 28 x 24                    | 35 x 41                   | 1.75                 |
| 16   | 2.4 Equivalent | B         | ---                        | ---                       | 2.25                 |
| 17   | 2.7 Cased      | C         | ---                        | Small Raised<br>Section   | 0.75                 |
| 18   | 2.7 Equivalent | C         | ---                        | Small Raised<br>Section   | 2.00                 |
| 19   | 2.4 Cased      | C         | 12 x 8                     | 24 x 13                   | .875                 |
| 20   | 2.4 Equivalent | C         | ---                        | ---                       | 1.25                 |

Note: (1) Not a complete breach through the thickness.

summary of wall damage for those tests. Review of the high-speed footage indicated that the backface failure was hemispherical in pattern over the 12 inch red square.

b. Test 10

Test 10 was conducted on the Type A panel using the equivalent bare charge (replicating the 2.7 cased) which was 2.4 pounds of C4 at a standoff of 6 inches. The wall was bolted to the reaction structure. A second high-speed camera and a grid background for use in measuring the wall fragment velocities were introduced for this test. The wall sustained a considerable amount of damage as shown in Figure 42. An area approximately 14 inches wide by 7 inches high was broken into small pieces which remained confined in the wall by the reinforcement as shown in Figure 43. The reinforcement was deformed but did not fail. The small rubble was removed and a complete breach 14 inches by 7 inches was evident (Figure 44). The wall spalled over an area approximately 38 inches wide by 24 inches high. A major vertical failure was evident midway across the span and the wall rotated 8 inches as shown in Figure 45. Damage to the charge side of the wall is shown in Figure 46. Subsequent evaluations of the high-speed film showed that the wall area directly behind the charge (the area painted red in Figure 36) deformed initially in a conical pattern with the debris initially emanating from the center of the panel and was ejected with considerable velocity. Additional fragments were ejected from the wall, however, these pieces were found to be traveling at much slower speeds. The evaluation of the film showed that the fastest fragments were traveling approximately 168 fps while the slower fragments were traveling at an average velocity of approximately 70 fps. The wall damage was documented and photographed and the wall was removed. A schematic of the back face is shown in Figure 47.

c. Test 11

This test involved the 2.4-pound cased charge and Panel-Type A. The cased charge was positioned 6 inches from the wall and detonated remotely using the high-speed camera to initiate the detonator. A post-test inspection showed that the wall had sustained major damage with a breach approximately 28 inches wide by 12 inches high as shown in Figure 48. The spall area was 32 inches wide by 21 inches high and several reinforcement bars were severed by the blast and casing fragments (Figure 49). The wall suffered a major vertical crack at midspan and rotated approximately 5.25 inches as shown in Figure 50. Damage to the charge side of the wall indicated a very directional casing fragment spray (Figure 51). The evaluations of the high-speed film showed that the wall failed similar to the previous cased charge test with a hemispherical failure directly behind the charge. The wall fragments in this area were ejected at a velocity of 336 fps as measured by the

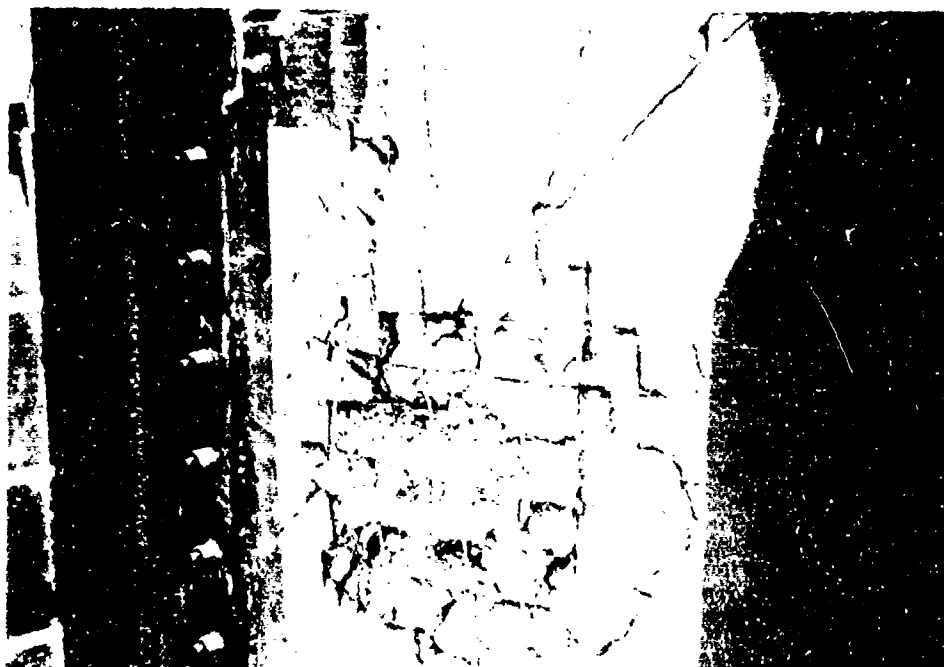


Figure 42. Test 10 Wall Damage (Type A, 2.4-Pound Equivalent Charge).

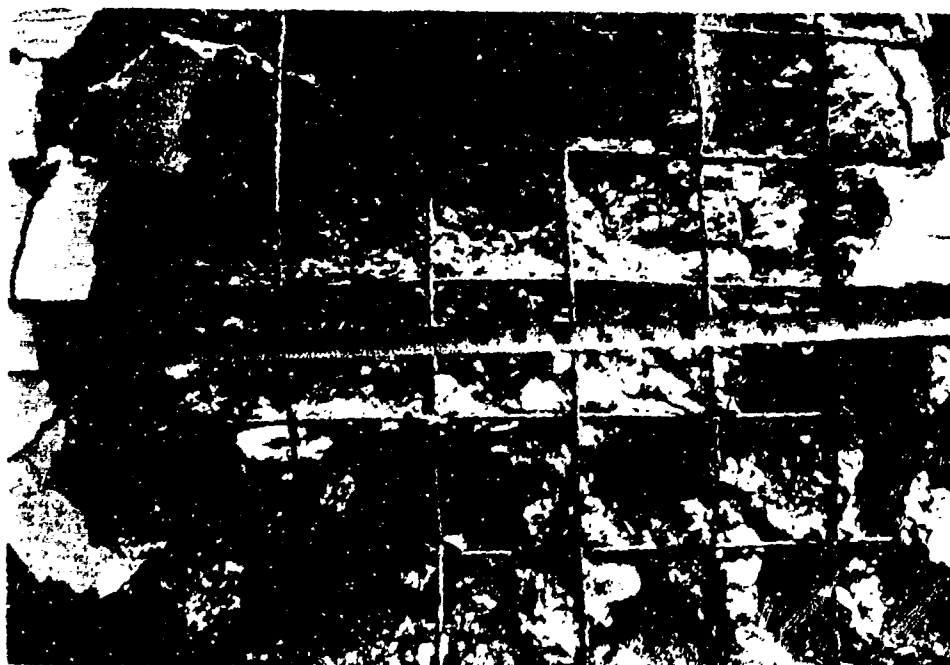


Figure 43. Test 10 Wall Damage Detail (Type A, 2.4-Pound Equivalent Charge).

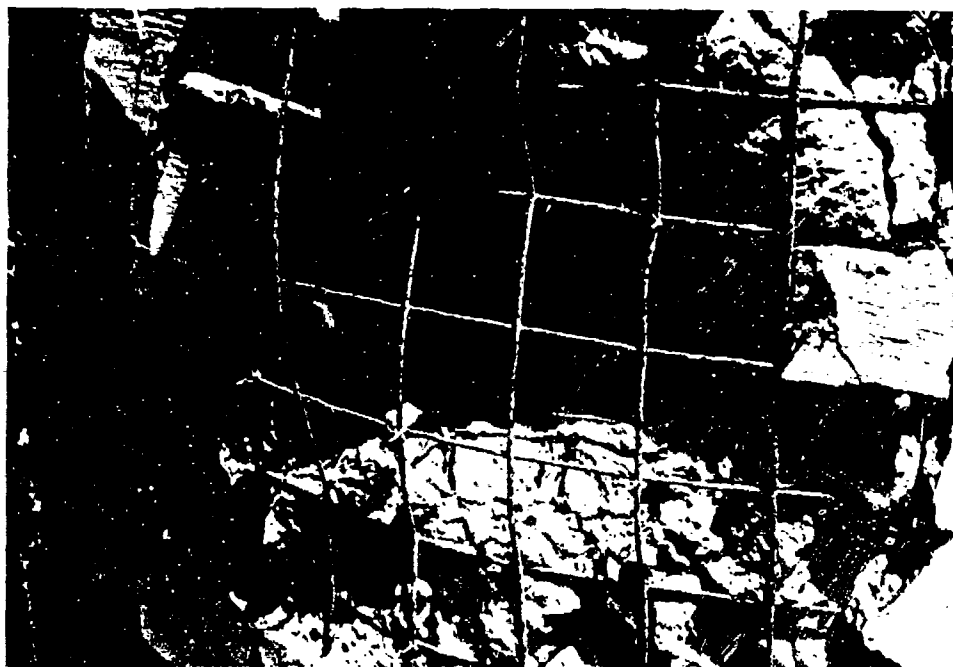


Figure 44. Test 10 Breach Detail after Debris Removal. (Type A, 2.4-Pound Equivalent Charge).

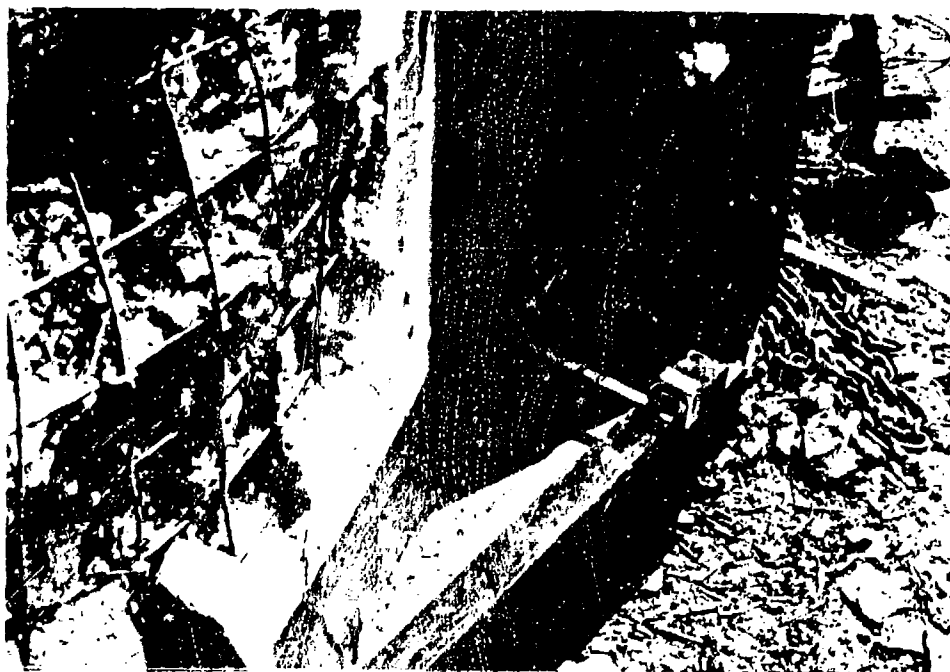


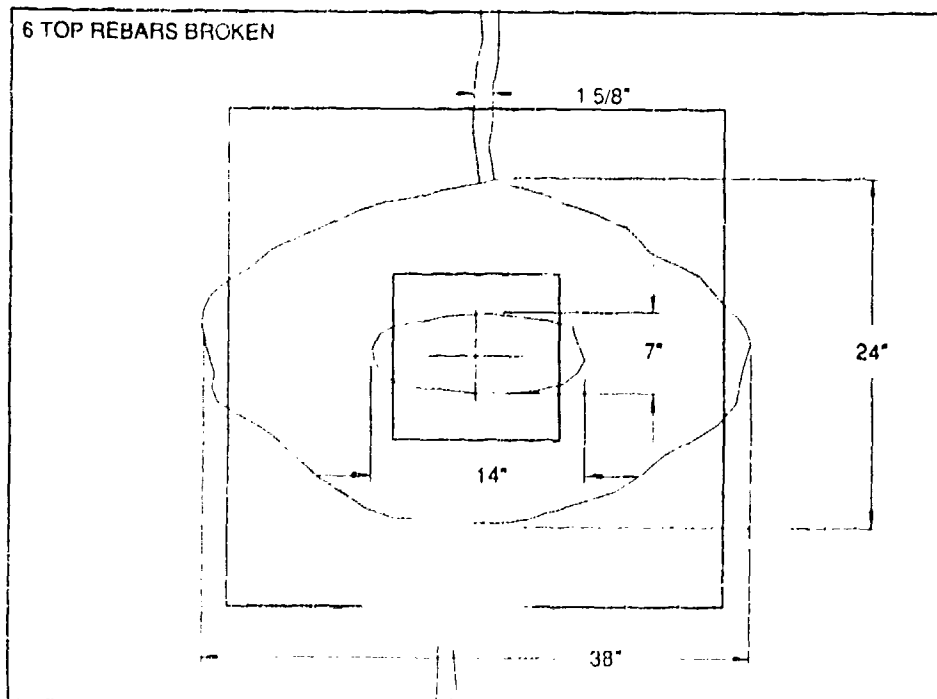
Figure 45. Test 10 Panel Rotation (Type A, 2.4-Pound Equivalent Charge).





Figure 46. Test 10 Charge Side Wall Damage (Type A, 2.4-Pound Equivalent Charge).

TEST NO. 10 2.4 #EQUIV./TYPE A



WALL DEFORMED 8"

Figure 47. A Schematic of Test 10 Wall Damage (Type A, 2.4-Pound Equivalent Charge).

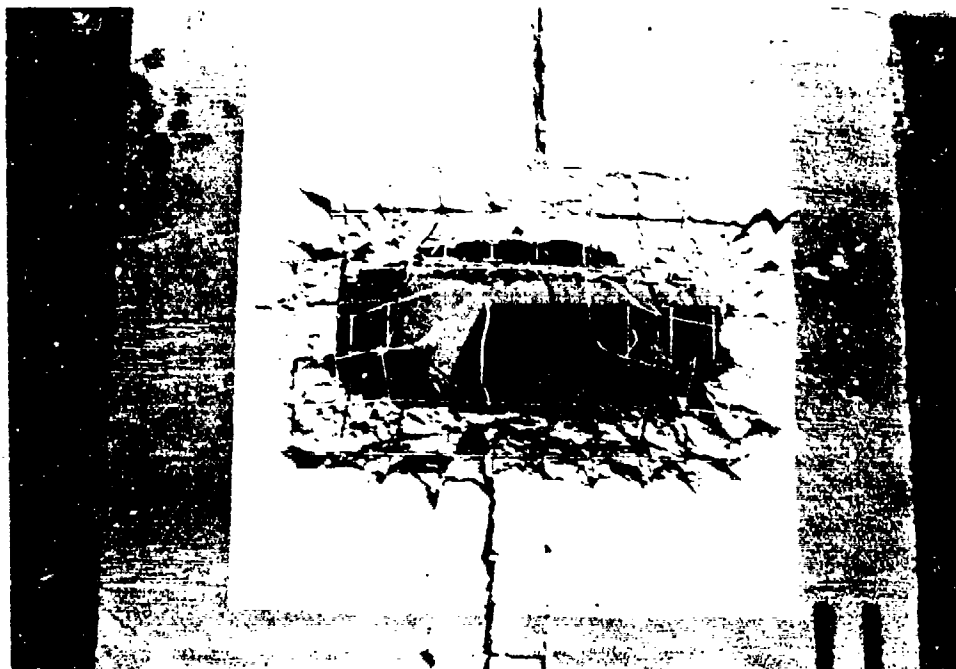


Figure 48. Test 11 Wall Damage (Type A, 2.4-Pound Cased Charge).



Figure 49. Test 11 Wall Damage Detail (Type A, 2.4-Pound Cased Charge).



Figure 50. Test 11 Wall Rotation (Type A, 2.4-Pound Cased Charge).



Figure 51. Test 11 Charge Side Wall Damage (Type A, 2.4-Pound Cased Charge).

high-speed camera. The slower fragments were traveling at approximately 76 fps. A schematic of the back face damage is shown in Figure 52.

#### d. Test 12

Test 12 was conducted on the Type A panel using the equivalent bare charge (replicating the 2.4 lb. cased charge) of 2.8 lbs. of C4 at a standoff of 7 inches. The wall was bolted to the reaction structure and the bare charge positioned. The wall suffered a considerable amount of damage as shown in Figure 53. An area approximately 14 inches wide by 8 inches high was broken into small pieces which remained confined in the wall by the reinforcement as shown in Figure 54. The reinforcement was deformed but did not fail. The wall sustained major damage over an area approximately 36 inches wide by 34 inches high consisting primarily of back face spall. A major vertical crack was found midway across the span and the wall rotated 14.0 inches as shown in Figure 55. Damage to the charge side of the wall is shown in Figure 56. Subsequent evaluations of the high-speed film showed that the wall area directly behind the charge deformed initially in a conical pattern with debris emanating from a point as was noticed on the previous equivalent bare charge test. The faster fragments were ejected with a velocity of 140 fps which is similar to the velocity of the fragments generated in Test 10. The slower fragments were traveling at a velocity of 70 fps as measured from the high-speed film which is also comparable to the velocities in Test 10. The damage was documented and photographed and the wall was removed. A schematic of the back face response is shown in Figure 57.

### 2. Type B Panel Tests

#### a. Test 13

Test 13 was conducted using the 2.7-pound cased charge against the heavier reinforced panel design. This particular test panel design was instrumented with Dynasen piezoresistive shock pressure carbon gages and with piezocrystals for measuring the time-of-arrival of the shock wave. Detailed descriptions of the instrumentation is presented in Section II of this report. The test panel was mounted in the concrete reaction structure and the cased charge was positioned at the 6 inches standoff. This test utilized one high-speed camera positioned to record the reinforced concrete wall failure pattern and a second high-speed camera to measure the resultant wall fragment velocities. The piezocrystals and piezoresistive shock pressure carbon gage outputs were recorded on magnetic tape for later analyses. The cased charge was detonated using an RP-83 detonator located approximately 1 inch from the top of the cased charge. Post-test inspection of the wall showed that the cased charge created an extensive amount of damage. The concrete was broken up into small pieces in an area 21 inches wide by 18

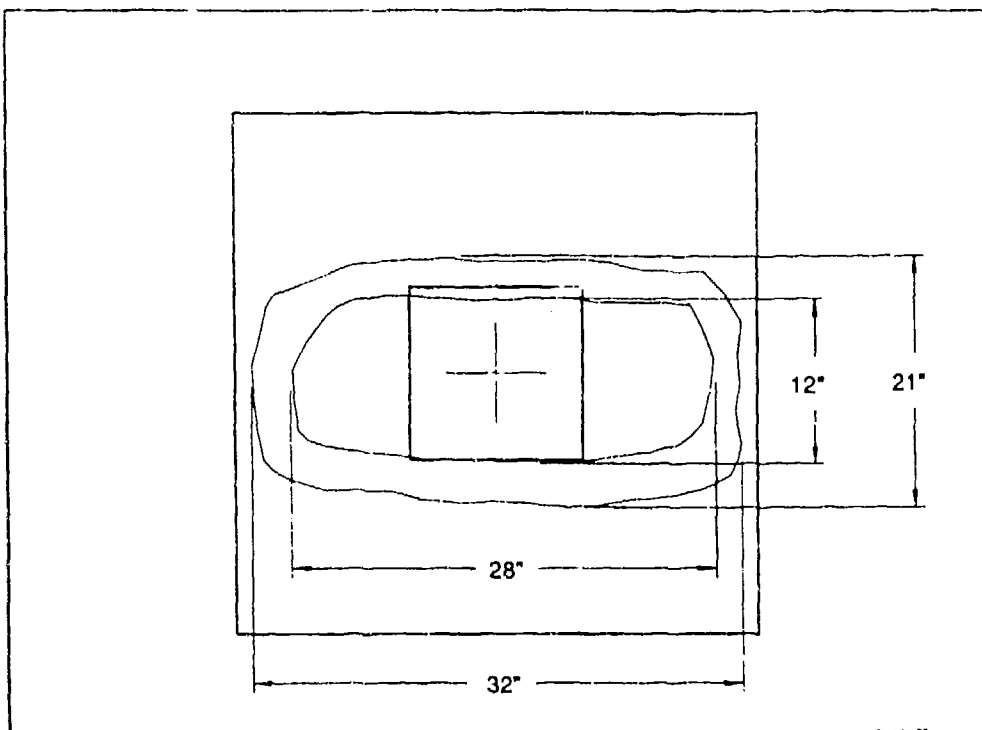


Figure 52. A Schematic of Test 11 Wall Damage (Type A, 2.4-Pound Cased Charge).



Figure 53. Test 12 Wall Damage (Type A, 2.8-Pound Equivalent Charge).



Figure 54. Test 12 Wall Damage Detail (Type A, 2.8-Pound Equivalent Charge).

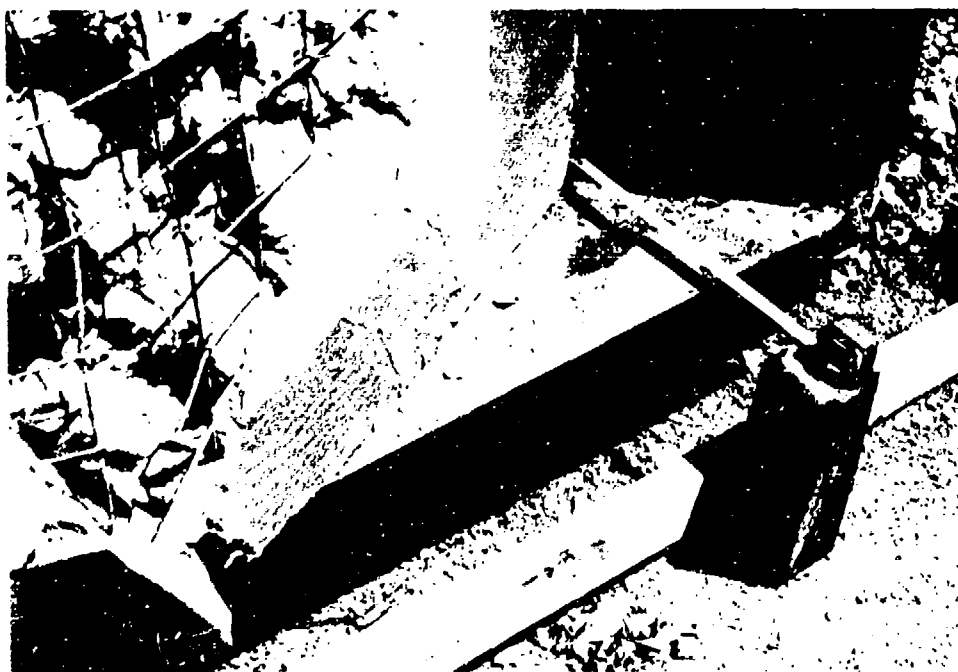


Figure 55. Test 12 Wall Rotation (Type A, 2.8-Pound Equivalent Charge).

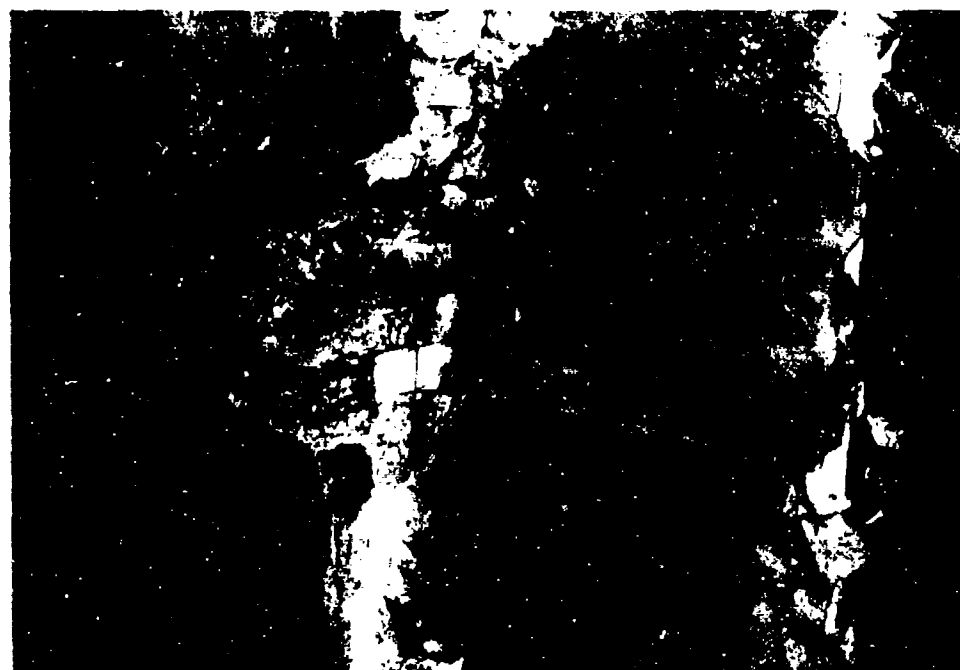


Figure 56. Test 12 Charge Side Wall Damage (Type A, 2.8-Pound Equivalent Charge).

TEST NO. 12 2.8 EQUIV./TYPE A

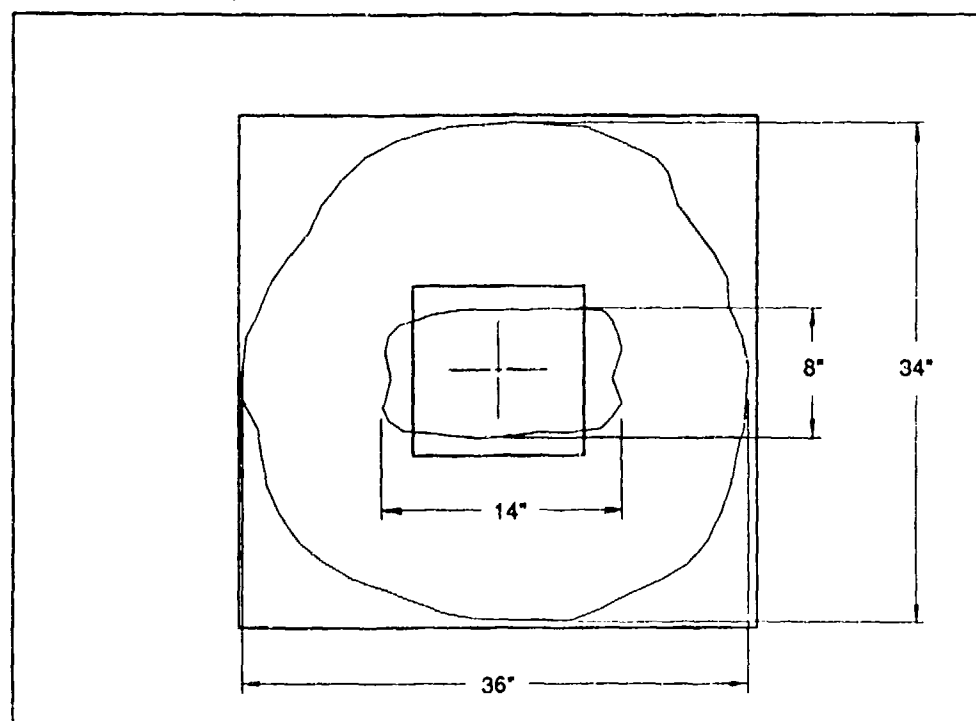


Figure 57. A Schematic of Test 12 Wall Damage (Type A, 2.8-Pound Equivalent Charge).

inches high as shown in Figure 58. The reinforcement was deformed but did not fail and the bulk of the concrete rubble was trapped by the reinforcement. The wall had a large spall area of about 30 inches wide by 35 inches high. The small rubble was removed from the wall revealing a breach 21 inches wide by 18 in high. The wall had a major vertical crack about 18 inches from the right side of the wall coinciding with the locations of the carbon gages. The midpoint of the wall rotated approximately 1.75 inches as shown in Figure 59. The charge side of the wall also exhibited major damage as shown in Figure 60. The high-speed films were reviewed and showed that the wall failed in a manner similar to the previous cased charge tests on the standard reinforced concrete panels, that is, hemispherical section of material behind the charge exiting at a high velocity. The wall fragments in this area were traveling at a speed of 210 fps as measured by the fragment high-speed camera. The slower fragments ejected later were traveling at approximately 60 fps. The signals from the crystals and from the carbon gages were analyzed and plots of these data are presented in Appendix C. The wall damage was documented and the wall was removed. A schematic of wall response is shown in Figure 61. TABLE 16 presents the peak pressures generated from carbon gage records for Tests 13 - 16 and 19 - 20. TABLE 17 presents TOA data.

b. Test 14

Test 14 was conducted using our equivalent bare charge (replicating the 2.7-pound cased charge) weighing 2.4 pounds at a standoff of 6 inches. The instrumented wall was bolted to the reaction structure. The piezocrystals and the piezoresistive carbon gage outputs were recorded on magnetic tape. The wall sustained a considerable amount of damage as shown in Figure 62. The wall had a vertical crack coinciding with the positioning of the carbon gages. An area approximately 14 inches wide by 10 inches high was broken into small pieces which remained confined in the wall by the reinforcement as shown in Figure 63. The reinforcement in this test was also deformed but did not fail and served to trap the smaller rubble. Unlike the previous test, the entire thickness of the wall was not broken up and a complete breach was not found. The portion of the wall that sustained spall damage was approximately 22 inches wide by 37 inches high. The wall rotated 2.0 inches at the mid-point as shown in Figure 64. Damage to the charge side of the wall is shown in Figure 65. Subsequent evaluations of the high-speed film showed that the wall area directly behind the charge deformed initially in a conical pattern with debris originating at a point and was ejected with considerable velocity. The fastest fragments were traveling approximately 140 fps while the slower fragments were traveling at an average of approximately 52 fps. The signals from the crystals and from the carbon gages were analyzed and plots of these data are presented in Appendix C. The wall damage was documented and photographed and the wall was removed. A schematic of the wall failure is presented in Figure 66.



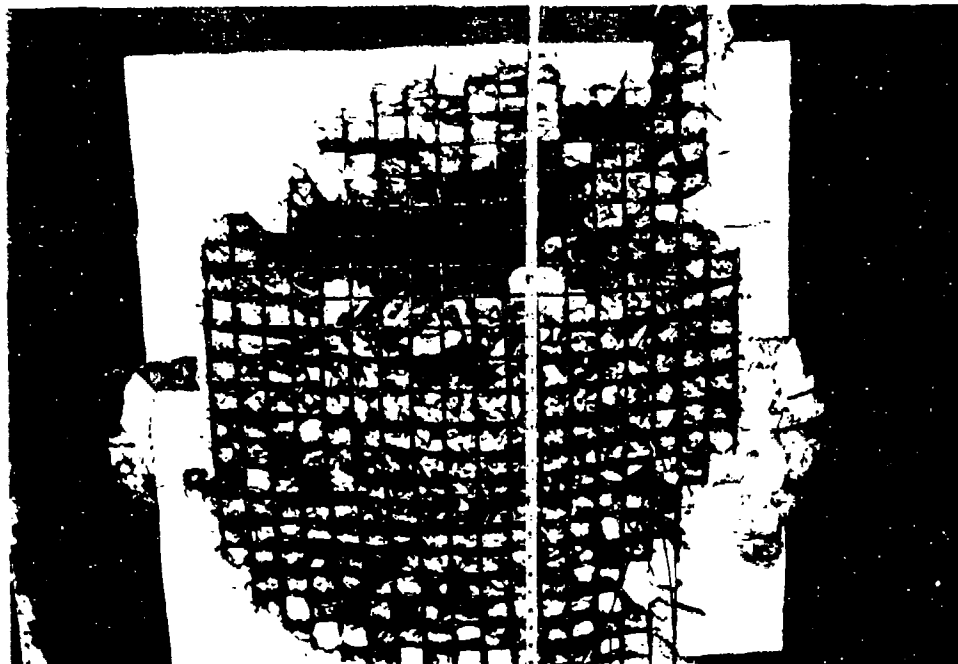


Figure 58. Test 13 Wall Damage (Type B, 2.7-Pound Cased Charge).



Figure 59. Test 13 Wall Rotation (Type B, 2.7-Pound Cased Charge).

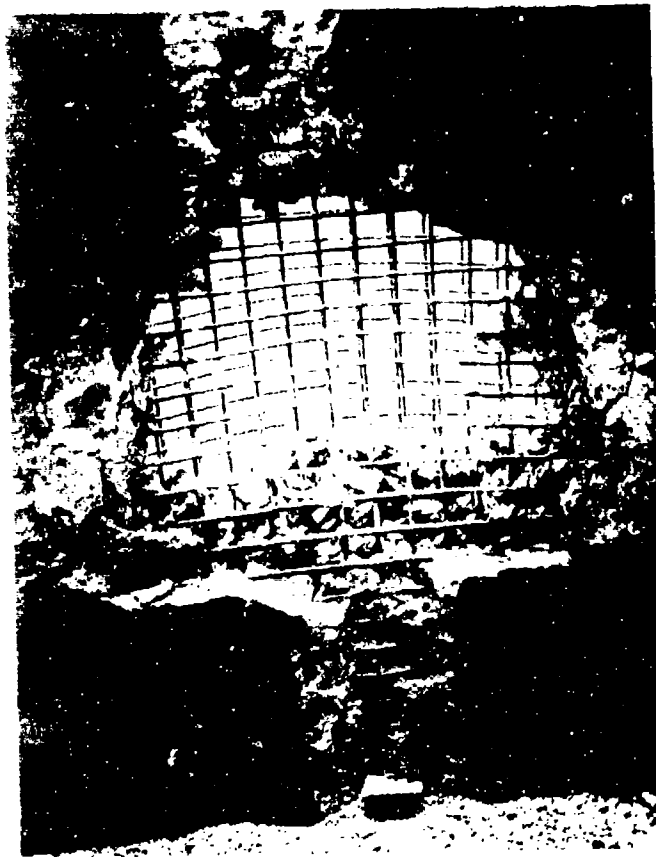


Figure 60. Test 13 Charge Side Wall Damage (Type B, 2.7-Pound Cased Charge).

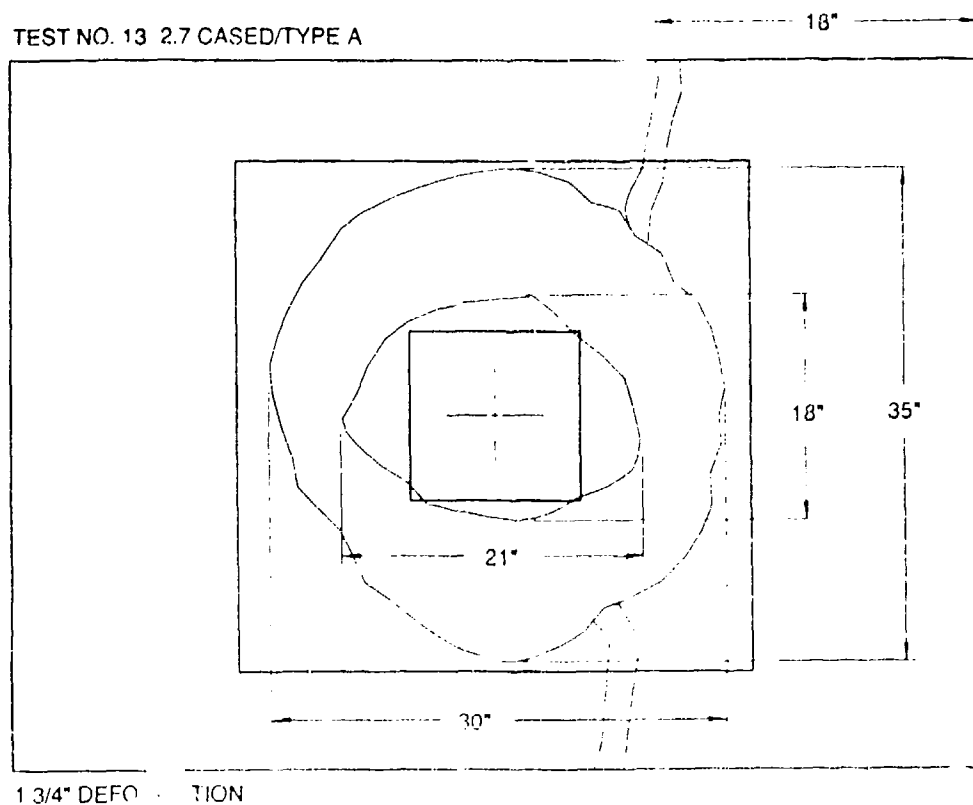


Figure 60. A Schematic of Test 13 Wall Damage (Type B, 2.7-Pound Cased Charge).

TABLE 16. PIEZORESISTIVE SHOCK PRESSURE CARBON GAGE (CG) DATA.

| Gage Location<br>(App. C Location) | Pressures (psi)     |                     |                                  |                     |                                   |                     |
|------------------------------------|---------------------|---------------------|----------------------------------|---------------------|-----------------------------------|---------------------|
|                                    | Test 13<br>(B/2.7C) | Test 14<br>(B/2.4E) | Test 15<br>(B2.4C)<br>(2nd Peak) | Test 16<br>(B/2.8E) | Test 19<br>(C/2.4C)<br>(2nd Peak) | Test 20<br>(C/2.8E) |
| CG1:<br>(11)                       | 34467               | 7250                | 58000                            | 14000               | >100000                           | >100000             |
| CG2:<br>(9)                        | 33495               | 4133                | 43500                            | 8200                | 68000<br>(22000)                  | 14500               |
| CG3:<br>(12)                       | 32973               | 4688                | 39000<br>(6000)                  | 4592                | 18000                             | 9650                |
| CG4:<br>(10)                       | 35054               | 3432                | 15000<br>(7500)                  | No Data             | 7000<br>(3000)                    | 3000                |

Note: (B/2.7C) = Wall Type B/2.7-pound Cased Charge  
 (B/2.4E) = Wall Type B/2.4-pound Equivalent Bare Charge  
 (B/2.4C) = Wall Type B/2.4-pound Cased Charge  
 (B/2.8E) = Wall Type B/2.8-pound Equivalent Bare Charge  
 (C/2.4C) = Wall Type C/2.4-pound Cased Charge  
 (C/2.8E) = Wall Type C/2.8-pound Equivalent Bare Charge

TABLE 17. PIEZOCRYSTAL SHOCK WAVE ARRIVAL TIMES.

| Crystal Location | Time of Arrival ( $\mu$ sec) |                     |                    |                     |                     |                     |
|------------------|------------------------------|---------------------|--------------------|---------------------|---------------------|---------------------|
|                  | Test 13<br>(B/2.7C)          | Test 14<br>(B/2.4E) | Test 15<br>(B2.4C) | Test 16<br>(B/2.8E) | Test 19<br>(C/2.4C) | Test 20<br>(C/2.8E) |
| T1:              | 71.8                         | 65                  | 104                | 47                  | 105                 | 60                  |
| T2:              | 76.8                         | 66                  | 111                | 51                  | 120                 | 67                  |
| T3:              | 77.3                         | 67                  | 116                | 53                  | 120                 | 74                  |
| T4:              | 77.4                         | 68                  | 122                | ---                 | 120                 | 80                  |
| T5:              | 77.7                         | 60                  | 122                | 52                  | 125                 | 86                  |
| T6:              | 77.7                         | ---                 | 122                | 51                  | 125                 | 91                  |
| T7:              | 77.7                         | ---                 | 122                | 51                  | 125                 | 91                  |
| T8:              | 77.7                         | 60                  | 122                | 53                  | 125                 | 93                  |

Note: (B/2.7C) = Wall Type B/2.7-pound Cased Charge  
 (B/2.4E) = Wall Type B/2.4-pound Equivalent Bare Charge  
 (B/2.4C) = Wall Type B/2.4-pound Cased Charge  
 (B/2.8E) = Wall Type B/2.8-pound Equivalent Bare Charge  
 (C/2.4C) = Wall Type C/2.4-pound Cased Charge  
 (C/2.8E) = Wall Type C/2.8-pound Equivalent Bare Charge

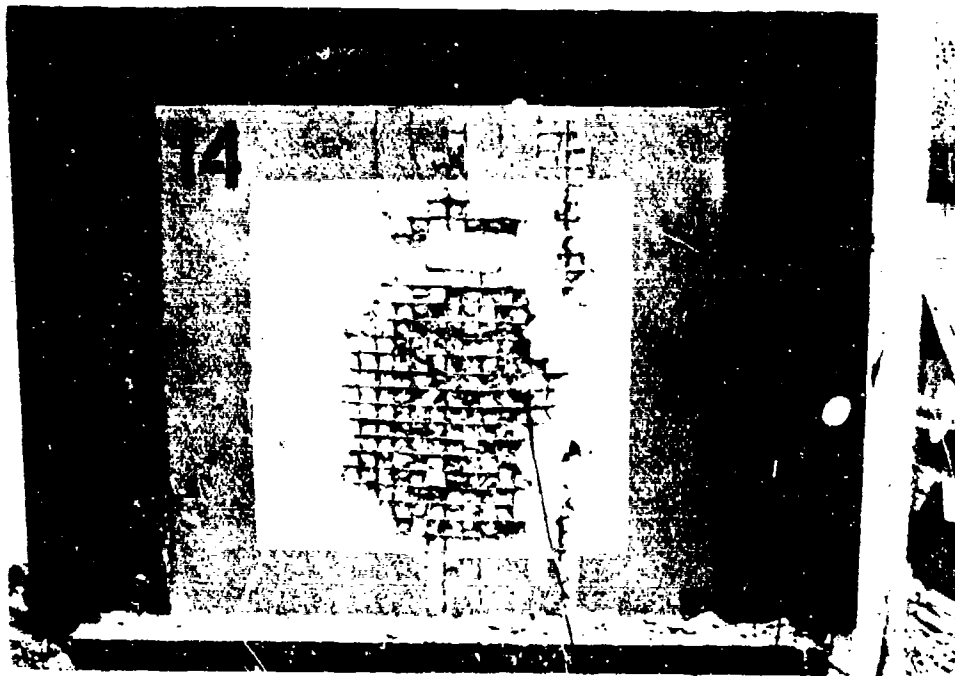


Figure 62. Test 14 Wall Damage (Type B, 2.4-Pound Equivalent Charge).

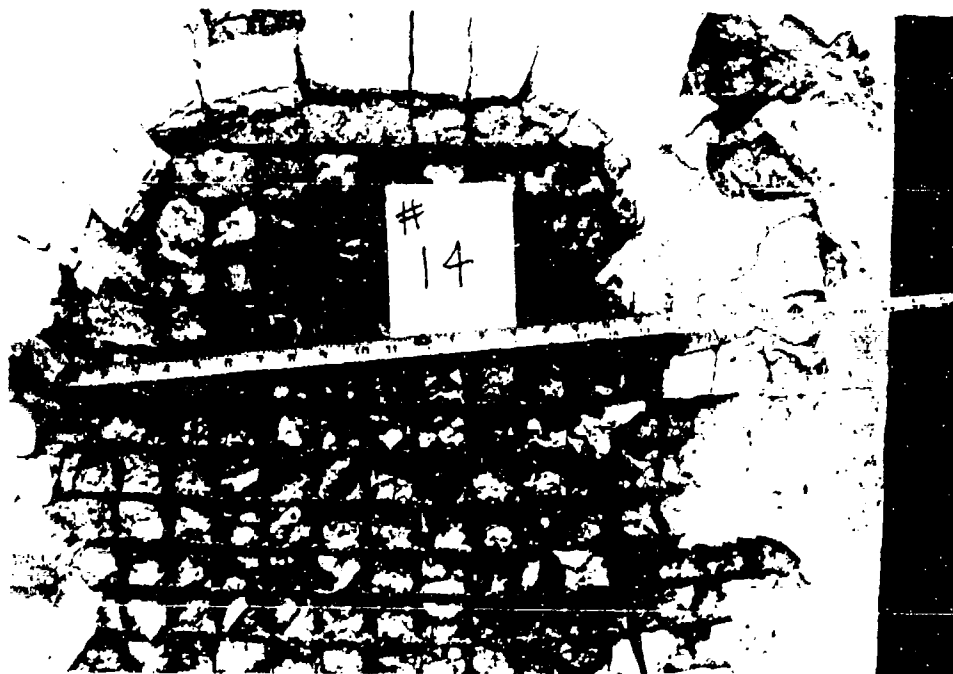


Figure 63. Test 14 Wall Damage Detail (Type B, 2.4-Pound Equivalent Charge).



Figure 64. Test 14 Wall Rotation (Type B, 2.4-Pound Equivalent Charge).

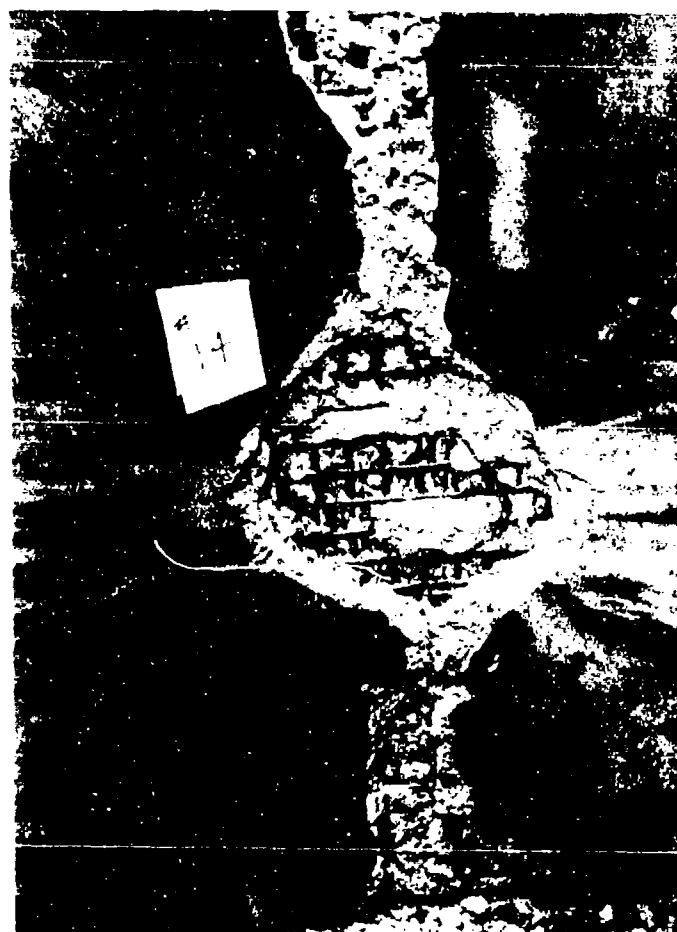


Figure 65. Test 14 Charge Side Wall Damage (Type B, 2.4-Pound Equivalent Charge).

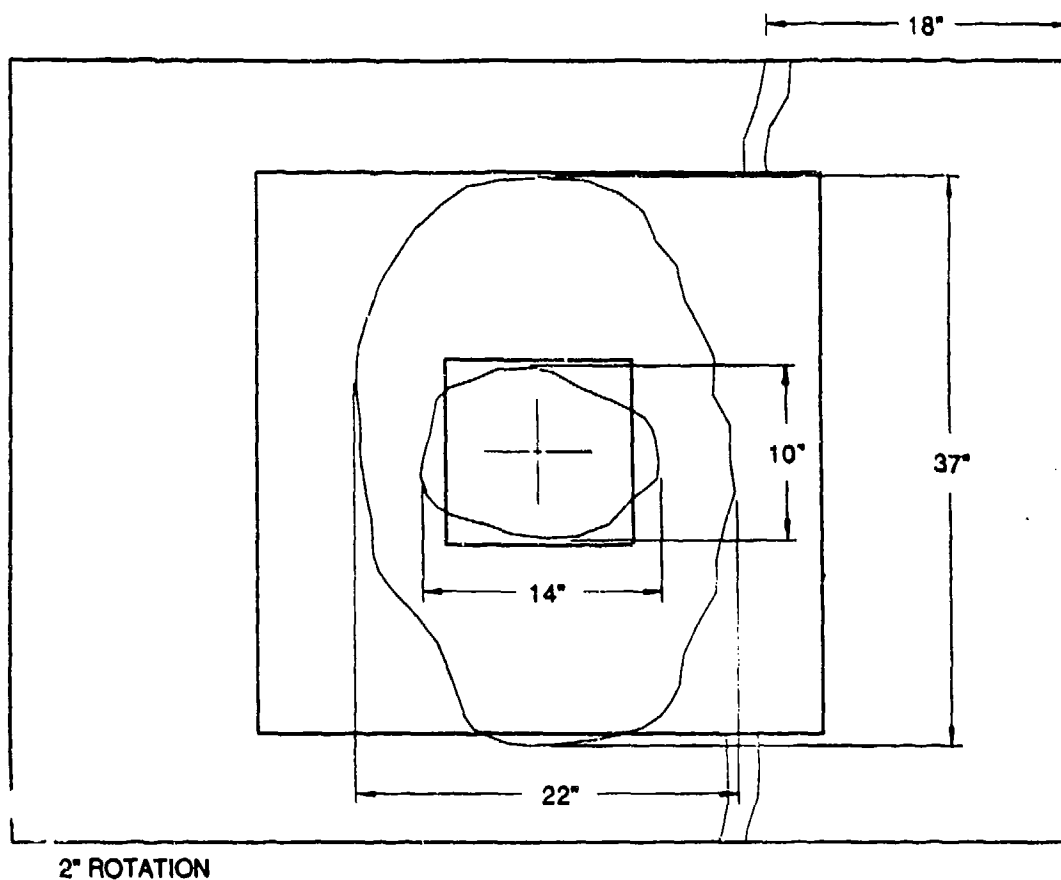


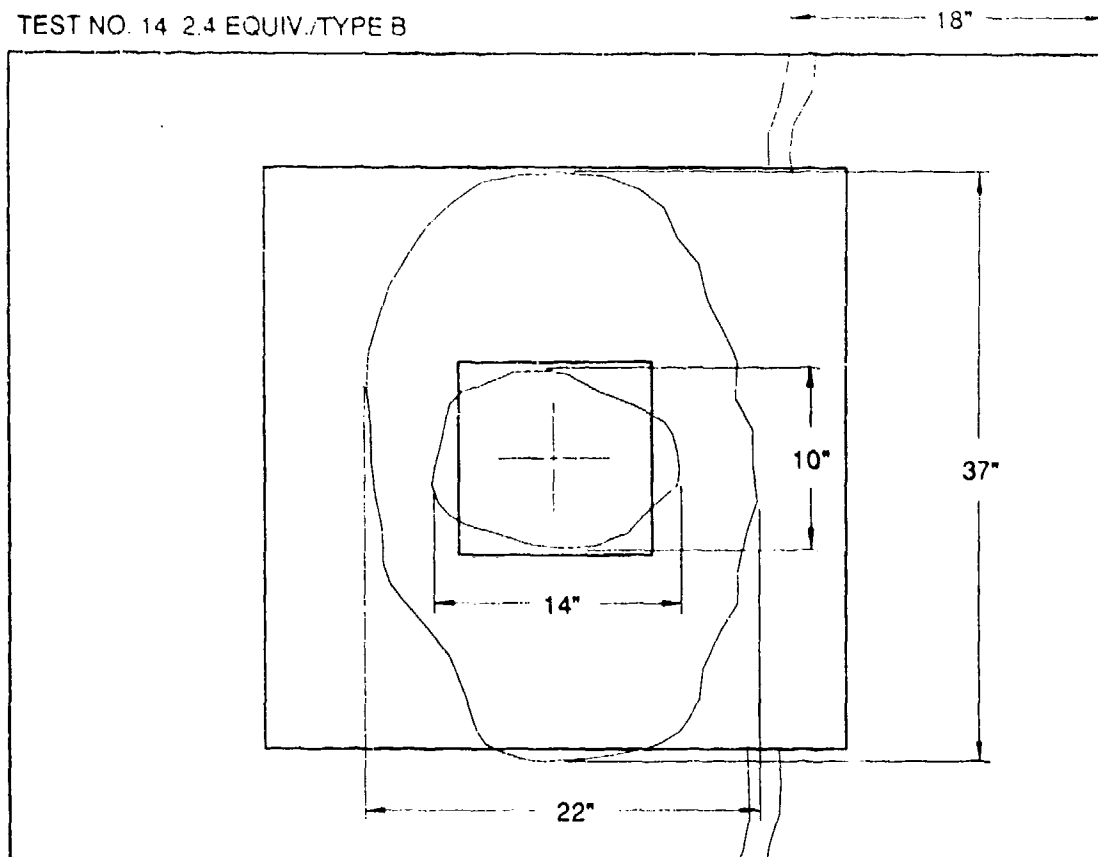
**Figure 66.** A Schematic of Test 14 Wall Damage (Type B, 2.4-Pound Equivalent Charge).

c. Test 15

This test involved the 2.4-pound cased charge. The cased charge was positioned 6 inches from the heavier reinforced wall and detonated remotely using the high-speed camera to initiate the detonator. The outputs of the piezoresistive shock pressure carbon gages and the piezocrystals were recorded on magnetic tape for later processing. A post-test inspection of the wall showed that the wall had sustained major damage with a breach approximately 28 inches wide by 24 inches high as shown in Figure 67. The spall area was 35 inches wide by 41 inches high. The reinforcement steel was deformed by the blast and casing fragments (Figure 68). The wall sustained several vertical cracks and rotated approximately 1.75 inches as shown in Figure 69. Damage to the charge side of the wall (Figure 70) indicated a very directional casing fragment spray. The evaluations of the high-speed film showed that the wall failed similar to the previous cased charge test with a hemispherical failure directly behind the charge. The wall fragments in this area were ejected at a velocity of 291 fps as measured by the fragment high-speed camera. The slower fragments were traveling at approximately 76 fps. Computer generated plots of the outputs from the crystals and from the carbon gages are presented in Appendix C. A schematic of the wall damage is shown in Figure 71.

d. Test 16

Test 16 was conducted on the Type B panel using the equivalent bare charge of 2.8 pounds of C4 (replicating the 2.4-pound cased charge) at a standoff of 7 inches. The charge shape was changed for this test and a spherical charge was used instead of a cylindrical charge as had been used in all of the previous tests. The charge shape was changed to see what effect shape had on the damage mechanism and measured stress. The wall was bolted to the reaction structure and the bare charge positioned. The charge was remotely detonated using the RP-83 detonator which was initiated by a pulse from the high-speed camera used to record the wall failure mechanism. The damage suffered by the wall was considerably less than previous tests as shown in Figure 72. The wall suffered some small amounts of back face spall with no significant failures or breaches. A rotation of 2.25 inches was measured. Damage to the charge side of the wall is shown in Figure 73. The high-speed film from the fragment camera showed that very few fragments were ejected and the faster fragments were ejected with a velocity of 120 fps. The slower fragments were traveling at a velocity of 31 fps. The wall damage for this test and for Test 14 were very different in magnitude. The piezocrystals and the piezoresistive carbon gage outputs which had been recorded on magnetic tape were analyzed and plots of these data are presented in Appendix C. A schematic of wall damage is shown in Figure 74.



2" ROTATION

Figure 67. Test 15 Wall Damage (Type B, 2.4-Pound Cased Charge).

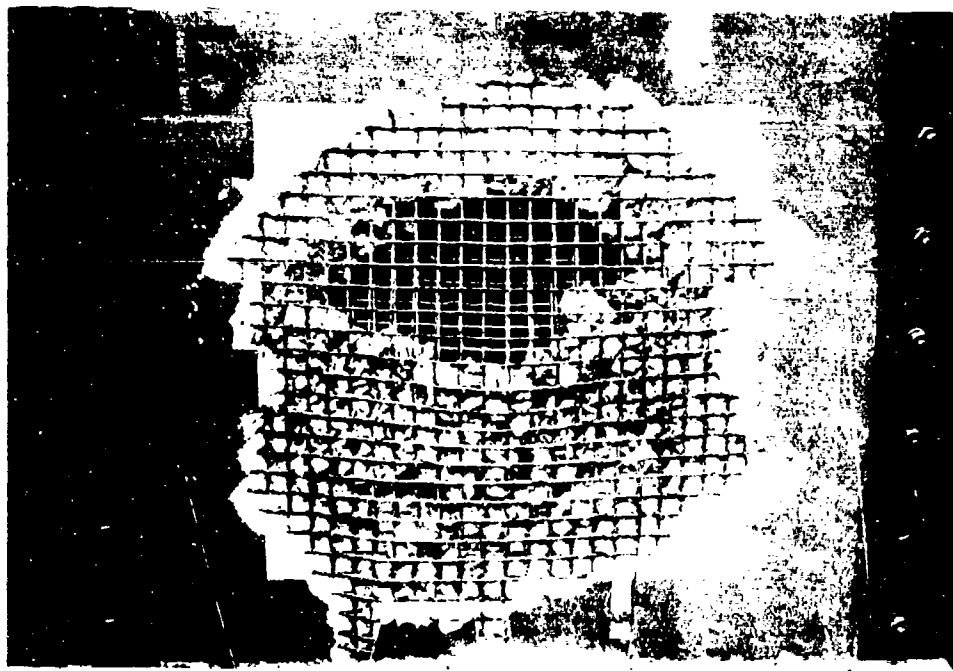


Figure 68. Test 15 Wall Damage Detail (Type B, 2.4-Pound Cased Charge.)



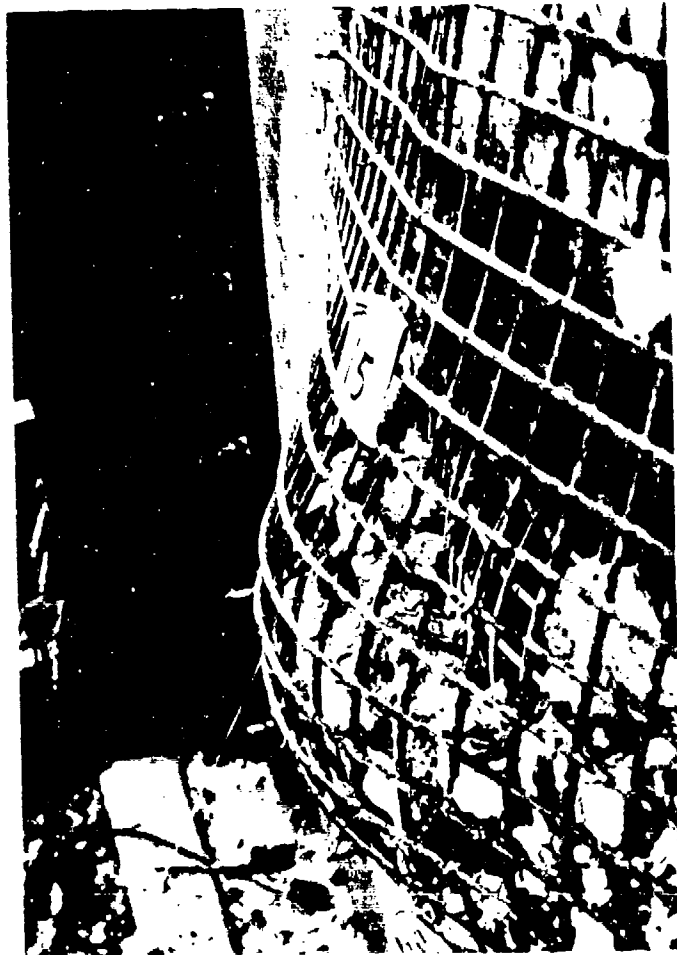


Figure 69. Test 15 Wall Rotation (Type B, 2.4-Pound Cased Charge).

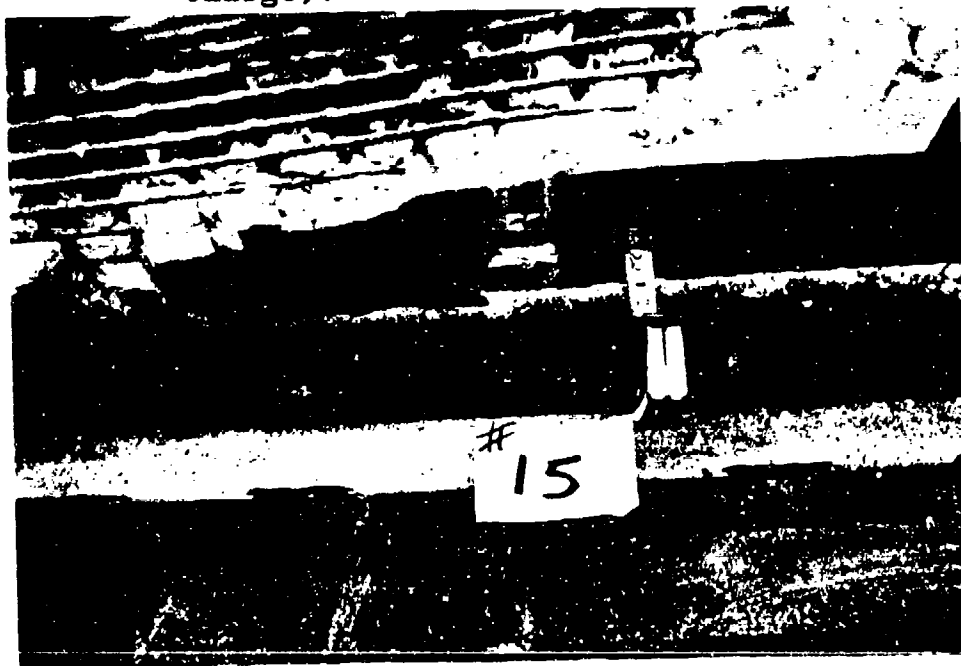
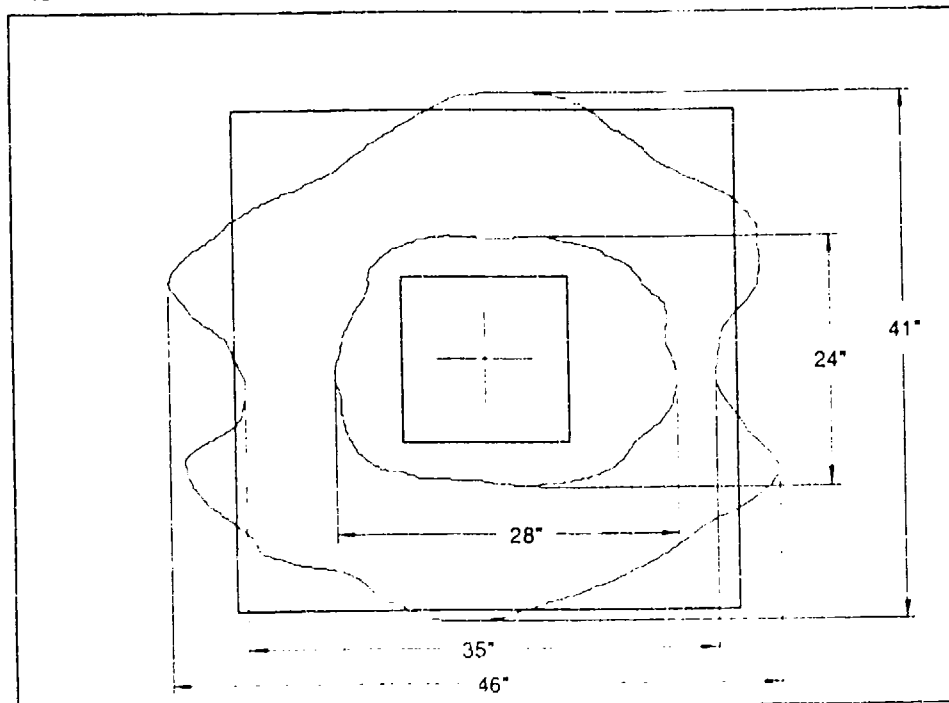


Figure 70. Test 15 Charge Side Wall Damage (Type B, 2.4-Pound Cased Charge).



Figure 71. A Schematic of Test 15 Wall Damage (Type B, 2.4-Pound Cased Charge).

TEST NO. 15 2.4 CASSED/TYPE B



1 1/4" ROTATION

Figure 72. Test 16 Wall Damage (Type B, 2.8-Pound Equivalent Spherical Charge.)

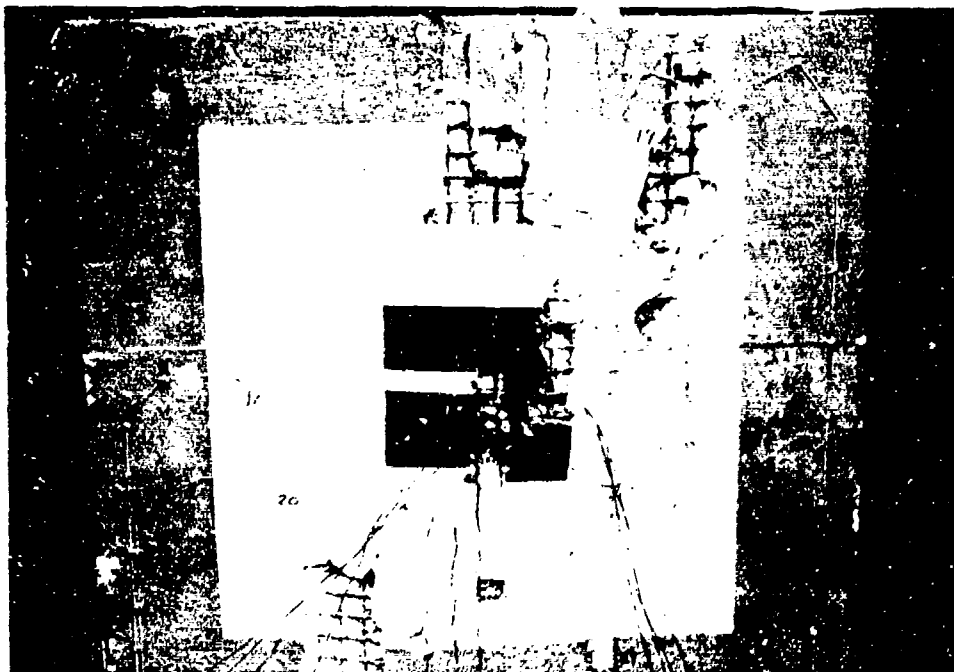


Figure 73. Test 16 Charge Side Wall Damage (Type B, 2.8-Pound Equivalent Spherical Charge).



Figure 74. A Schematic of Test 16 Wall Damage (Type B, 2.8-Pound Equivalent Spherical Charge).

### 3. Type C Panel Tests

#### a. Test 17

Test 17 was conducted using the 2.7-pound cased charge against a reinforced SIFCON panel without instrumentation. The test panel was mounted in the concrete reaction structure and the cased charge was positioned at the correct standoff. The charge was initiated using a pulse from the high-speed camera used to record the wall failure pattern. Post-test inspection of the wall showed that the wall had suffered very slight damage which was confined to the area directly behind the cased charge. The wall did have a vertical crack, however, and the wall rotation was 0.75 inches. A section of the SIFCON wall was rotated out from the back face as shown in Figure 75 and very fine pieces of the wall were ejected. The material ejected was not distinguishable in the high-speed films as fragments and velocities were not measured. Figure 76 shows a closeup of the back face. Figure 77 shows charge side damage. A schematic of wall damage is shown in Figure 78.

#### b. Test 18

Test 18 was also conducted on the Type C panel. An equivalent bare charge (replicating the 2.7-pound cased charge) which was 2.4 pounds of C4 at a standoff of 6 inches was used. The wall was bolted to the reaction structure. The charge was remotely detonated using the RP-83 detonator. The wall sustained only a minimal amount of damage limited to the area directly behind the charge. This damage consisted of cracks in the wall and a slightly raised portion as shown in Figure 79. A 2-inch rotation was measured and is shown in Figure 80. No measurable fragments were seen in the high-speed films. The wall damage was documented and photographed and the wall was removed. Figure 81 shows a close up of back face damage. Figure 82 shows charge side damage. A schematic of the damage is also shown in Figure 83.

#### c. Test 19

This test involved the 2.4-pound cased charge. The cased charge was positioned 6 inches from the reinforced SIFCON wall and detonated remotely using the high-speed camera to initiate the detonator. The outputs of the piezoresistive shock pressure gages and the piezocrystals were recorded on magnetic tape for processing after the test. A post-test inspection of the wall showed that the wall had sustained major damage with a breach approximately 12 inches wide by 8 inches high as shown in Figure 84. The spall area was 24 inches wide by 13 inches high. The wall suffered some vertical cracks and rotated approximately 0.875 inches as shown in Figure 85. Damage to the charge side of the wall indicated a very directional casing fragment spray. The high-speed film from the fragment camera showed that the high velocity fragments



Figure 75. Test 17 Wall Damage (Type C, 2.7-Pound Cased Charge).



Figure 76. Test 17 Wall Damage Detail (Type C, 2.7-Pound Cased Charge).

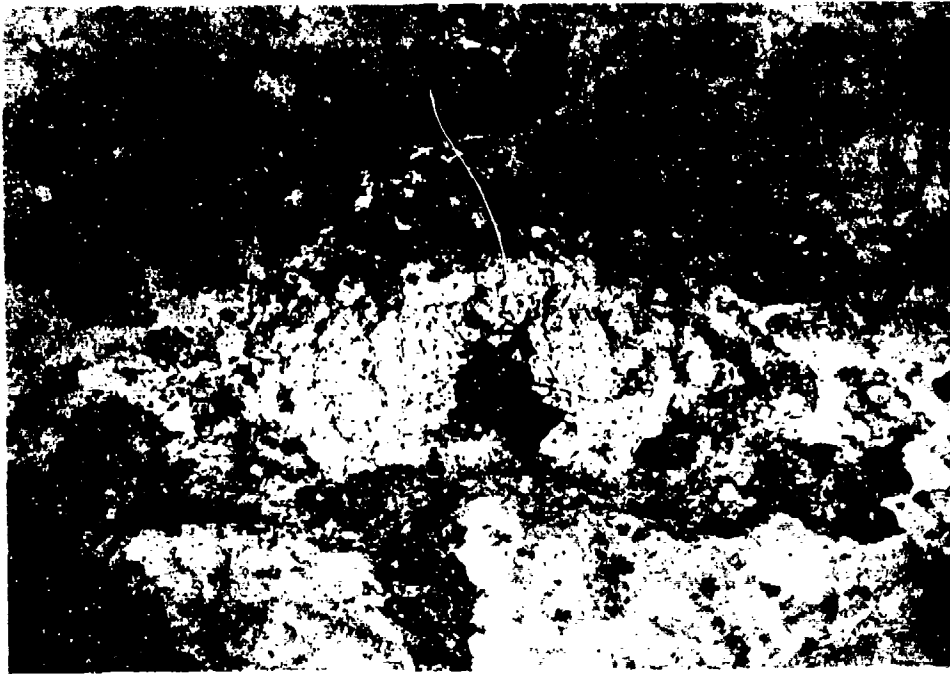


Figure 77. Test 17 Charge Side Wall Damage (Type C, 2.7-Pound Cased Charge).

TEST NO. 17 2.7 CASSED/TYPER C

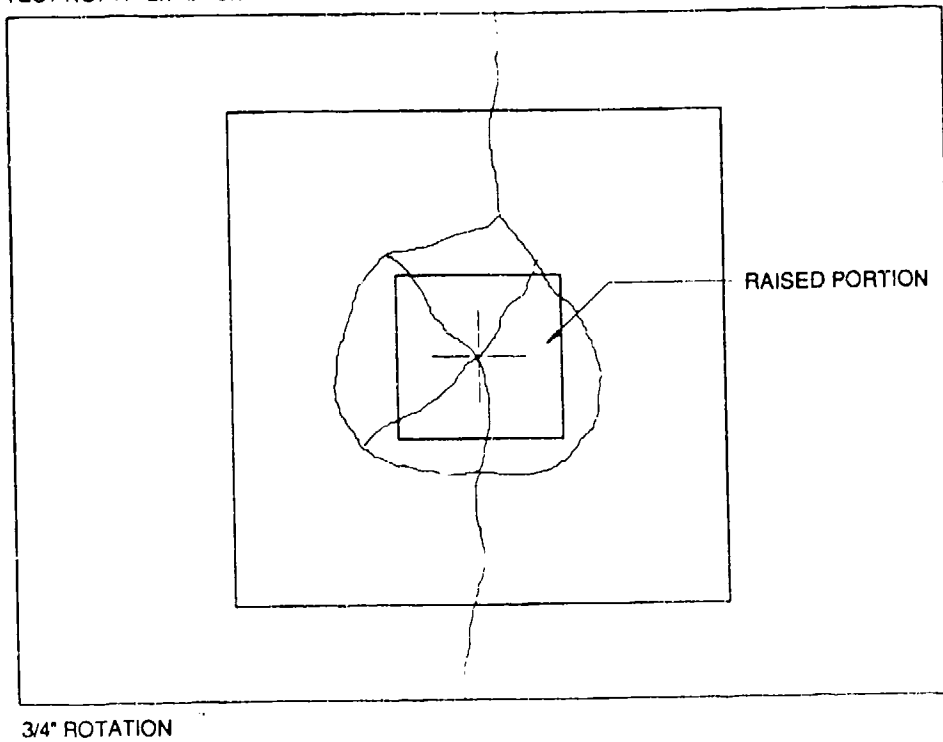


Figure 78. A Schematic of Test 17 Wall Damage (Type C, 2.7-Pound Cased Charge).

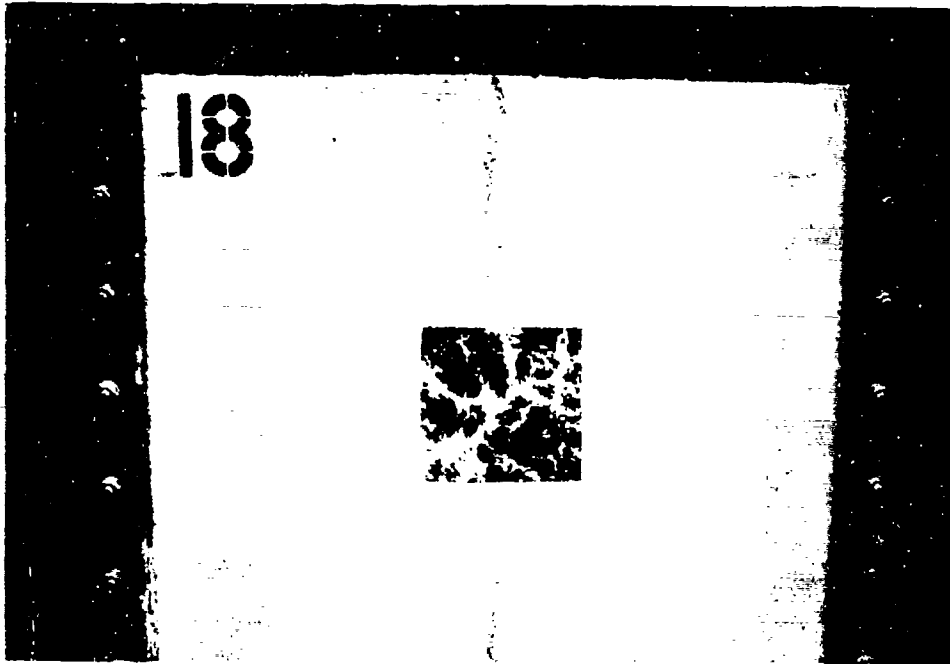


Figure 79. Test 18 Wall Damage (Type C, 2.4-Pound Equivalent Charge).

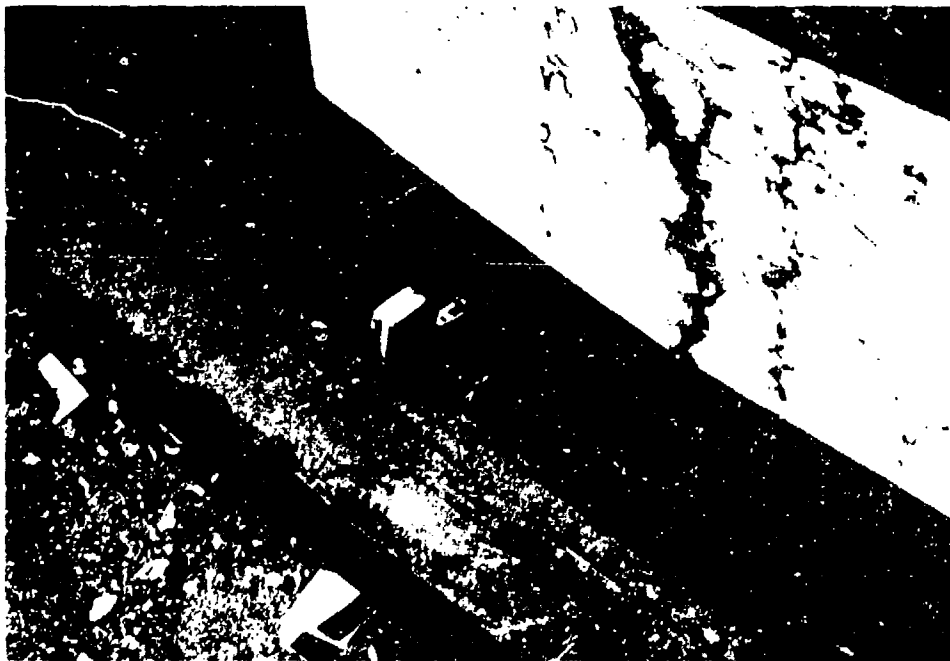


Figure 80. Test 18 Wall Rotation (Type C, 2.4-Pound Equivalent Charge).

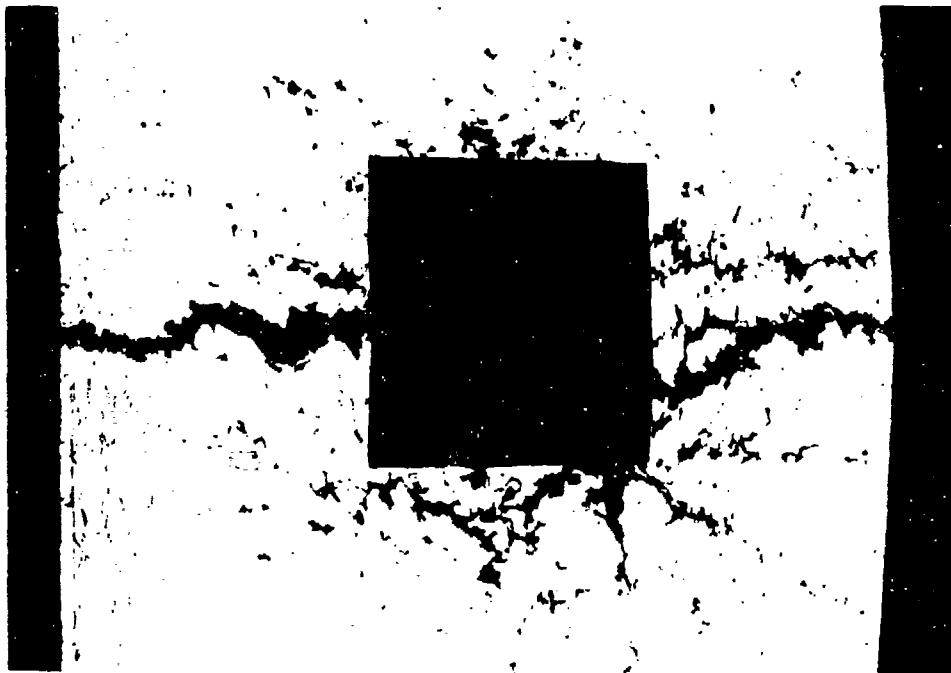


Figure 81. Test 18 Wall Damage Detail (Type C, 2.4-Pound Equivalent Charge).

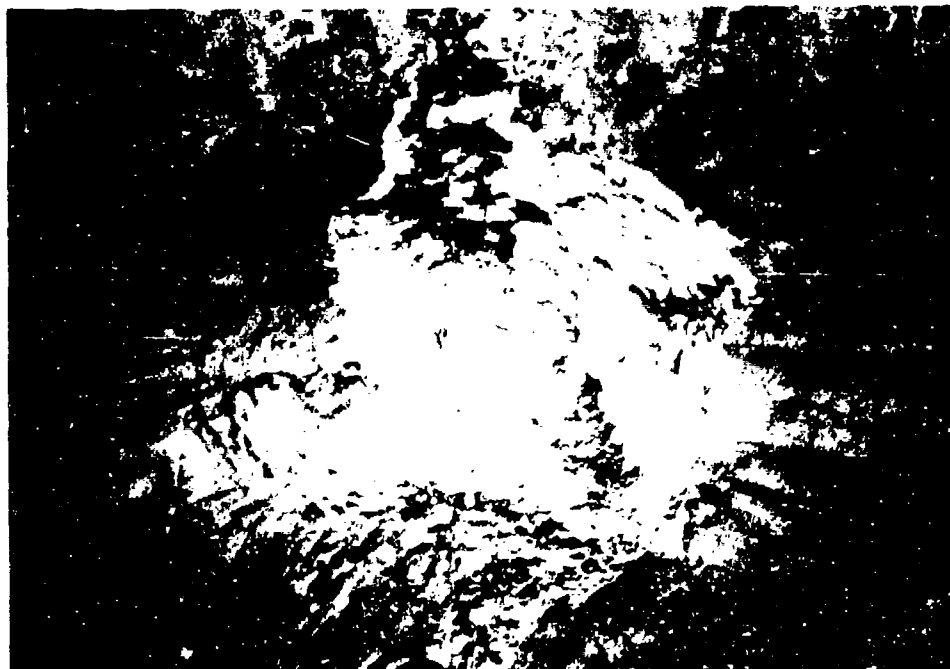


Figure 82. Test 18 Charge Side Wall Damage (Type C, 2.4-Pound Equivalent Charge).



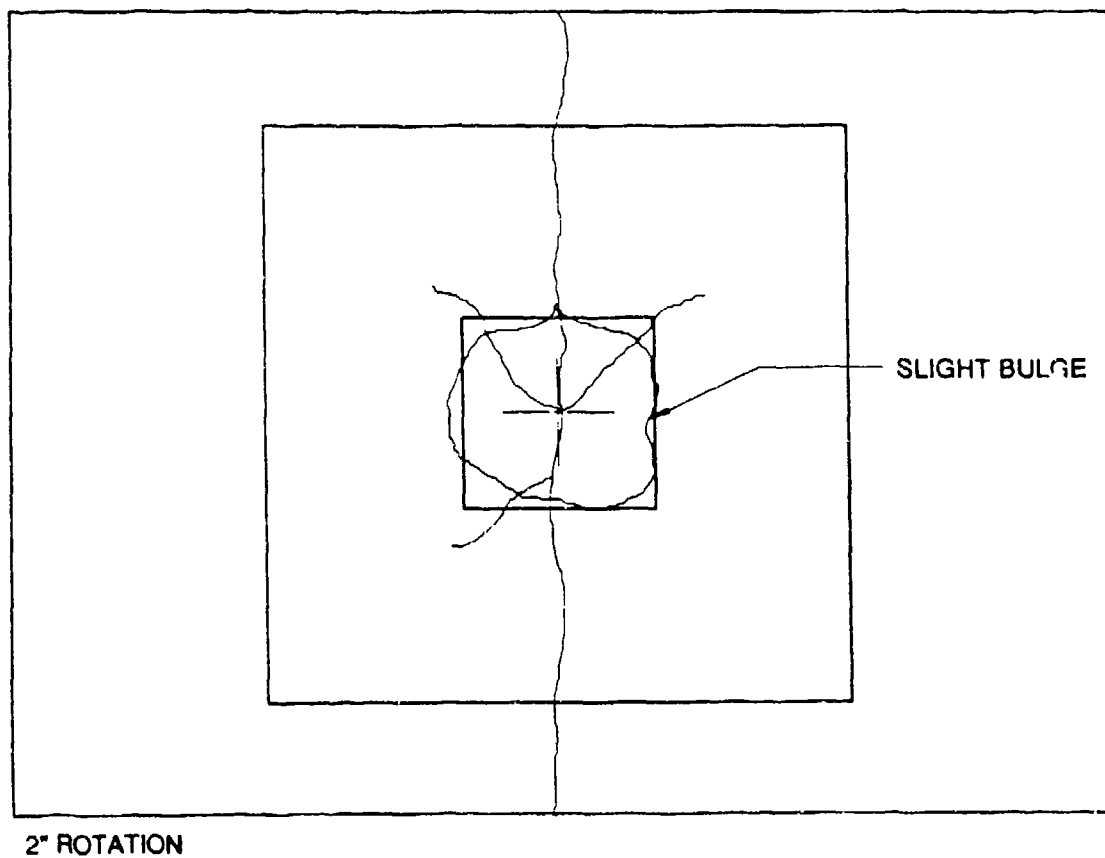


Figure 83. A Schematic of Test 18 Wall Damage (Type C, 2.4-Pound Equivalent Charge).



Figure 84. Test 19 Wall Damage (Type C, 2.4-Pound Cased Charge).



Figure 85. Test 19 Wall Rotation (Type C, 2.4-Pound Cased Charge).

were traveling at a velocity of approximately 288 fps. The rear face debris formed a hemispherical pattern. The slower fragments, shown in Figure 86, were traveling at a velocity of 70 fps. The signals from the crystals and from the carbon gages were analyzed and plots of these data are presented in Appendix C. Figure 87 shows charge side damage. A schematic of the wall failure is shown in Figure 88.

d. Test 20

Test 20 was conducted on the instrumented Type C panel using the equivalent bare charge (replicating the 2.4-pound cased charge) of 2.8 pounds of C4 at a standoff of 7 inches. The wall was bolted to the reaction structure and the bare cylindrical charge positioned. The charge was remotely detonated using the RP-83 detonator which was initiated by a pulse from the high-speed camera used to record the wall failure mechanism. The damage suffered by the wall was considerably less than the cased charge test with no significant breaches or failures, as shown in Figure 89. The actual wall damage is more of a petaline of the back face as is usually found in metal targets rather than a spall failure as is normally found in reinforced concrete walls. The wall did sustain a vertical crack and rotated approximately 1.25 inches. Damage to the charge side of the wall is shown in Figure 90. The high-speed film showed that very few fragments were ejected and the faster fragments were traveling at a velocity of 105 fps. The carbon gage data and the crystal data was processed and plots of the data are included in Appendix C. A closeup of back face damage is shown in Figure 91. Figure 92 shows a schematic of wall damage.



Figure 86. Test 19 Wall Debris (Type C, 2.4-Pound Cased Charge).

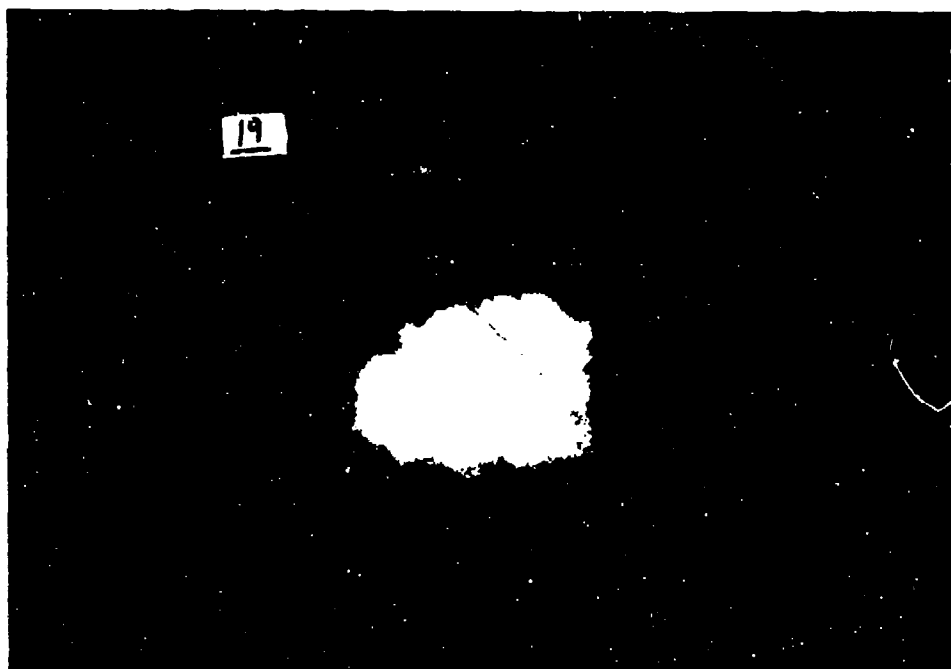
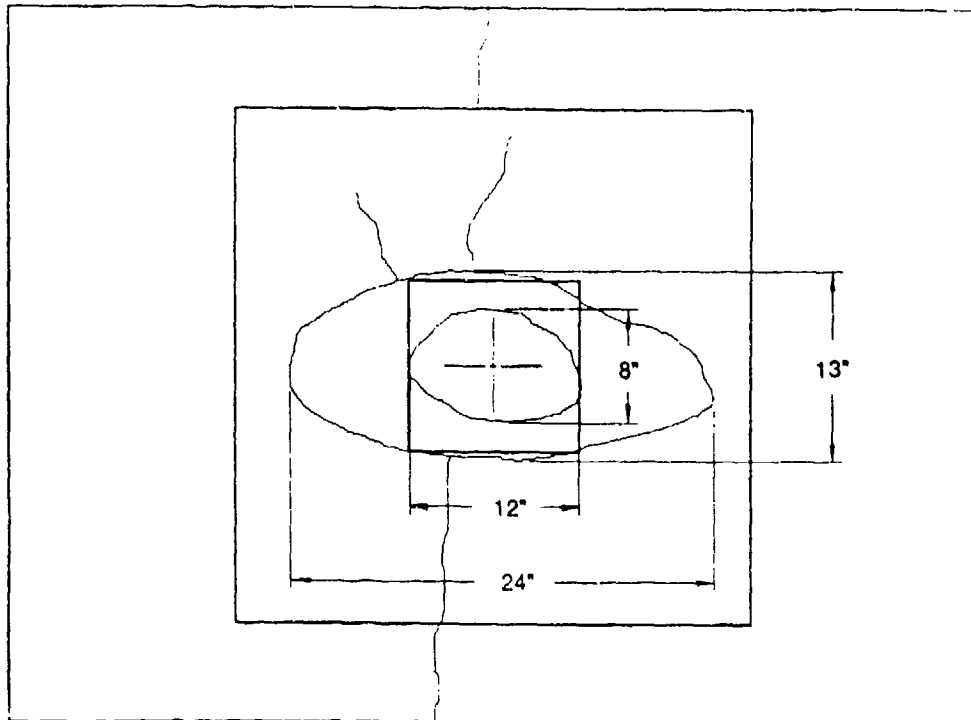


Figure 87. Test 19 Charge Side Wall Damage (Type C, 2.4-Pound Cased Charge).



7/8" ROTATION

Figure 88. A Schematic of Test 19 Wall Damage (Type C, 2.4-Pound Cased Charge).



Figure 89. Test 20 Wall Damage (Type C, 2.8-Pound Equivalent Charge).

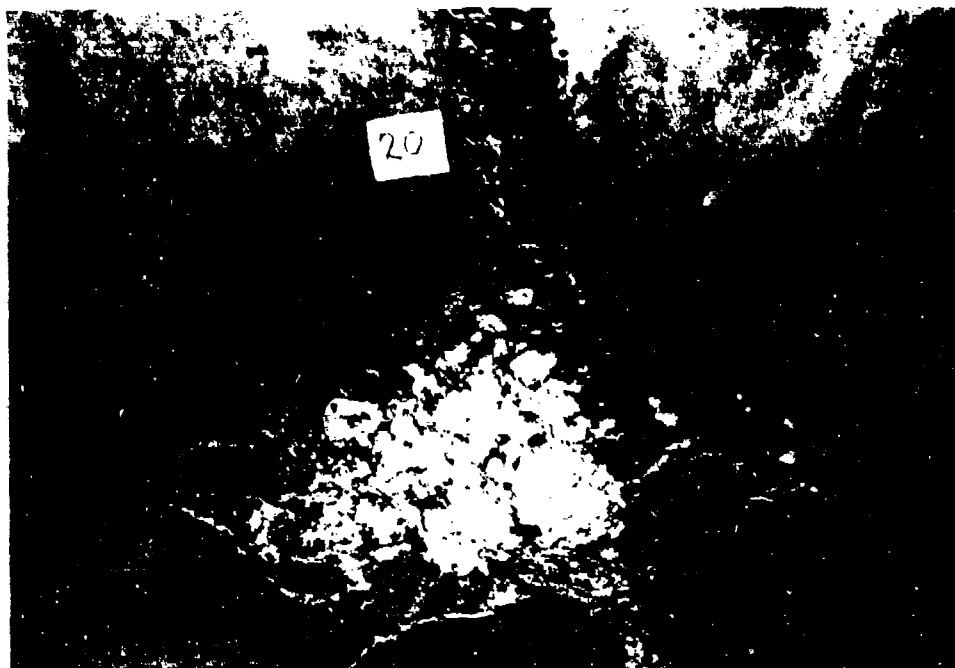


Figure 90. Test 20 Charge Side Wall Damage (Type C, 2.8-Pound Equivalent Charge).



Figure 91. Test 20 Wall Damage Detail (Type C, 2.8-Pound Equivalent Charge).

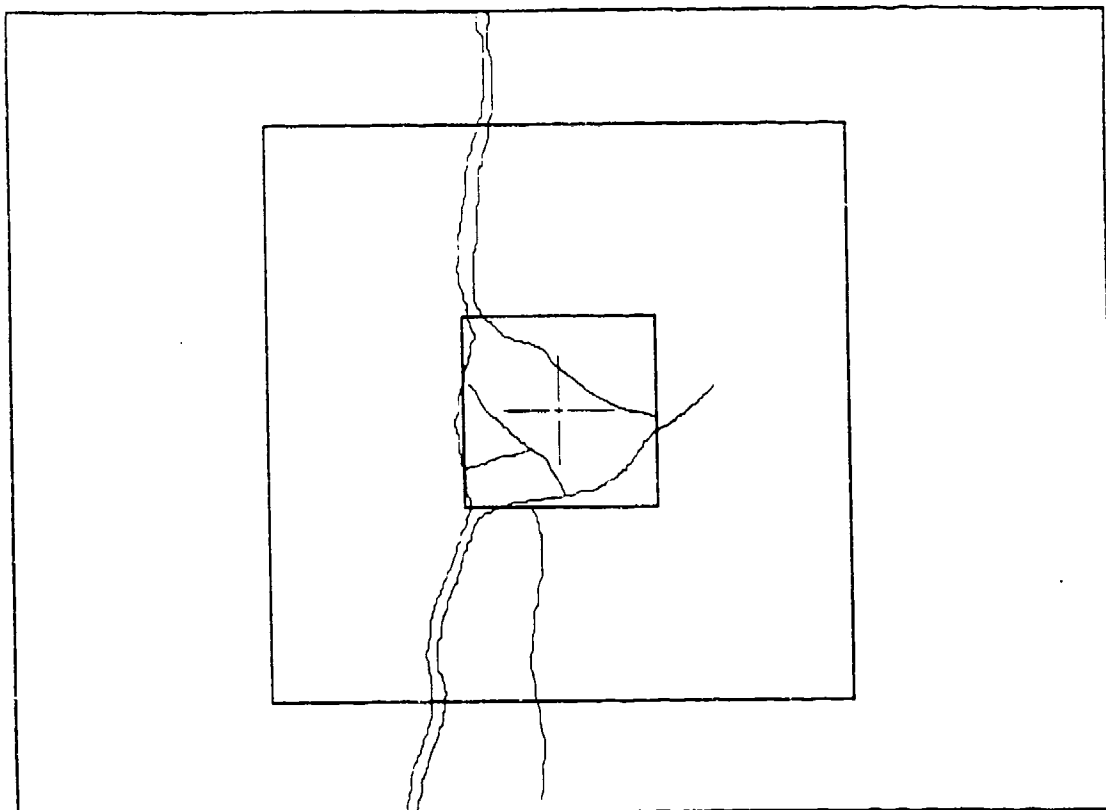


Figure 92. A Schematic of Test 20 Wall Damage (Type C, 2.8-Pound Equivalent Charge).

## SECTION IV

### ANALYSIS OF RESULTS

#### A. DISCUSSION OF RESULTS

As described previously, the loads tests were conducted for two principal reasons. First, the impulse plate fixture was shown to be a solid test device for load quantification for bare explosive tests. While the plate was not used to generate data later in the program for equivalent bare charges due to schedule and funding constraints, it can be effectively used in follow-on work. The second reason for the loads test concerned the quantification of cased charge airblast and fragment impulse. These test directly supported the panel testing effort.

##### 1. Loads Tests

The bare charge tests and the cased charge tests were conducted to quantify the loads generated by the cased weapon for use in establishing an equivalent bare charge. In the bare charge tests conducted at SwRI, measurements of the side-on pressure, reflected pressure, and impulse distribution were made. The cased charge tests included measurements of the side-on pressure, reflected pressure, impulse distribution and fragment characterization, that is, fragment size, weight, and velocity. The combination of the bare charge data and the cased charge data were used to develop the equivalent bare charge. The following paragraphs provide a general discussion of the results of the loads tests.

##### a. Bare Charge Tests

The data measured in the bare charge tests have been summarized in TABLES 4 - 7 and includes the pressure data, integrated impulses, the impulse plug velocities and the calculated impulses on the plugs. This impulse data were calculated using the velocity data and the area of the plugs. The side-on pressure data are given in TABLE 4, gages number P1-P4. As can be seen in TABLE 4, the data vary considerably; however, this variation is because the gage positioning varied from test to test. Comparisons of the measured side-on pressures to a predicted side-on pressure yielded acceptable results. The reflected pressures are shown in locations P5-P12. The first three tests were conducted with a total of five reflected pressure gages, using PCB high pressure gages close to the charge. As can be seen in TABLE 4, gages failed in every test, primarily close in to the charge at the very high pressure areas (locations 8 and 10). Tests 4 and 5 were conducted using a larger number of gages. These tests also had a significant number of gage failures. A comparison of the reflected pressures for the five tests shows a fairly good agreement between the tests conducted



using the same charge weight. Tests 2 and 4 both involved 2.7 pounds of C4 and as shown in TABLE 4, the recorded pressures at locations 9, 10, and 12 show good agreement. Similarly, Tests 1 and 3, used the 2.4-pound charge and show good agreement at location P9 and Tests 3 and 5 show good agreement at locations P11 and P12. The integrated impulse data are presented in TABLE 5 and shows the same trends.

The impulse plug velocity data are summarized in TABLE 6. A comparison of the 2.4-pound tests (Tests 1, 3 and 5) shows a considerable variation especially in the results of Test 1. This variation is due in part to the fact that Test 1 used the fiber optic break wires while Tests 3 and 5 used the position transducers. Similarly, Test 2 used the fiber-optic break wires while Test 4 used the position transducers. A comparison of the actual velocities measured in Test 3 to a predicted calculated impulse showed that for the plugs closest to the charge (Plugs 3-7) the measured velocities for four of the plugs were within 12 percent of the predicted. One of the velocities, that of Plug 5, was within 24 percent of predicted. Similarly, a comparison of the actual velocities measured in Test 5 to the predicted calculated impulse showed variations ranging from 11 percent from predicted for Plug 5 to 28 percent for Plug 3. The remaining plugs varied between 19 percent and 23 percent. The comparison of Test 4 (the 2.7 pound test) to the predicted velocities for that test showed a very good agreement between the measured and the predicted. Variations ranged from a maximum of 14.5 percent at Location 7 to a minimum of 0 percent at Location 3. Locations 4 and 6 were all within 9 percent of the predicted velocity and Location 5, which was directly in front of the charge, within 3.9 percent. The impulse acting on the plugs was calculated using the measured velocities and these impulses are summarized in TABLE 6. All predictions were made using the Tables presented in Reference 1.

#### b. Cased Charge Tests

The cased charge data have been summarized in TABLES 8 - 10 and they include the measured pressures, integrated impulses, plug velocity and casing fragment velocities as recorded by the break screens. A comparison of the measured side-on and reflected pressures to calculated pressures shows a relatively good agreement for Test 6. This agreement indicates that the airblast pressure is not significantly reduced by the light casing on the 2.7-pound charge. A direct comparison of the 2.7-pound bare charge and the 2.7-pound cased charge shows an average 35 percent reduction in side-on pressures. A comparison of impulse shows very little reduction due to casing effects.

Pressures and impulses were more dramatically reduced by the heavy casing of the 2.4-pound charge. TABLES 4, 5 and 10 show that pressures were reduced an average of 66 percent and impulse by 48 percent.

A comparison of the highest measured fragment velocities to a calculated "Gurney" velocity for the 2.7-pound cased charge and for the 2.4-pound cased charge showed reasonable agreement. The Gurney initial fragment velocity for the 2.7-pound cased charge was calculated to be 8079 fps while the highest measured velocity for Test 6 was 6906 fps. The Gurney initial fragment velocity for the 2.4-pound cased charge was 4815 fps and the highest measured velocity in Test 7 was 6757 fps.

## 2. Panel Tests

### a. Response Mode

#### (1). Comparison of Bare and Cased Charge Responses

The tests conducted on the three types of wall construction using the cased charges and the equivalent bare charges demonstrated that the combination of the fragment impact loads and the blast pressure loads associated with the detonation of a cased charge were a more severe environment than that created by the blast loads from an equivalent bare charge. In all of the tests conducted on the reinforced concrete panels, the cased charges created larger breaches in the panels than did any of the corresponding equivalent bare charges. The cased charge tests also generated concrete debris traveling at higher velocities than did the debris created by the equivalent bare charges. The initial shapes of the failed material was also different for the two charges. The bare charges produced a conical material failure shape which indicated the initiation of the failure at a point. The cased charges, however, produced a failure pattern on the rear face of the slabs which was hemispherical in shape indicating a spall and breach initiation over a larger area due to higher stresses generated by the combination of the fragment and blast impulses. The total back face spall areas were approximately the same size for the cased and equivalent bare charge tests and the equivalent bare charge tests caused a larger amount of wall rotation at the midspan than did the cased charge tests. The following paragraphs present details on the analyses of the data for each of the panel types:

Tests on Panel-Type A - The tests conducted on the lighter reinforced concrete panel (Tests 9 - 12) demonstrated that the cased charges created significantly more breach damage to the panels than did the equivalent bare charges. TABLE 11 presents the maximum and the average velocities for the concrete debris generated by each of the tests with the exception of Test 9 which

had no debris velocity measurements. The debris for Test 10 which was the 2.7-pound equivalent bare charge test was measured at a velocity of 168 fps for the fastest fragments. The measured debris velocities for Test 11 (the 2.4-pound cased charge) and Test 12 (the 2.4-pound equivalent bare charge) are presented in TABLE 11 and show that the maximum debris velocity is much higher for the cased charge than for the bare charge, 336 fps for Test 11 and 140 fps for Test 12. TABLE 12 compares the damage to the panels and includes data on the breach size, the back face spall size and the midspan rotation. As shown in TABLE 12, the 2.7 -pound cased charge test (Test 9) created a breach in the test panel approximately 20 inches x 14 inches while the bare charge, Test 10 had a smaller breach of 14 inches x 7 inches. The spall area was relatively similar for both the cased charge (32 inches x 25 inches) and the bare equivalent charge (38 inches x 24 inches); however, the amount of rotation at the wall midspan was larger for the equivalent bare charge than for the cased charge, 8 inches as compared to 5.75 inches. Tests 11 and 12 yielded results similar to that obtained in Tests 9 and 10, with the cased charge creating much more damage to the panel than the bare charge. The breach area for the cased charge is 28 inches x 12 inches as compared to 14 inches x 8 inches for the bare charge. The area of the back face that spalled is very similar for the two tests, 32 inches x 21 inches for the cased charge and 36 inches x 34 inches for the bare charge. The rotation at the wall midspan was larger for the equivalent bare charge (7 inches) than the rotation for the cased charge (5.25 inches).

A comparison between the two cased charge tests, Test 9 and 11, shows that both the concrete spall velocity and the degree of damage are much higher for the thicker casing than for the thin casing.

Tests on Panel-Type B - Tests 13 - 16 were tests conducted on the heavier reinforced concrete panels. These tests also showed that the cased charge tests created significantly more breach damage to the panels than did the equivalent bare charges. The maximum concrete debris velocities given in TABLE 11 show that the 2.7-pound cased charge (Test 13) generated debris traveling at a velocity of 210 fps while the debris for the 2.7-pound equivalent bare charge (Test 14) was traveling at 140 fps. The 2.4-pound cased test (Test 15) generated debris traveling at a velocity of approximately 291 fps. The 2.4-pound equivalent bare charge (Test 16) involved a spherical charge rather than the cylindrical charges that were used on the other bare charge tests. The debris velocity for this spherical charge test was measured at 120 fps. The damage sustained by the panels is also presented in TABLE 12. As shown in TABLE 12, the 2.7-pound cased charge test (Test 13) created a breach in the test panel approximately 21 inches x 18 inches while the bare charge, Test 14 had a smaller breach of 14 inches x 10 inches. The spall area for both tests was very similar. The cased charge created a spall area of 32 inches x 25 inches and the

equivalent bare charge created a spall area of 38 inches x 24 inches. The panel rotation at the midspan was larger for the equivalent bare charge (2 inches) than for the cased charge which was 1.75 inches. The 2.4-pound cased charge and the 2.4-pound equivalent bare charge had different charge geometries and are discussed later in this section.

A comparison of Tests 13 and 15, the two cased charge tests, shows that the concrete debris velocity for the 2.4-pound cased charge was traveling at a much higher velocity than the debris for the 2.7-pound cased charge. Similarly, the degree of damage is much higher for the thicker casing than for the thin casing.

Tests on Panel-Type C - The tests conducted on the reinforced SIFCON panels, Tests 17 through 20 showed that the reinforced SIFCON panels sustained considerably less damage than the reinforced concrete panels, especially with the 2.7-pound cased and equivalent bare charge. As shown in TABLE 11, there were no measurable debris velocities for either the 2.7-pound cased charge or the 2.7-pound equivalent charge. The 2.4-pound cased and bare charge tests showed that the debris generated by the cased charge was traveling at much higher speeds than the debris for the 2.4-pound bare charge. The cased charge generated debris was traveling at a maximum velocity of 288 fps and the 2.4-pound equivalent bare charge generated debris was traveling at a slower velocity of 105 fps. The actual damage sustained by the reinforced SIFCON panels tested with the 2.7-pound cased charge consisted of several cracks in the panel and one corner of a small section of SIFCON fibers separating from the wall. The panel rotated 0.75 inches at the midspan. The 2.7-pound equivalent bare charge caused even less damage with the wall having only a slight bulge in the center, but did cause a larger rotation of approximately 2 inches. These tests did show that even though the damage caused was minor, the cased charge created more damage than the equivalent bare charge. The tests with the 2.4-pound cased charge and the 2.4-pound bare charge further demonstrated the difference in damage mechanisms between the cased and bare charges. The 2.4-pound cased charge test resulted in a 12 inch x 8 inch breach and a 24 inch x 13 inch spall area while the 2.4-pound equivalent bare charge had no breach or spall area. As in the previous tests, the bare charge test resulted in a larger panel rotation (1.25 inches) than did the cased charge (0.875 inches).

As was the case with the reinforced concrete tests, the comparison of the two cased tests, the 2.7-pound cased and the 2.4-pound cased, showed that the thicker casing of the 2.4-pound cased charge caused considerably more damage than the thinner case.

(2). Comparison of Spherical and Cylindrical Charges

As previously mentioned, Test 16 which was the 2.4-pound equivalent bare charge test, using a spherical charge instead of a cylindrical charge. The purpose of this test was to determine what effects charge shape would have on the damage mechanisms. The spherical shaped charge test showed that shape does affect the damage mechanisms since the panel tested using the spherical bare charge sustained only minor damage, consisting primarily of several cracks in the panel with no breach or major spall. In all of the previous tests, the cased charges and their corresponding equivalent bare charges caused some type of breach in the panels (see TABLE 12) even though the cased charges did cause the larger breaches. In addition, the spall areas for the cased and the bare charge tests were very similar in size. Since Test 15 (the 2.4-pound cased charge) resulted in damage to the panel consisting of a 28 inch x 24 inch breach area and a 35 inch x 41 inch spall area, considerably more damage was expected from the 2.4-pound spherical bare charge than was found. The reduction in the amount of damage to the panel in Test 16 cannot be attributed to the heavier reinforcement, because the 2.7-pound cased and the 2.7-pound equivalent bare charge tests conducted on the same heavier reinforced panel construction (Tests 13 and 14) both resulted in breaches and in sizable spall areas. The reduction in the damage to the test panel has to be attributed to the spherical shape of the charge which, in effect, reduces the area of the explosive which is in near contact with the panel.

b. Pressures and Pressure Decay

TABLES 16 and 17 contain reduced data from the carbon stress gage measurements and piezocrystal measurements made in Tests 13 through 16 and 19 and 20. While interpretation of these data are difficult, some discussion is provided in the paragraphs below.

The first comparison that can be made is between the measured stresses generated by the lightly cased, heavily cased and bare equivalent charges. TABLE 16 shows that the heavily cased charges (2.4-pound cased) in Tests 15 and 19 produced significantly higher interior stresses than the lightly cased test (2.7-pound cased, Test 13) by a factor of 1.7 in the Type B panel. Additionally, the heavily cased charge produced stresses four times higher than the equivalent bare charge for Type B. In the SIFCON panels (Type C) the stresses are much higher due to the increased density and impedance. CG2 in the SIFCON shows an increase of 4.5 times over the equivalent bare charge.

Attenuation of the stress is also difficult to analyze because of gage location effects (carbon stress gages were not located directly behind one another). It should be noted, however, that attenuation is significantly larger in the equivalent charge tests (14, 16 and 20) than in the cased charge tests.

Last, time-of-arrival data are troublesome. The piezocrystal responses are omnidirectional and apparently responded to both through thickness and lateral wave propagation. These gages can be used more successfully in future work by isolating the gage sides from the stress pulse such that their responses are unidirectional.

#### c. Data Analysis and Comparison with Existing Data

Data from reference 21 were reviewed and combined with data generated in this test program to assess the local effects of blast and fragments on breach and spall. TABLE 18 presents these data along with calculations made for adjusted charge weight, scaled spall diameter, breach diameter and applied impulse rate. The charge weights of all of the explosive charges considered in the table and in Figures 93-96 were adjusted first according to surface conditions (ground or free air), second by aspect ratio of the charge to account for enhanced effects of cylinders at small standoffs, and finally according to casing effects by increasing the charge weight linearly as a function of charge weight to case weight ratio. Aspect ratio effects were considered to be negligible at scaled standoffs greater than  $1.0 \text{ ft/lb}^{1/3}$ , and were a maximum of the square root of the aspect ratio times the charge weight at very small standoffs. Casing effects were considered to be negligible at standoffs greater than a standoff to case diameter ratio of 10.0, and were a maximum of  $\frac{(W+C)}{W}$  times the charge weight at very small standoffs.

The relationships developed and presented in TABLE 18 are estimates of the true interactions at small standoffs, but are reasonable, and serve to illustrate the trends of spall and breach diameter shown in Figures 93 and 94. The objective of future research in the combination of blast and fragment loads will be to define the true relationships between fragment density and generated stress, and the resulting structural damage and breach. Figures 95 and 96 show the effect of load rate on spall diameter and breach diameter for given charge weights. Measured stresses and durations from tests reported in the previous sections as well as those presented in Reference 21 were used to generate a load rate, which is simply the rate of application of impulse or one-half the peak stress value for a triangular load. The point here is that the combined blast and impact (fragment) loads produced much shorter pulses (a higher rate) and larger or greater damage.

## B. EVALUATION OF EXISTING PREDICTIVE TECHNIQUES

Three techniques for local breach prediction were reviewed for applicability for prediction of breaching responses in reinforced concrete.

### 1. Severe Dynamic Loads (Krauthammer) Code

The techniques presented and the code described in the references reviewed (References 17 and 18) do not truly consider breaching response in concrete structures. Localized loads are considered, but only to predict shear response and flexural response. One calculation with this code was made for the 2.7-pound charge and the Type A panel. A maximum displacement of 1.2 inches was predicted with no local breach. A rotation of 5.75 inches was achieved in Test 9. Data from the analysis are included in Appendix H.

### 2. WES Code

The techniques presented in Reference 19 do not specifically address breach; however, some details of localized, nonuniform loading presented are more complete than those considered in the other codes. No calculations were made since breach was not considered.

### 3. REICON

The REICON code (Reference 20) was exercised for all cases tested. This code considers localized loading and breaching as well as charge shape effects. Comparisons of REICON predictions and test values are presented in TABLE 19. It can be seen that the casing effects (not considered in REICON) cause some disparity to occur between predicted and actual results. Output from code runs is included in Appendix I.

TABLE 18. SCALED SPALL DIAMETER, BREACH DIAMETER, AND LOAD RATE VERSUS SCALED RANGE.

| Seq | Ref         | Test No | R (in) | W<br>TNT<br>(lb) | Chg Len<br>(in) | Chg Dia<br>(in) | Aspect | Pred<br>ir<br>(psi-ms) | Impulse<br>Increase<br>(%) | Adj<br>Impulse<br>(psi-ms) | Eqv<br>W<br>(lb) | Case<br>Thk.<br>(in) | Case<br>Wt.<br>(lb) | RW <sup>1/3</sup><br>(adj)<br>(ft/lb <sup>1/3</sup> ) | R/W <sup>1/3</sup><br>(ft/lb <sup>1/3</sup> +C) | T<br>(in) | f <sub>c</sub> |
|-----|-------------|---------|--------|------------------|-----------------|-----------------|--------|------------------------|----------------------------|----------------------------|------------------|----------------------|---------------------|-------------------------------------------------------|-------------------------------------------------|-----------|----------------|
| 1   | McVay       | 1c      | 1      | 1.472            | 6               | 2               | 3.00   | 35980.576              | 13.439222                  | 46327.43                   | 1.72             | 0                    | 0.000               | 0.069380759                                           | 0.069380759                                     | 8.50      | 5090           |
| 2   | McVay       | 1d      | 18.5   | 10.195           | 11.44           | 3.81            | 3.00   | 389.25951              | 4.1797721                  | 46052867                   | 11.00            | 0                    | 0.000               | 0.693148317                                           | 0.693148317                                     | 8.50      | 5090           |
| 3   | McVay       | 2c      | 1      | 1.472            | 6               | 2               | 3.00   | 35980.576              | 13.439222                  | 46327.43                   | 1.72             | 0.047                | 0.490               | 0.069380759                                           | 0.054146957                                     | 8.50      | 4850           |
| 4   | McVay       | 3a      | 29.25  | 40.295           | 18.25           | 6               | 3.04   | 389.26023              | 4.3442843                  | 4061708                    | 43.61            | 0                    | 0.000               | 0.69247078                                            | 0.69247078                                      | 8.50      | 5080           |
| 5   | McVay       | 3b      | 18.5   | 10.195           | 11.25           | 3.75            | 3.00   | 389.25951              | 3.118038                   | 401.59677                  | 10.80            | 0.088                | 3.223               | 0.697560957                                           | 0.577170953                                     | 8.50      | 5080           |
| 6   | McVay       | 4b      | 29.25  | 19.719           | 14.25           | 4.75            | 3.00   | 267.49615              | 1.4181019                  | 271.28951                  | 20.27            | 0.111                | 6.524               | 0.89403268                                            | 0.676323103                                     | 8.50      | 5290           |
| 7   | McVay       | 5a      | 18.5   | 9.702            | 11.25           | 3.75            | 3.00   | 379.06954              | 4.0218782                  | 394.31526                  | 10.44            | 0.088                | 3.223               | 0.703307379                                           | 0.538961713                                     | 8.50      | 13815          |
| 8   | McVay       | 5b      | 18.5   | 4.968            | 9               | 3               | 3.00   | 266.9139               | 1.3993556                  | 270.64897                  | 5.10             | 0.07                 | 1.641               | 0.895404494                                           | 0.677547876                                     | 8.50      | 13815          |
| 9   | McVay       | 5c      | 1      | 1.472            | 6               | 2               | 3.00   | 35980.576              | 13.439222                  | 46327.43                   | 1.72             | 0.047                | 0.490               | 0.069380759                                           | 0.054146957                                     | 8.50      | 13815          |
| 10  | McVay       | 6c      | 1      | 1.472            | 6               | 2               | 3.00   | 35980.576              | 13.439222                  | 46327.43                   | 1.72             | 0.047                | 0.490               | 0.069380759                                           | 0.054146957                                     | 8.50      | 4605           |
| 11  | McVay       | 7c      | 1      | 1.472            | 6               | 2               | 3.00   | 35980.576              | 13.439222                  | 46327.43                   | 1.72             | 0.047                | 0.490               | 0.069380759                                           | 0.054146957                                     | 8.50      | 4605           |
| 12  | McVay       | 8c      | 18.5   | 4.968            | 9               | 3.03            | 2.97   | 266.9139               | 1.5098454                  | 270.94389                  | 5.11             | 0.1875               | 4.921               | 0.89477336                                            | 0.456041933                                     | 5.38      | 4000           |
| 13  | McVay       | 10a     | 29.25  | 19.719           | 14.25           | 4.75            | 3.00   | 267.49615              | 1.4181019                  | 271.28951                  | 20.27            | 0.111                | 6.524               | 0.89403268                                            | 0.676323103                                     | 8.50      | 4300           |
| 14  | McVay       | 10c     | 1      | 1.472            | 6               | 2               | 3.00   | 35980.576              | 13.439222                  | 46327.43                   | 1.72             | 0.047                | 0.490               | 0.069380759                                           | 0.054146957                                     | 8.50      | 4300           |
| 15  | McVay       | Box-2   | 18.5   | 4.968            | 9               | 3               | 3.00   | 266.83666              | 1.4005596                  | 270.59618                  | 5.10             | 0                    | 0.000               | 0.895517611                                           | 0.895517611                                     | 11.25     | 5010           |
| 16  | McVay       | Box-3   | 18.5   | 4.968            | 9               | 3               | 3.00   | 266.83666              | 1.4005596                  | 270.59618                  | 5.10             | 0.1875               | 4.868               | 0.895517611                                           | 0.458263938                                     | 11.25     | 5010           |
| 17  | McVay       | Box-5   | 18.5   | 10.189           | 11.69           | 3.81            | 3.07   | 389.13672              | 4.9135947                  | 408.25732                  | 11.14            | 0.088                | 3.404               | 0.690278388                                           | 0.528717902                                     | 11.25     | 5010           |
| 18  | McVay       | Box-6   | 18.5   | 10.189           | 11.69           | 3.81            | 3.07   | 389.13672              | 4.9135947                  | 408.25732                  | 11.14            | 0.34275              | 12.351              | 0.690278388                                           | 0.327347574                                     | 11.25     | 5010           |
| 19  | McVay       | Box-7   | 24     | 16.44            | 17.5            | 3.94            | 4.44   | 331.38052              | 6.760798                   | 355.78449                  | 18.61            | 0                    | 0.000               | 0.754738383                                           | 0.754738383                                     | 11.25     | 5010           |
| 20  | McVay       | Box-9   | 24     | 8.062            | 14.31           | 3.06            | 4.68   | 229.45508              | 0.088591                   | 229.63837                  | 8.08             | 0.13625              | 5.772               | 0.996847673                                           | 0.581338511                                     | 11.25     | 5010           |
| 21  | Ball        |         | 1.62   | 1                | 3.24            | 3.24            | 1.00   | 8792.4119              | 0                          | 8792.4119                  | 1.00             | 0                    | 0.000               | 0.135000021                                           | 0.135000021                                     | 6.00      | 3500           |
| 22  | Ball        |         | 2.04   | 2                | 4.08            | 4.08            | 1.00   | 8802.4793              | 0                          | 8802.4793                  | 2.00             | 0                    | 0.000               | 0.134929114                                           | 0.134929114                                     | 6.00      | 3500           |
| 23  | Ball        |         | 2.58   | 4                | 5.16            | 5.16            | 1.00   | 8730.1274              | 0                          | 8730.1274                  | 4.00             | 0                    | 0.000               | 0.13544154                                            | 0.13544154                                      | 6.00      | 3500           |
| 24  | Ball        |         | 3.54   | 10               | 7.08            | 7.08            | 1.00   | 8525.5135              | 0                          | 8525.5135                  | 10.00            | 0                    | 0.000               | 0.136926903                                           | 0.136926903                                     | 6.00      | 2500           |
| 25  | Ball        |         | 2.58   | 4                | 5.16            | 5.16            | 1.00   | 8730.1274              | 0                          | 8730.1274                  | 4.00             | 0                    | 0.000               | 0.13544154                                            | 0.13544154                                      | 10.00     | 3500           |
| 26  | Ball        |         | 3.54   | 10               | 7.08            | 7.08            | 1.00   | 8525.5135              | 0                          | 8525.5135                  | 10.00            | 0                    | 0.000               | 0.136926903                                           | 0.136926903                                     | 10.00     | 3500           |
| 27  | Ball        |         | 4.08   | 16               | 8.16            | 8.16            | 1.00   | 8802.4792              | 0                          | 8802.4792                  | 16.00            | 0                    | 0.000               | 0.134929123                                           | 0.134929123                                     | 10.00     | 3500           |
| 28  | Ball        |         | 4.5    | 21               | 9               | 9               | 1.00   | 8663.0598              | 0                          | 8663.0598                  | 21.00            | 0                    | 0.000               | 0.135972582                                           | 0.135972582                                     | 10.00     | 3500           |
| 29  | Ball        |         | 6      | 30               | 12              | 12              | 1.00   | 8691.0679              | 0                          | 8691.0679                  | 30.00            | 0                    | 0.000               | 0.135720921                                           | 0.135720921                                     | 20.00     | 3500           |
| 30  | Colliery    | 1       | -      | 47.95            | -               | -               | -      | ERR                    | 0                          | ERR                        | ERR              | 0                    | 0.000               | ERR                                                   | ERR                                             | 20.00     | 3500           |
| 31  | Colliery    | 2       | -      | 47.95            | -               | -               | -      | ERR                    | 0                          | ERR                        | ERR              | 0                    | 0.000               | ERR                                                   | ERR                                             | 8.00      | 3500           |
| 32  | Kruppschick | 1       | 59.05  | 76.24            | 25.59           | 7.87            | 3.25   | 182.92428              | 0                          | 182.92428                  | 76.24            | 0.236                | 40.989              | 1.16048199                                            | 0.754759019                                     | 12.80     | 5817           |
| 33  | Kruppschick | 2       | 33.40  | 15.673           | 19.85           | 4.13            | 4.81   | 194.30822              | 0                          | 194.30822                  | 15.67            | 0.197                | 13.674              | 1.14193187                                            | 0.595064941                                     | 12.80     | 6817           |
| 34  | Marchand    | 9       | 6      | 2.7              | 10.7            | 2.51            | 4.26   | 1252.1251              | 4.5315954                  | 1822.0873                  | 4.96             | 0.0697               | 1.618               | 0.937245363                                           | 0.221080183                                     | 4.00      | 5890           |
| 35  | Marchand    | 10      | 6      | 2.4              | 10.7            | 2.23            | 4.80   | 1166.1528              | 40.321698                  | 1634.3654                  | 4.17             | 0                    | 0.000               | 0.310530497                                           | 0.310530497                                     | 4.00      | 5890           |
| 36  | Marchand    | 11      | 6      | 2.4              | 7.54            | 3.26            | 2.32   | 1166.1528              | 43.286243                  | 1671.0531                  | 4.32             | 0.302                | 5.980               | 0.307065264                                           | 0.128738672                                     | 4.00      | 5890           |
| 37  | Marchand    | 12      | 7      | 2.8              | 7.54            | 2.87            | 2.63   | 970.36246              | 20.220482                  | 1168.5744                  | 3.81             | 0                    | 0.000               | 0.373737568                                           | 0.373737568                                     | 4.00      | 5890           |
| 38  | Marchand    | 13      | 6      | 2.7              | 10.7            | 2.51            | 4.26   | 1252.1251              | 4.5315954                  | 1822.0873                  | 4.96             | 0.0697               | 1.618               | 0.937245363                                           | 0.221080183                                     | 4.00      | 5890           |
| 39  | Marchand    | 14      | 6      | 2.4              | 10.7            | 2.23            | 4.80   | 1166.1528              | 40.321698                  | 1634.3654                  | 4.17             | 0                    | 0.000               | 0.310530497                                           | 0.310530497                                     | 4.00      | 5890           |
| 40  | Marchand    | 15      | 6      | 2.4              | 7.54            | 3.26            | 2.32   | 1166.1528              | 43.286243                  | 1671.0531                  | 4.32             | 0.302                | 5.980               | 0.307065264                                           | 0.128738672                                     | 4.00      | 5890           |



TABLE 18. SCALED SPALL DIAMETER, BREACH DIAMETER, AND LOAD RATE VERSUS SCALED RANGE  
(CONTINUED).

| Seq | Ref        | Test No | Rebar Spg<br>(Avg.) v<br>(in) | P<br>(per face) | Spall<br>Avg. Dia.<br>(in) | Spall<br>Depth<br>(in) | Breach<br>Avg. Dia.<br>(in) | Meas.<br>Peak<br>(psi) | Meas.<br>Duration<br>(ms) | Meas.<br>Spall Vel.<br>(ips) | Ds bar | Db bar | Adjusted<br>Sc. Range | I dot  |
|-----|------------|---------|-------------------------------|-----------------|----------------------------|------------------------|-----------------------------|------------------------|---------------------------|------------------------------|--------|--------|-----------------------|--------|
| 1   | McVay      | 1c      | 5.5                           | 0.0035          | 19.15                      | 2.5                    | 0                           | 1220                   | 0.15                      | 636                          | 30.75  | 0.00   | 0.0695808             | 87.67  |
| 2   | McVay      | 1d      | 5.5                           | 0.0035          | 14.35                      | 2.25                   | 0                           | --                     | --                        | 336                          | 2.37   | 0.00   | 0.6931483             | ERR    |
| 3   | McVay      | 2c      | 5.5                           | 0.0035          | 20.75                      | 2.25                   | 0                           | 1450                   | 0.14                      | 684                          | 33.32  | 0.00   | 0.054147              | 133.89 |
| 4   | McVay      | 2a      | 5.5                           | 0.0035          | 32.50                      | 8.5                    | 0                           | 7350                   | 0.135                     | 828                          | 5.38   | 0.00   | 0.6924708             | 5.31   |
| 5   | McVay      | 3b      | 5.5                           | 0.0035          | 19.20                      | 1.38                   | 0                           | 7350                   | 0.055                     | 468                          | 3.18   | 0.00   | 0.537171              | 6.84   |
| 6   | McVay      | 4b      | 5.5                           | 0.0035          | 16.50                      | 1.81                   | 0                           | 3500                   | 0.107                     | 528                          | 2.15   | 0.00   | 0.6763231             | 2.59   |
| 7   | McVay      | 5a      | 5.5                           | 0.0035          | 26.65                      | 3.75                   | 0                           | 23300                  | 0.045                     | --                           | 4.34   | 0.00   | 0.5389617             | 21.62  |
| 8   | McVay      | 5b      | 5.5                           | 0.0035          | 12.25                      | 1.06                   | 0                           | 5350                   | 0.046                     | 204                          | 1.60   | 0.00   | 0.6775479             | 3.95   |
| 9   | McVay      | 5c      | 5.5                           | 0.0035          | 21.50                      | 4.38                   | 0                           | 61000                  | 0.073                     | 1068                         | 34.53  | 0.00   | 0.054147              | 563.28 |
| 10  | McVay      | 6c      | 5.5                           | 0.0035          | 14.55                      | 3.75                   | 0                           | --                     | --                        | 528                          | 23.37  | 0.00   | 0.054147              | ERR    |
| 11  | McVay      | 7c      | 5.5                           | 0.0035          | 9.00                       | 2                      | 0                           | --                     | --                        | 420                          | 14.45  | 0.00   | 0.054147              | ERR    |
| 12  | McVay      | 8c      | 4.3125                        | 0.0035          | --                         | --                     | 7.44                        | --                     | --                        | 780                          | 0.00   | 1.53   | 0.4560419             | ERR    |
| 13  | McVay      | 10a     | 1.375                         | 0.0035          | 6.50                       | 1.25                   | 0                           | 14800                  | 0.135                     | 444                          | 0.85   | 0.00   | 0.6763231             | 10.94  |
| 14  | McVay      | 10c     | 1.375                         | 0.0035          | 13.25                      | 0.62                   | 0                           | 32920                  | 0.152                     | 840                          | 21.28  | 0.00   | 0.054147              | 303.99 |
| 15  | McVay      | Bur-2   | 8                             | 0.0157          | 8.50                       | 2.5                    | 0                           | --                     | --                        | --                           | 0.84   | 0.00   | 0.8955176             | ERR    |
| 16  | McVay      | Bur-3   | 8                             | 0.0157          | 18.00                      | 3                      | 0                           | --                     | --                        | --                           | 1.77   | 0.00   | 0.4582639             | ERR    |
| 17  | McVay      | Bur-5   | 8                             | 0.0157          | 27.50                      | 3.75                   | 0                           | --                     | --                        | --                           | 3.44   | 0.00   | 0.5287179             | ERR    |
| 18  | McVay      | Bur-6   | 8                             | 0.0157          | 35.00                      | 3.25                   | 0                           | --                     | --                        | --                           | 4.37   | 0.00   | 0.3273476             | ERR    |
| 19  | McVay      | Bur-7   | 8                             | 0.0157          | 31.50                      | 3                      | 0                           | --                     | --                        | --                           | 3.56   | 0.00   | 0.7547584             | ERR    |
| 20  | McVay      | Bur-7   | 8                             | 0.0157          | 30.00                      | 3                      | 0                           | --                     | --                        | --                           | 2.67   | 0.00   | 0.5813385             | ERR    |
| 21  | Ball       |         | 11.875                        | 0.00372         | 17.40                      | 2.4                    | 0                           | --                     | --                        | --                           | 21.48  | 0.00   | 0.135                 | ERR    |
| 22  | Ball       |         | 11.875                        | 0.00372         | --                         | --                     | 18.36                       | --                     | --                        | --                           | 0.00   | 22.68  | 0.1345291             | ERR    |
| 23  | Ball       |         | 11.875                        | 0.00372         | --                         | --                     | 26.4                        | --                     | --                        | --                           | 0.00   | 32.49  | 0.1354415             | ERR    |
| 24  | Ball       |         | 11.875                        | 0.0066          | --                         | --                     | --                          | --                     | --                        | --                           | 0.00   | 35.06  | 0.1369269             | ERR    |
| 25  | Ball       |         | 11.875                        | 0.0066          | 10.20                      | 5.76                   | 0                           | --                     | --                        | --                           | 7.53   | 0.00   | 0.1354415             | ERR    |
| 26  | Ball       |         | 11.875                        | 0.0066          | --                         | --                     | 38.28                       | --                     | --                        | --                           | 0.00   | 27.96  | 0.1369269             | ERR    |
| 27  | Ball       |         | 11.875                        | 0.0066          | --                         | --                     | 42.72                       | --                     | --                        | --                           | 0.00   | 31.66  | 0.1349291             | ERR    |
| 28  | Ball       |         | 11.875                        | 0.0066          | --                         | --                     | 47.52                       | --                     | --                        | --                           | 0.00   | 34.96  | 0.1359226             | ERR    |
| 29  | Ball       |         | 11.375                        | 0.00693         | --                         | --                     | 68.28                       | --                     | --                        | --                           | 0.00   | 25.15  | 0.1357209             | ERR    |
| 30  | Colbarr    | 1       | 12                            | 0.0018          | --                         | --                     | 28                          | --                     | --                        | --                           | ERR    | ERR    | ERR                   | ERR    |
| 31  | Colbarr    | 2       | 12                            | 0.005           | --                         | --                     | 26                          | --                     | --                        | --                           | ERR    | ERR    | ERR                   | ERR    |
| 32  | Kroyischek | 1       | --                            | 0.00166         | --                         | --                     | 42.35                       | --                     | --                        | --                           | 0.00   | 2.85   | 0.754729              | ERR    |
| 33  | Kroyischek | 2       | --                            | 0.00166         | 25.60                      | 6.7                    | 0                           | --                     | --                        | --                           | 0.00   | 0.00   | 0.5950495             | ERR    |
| 34  | Marchand   | 9       | 3                             | 0.004           | --                         | --                     | 17                          | --                     | --                        | --                           | 0.00   | 11.84  | 0.2210802             | ERR    |
| 35  | Marchand   | 10      | 3                             | 0.004           | --                         | --                     | 10.5                        | --                     | --                        | 840                          | 0.00   | 7.03   | 0.3105305             | ERR    |
| 36  | Marchand   | 11      | 3                             | 0.004           | --                         | --                     | 20                          | --                     | --                        | 912                          | 0.00   | 13.39  | 0.1287387             | ERR    |
| 37  | Marchand   | 12      | 3                             | 0.004           | --                         | --                     | 11                          | --                     | --                        | 840                          | 0.00   | 6.64   | 0.373757              | ERR    |
| 38  | Marchand   | 13      | 1.5                           | 0.0182          | --                         | --                     | 19.5                        | 34467                  | 0.015                     | 720                          | 0.00   | 13.58  | 0.2210802             | 77.95  |
| 39  | Marchand   | 14      | 1.5                           | 0.0182          | --                         | --                     | 12                          | 7250                   | 0.06                      | 624                          | 0.00   | 8.03   | 0.3105305             | 11.67  |
| 40  | Marchand   | 15      | 1.5                           | 0.0182          | --                         | --                     | 26                          | --                     | --                        | 912                          | 0.00   | 17.41  | 0.1287387             | ERR    |

TABLE 19. COMPARISONS BETWEEN REICON CODE PREDICTIONS AND TEST MEASUREMENTS FOR PANEL TESTS 9 - 20.

| Test | Charge Weight | Panel Type | Predicted Breach <sup>1</sup><br>(inches) | Actual Breach <sup>2</sup><br>(inches) | Predicted Rotation<br>(inches) | Actual Rotation<br>(inches) |
|------|---------------|------------|-------------------------------------------|----------------------------------------|--------------------------------|-----------------------------|
| 9    | 2.7           | A          | 21.5                                      | 17.0                                   | 9.69                           | 5.75                        |
| 11   | 2.4           | A          | 19.0                                      | 20.0                                   | 7.38                           | 5.25                        |
| 13   | 2.7           | B          | 13.4                                      | 19.5                                   | 2.56                           | 1.75                        |
| 15   | 2.4           | B          | 8.6                                       | 26.0                                   | 1.94                           | 1.75                        |
| 17   | 2.7           | C          | 7.2                                       | 0.0                                    | 1.54                           | 0.75                        |
| 19   | 2.4           | C          | 0.0                                       | 10.0                                   | 1.17                           | 0.88                        |

Notes:

- 1) Circular breach
- 2) Average of horizontal and vertical diameters measured

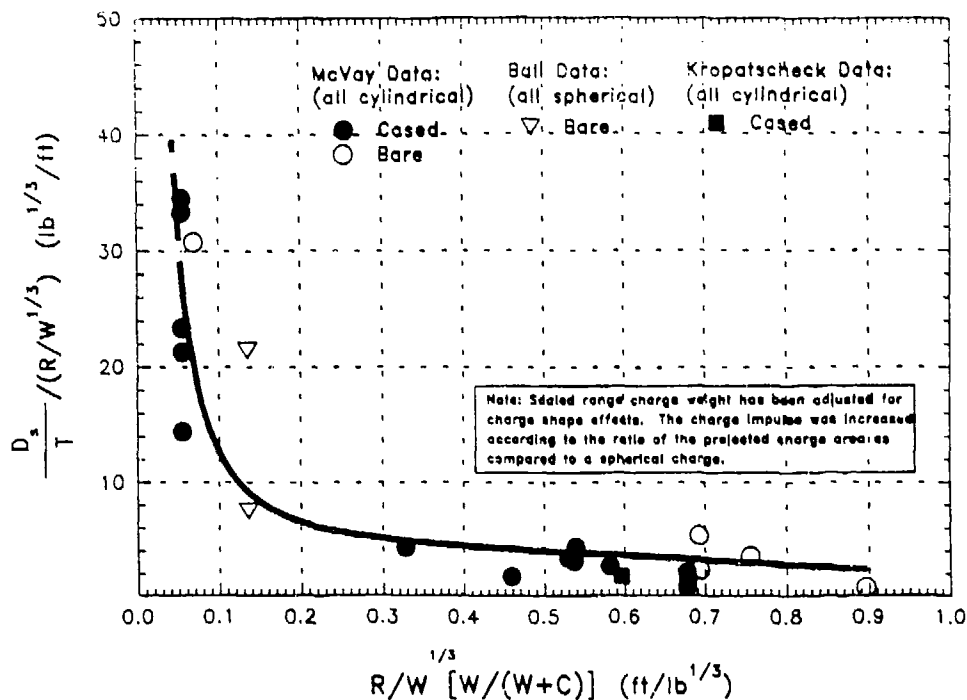


Figure 93. Scaled Spall Diameter versus Scaled Range.

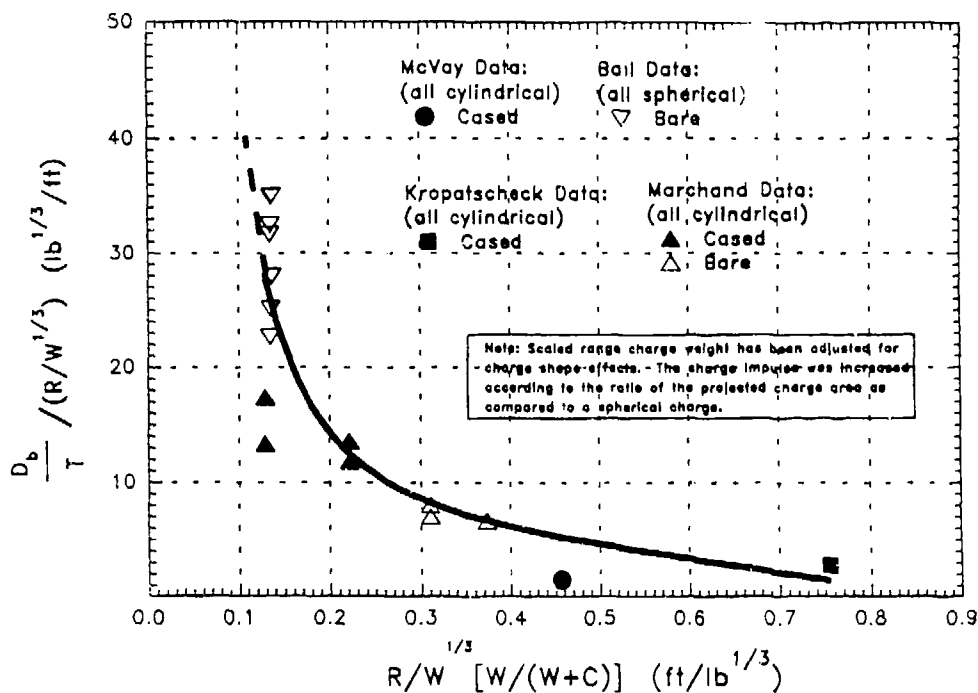


Figure 94. Scaled Breach Diameter versus Scaled Range.

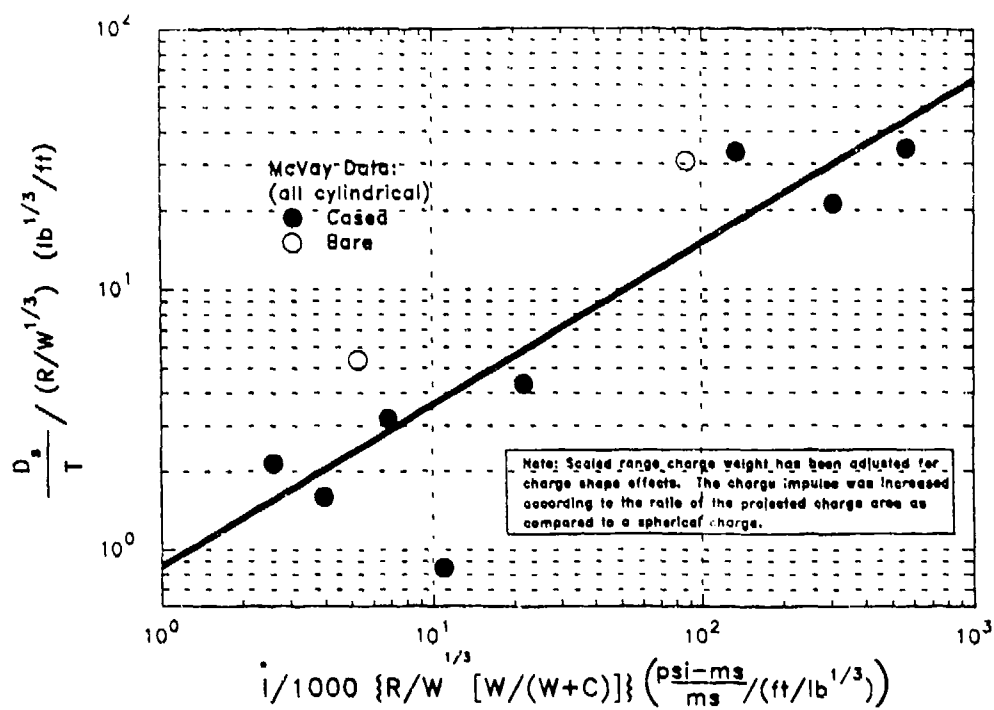


Figure 95. Scaled Spall Diameter versus Load Rate.

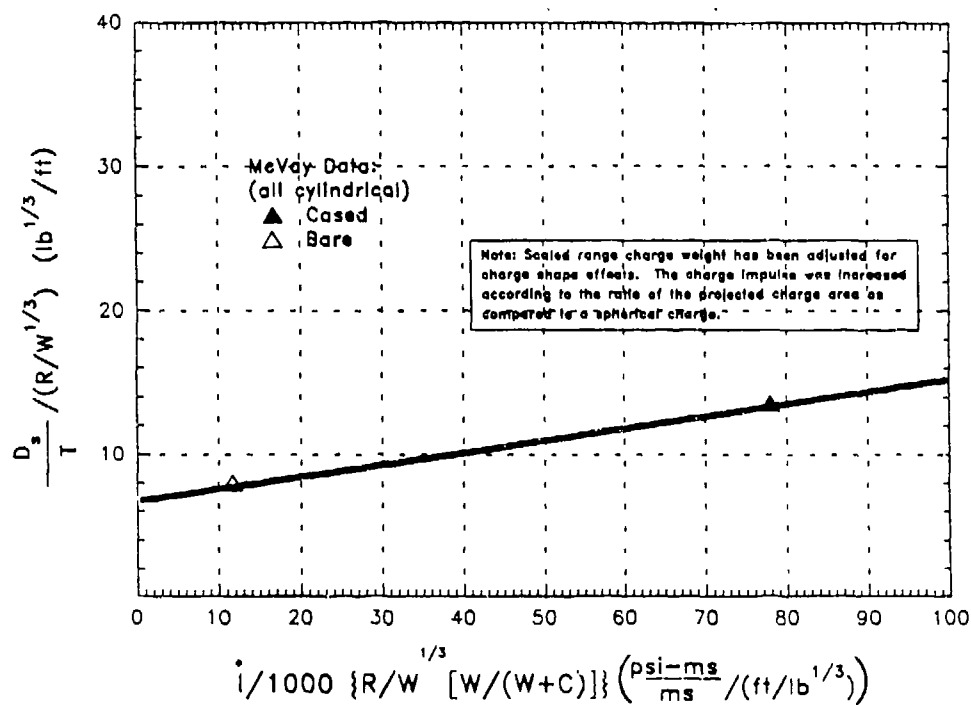


Figure 96. Scaled Breach Diameter versus Load Rate.

## SECTION V

### CONCLUSIONS AND RECOMMENDATIONS

#### A. CONCLUSIONS

This report has documented the Phase I procedures used and tests conducted in support of the overall study concerning the synergism observed between blast and fragments for close in bomb loadings on common construction materials.

The results reported in the previous sections serve well to indicate the validity of the synergism in the described loadings. Increases in panel damage were observed, and loads were quantified and measured on the exterior and inside the tested structures to define the fragment effects. Increases in stresses internal to the panels were shown to be up to four times those observed for bare explosive charges.

Specifically, the tests conducted on the three types of wall construction using the cased charges and the equivalent bare charges demonstrated that the combination of the fragment impact loads and the blast pressure loads associated with the detonation of a cased charge were a more severe environment than that created by the blast loads from an equivalent bare charge. In all of the tests conducted on the reinforced concrete panels, the cased charges created larger breaches in the panels than did any of the corresponding equivalent bare charges. The cased charge tests also generated concrete debris traveling at higher velocities than did the debris created by the equivalent bare charges. The initial shapes of the failed material was also different for the two charges.

The important comparison that can be made is between the measured stresses generated by the lightly cased, heavily cased and bare equivalent charges. It can be seen from TABLE 20 that the heavily cased charges (2.4-pound cased) in tests 15 and 19 produced significantly higher interior stresses than the lightly cased test (2.7-pound cased, test 13) by a factor of 1.7 in the Type B panel. Additionally, the heavily cased charge produced stresses 4 times higher than the equivalent bare charge for Type B. In the SIFCON panels (Type C) the stresses are much higher due to the increased density and impedance. CG2 in the SIFCON shows an increase of 4.5 times over the equivalent bare charge. It is important to note that these comparisons are being made for charges of equivalent impulse, not simply equivalent explosive weight. The fragment impulse is being accounted for in the bare charge equivalent weight.

TABLE 20. PIEZORESISTIVE SHOCK PRESSURE CARBON GAGE (CG) DATA.

| Gage Location<br>(App. C Location) | Pressures (psi)     |                     |                                   |                     |                                   |                     |
|------------------------------------|---------------------|---------------------|-----------------------------------|---------------------|-----------------------------------|---------------------|
|                                    | Test 13<br>(B/2.7C) | Test 14<br>(B/2.4E) | Test 15<br>(B/2.4C)<br>(2nd Peak) | Test 16<br>(B/2.8E) | Test 19<br>(C/2.4C)<br>(2nd Peak) | Test 20<br>(C/2.8E) |
| CG1:<br>(11)                       | 34467               | 7250                | 58000                             | 14000               | >100000                           | >100000             |
| CG2:<br>(9)                        | 33495               | 4133                | 43500                             | 8200                | 68000<br>(22000)                  | 14500               |
| CG3:<br>(12)                       | 32973               | 4688                | (6000)                            | 4592                | 18000                             | 9650                |
| CG4:<br>(10)                       | 35054               | 3432                | 15000<br>(7500)                   | No Data             | 7000<br>(3000)                    | 3000                |

Note: (B/2.7C) = Wall Type B/2.7-pound Cased Charge  
 (B/2.4E) = Wall Type B/2.4-pound Equivalent Bare Charge  
 (B/2.4C) = Wall Type B/2.4-pound Cased Charge  
 (B/2.8E) = Wall Type B/2.8-pound Equivalent Bare Charge  
 (C/2.4C) = Wall Type C/2.4-pound Cased Charge  
 (C/2.8E) = Wall Type C/2.8-pound Equivalent Bare Charge

## B. RECOMMENDATIONS

Future work in the definition of the synergism in blast and fragment loadings should include a second phase of laboratory testing and some additional analysis as well as some effort to integrate the information derived from research and testing into design guidance for protective construction. These phases should be conducted as follows:

### PHASE II:

- (1) *Laboratory tests and numerical analysis to define fragment and blast shock front interaction and material failure in a loaded specimen. These tests would consist of gun launching fragments into instrumented construction targets. Measured stresses would indicate the extent to which the stress pulses from blast and impact coalesce. They would be assessed with blast by simultaneously detonating a sheet of high explosive to create a simulated concurrent blast pulse.*

would be assessed with blast by simultaneously detonating a sheet of high explosive to create a simulated concurrent blast pulse.

- (2) *Characterization of response mode change with respect to standoff based on fragment density and shock intensity calculations. It will be essential to define the standoffs at which synergism or blast fragment interaction for stress wave generation can be expected. These tests can be conducted subscale with modelled bombs and targets.*

PHASE III:

- (1) *Analytic model development/refinement to allow the prediction and definition of synergistic effects, response modes, and response magnitude*
- (2) *Selection of optimum materials and structural configurations for combined blast and fragment loading scenarios*

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## APPENDIX A

### Test Data from Bare Charge Loads Tests

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 1 LOC= 1 TEST=001

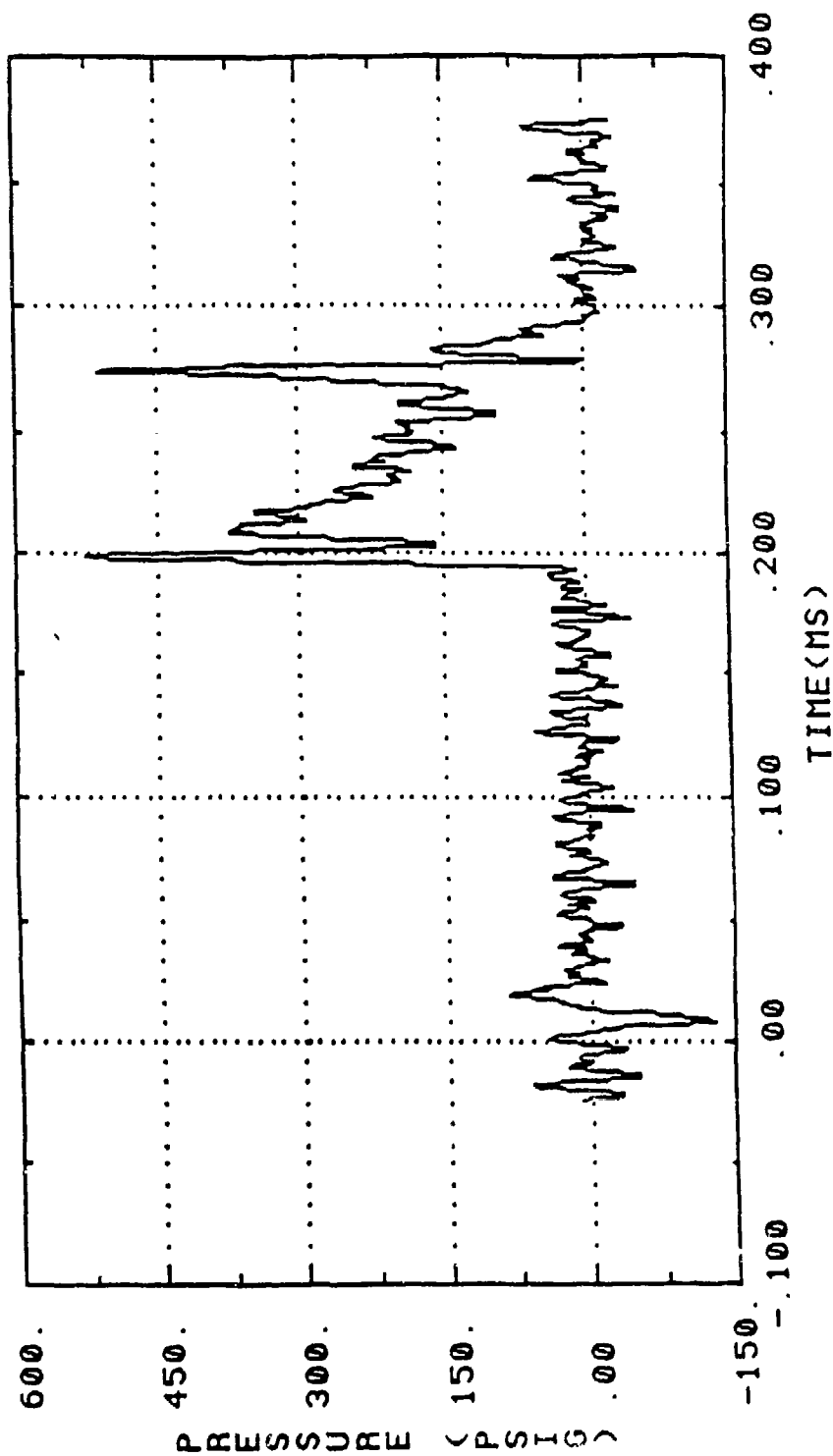


Figure A-1. Loads Test Data, Test 1, LOC 1.

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 2 LOC= 2 TEST=001

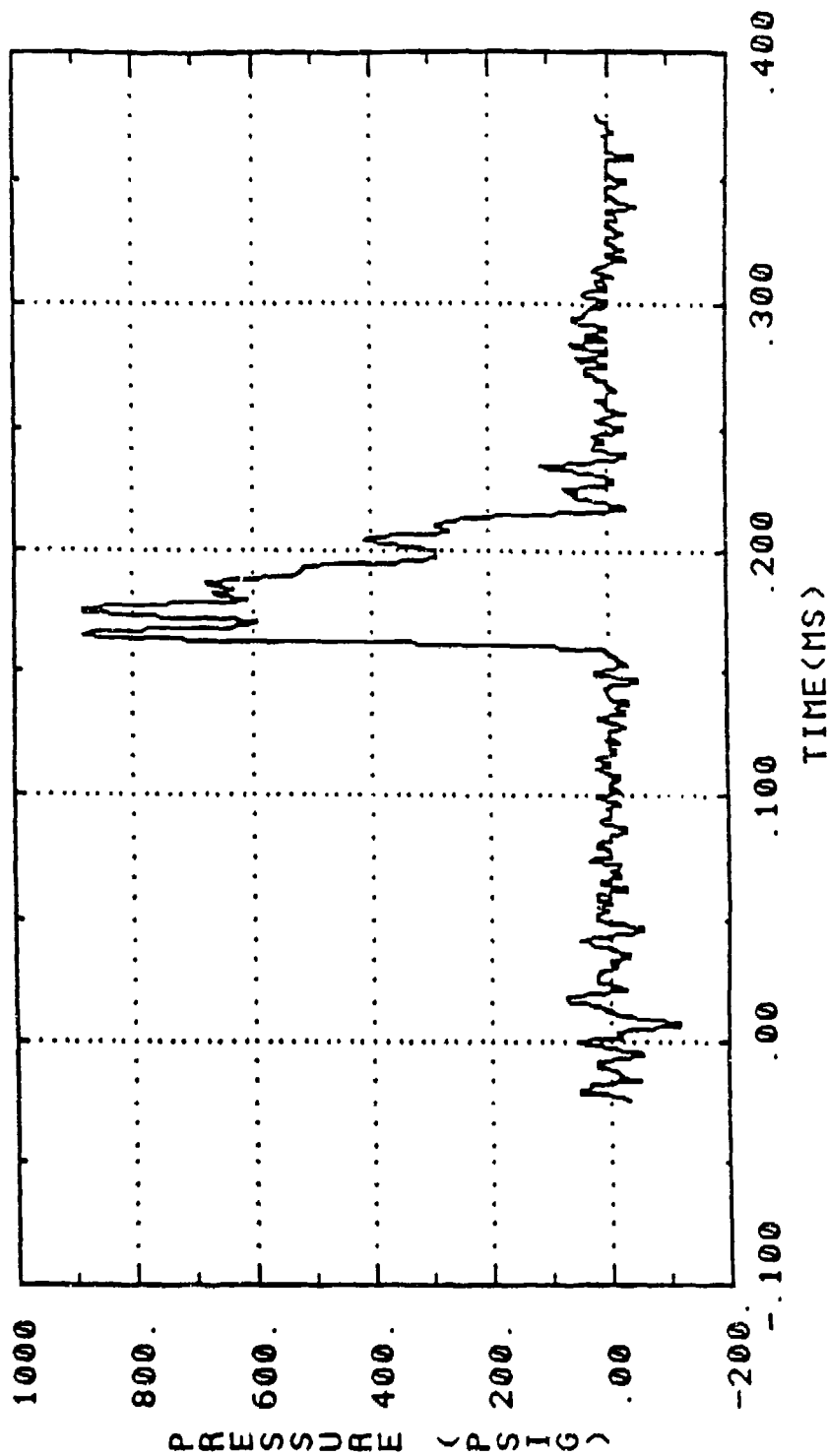


Figure A-2. Loads Test Data, Test 1, LOC 2.

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 3 LOC= 3 TEST=001

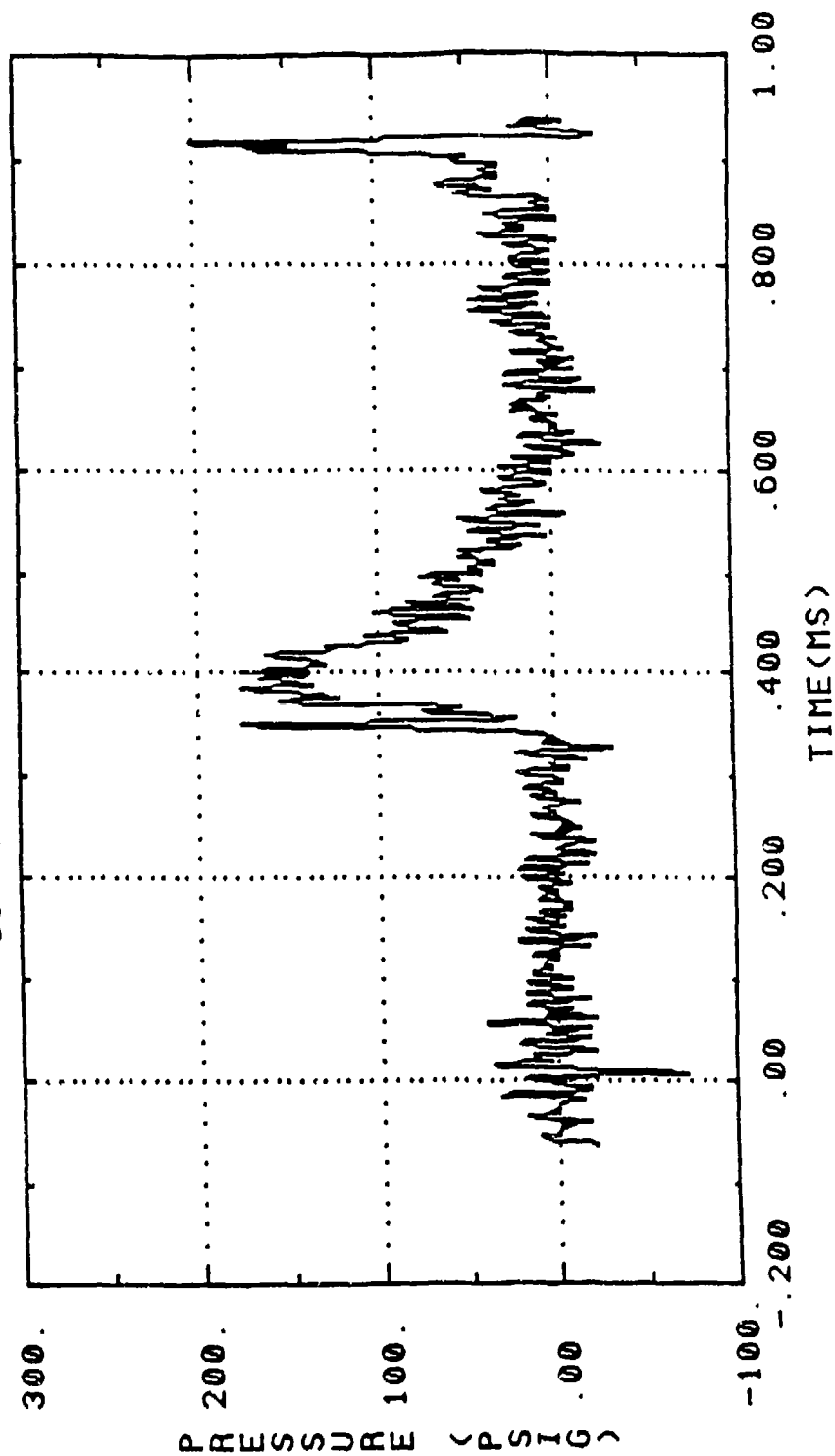


Figure A-3. Loads Test Data, Test 1, LOC 3.

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 4 LOC= 4 TEST=001

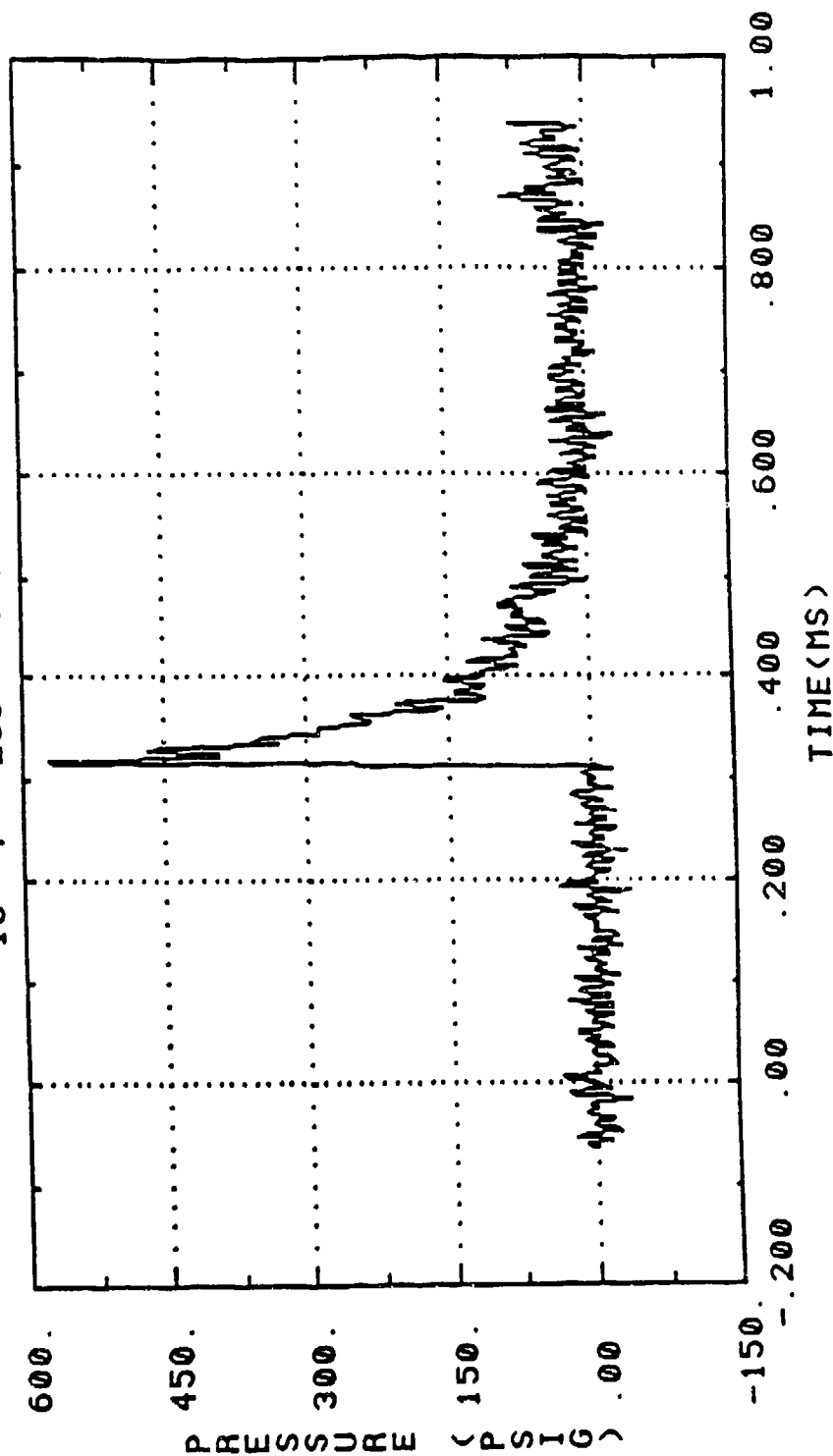


Figure A-4. Loads Test Data, Test 1, LOC 4.

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 7 LOC= 6 TEST=001

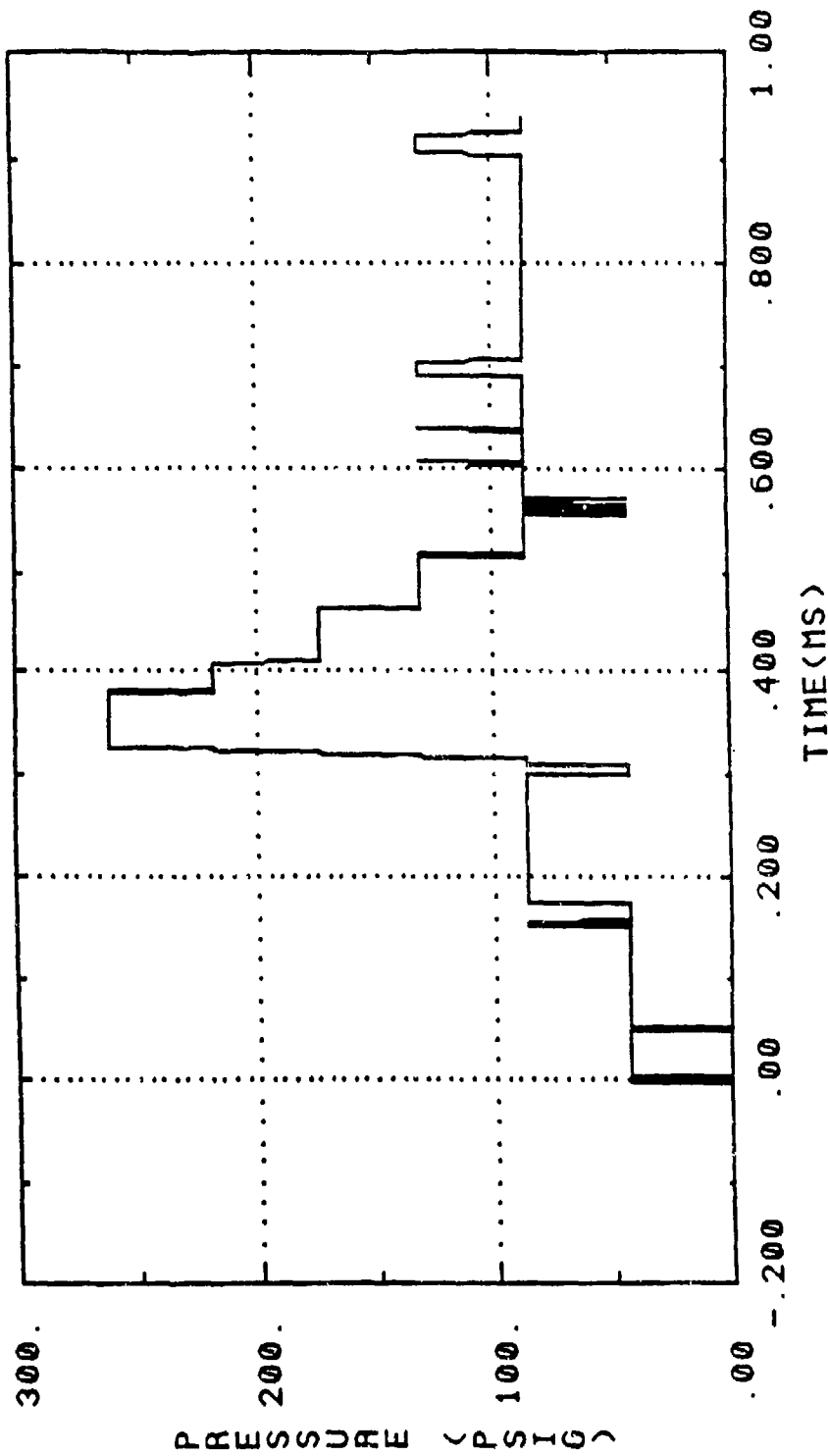


Figure A-5. Loads Test Data, Test 1, LOC 6.

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 8 LOC= 7 TEST=001

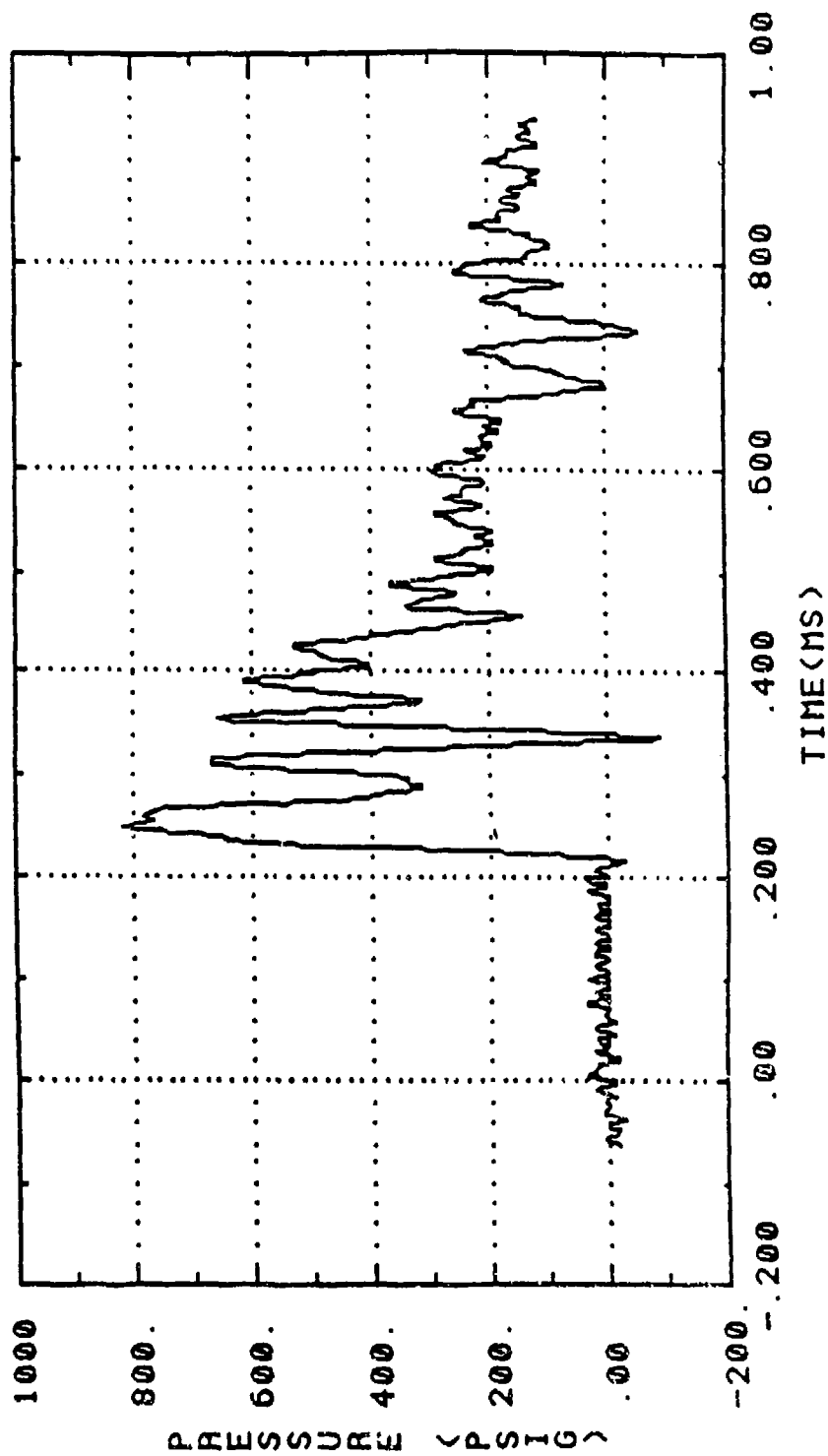


Figure A-6. Loads Test Data, Test 1, LOC 7.



\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 5 LOC= 8 TEST=001

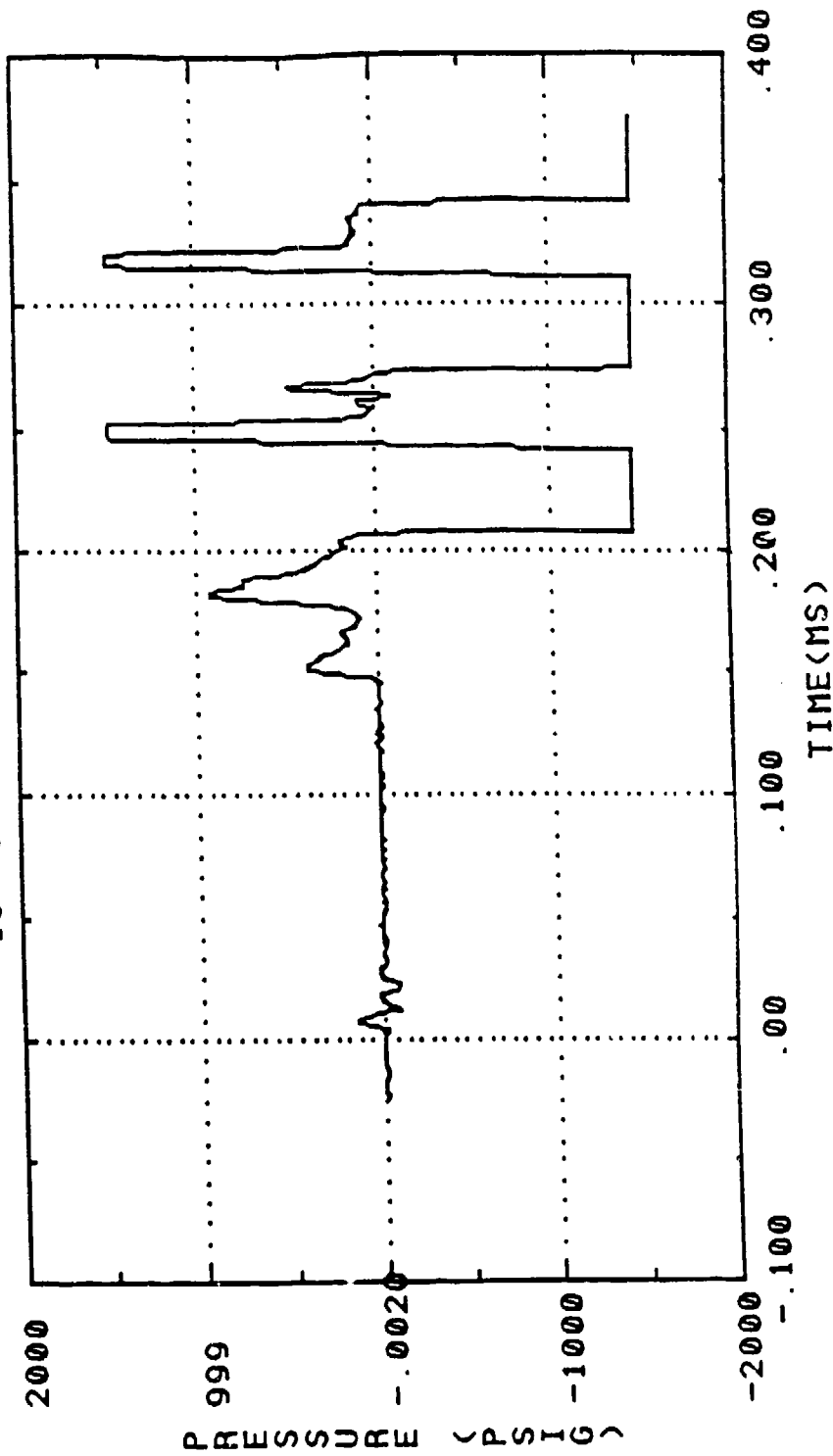


Figure A-7. Loads Test Data, Test 1, LOC 8.

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 5 LOC= 8 TEST=001

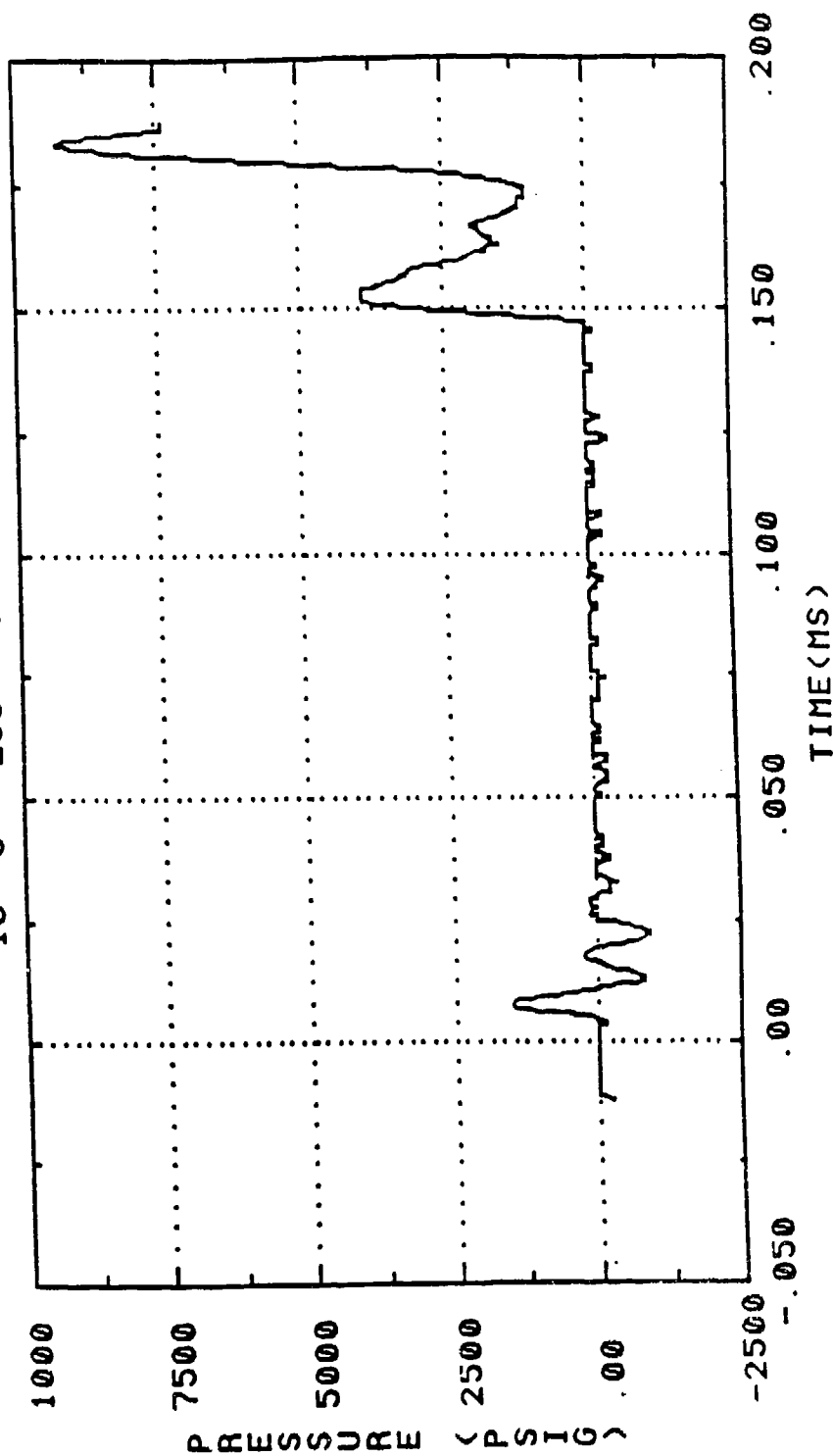


Figure A-8. Loads Test Data, Test 1, LOC 8.

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 9 LOC= 9 TEST=001

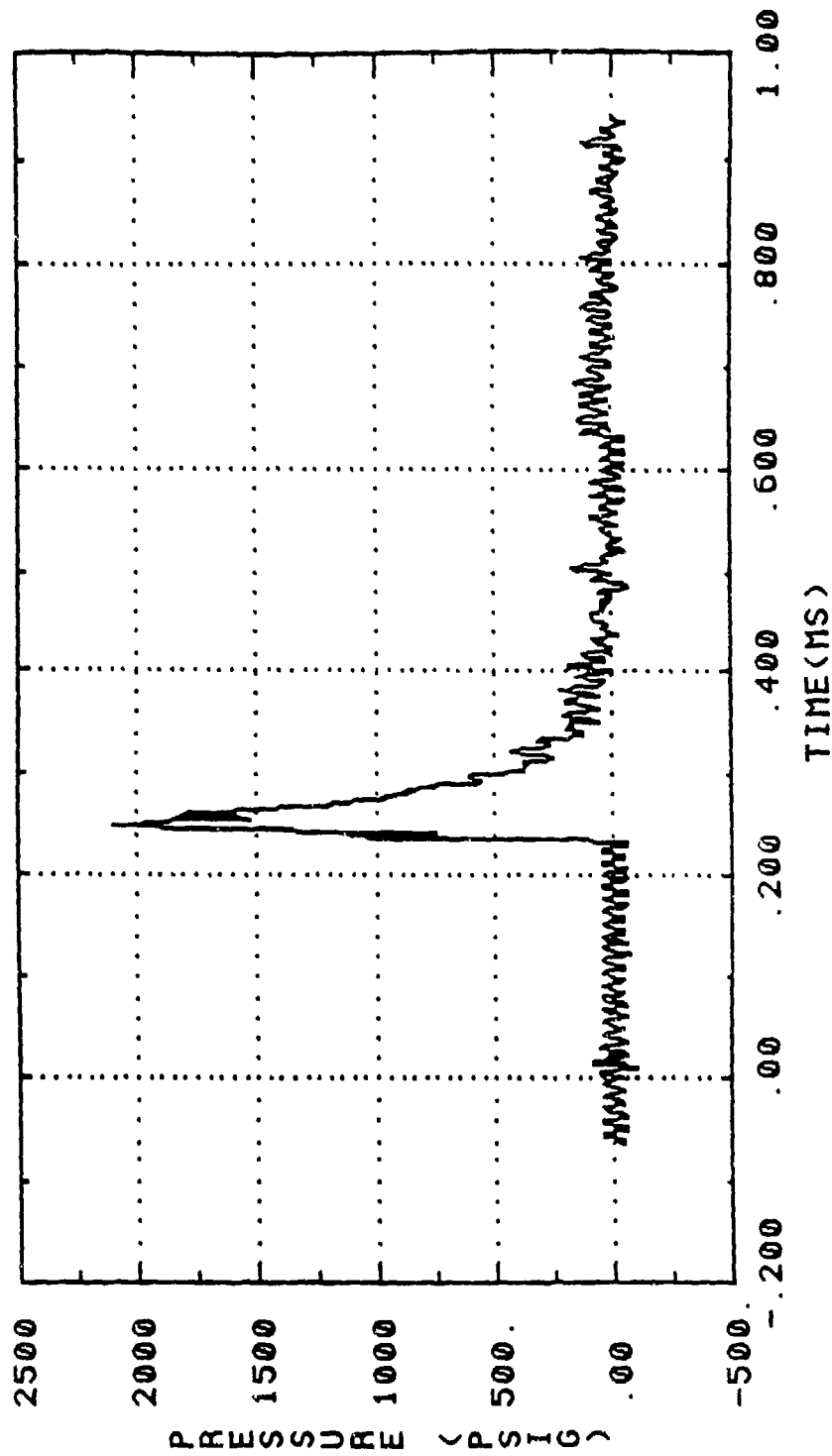


Figure A-9. Loads Test Data, "Test 1, LOC 9.

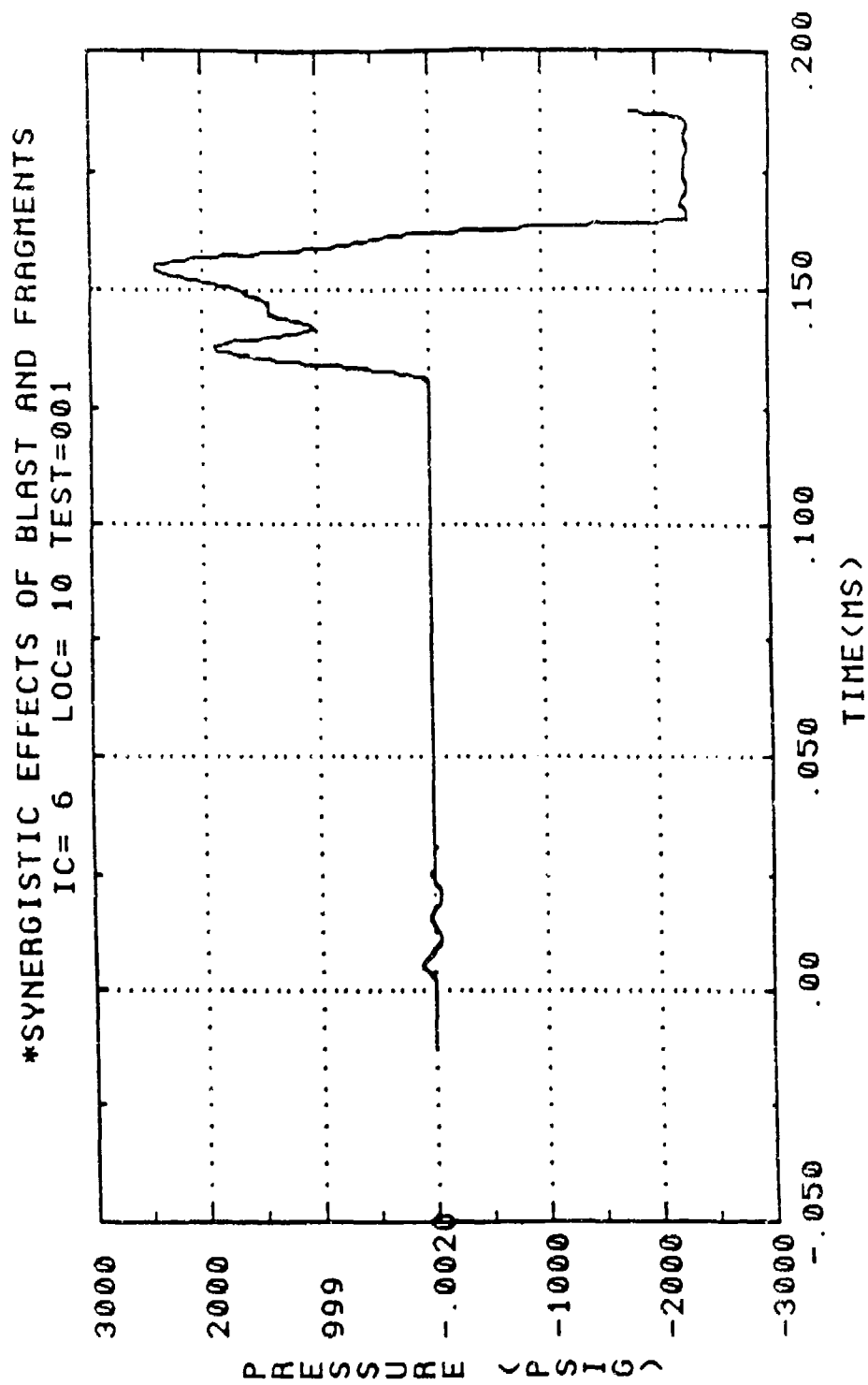


Figure A-10. Loads Test Data, Test 1, LOC 10.

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 1 LOC= 1 TEST=002

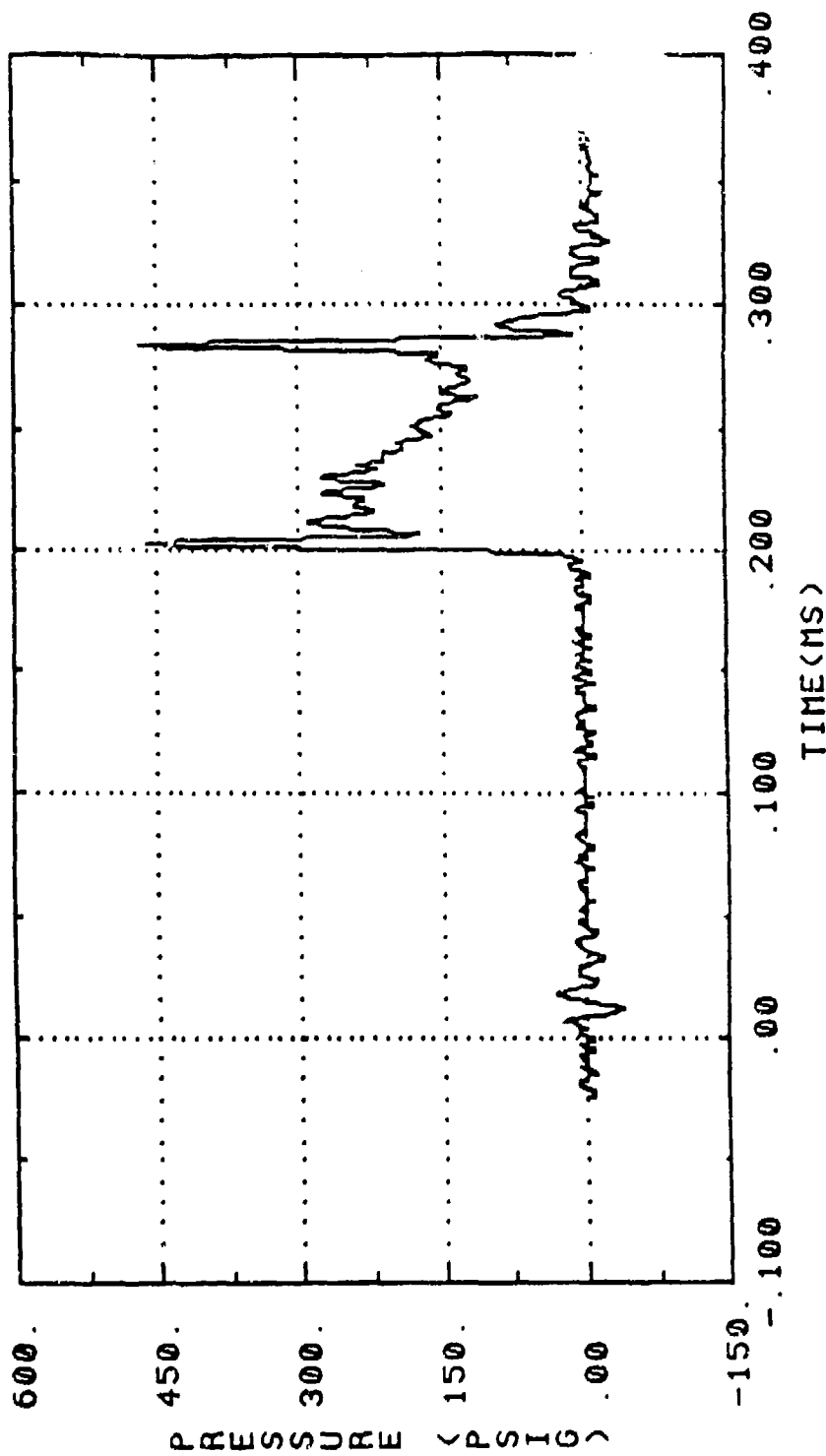


Figure A-11. Loads Test Data, Test 2, LOC 1

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 2 LOC= 2 TEST=002

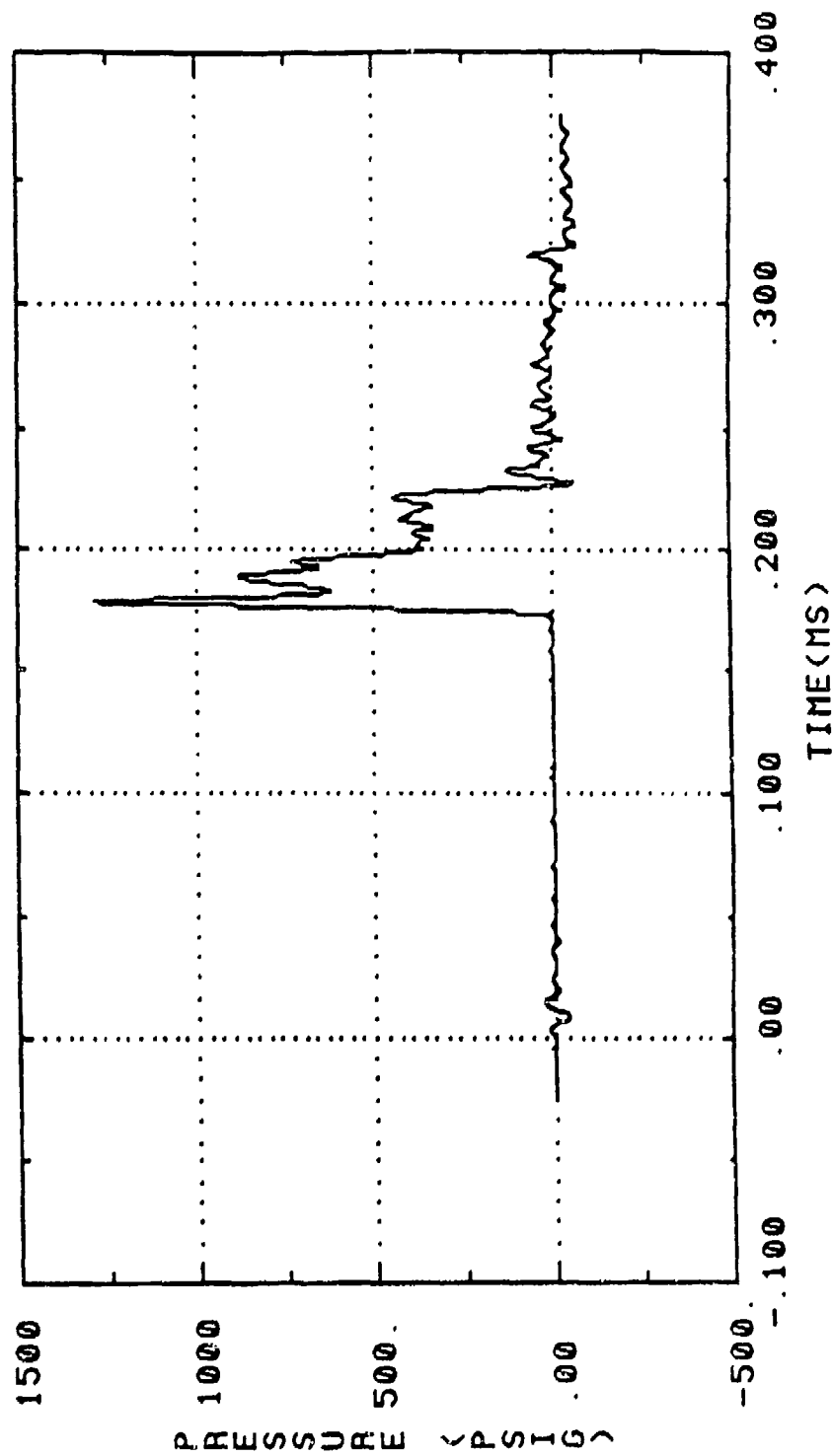


Figure A-12. Loads Test Data, "Test 2, LOC 2

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 3 LOC= 3 TEST=002

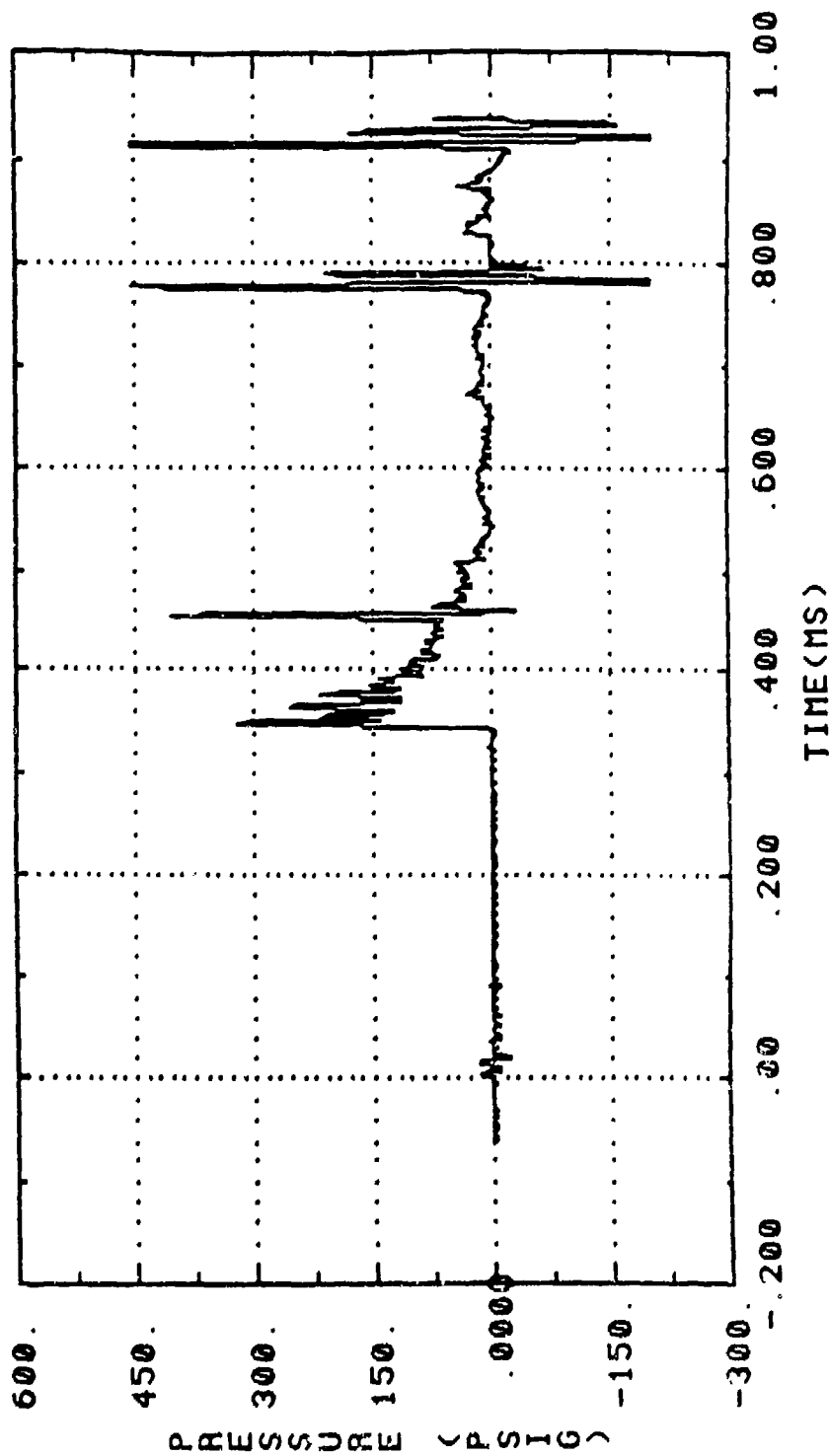


Figure A-13. Loads Test Data, Test 2, LOC 3

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 4 LOC= 4 TEST=002

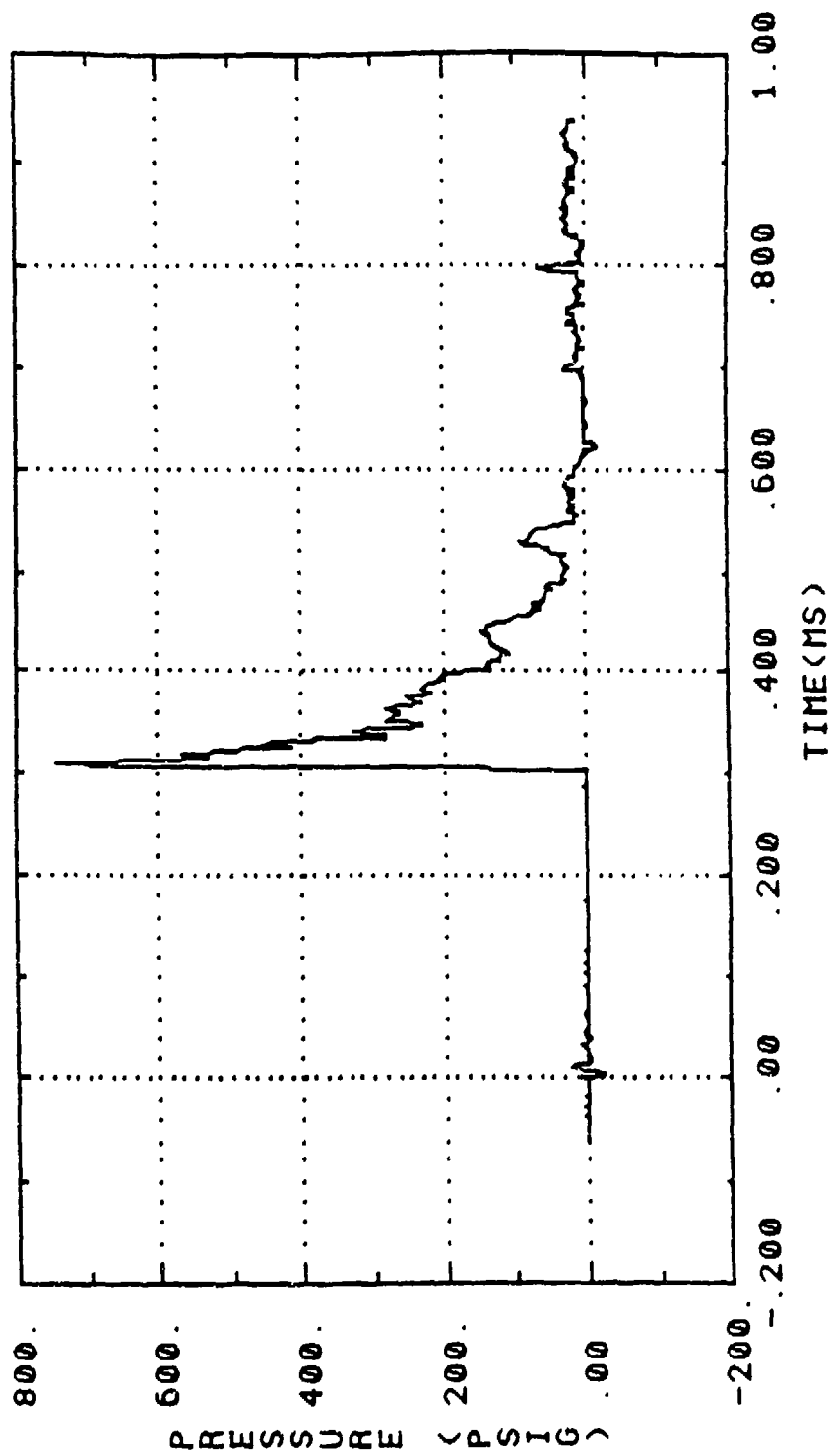


Figure A-14. Loads Test Data, Test 2, LOC 4



\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 5 LOC= 8 TEST=002

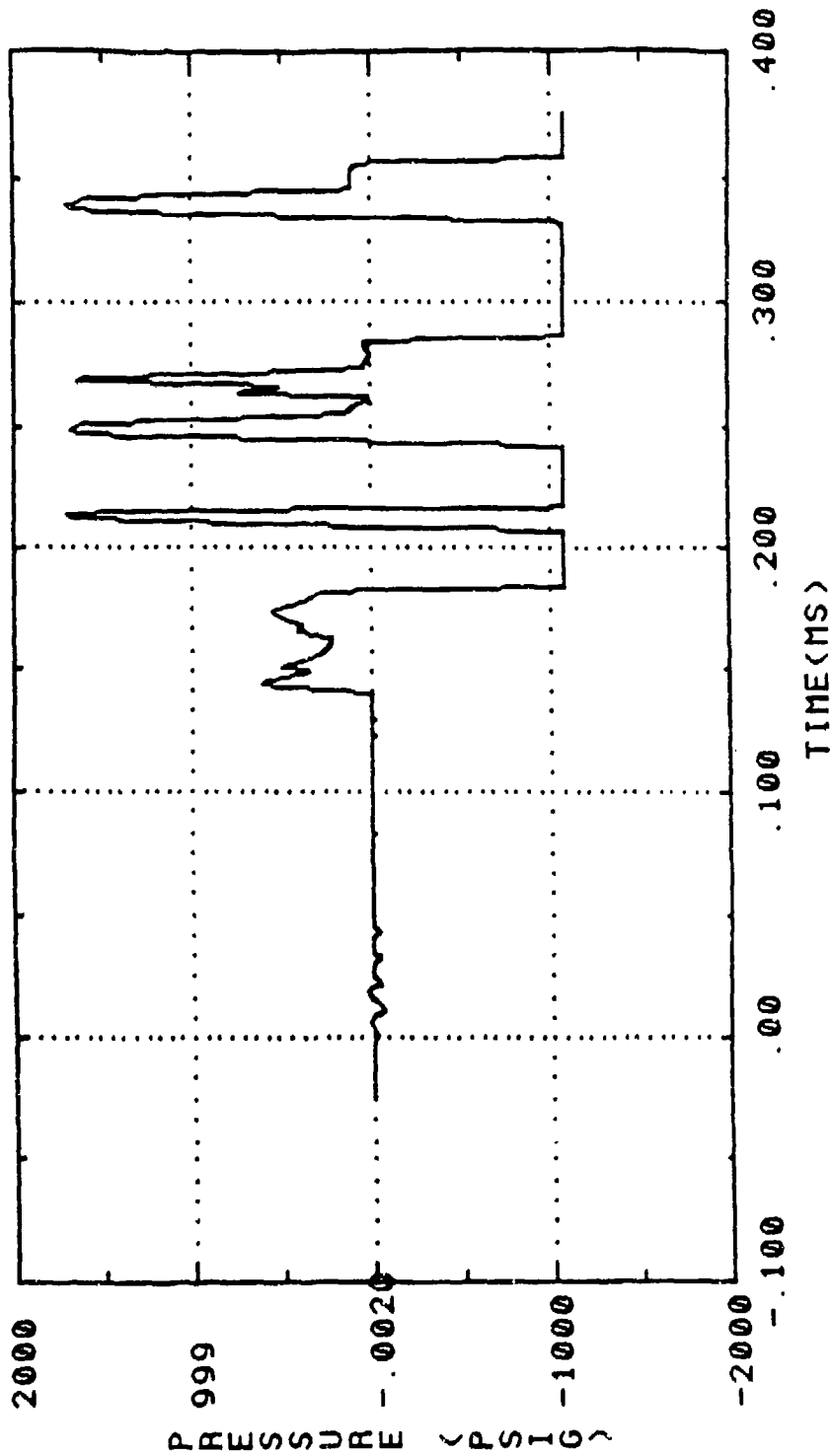


Figure A-15. Loads Test Data, Test 2, LOC 8

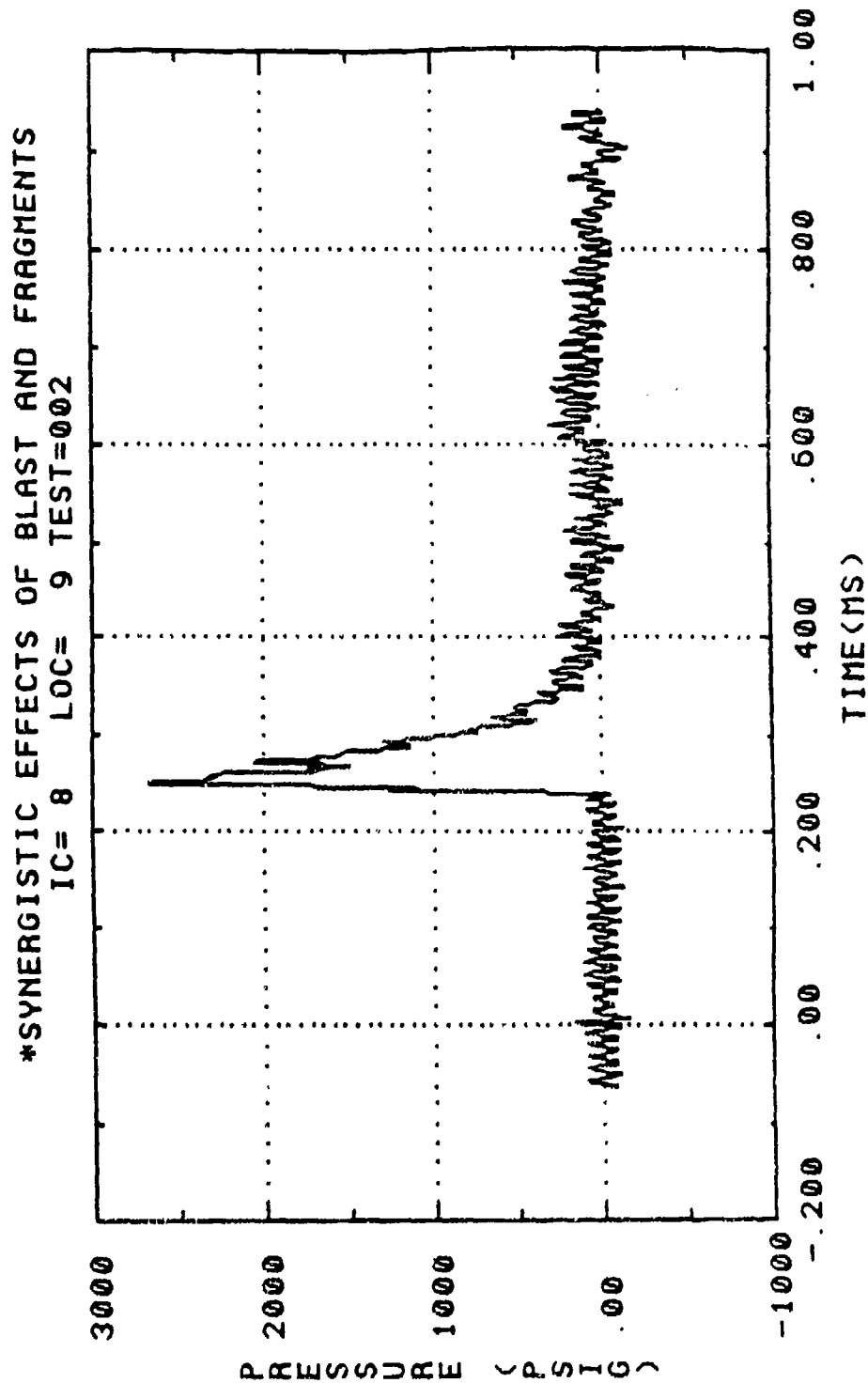


Figure A-16. Loads Test Data, Test 2, LOC 9

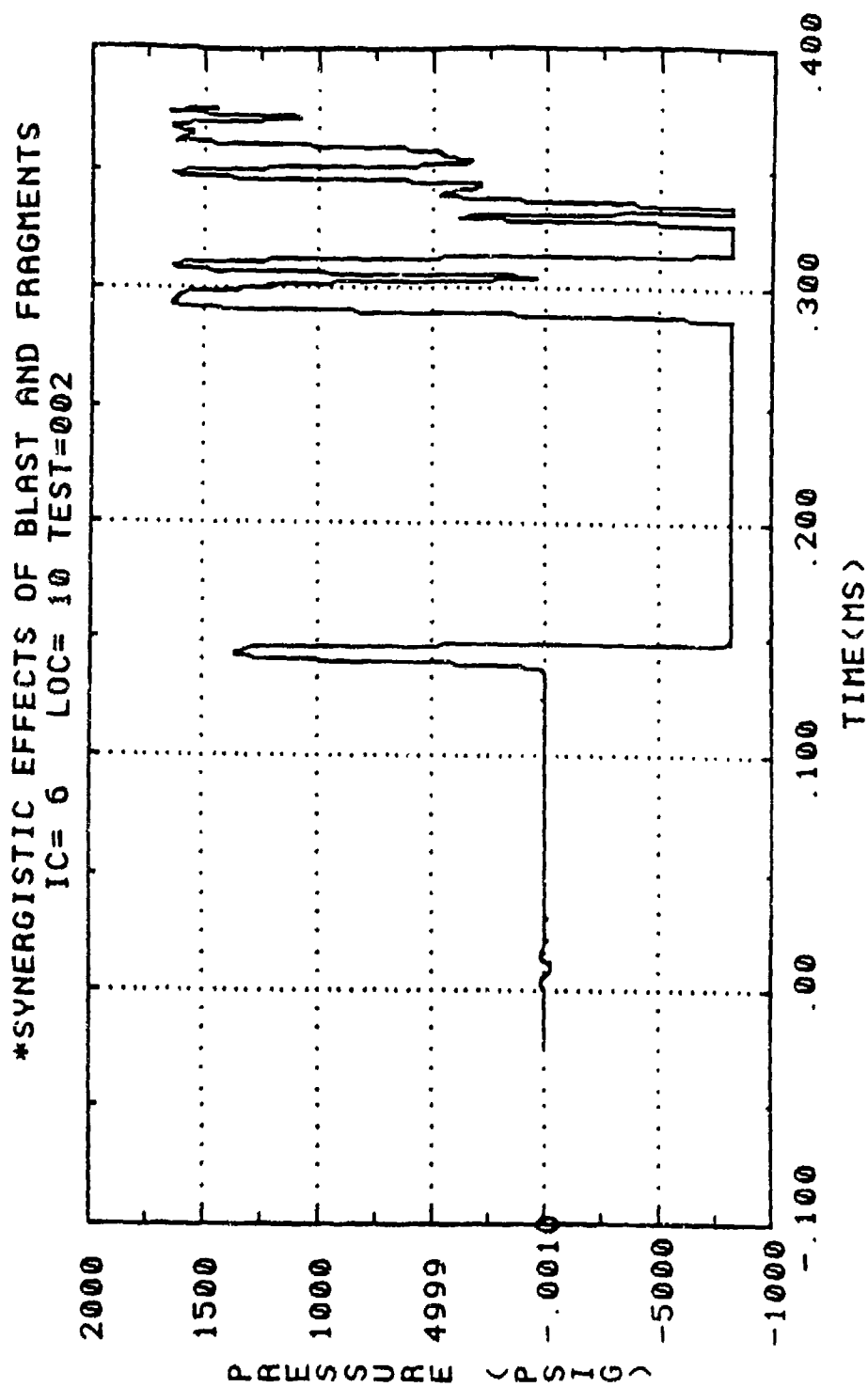


Figure A-17. Loads Test Data, Test 2, LOC 10

SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 9 LOC= 11 TEST=002

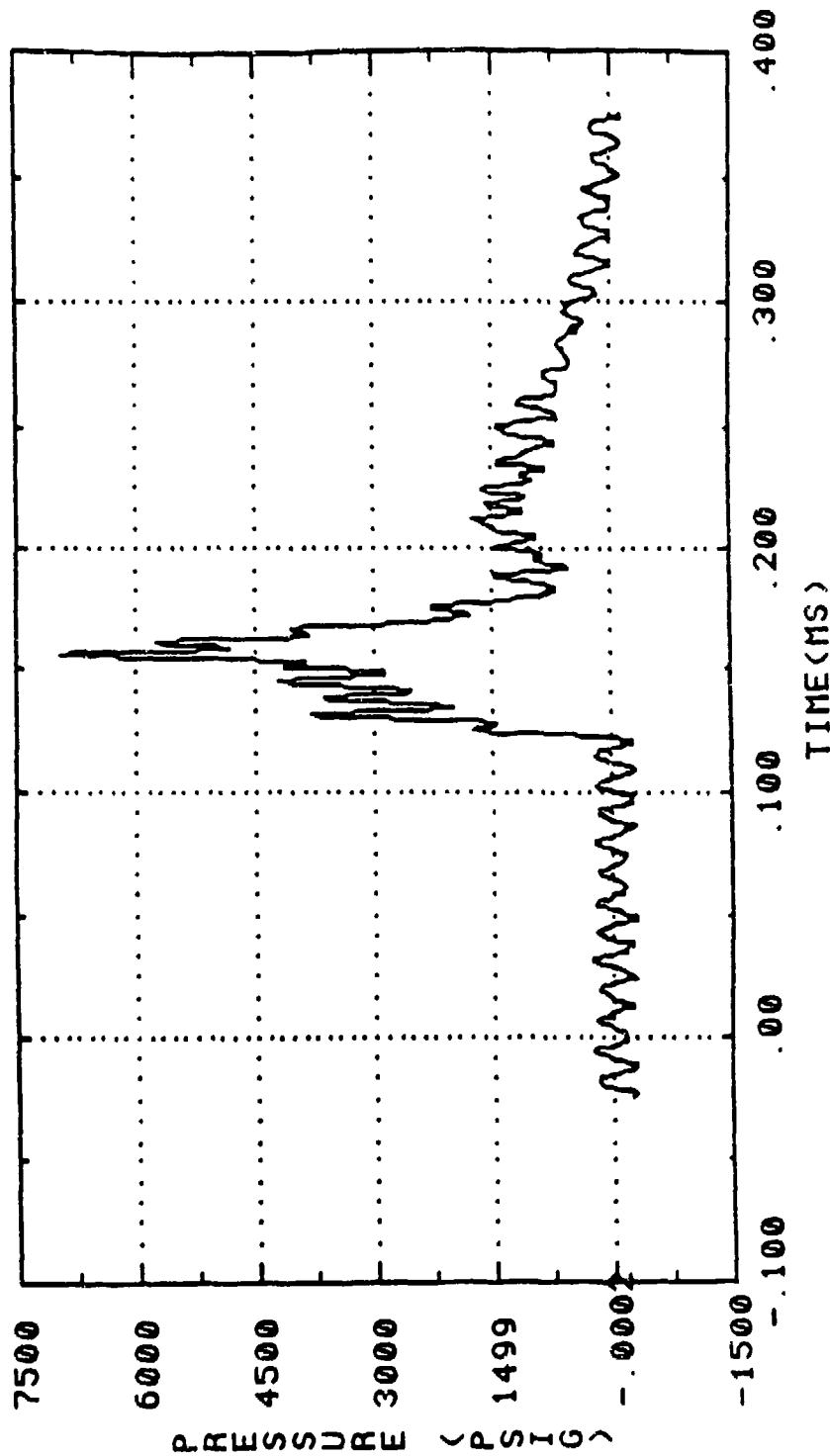


Figure A-18. Loads Test Data, "Test 2, LOC 11

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC=10 LOC= 12 TEST=002

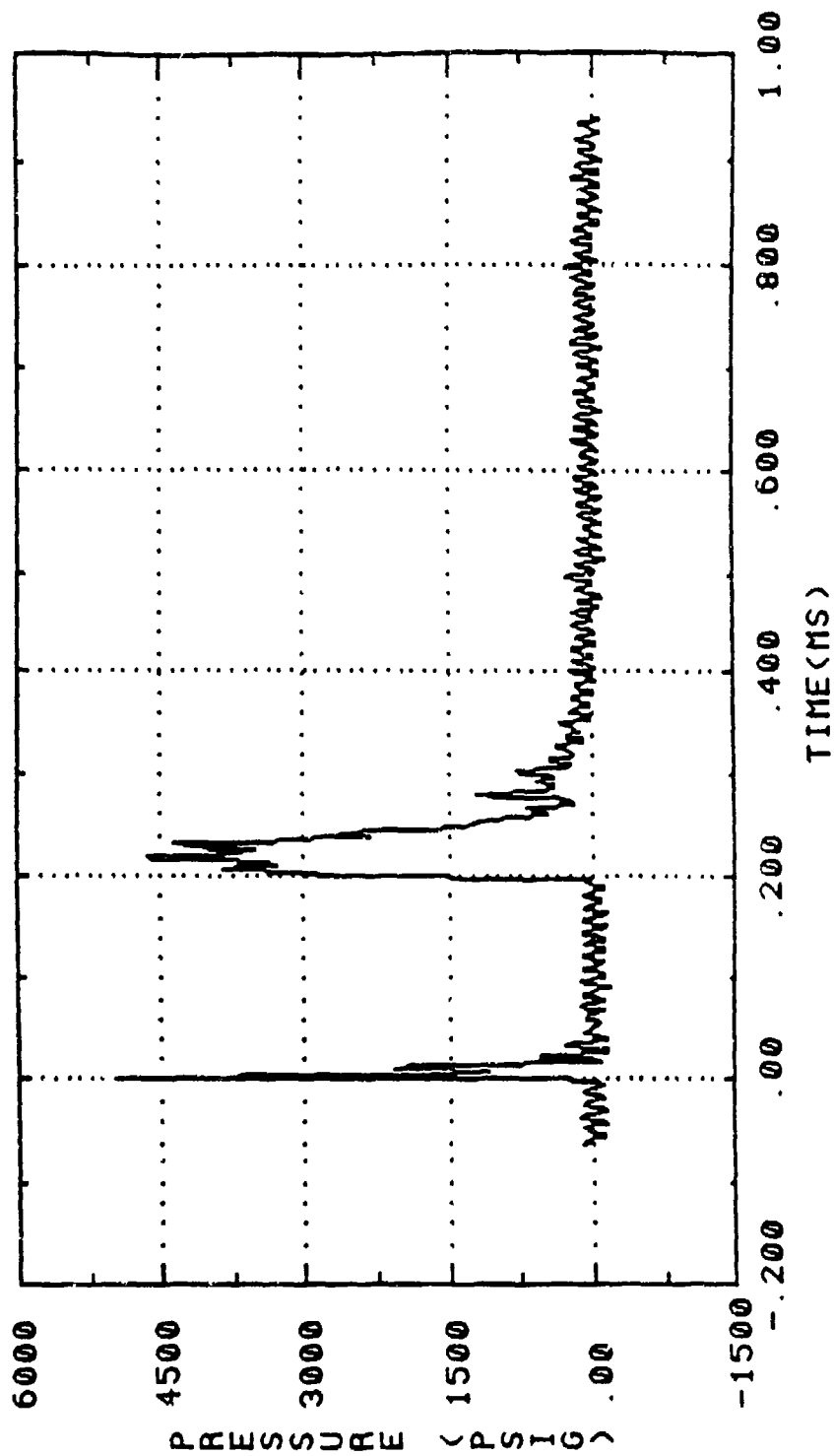


Figure A-19. Loads Test Data, Test 2, LOC 12

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 1 LOC= 1 TEST=003

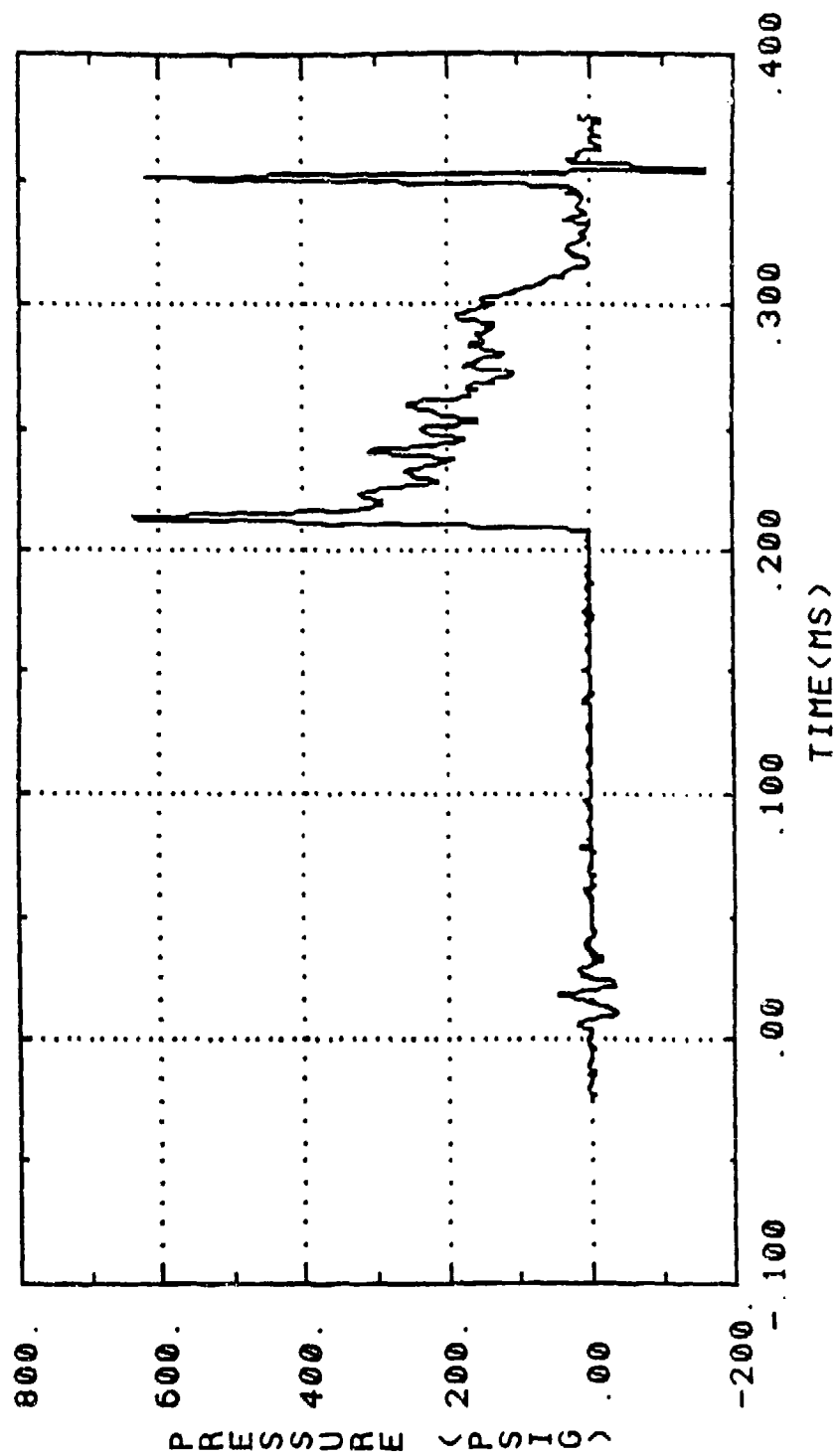


Figure A-20. Loads Test Data, Test 3, LOC 1

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 2 LOC= 2 TEST=003

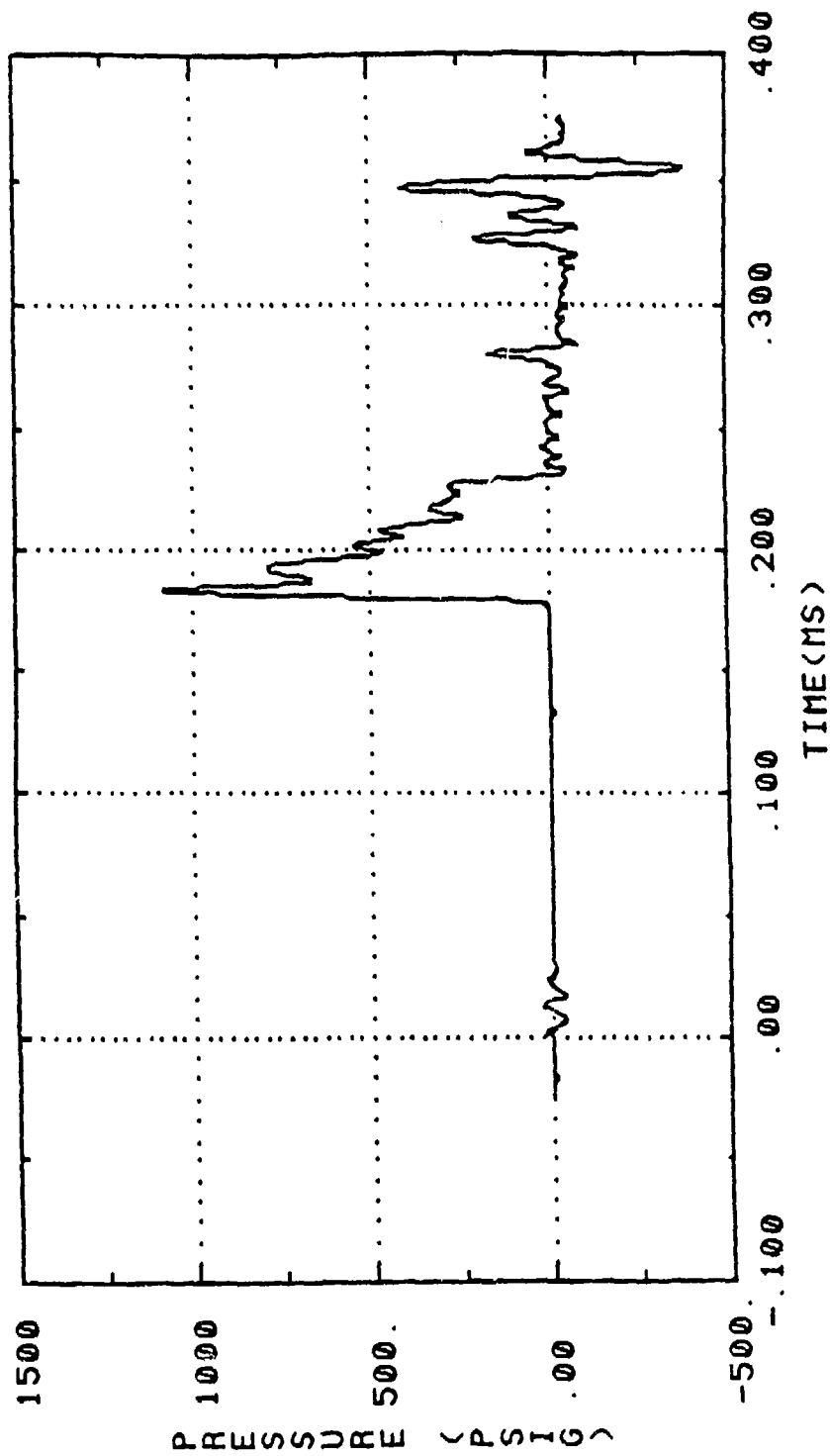


Figure A-21. Loads Test Data, Test 3, LOC 2

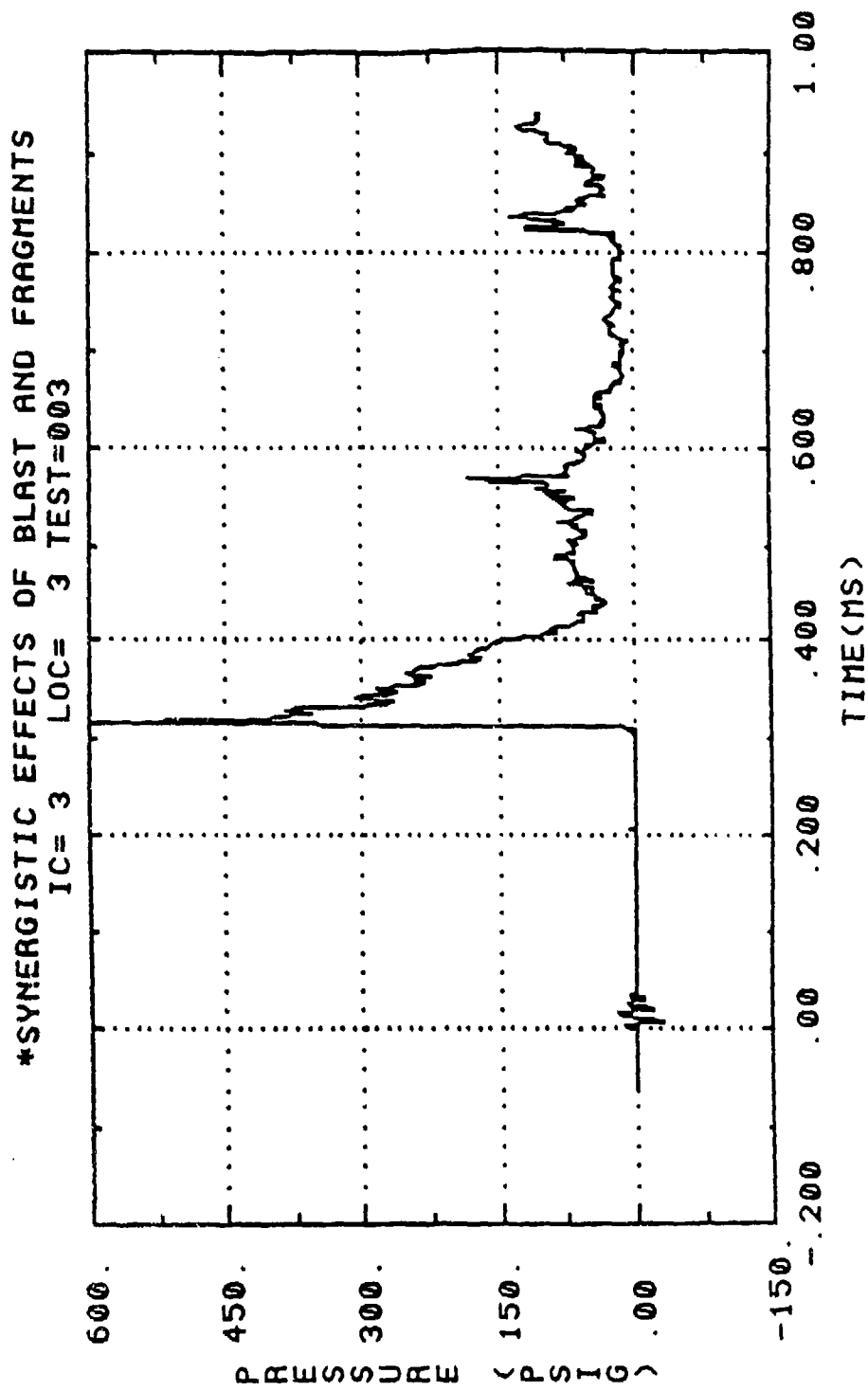


Figure A-22. Loads Test Data, "Test 3, LOC 3



\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 4 LOC= 4 TEST=003

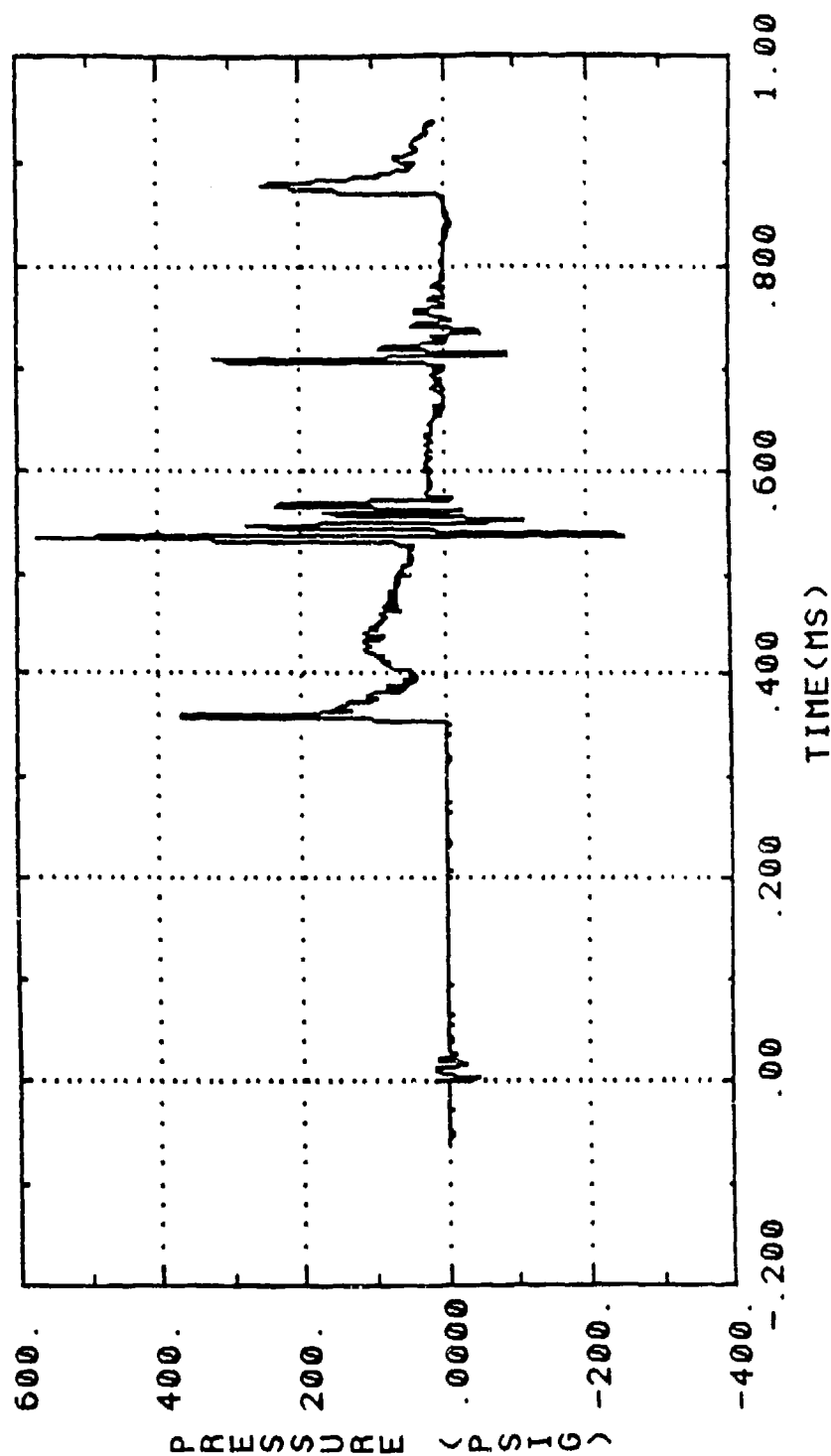


Figure A-23. Loads Test Data, Test 3, LOC 4

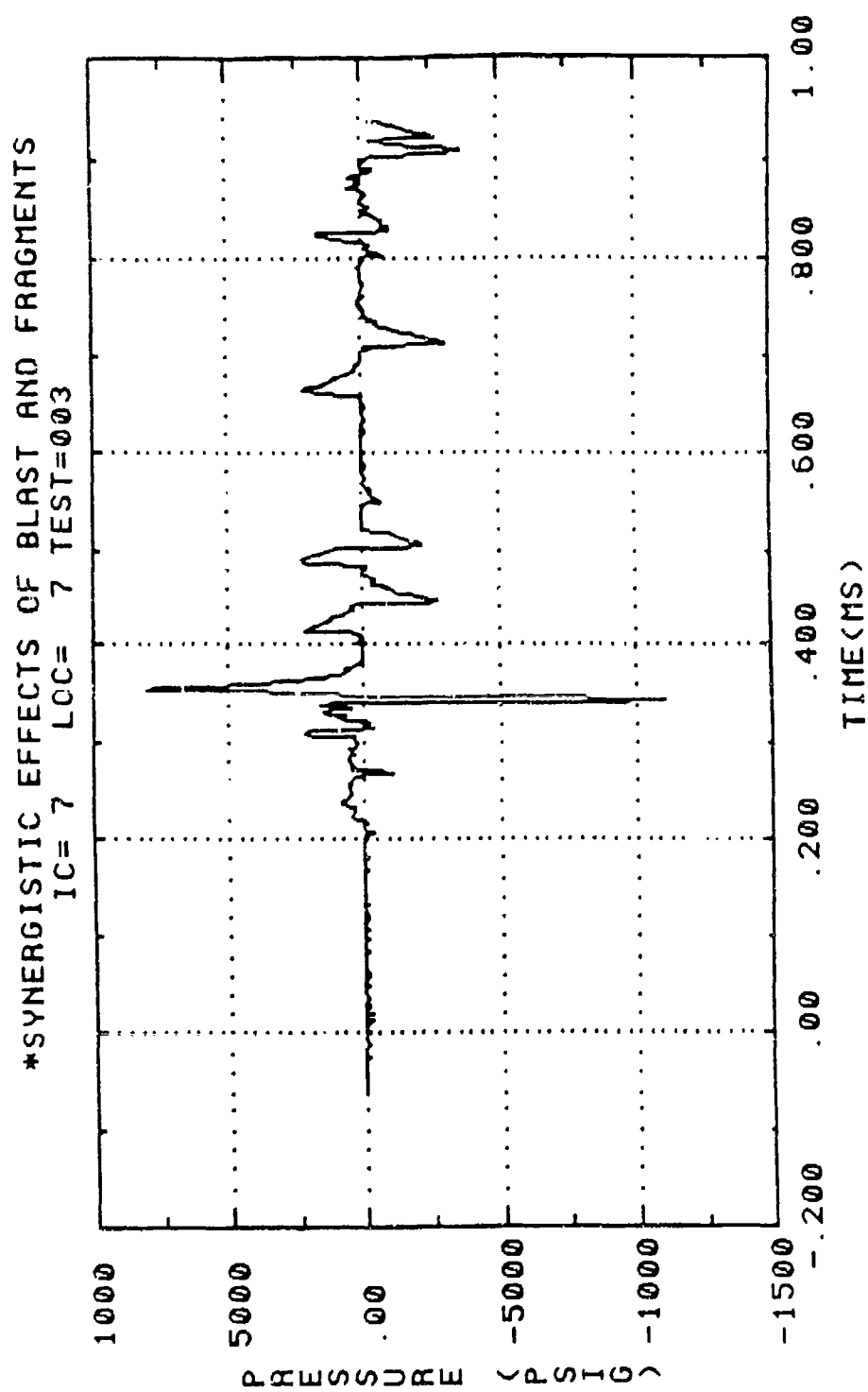


Figure A-24. Loads Test Data, "Test 3, LOC 7

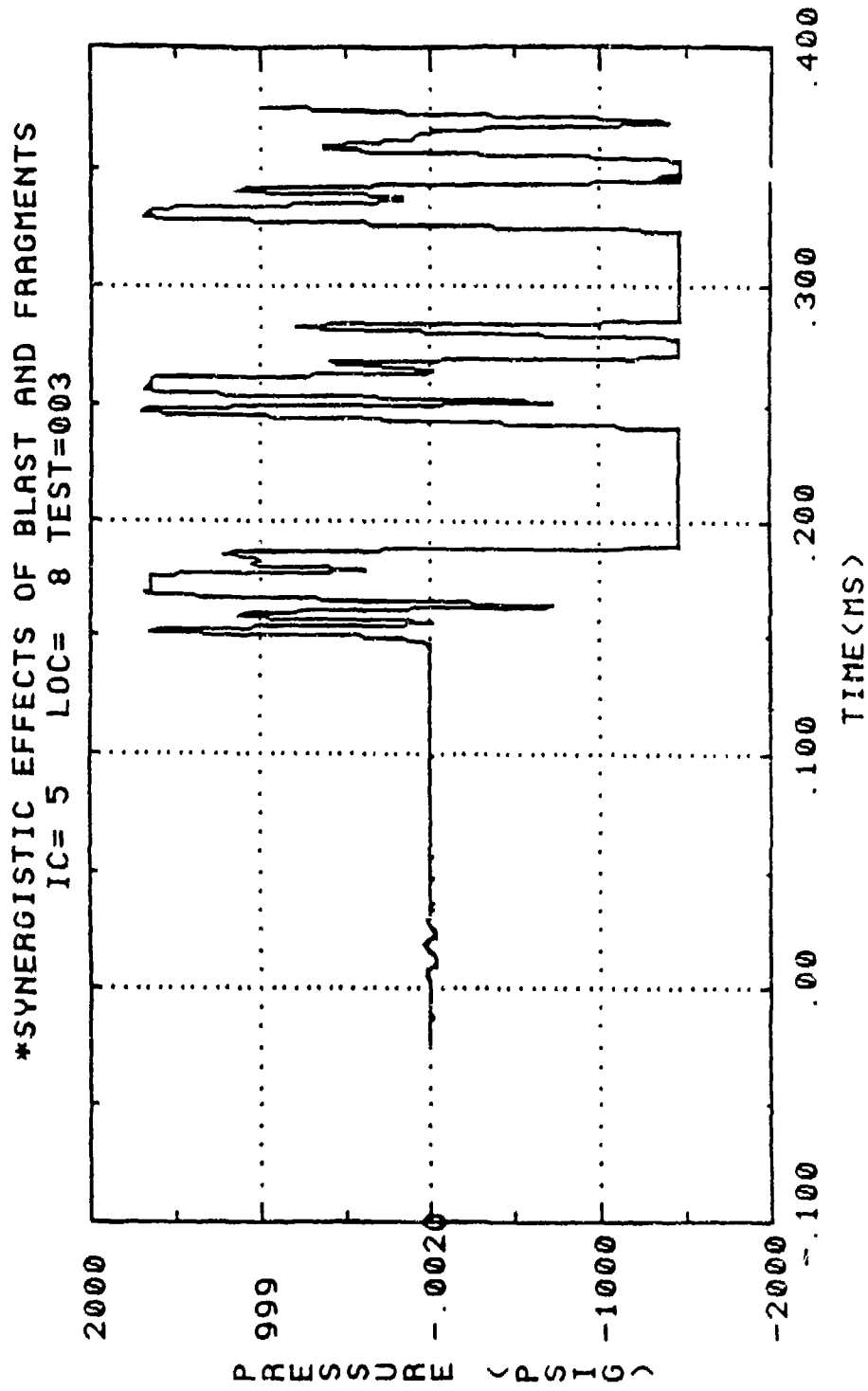


Figure A-25. Loads Test Data, "Test 3, LOC 8

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 8 LOC= 9 TEST=003

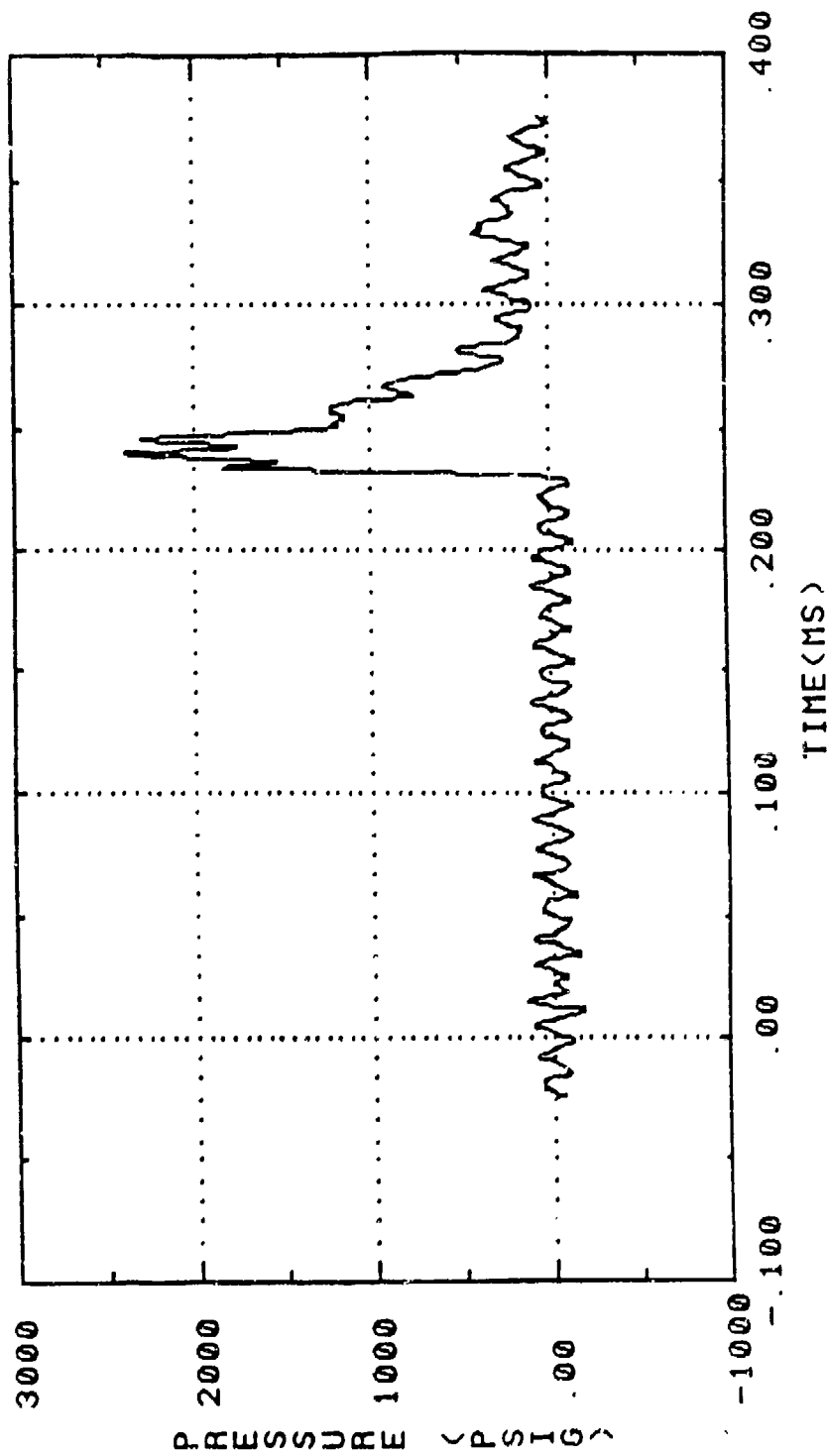


Figure A-26. Loads Test Data, "Test 3, LOC 9

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 6 LOC= 10 TEST=003

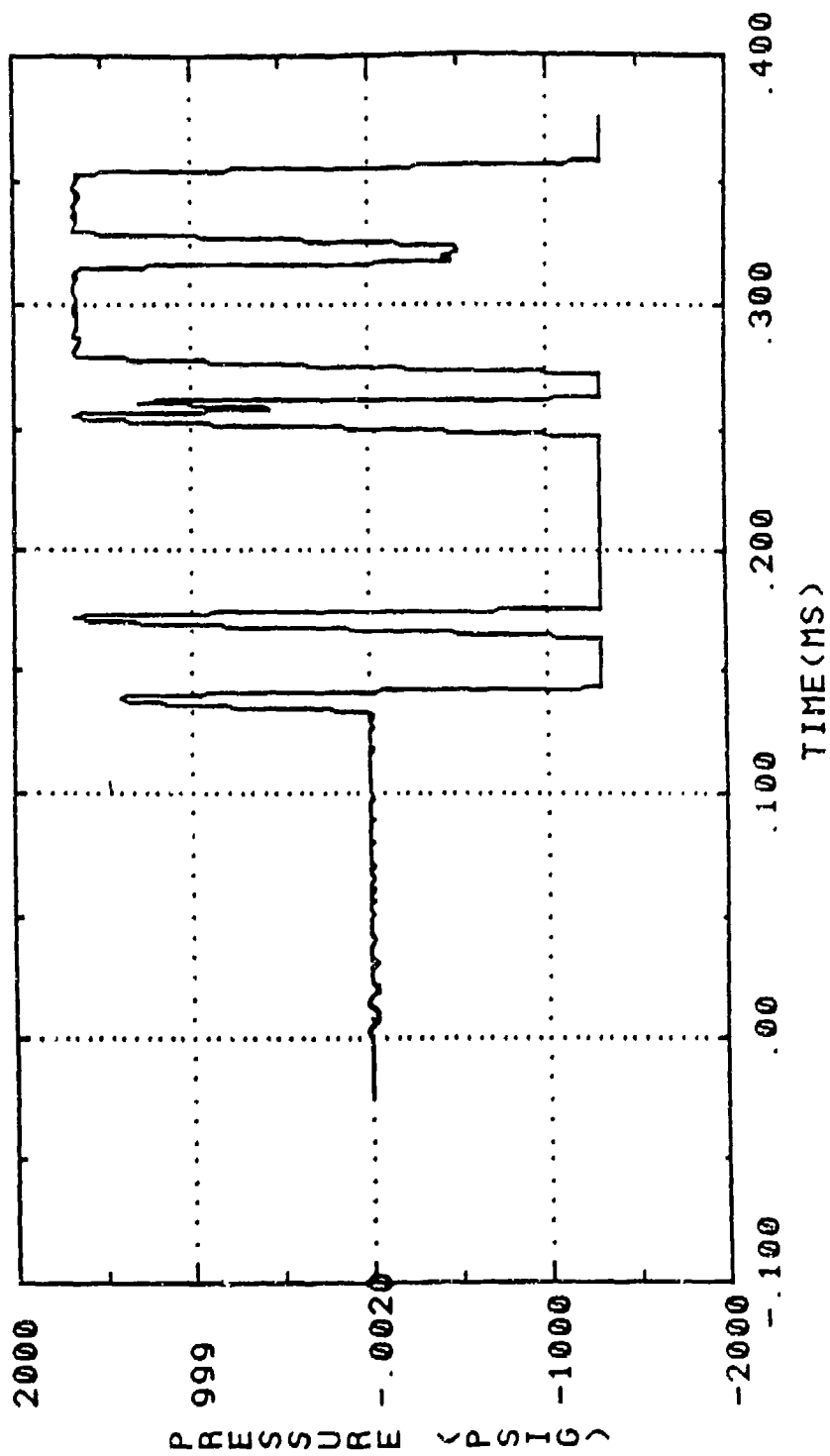


Figure A-27. Loads Test Data, Test 3, LOC 10

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 9 LOC= 11 TEST=003

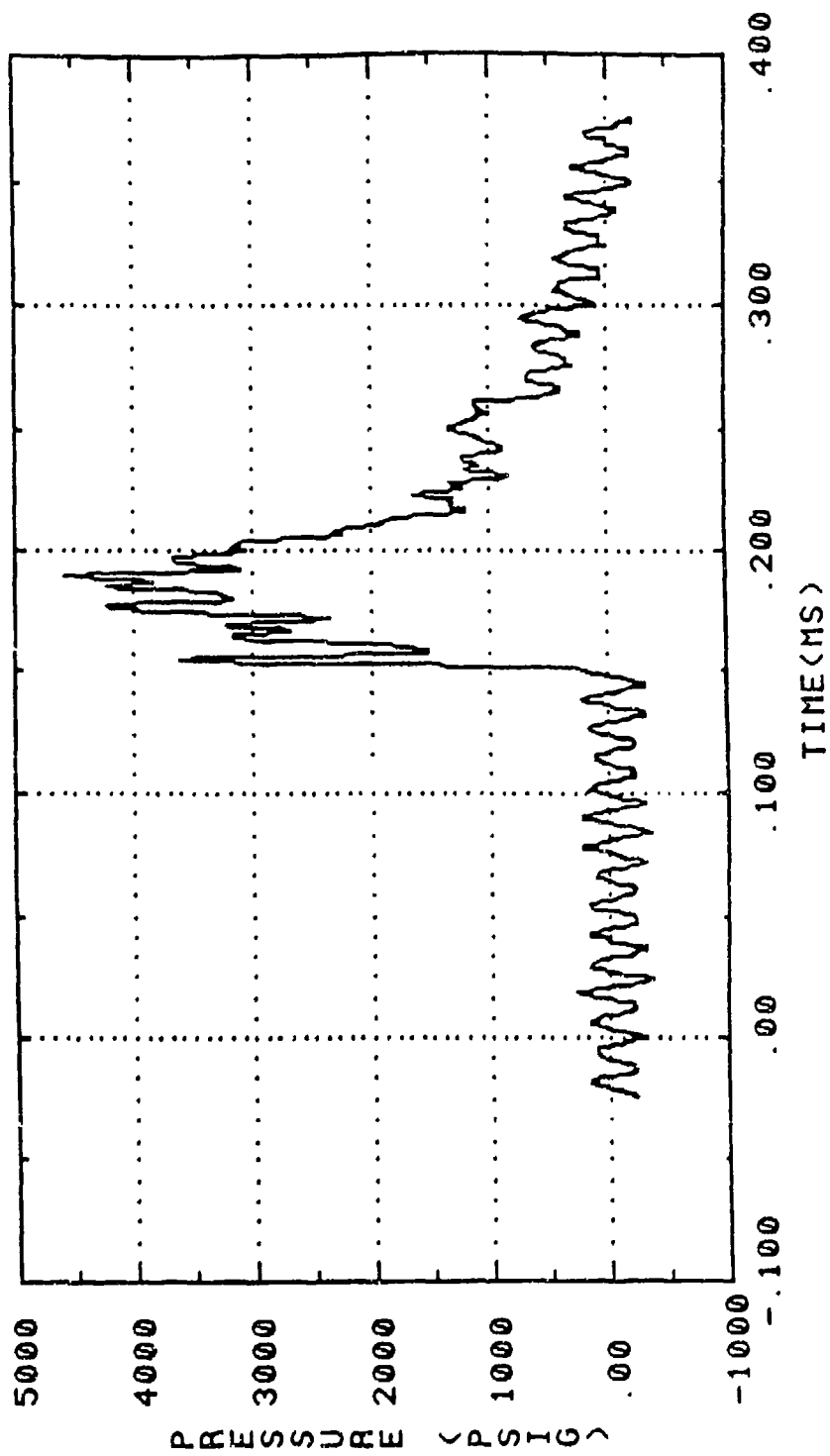


Figure A-28. Loads Test Data, Test 3, LOC 11

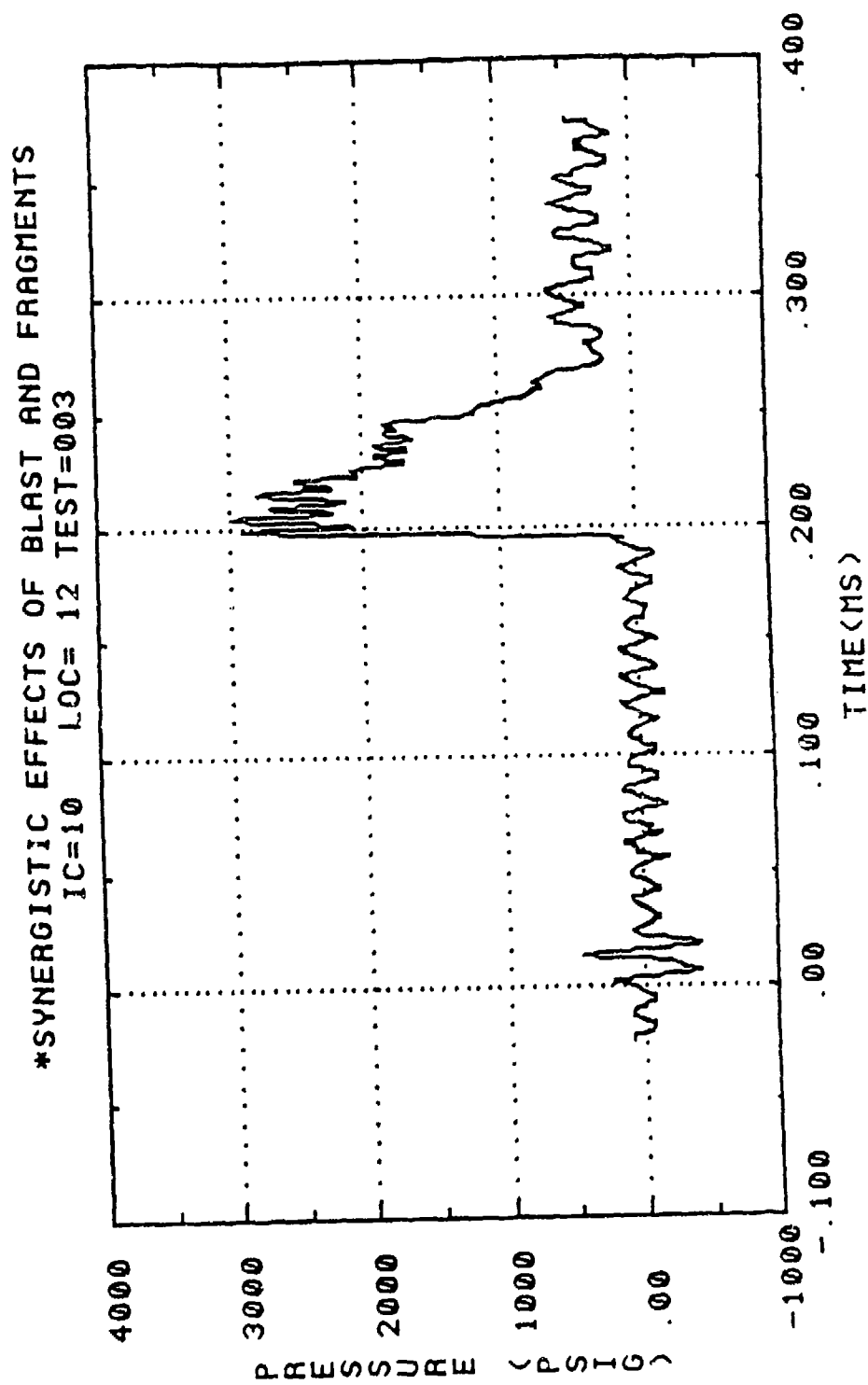


Figure A-29. Loads Test Data, Test 3, LOC 12

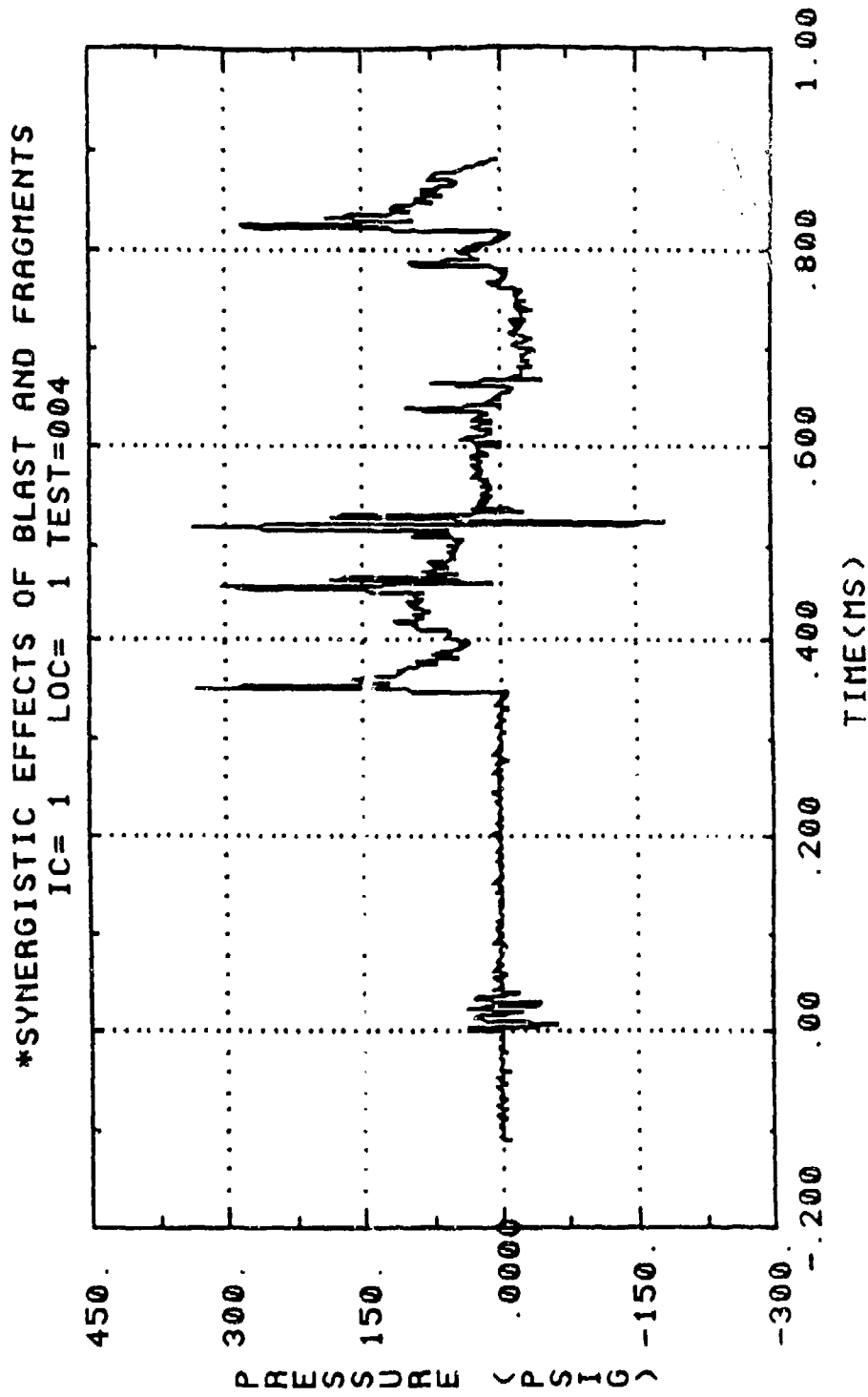


Figure A-30. Loads Test Data, Test 4, LOC 1



\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 2 LOC= 2 TEST=004

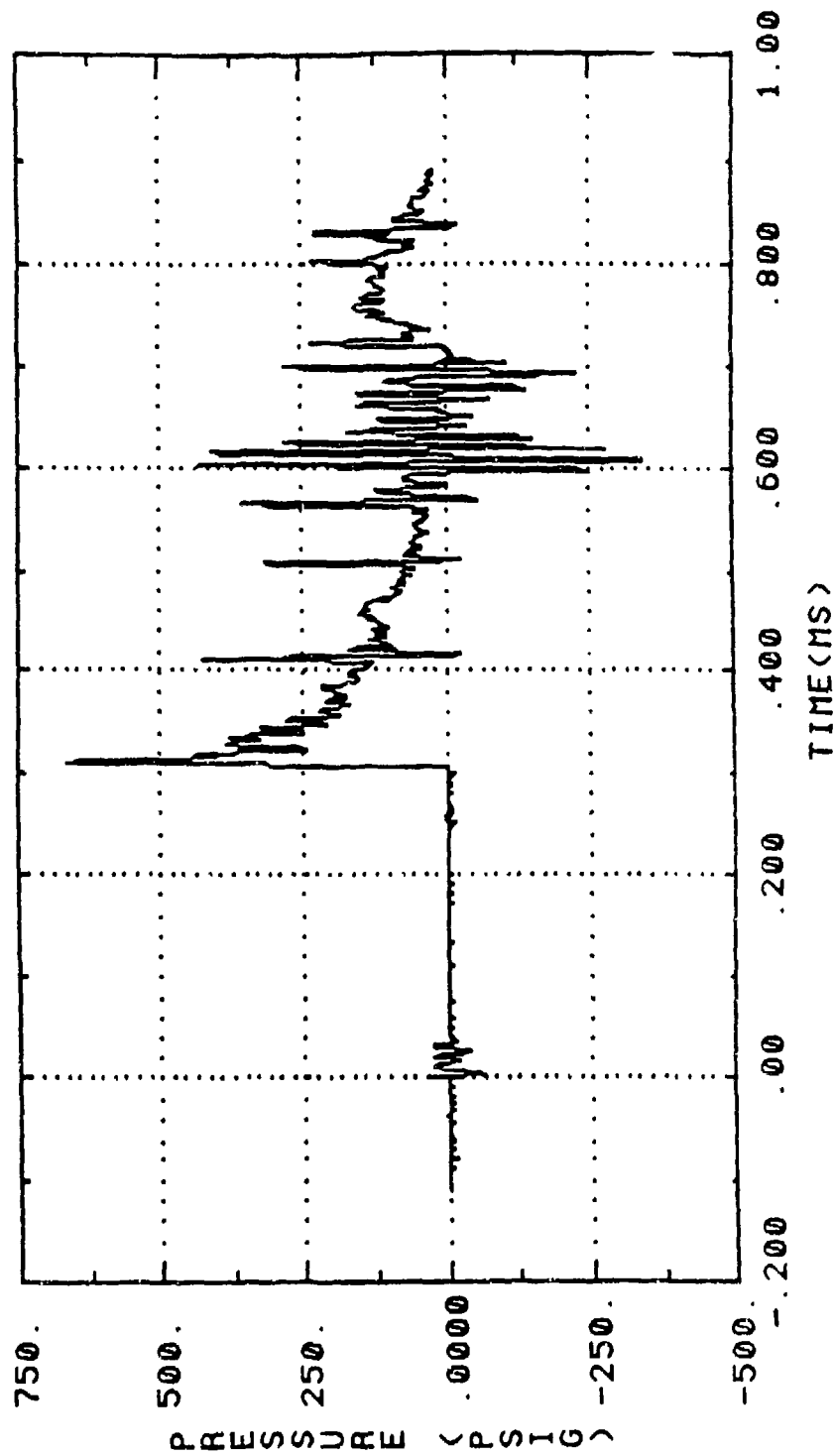


Figure A-31. Loads Test Data, Test 4, LOC 2

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 3 LOC= 3 TEST=004

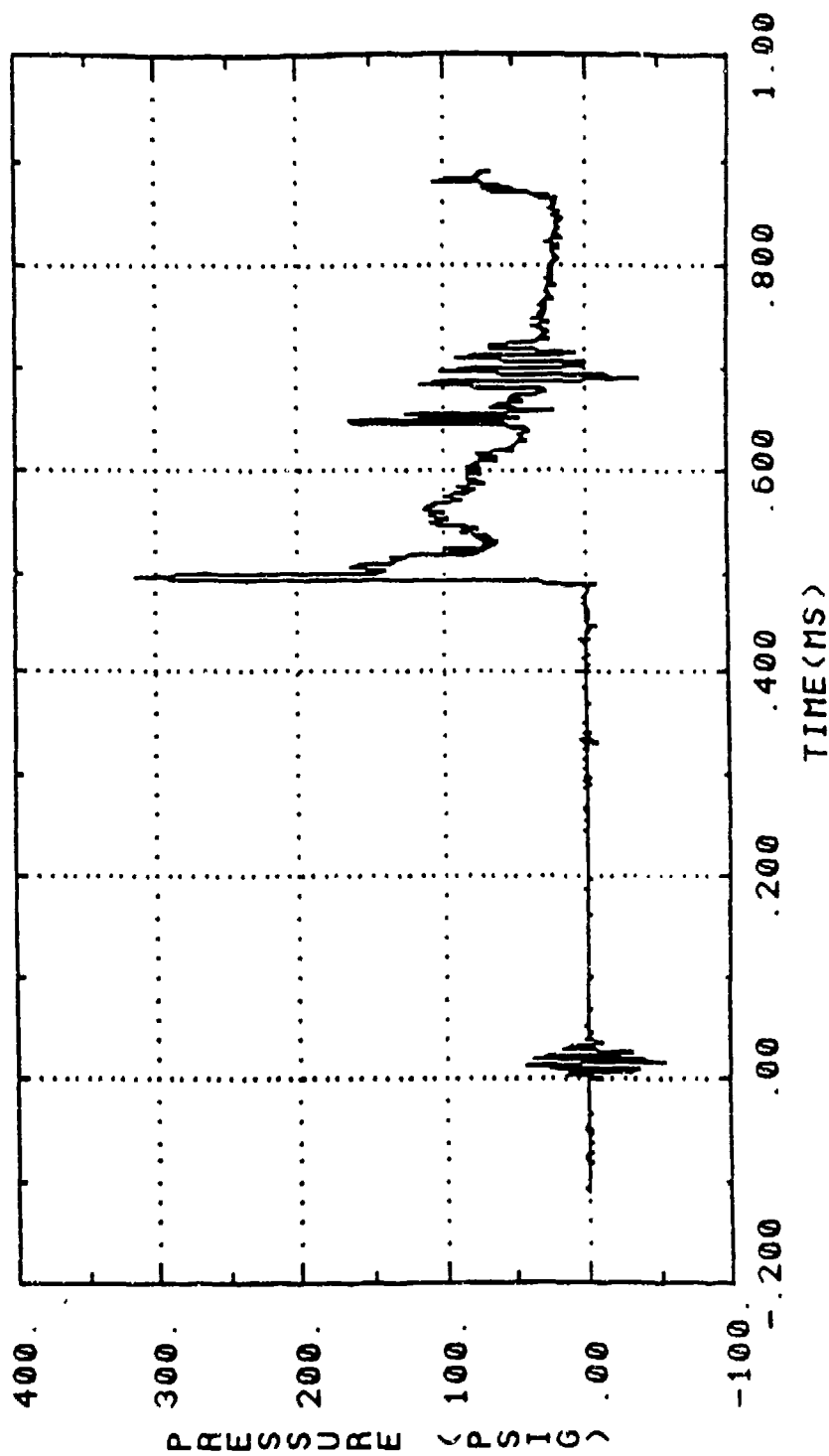


Figure A-32. Loads Test Data, Test 4, LOC 3

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 4 LOC= 4 TEST=004

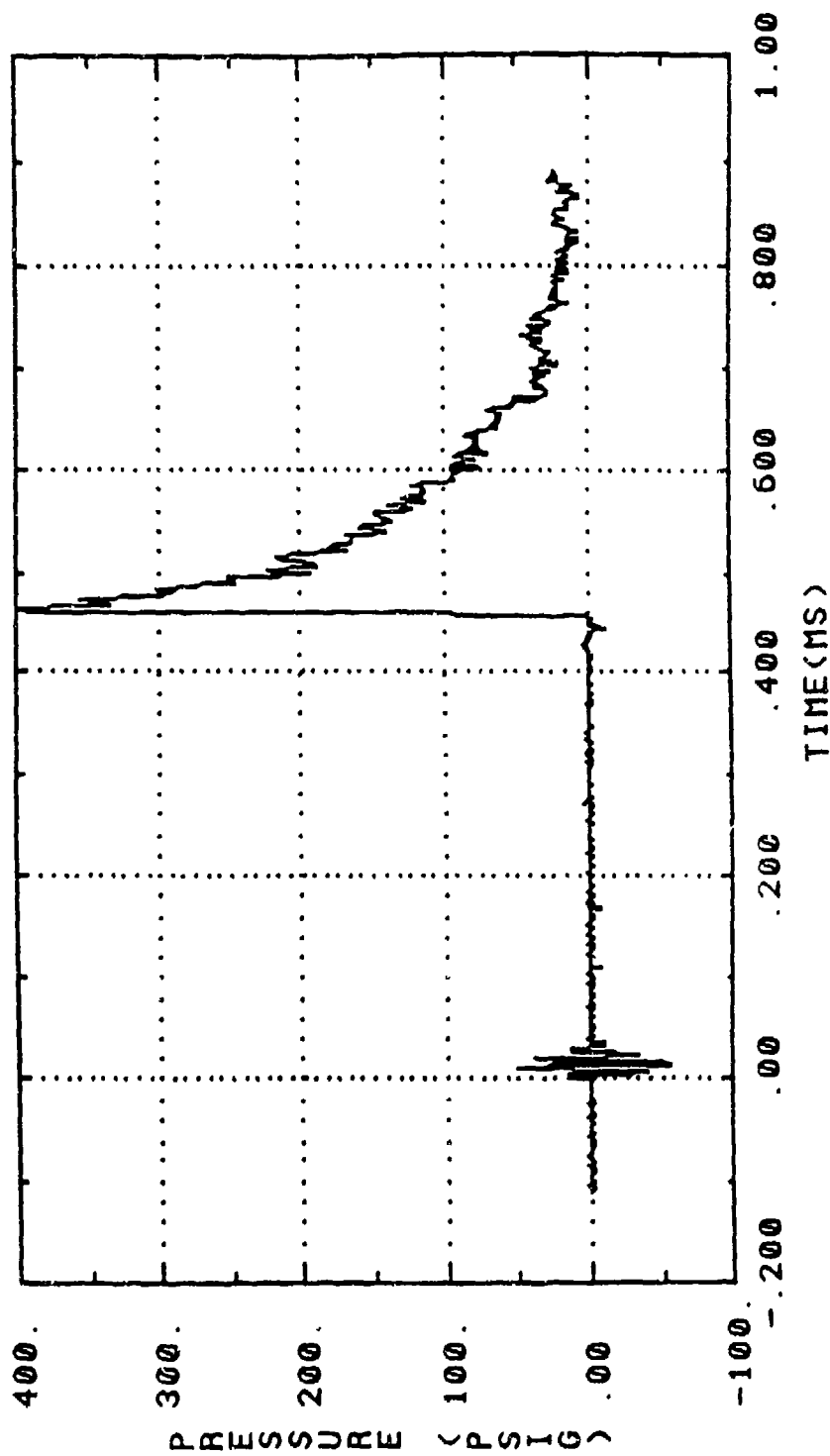


Figure A-33. Loads Test Data, Test 4, LOC 4

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 7 LOC= 7 TEST=004

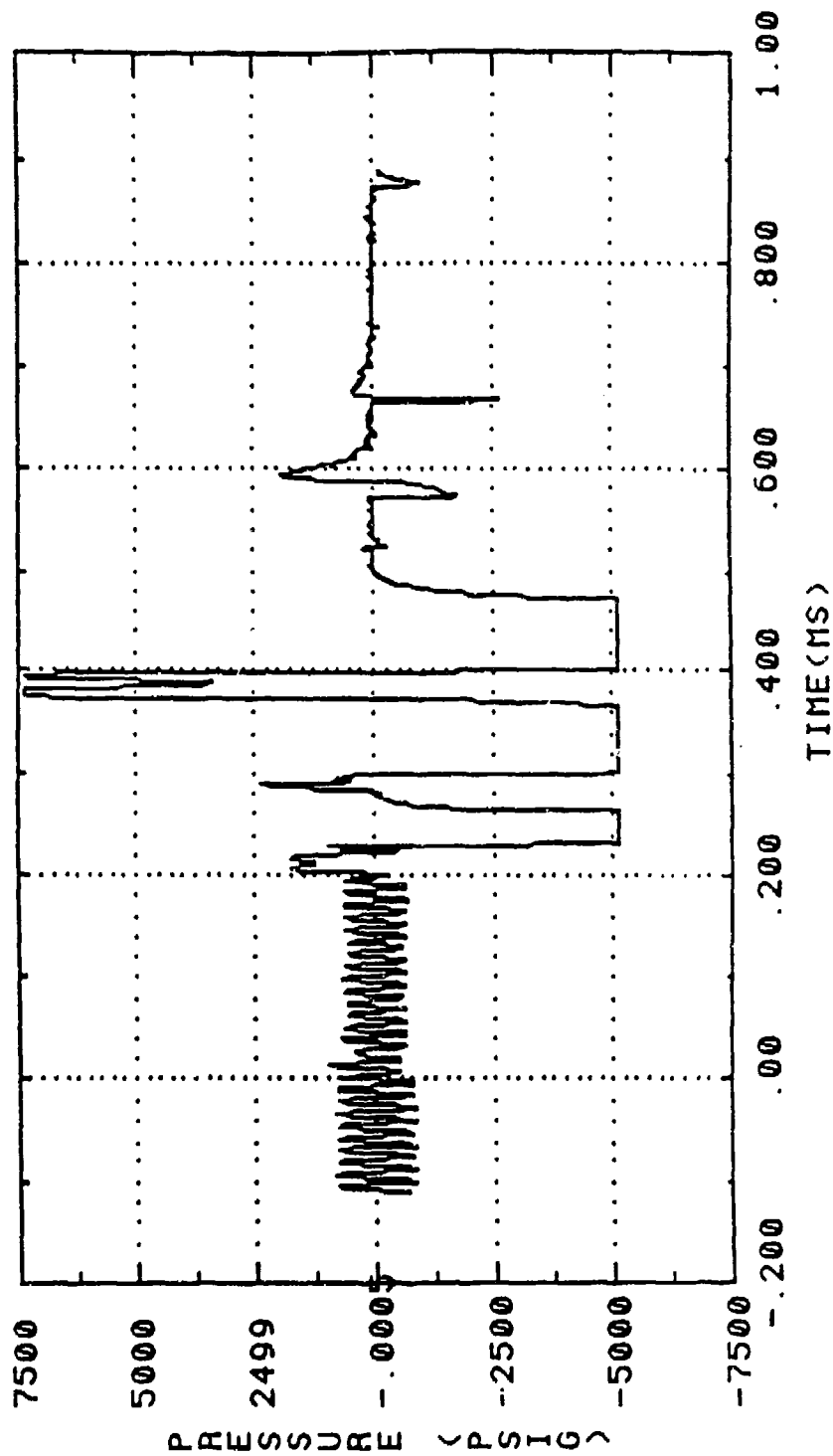


Figure A-34. Loads Test Data, "Test 4, LOC 7

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 5 LOC= 8 TEST=004

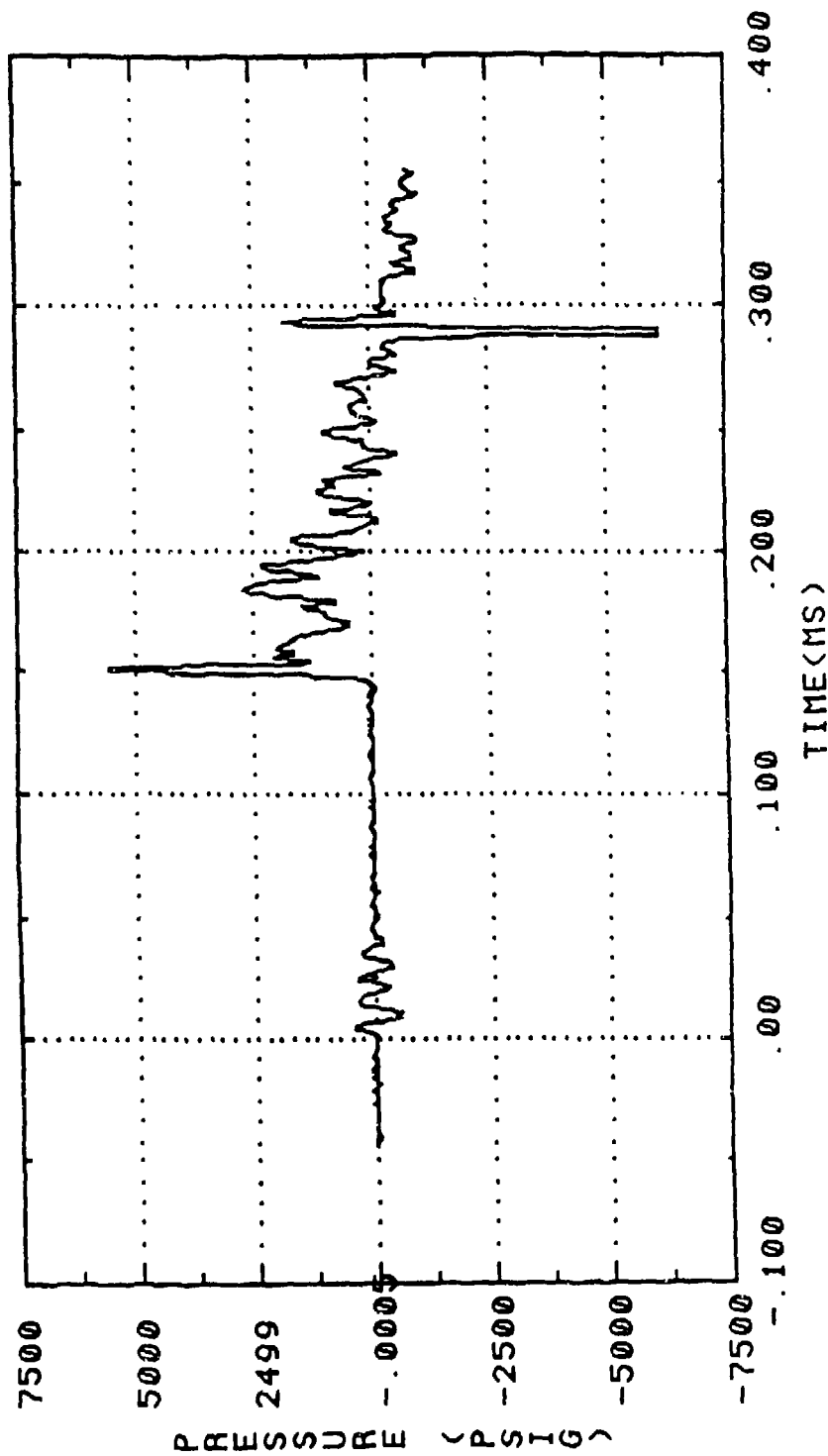


Figure A-35. Loads Test Data, "Test 4, LOC 8

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 8 LOC= 9 TEST=004

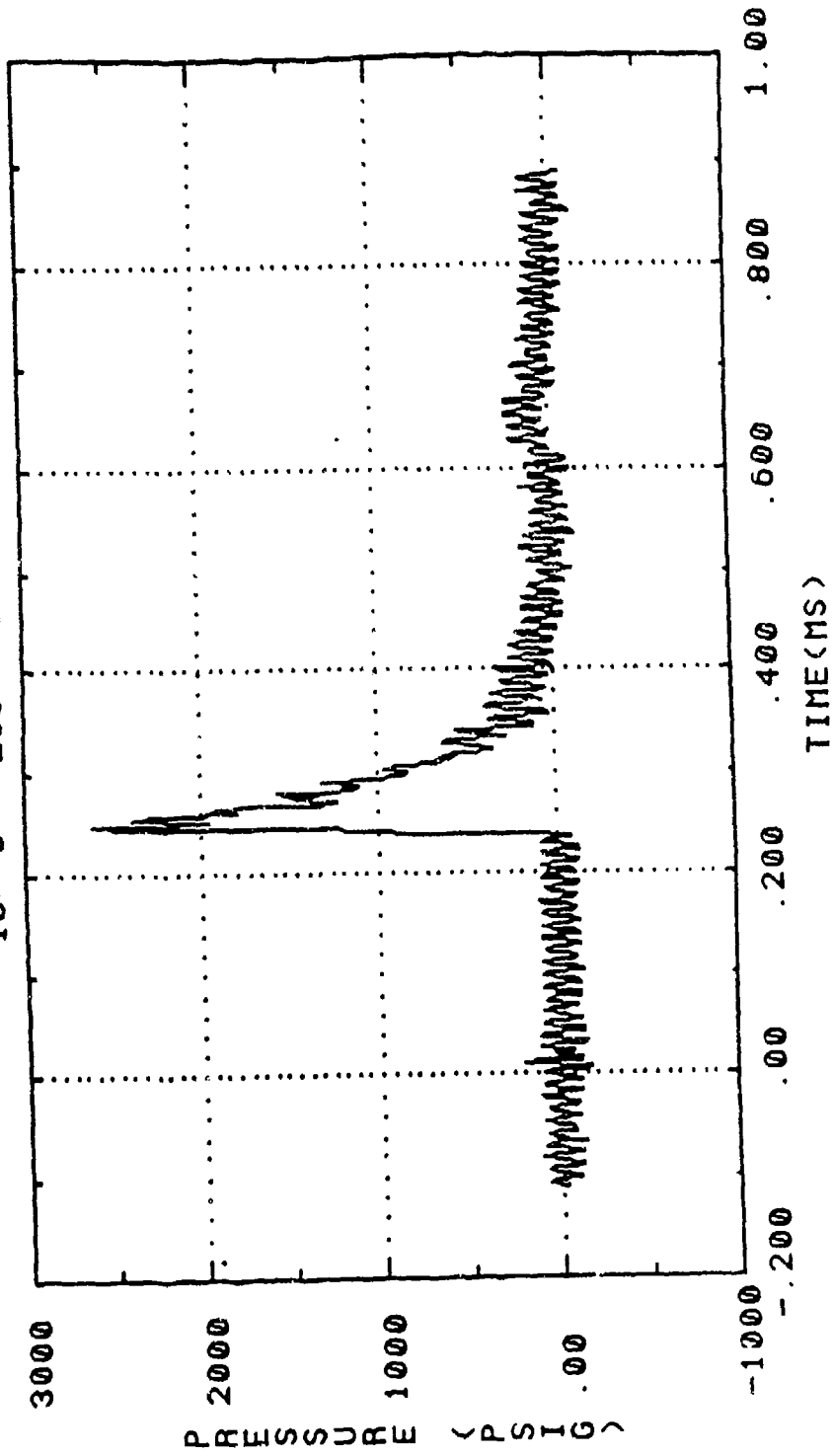


Figure A-36. Loads Test Data, "Test 4, LOC 9

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 6 LOC= 10 TEST=004

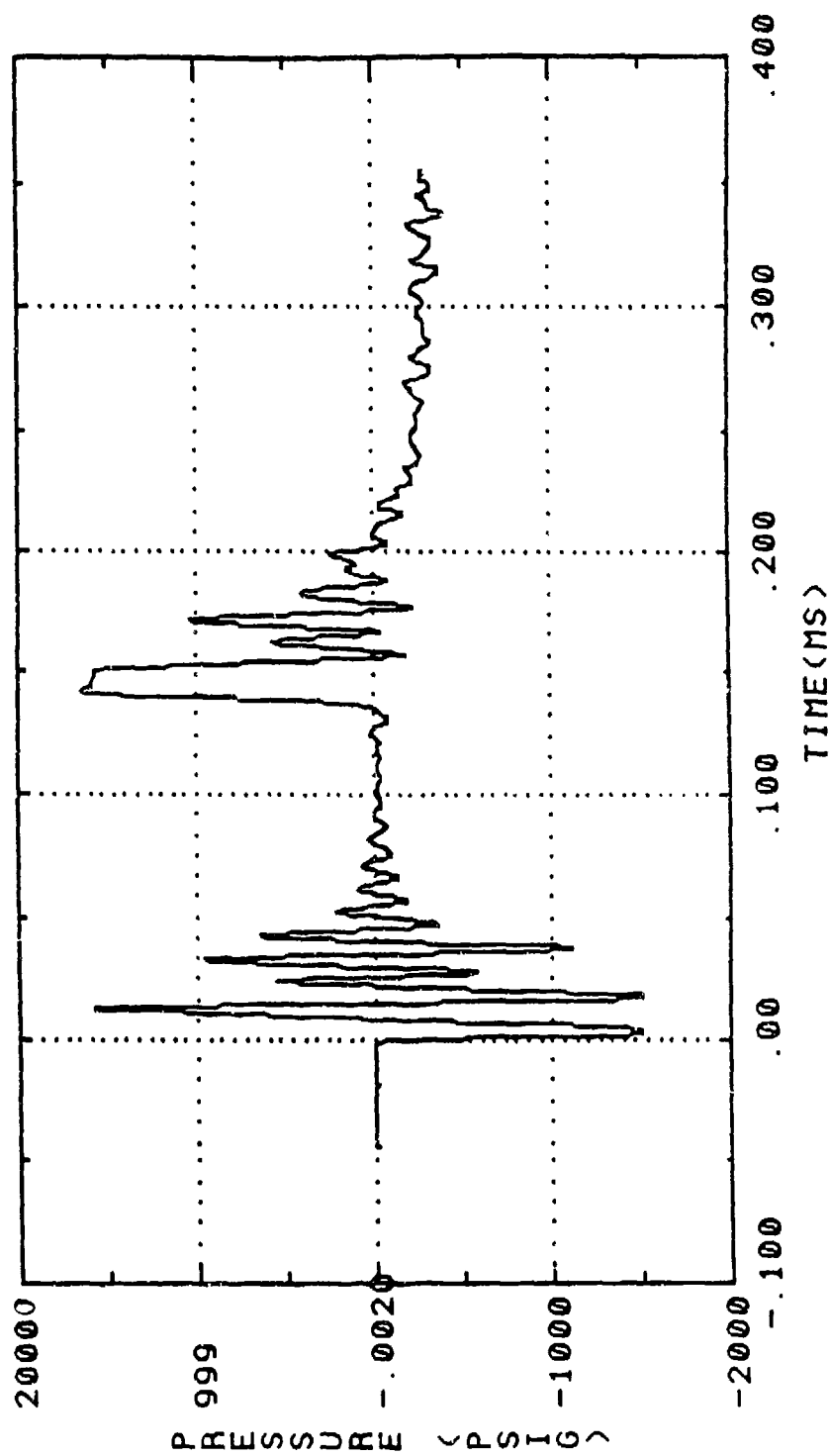


Figure A-37. Loads Test Data, Test 4, LOC 10

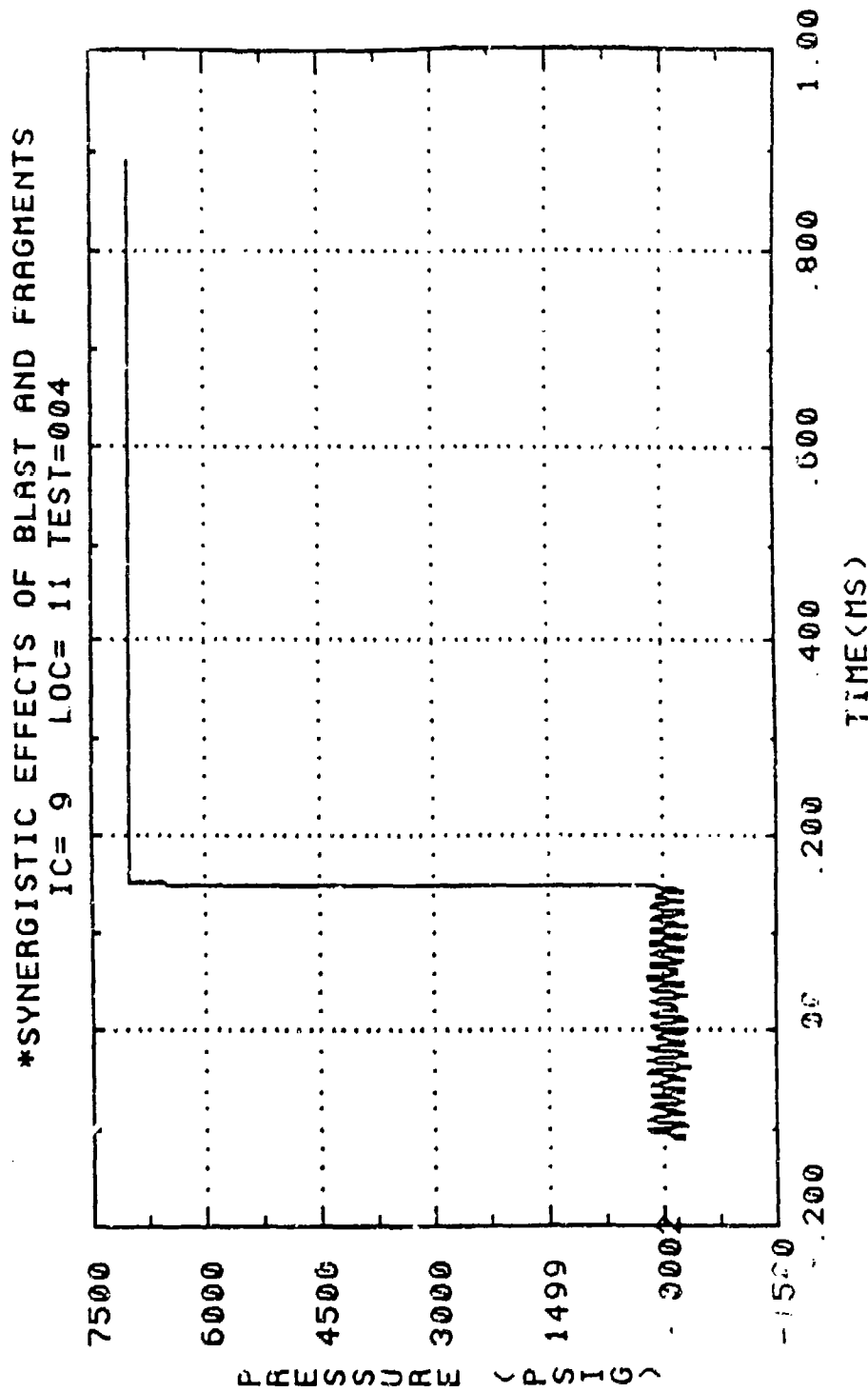


Figure A-38. Loads Test Data, Test 4, LOC 11



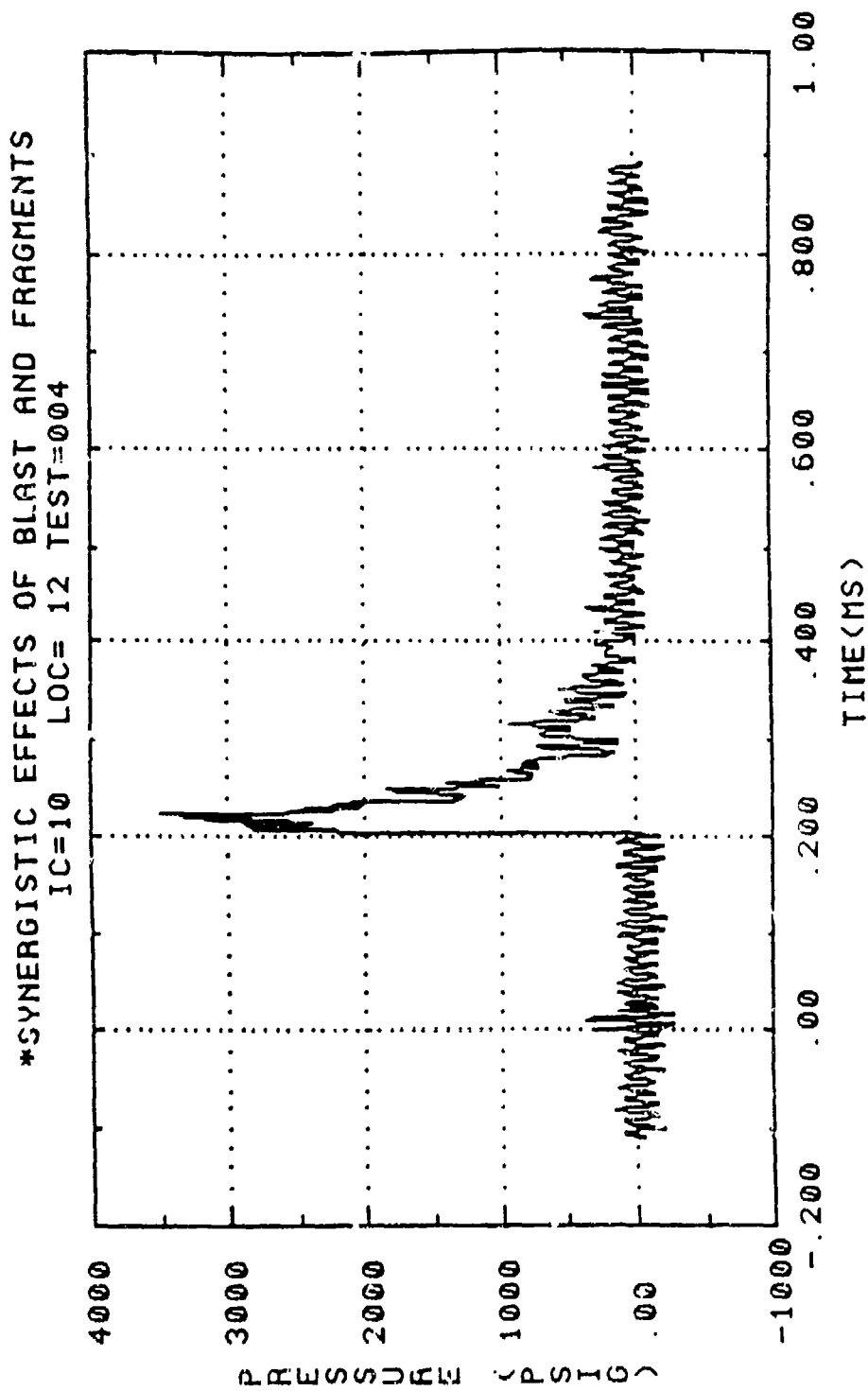


Figure A-39. Loads Test Data, Test 4, LOC 12

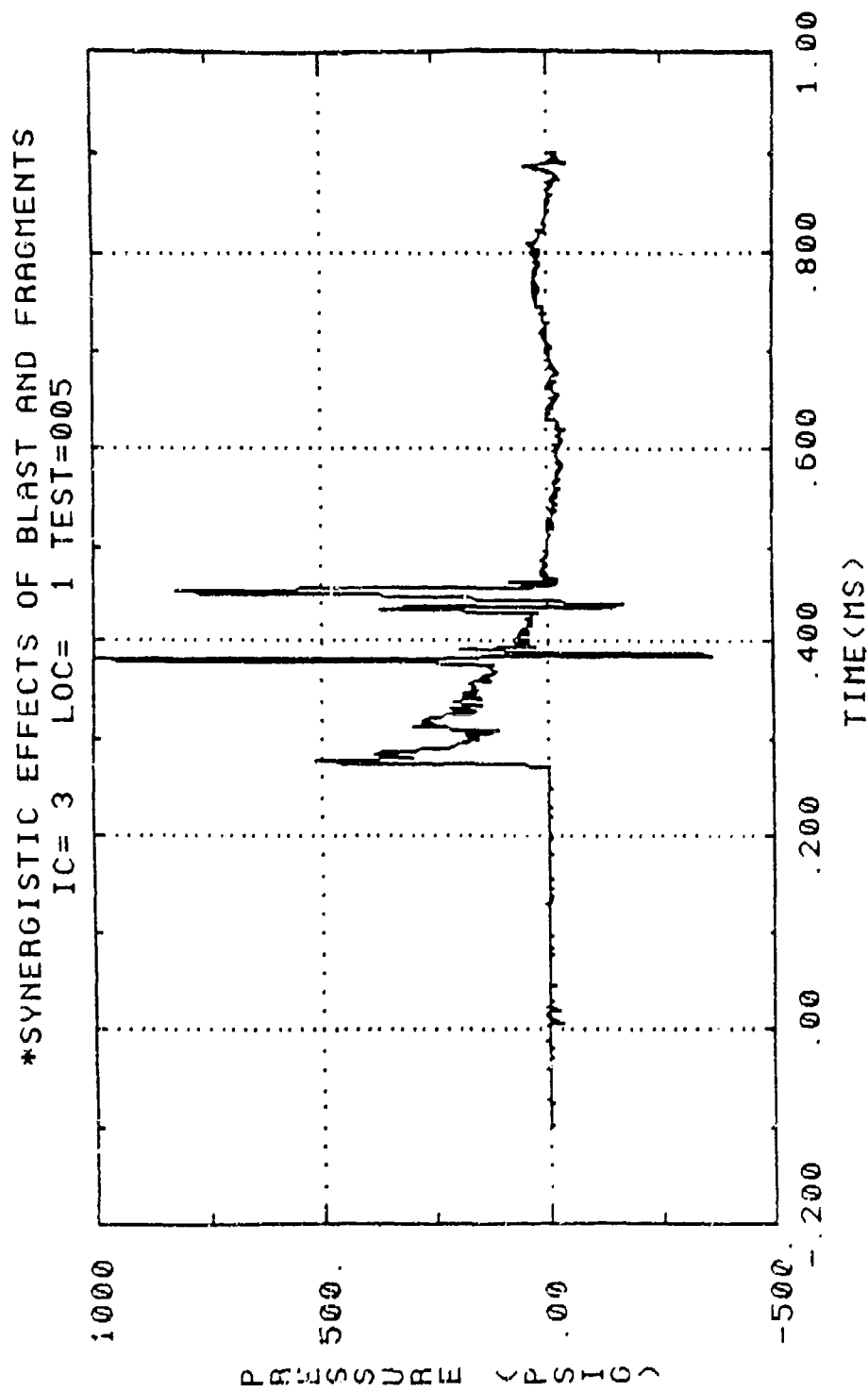


Figure A-40. Loads Test Data, "Test 5, LOC 1

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 4 LOC= 2 TEST=005

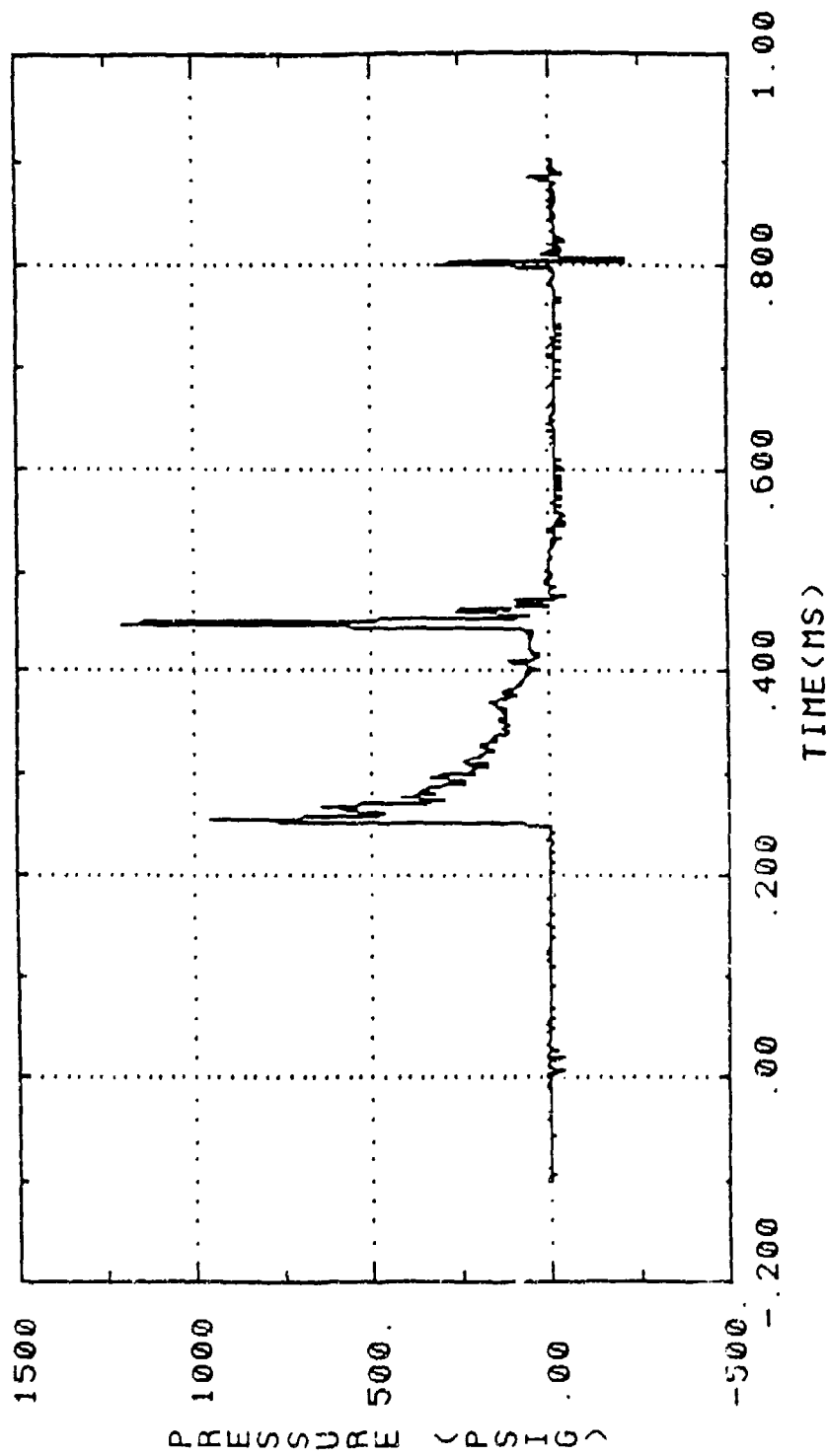


Figure A-41. Loads Test Data, "Test 5, LOC 2

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 1 LOC= 5 TEST=005

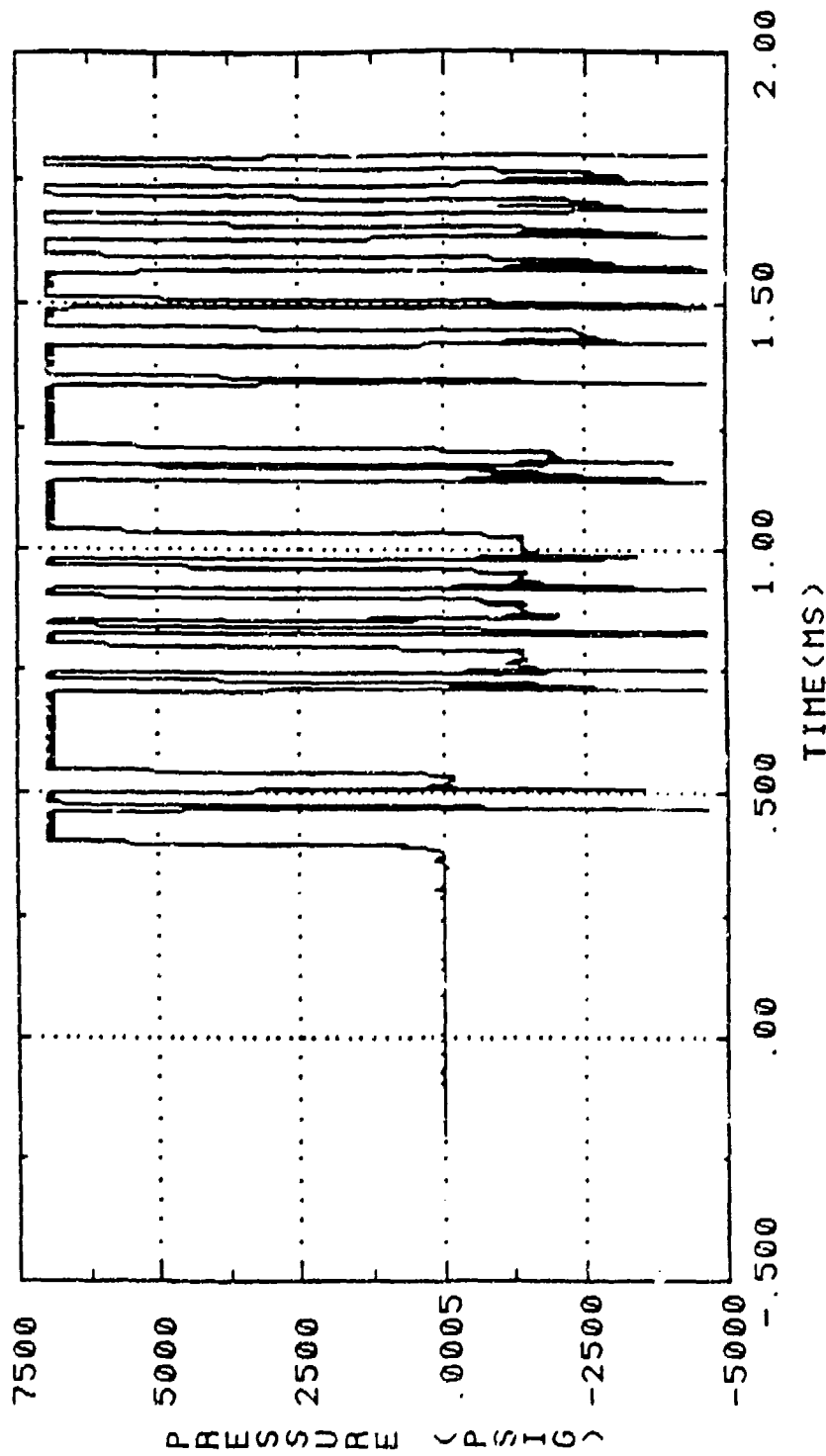


Figure A-42. Loads Test Data, Test 5, LOC 5

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 7 LOC= 6 TEST=005

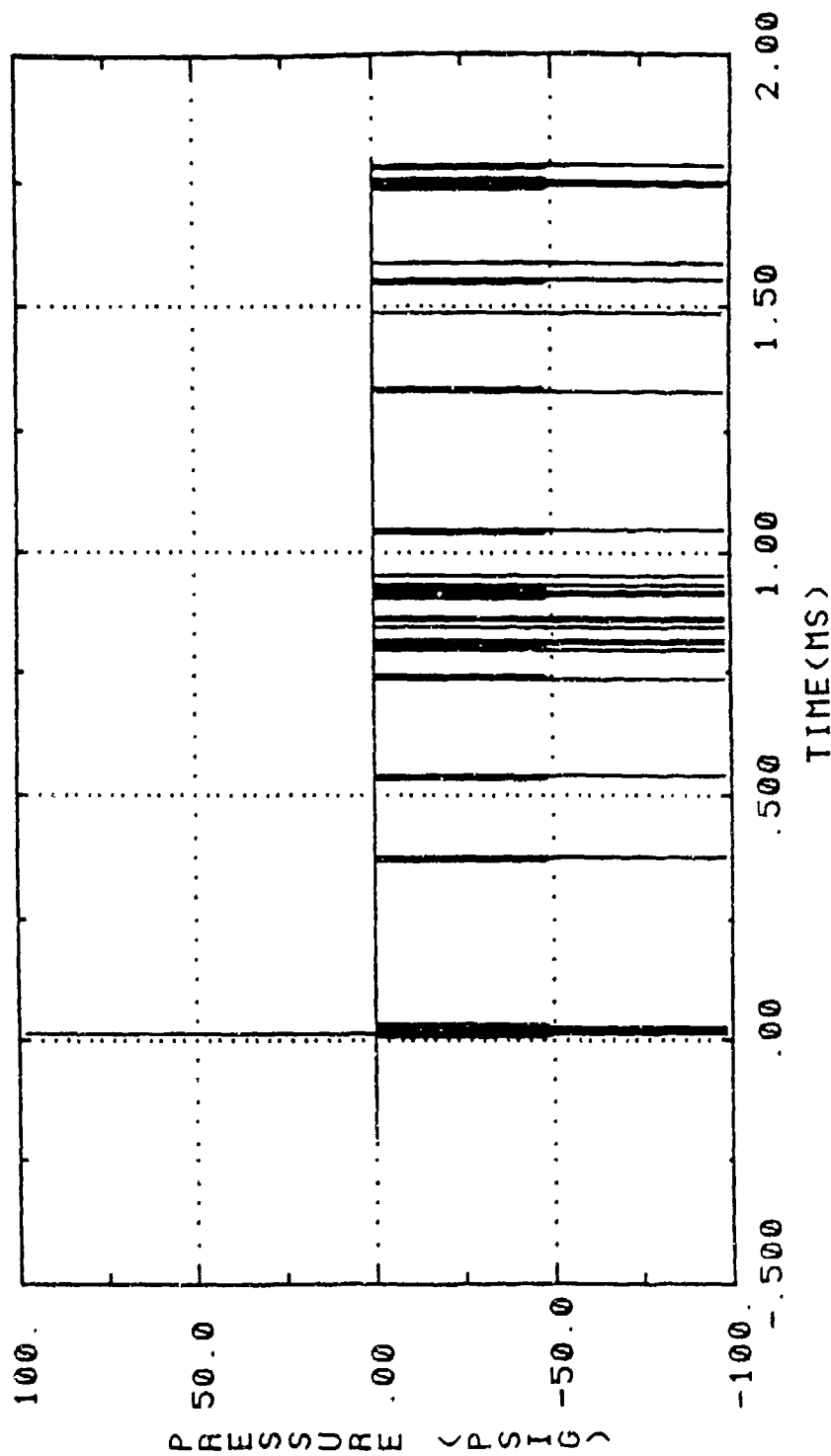


Figure A-43. Loads Test Data, Test 5, LOC 6

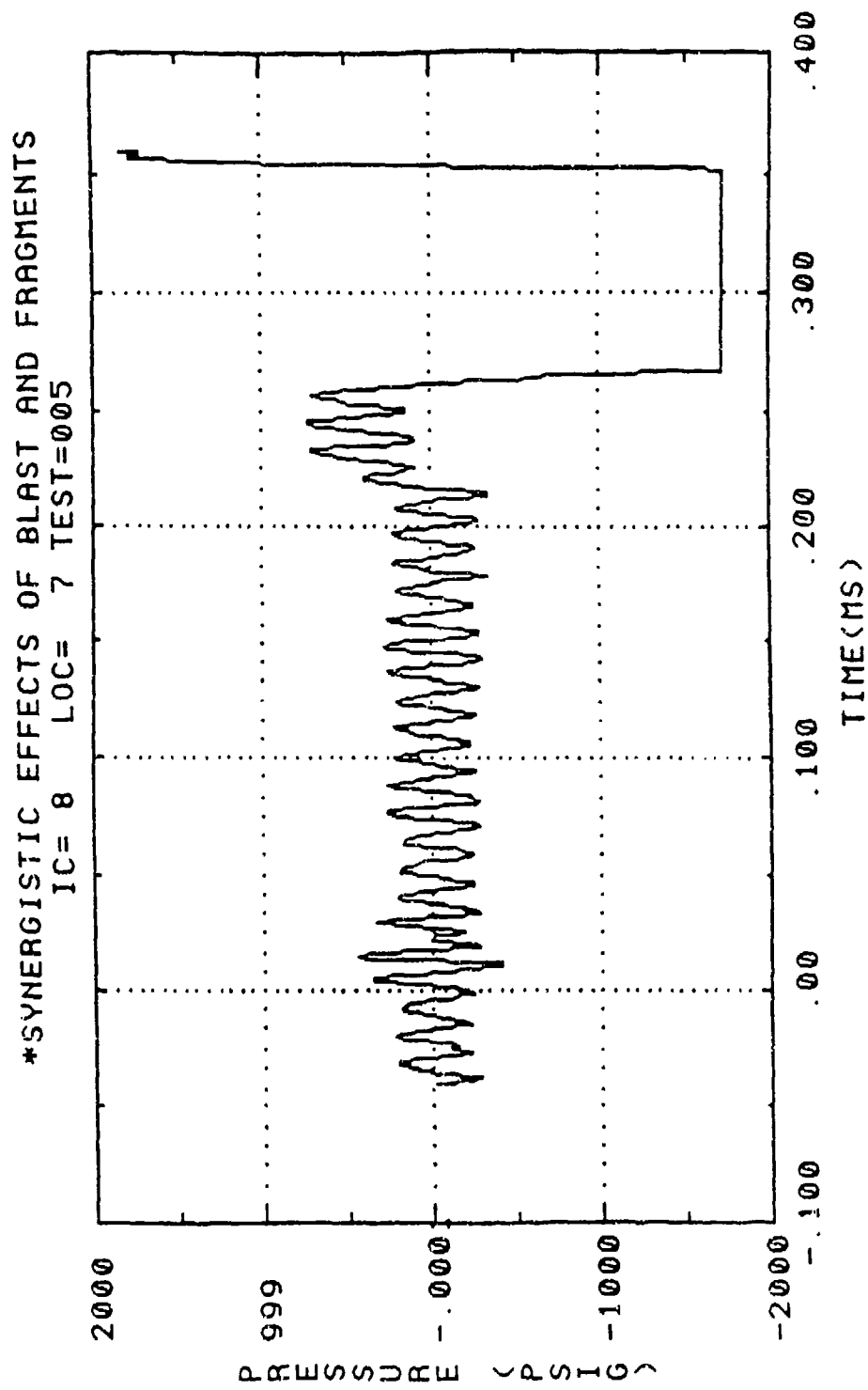


Figure A-44. Loads Test Data, Test 5, LOC 7

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 5 LOC= 8 TEST=005

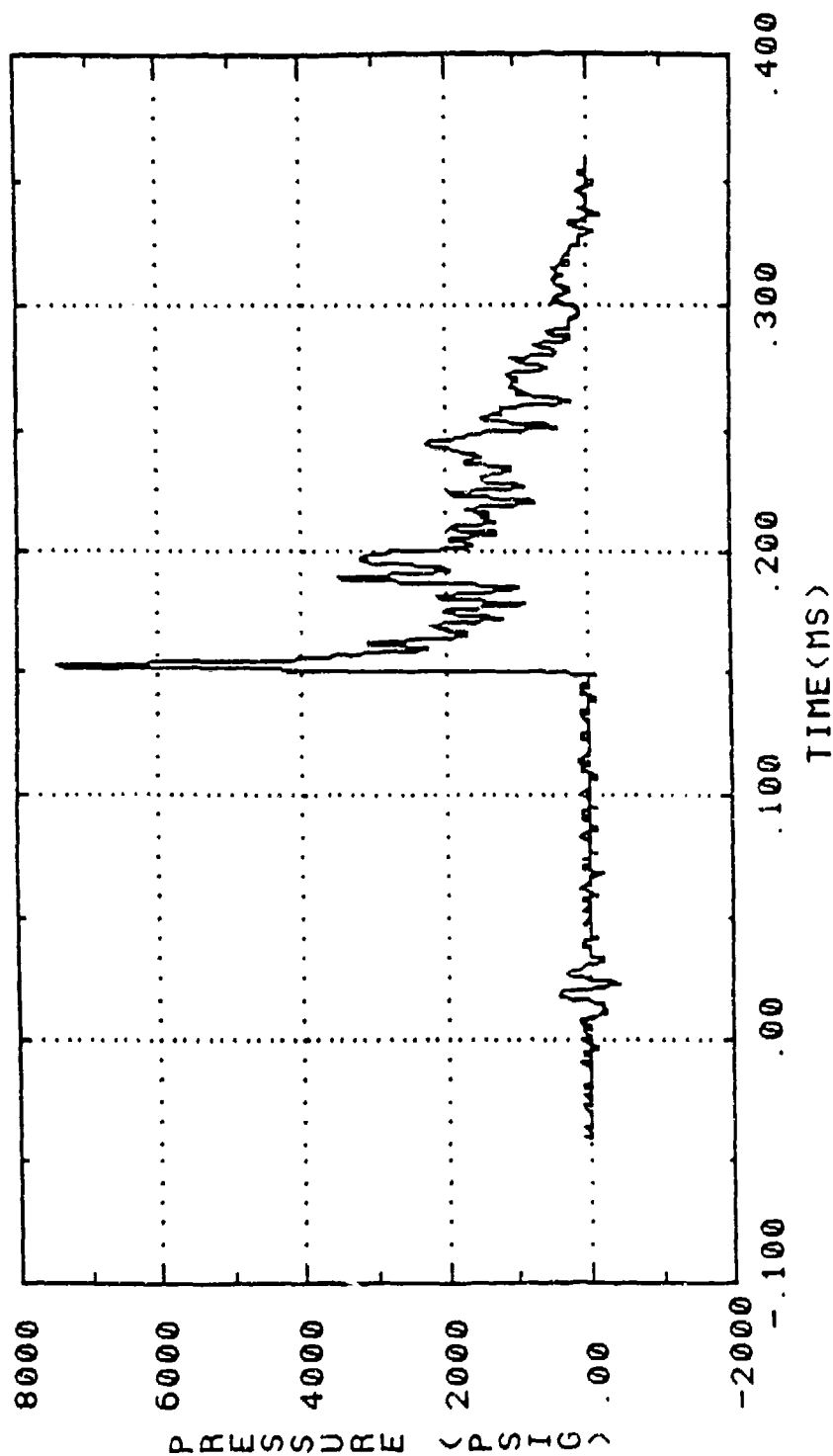


Figure A-45. Loads Test Data, Test 5, LOC 8

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 9 LOC= 9 TEST=005

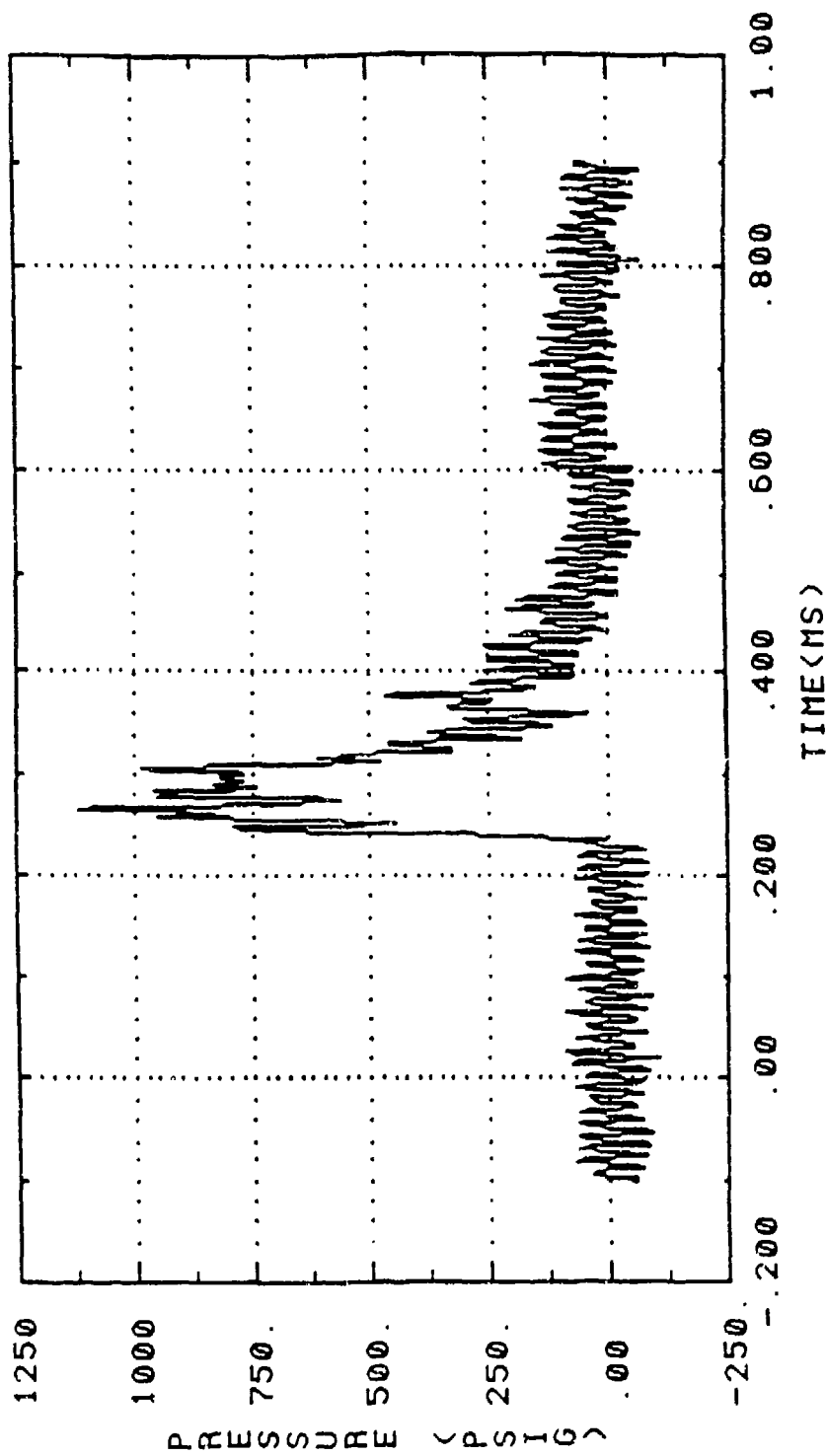


Figure A-46. Loads Test Data," Test 5, LOC 9



\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 6 LOC= 10 TEST=005

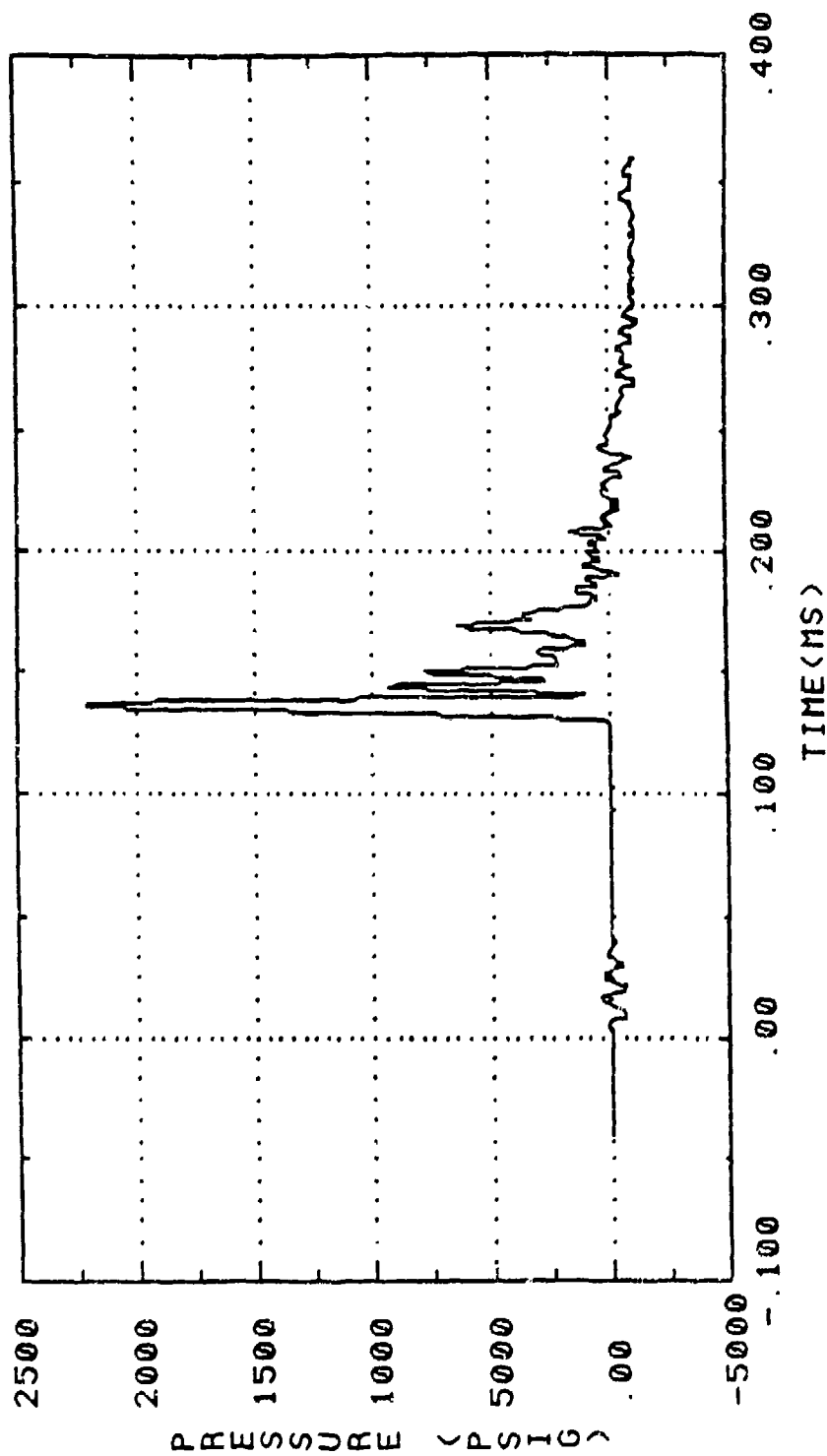


Figure A-47. Loads Test Data, "Test 5, LOC 10

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 2 LOC= 11 TEST=005

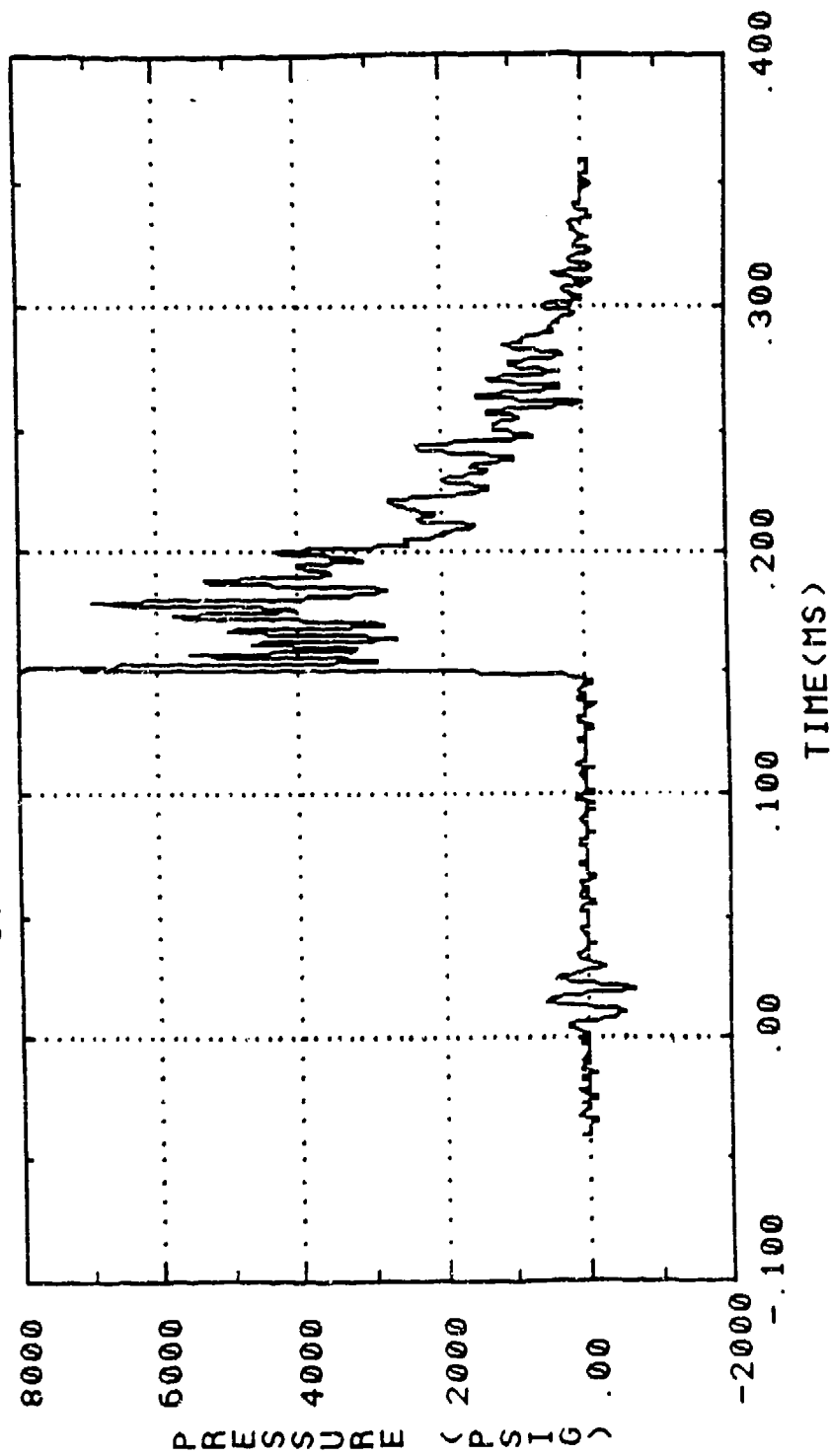


Figure A-48. Loads Test Data, Test 5, LOC 11

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC=10 LOC= 12 TEST=005

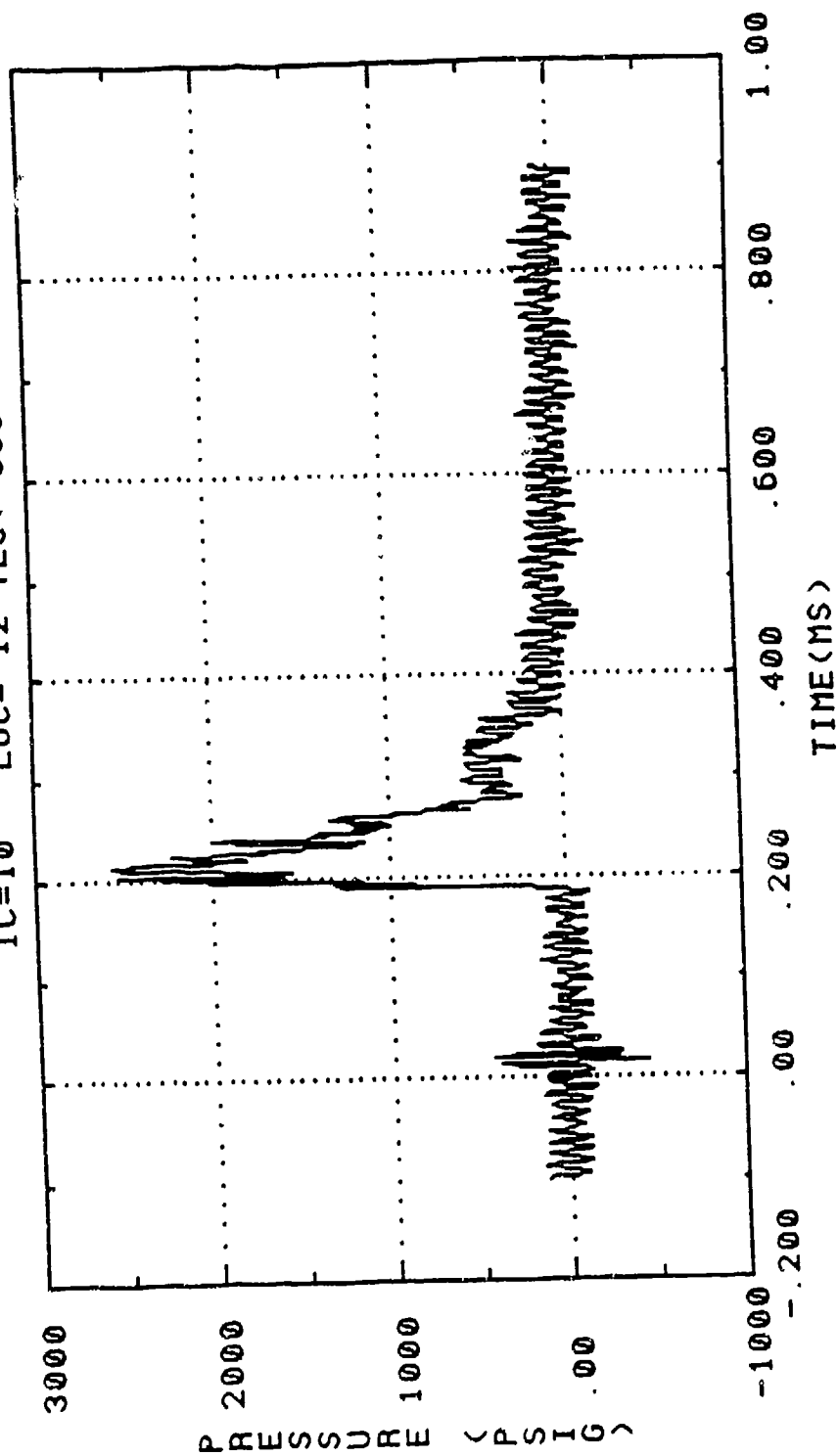


Figure A-49. Loads Test Data, "Test 5, LOC 12

## **APPENDIX B**

### **Test Data from Cased Charge Loads Tests**

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 3 LOC= 1 TEST=006

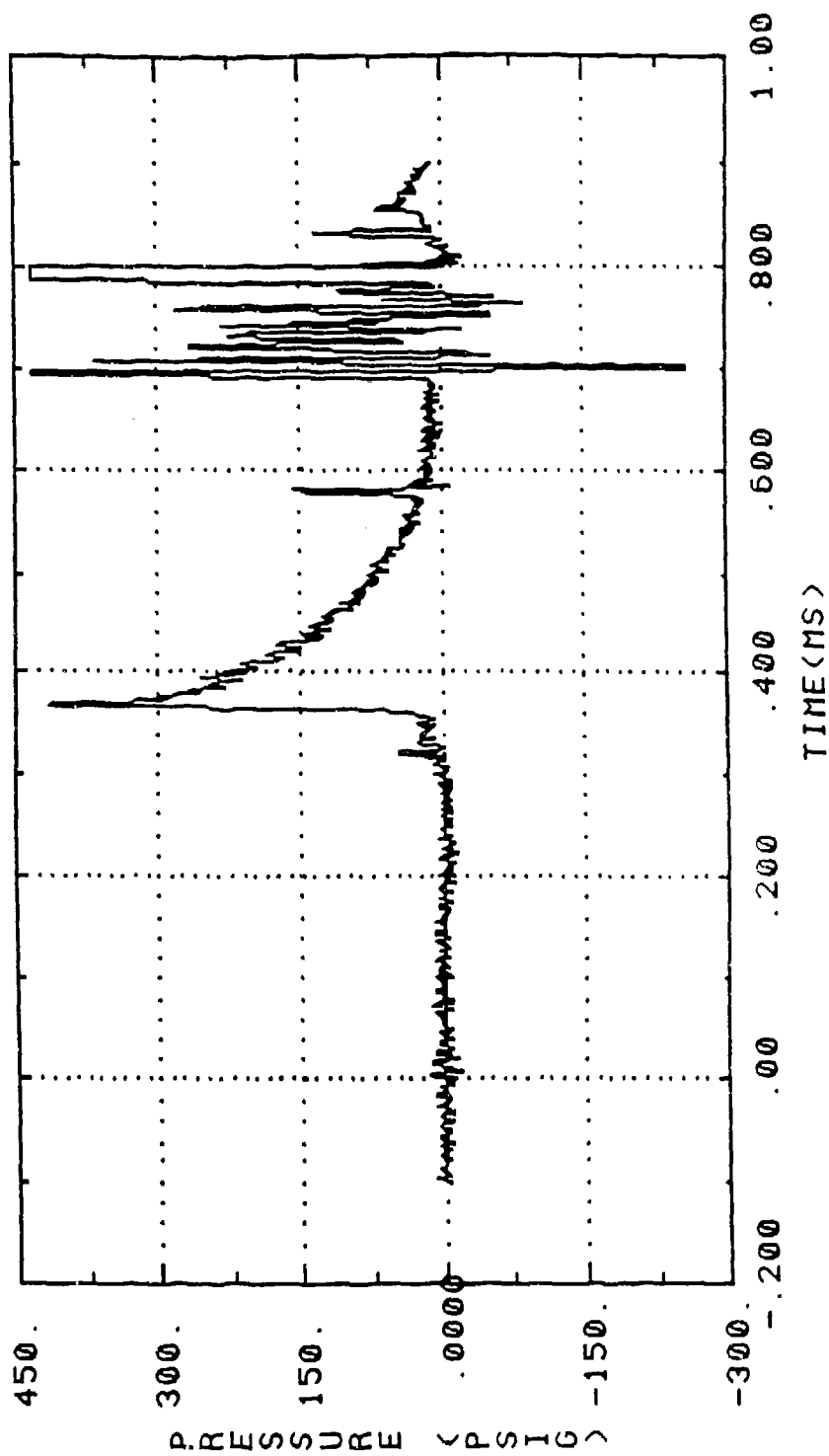


Figure B-1. Loads Test Data, Test 6, LOC 1

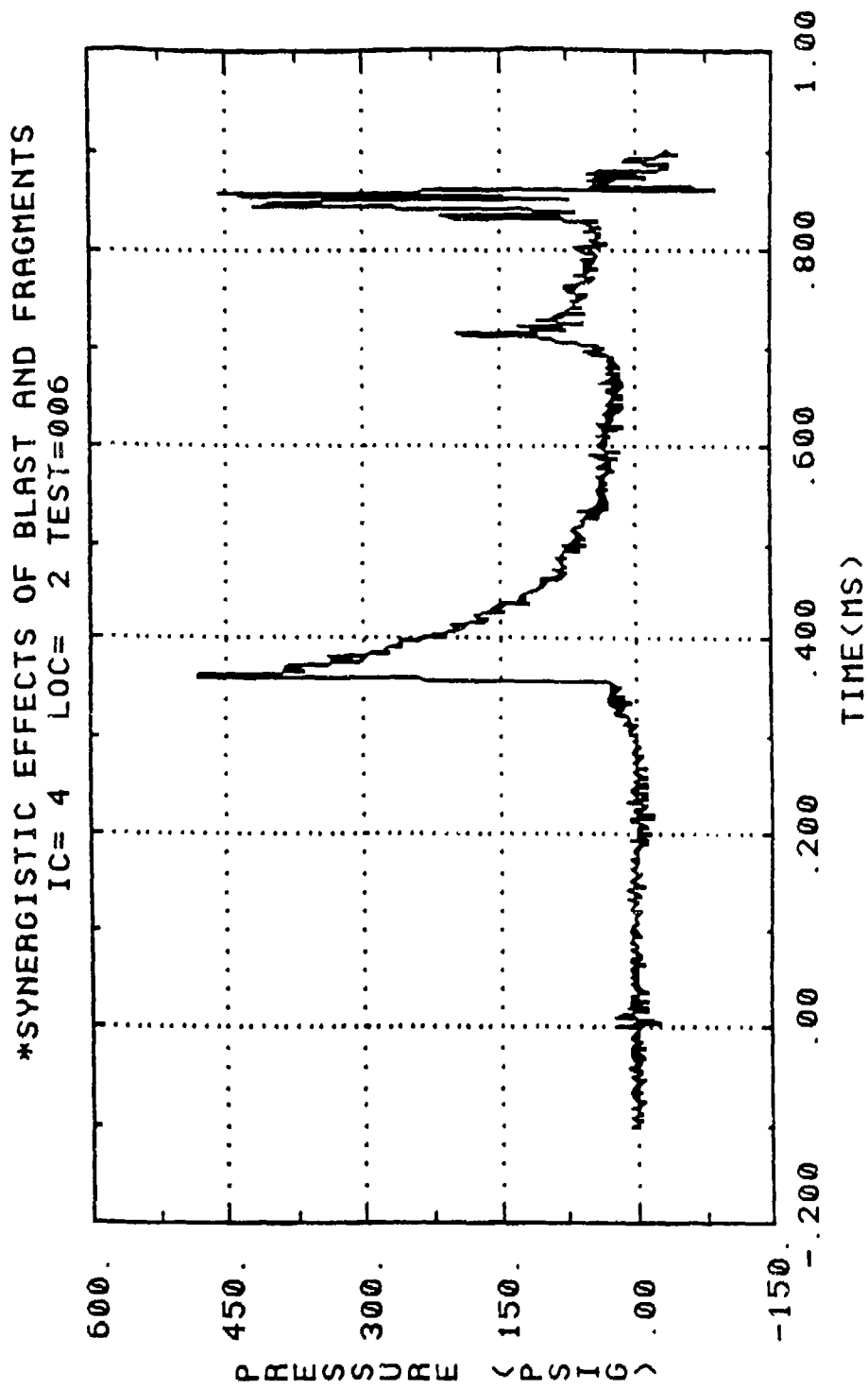


Figure B-2. Loads Test Data, "Test 6, LOC 2

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 1 LOC= 5 TEST=006

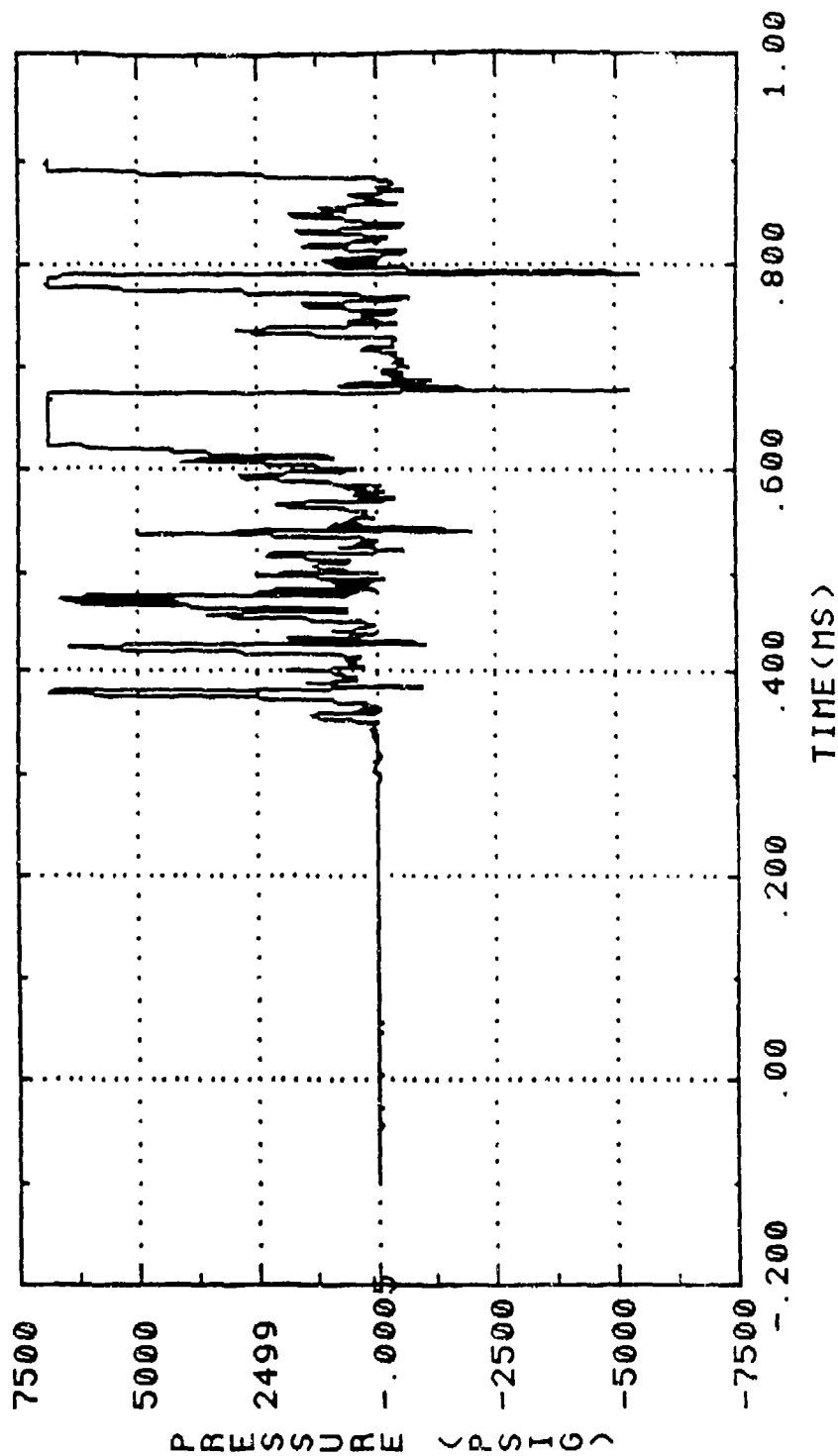


Figure B-3. Loads Test Data, Test 6, LOC 5

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 7 LOC= 6 TEST=006

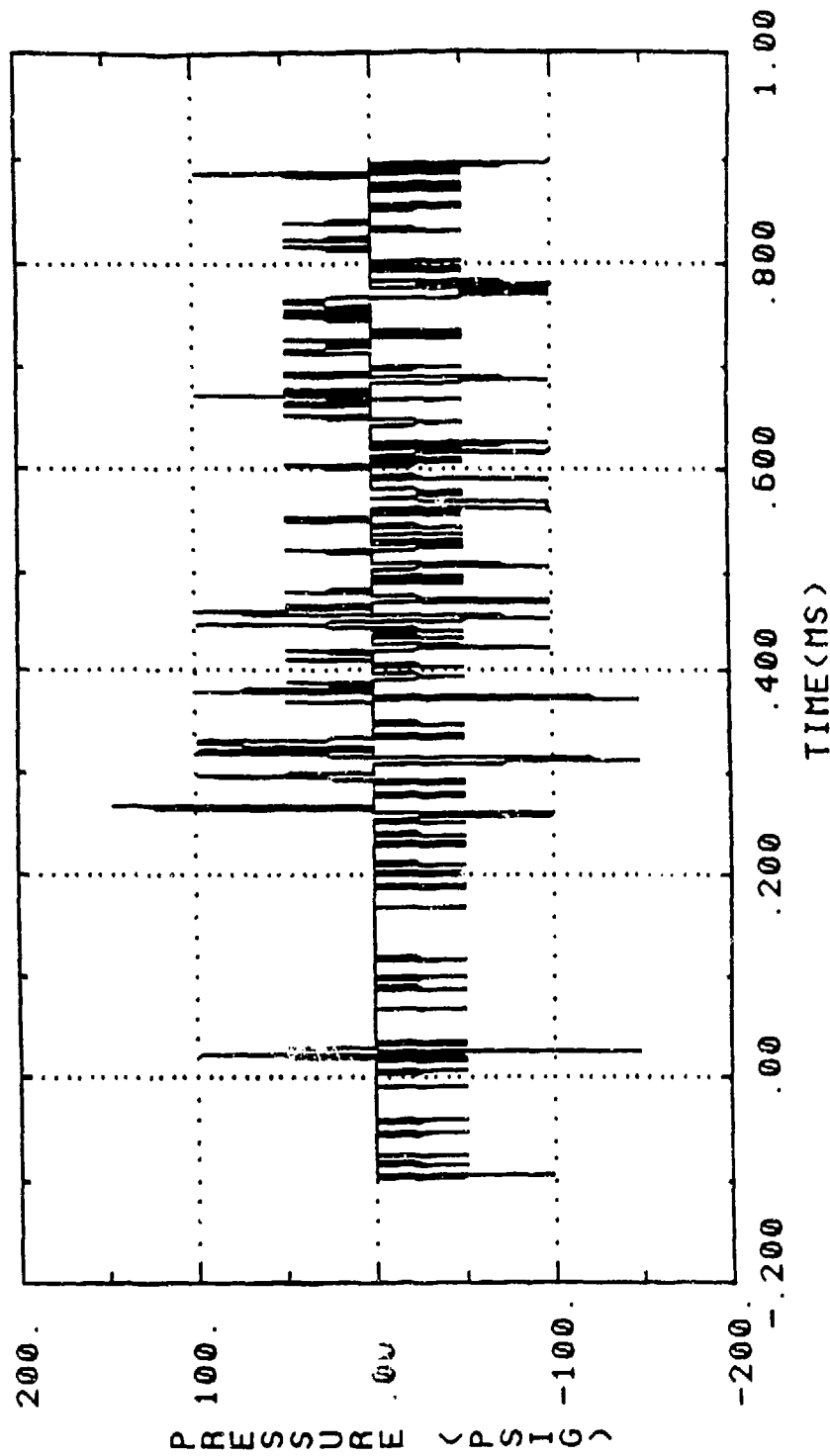


Figure B-4. Loads Test Data, "Test 6, LOC 6



\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 8 LOC= 7 TEST=006

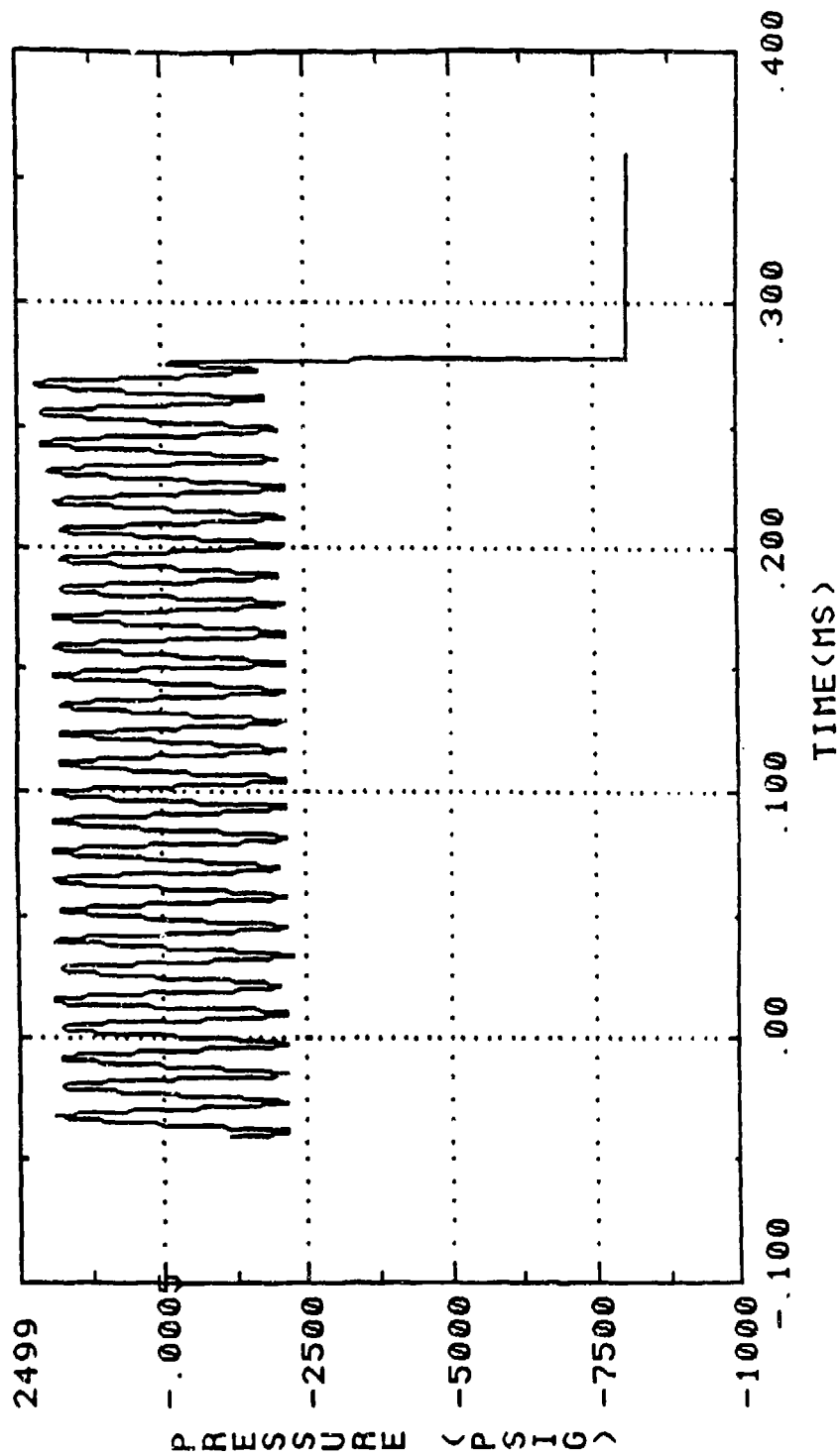


Figure B-5. Loads Test Data, Test 6, LOC 7

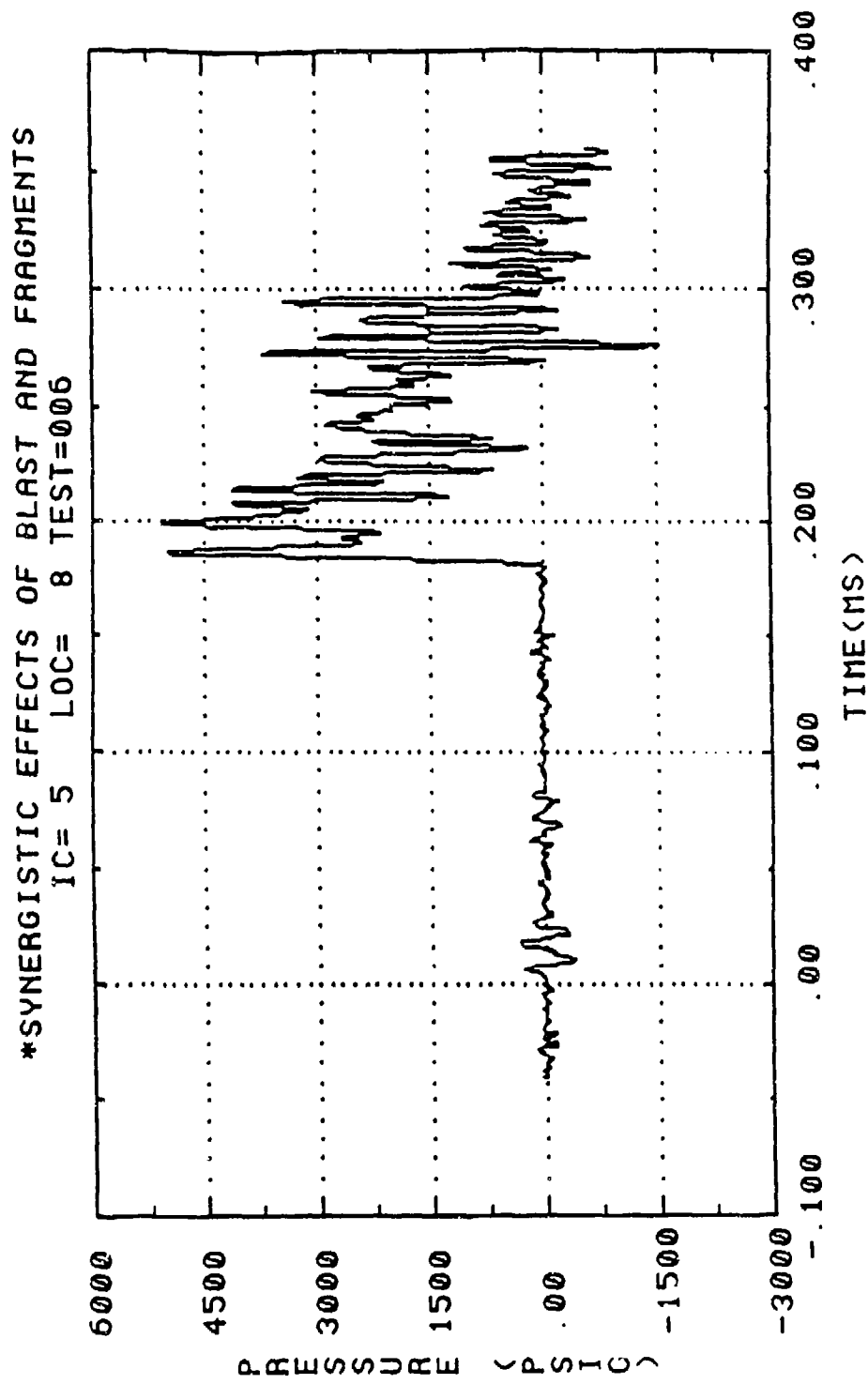


Figure B-6. Load's Test Data, Test 6, LOC 8

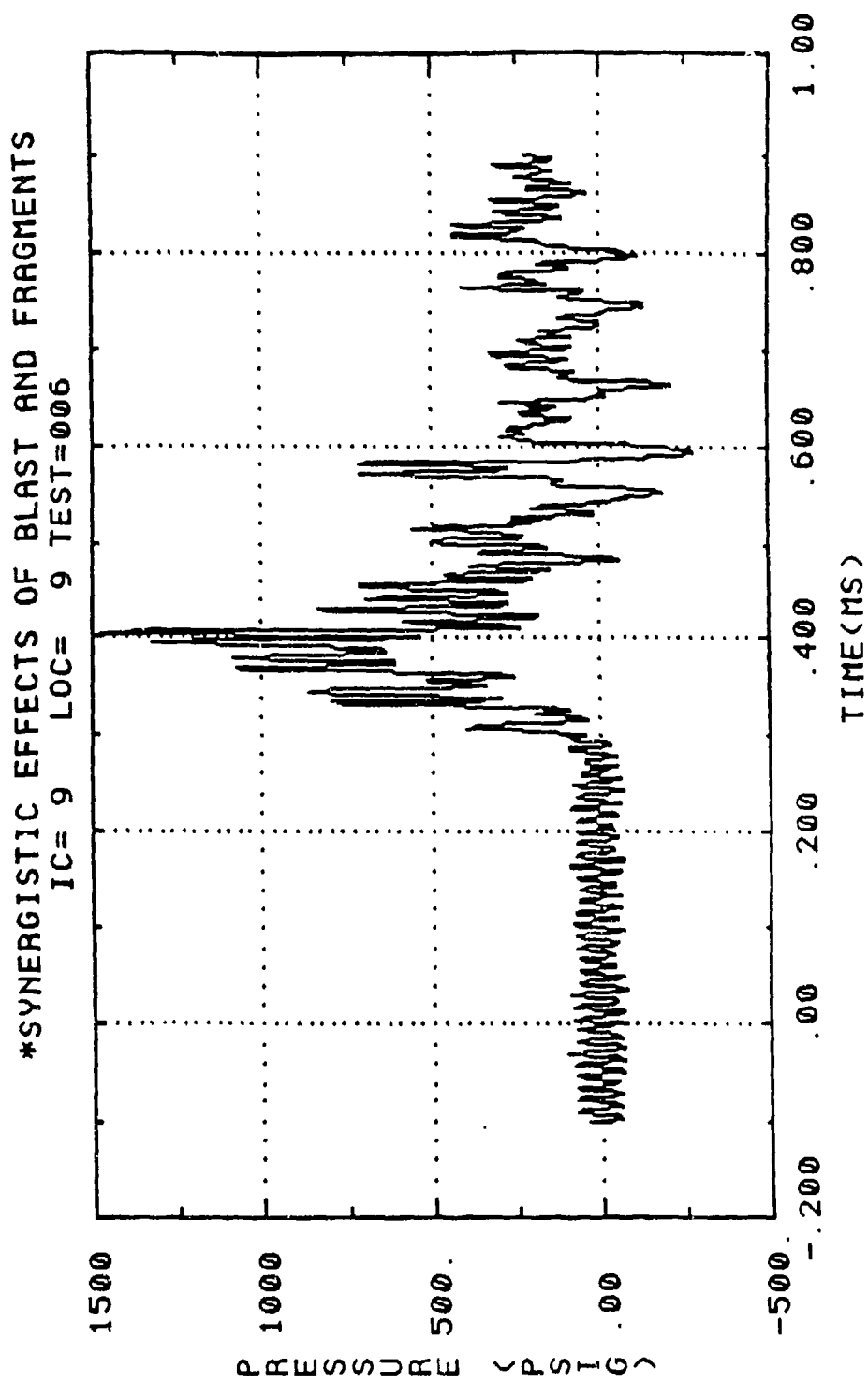


Figure B-7. Loads Test Data, Test 6, LOC 9

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 6 LOC= 10 TEST=006

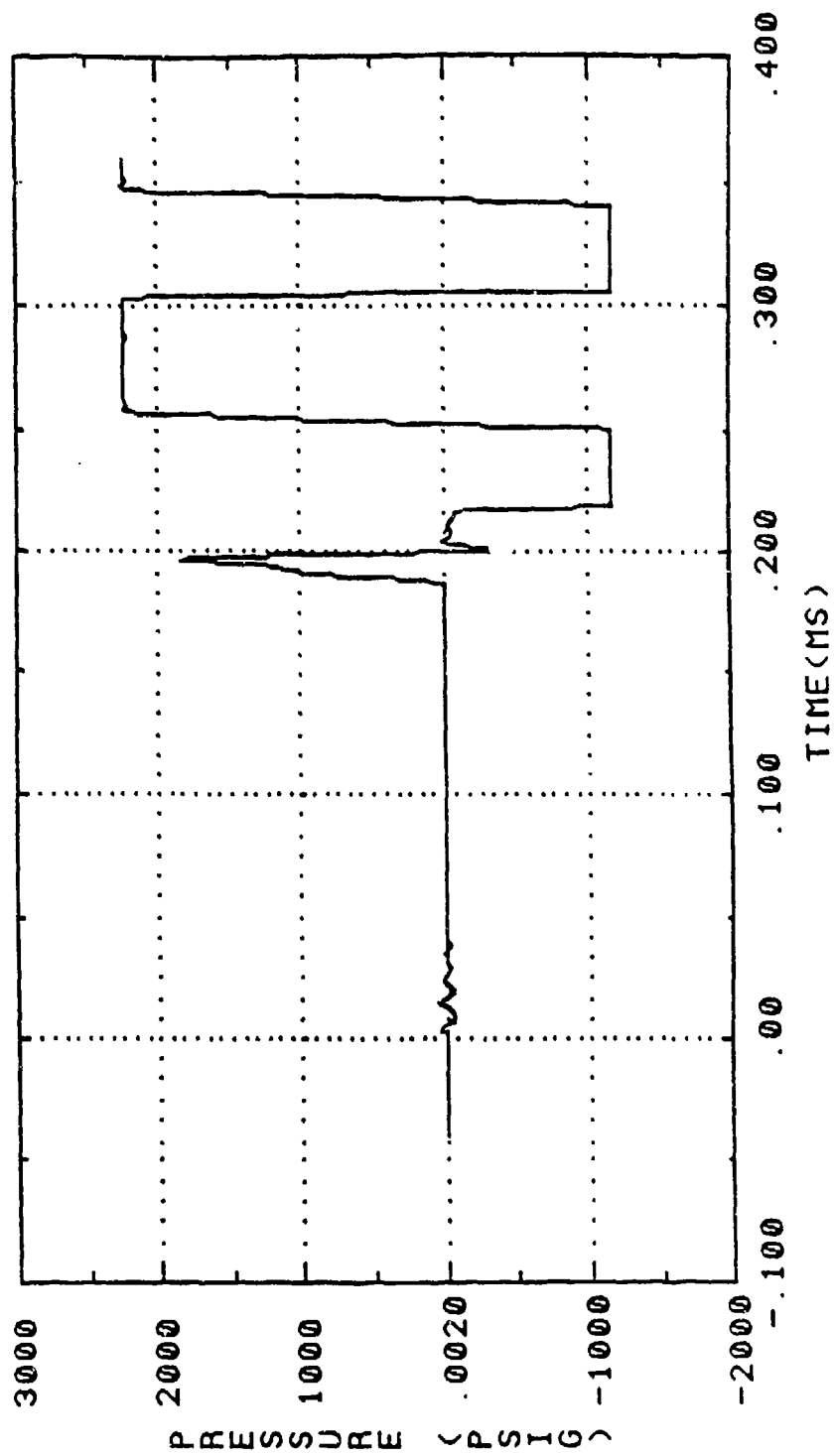


Figure B-8. Loads Test Data, Test 6, LOC 10

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 2 LOC= 11 TEST=006

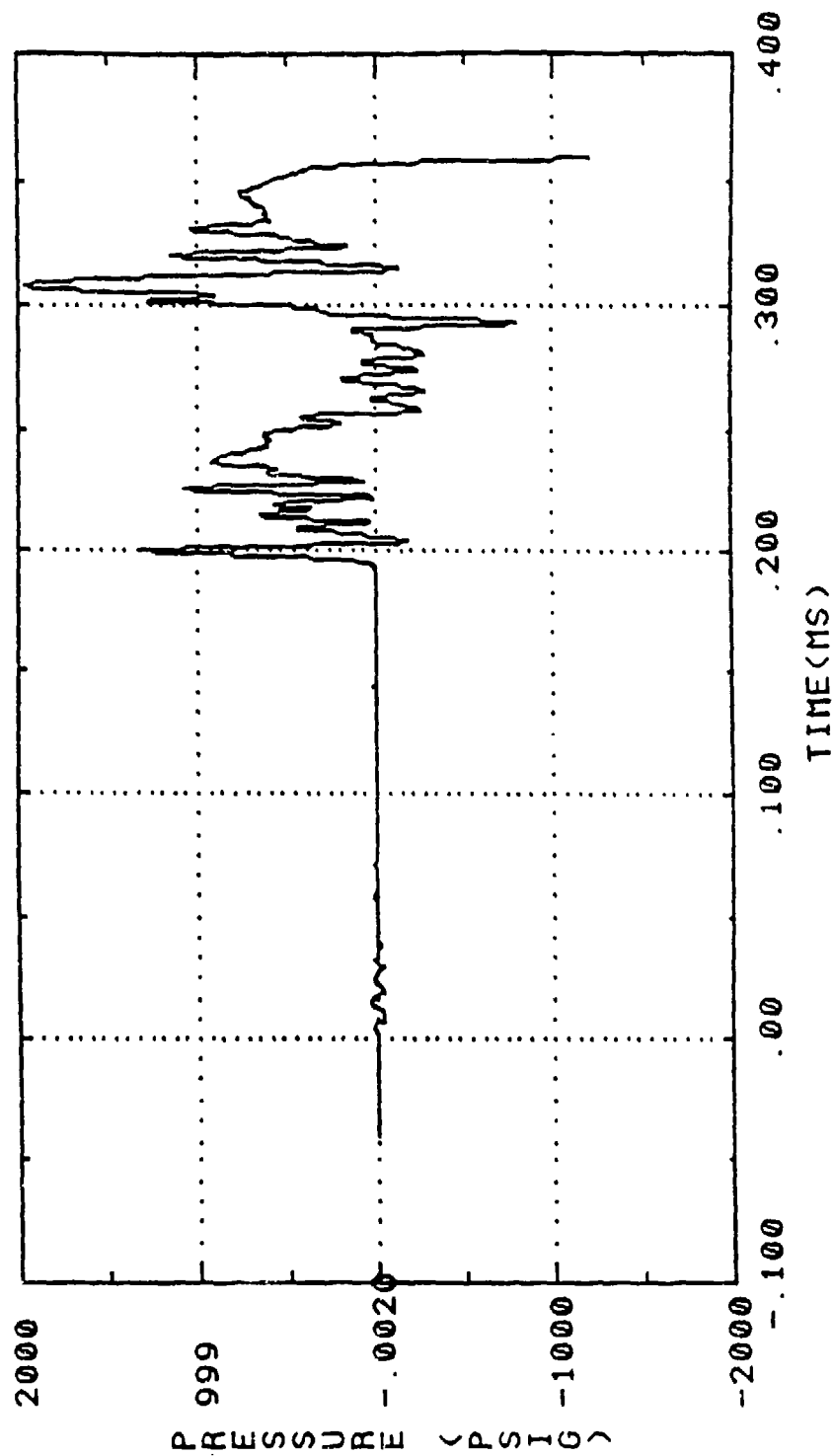


Figure B-9. Loads Test Data, Test 6, LOC 11

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC=10 LOC= 12 TEST=006

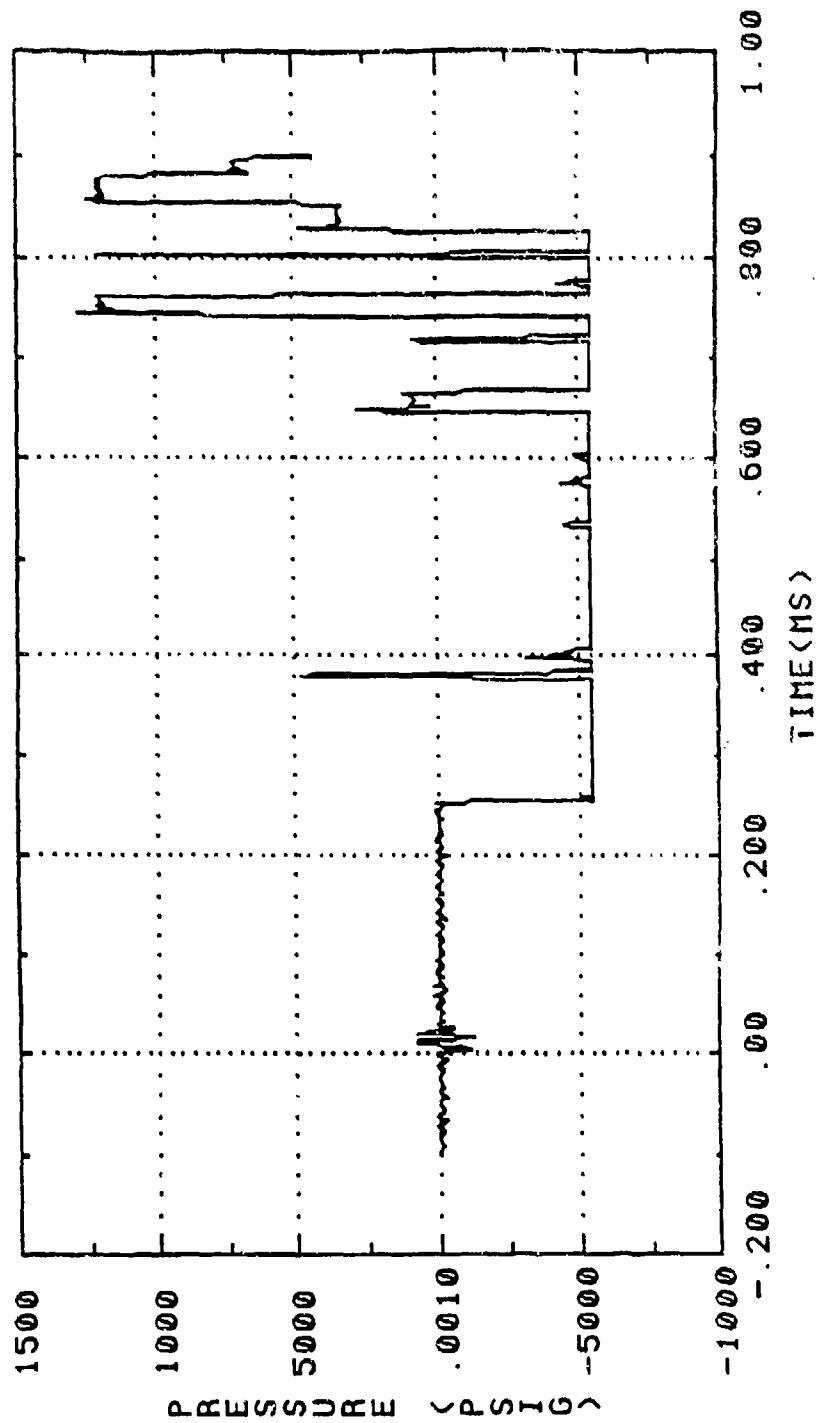


Figure B-10. Loads Test Data, Test 6, LOC 12

# TEST 7 LOC 1

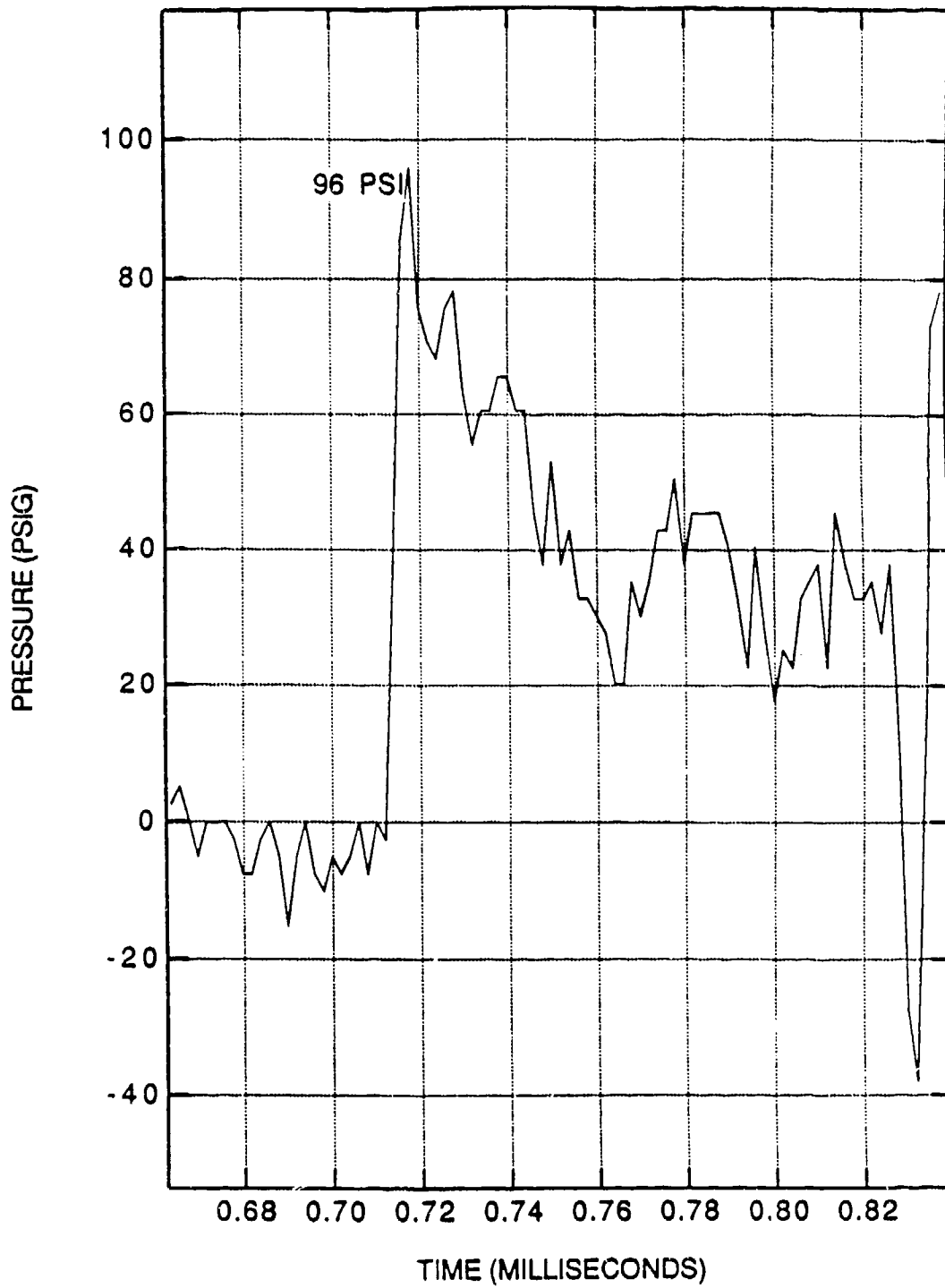


Figure B-11. Loads Test Data, Test 7, LOC 1

# TEST 7 LOC 2

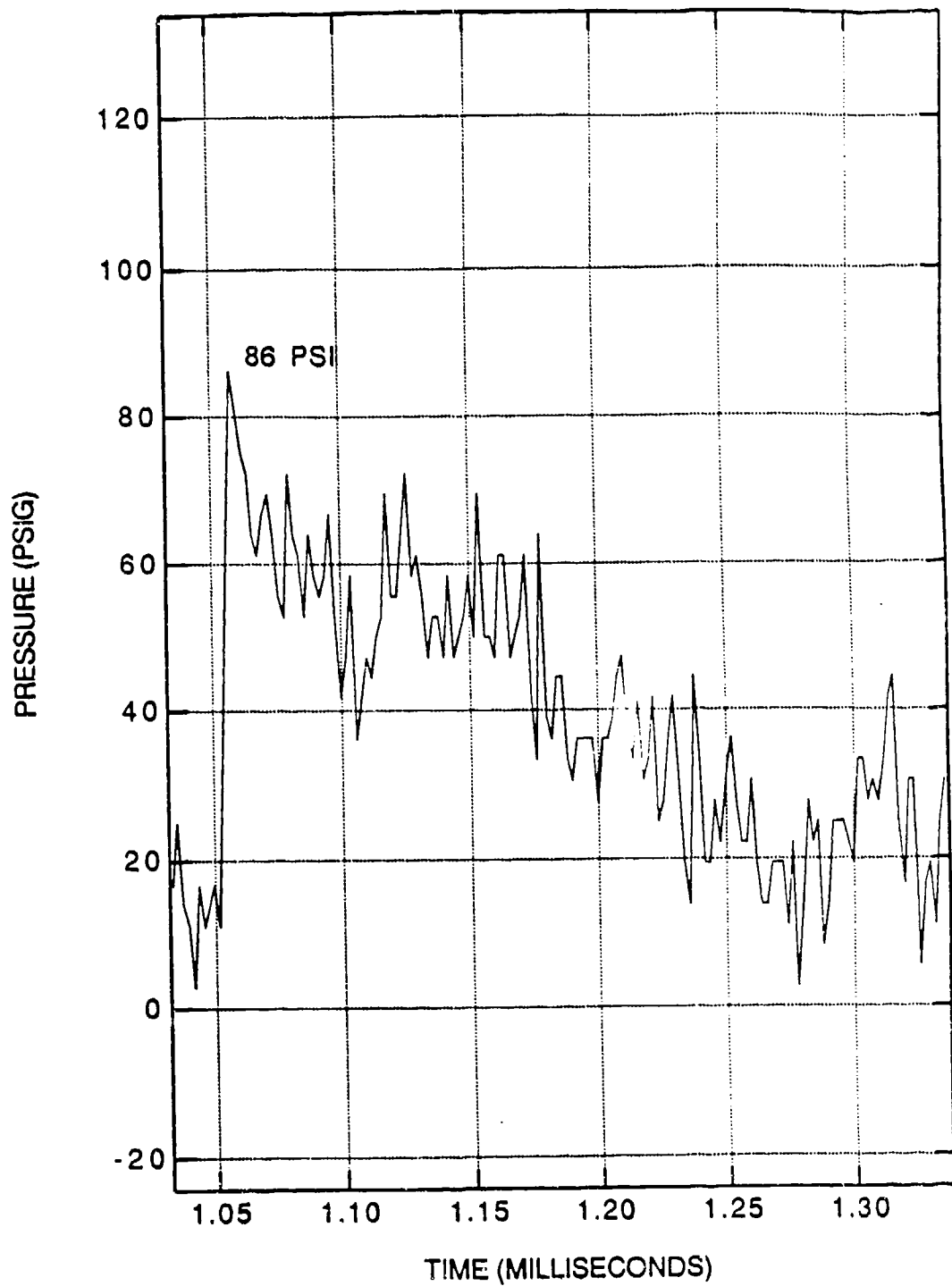


Figure B-12. Loads Test Data, Test 7, LOC 2



\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 1 LOC= 1 TEST=008

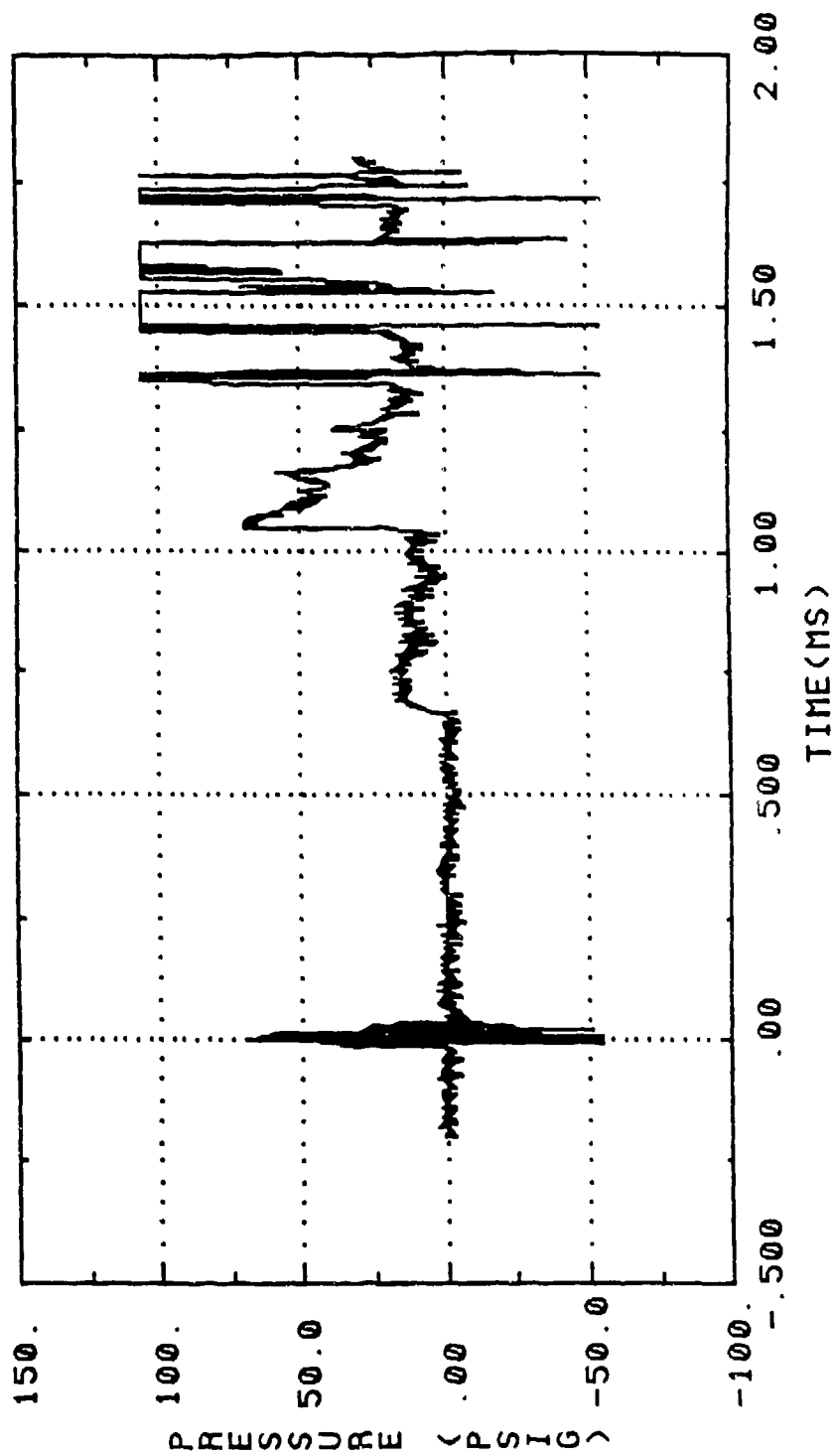


Figure B-13. Loads Test Data, "Test 8, LOC 1

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 2 LOC= 2 TEST=008

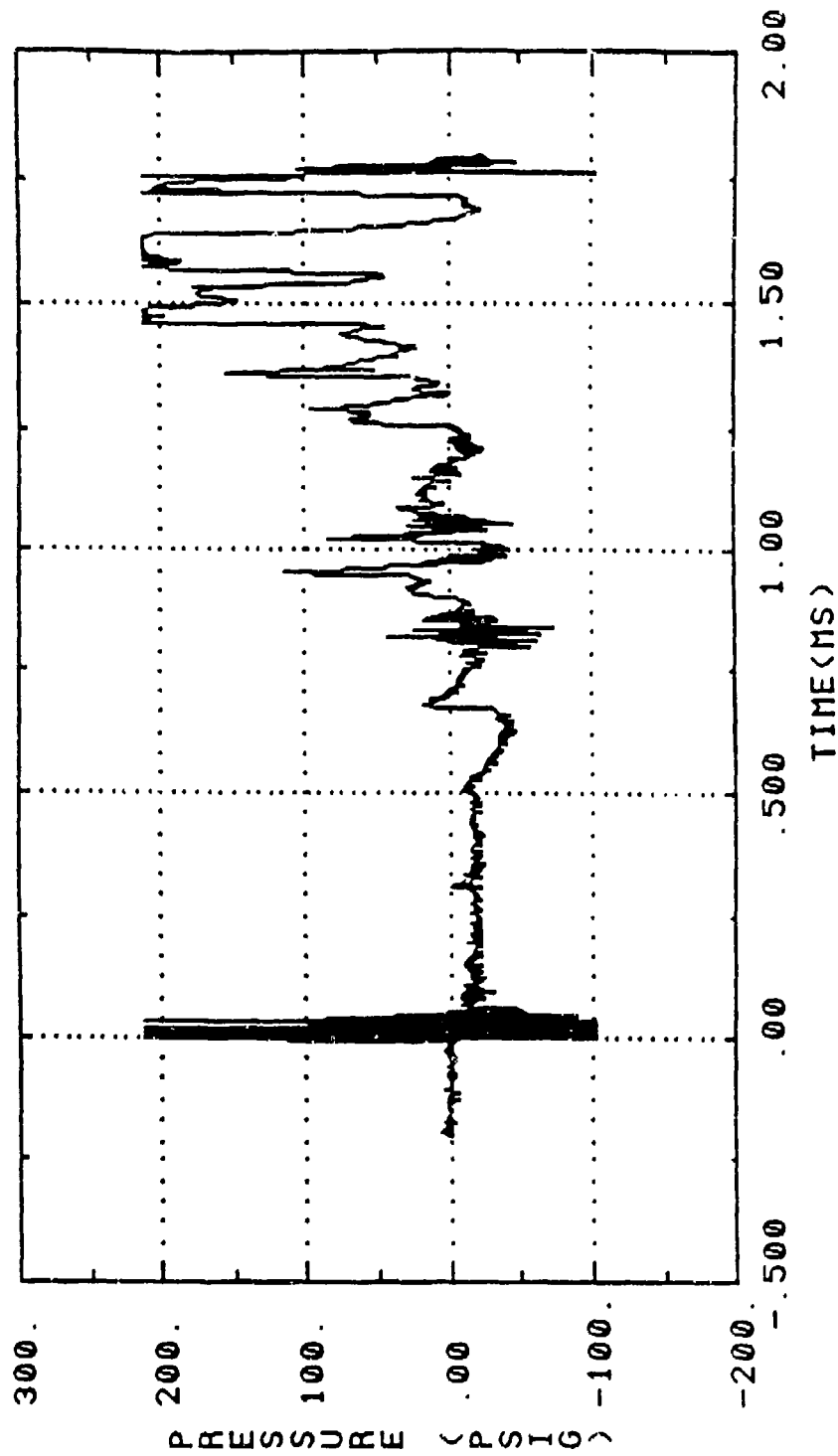


Figure B-14. Loads Test Data, Test 8, LOC 2

## **APPENDIX C**

### **Test Data from Panel Tests**

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 1 LOC= 1 TEST=013

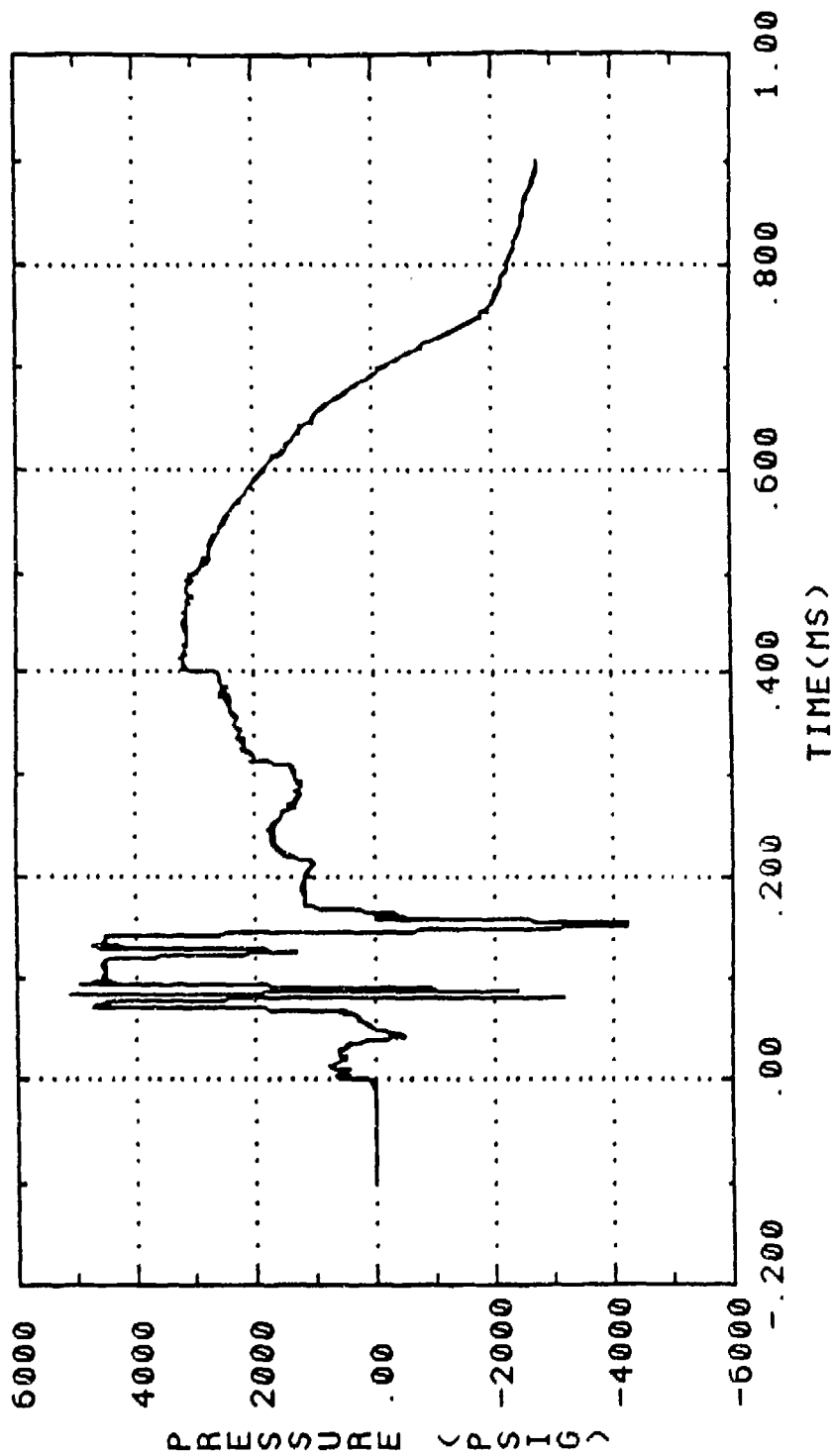


Figure C-1. Loads Test Data, Test 13, LOC 1

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 3 LOC= 2 TEST=013

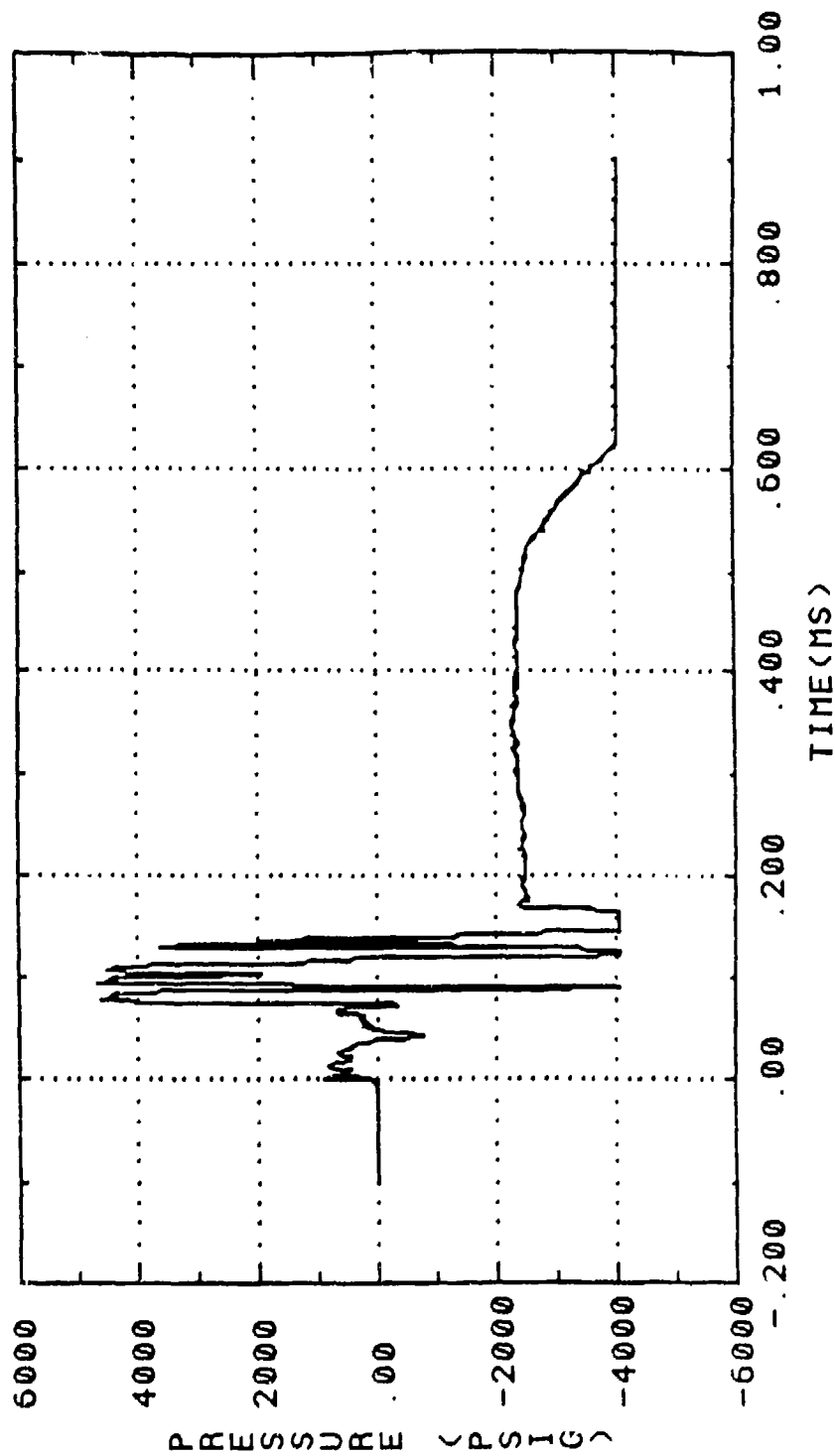


Figure C-2. Loads Test Data, Test 13, LOC 2

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 5 LOC= 3 TEST=013

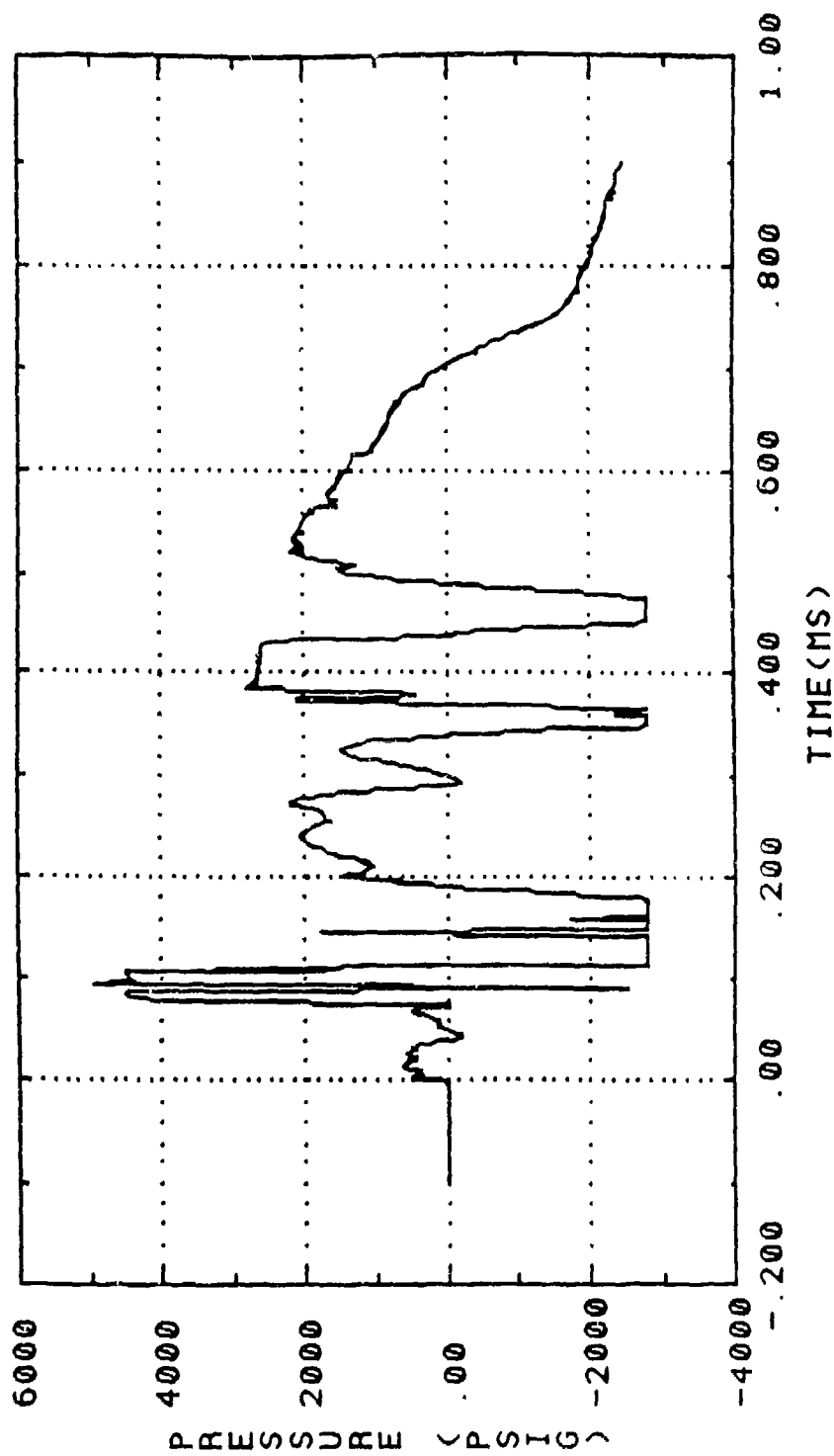


Figure C-3. Loads Test Data, Test 13, LOC 3

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 7 LOC= 4 TEST=013

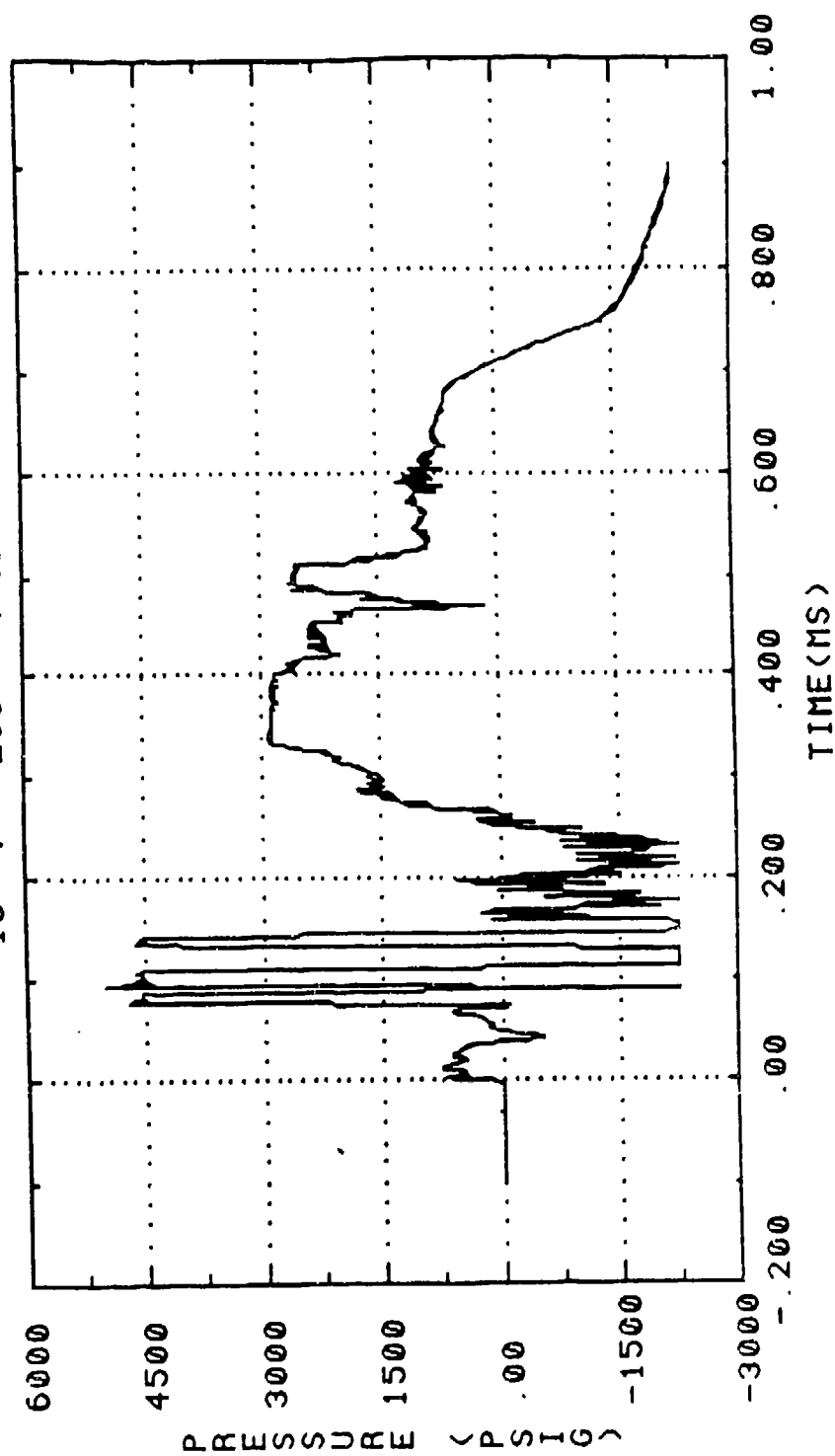


Figure C-4. Loads Test Data, Test 13, LOC 4

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 9 LOC= 5 TEST=013

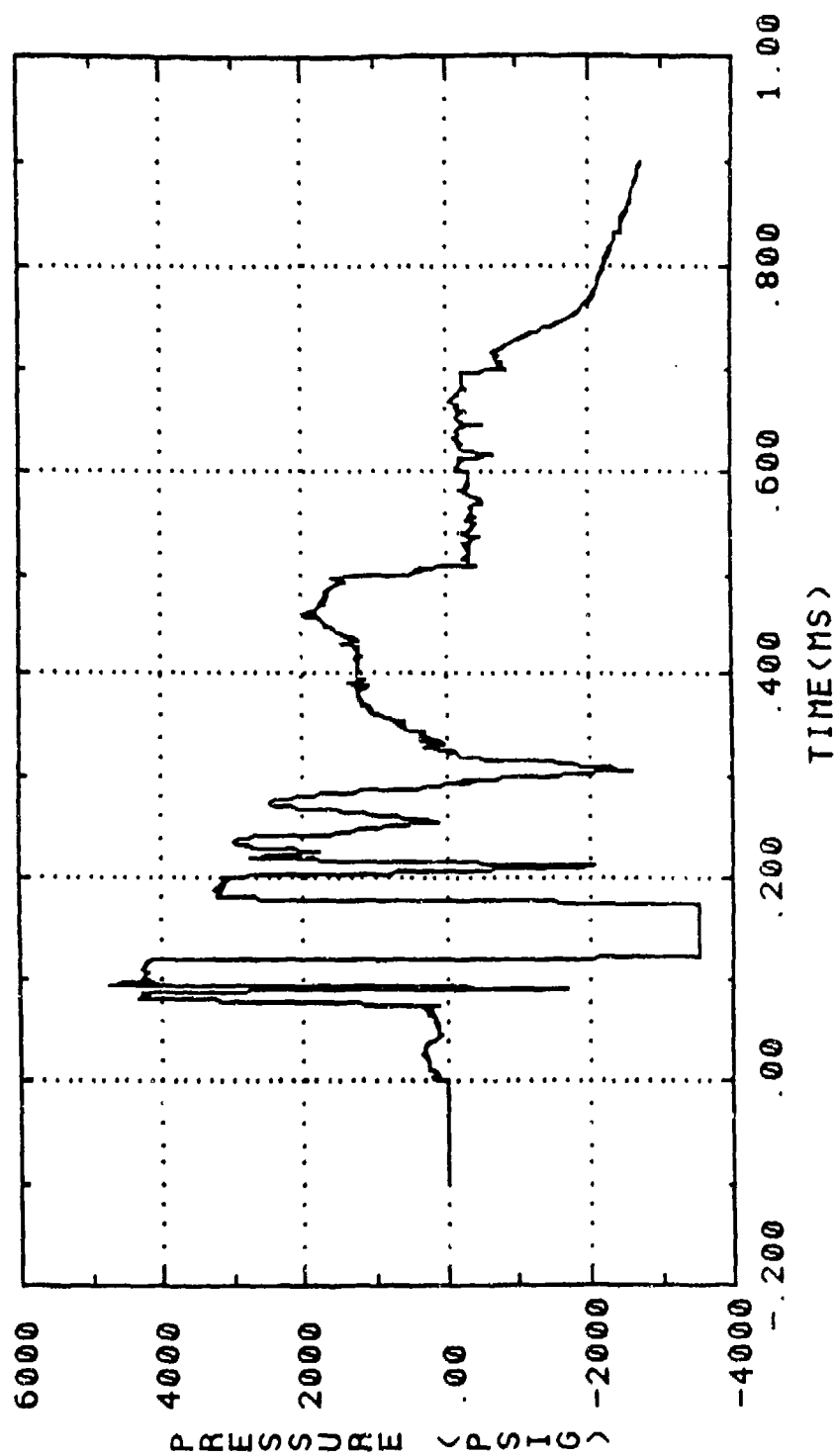


Figure C-5. Loads Test Data, Test 13, LOC 5



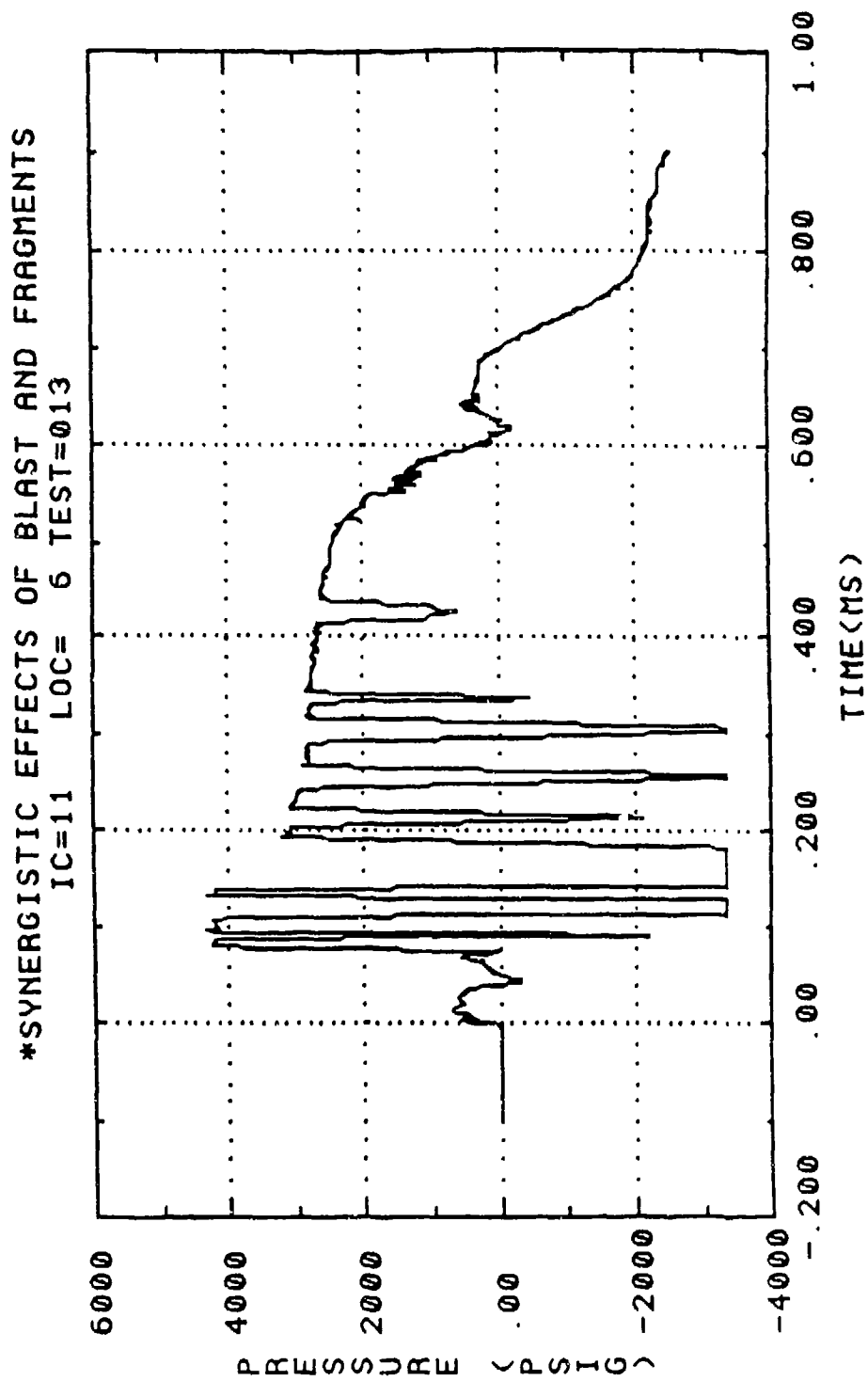


Figure C-6. Loads Test Data, Test 13, LOC 6

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC=13 LOC= 7 TEST=013

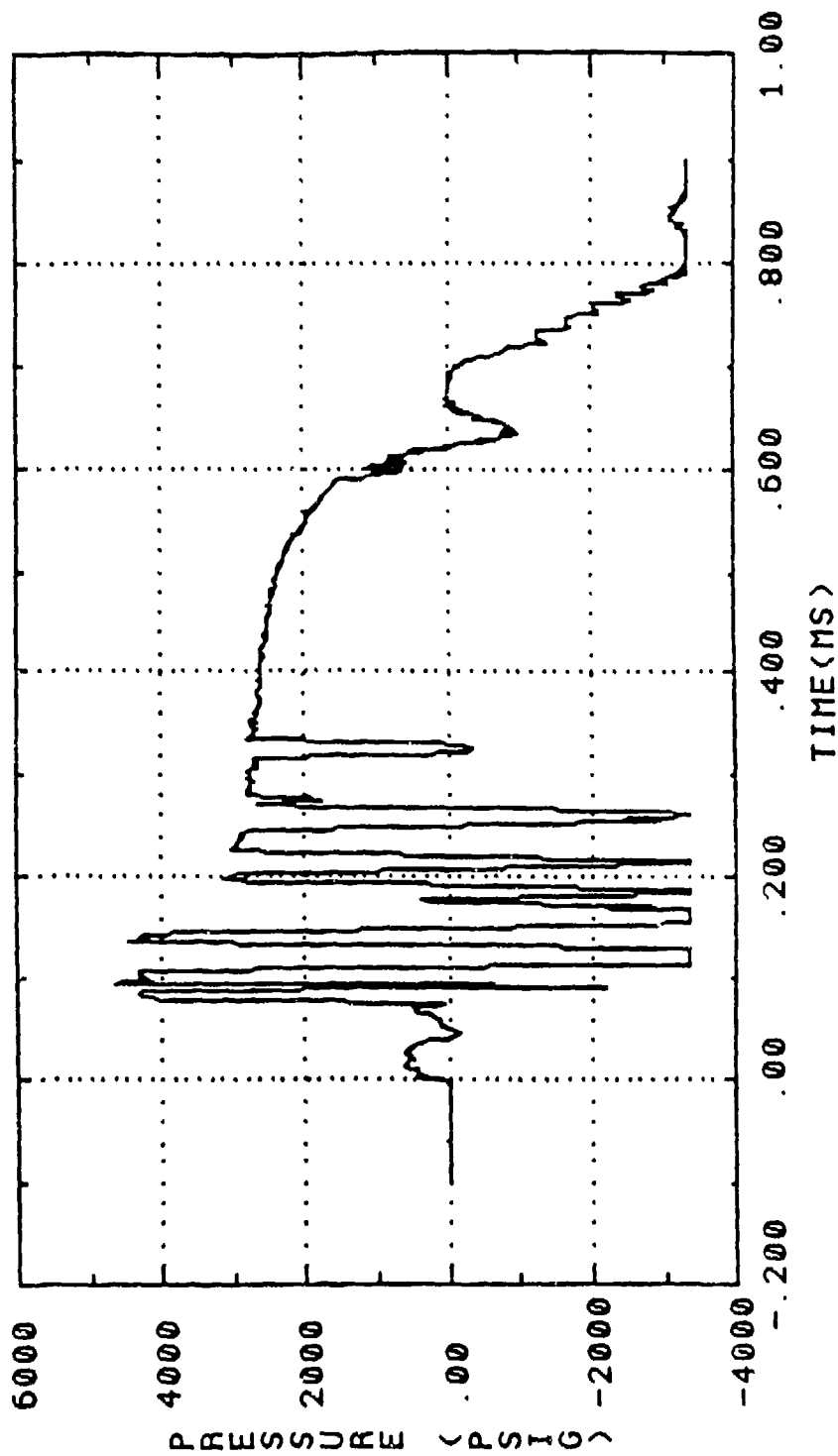


Figure C-7. Loads Test Data, Test 13, LOC 7

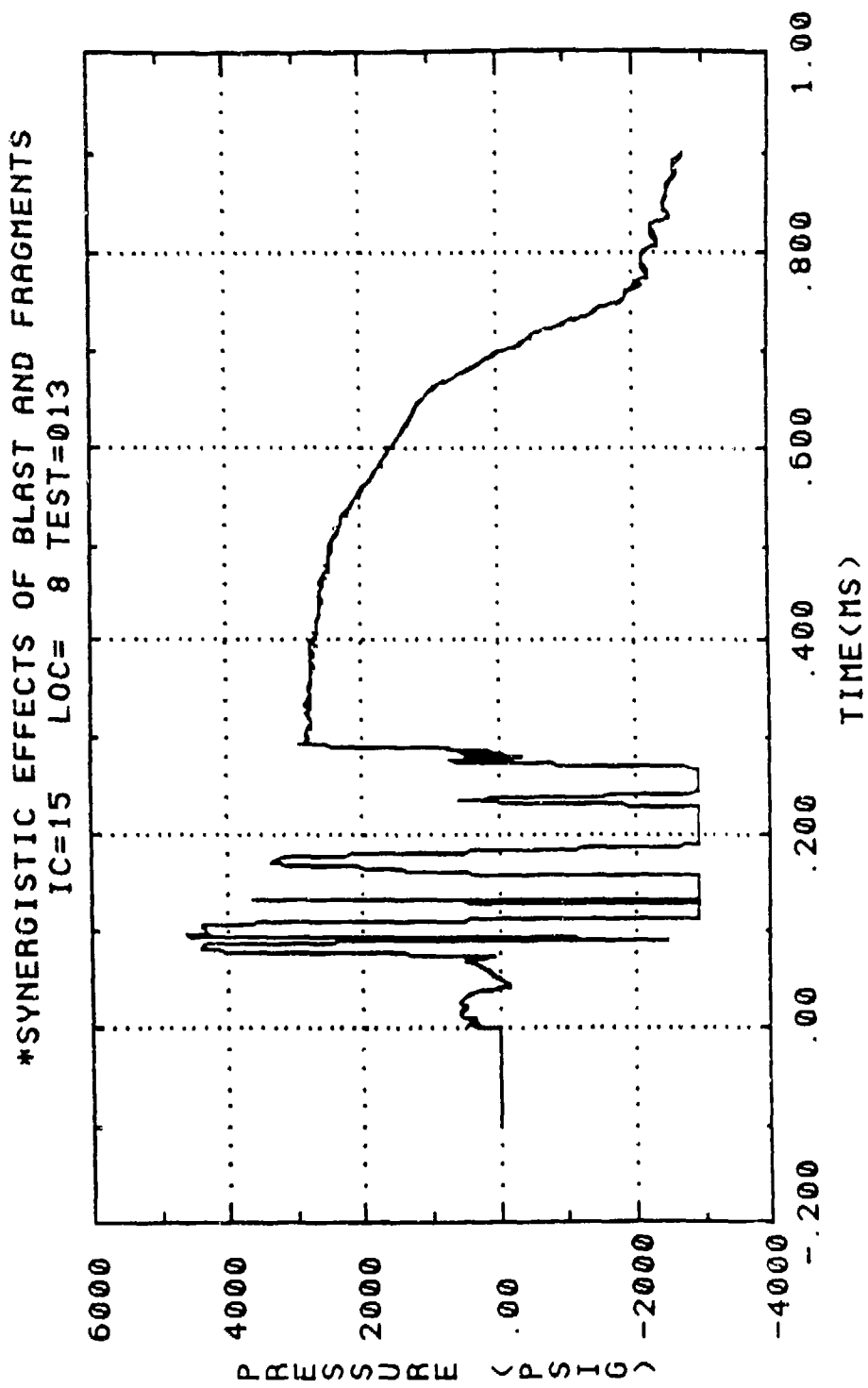


Figure C-8. Loads Test Data, Test 13, LOC 8

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 4 LOC= 9 TEST=013

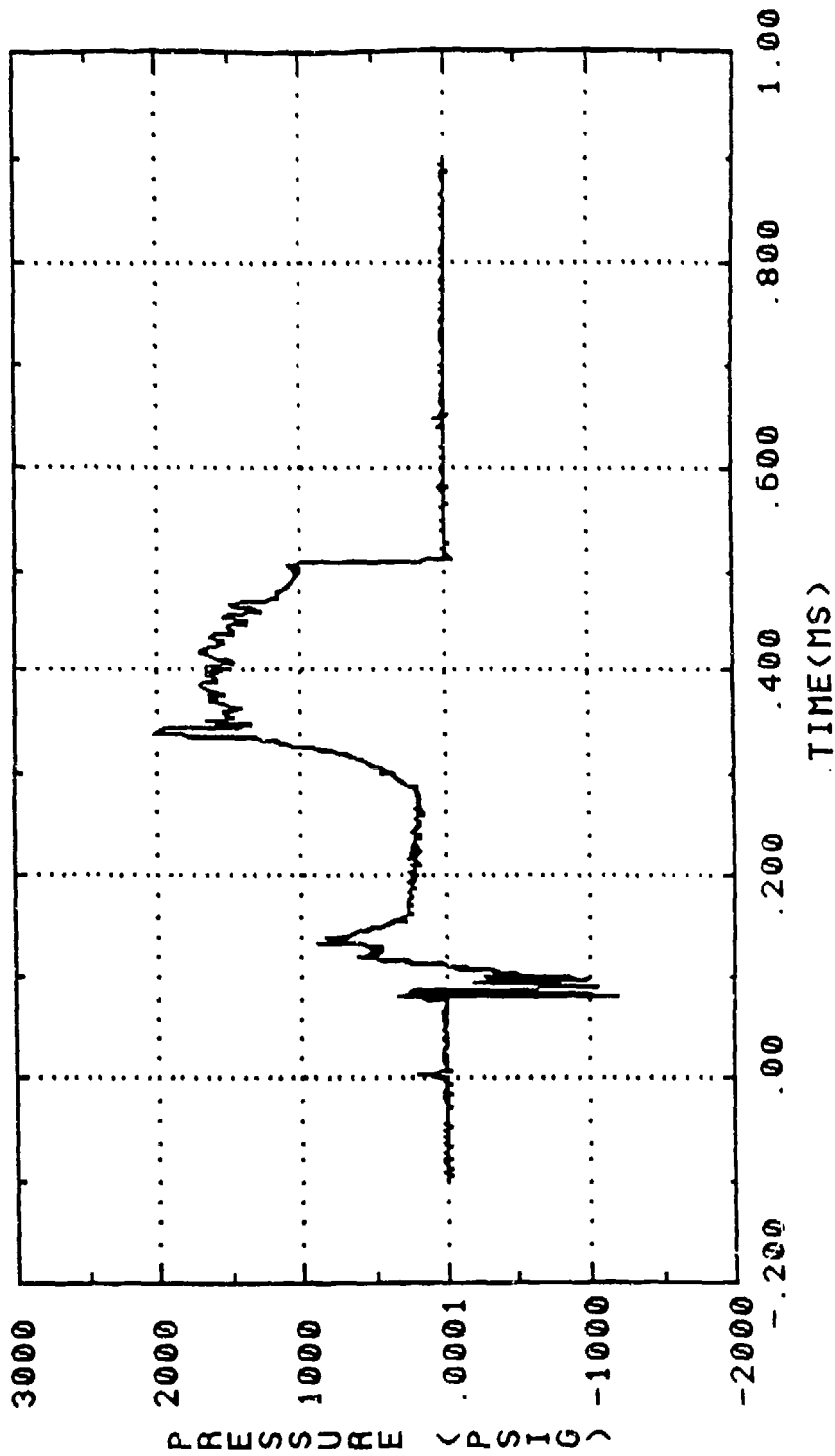


Figure C-9. Loads Test Data, Test 13, LOC 9

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 6 LOC= 10 TEST=013

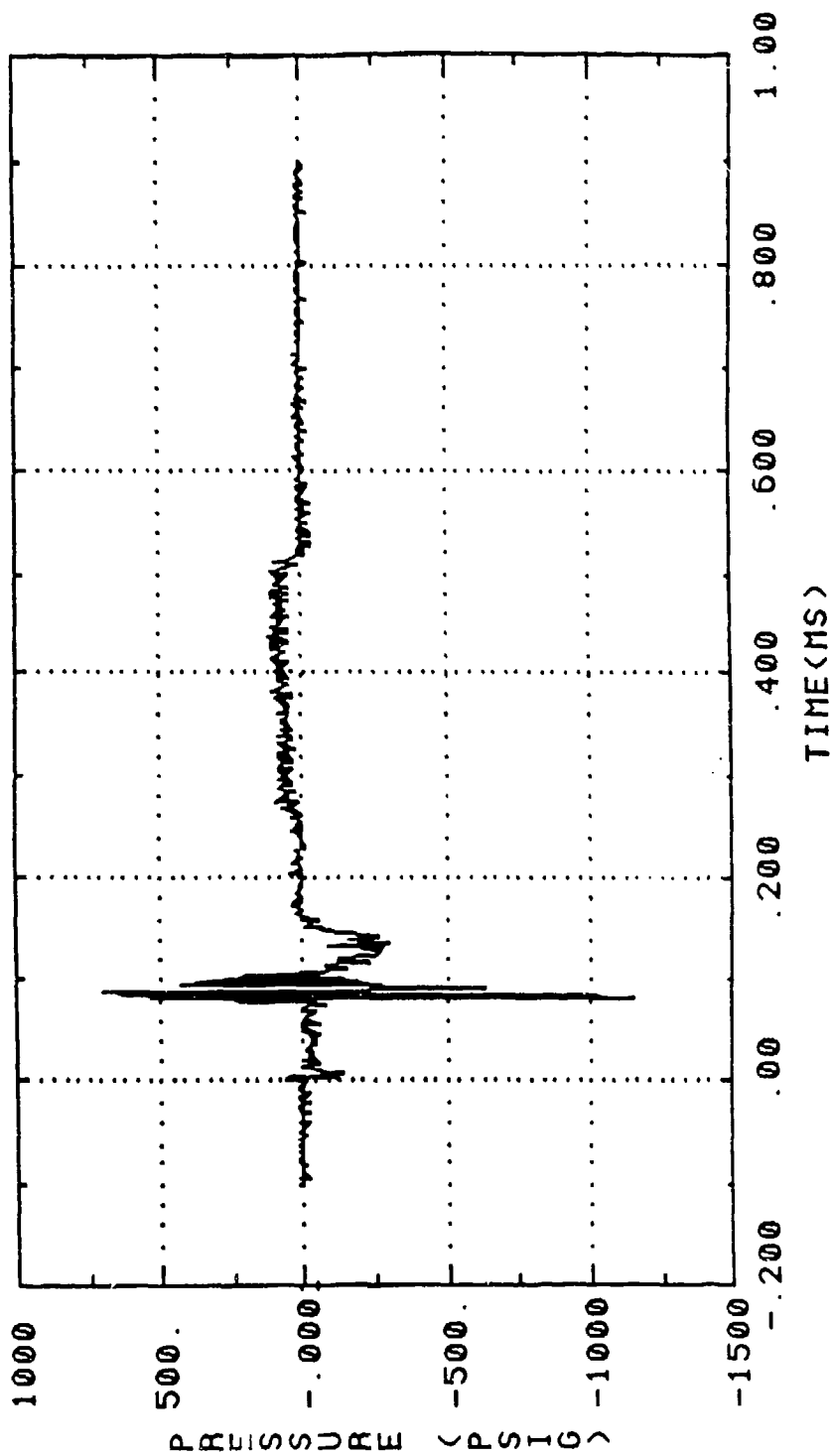


Figure C-10. Loads Test Data, Test 13, LOC 10

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 8 LOC= 11 TEST=013

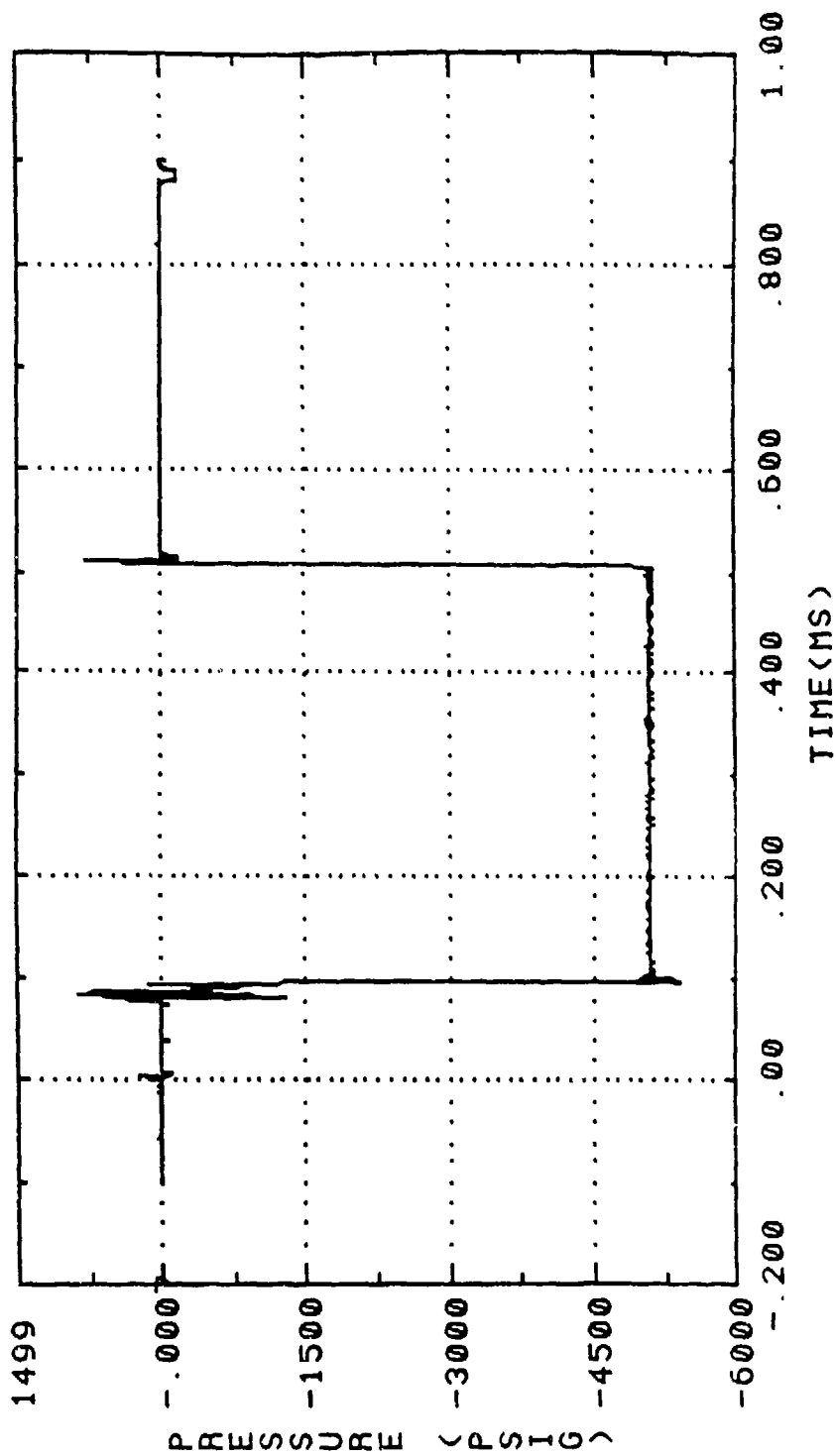


Figure C-11. Loads Test Data, Test 13, LOC 11

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC=10 LOC= 12 TEST=013

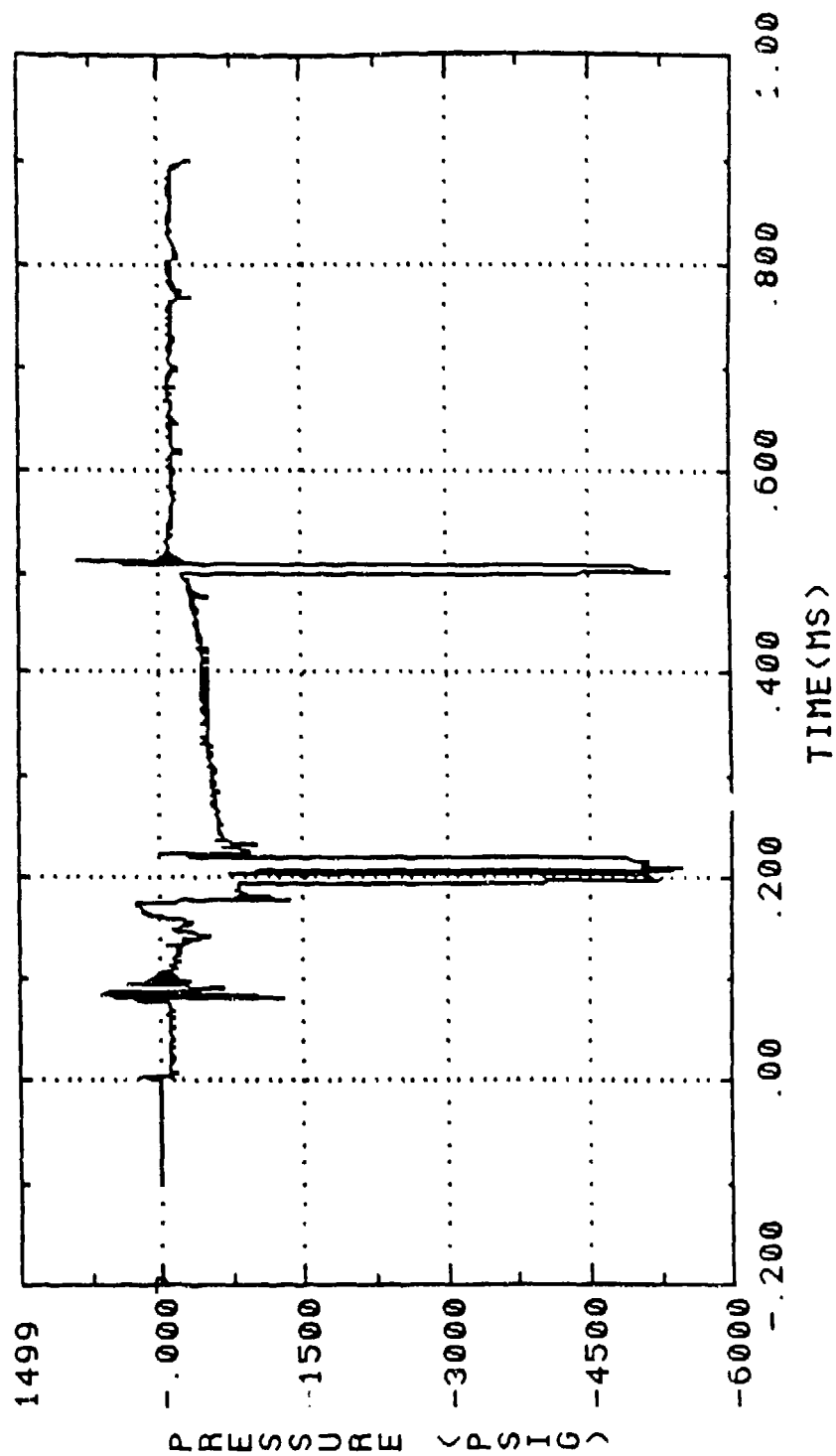


Figure C-12. Loads Test Data, Test 13, LOC 12

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 1 LOC= 1 TEST=914

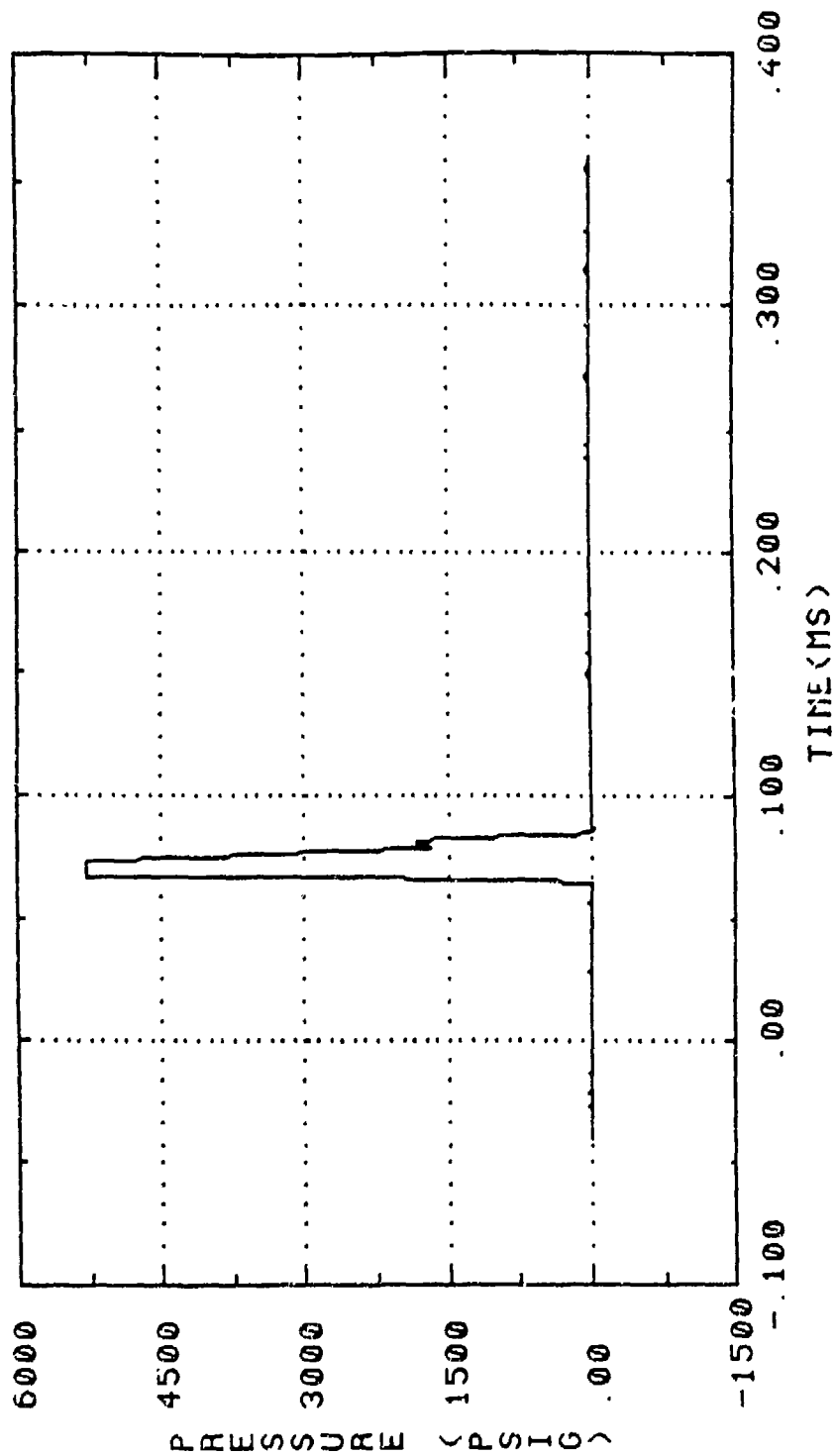


Figure C-13. Loads Test Data, Test 914, LOC 1



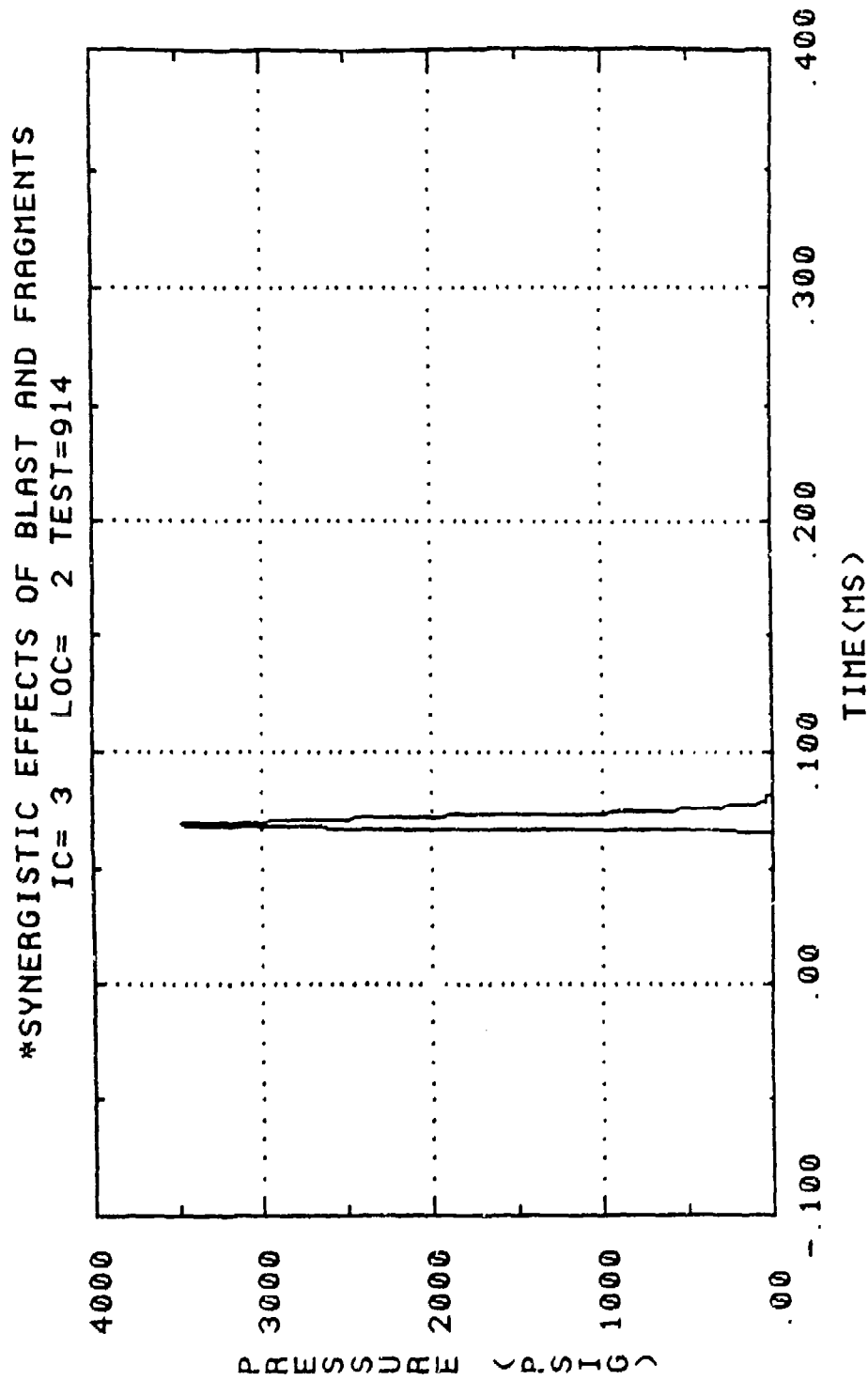


Figure C-14. Loads Test Data, Test 914, LOC 2

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 5 LOC= 3 TEST=914

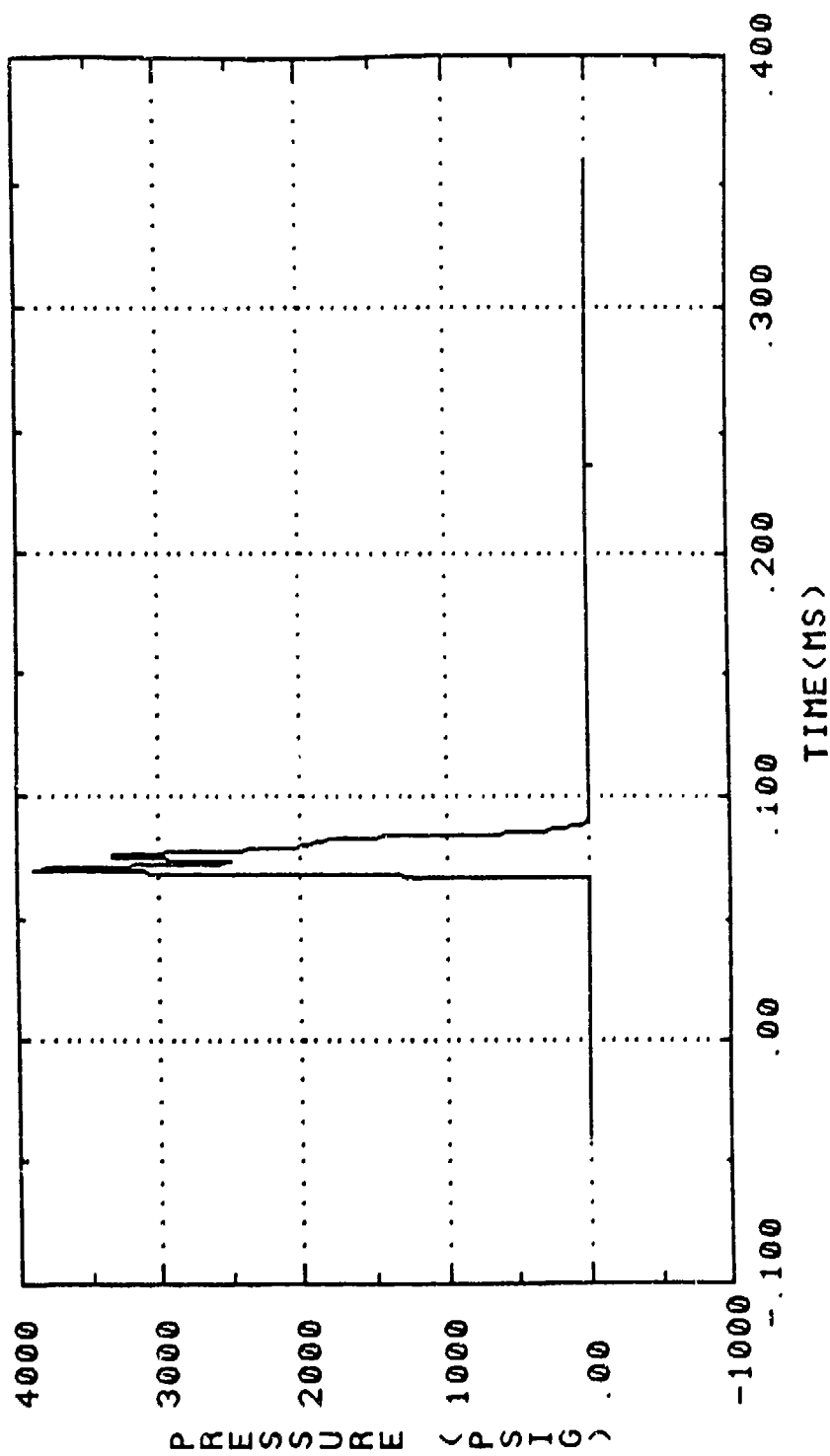


Figure C-15. Loads Test Data, Test 914, LOC 3

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 7 LOC= 4 TEST=914

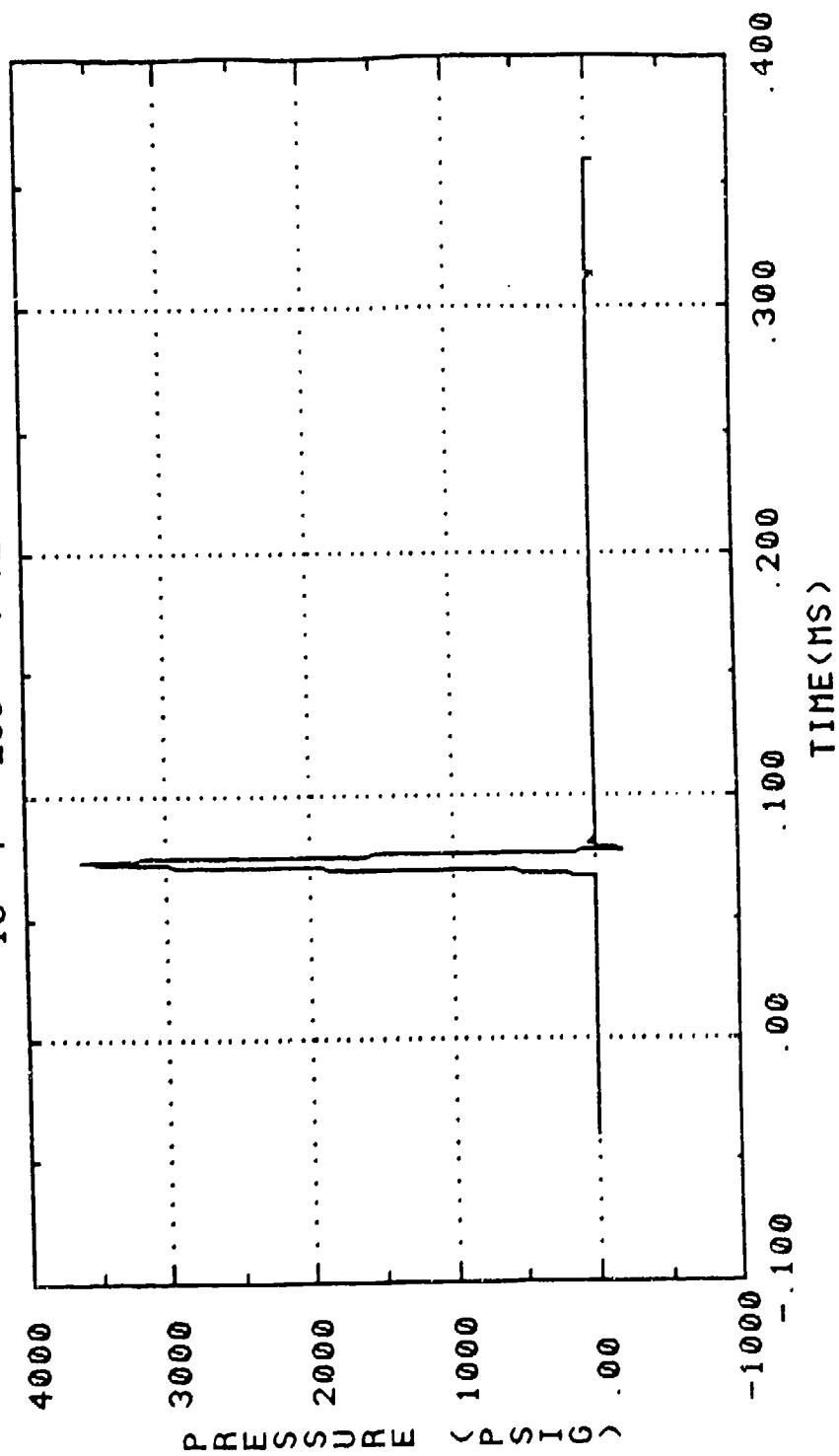


Figure C-16. Loads Test Data, Test 914, LOC 4

\*SYNERGISTIC EFFECTS OF BLAST AND FRGMENTS  
 IC= 9 LOC= 5 TEST=014

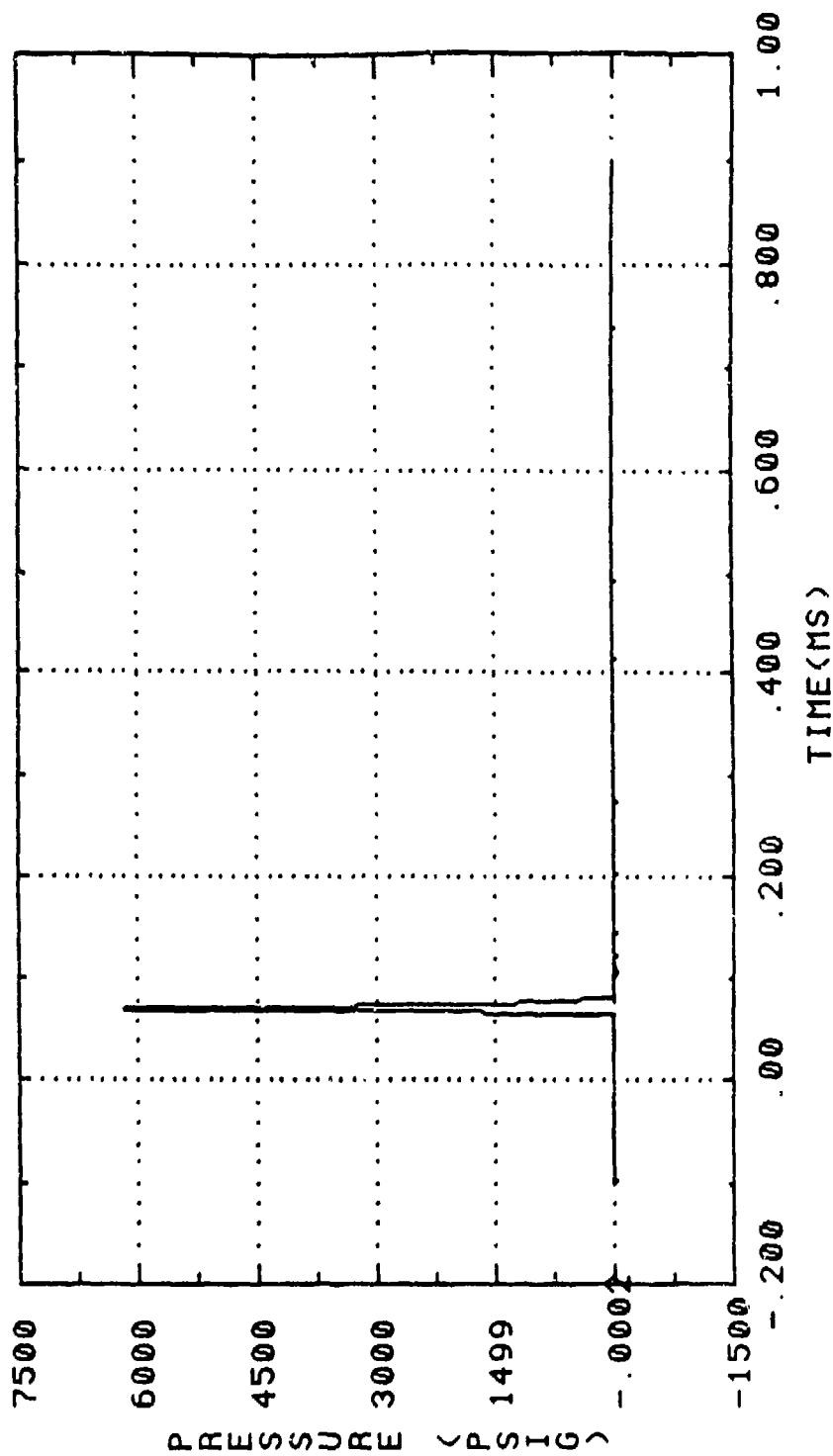


Figure C-17. Loads Test Data, Test 014, LOC 5

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC=15 LOC= 8 TEST=014

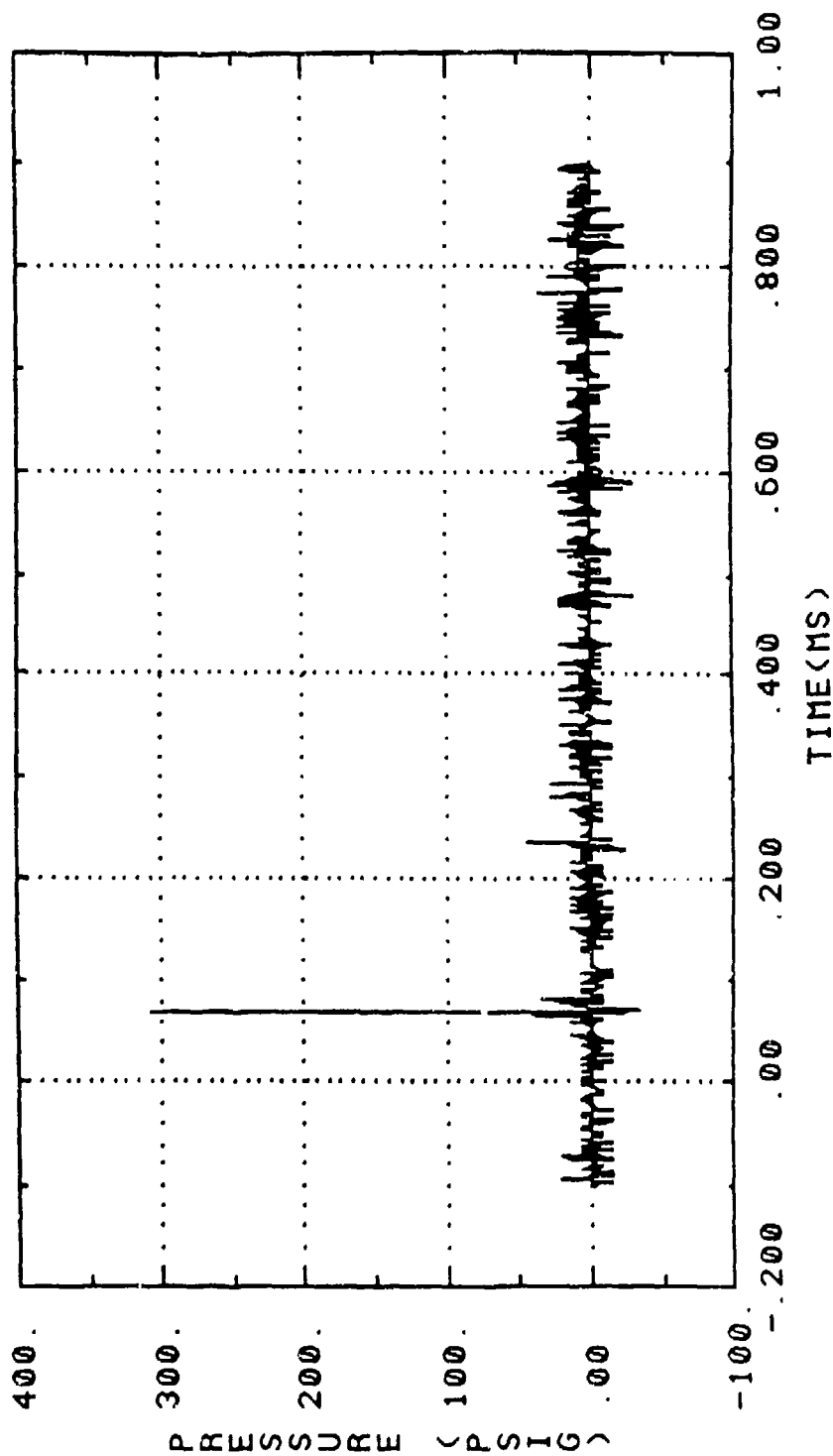


Figure C-18. Loads Test Data, Test 014, LOC 8

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 4 LOC= 9 TEST=914

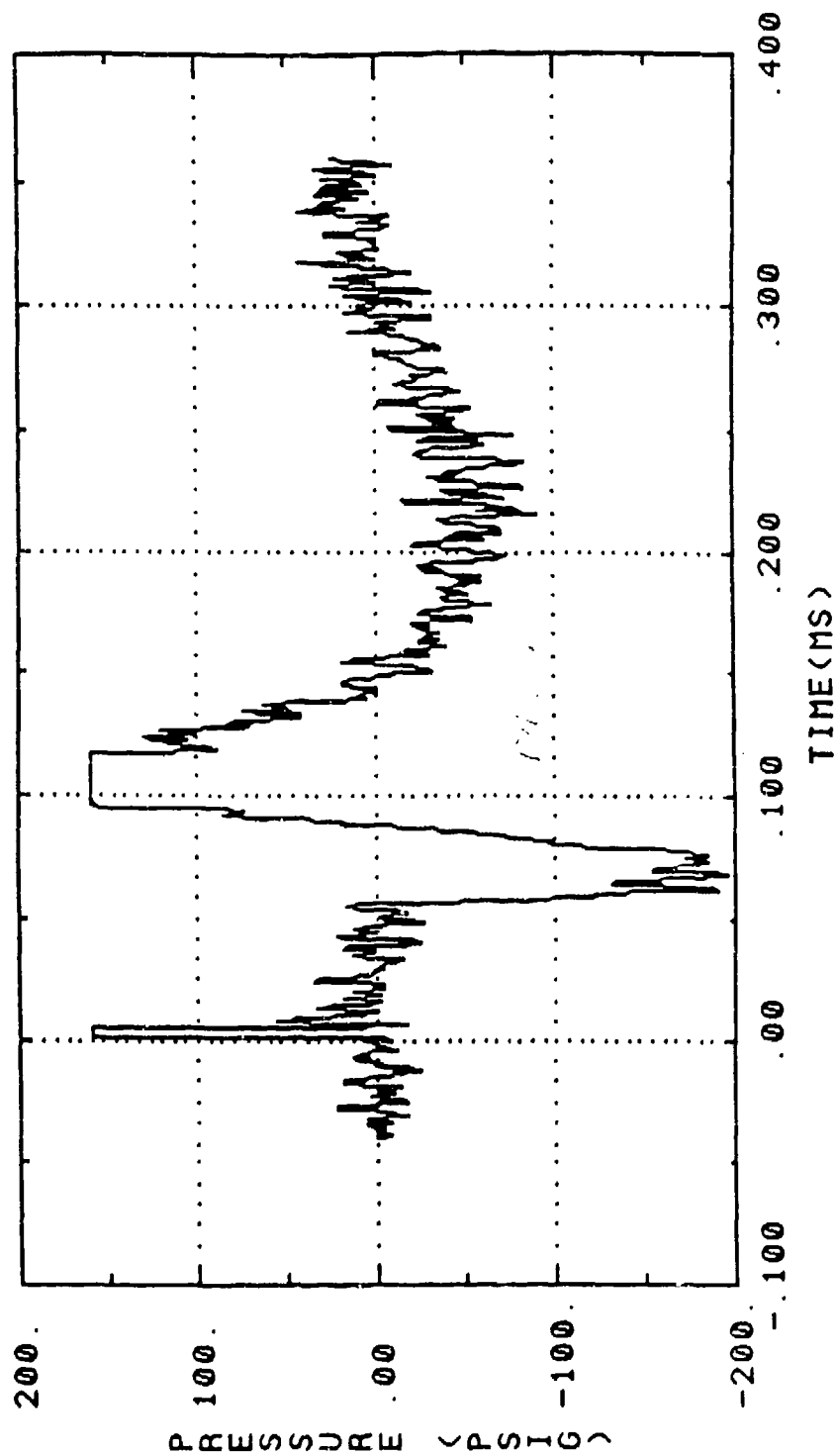


Figure C-19. Loads Test Data, Test 914, LOC 9

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 6 LOC= 10 TEST=914

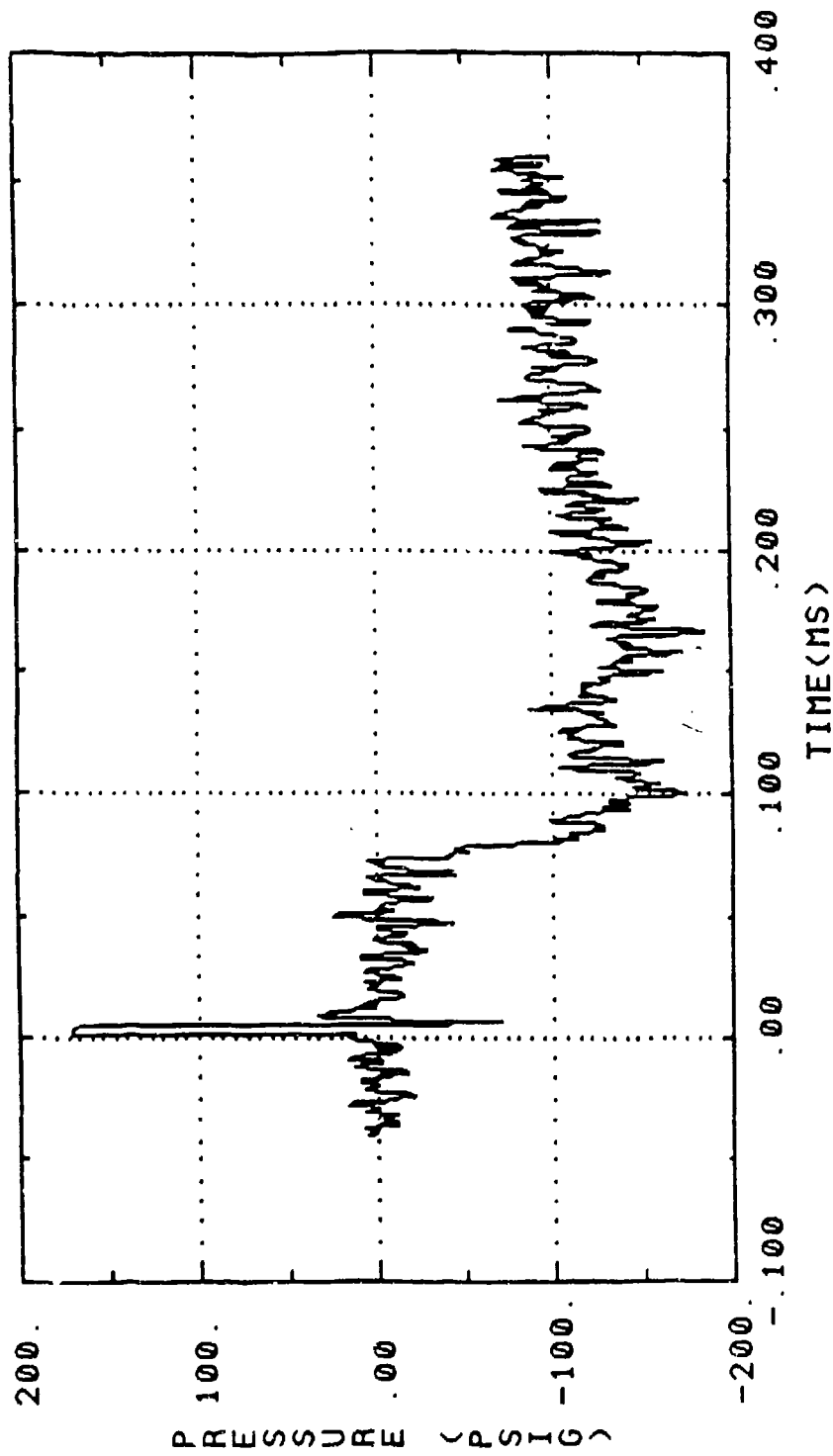


Figure C-20. Loads Test Data, Test 914, LOC 10

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 8 LOC= 11 TEST=914

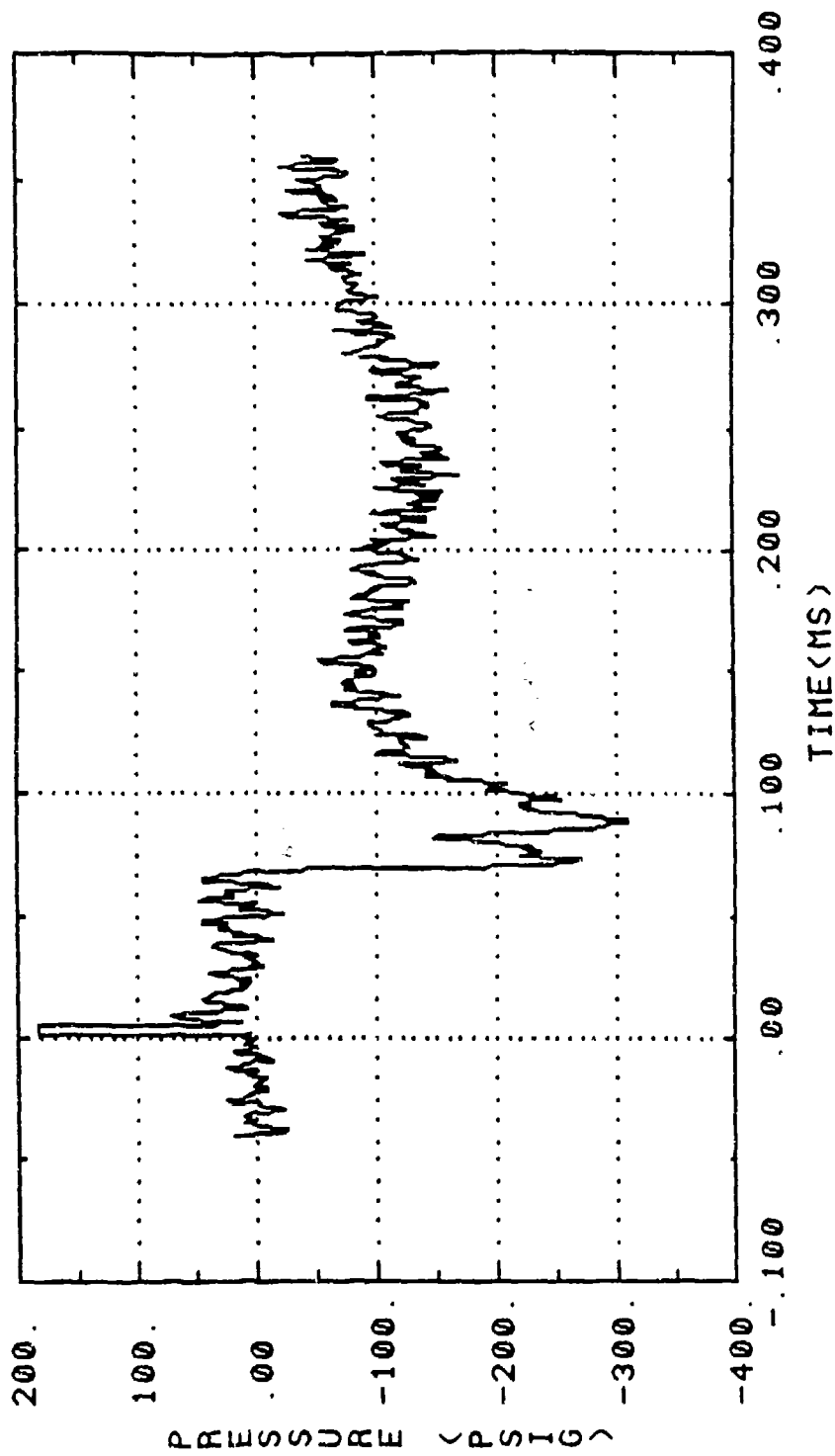


Figure C-21. Loads Test Data, Test 914, LOC 11



\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC=10 LOC= 12 TEST=914

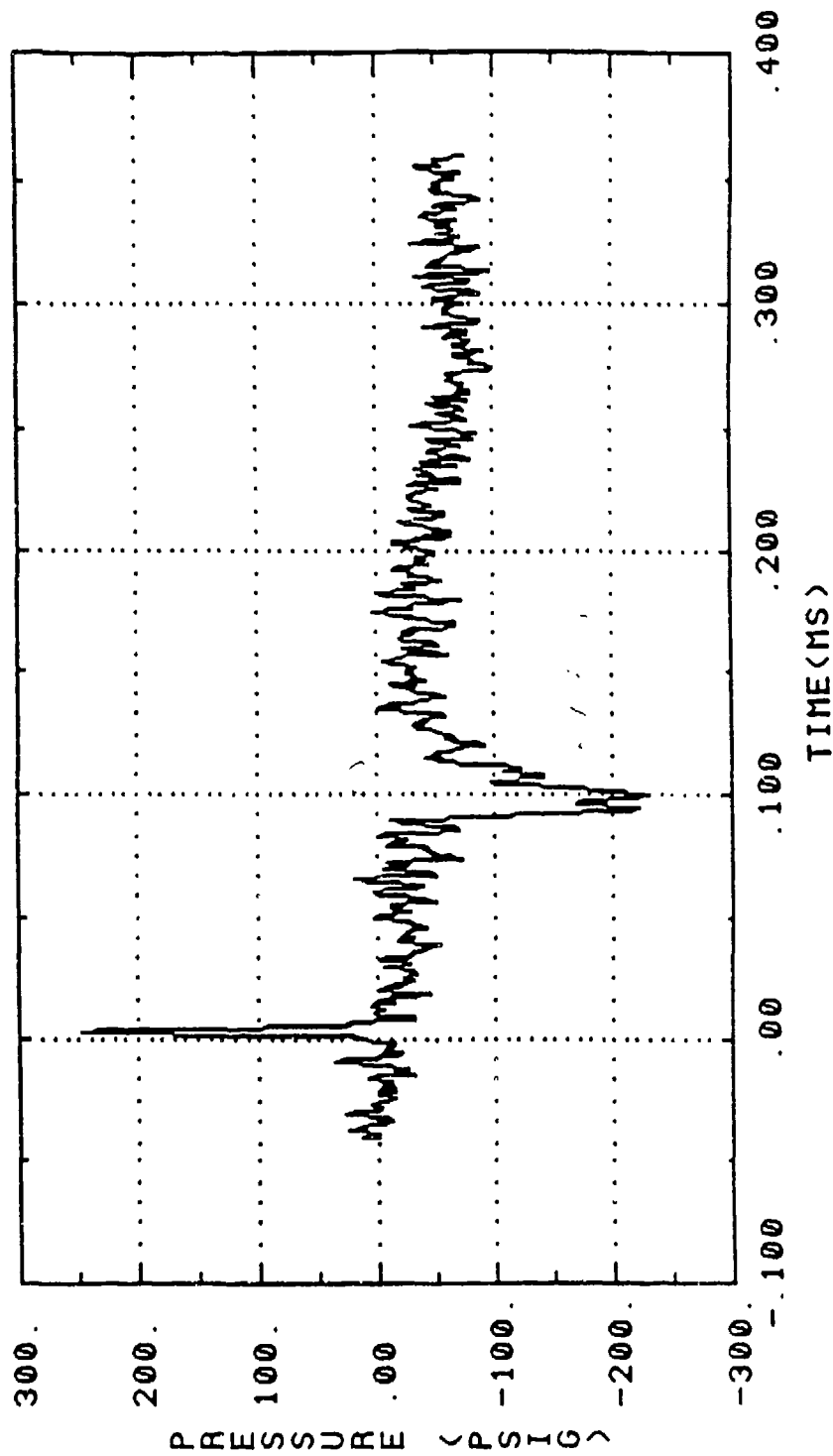


Figure C-22. Loads Test Data, Test 914, LOC 12

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 1 LOC= 1 TEST=015

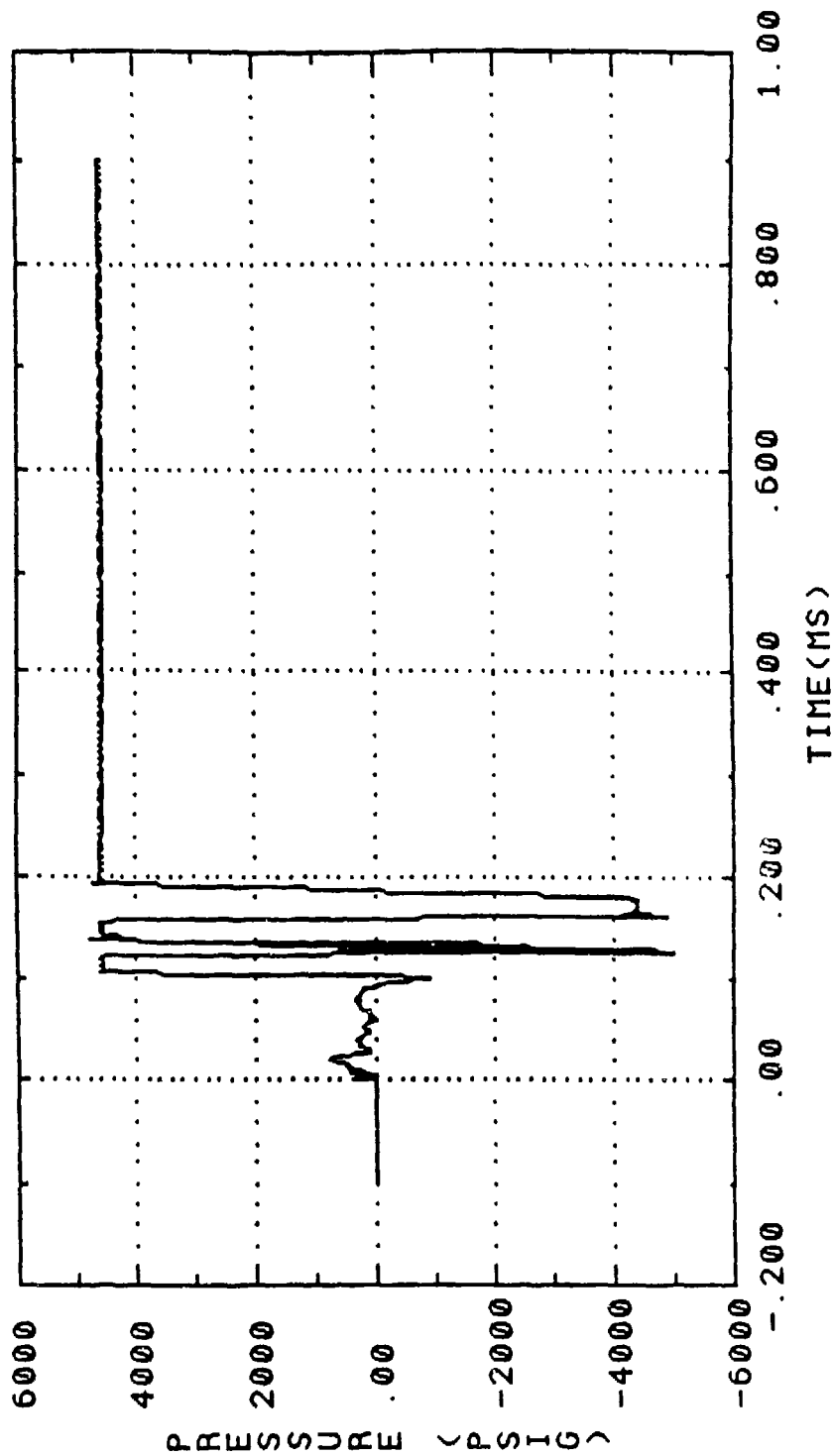


Figure C-23. Loads Test Data, Test 15, LOC 1

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 3 LOC= 2 TEST=015

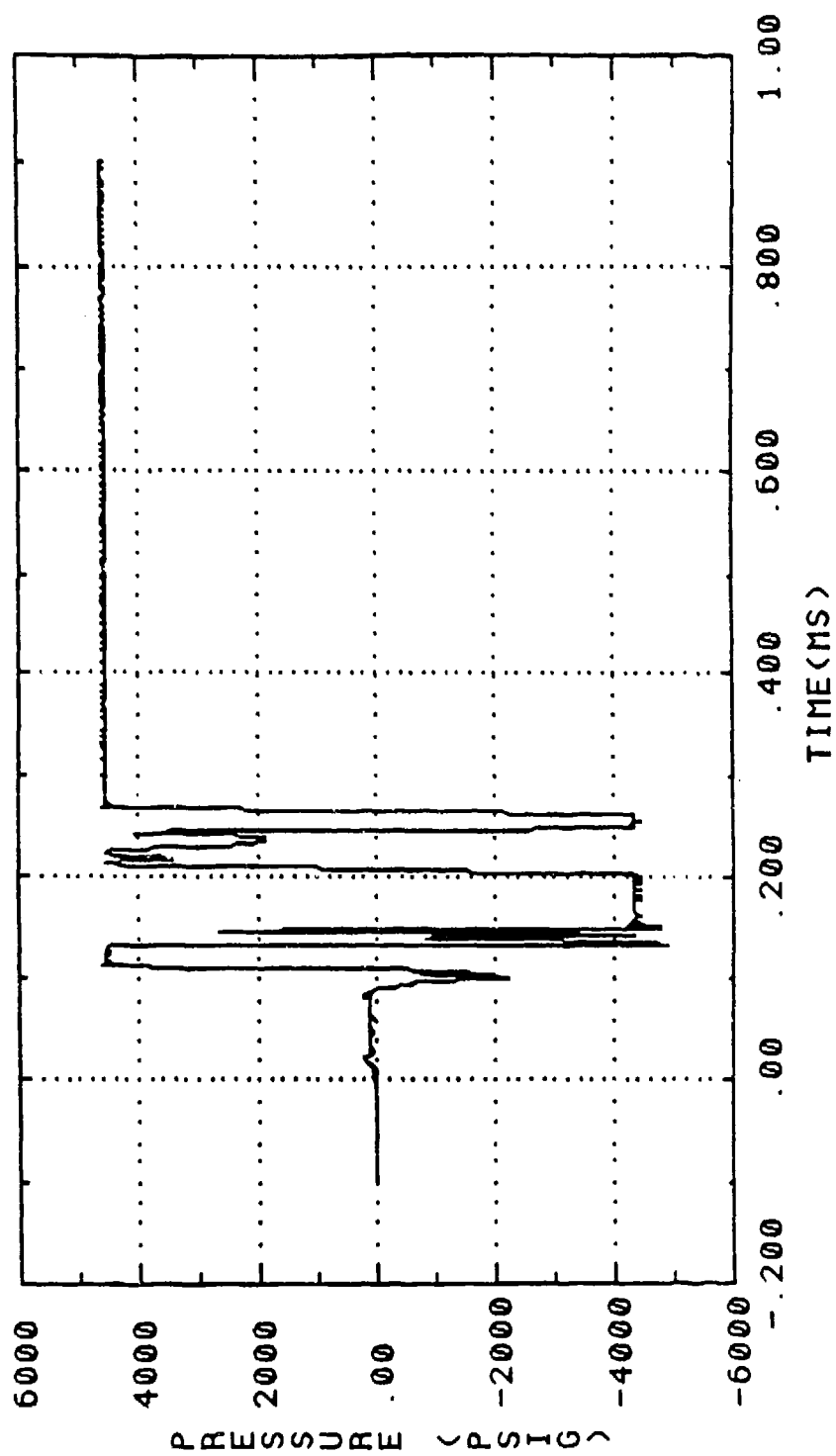


Figure C-24. Loads Test Data, Test 15, LOC 2

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 5 LOC= 3 TEST=015

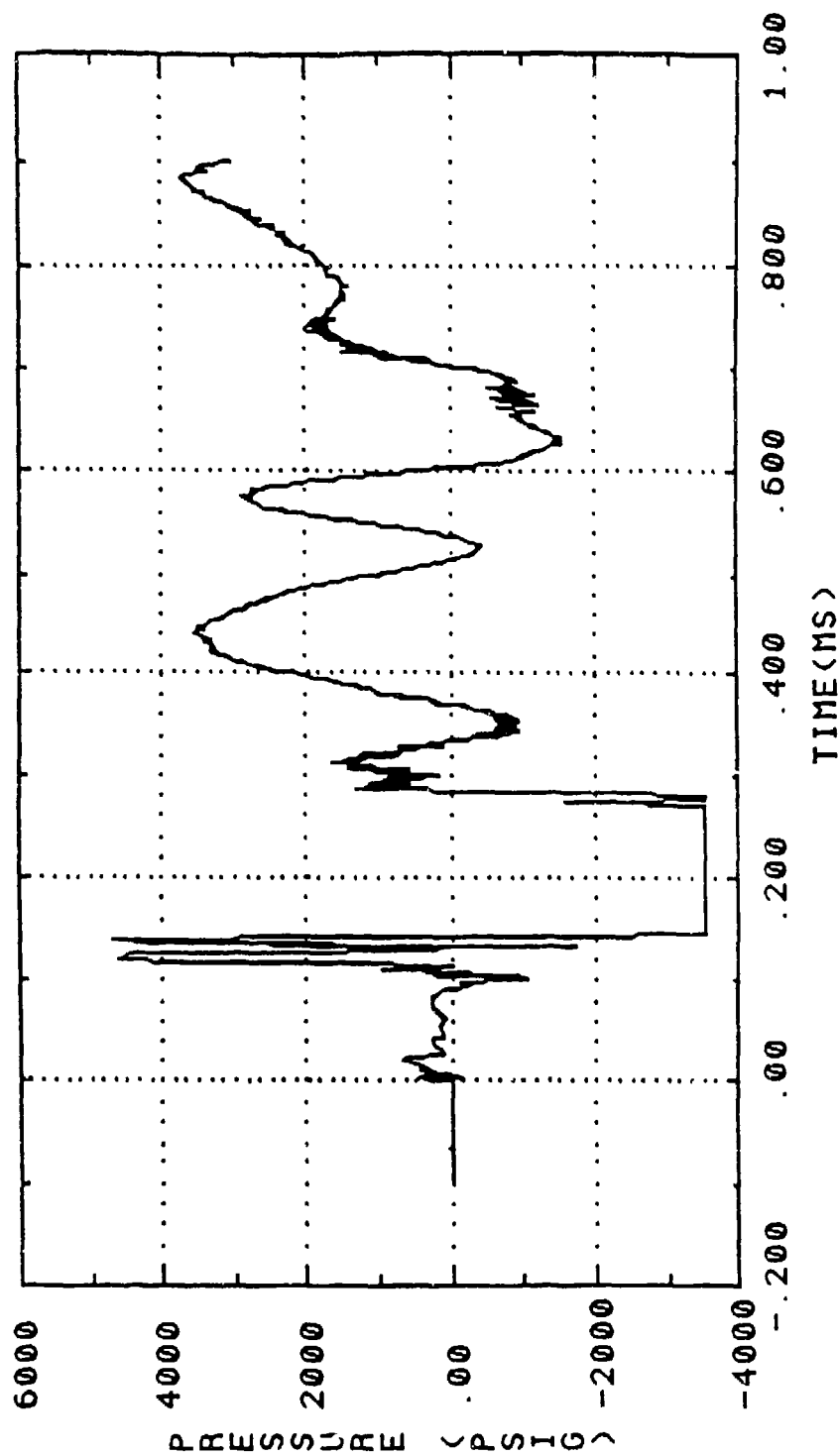


Figure C-25. Loads Test Data, Test 15, LOC 3

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 7 LOC= 4 TEST=015

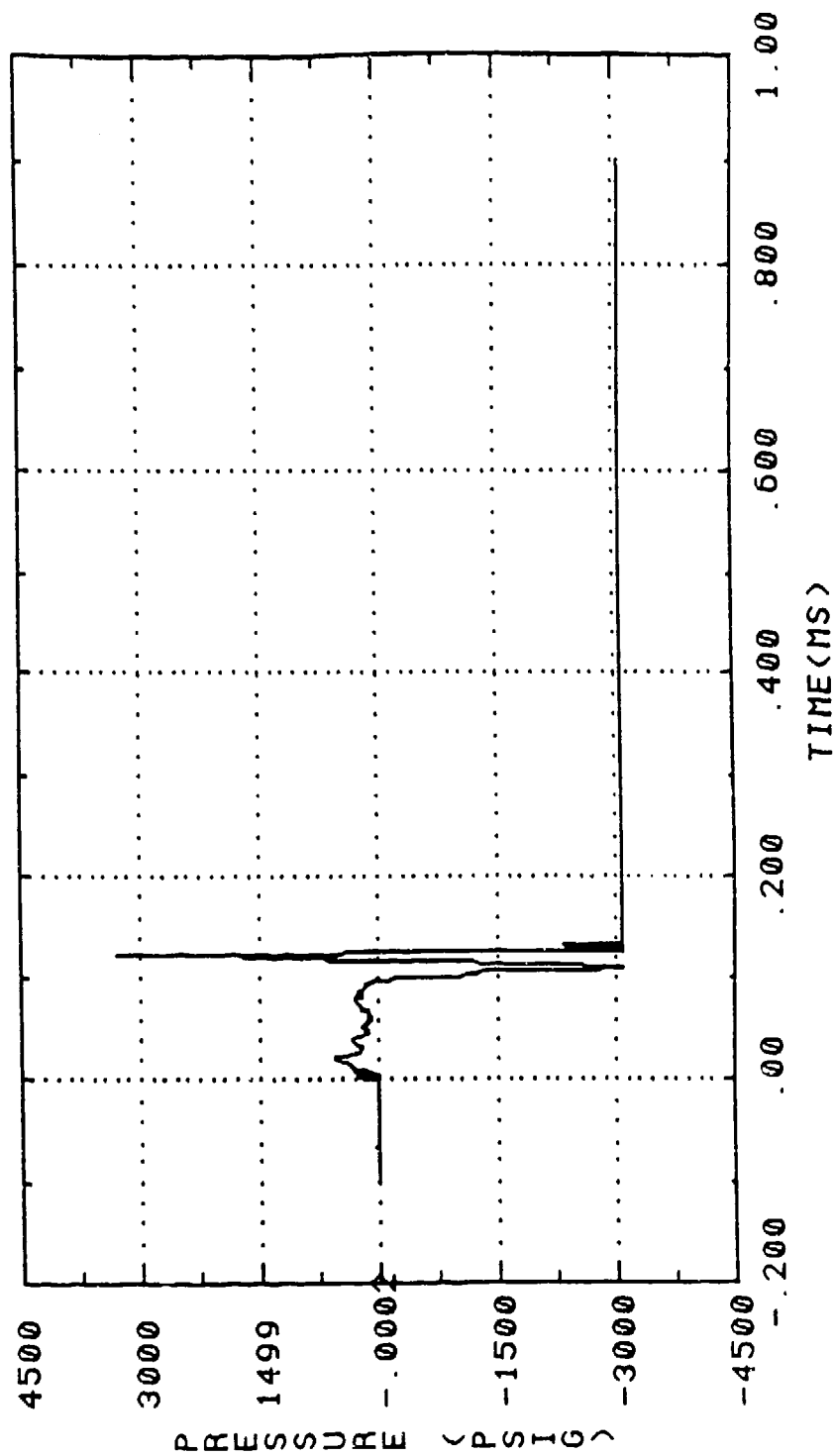


Figure C-26. Loads Test Data, Test 15, LOC 4

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 9 LOC= 5 TEST=015

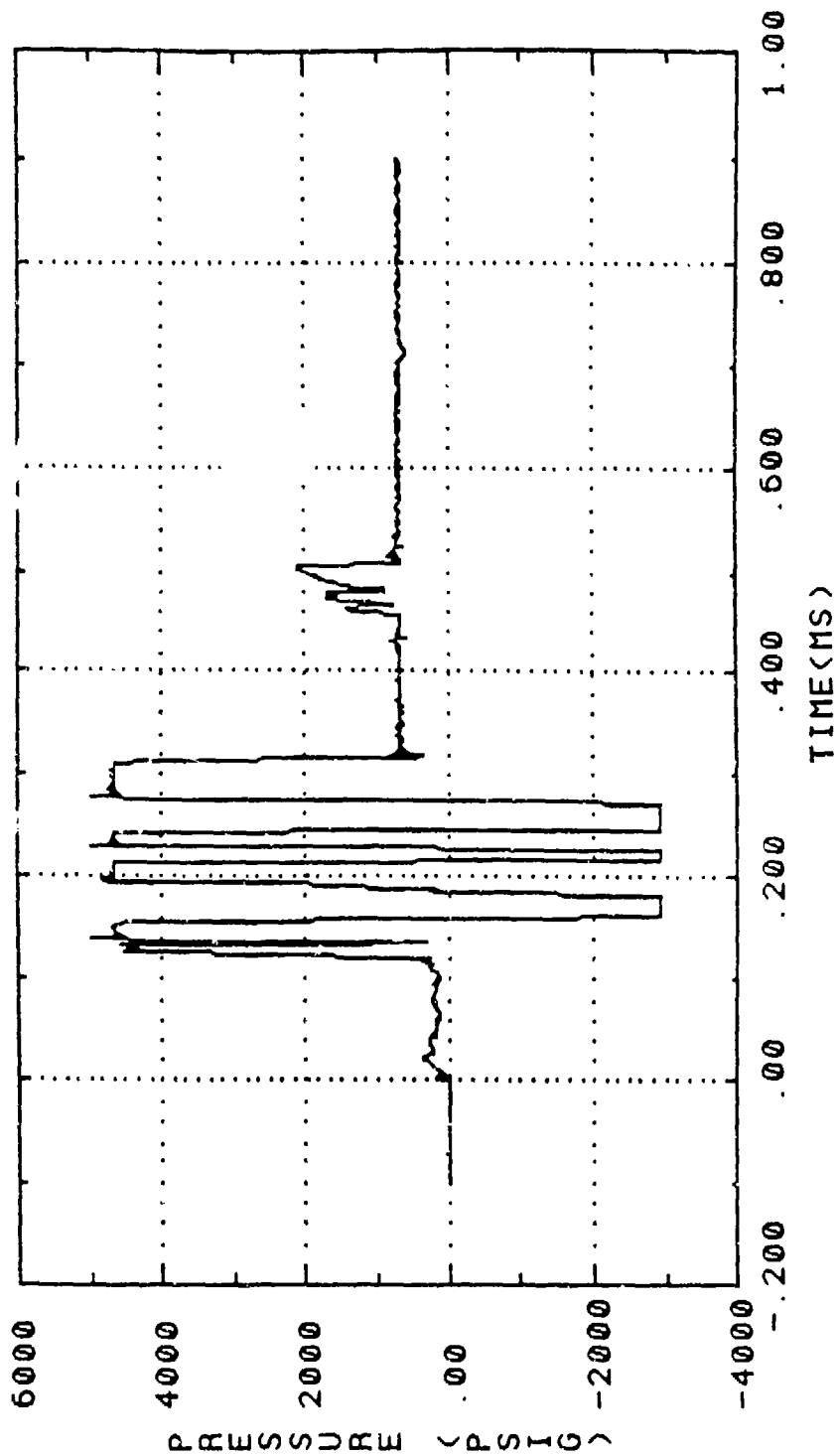


Figure C-27. Loads Test Data, Test 15, LOC 5

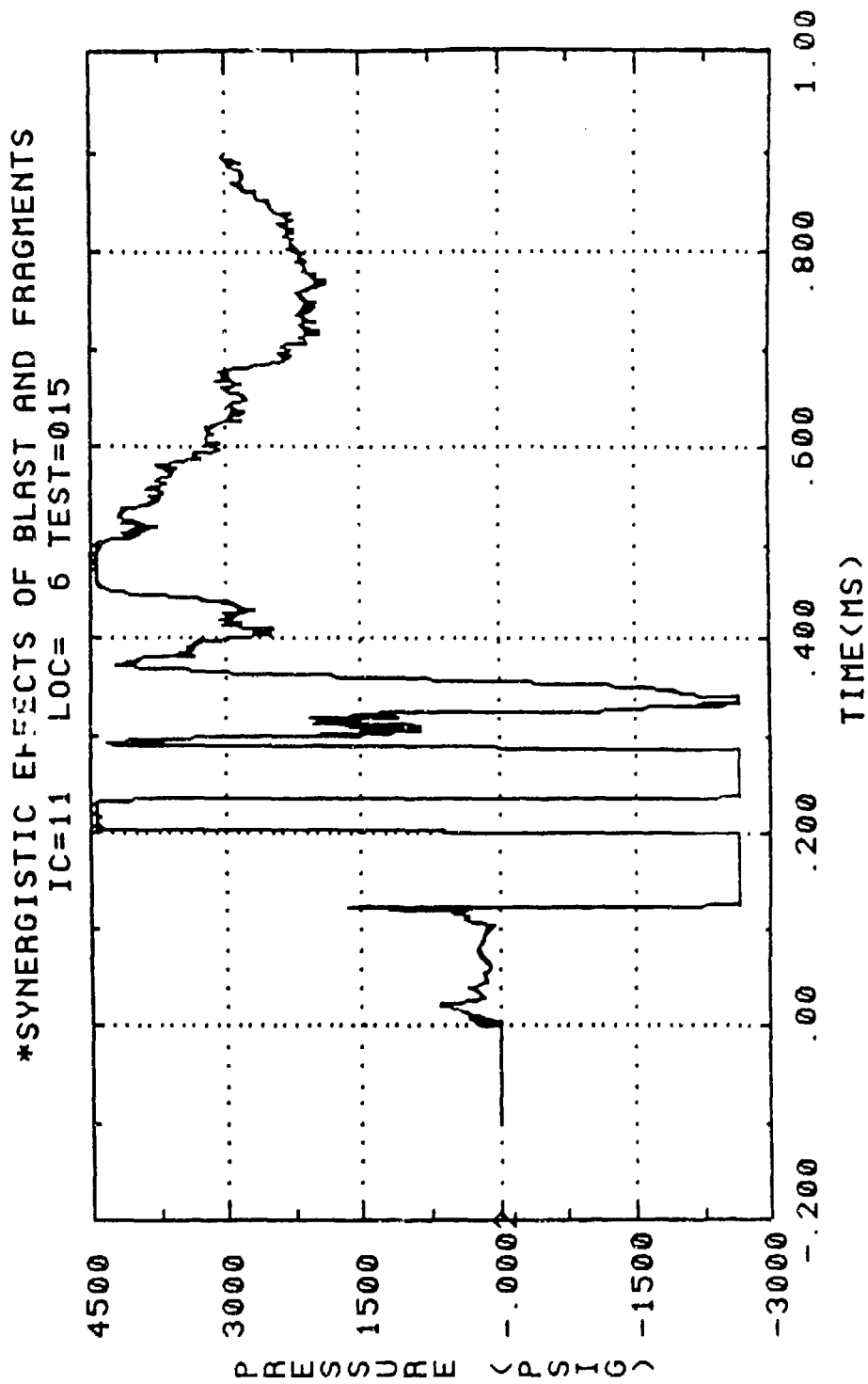


Figure C-28. Loads Test Data, Test 15, LOC 6

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC=13 LOC= 7 TEST=015

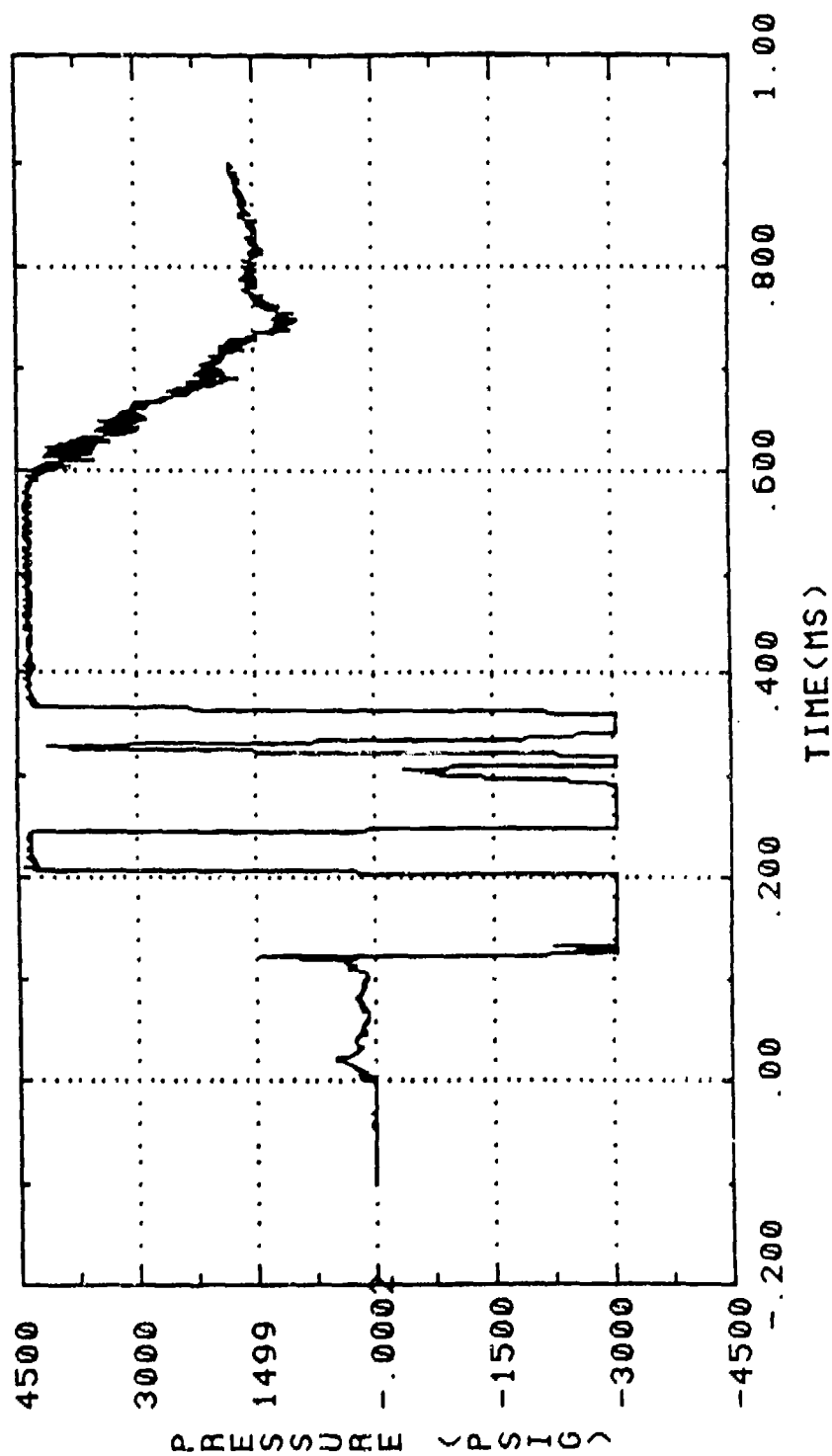


Figure C-29. Loads Test Data, Test 15, LOC 7



\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC=15 LOC= 8 TEST=015

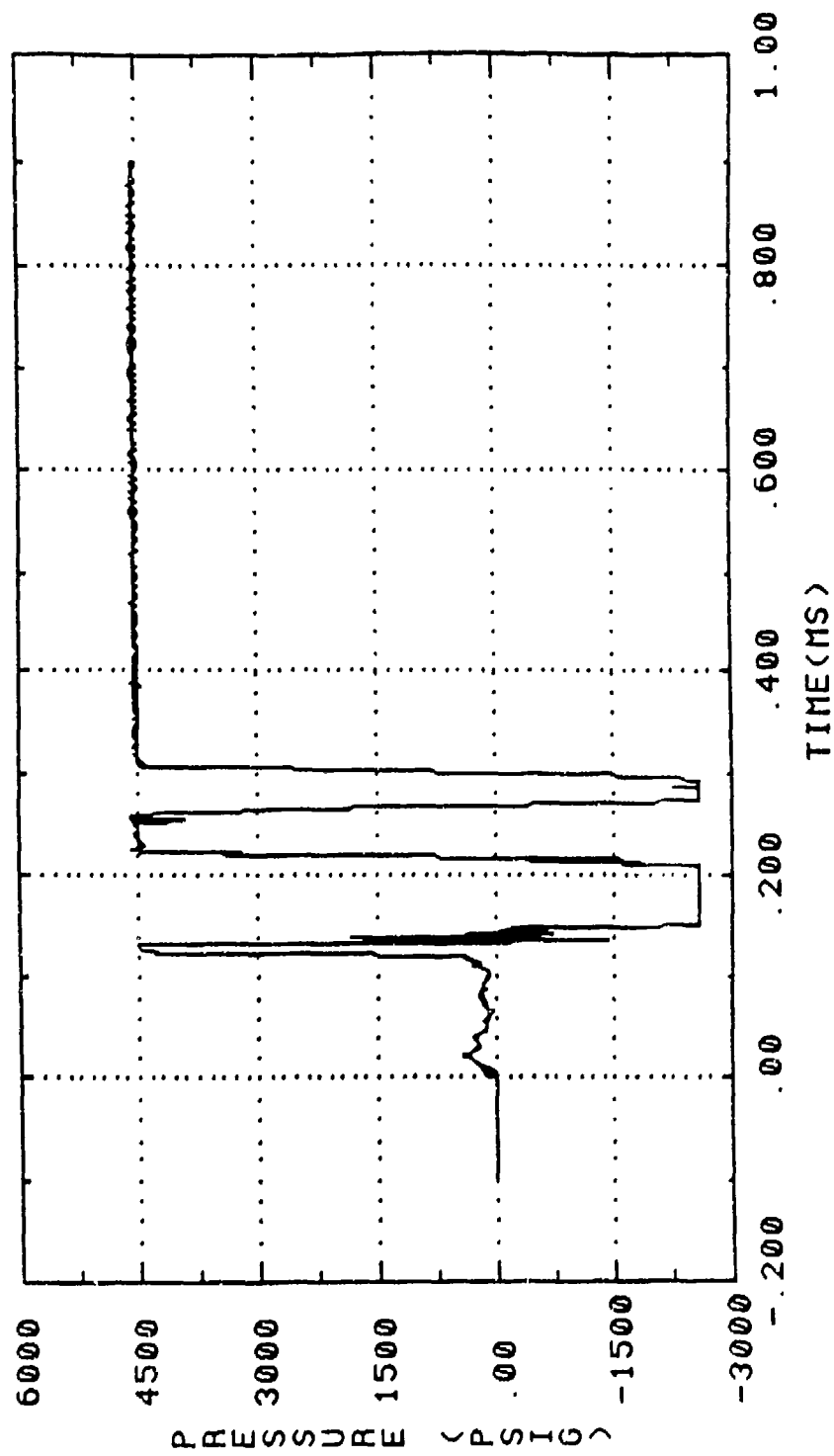


Figure C-30. Loads Test Data, Test 15, LOC 8

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 4 LOC= 9 TEST=015

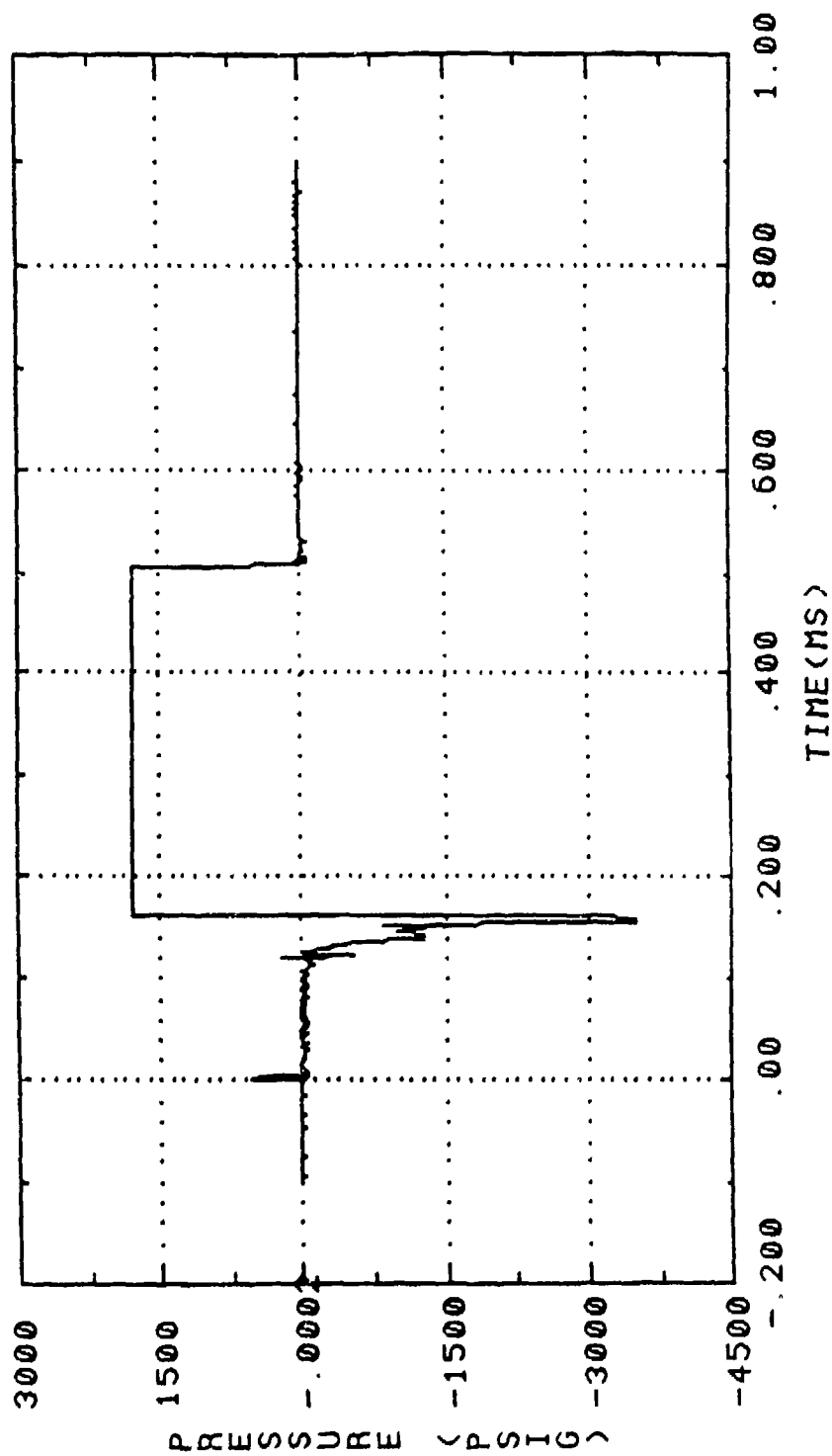


Figure C-31. Loads Test Data, Test 15, LOC 9

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 6 LOC= 10 TEST=015

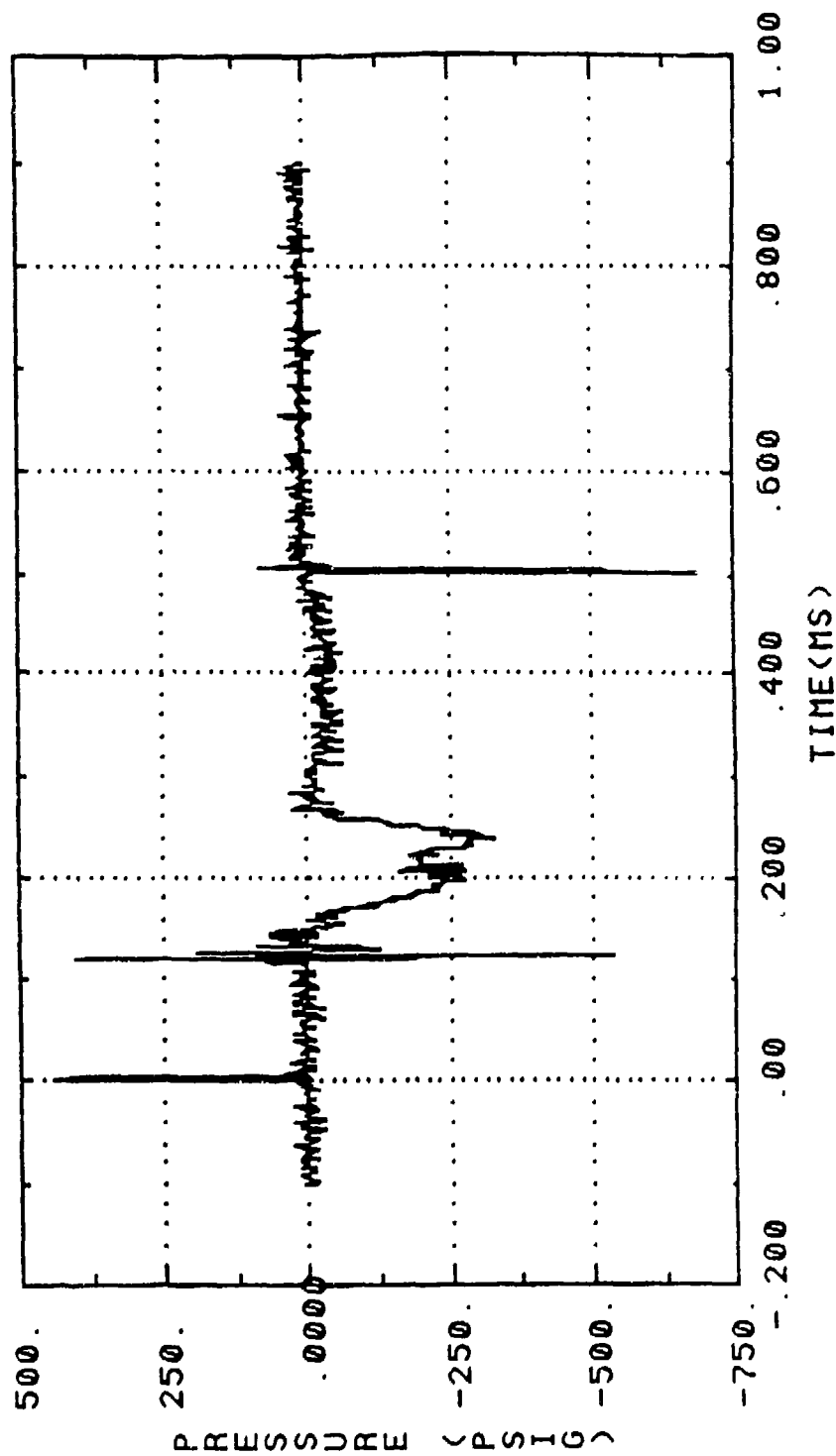


Figure C-32. Loads Test Data, Test 15, LOC 10

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 8 LOC= 11 TEST=015

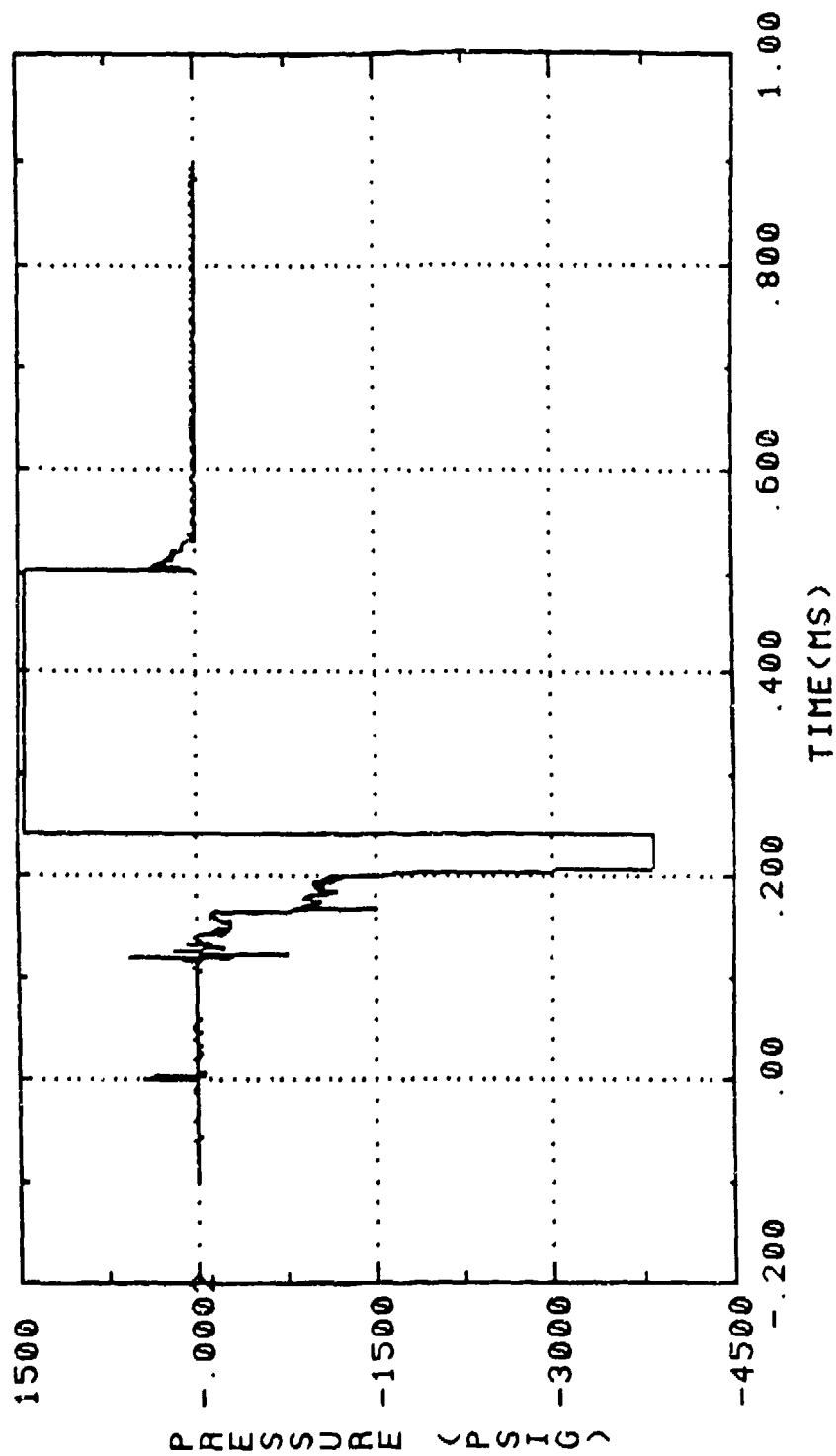


Figure C-33. Loads Test Data, Test 15, LOC 11

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC=10 LOC= 12 TEST=015

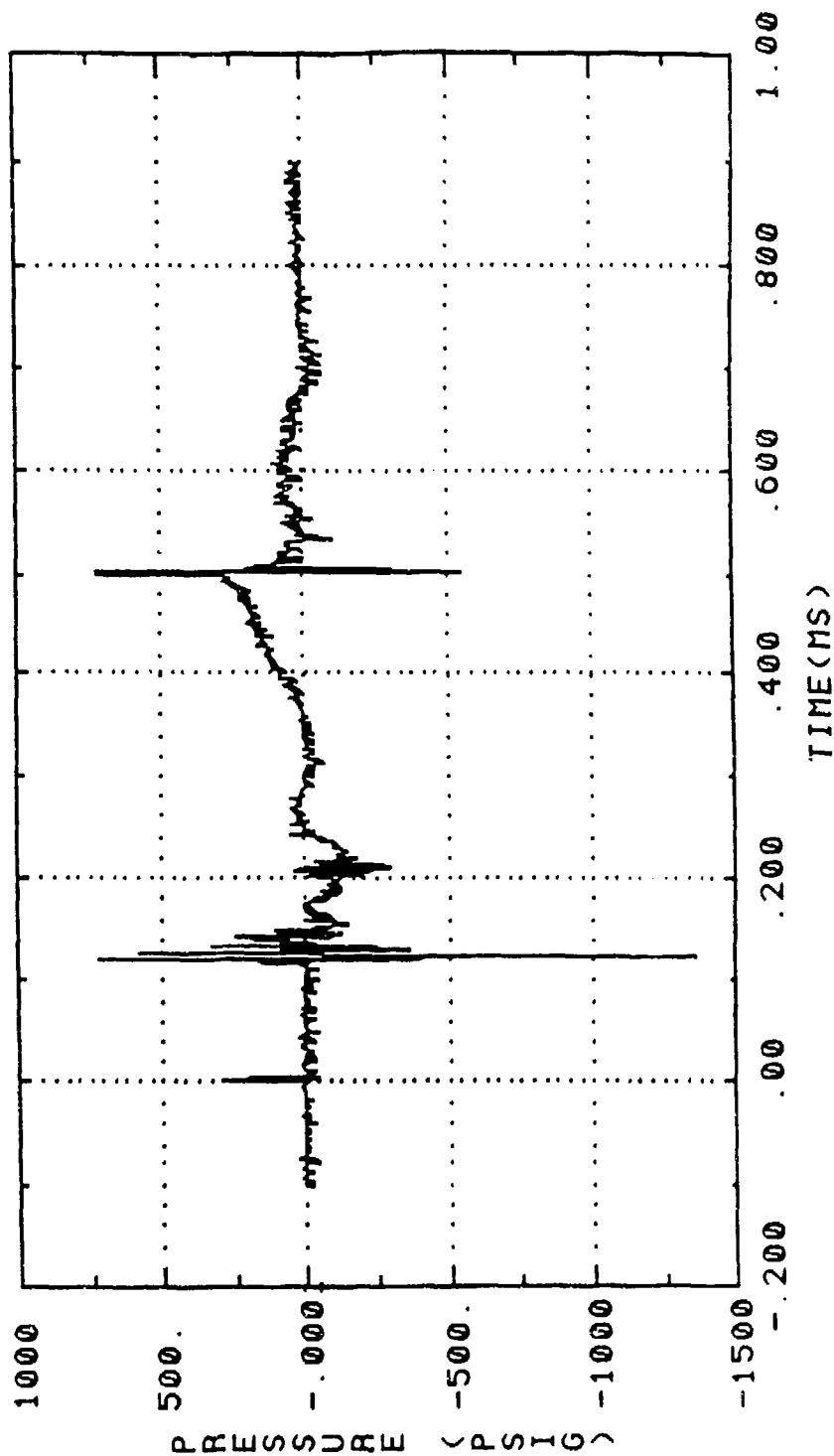


Figure C-34. Loads Test Data, Test 15, LOC 12

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 1 LOC= 1 TEST=016

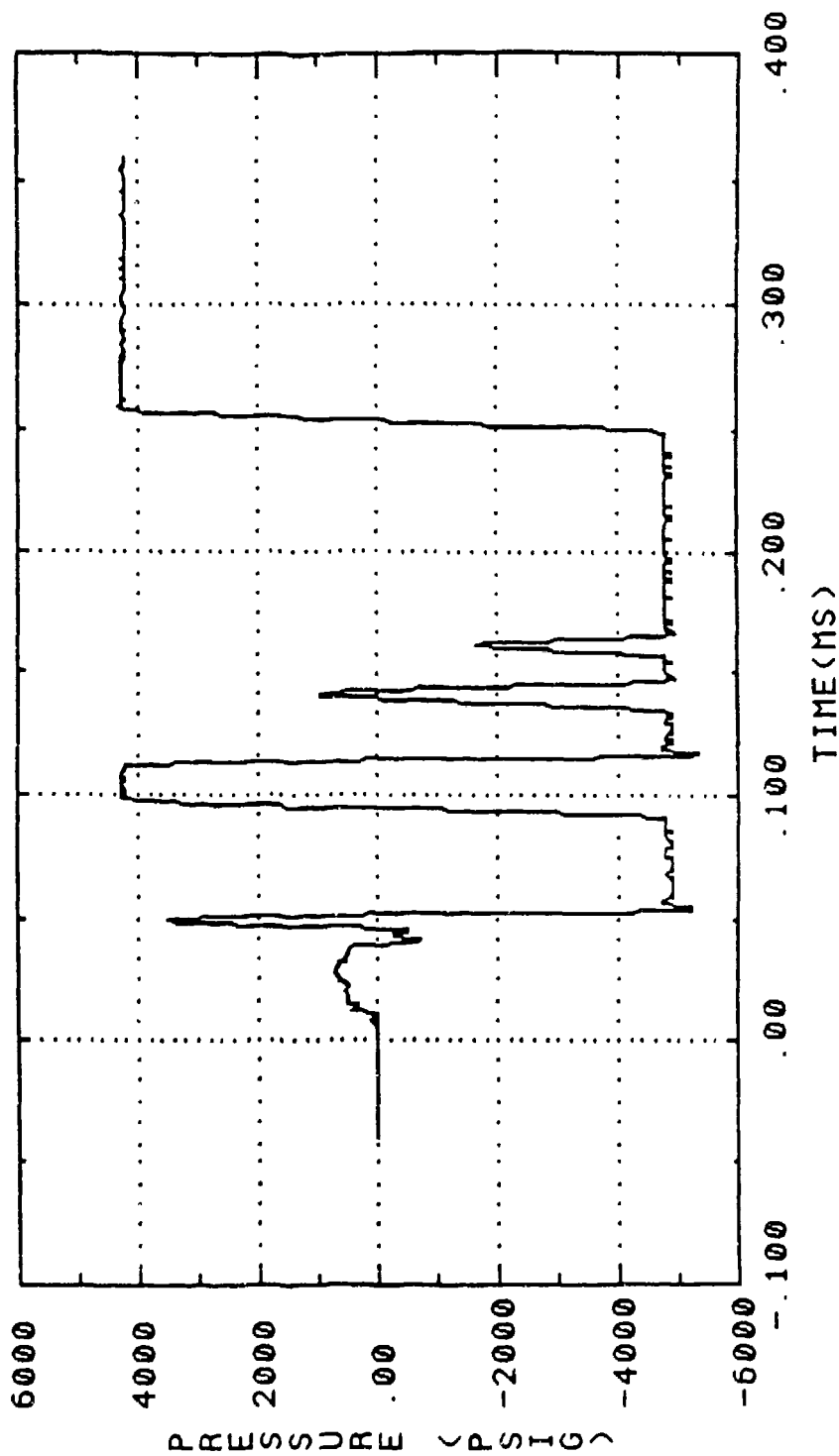


Figure C-35. Loads Test Data, Test 16, LOC 1

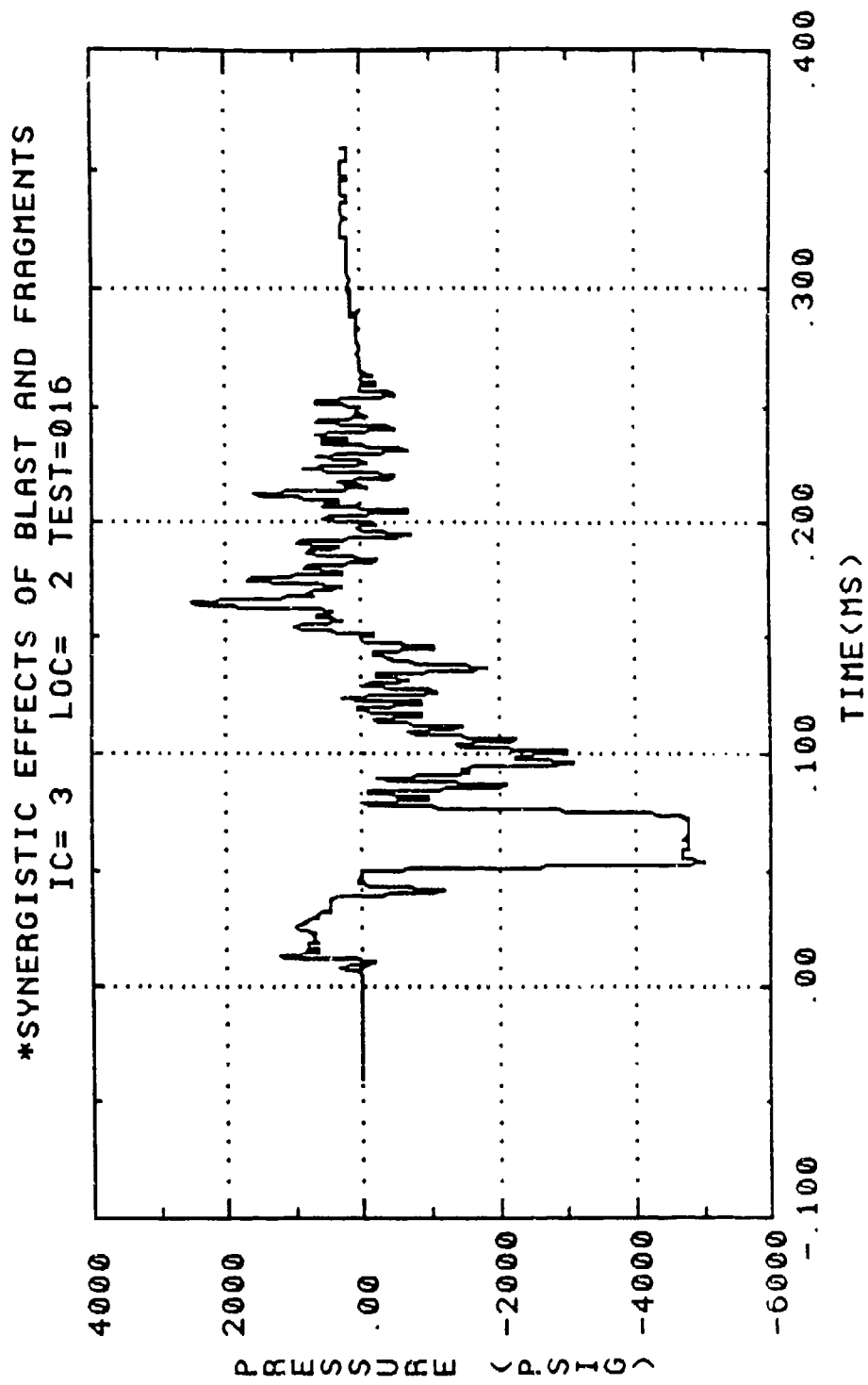


Figure C-36. Loads Test Data, Test 16, LOC 2

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 5 LOC= 3 TEST=016

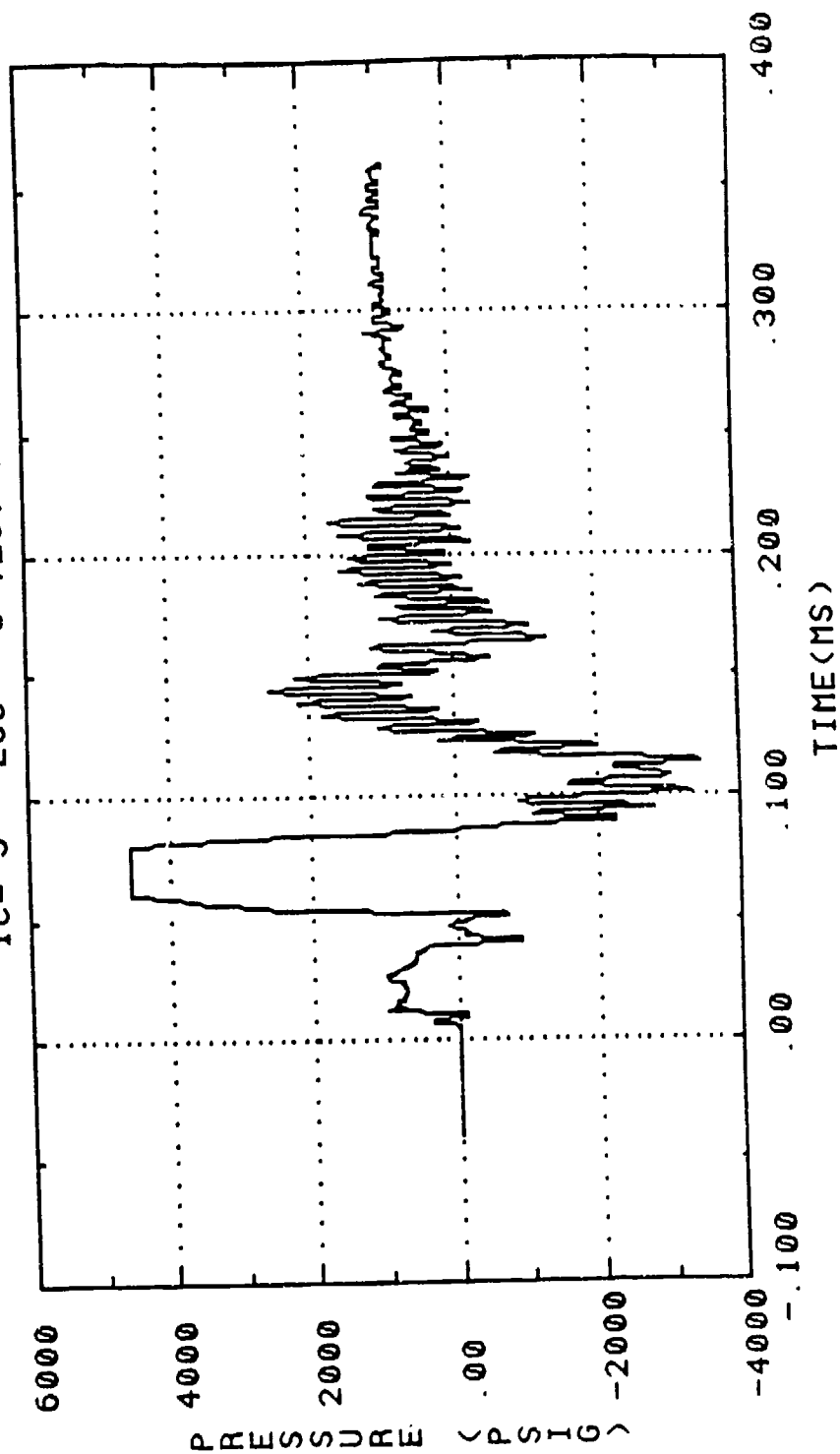


Figure C-37. Loads Test Data, Test 16, LOC 3



\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 7 LOC= 4 TEST=016

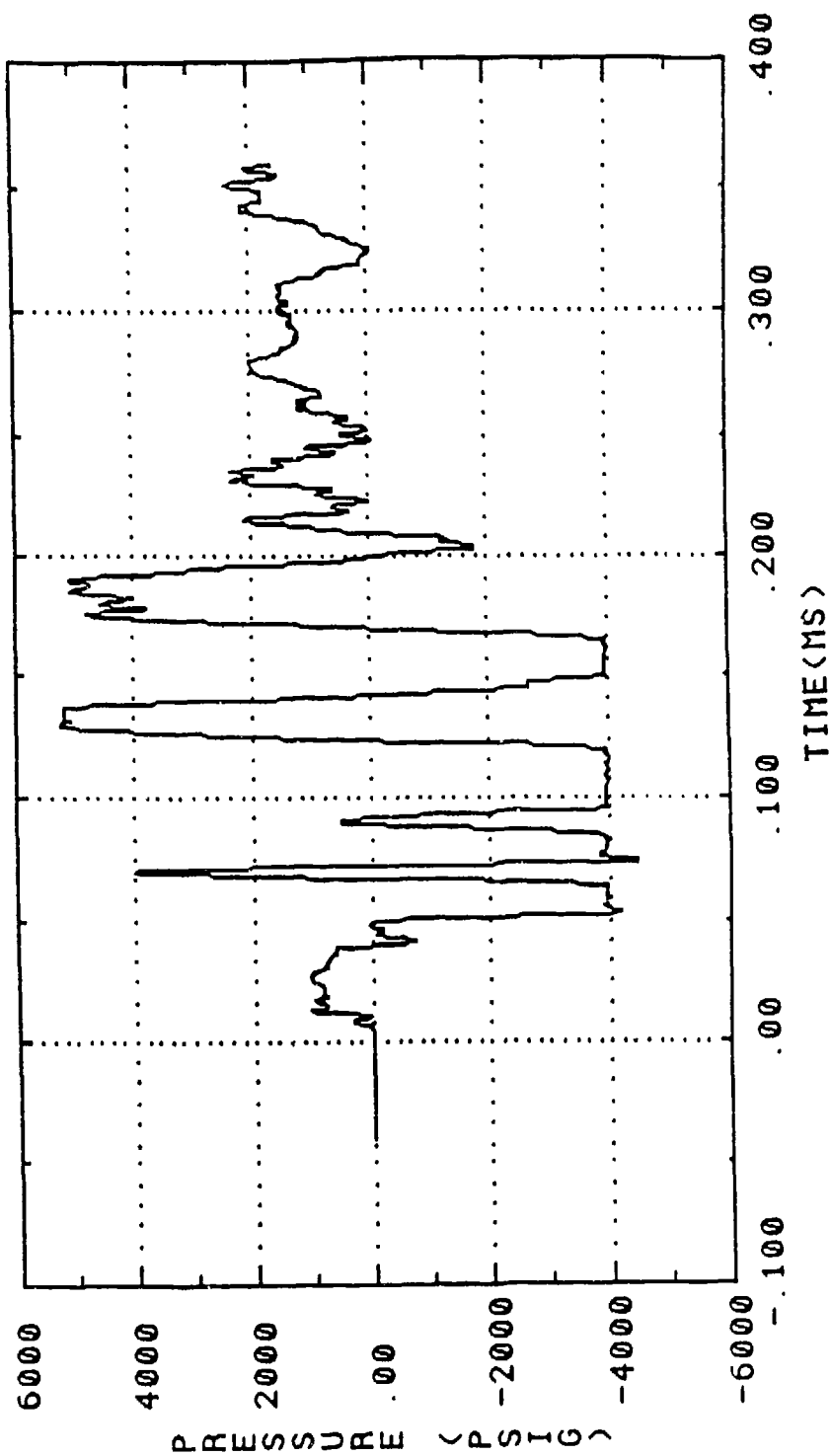


Figure C-38. Loads Test Data, Test 16, LOC 4

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 9 LOC= 5 TEST=016

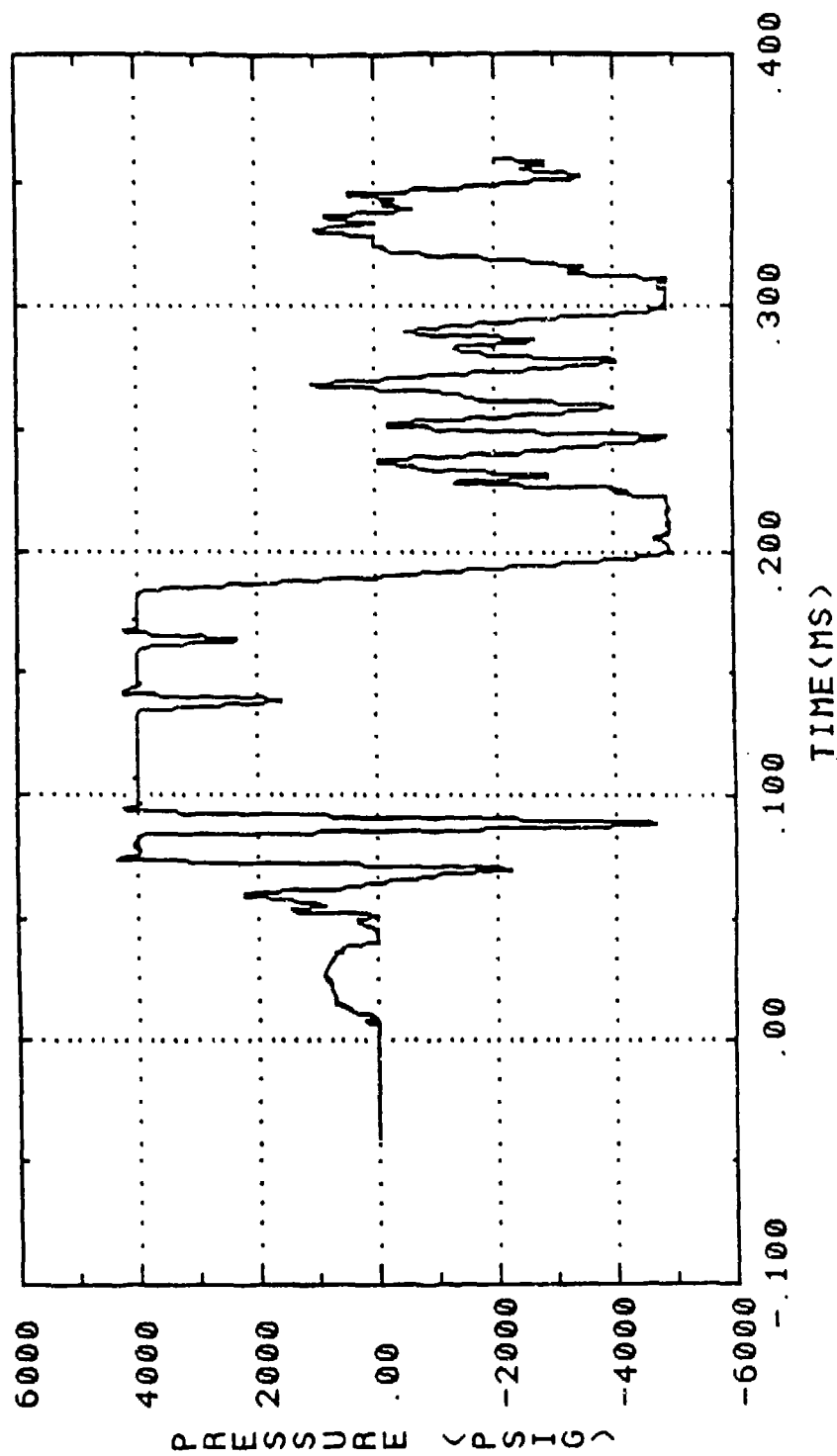


Figure C-39. Loads Test Data, Test 16, LOC 5

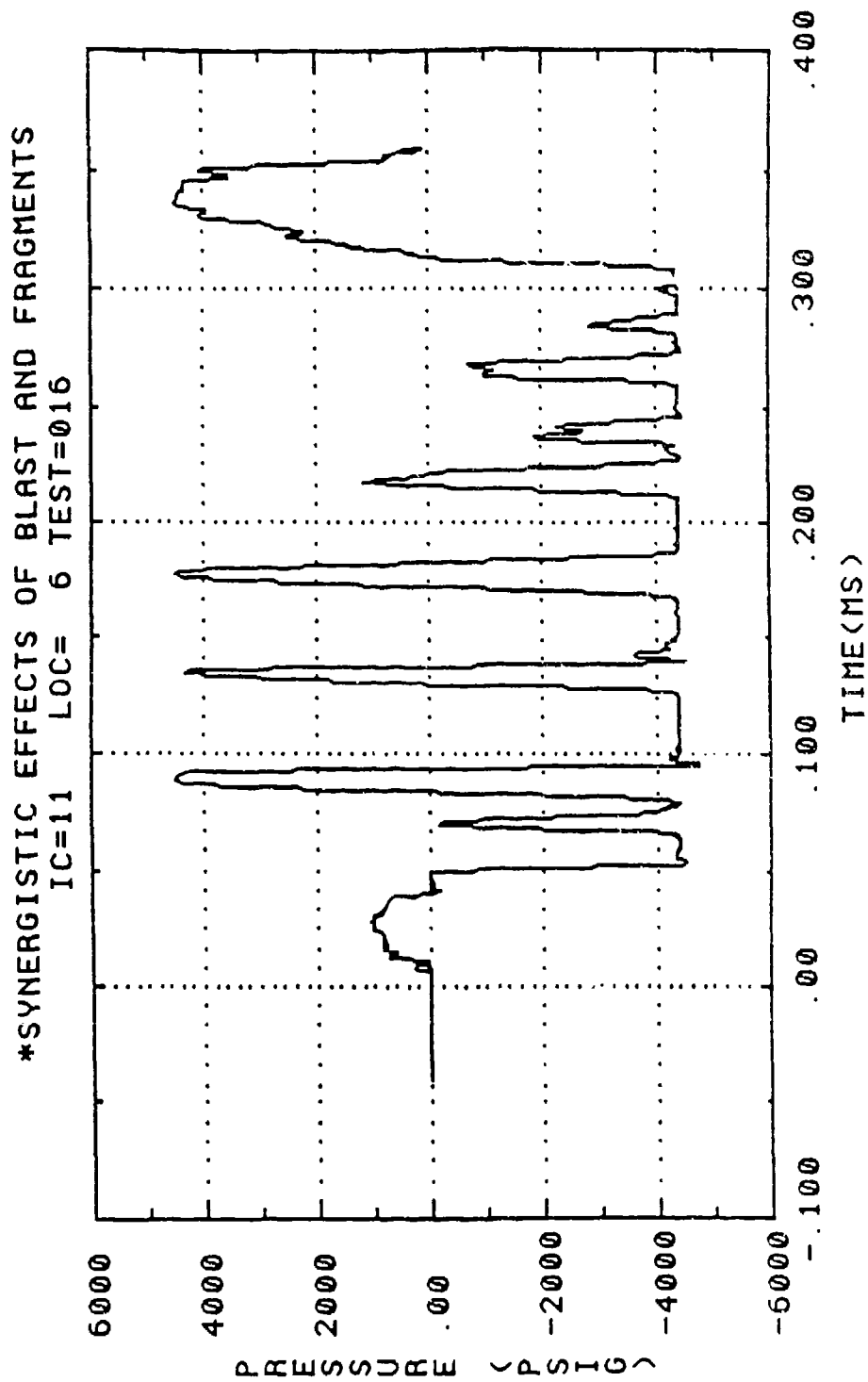


Figure C-40. Loads Test Data, Test 16, LOC 6

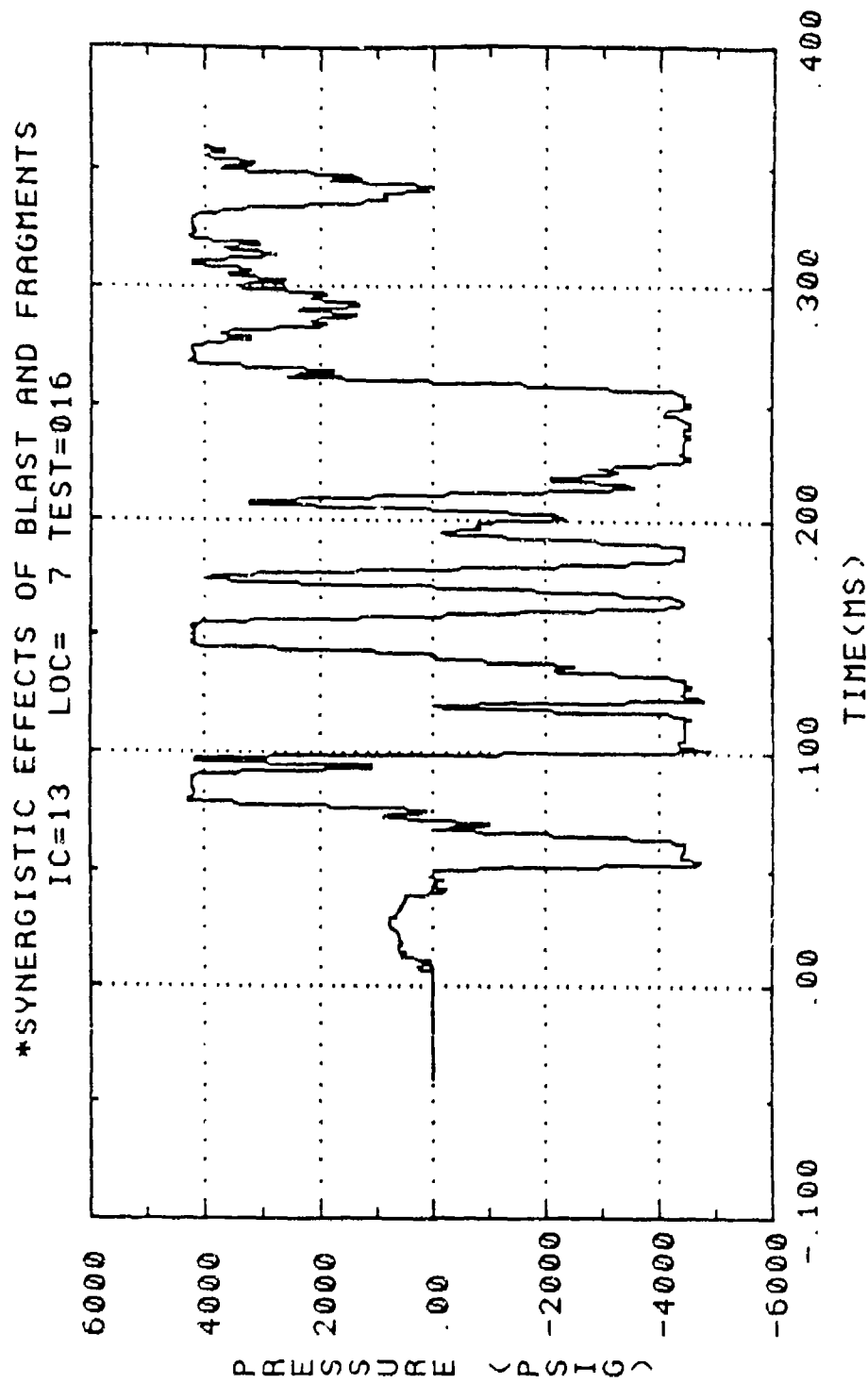


Figure C-41. Loads Test Data, Test 16, LOC 7

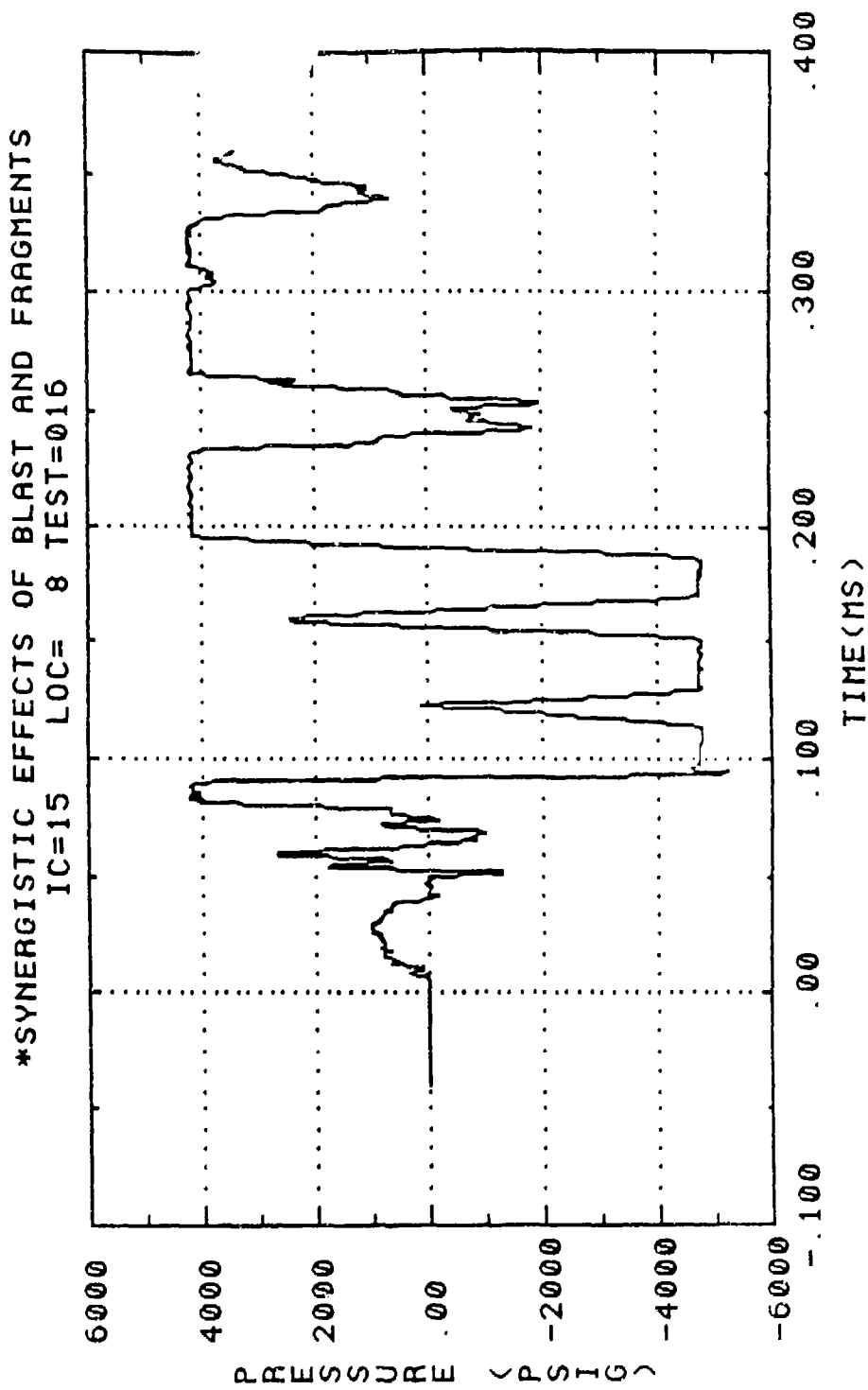


Figure C-42. Loads Test Data, Test 16, LOC 8

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 4 LOC= 9 TEST=016

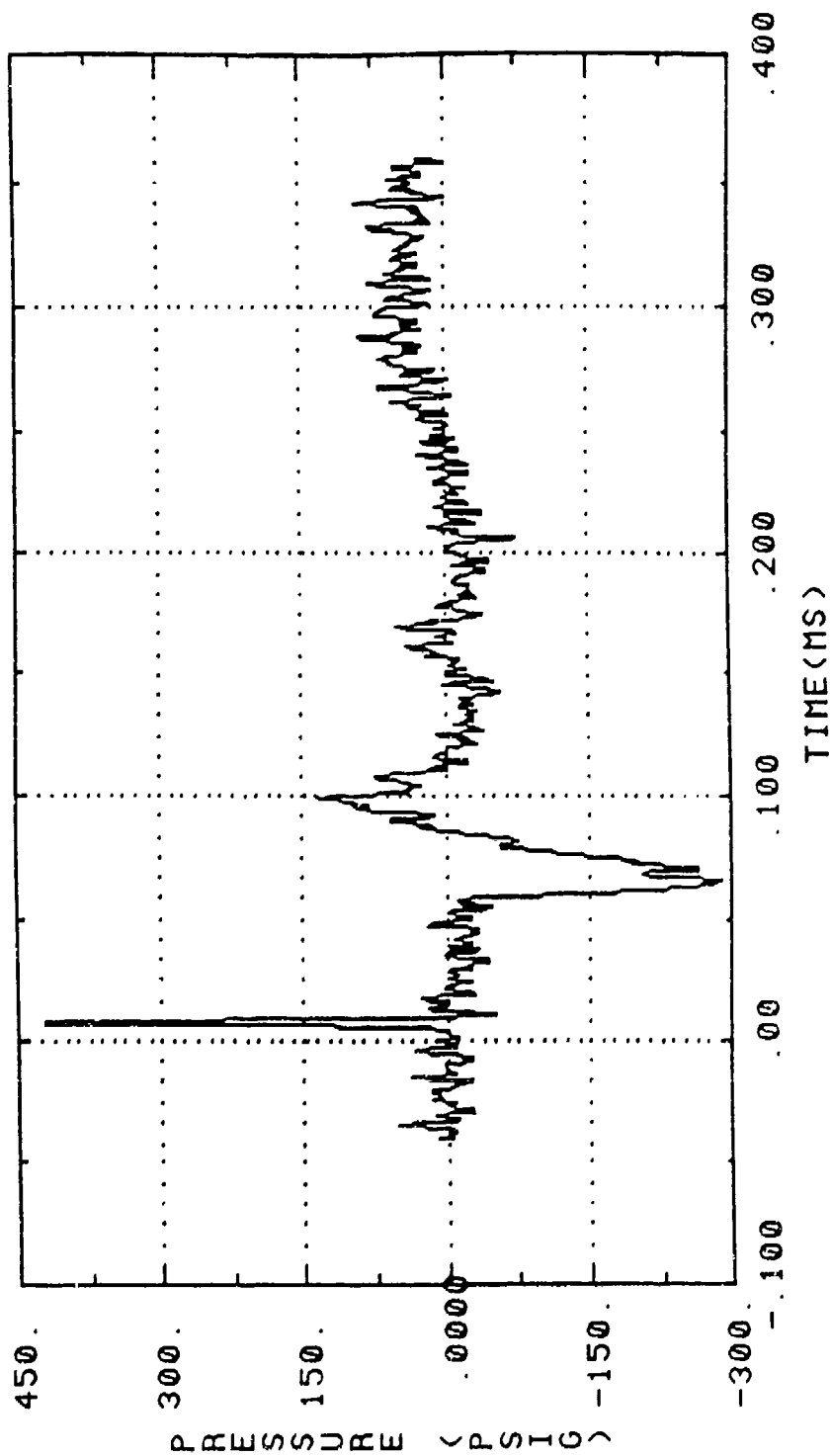


Figure C-43. Loads Test Data, Test 16, LOC 9

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 6 LOC= 10 TEST=016

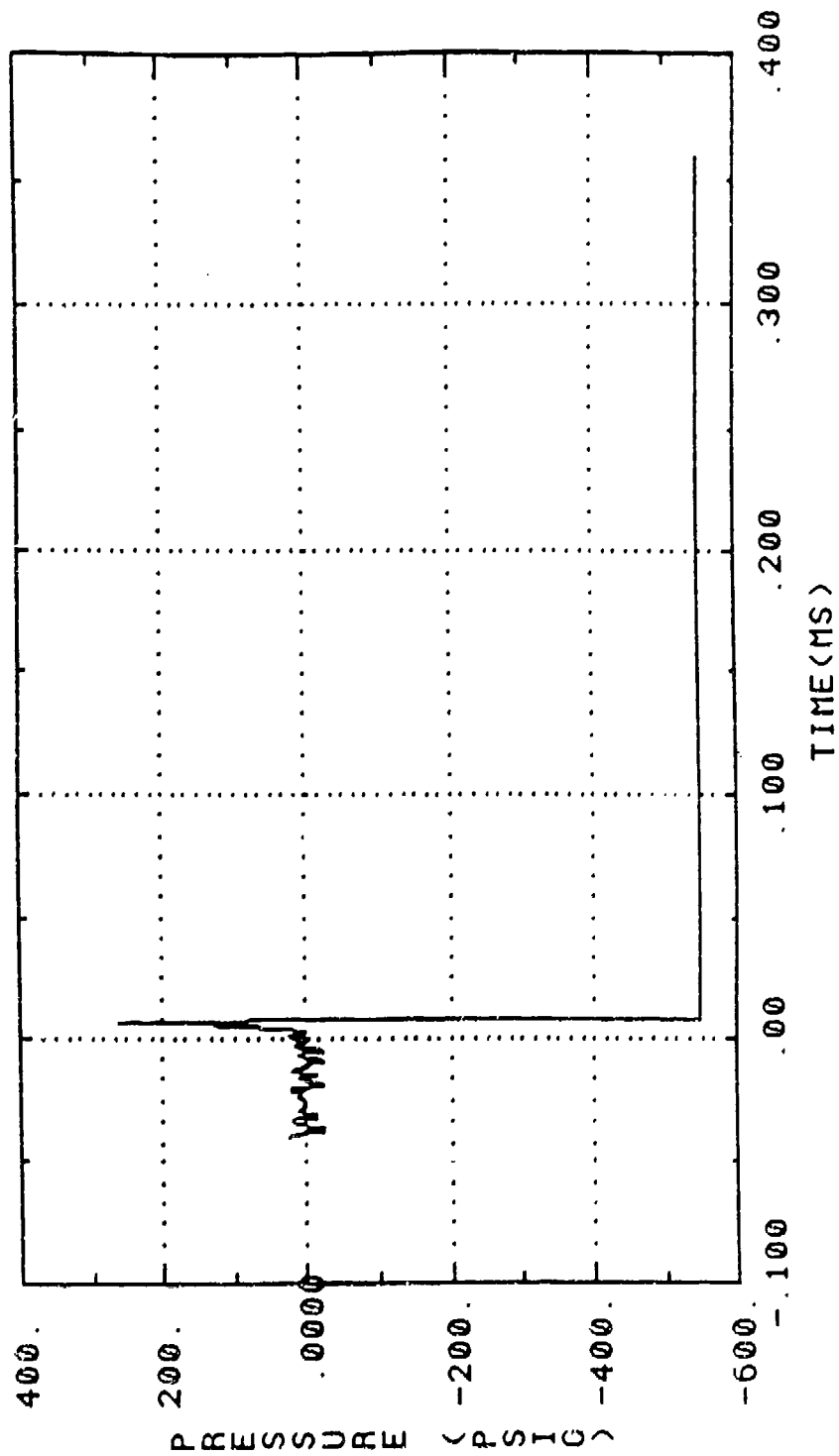


Figure C-44. Loads Test Data, Test 16, LOC 10

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 8 LOC= 11 TEST=016

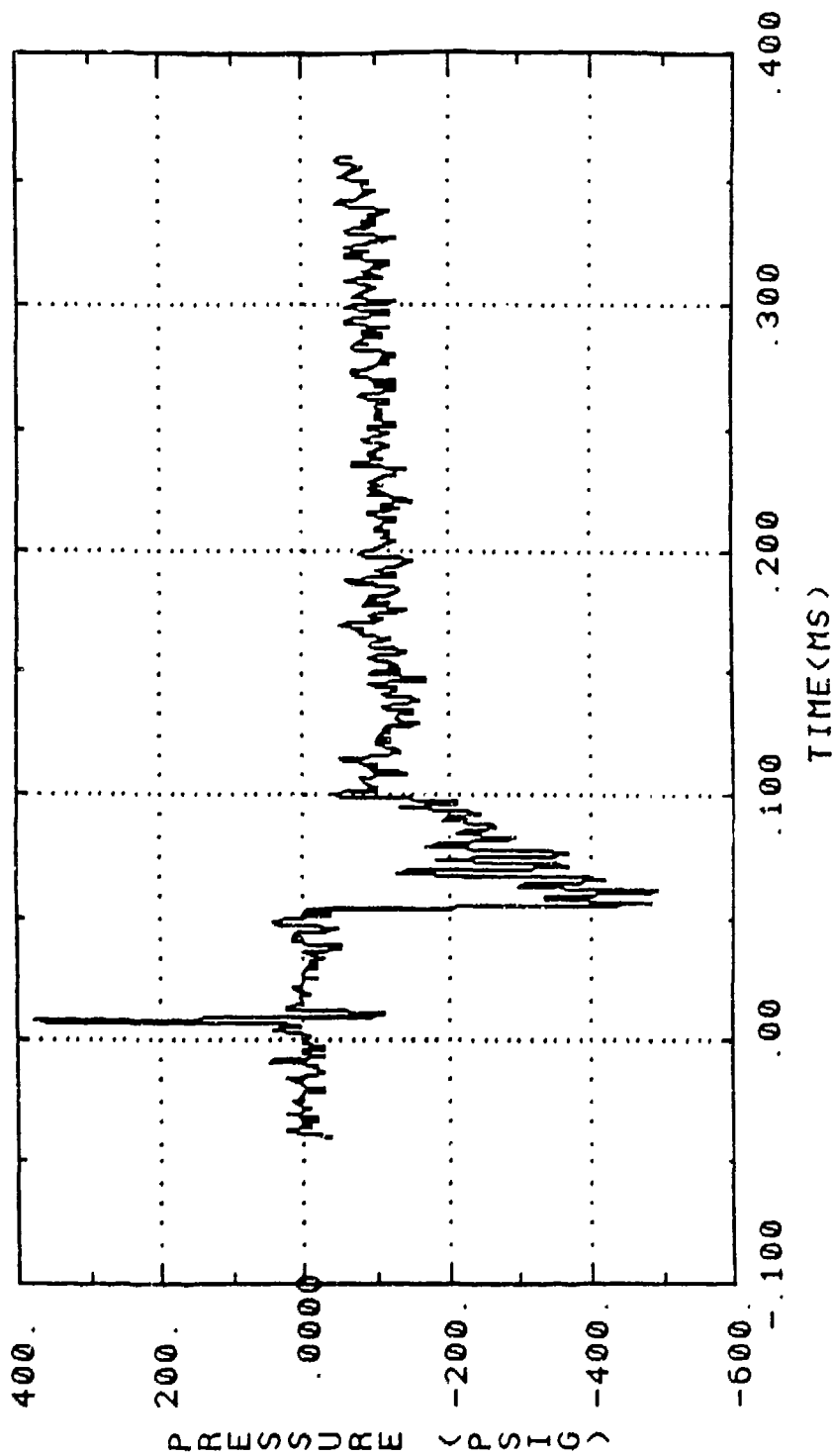


Figure C-45. Loads Test Data, Test 16, LOC 11



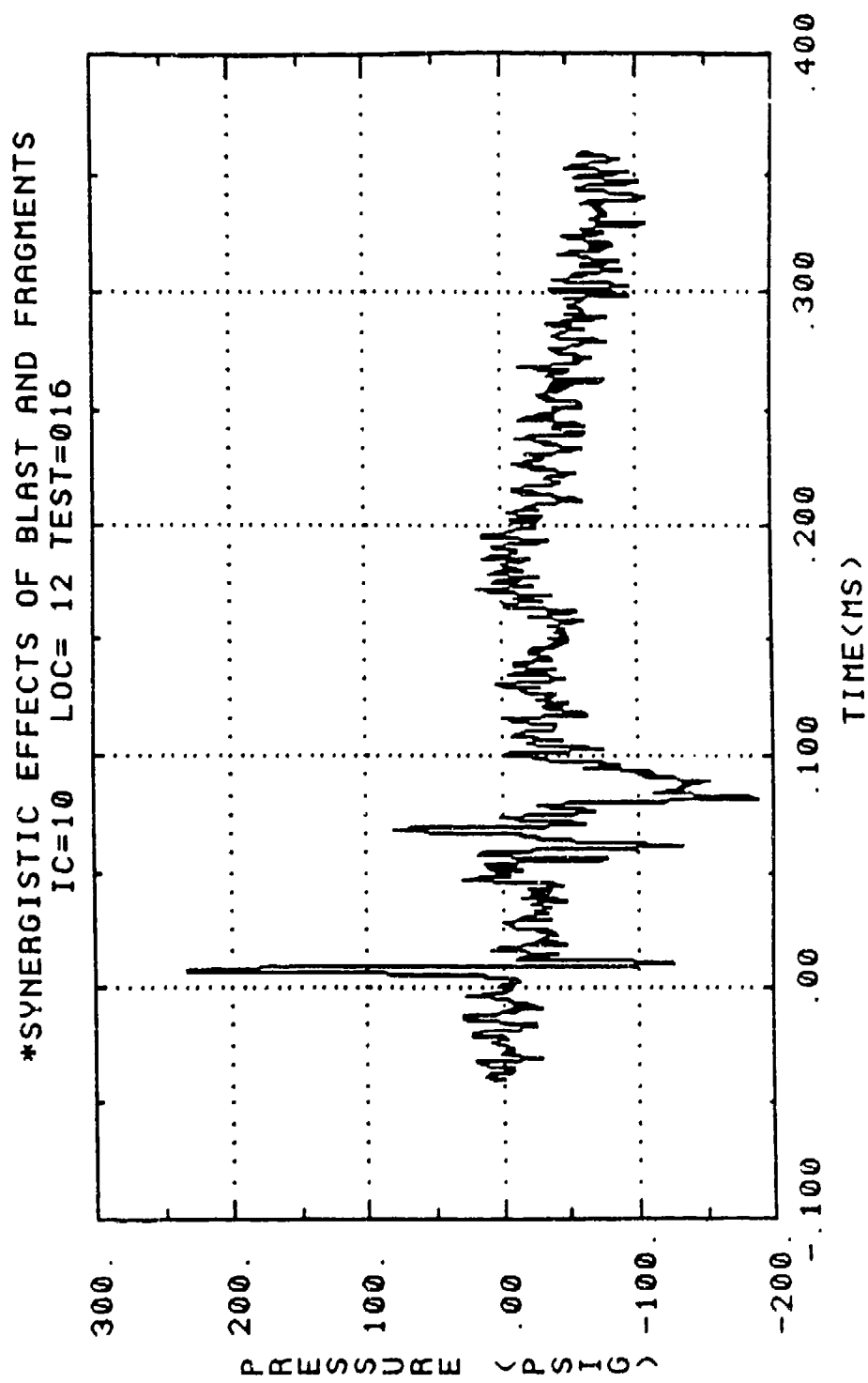


Figure C-46. Loads Test Data, Test 16, LOC 12

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 1 LOC= 1 TEST=019

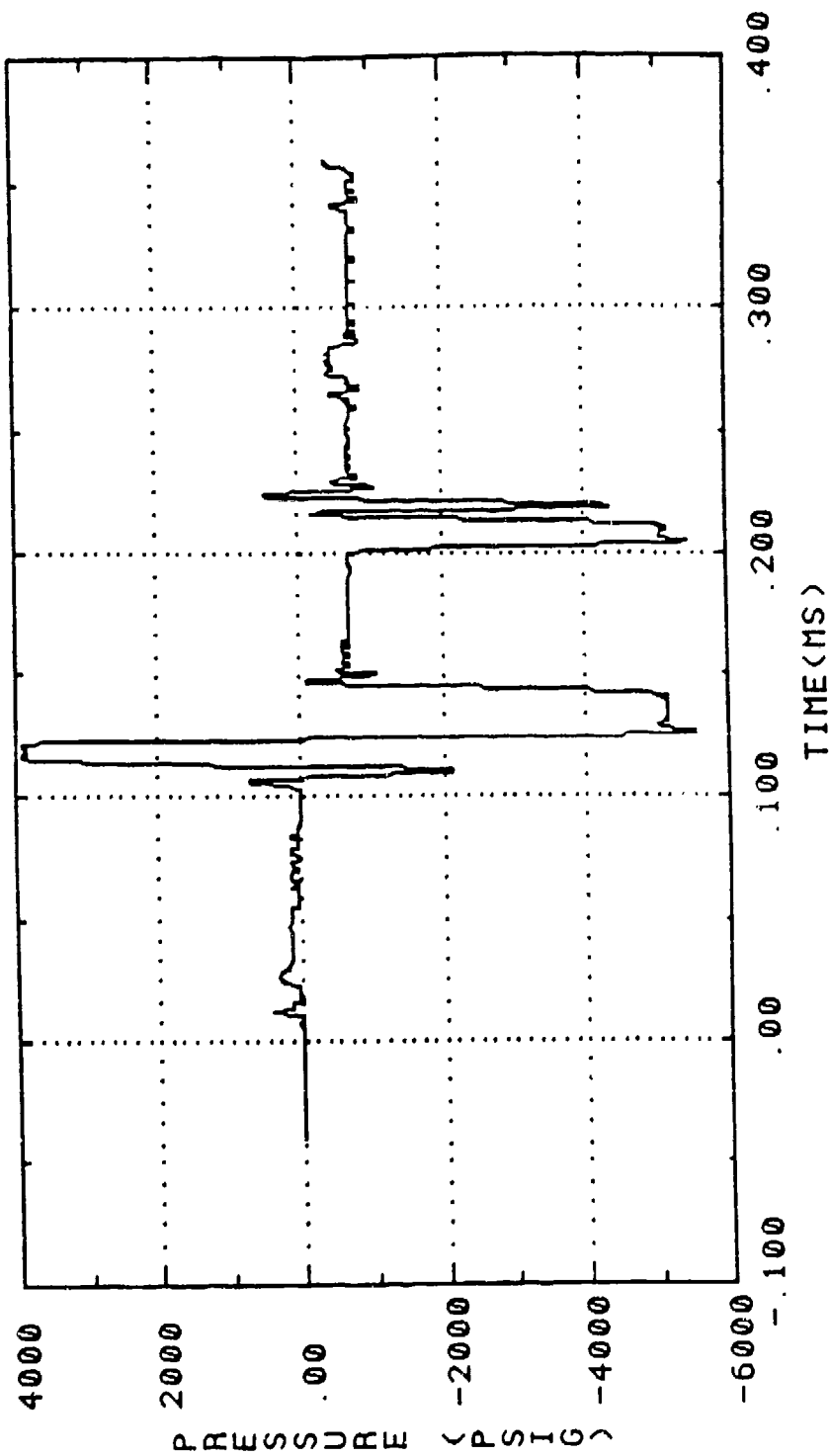


Figure C-47. Loads Test Data, Test 19, LOC 1

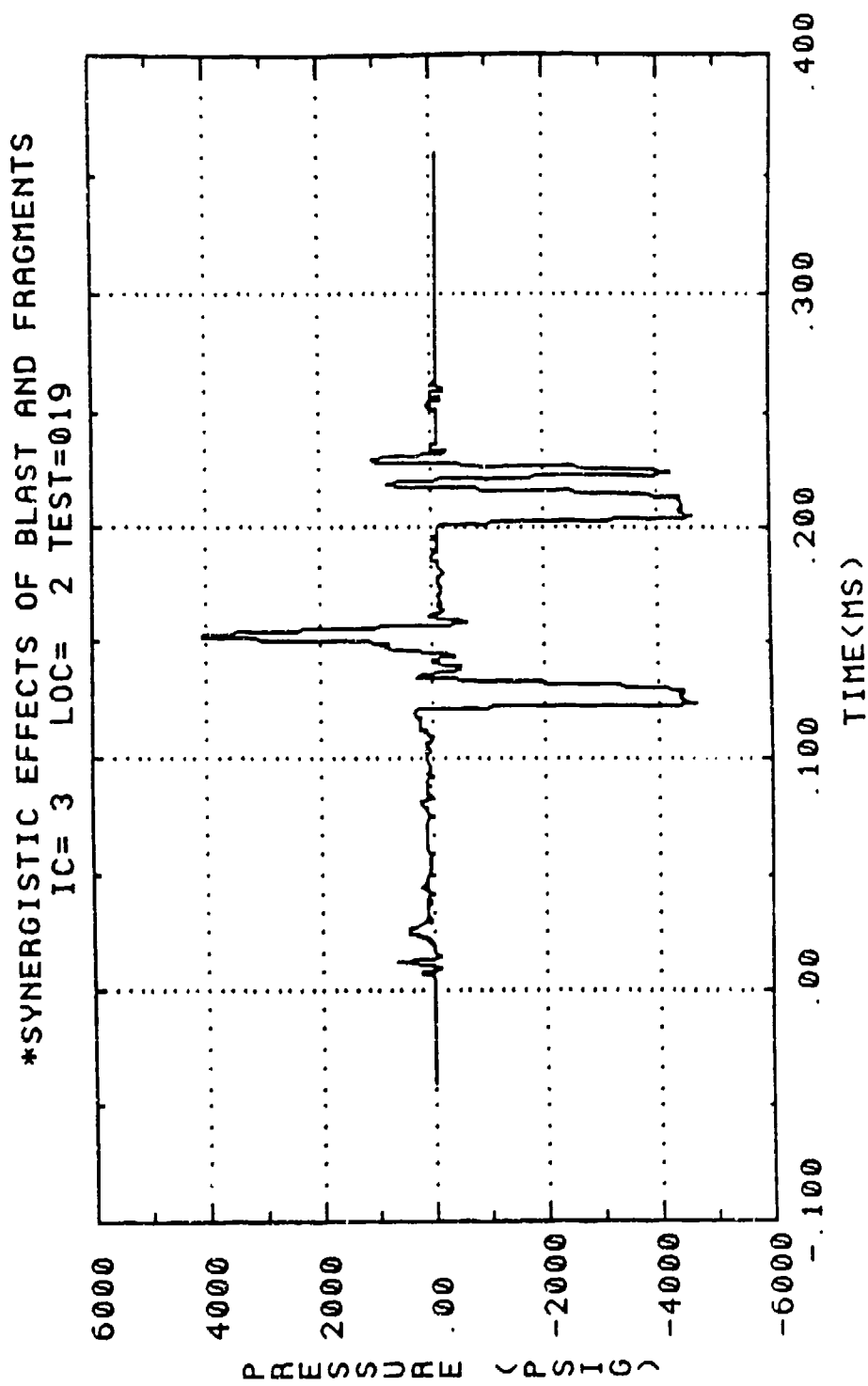


Figure C-48. Loads Test Data, Test 19, LOC 2

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 5 LOC= 3 TEST=019

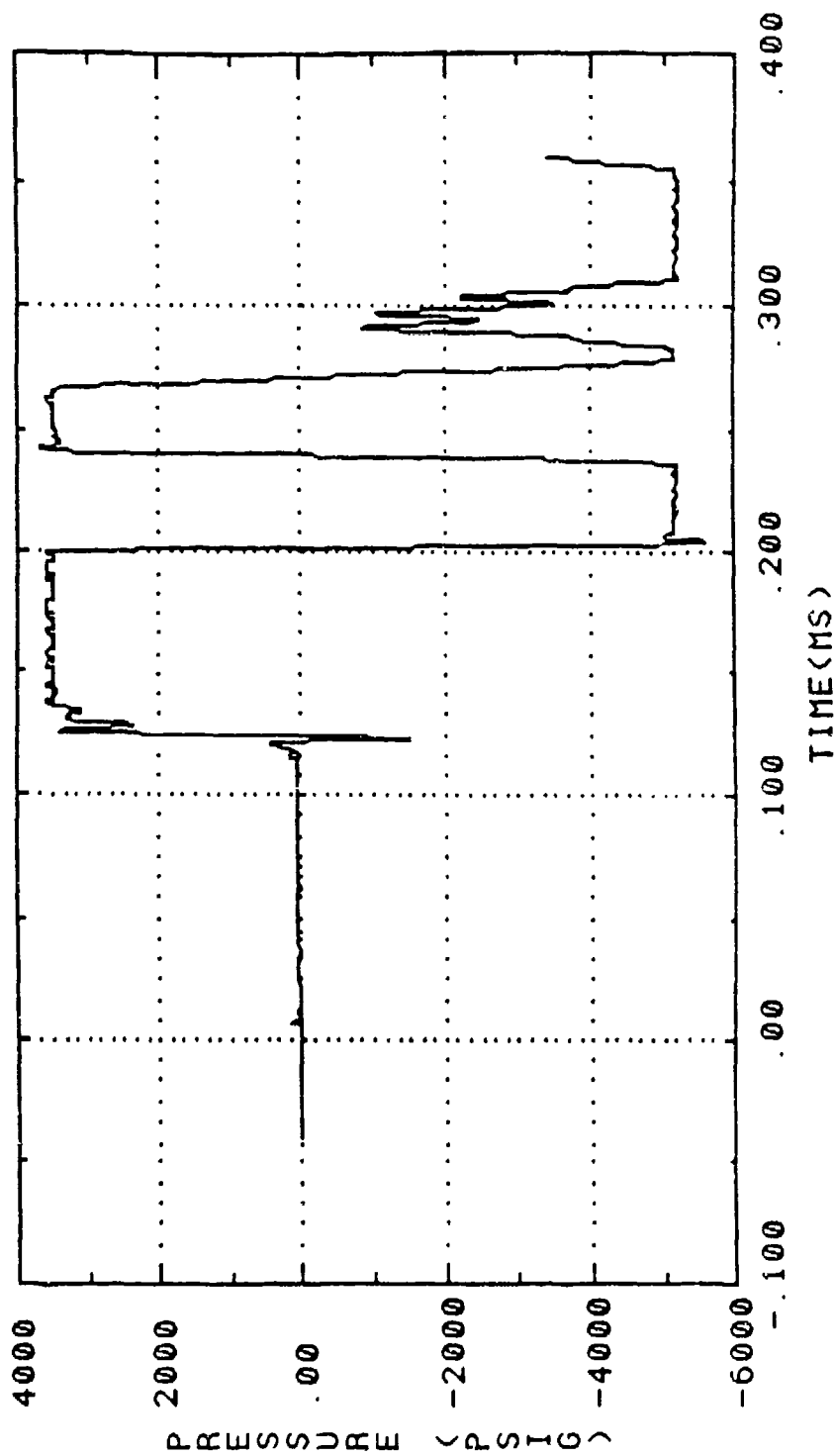


Figure C-49. Loads Test Data, Test 19, LOC 3

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 7 LOC= 4 TEST=019

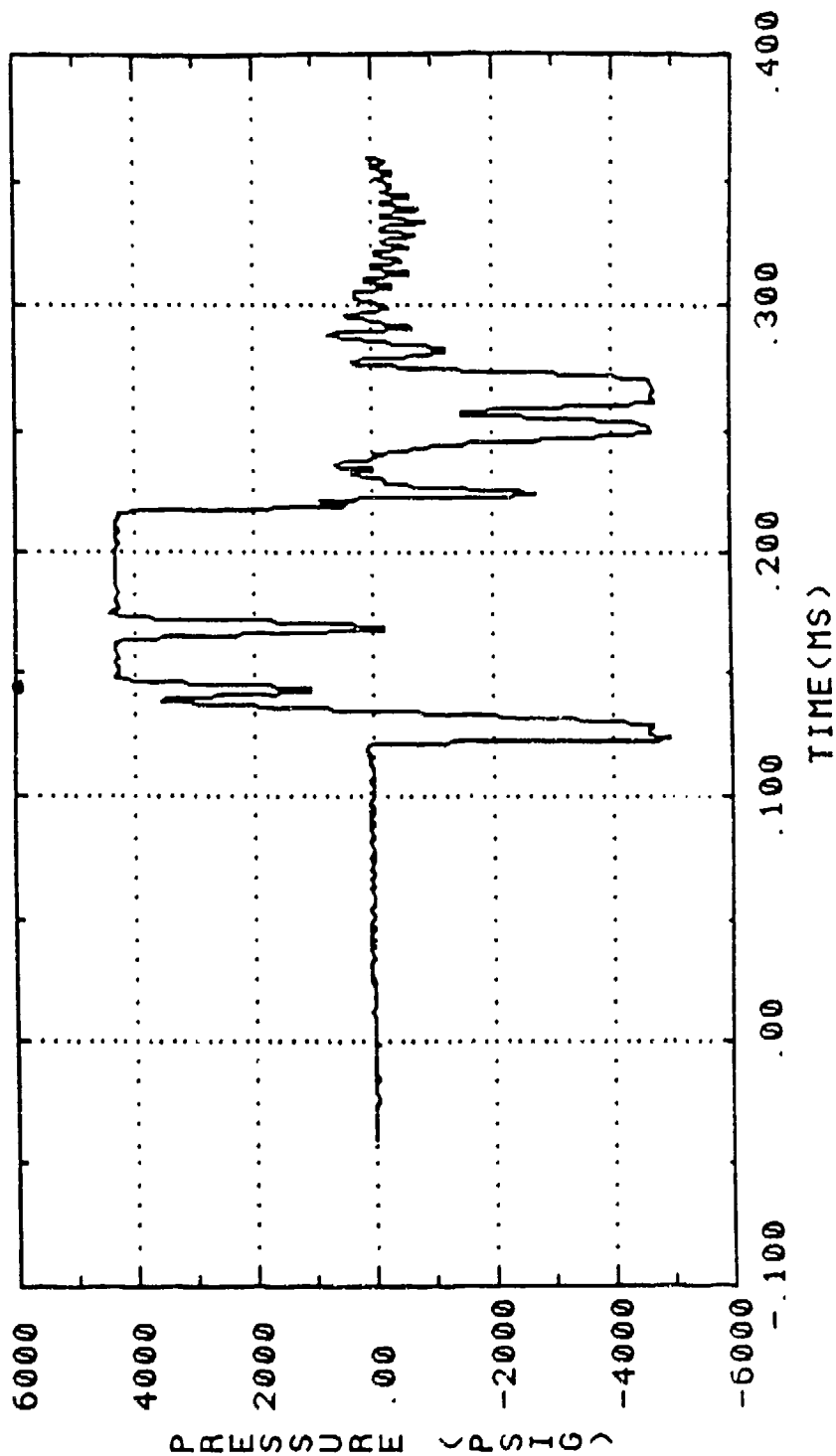


Figure C-50. Loads Test Data, Test 19, LOC 4

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 9 LOC= 5 TEST=019

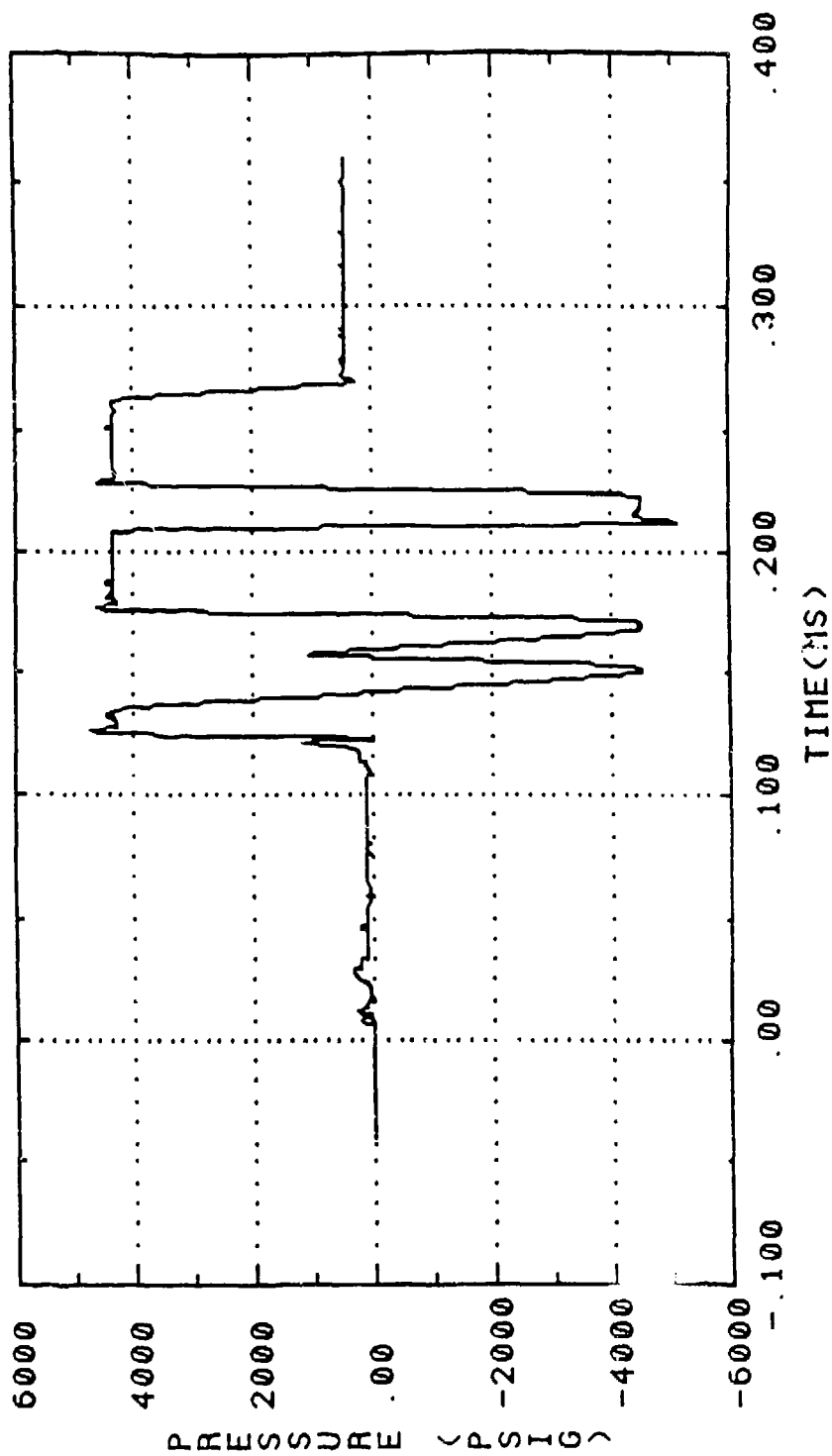


Figure C-51. Loads Test Data, Test 19, LOC 5

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC=11 LOC= 6 TEST=019

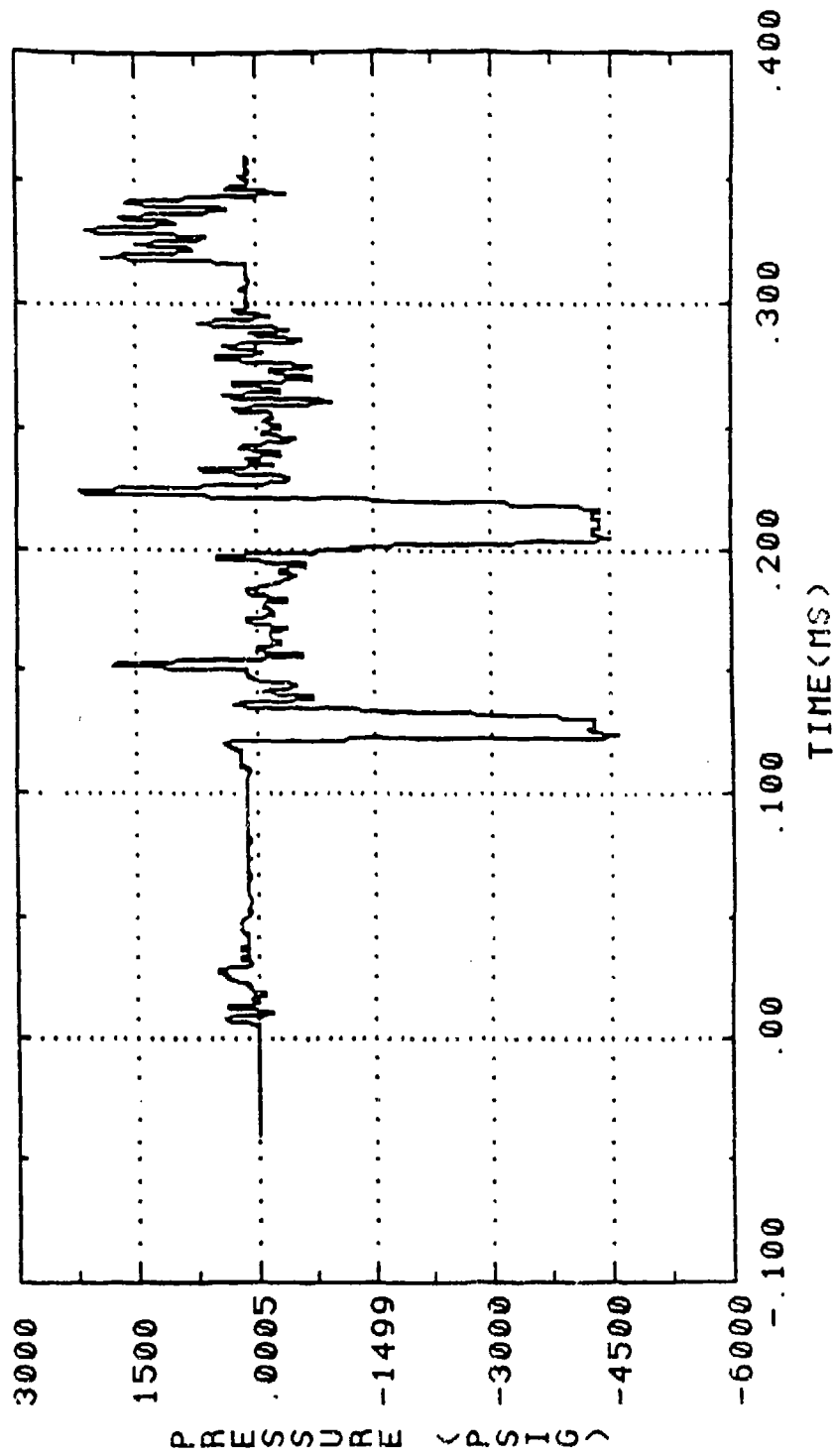


Figure C-52. Loads Test Data, Test 19, LOC 6

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC=13 LOC= 7 TEST=019

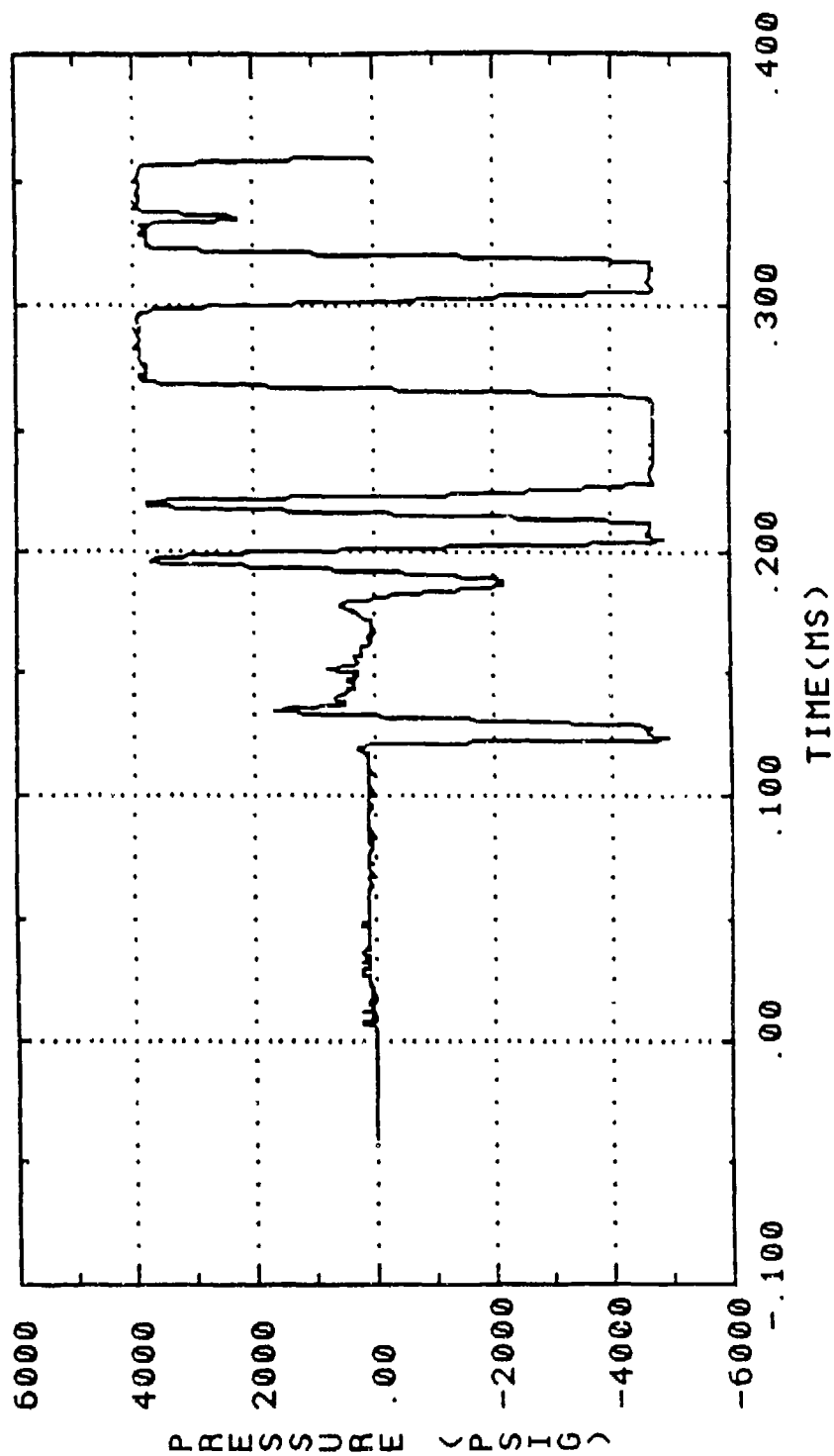


Figure C-53. Loads Test Data, Test 19, LOC 7



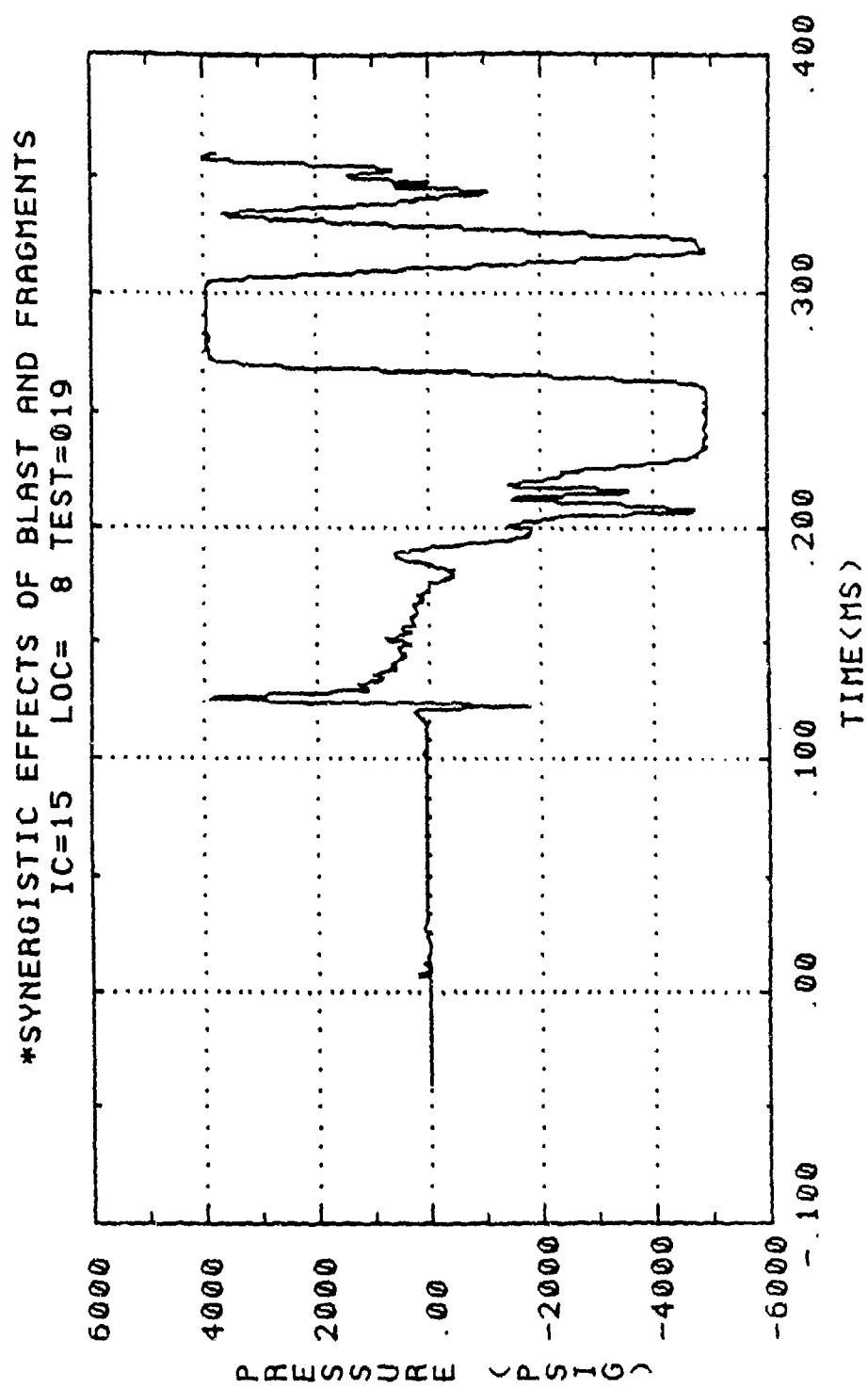


Figure C-54. Loads Test Data, Test 19, LOC 8

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 4 LOC= 9 TEST=019

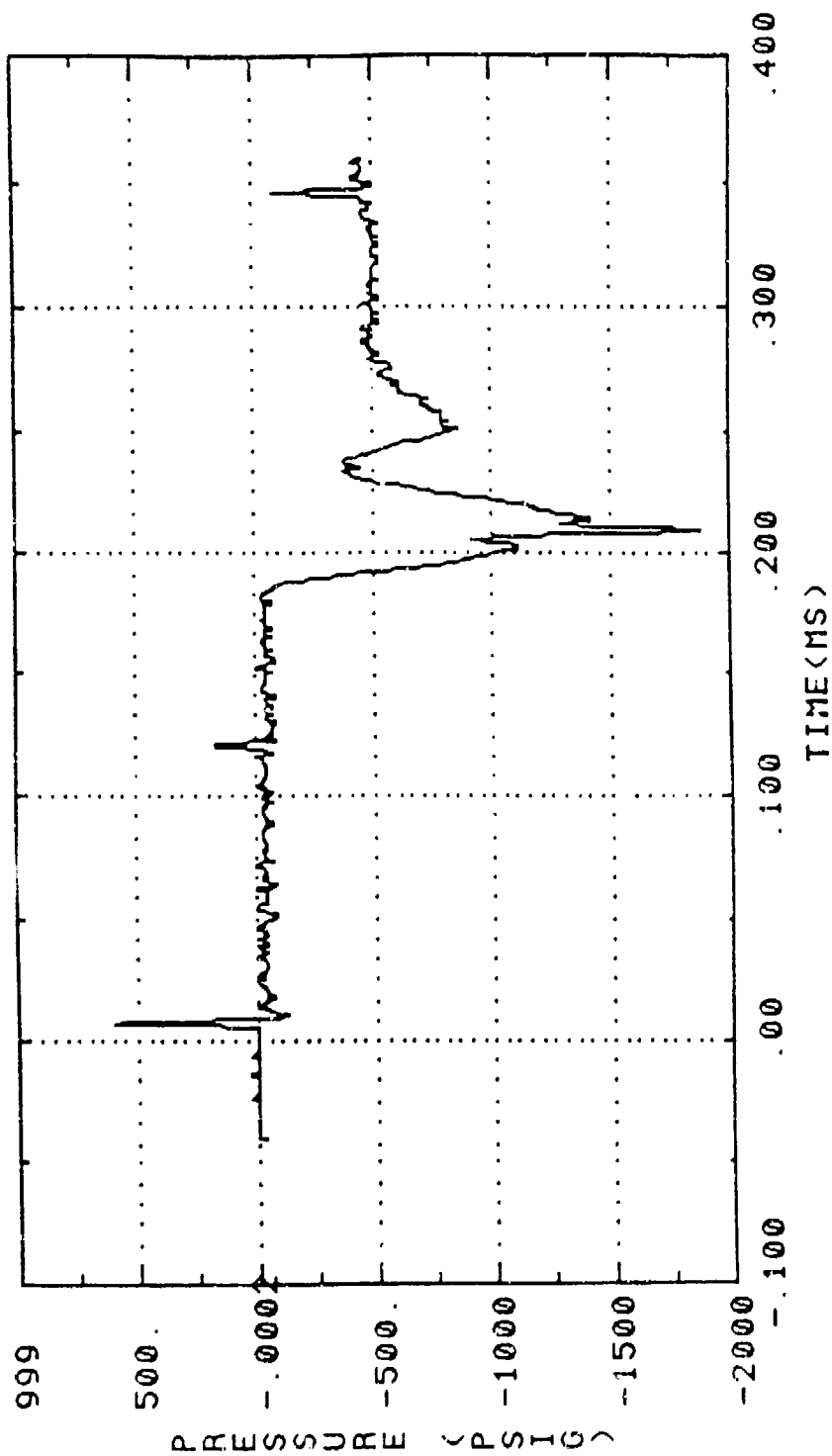


Figure C-55. Loads Test Data, Test 19, LOC 9

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 6 LOC= 10 TEST=019

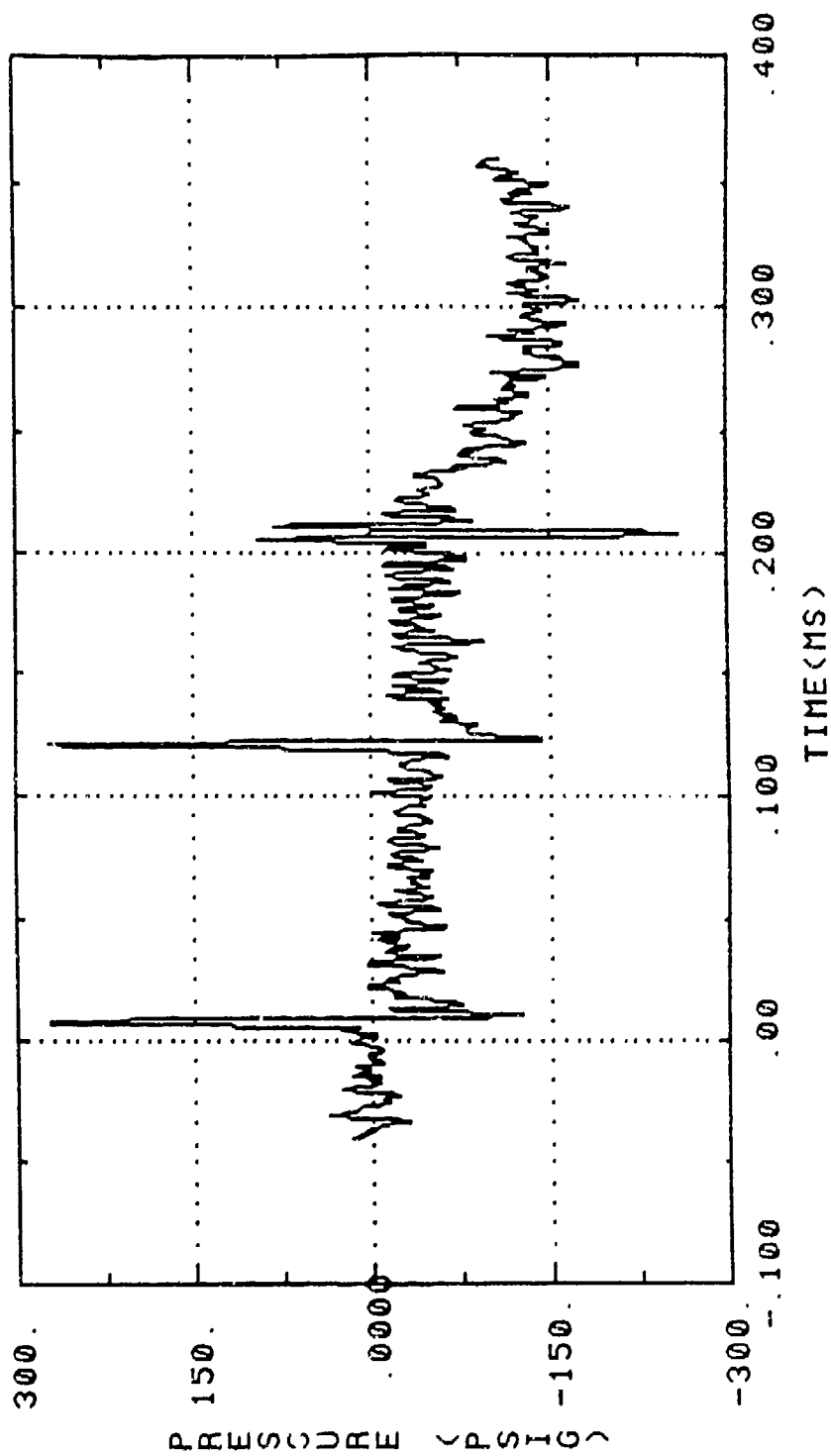


Figure C-56. Loads Test Data, Test 19, LOC 10

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC= 8 LOC= 11 TEST=019

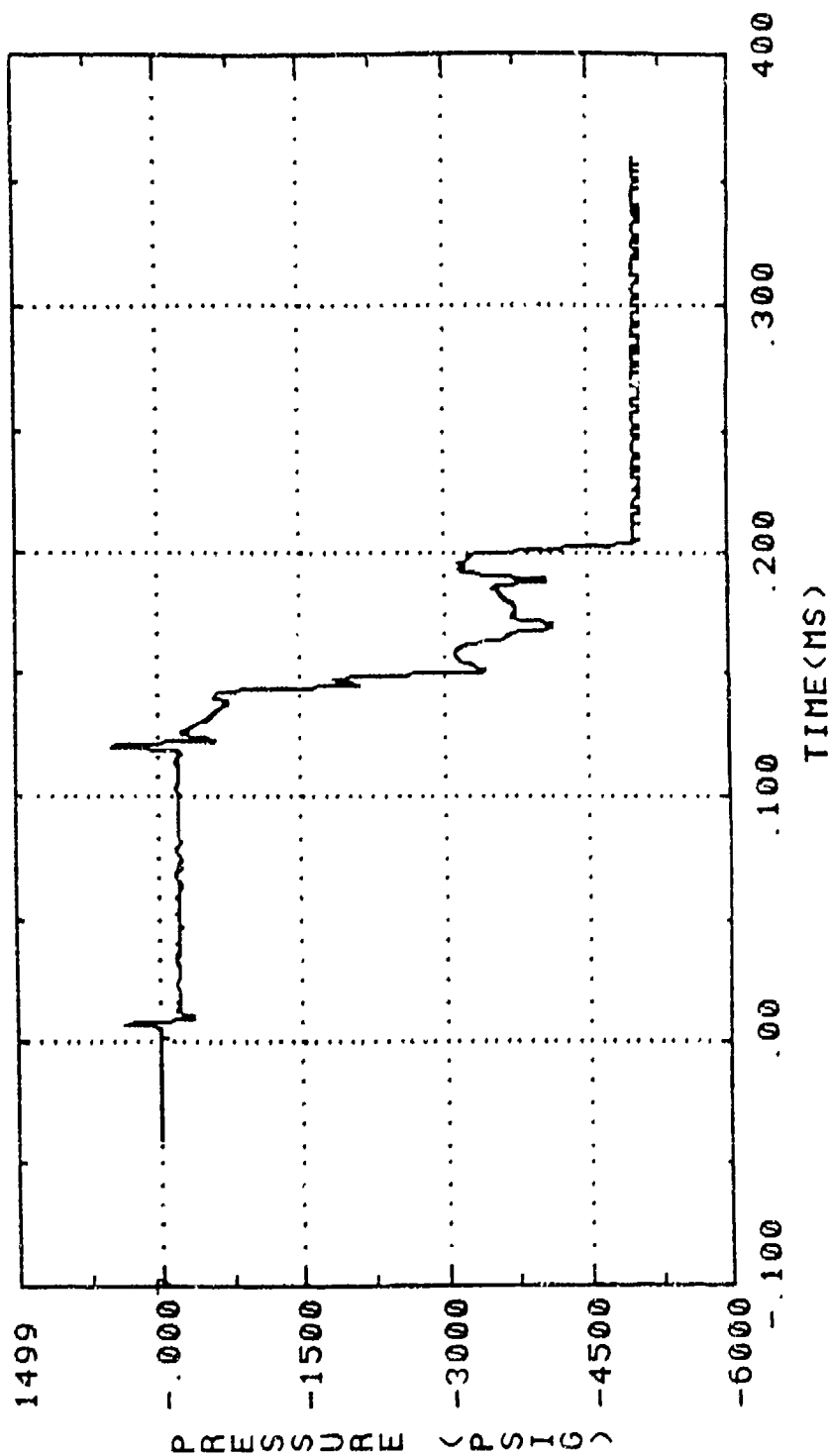


Figure C-57. Loads Test Data, Test 19, LOC 11

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC=10 LOC= 12 TEST=019

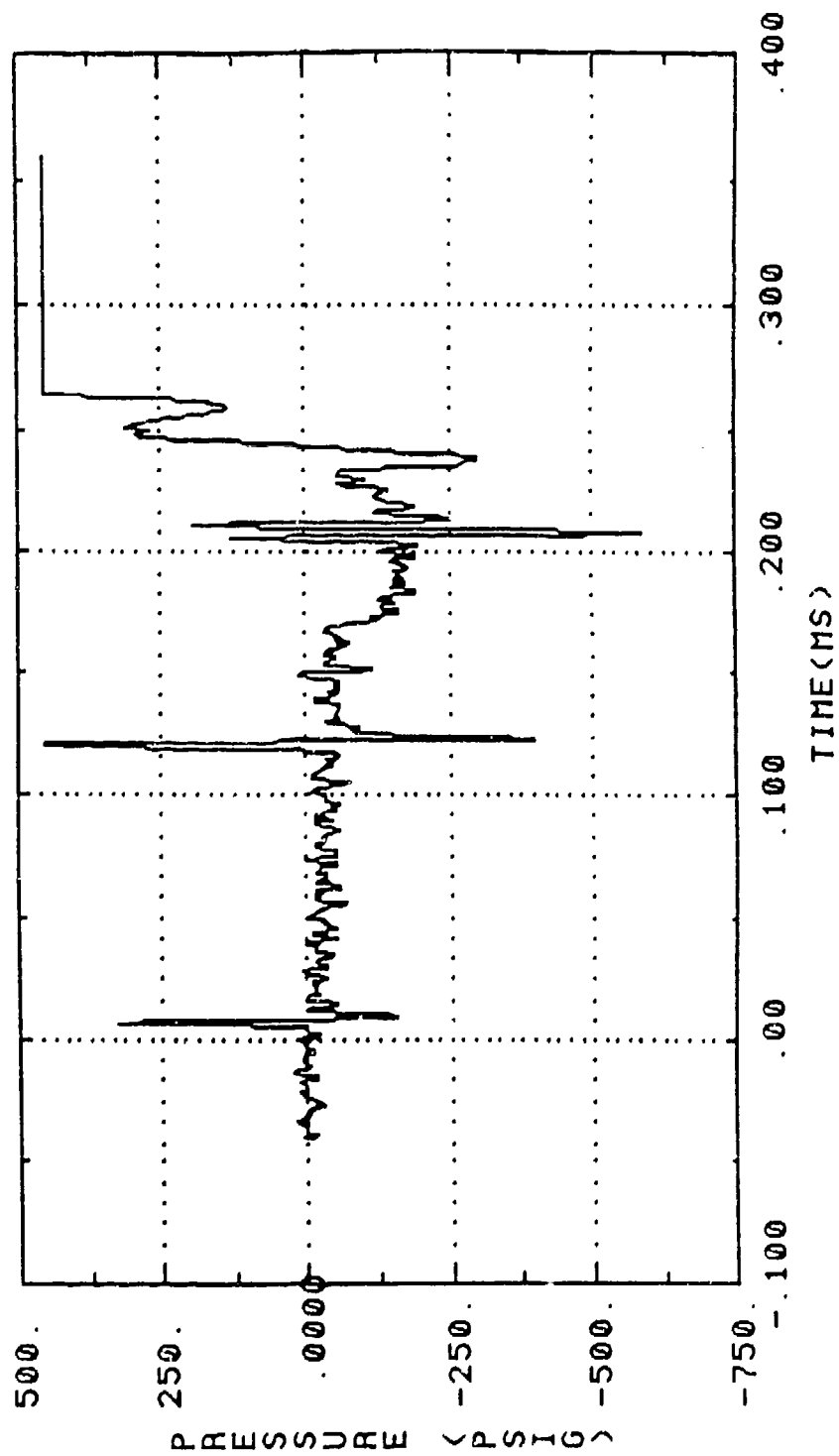


Figure C-58. Loads Test Data, Test 19, LOC 12

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 5 LOC= 3 TEST=020

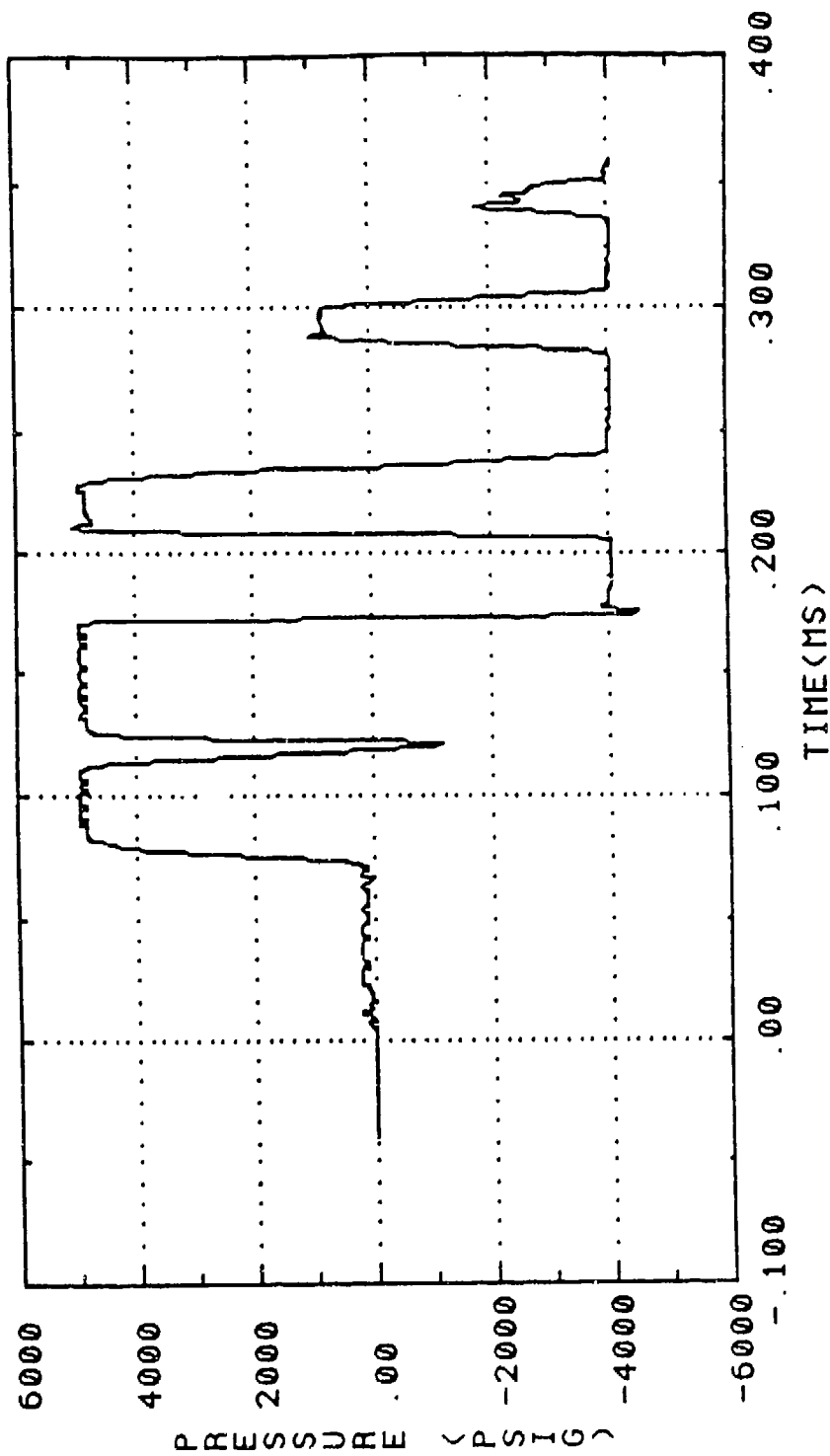


Figure C-59. Loads Test Data; Test 20, LOC 3

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 7 LOC= 4 TEST=020

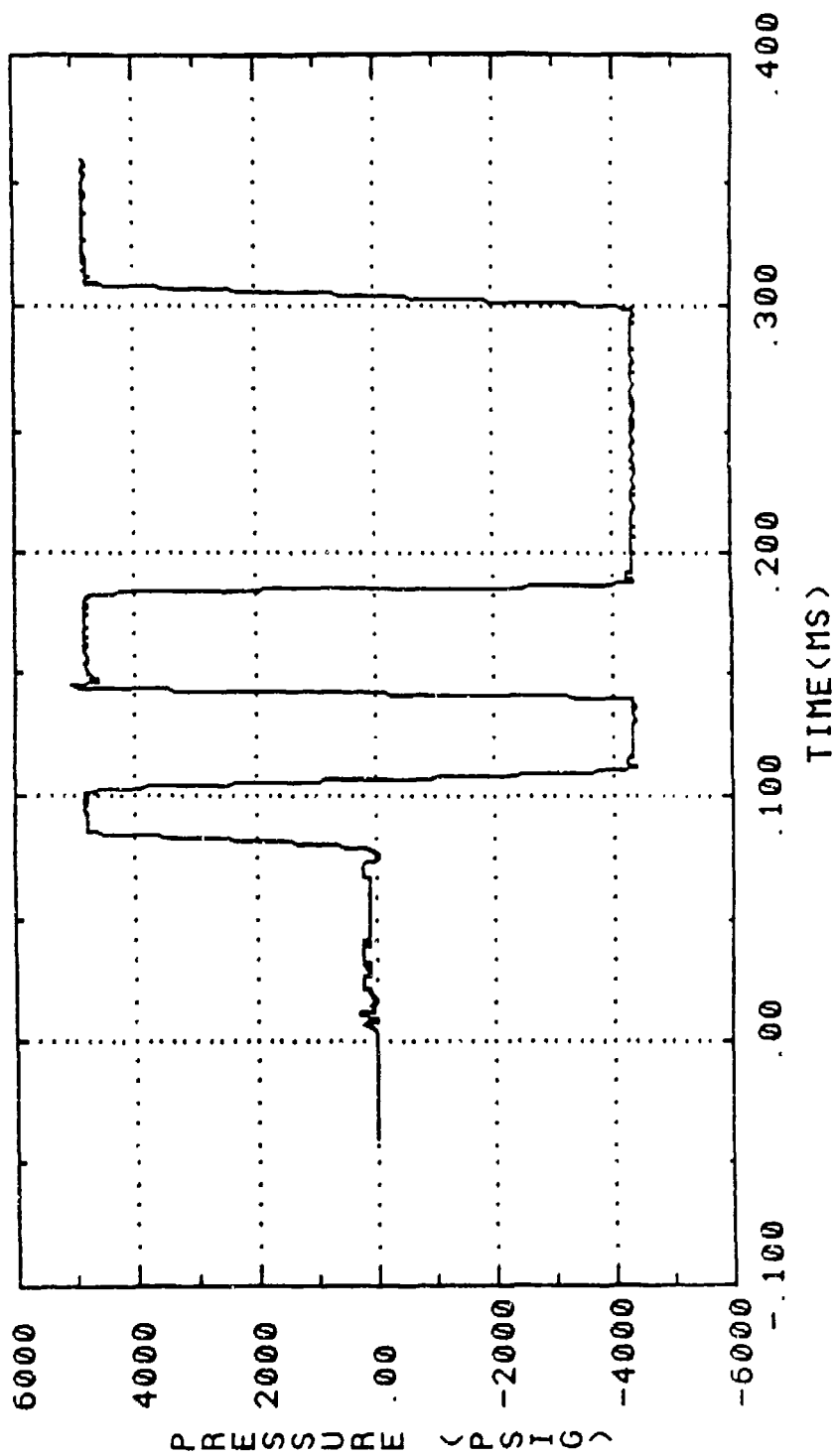


Figure C-60. Loads Test Data, Test 20, LOC 4

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 9 LOC= 5 TEST=020

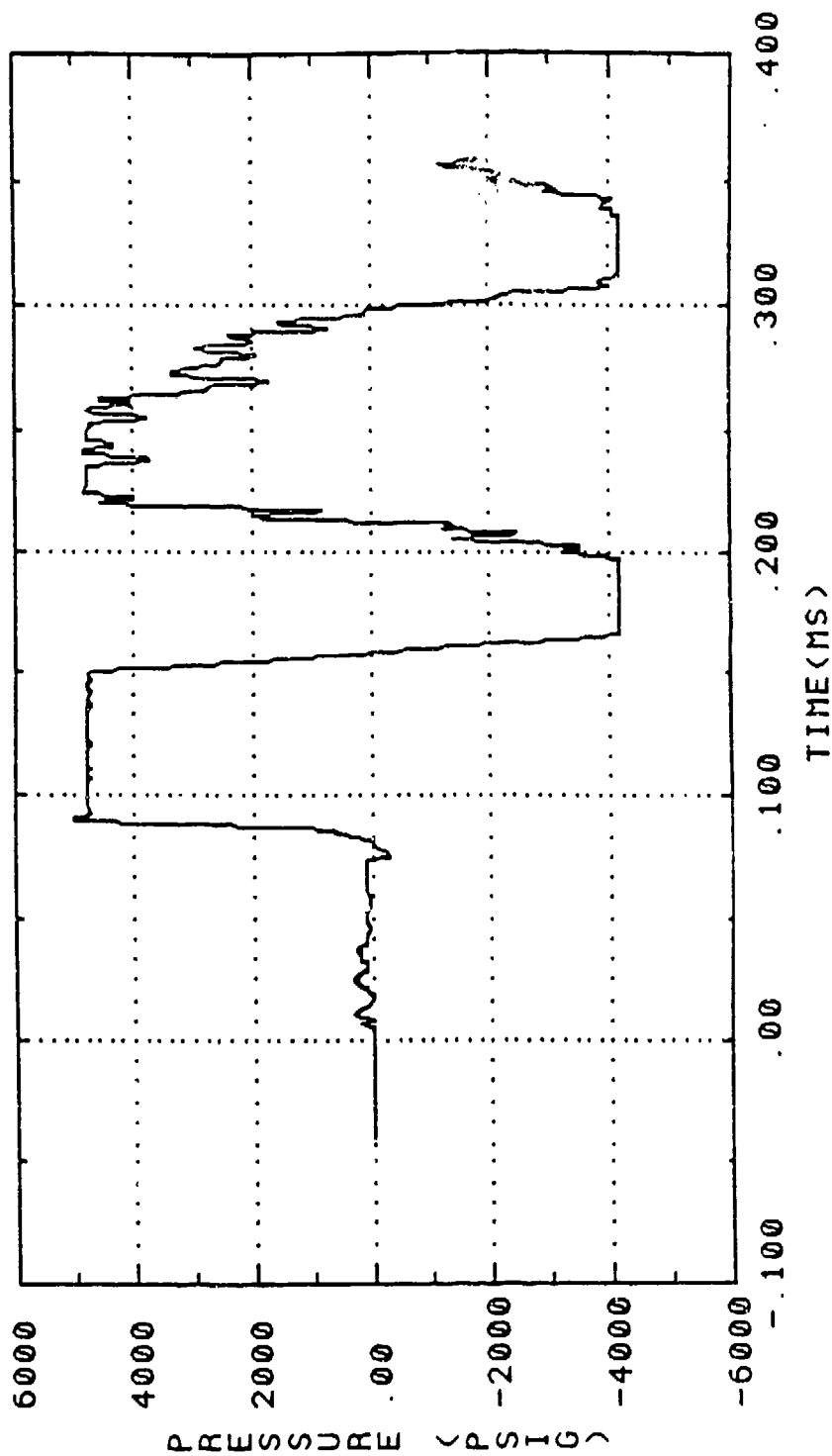


Figure C-61. Loads Test Data, Test 20, LOC 5



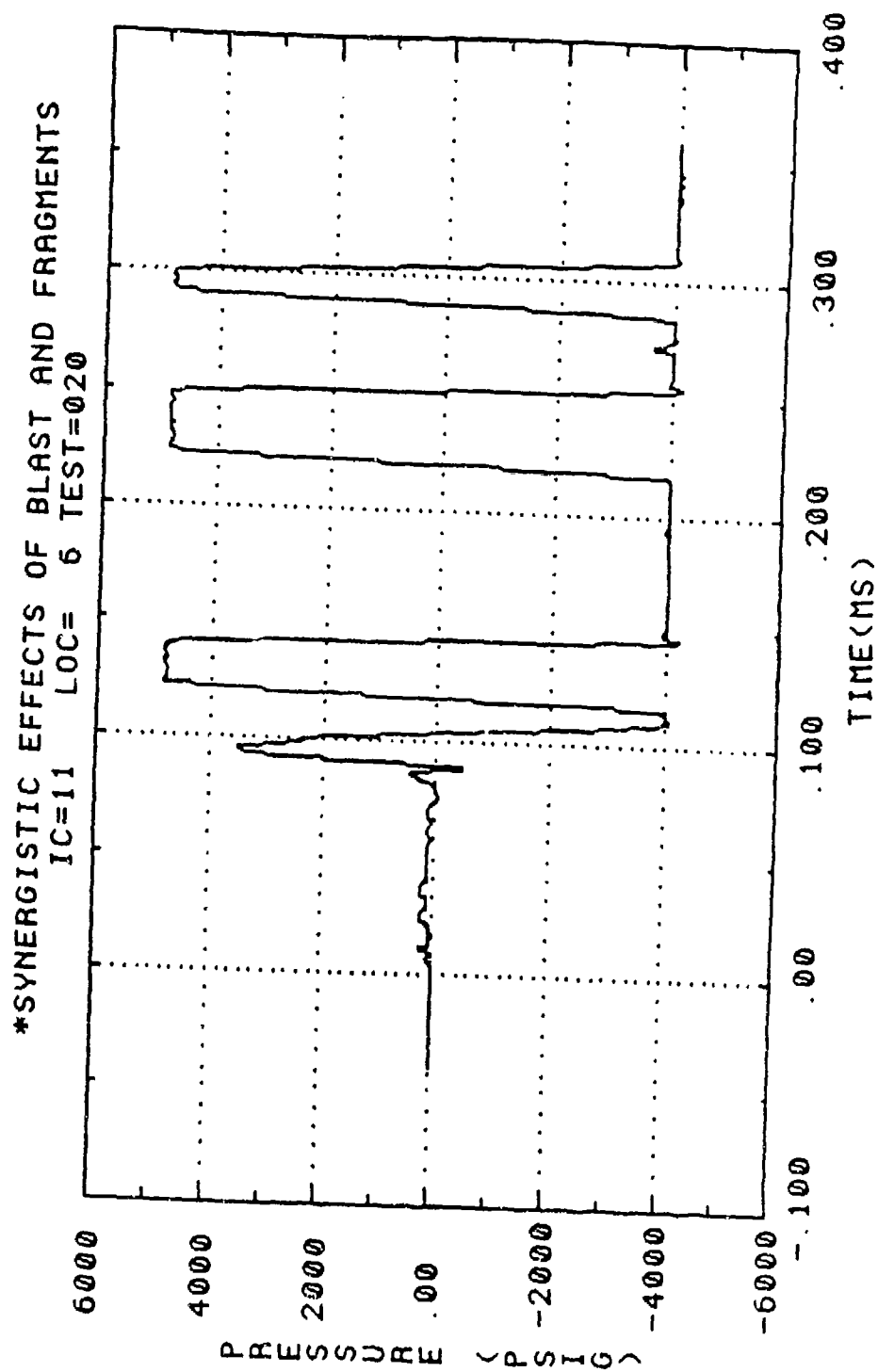


Figure C-62. Loads Test Data, Test 20, LOC 6

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
 IC=13 LOC= 7 TEST=020

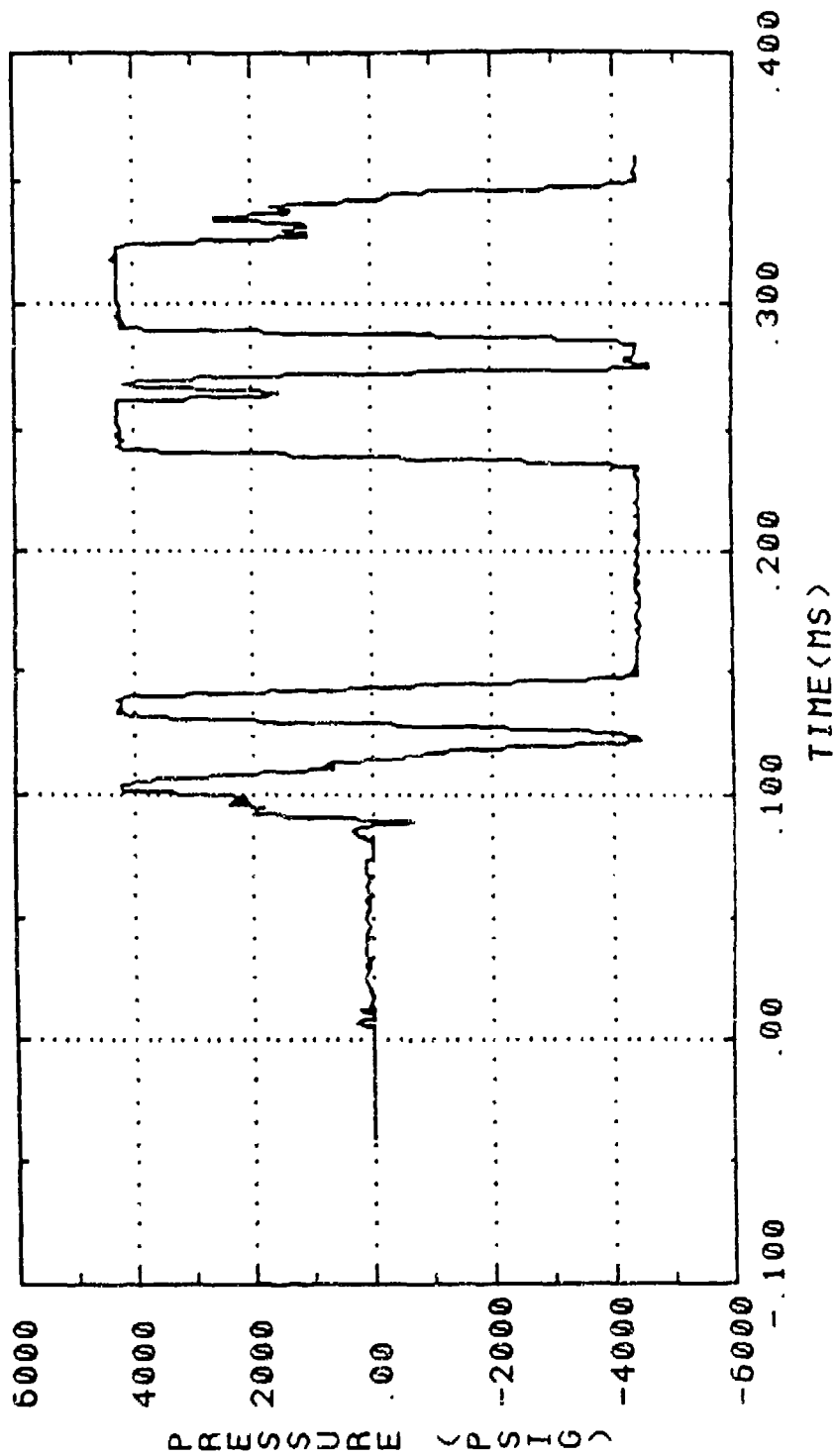


Figure C-63. Loads Test Data, Test 20, LOC 7

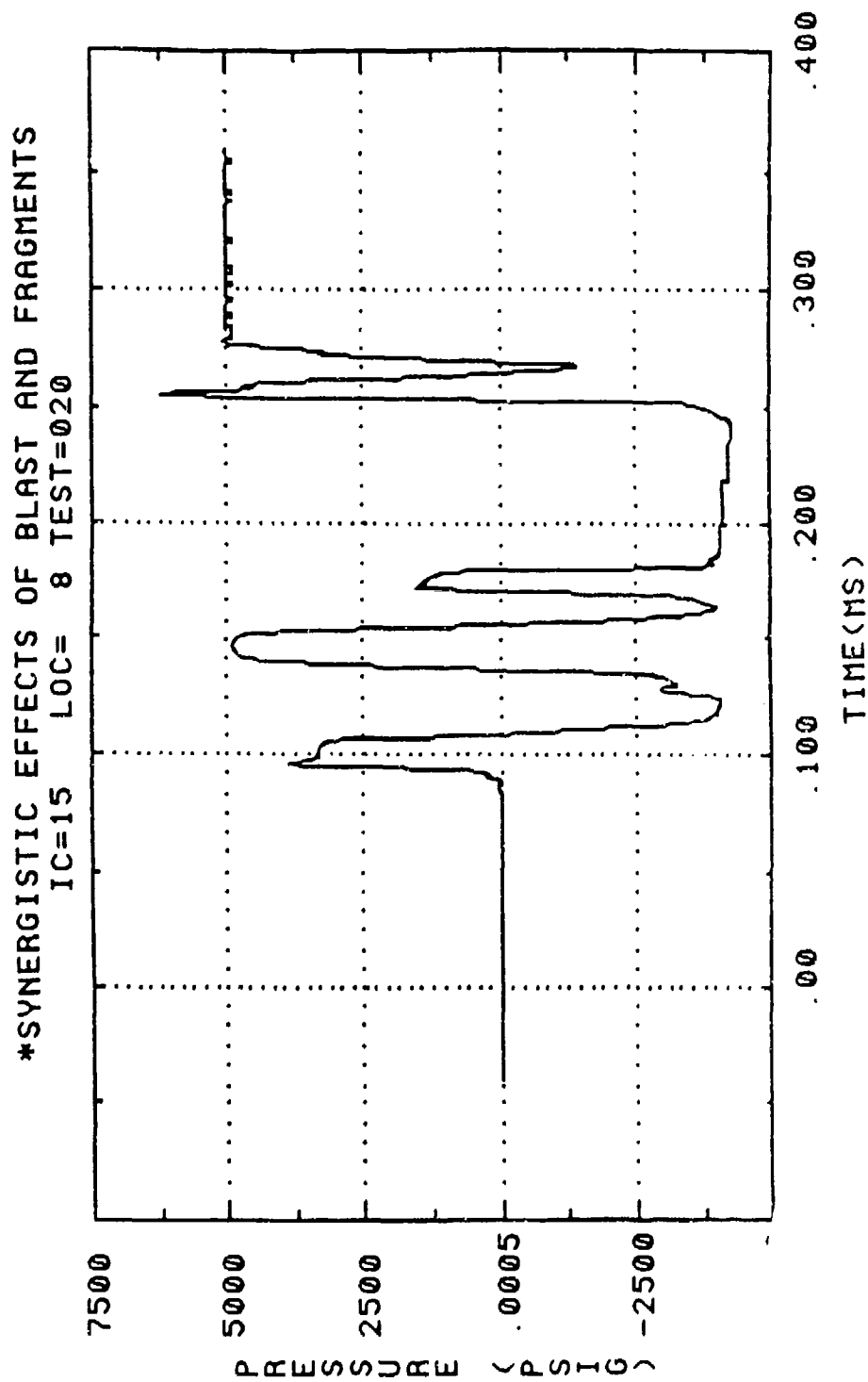


Figure C-64. Loads Test Data, Test 20, LOC 8

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS

IC= 4 LOC= 9 TEST=020

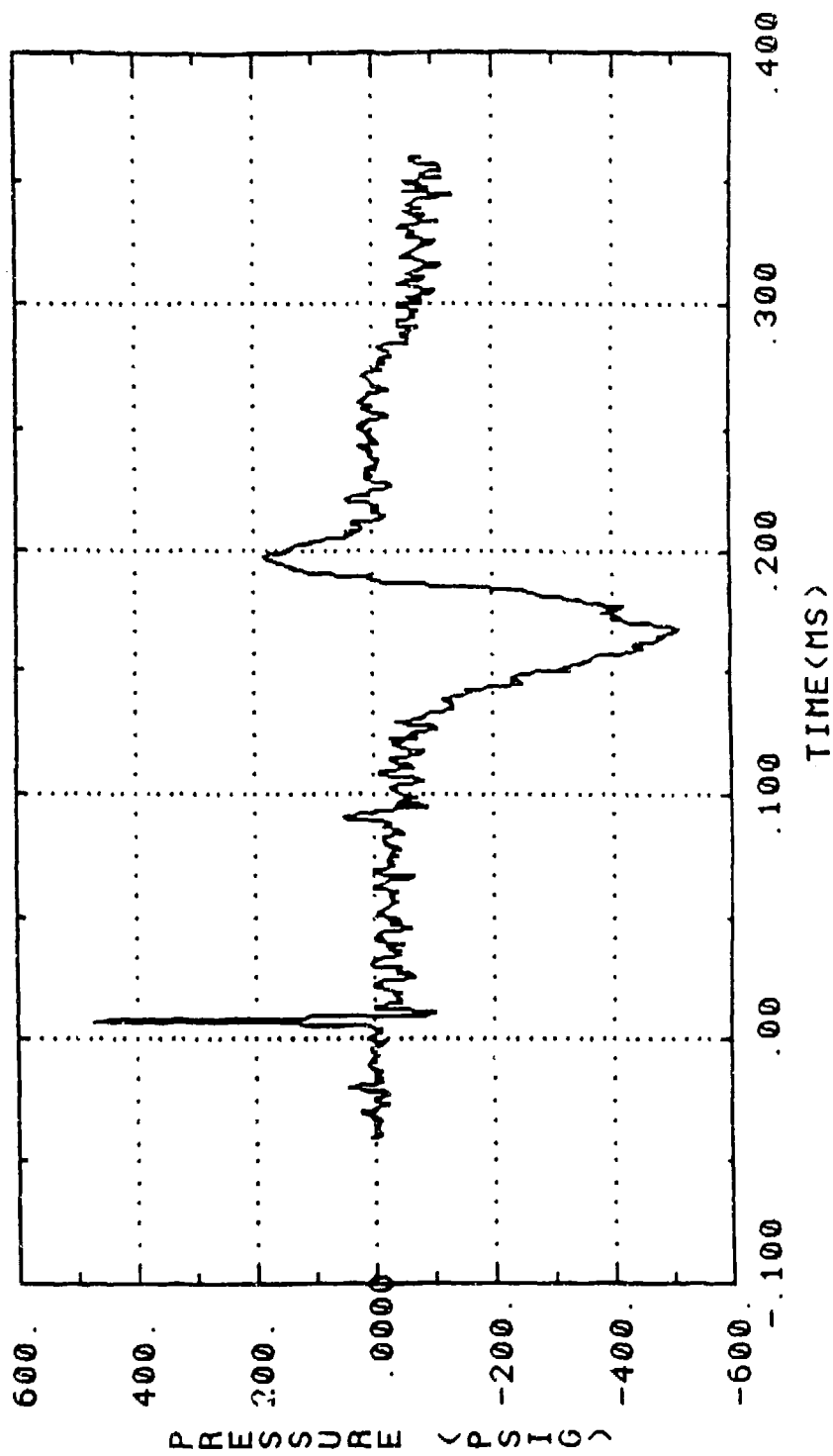


Figure C-65. Loads Test Data, Test 20, LOC 9

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 6 LOC= 10 TEST=020

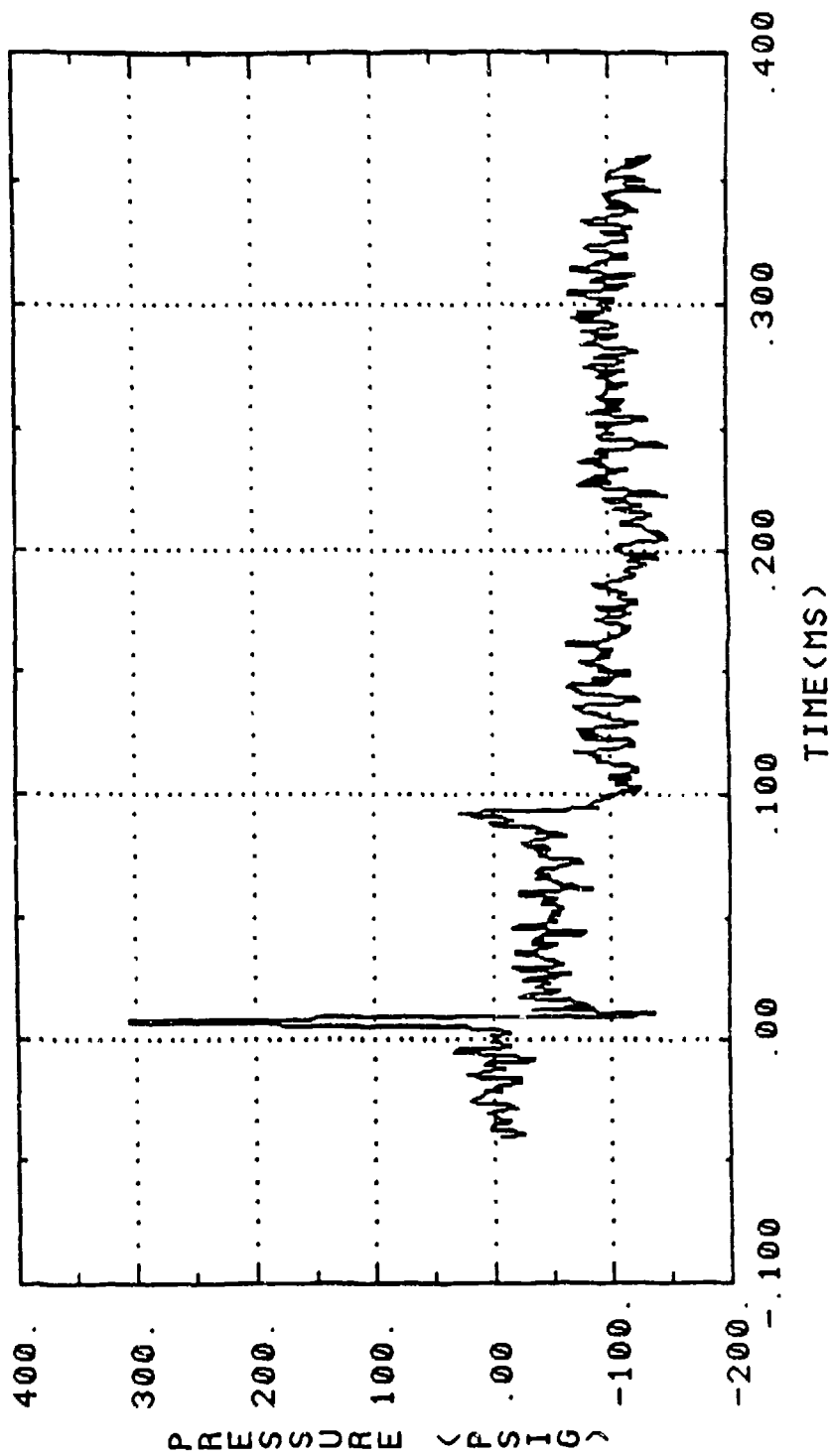


Figure C-66. Loads Test Data, Test 20, LOC 10

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC= 8 LOC= 11 TEST=020

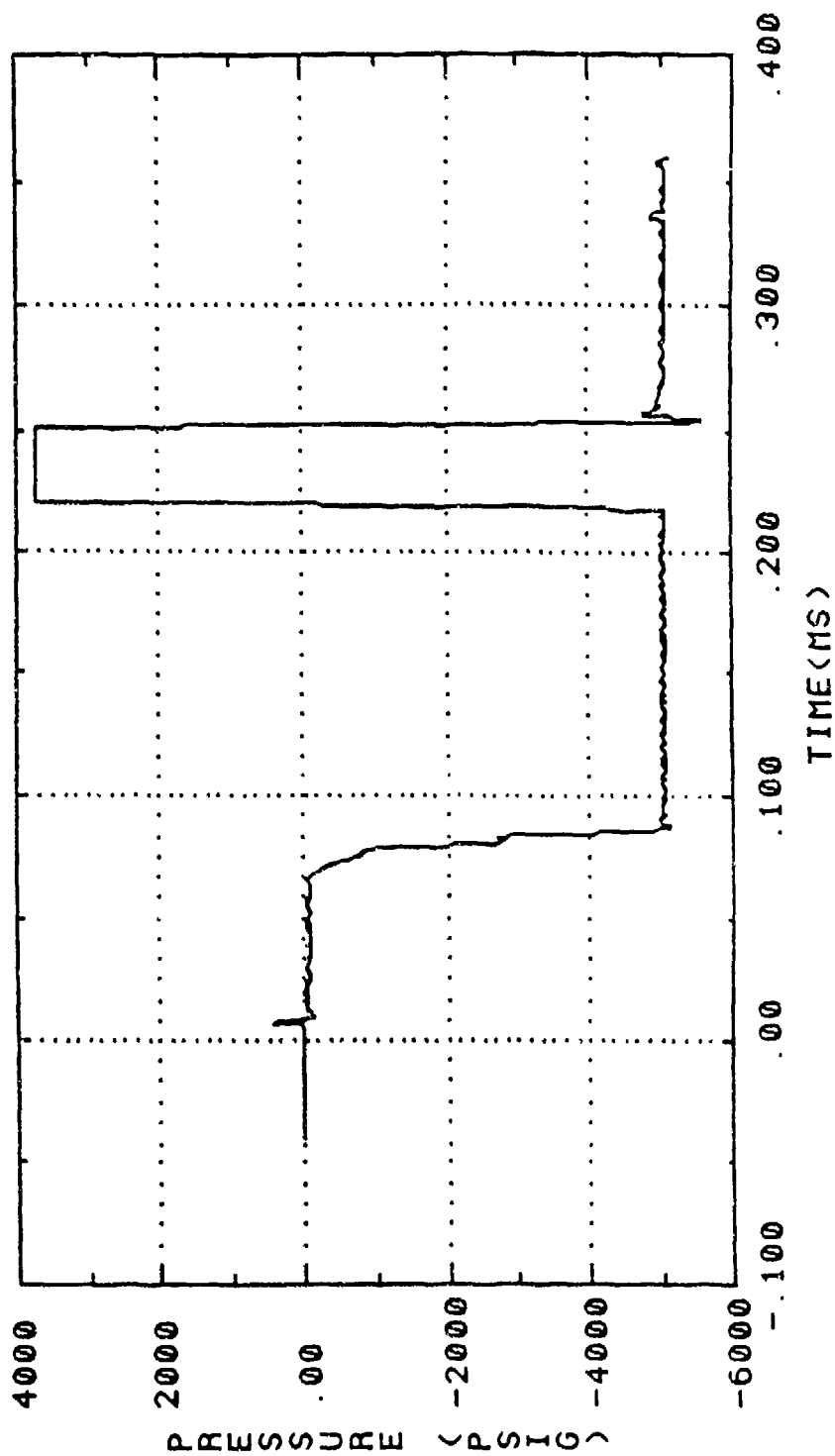


Figure C-67. Loads Test Data, Test 20, LOC 11

\*SYNERGISTIC EFFECTS OF BLAST AND FRAGMENTS  
IC=10 LOC= 12 TEST=020

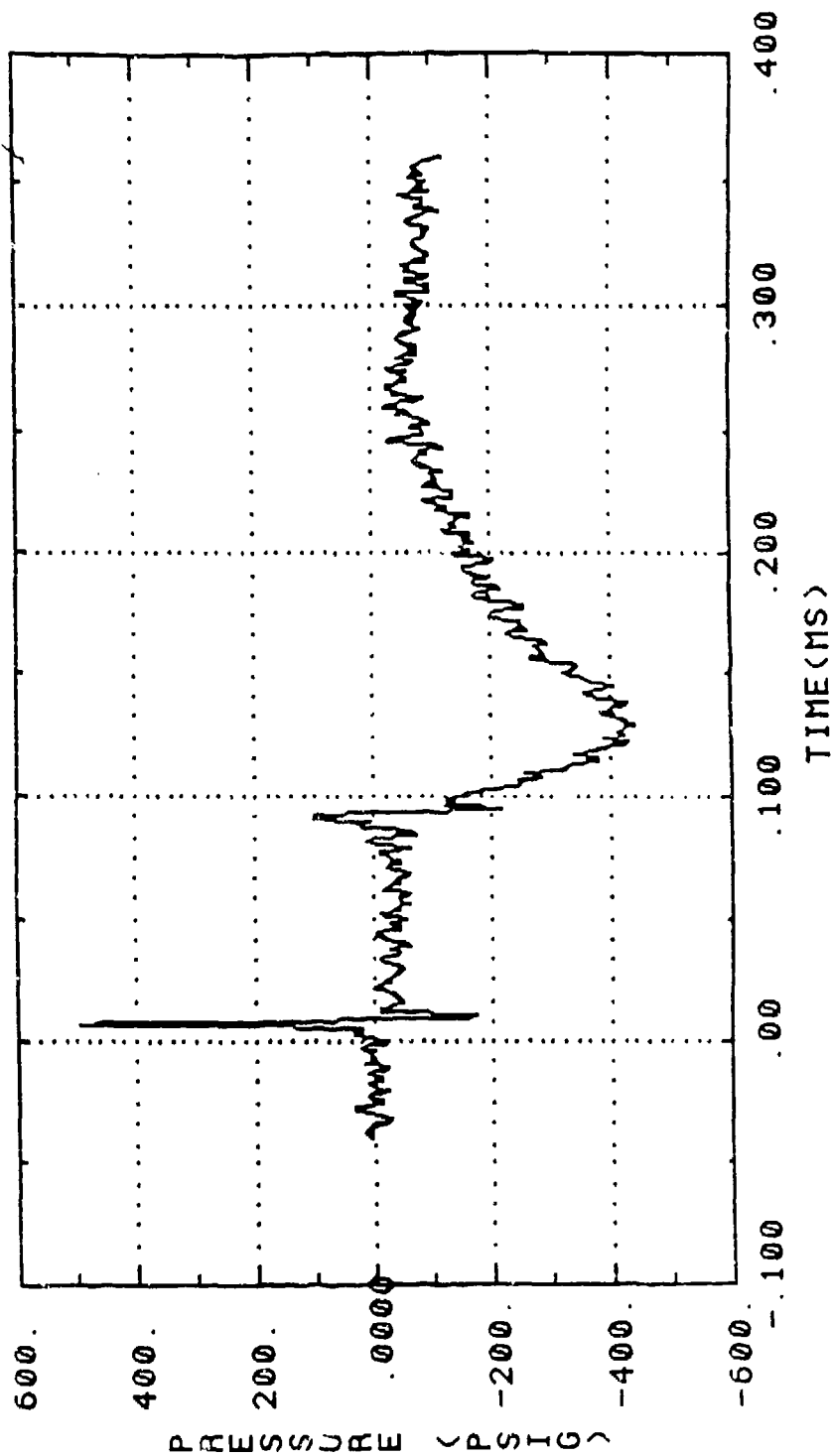


Figure C-68. Loads Test Data, Test 20, LOC 12

## APPENDIX D

### Dynasen Carbon Stress Gage Calibration Data



TABLE D-1. CARBON GAGE CALIBRATION DATA.

Wed, Mar 7, 1990 10:08

gage.dat

|    | Column 1    | Column 2 | Column 3   | Column 4  | Column 5  | Column 6  | Column 7   | Column 8  | Column 9   |
|----|-------------|----------|------------|-----------|-----------|-----------|------------|-----------|------------|
| 1  | 0.0000      | 0.0      | 0.0000     | 0.000     | 0.000     | 0.000     | 0.0000     | 0.000     | 0.0000     |
| 2  | 7250.0000   | 0.5      | -279.2000  | -300.000  | -290.000  | -307.000  | -277.8000  | -284.000  | -286.8000  |
| 3  | 14500.0000  | 1.0      | -537.2000  | -568.000  | -562.000  | -582.000  | -544.8000  | -548.000  | -560.8000  |
| 4  | 21750.0000  | 1.5      | -723.2000  | -788.000  | -786.000  | -810.000  | -760.9000  | -776.000  | -772.8000  |
| 5  | 29000.0000  | 2.0      | -961.2000  | -1028.000 | -1028.000 | -1046.000 | -992.9000  | -996.000  | -1008.8000 |
| 6  | 36250.0000  | 2.5      | -1161.2000 | -1220.000 | -1234.000 | -1278.000 | -1192.8000 | -1196.000 | -1216.8000 |
| 7  | 43500.0000  | 3.0      | -1361.2000 | -1436.000 | -1442.000 | -1470.000 | -1384.8000 | -1388.000 | -1416.8000 |
| 8  | 50750.0000  | 3.5      | -1553.2000 | -1620.000 | -1634.000 | -1662.000 | -1576.8000 | -1588.000 | -1624.8000 |
| 9  | 58000.0000  | 4.0      | -1729.2000 | -1804.000 | -1810.000 | -1862.000 | -1744.8000 | -1748.000 | -1776.8000 |
| 10 | 65250.0000  | 4.5      | -1897.2000 | -1972.000 | -2010.000 | -2038.000 | -1904.8000 | -1924.000 | -1984.8000 |
| 11 | 72500.0000  | 5.0      | -2033.2000 | -2148.000 | -2170.000 | -2214.000 | -2096.8000 | -2084.000 | -2144.8000 |
| 12 | 79750.0000  | 5.5      | -2193.2000 | -2308.000 | -2362.000 | -2390.000 | -2256.8000 | -2292.000 | -2336.8000 |
| 13 | 87000.0000  | 6.0      | -2353.2000 | -2468.000 | -2506.000 | -2566.000 | -2432.8000 | -2420.000 | -2496.8000 |
| 14 | 94250.0000  | 6.5      | -2513.2000 | -2660.000 | -2682.000 | -2726.000 | -2592.8000 | -2580.000 | -2656.8000 |
| 15 | 101500.0000 | 7.0      | -2689.2000 | -2820.000 | -2858.000 | -2918.000 | -2752.8000 | -2772.000 | -2832.8000 |
| 16 | 108750.0000 | 7.5      | -2849.2000 | -2980.000 | -3018.000 | -3078.000 | -2912.8000 | -2932.000 | -2960.8000 |

TABLE D-1. CARBON GAGE CALIBRATION DATA (CONTINUED).

Wed, Mar 7, 1990 10.08

gage.dat

|    | Column 10  | Column 11  | Column 12 | Column 13 | Column 14 | Column 15 | Column 16  | Column 17 | Column 18 |
|----|------------|------------|-----------|-----------|-----------|-----------|------------|-----------|-----------|
| 1  | 0.0000     | 0.0000     | 0.000     | 0.000     | 0.000     | 0.000     | 0.0000     | 0.000     | 0.000     |
| 2  | -301.2000  | -329.6000  | -341.000  | -333.000  | -324.000  | -308.000  | -318.6000  | -326.000  | -327.000  |
| 3  | -573.2000  | -629.6000  | -648.000  | -639.000  | -641.000  | -582.000  | -609.6000  | -616.000  | -618.000  |
| 4  | -793.2000  | -881.6000  | -904.000  | -891.000  | -913.000  | -818.000  | -849.6000  | -852.000  | -866.000  |
| 5  | -1029.2000 | -1145.6000 | -1176.000 | -1163.000 | -1177.000 | -1062.000 | -1073.6000 | -1100.000 | -1122.000 |
| 6  | -1253.2000 | -1377.6000 | -1408.000 | -1403.000 | -1417.000 | -1282.000 | -1321.6000 | -1340.000 | -1354.000 |
| 7  | -1453.2000 | -1609.6000 | -1540.000 | -1627.000 | -1657.000 | -1498.000 | -1529.6000 | -1548.000 | -1555.000 |
| 8  | -1637.2000 | -1833.6000 | -1848.000 | -1843.000 | -1905.000 | -1690.000 | -1729.6000 | -1772.000 | -1786.000 |
| 9  | -1829.2000 | -2057.6000 | -2072.000 | -2099.000 | -2129.000 | -1898.000 | -1921.6000 | -1956.000 | -1986.000 |
| 10 | -2005.2000 | -2249.6000 | -2280.000 | -2275.000 | -2305.000 | -2090.000 | -2145.6000 | -2188.000 | -2162.000 |
| 11 | -2197.2000 | -2425.6000 | -2456.000 | -2451.000 | -2497.000 | -2234.000 | -2305.6000 | -2348.000 | -2354.000 |
| 12 | -2373.2000 | -2817.6000 | -2664.000 | -2659.000 | -2721.000 | -2426.000 | -2513.6000 | -2524.000 | -2546.000 |
| 13 | -2533.2000 | -2808.6000 | -2840.000 | -2851.000 | -2881.000 | -2586.000 | -2641.6000 | -2716.000 | -2706.000 |
| 14 | -2693.2000 | -3001.6000 | -3016.000 | -3043.000 | -3105.000 | -2810.000 | -2865.6000 | -2908.000 | -2898.000 |
| 15 | -2885.2000 | -3209.6000 | -3240.000 | -3251.000 | -3281.000 | -2954.000 | -3057.6000 | -3068.000 | -3122.000 |
| 16 | -3045.2000 | -3401.6000 | -3416.000 | -3443.000 | -3473.000 | -3114.000 | -3201.6000 | -3276.000 | -3298.000 |

**GAGE A, 48 OHMS, CHAN 1**

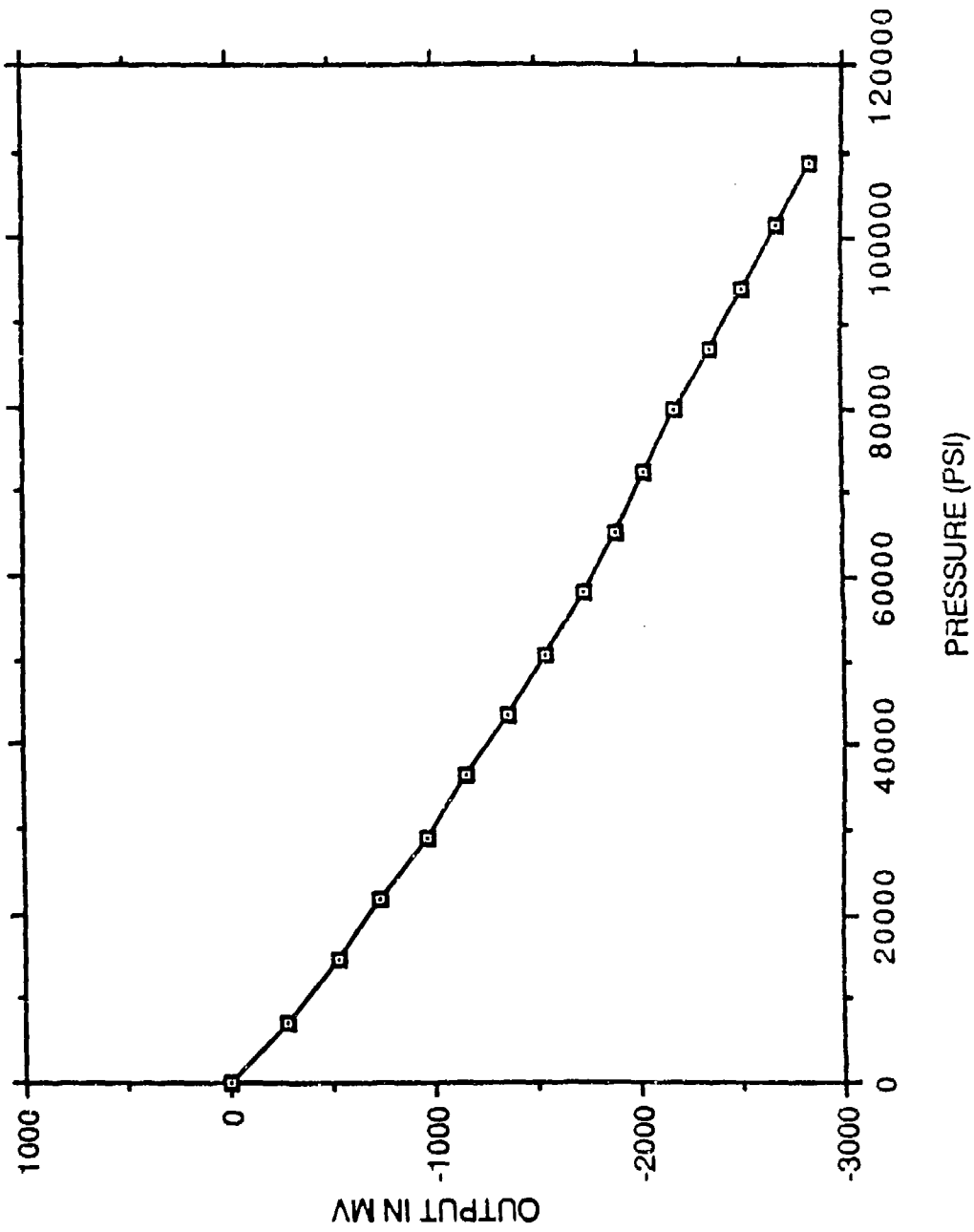


Figure D-1. Gage Calibration Curve.

**GAGE B, 50 OHMS, CHAN 1**

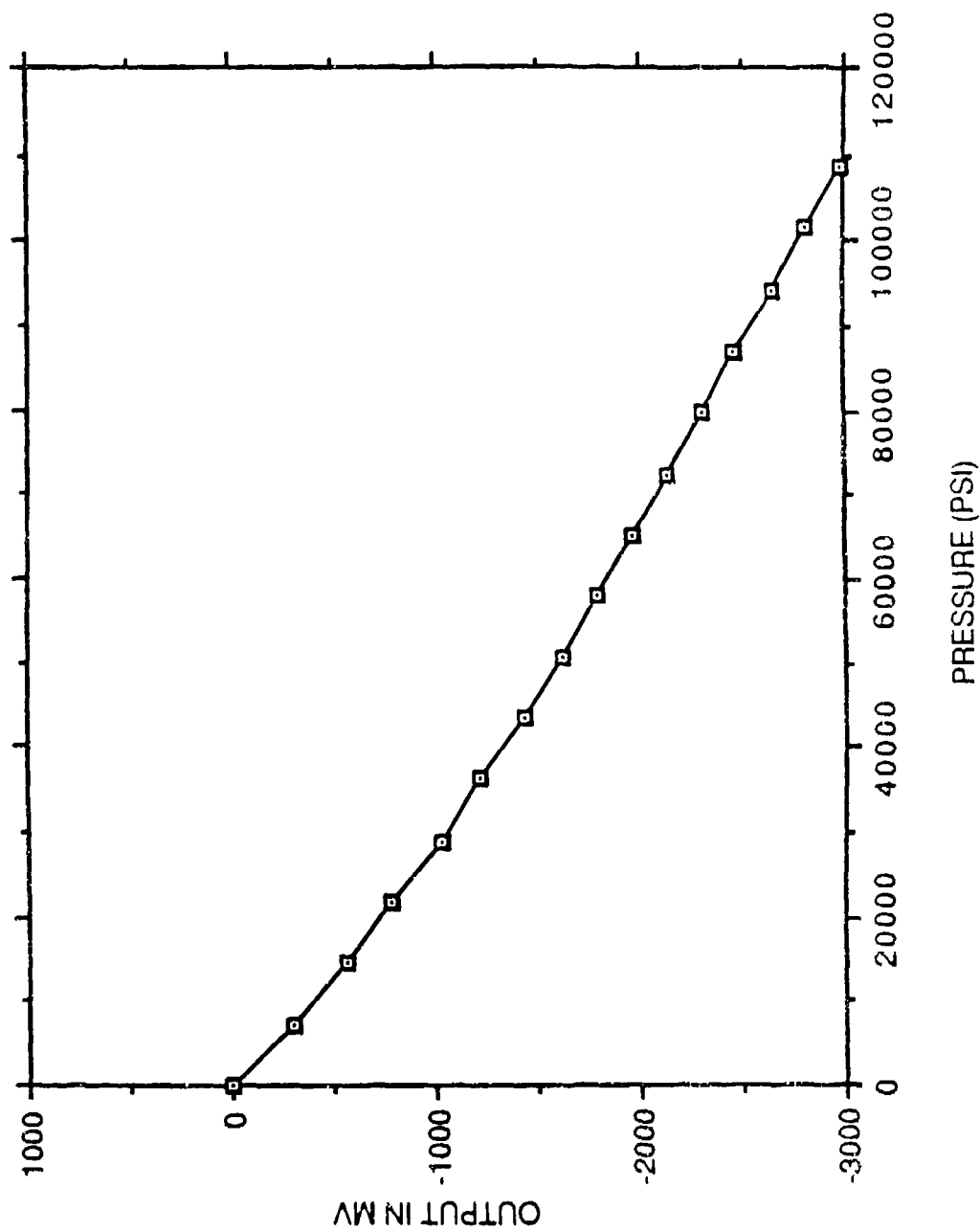


Figure D-2. Gage Calibration Curve.

# GAGE C, 52 OHMS, CHAN 1

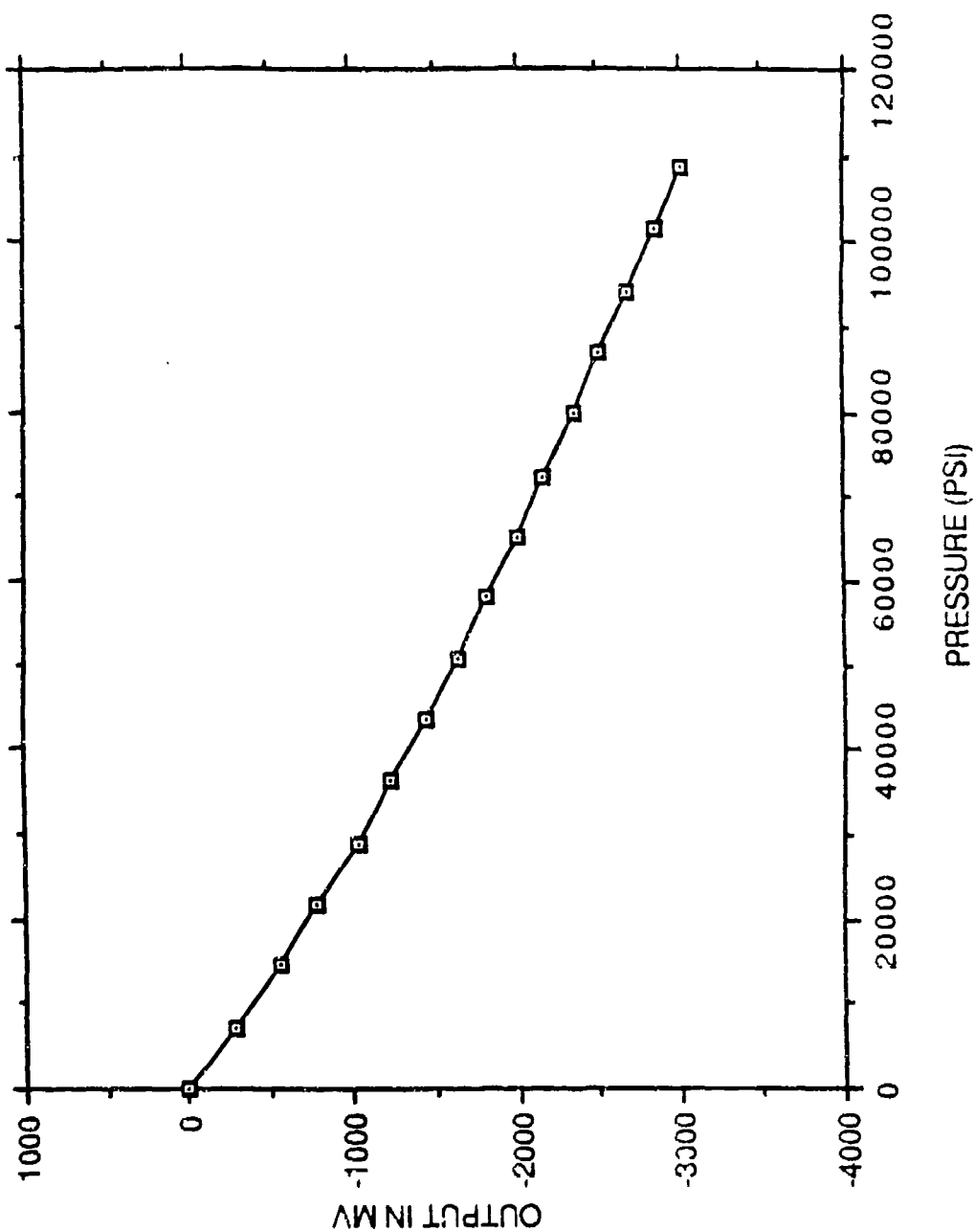


Figure D-3. Gage Calibration Curve.

# GAGE D, 54 OHMS, CHAN 1

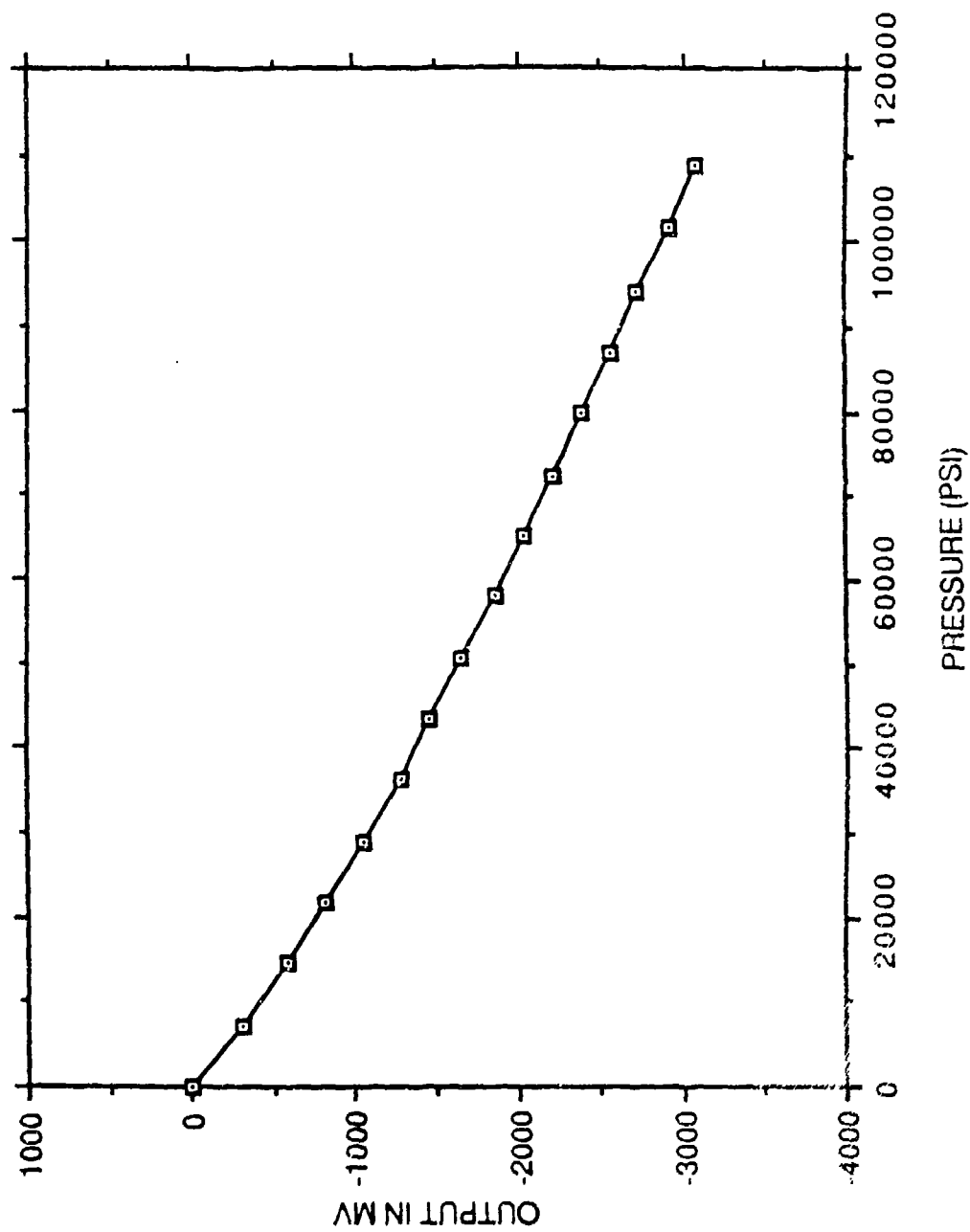


Figure D-4. Gage Calibration Curve.

# GAGE E, 48 OHMS, CHAN 2

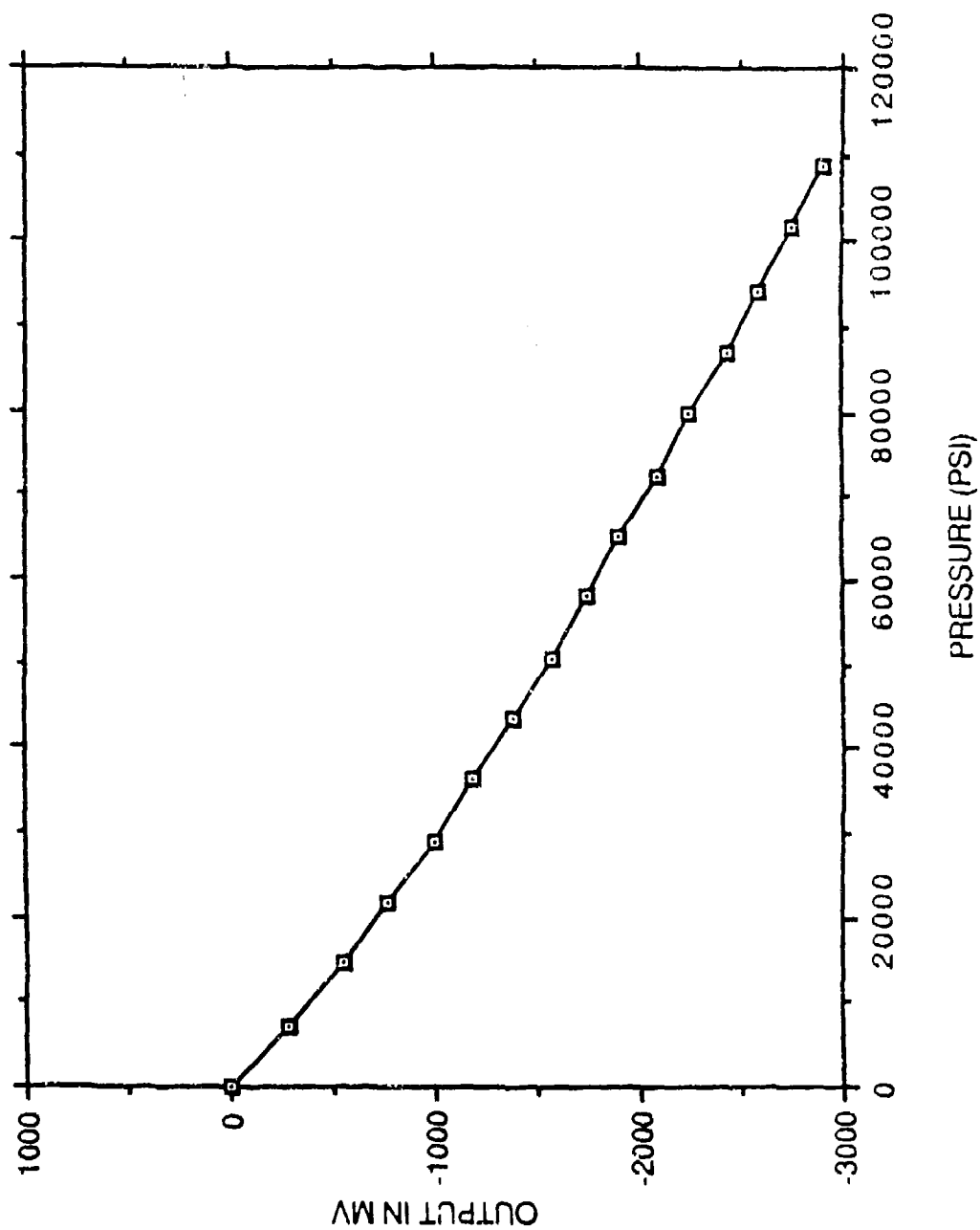


Figure D-5. Gage Calibration Curve.

# GAGE F, 50 OHMS, CHAN 2

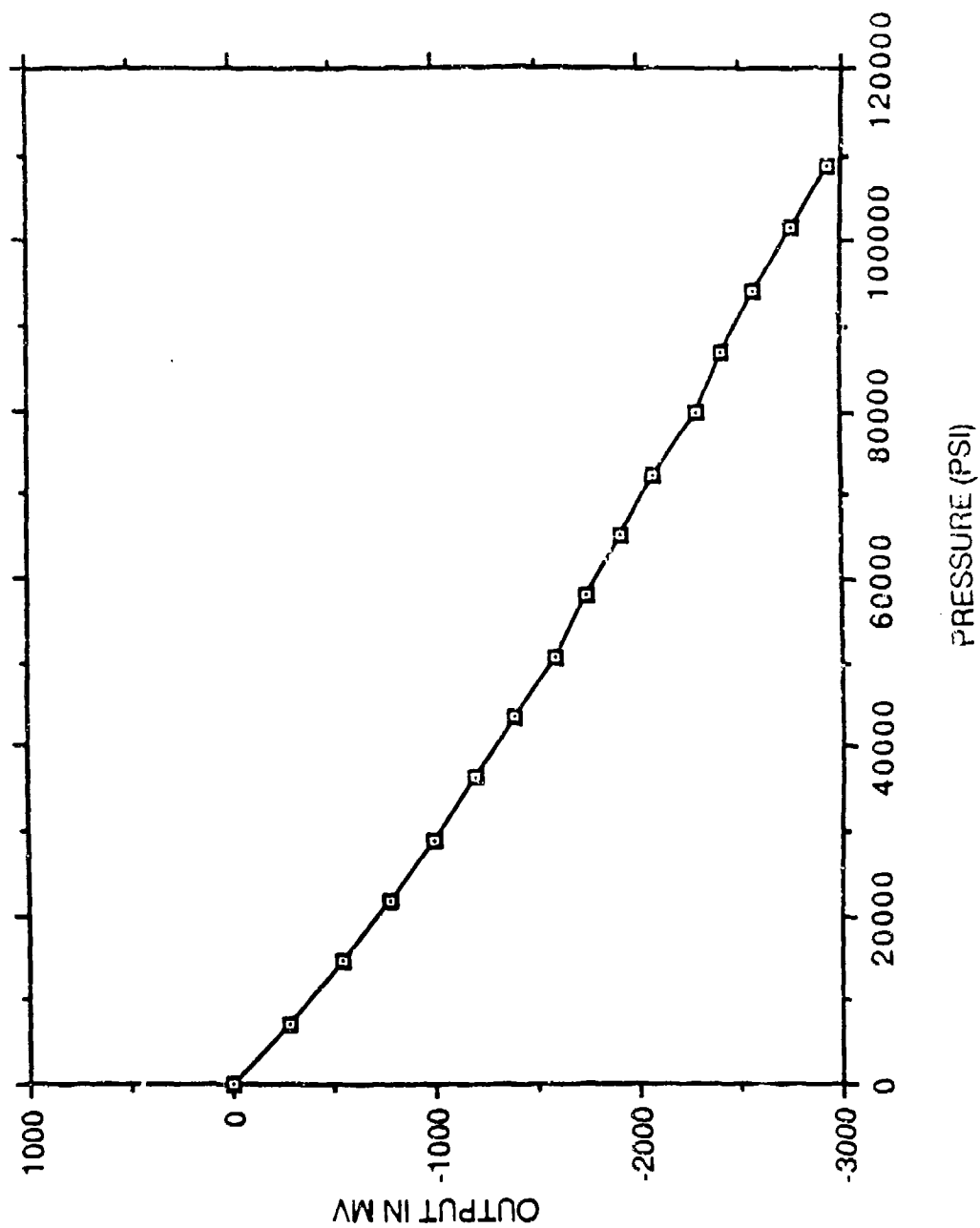


Figure D-6. Gage Calibration Curve.



# GAGE G, 52 OHMS, CHAN 2

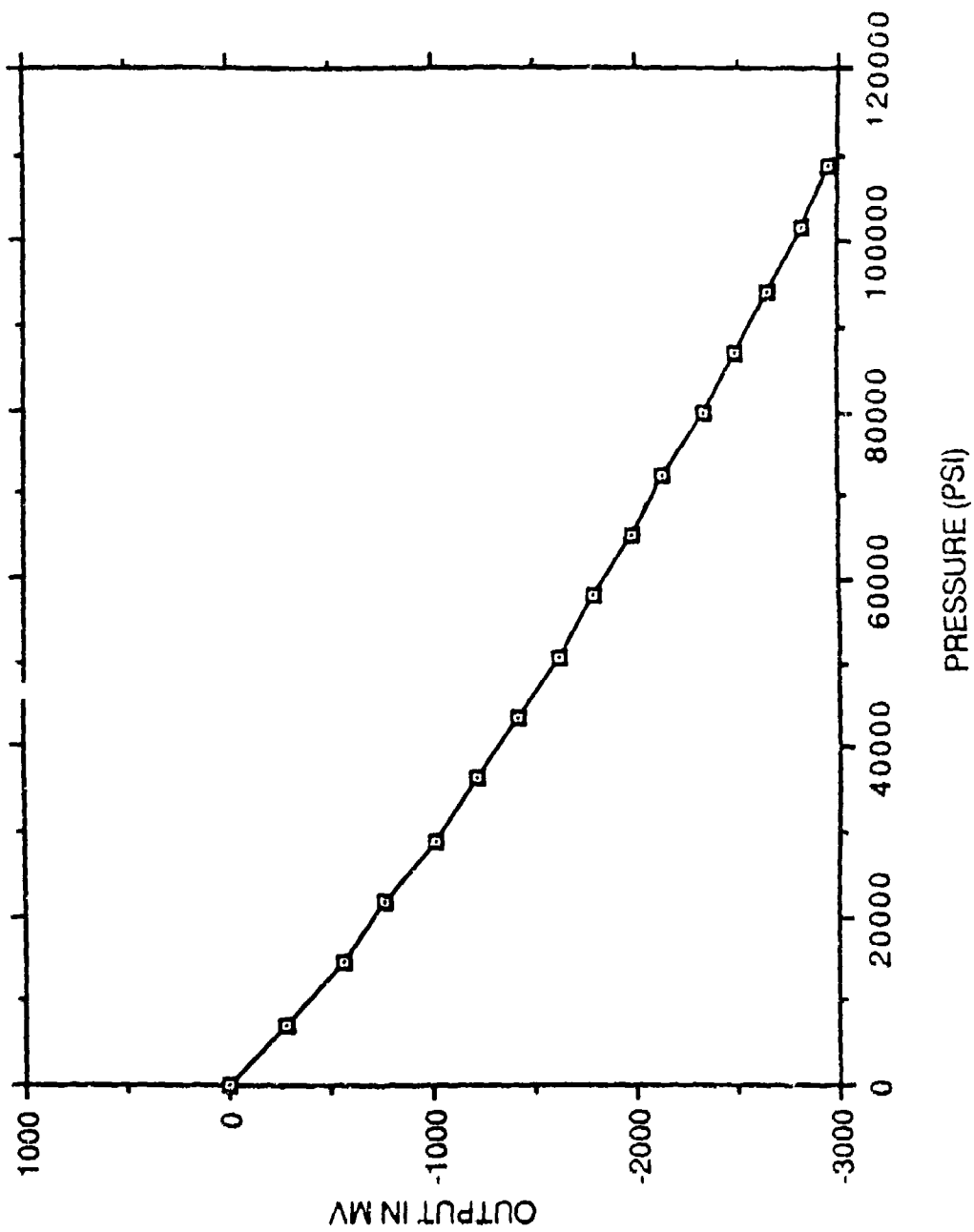


Figure D-7. Gage Calibration Curve.

# GAGE H, 54 OHMS, CHAN 2

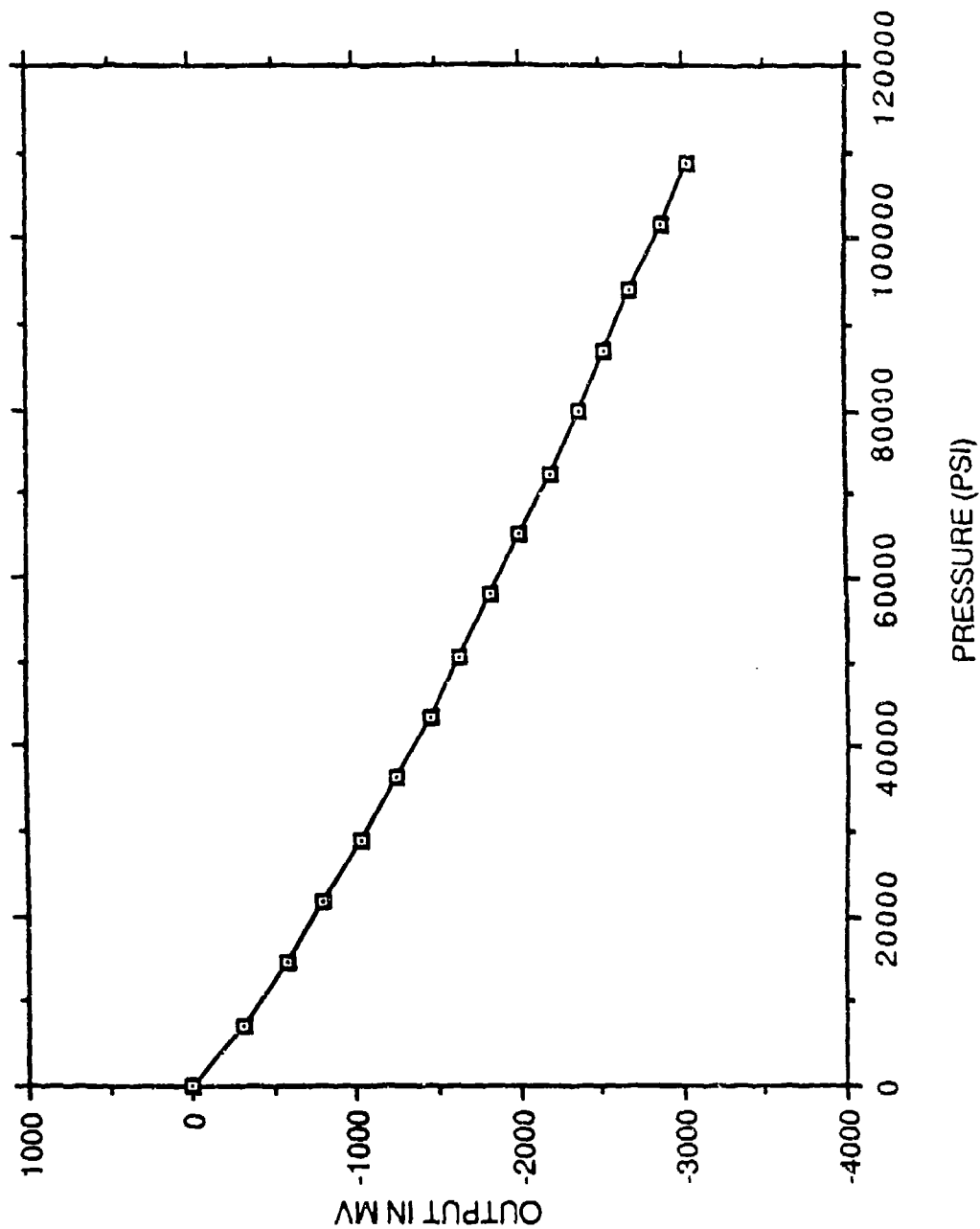


Figure D-8. Gage Calibration Curve.

# GAGE I, 48 OHMS, CHAN 3

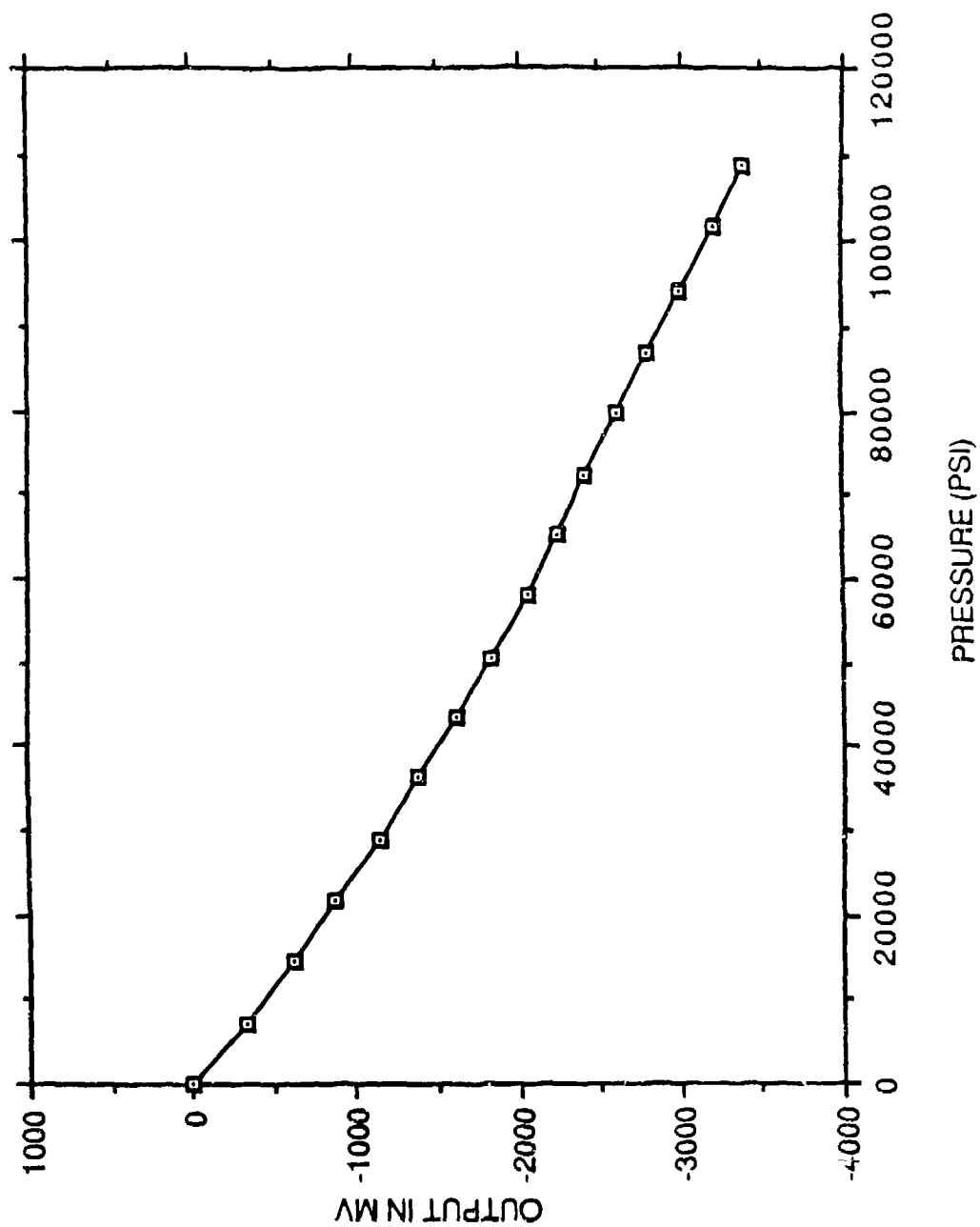


Figure D-9. Gage Calibration Curve.

# GAGE J, 50 OHMS, CHAN 3

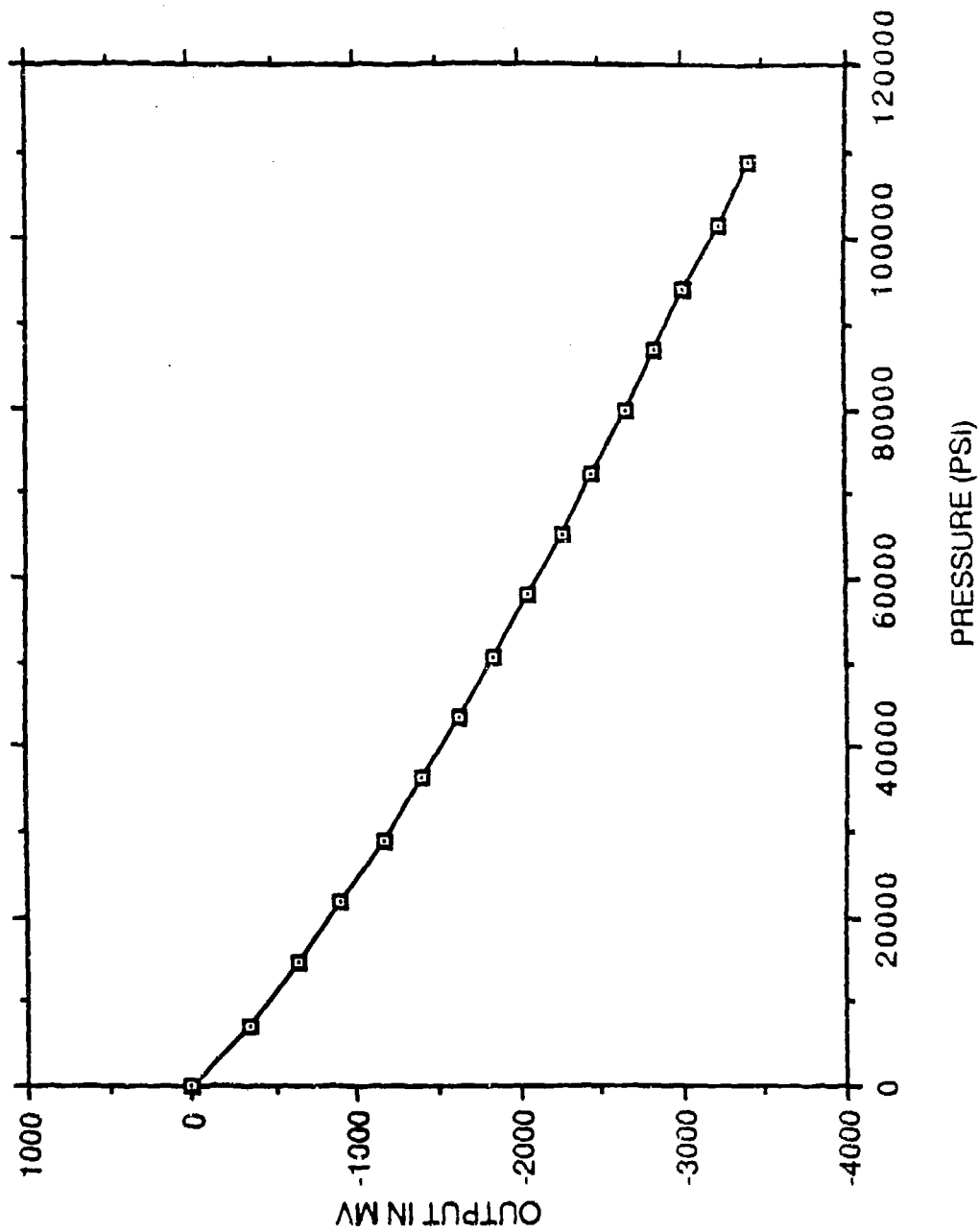


Figure D-10. Gage Calibration Curve.

# GAGE K, 52 OHMS, CHAN 3

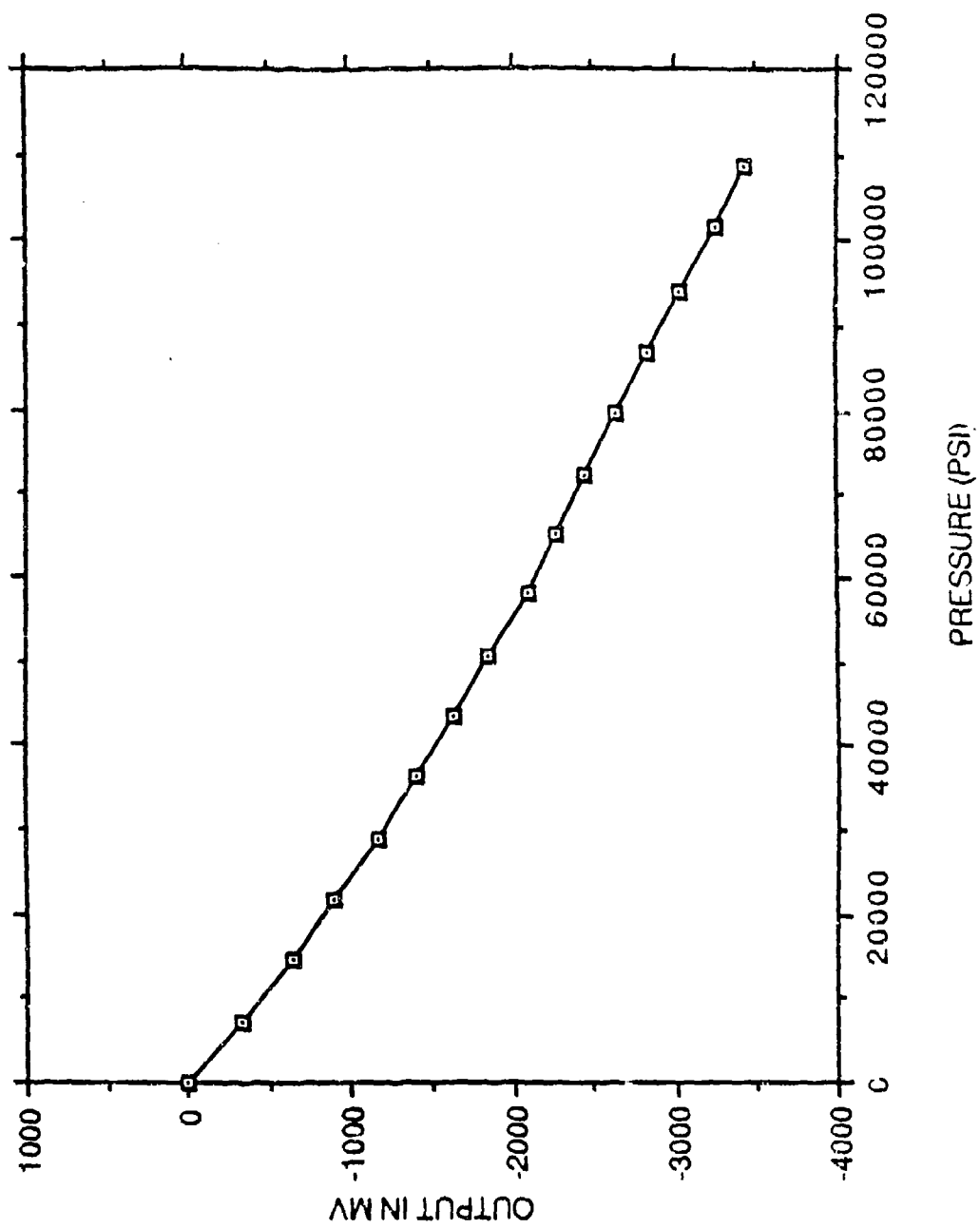


Figure D-11. Gage Calibration Curve.

# GAGE L, 54 OHMS, CHAN 3

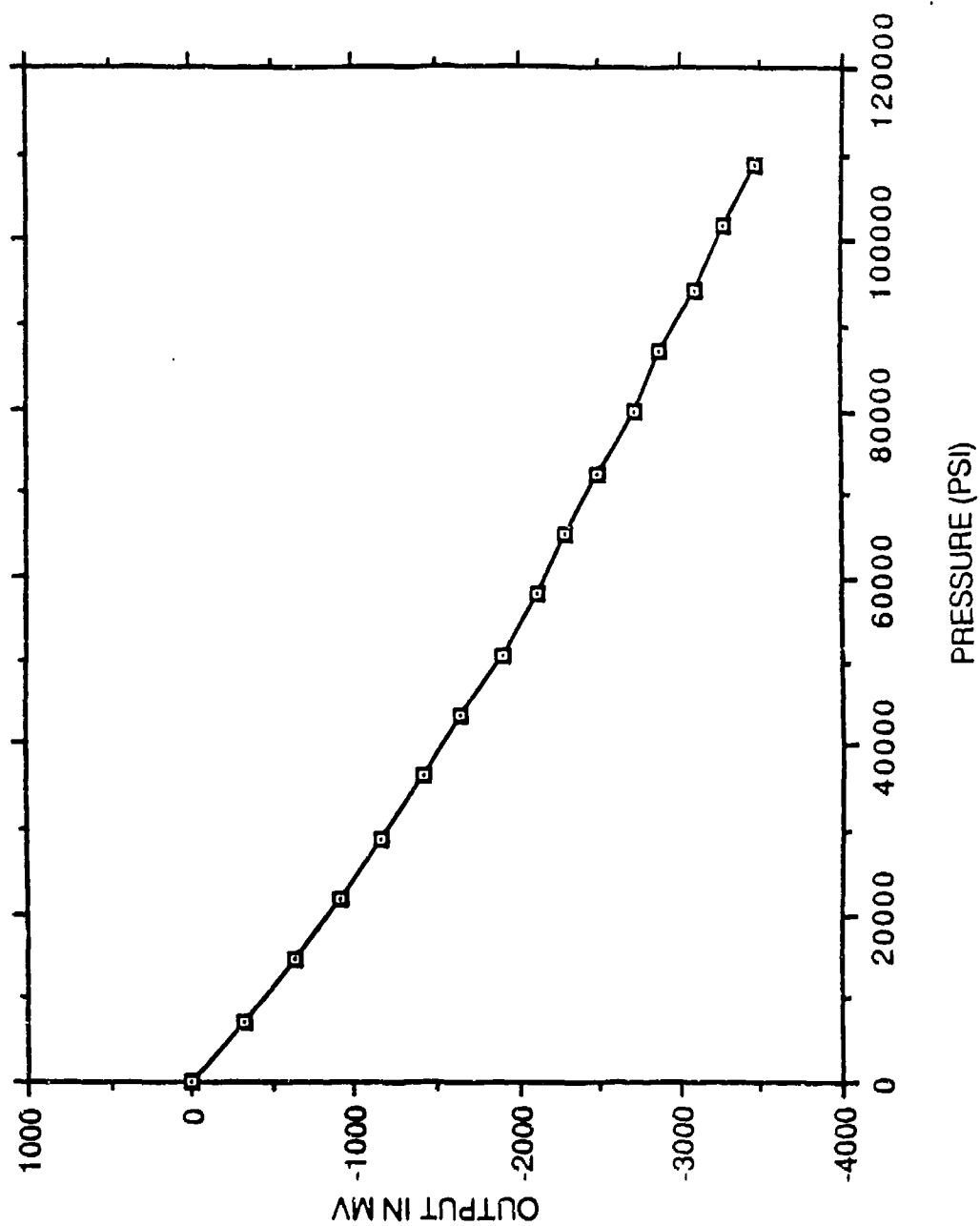


Figure D-12. Gage Calibration Curve.

# GAGE M, 48 OHMS, CHAN 4

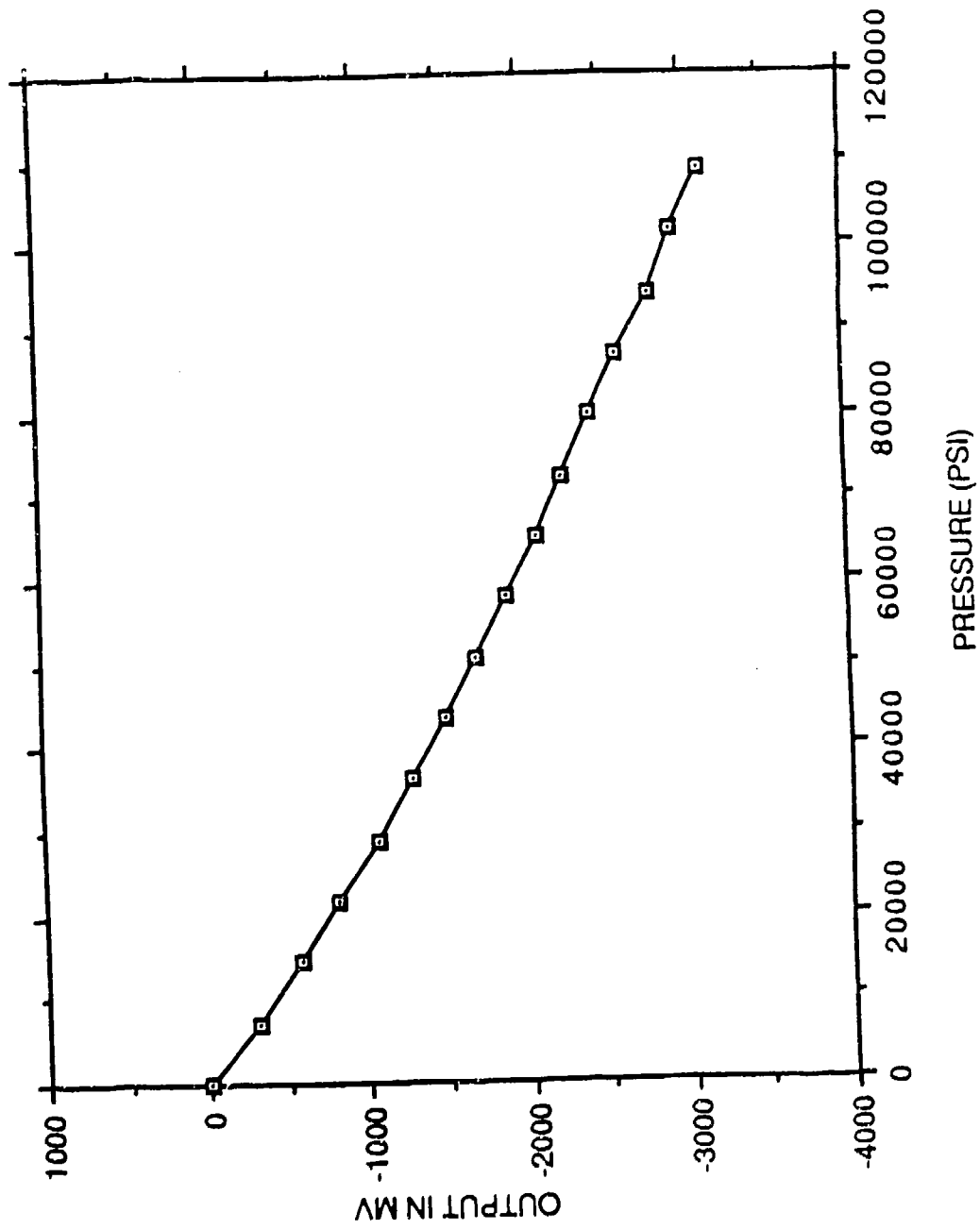


Figure D-13. Gage Calibration Curve.

# GAGE N, 50 OHMS, CHAN 4

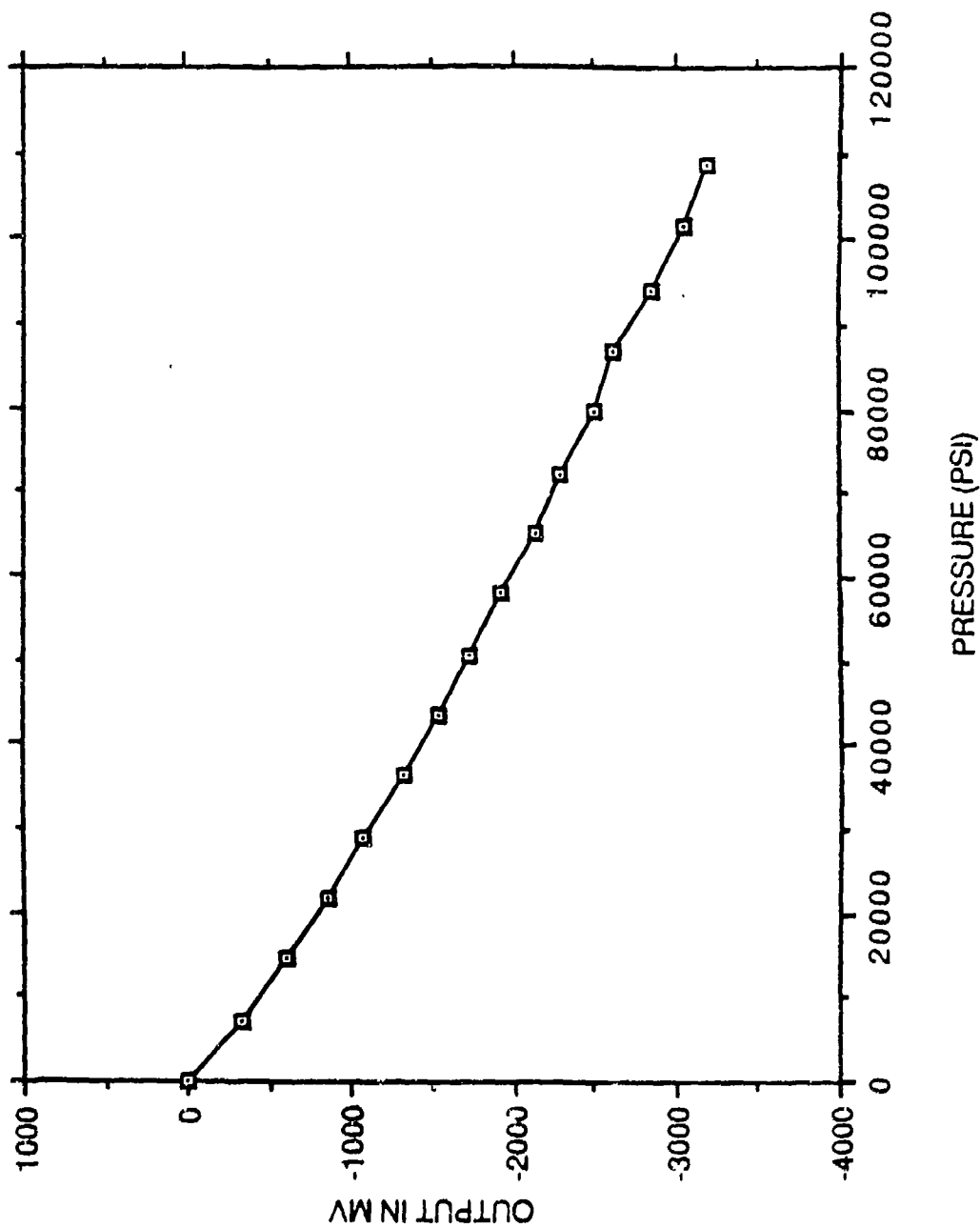


Figure D-14. Gage Calibration Curve.



# GAGE O, 52 OHMS, CHAN 4

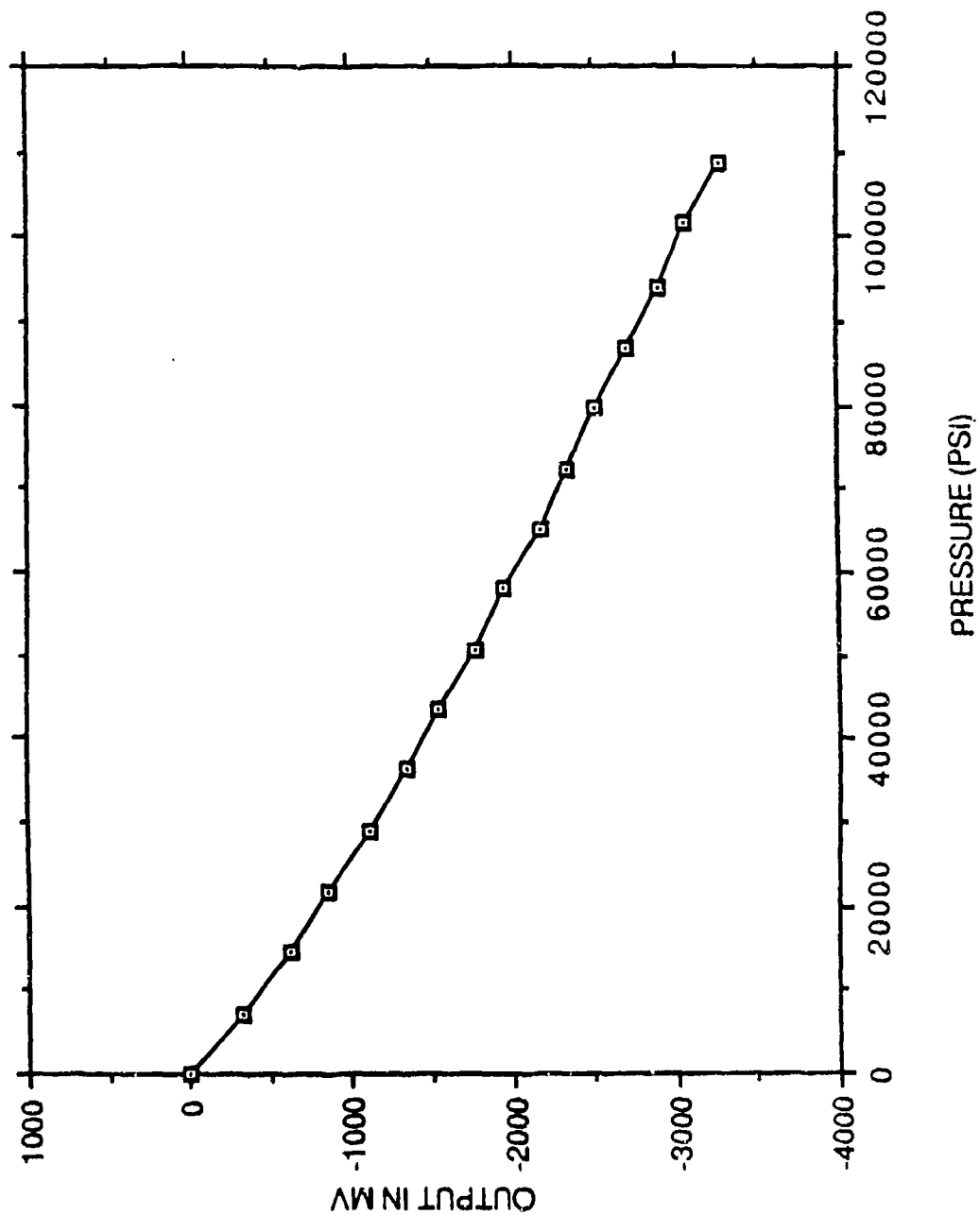


Figure D-15. Gage Calibration Curve.

# GAGE P, 54 OHMS, CHAN 4

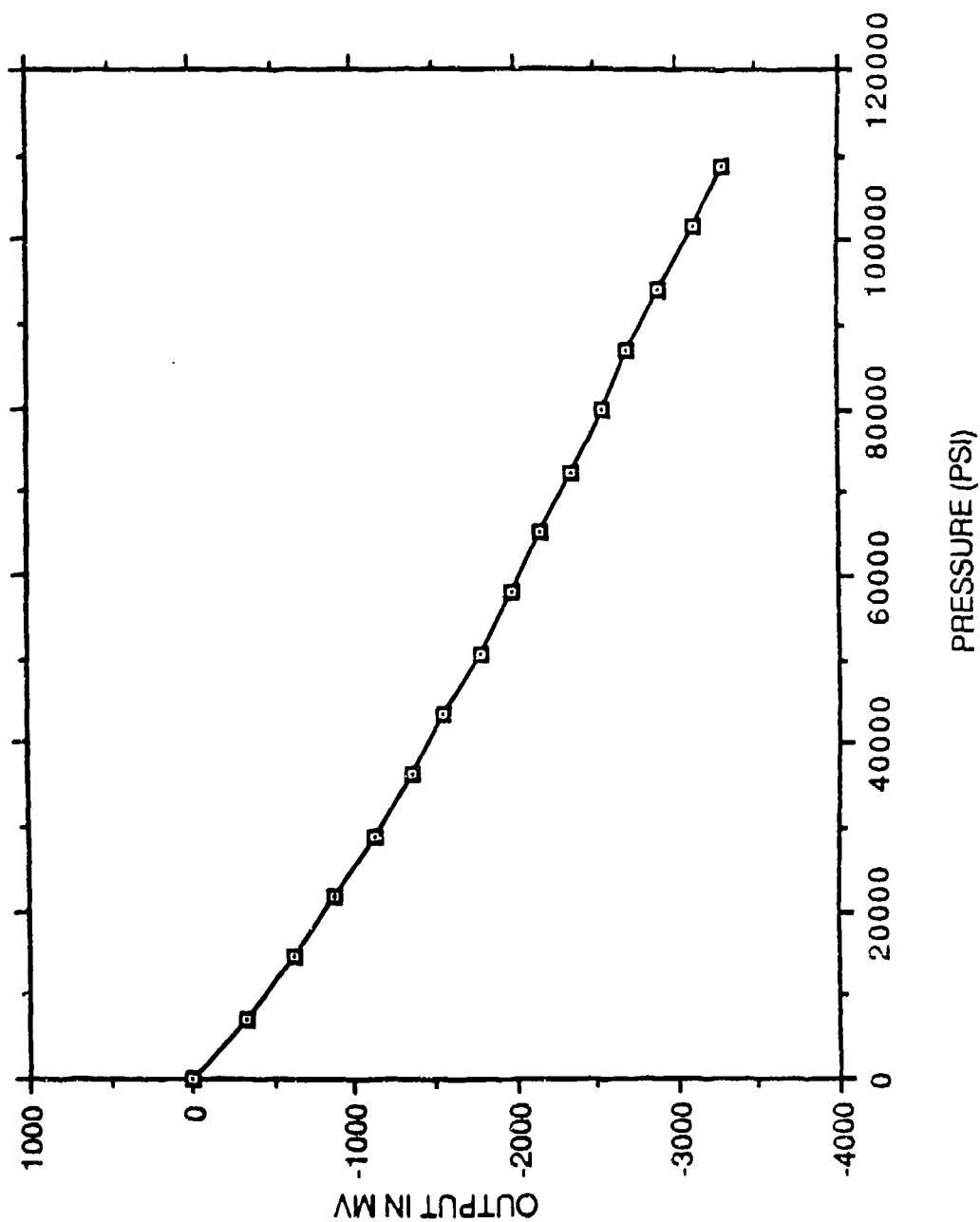


Figure D-16. Gage Calibration Curve.

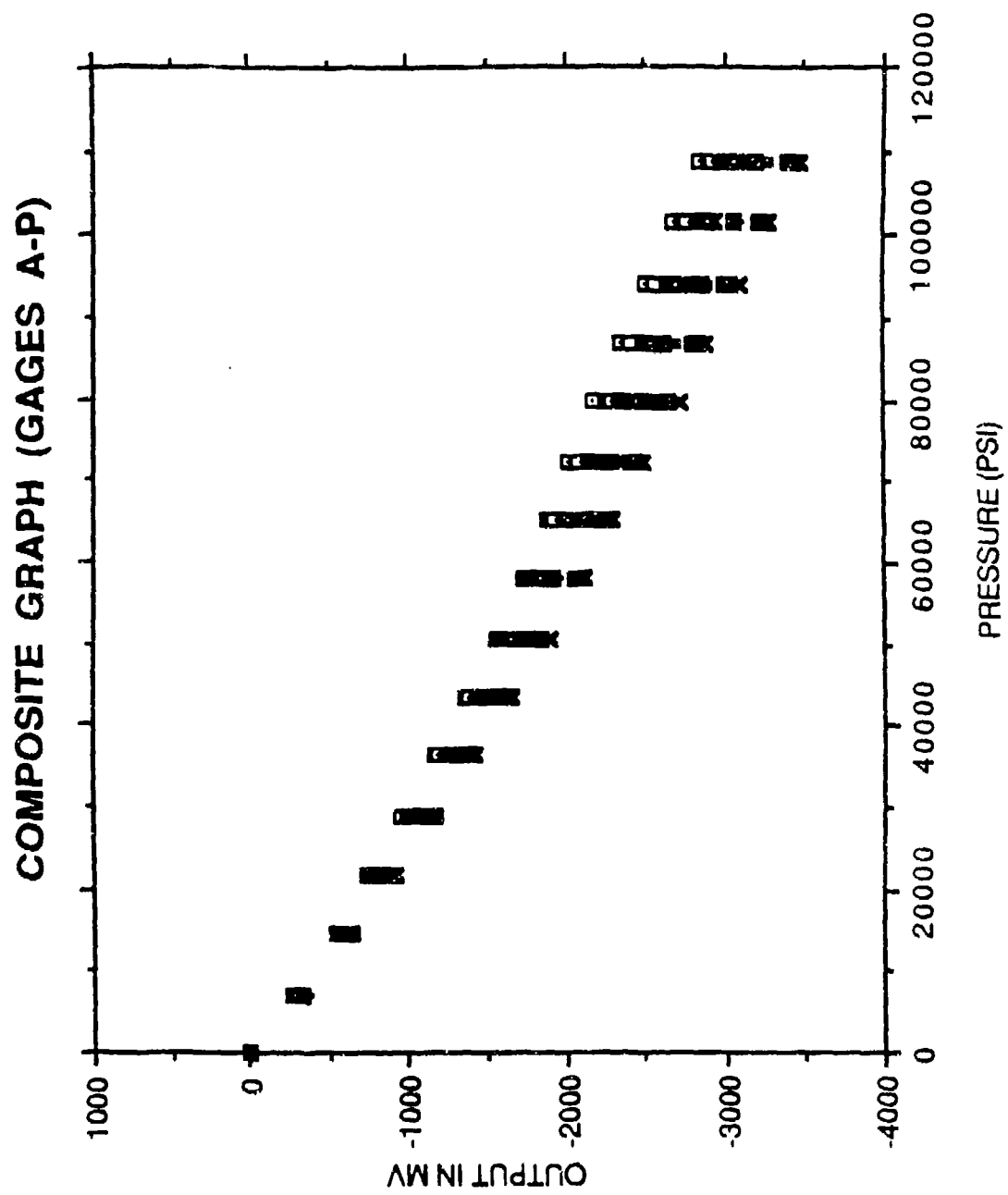


Figure D-17. Composite Calibration Curve.

## **APPENDIX E**

### **Fragment Data from the 2.7 Pound Cased Charge Test**

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST.

| FRAG<br>NUM | SHEET<br>No. | SHEET<br>X (in) | SHEET<br>Y (in) | POSITION<br>Y (in) | MRSS<br>(grams) | LEN<br>(in) | WID<br>(in) | THIC<br>(in) | L/D      | X (in)  | Y (in)  | Z (in) | PATH<br>R (in) |
|-------------|--------------|-----------------|-----------------|--------------------|-----------------|-------------|-------------|--------------|----------|---------|---------|--------|----------------|
| 1           | 1            | 3.5             |                 | 16                 | 0.22            | 0.228       | 0.165       | 0.1          | 1.381818 | -44.5   | -8      | 111.5  | 120.3183       |
| 2           | 1            | 15              |                 | 10.385             | 0.01            | 0.118       | 0.09        | 0.018        | 1.311111 | -33     | -13.615 | 111.5  | 117.0752       |
| 3           | 1            | 13.5            |                 | 19.25              | 0.03            | 0.08        | 0.127       | 0.023        | 0.629921 | -34.5   | -4.75   | 111.5  | 116.8120       |
| 4           | 1            | 13.825          |                 | 43.5               | 0.12            | 0.266       | 0.141       | 0.051        | 1.886524 | -34.175 | 19.5    | 111.5  | 118.2388       |
| 5           | 1            | 17.25           |                 | 29                 | 0.02            | 0.157       | 0.143       | 0.019        | 1.097302 | -30.75  | 5       | 111.5  | 115.7705       |
| 6           | 1            | 17.385          |                 | 37.5               | 0.03            | 0.216       | 0.119       | 0.032        | 1.815126 | -30.615 | 13.5    | 111.5  | 116.4121       |
| 7           | 1            | 30.625          |                 | 16.5               | 0.04            | 0.2         | 0.095       | 0.046        | 2.352341 | -17.375 | -7.5    | 111.5  | 113.0946       |
| 8           | 1            | 19              |                 | 24.25              | 0.02            | 0.217       | 0.085       | 0.021        | 2.552911 | -29     | 0.25    | 111.5  | 115.2098       |
| 9           | 1            | 45              |                 | 15.5               | 0.1             | 0.185       | 0.15        | 0.069        | 1.233333 | -8.5    | -8.5    | 111.5  | 111.8637       |
| 10          | 1            | 20.875          |                 | 16                 | 0.01            | 0.139       | 0.065       | 0.021        | 2.138461 | -27.125 | -8      | 111.5  | 115.0304       |
| 11          | 1            | 44.5            |                 | 4.25               | 0.18            | 0.491       | 0.271       | 0.111        | 1.811808 | -3.5    | -19.75  | 111.5  | 113.2897       |
| 12          | 1            | 18.5            |                 | 26.125             | 0.02            | 0.119       | 0.064       | 0.023        | 1.859375 | -29.5   | 2.125   | 111.5  | 115.3560       |
| 13          | 1            | 43              |                 | 6                  | 0.02            | 0.142       | 0.1         | 0.021        | 1.42     | -5      | -18     | 111.5  | 113.0541       |
| 14          | 1            | 29.5            |                 | 10                 | 0.01            | 0.115       | 0.053       | 0.031        | 1.962258 | -18.5   | -14     | 111.5  | 113.8881       |
| 15          | 1            | 18.5            |                 | 31.75              | 0.06            | 0.238       | 0.133       | 0.063        | 1.724637 | -29.5   | 7.75    | 111.5  | 115.5965       |
| 16          | 1            | 45.75           |                 | 6.5                | 0.02            | 0.128       | 0.093       | 0.039        | 1.376344 | -2.25   | -17.5   | 111.5  | 112.8873       |
| 17          | 1            | 15.5            |                 | 39.75              | 0.1             | 0.206       | 0.175       | 0.044        | 1.177142 | -32.5   | 15.75   | 111.5  | 117.2030       |
| 18          | 1            | 18              |                 | 44.25              | 0.05            | 0.276       | 0.093       | 0.033        | 2.967741 | -30     | 20.25   | 111.5  | 117.2276       |
| 19          | 1            | 69.5            |                 | 8                  | 0.06            | 0.211       | 0.189       | 0.026        | 1.116402 | 21.5    | -16     | 111.5  | 114.6756       |
| 20          | 1            | 20.5            |                 | 35                 | 0.01            | 0.112       | 0.09        | 0.015        | 1.244444 | -27.5   | 11      | 111.5  | 115.3668       |
| 21          | 1            | 22              |                 | 39.5               | 0.01            | 0.15        | 0.052       | 0.027        | 2.884615 | -26     | 15.5    | 111.5  | 115.5357       |
| 22          | 1            | 60.5            |                 | 9                  | 0.03            | 0.147       | 0.075       | 0.023        | 1.96     | 12.5    | -15     | 111.5  | 113.1967       |
| 23          | 1            | 21.75           |                 | 24                 | 0.02            | 0.166       | 0.1         | 0.025        | 1.66     | -26.25  | 0       | 111.5  | 114.5482       |
| 24          | 1            | 58.5            |                 | 17.25              | 0.04            | 0.215       | 0.141       | 0.035        | 1.524822 | 10.5    | -6.75   | 111.5  | 112.1965       |
| 25          | 1            | 22              |                 | 26.5               | 0.05            | 0.218       | 0.184       | 0.026        | 1.184782 | -26     | 2.5     | 111.5  | 114.5185       |
| 26          | 1            | 70              |                 | 12.5               | 0.29            | 0.375       | 0.271       | 0.038        | 1.383763 | 22      | -11.5   | 111.5  | 114.2300       |
| 27          | 1            | 20.75           |                 | 23.25              | 0.11            | 0.121       | 0.075       | 0.013        | 1.613333 | -27.25  | -0.75   | 111.5  | 114.7840       |
| 28          | 1            | 70.5            |                 | 14.5               | 0.01            | 0.301       | 0.126       | 0.043        | 2.388888 | 22.5    | -9.5    | 111.5  | 114.1435       |
| 29          | 1            | 22.25           |                 | 29.25              | 0.01            | 0.103       | 0.083       | 0.028        | 1.157303 | -25.75  | 5.25    | 111.5  | 114.5551       |
| 30          | 1            | 74.5            |                 | 10.5               | 0.16            | 0.425       | 0.134       | 0.063        | 3.171541 | 26.5    | -13.5   | 111.5  | 115.3982       |
| 31          | 1            | 22.5            |                 | 45.25              | 0.02            | 0.13        | 0.097       | 0.026        | 1.940206 | -25.5   | 21.25   | 111.5  | 116.3359       |
| 32          | 1            | 79              |                 | 6.5                | 0.08            | 0.253       | 0.135       | 0.042        | 1.874074 | 31      | -17.5   | 111.5  | 117.0448       |
| 33          | 1            | 24              |                 | 34.75              | 0.02            | 0.161       | 0.111       | 0.043        | 1.450450 | -24     | 10.75   | 111.5  | 114.5592       |
| 34          | 1            | 46              |                 | 25.25              | 0.01            | 0.109       | 0.103       | 0.027        | 1.137480 | -2      | 1.25    | 111.5  | 111.5249       |
| 35          | 1            | 23              |                 | 46.5               | 0.02            | 0.147       | 0.127       | 0.029        | 1.561543 | -25     | 22.5    | 111.5  | 116.4624       |
| 36          | 1            | 79              |                 | 19.5               | 0.01            | 0.114       | 0.073       | 0.024        | 2.123809 | 30      | 14      | 111.5  | 116.3110       |
| 37          | 1            | 23              |                 | 42                 | 0.03            | 0.223       | 0.105       | 0.022        | 1.491452 | -25     | -4.5    | 111.5  | 114.3568       |
| 38          | 1            | 78              |                 | 19.5               | 0.22            | 0.349       | 0.234       | 0.056        | 3.311320 | 31.5    | 17      | 111.5  | 117.1046       |
| 39          | 1            | 79.5            |                 | 41                 | 0.07            | 0.351       | 0.106       | 0.035        | 3.112020 | -26.5   | 9.75    | 111.5  | 115.0198       |
| 40          | 1            | 21.5            |                 | 33.75              | 0.01            | 0.119       | 0.099       | 0.035        | 3.140345 | 28.5    | 15.5    | 111.5  | 116.1238       |
| 41          | 1            | 76.5            |                 | 39.5               | 0.03            | 0.223       | 0.071       | 0.02         | 1.508620 | -30.5   | 11      | 111.5  | 116.1184       |
| 42          | 1            | 17.5            |                 | 35                 | 0.02            | 0.175       | 0.116       | 0.041        | 1.448863 | 24.5    | 22      | 111.5  | 117.4159       |
| 43          | 1            | 77.5            |                 | 46                 | 0.11            | 0.255       | 0.176       | 0.039        | 1.561983 | 47      | -19.5   | 111.5  | 122.5622       |
| 44          | 1            | 95              |                 | 4.5                | 0.04            | 0.189       | 0.121       | 0.031        | 1.015748 | 30.5    | -10.75  | 111.5  | 116.0950       |
| 45          | 1            | 78.5            |                 | 13.25              | 0.02            | 0.129       | 0.127       | 0.031        | 1.015748 | -24     | -4.25   | 111.5  | 114.1328       |
| 46          | 1            | 24              |                 | 19.75              | 0.1             | 0.153       | 0.063       | 0.02         | 2.217391 | 11      | -3.5    | 111.5  | 112.0959       |
| 47          | 1            | 59              |                 | 20.5               | 0.01            | 0.091       | 0.057       | 0.018        | 1.596441 | 23.5    | 22      | 111.5  | 116.0538       |
| 48          | 1            | 71.5            |                 | 46                 | 0.03            | 0.132       | 0.109       | 0.028        | 1.211009 | 45      | 23.5    | 111.5  | 122.5132       |
| 49          | 1            | 93              |                 | 47.5               | 0.03            | 0.136       | 0.105       | 0.029        | 1.295238 | -20.25  | -15.25  | 111.5  | 114.3454       |
| 50          | 1            | 27.75           |                 | 8.75               | 0.03            | 0.164       | 0.097       | 0.023        | 1.690721 | 34      | 15.5    | 111.5  | 117.5946       |
| 51          | 1            | 82              |                 | 39.5               | 0.03            | 0.212       | 0.122       | 0.029        | 1.737704 | -22     | 8.25    | 111.5  | 113.9487       |
| 52          | 1            | 26              |                 | 32.25              | 0.1             | 0.302       | 0.125       | 0.045        | 2.416    |         |         |        |                |

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | THIN X   | THIN Y    | X° (in)   | Y° (in)   | COORDINATE<br>Z° (in) | DEPTH<br>R° (in) | X <sub>0</sub> | Y <sub>0</sub> | PRESENTED<br>MAX. | AREA<br>MIN. |
|-------------|----------|-----------|-----------|-----------|-----------------------|------------------|----------------|----------------|-------------------|--------------|
| 1           | -0.39910 | -0.07174  | -0.13955  | -0.03587  | 0.5                   | 0.539544         | -44.3004       | -7.96412       | 0.017112          | 0.007505     |
| 2           | -0.29596 | -0.12210  | -0.14798  | -0.06105  | 0.5                   | 0.525001         | -32.8520       | -13.5539       | 0.004321          | 0.000659     |
| 3           | -0.30941 | -0.04260  | -0.15470  | -0.02130  | 0.5                   | 0.523820         | -34.3452       | -4.72869       | 0.010145          | 0.002916     |
| 4           | -0.30650 | -0.174897 | -0.15325  | -0.03743  | 0.5                   | 0.530219         | -34.0217       | 19.41255       | 0.018302          | 0.003509     |
| 5           | -0.27578 | -0.044843 | -0.13789  | 0.027421  | 0.5                   | 0.519150         | -30.6121       | 4.977573       | 0.008137          | 0.000390     |
| 6           | -0.27457 | -0.121076 | -0.13728  | 0.060533  | 0.5                   | 0.522027         | -30.4777       | 13.439946      | 0.007292          | 0.001080     |
| 7           | -0.15582 | -0.06726  | -0.07791  | -0.03363  | 0.5                   | 0.507150         | -17.2970       | -7.46636       | 0.006763          | 0.001555     |
| 8           | -0.26008 | -0.002242 | -0.13004  | 0.001121  | 0.5                   | 0.516636         | -28.8699       | 0.248878       | 0.007408          | 0.000716     |
| 9           | -0.02690 | -0.07623  | -0.01945  | -0.03811  | 0.5                   | 0.501631         | -2.98654       | -8.46188       | 0.011273          | 0.004204     |
| 10          | -0.24327 | -0.07174  | -0.12163  | -0.03587  | 0.5                   | 0.515831         | -27.0033       | -7.96412       | 0.003704          | 0.000559     |
| 11          | -0.03139 | -0.17713  | -0.01569  | -0.08856  | 0.5                   | 0.508025         | -3.48430       | -19.6614       | 0.082630          | 0.018693     |
| 12          | -0.26457 | -0.019058 | -0.13228  | -0.009523 | 0.5                   | 0.517291         | -29.3677       | 2.115470       | 0.006763          | 0.001307     |
| 13          | -0.04484 | -0.16143  | -0.03242  | -0.08971  | 0.5                   | 0.506969         | -4.97757       | -17.9192       | 0.007408          | 0.001095     |
| 14          | -0.16591 | -0.12556  | -0.03295  | -0.06278  | 0.5                   | 0.510708         | -18.4170       | -13.9372       | 0.002509          | 0.000676     |
| 15          | -0.26457 | -0.069506 | -0.13228  | -0.034753 | 0.5                   | 0.518370         | -29.3677       | 7.715246       | 0.007408          | 0.001960     |
| 16          | -0.02017 | -0.15695  | -0.01008  | -0.07847  | 0.5                   | 0.506221         | -2.23991       | -17.4215       | 0.003988          | 0.001215     |
| 17          | -0.29147 | -0.141255 | -0.14573  | -0.070627 | 0.5                   | 0.525574         | -32.3542       | 15.67937       | 0.017678          | 0.003775     |
| 18          | -0.26905 | -0.181614 | -0.13452  | -0.040807 | 0.5                   | 0.525684         | -29.8654       | 20.15919       | 0.011785          | 0.001409     |
| 19          | 0.192825 | -0.14349  | -0.096412 | -0.07174  | 0.5                   | 0.514240         | 21.40358       | -15.9282       | 0.017950          | 0.000694     |
| 20          | -0.24663 | -0.098654 | -0.12391  | -0.049327 | 0.5                   | 0.517339         | -27.3768       | 10.95067       | 0.005185          | 0.000518     |
| 21          | -0.23313 | -0.139013 | -0.11659  | -0.069506 | 0.5                   | 0.518097         | -25.8834       | 15.43049       | 0.002880          | 0.000518     |
| 22          | 0.112107 | -0.13452  | -0.053053 | -0.06726  | 0.5                   | 0.507608         | 12.44394       | -14.9327       | 0.010145          | 0.001587     |
| 23          | -0.23542 | 0         | -0.11771  | 0         | 0.5                   | 0.513669         | -26.1322       | 0              | 0.006222          | 0.000937     |
| 24          | 0.094170 | -0.06053  | 0.047085  | -0.03026  | 0.5                   | 0.503123         | 10.45291       | -5.71973       | 0.008839          | 0.001447     |
| 25          | -0.23313 | -0.022421 | -0.11659  | -0.011210 | 0.5                   | 0.513536         | -25.8834       | 2.488789       | 0.014958          | 0.001784     |
| 26          | 0.197309 | -0.10313  | -0.098654 | -0.05156  | 0.5                   | 0.512242         | -21.90134      | -11.4484       | 0.059362          | 0.006015     |
| 27          | -0.24439 | -0.00672  | -0.12219  | -0.00336  | 0.5                   | 0.514726         | -27.1278       | -0.74663       | 0.005983          | 0.000642     |
| 28          | 0.201793 | -0.08530  | -0.100896 | -0.04260  | 0.5                   | 0.511854         | 22.3910        | -9.45739       | 0.019898          | 0.002842     |
| 29          | -0.23094 | -0.047035 | -0.11547  | -0.023542 | 0.5                   | 0.513700         | -25.6345       | 5.226457       | 0.002778          | 0.000755     |
| 30          | 0.237668 | -0.12107  | -0.11834  | -0.06053  | 0.5                   | 0.517460         | -26.98116      | -13.4394       | 0.014994          | 0.002928     |
| 31          | -0.22863 | -0.190582 | -0.11434  | -0.095291 | 0.5                   | 0.521686         | -25.3856       | 21.15470       | 0.005983          | 0.001196     |
| 32          | 0.278026 | -0.15635  | 0.134013  | -0.07847  | 0.5                   | 0.524364         | 30.86098       | -17.4215       | 0.014816          | 0.002459     |
| 33          | -0.21524 | -0.096412 | -0.10776  | -0.040206 | 0.5                   | 0.519718         | -23.8923       | 10.70179       | 0.003617          | 0.000966     |
| 34          | -0.01793 | -0.011210 | -0.00896  | -0.005605 | 0.5                   | 0.500111         | -1.99103       | 1.244394       | 0.002592          | 0.000713     |
| 35          | -0.22421 | -0.201793 | -0.11210  | -0.00896  | 0.5                   | 0.522253         | -24.8878       | 22.39910       | 0.005761          | 0.001058     |
| 36          | 0.269058 | -0.125560 | -0.134529 | -0.062780 | 0.5                   | 0.521574         | 29.86547       | 13.93721       | 0.002682          | 0.000682     |
| 37          | -0.22421 | -0.04035  | -0.11210  | -0.02017  | 0.5                   | 0.512811         | -24.8878       | -4.47982       | 0.009723          | 0.001046     |
| 38          | 0.269058 | -0.161434 | -0.134529 | -0.090717 | 0.5                   | 0.524035         | 29.86547       | 17.91928       | 0.023767          | 0.004903     |
| 39          | 0.282511 | -0.152456 | 0.141255  | -0.076233 | 0.5                   | 0.525132         | 31.35874       | 16.92376       | 0.009723          | 0.001551     |
| 40          | -0.23766 | -0.067443 | -0.11883  | -0.043721 | 0.5                   | 0.515784         | -26.3811       | 9.706278       | 0.002232          | 0.000653     |
| 41          | 0.256605 | -0.139013 | -0.127802 | -0.039506 | 0.5                   | 0.520734         | 28.37219       | 15.43049       | 0.006667          | 0.001046     |
| 42          | -0.27364 | -0.098654 | -0.13677  | -0.043527 | 0.5                   | 0.520710         | -30.3632       | 10.95067       | 0.007778          | 0.000888     |
| 43          | 0.264573 | -0.187309 | 0.132286  | -0.098654 | 0.5                   | 0.525528         | 29.36771       | 21.90134       | 0.020869          | 0.003355     |
| 44          | 0.421524 | -0.17438  | 0.210762  | -0.08744  | 0.5                   | 0.549606         | 46.79323       | -19.4125       | 0.009428          | 0.001646     |
| 45          | 0.273542 | -0.09641  | -0.10762  | -0.01905  | 0.5                   | 0.520605         | 30.36322       | -10.7017       | 0.005018          | 0.001205     |
| 46          | -0.21524 | -0.03811  | -0.10762  | -0.01905  | 0.5                   | 0.511806         | -23.8923       | -4.23094       | 0.003839          | 0.000508     |
| 47          | 0.098654 | -0.03139  | -0.043327 | -0.01569  | 0.5                   | 0.502672         | 10.95067       | -3.48430       | 0.004321          | 0.000854     |
| 48          | 0.210762 | -0.197309 | 0.104337  | -0.01569  | 0.5                   | 0.520420         | 23.39481       | 23.39461       | 0.008334          | 0.001767     |
| 49          | 0.409587 | -0.210762 | 0.201793  | -0.098654 | 0.5                   | 0.549386         | 44.79020       | 23.39461       | 0.008334          | 0.001767     |
| 50          | -0.18161 | -0.13677  | -0.04080  | -0.06833  | 0.5                   | 0.512759         | -20.1591       | -15.1816       | 0.010145          | 0.001422     |
| 51          | 0.304332 | -0.139013 | 0.152456  | -0.069506 | 0.5                   | 0.527390         | 33.84753       | 15.43049       | 0.008046          | 0.001100     |
| 52          | -0.19730 | -0.073941 | -0.04865  | -0.036955 | 0.5                   | 0.510360         | -21.3013       | 8.213004       | 0.017235          | 0.002575     |



TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CAGED CHARGE TEST (CONTINUED).

[illegible]



TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASSED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | SHEET<br>No. | SHEET<br>X (in) | SHEET<br>Y (in) | POSITION<br>Y (in) | MRSS<br>(grams) | LEN<br>(in) | WID<br>(in) | THIC<br>(in) | L/D      | X (in) | POSITION<br>Y (in) | COORDINATES<br>Z (in) | PATH<br>R (in) |
|-------------|--------------|-----------------|-----------------|--------------------|-----------------|-------------|-------------|--------------|----------|--------|--------------------|-----------------------|----------------|
| 53          | 1            | 61              |                 | 45.5               | 0.07            | 0.253       | 0.141       | 0.04         | 1.794326 |        | 13                 | 21.5                  | 111.5 114.2956 |
| 54          | 1            | 63              |                 | 45.25              | 0.09            | 0.251       | 0.111       | 0.052        | 2.261261 |        | 15                 | 21.25                 | 111.5 114.4937 |
| 55          | 1            | 67.75           |                 | 0.32               | 0.02            | 0.143       | 0.06        | 0.038        | 2.383333 |        | 19.75              | -23.68                | 111.5 115.6851 |
| 56          | 1            | 45.75           |                 | 45                 | 0.02            | 0.182       | 0.141       | 0.041        | 1.290780 |        | -2.25              | 21                    | 111.5 113.4826 |
| 57          | 1            | 50.5            |                 | 43.5               | 0.11            | 0.394       | 0.142       | 0.09         | 2.774647 |        | 2.5                | 19.5                  | 111.5 113.2199 |
| 58          | 1            | 58              |                 | 40.5               | 0.03            | 0.178       | 0.103       | 0.026        | 1.633027 |        | 10                 | 16.5                  | 111.5 113.1569 |
| 59          | 1            | 53.5            |                 | 39.25              | 0.032           | 0.291       | 0.082       | 0.018        | 3.548780 |        | 5.5                | 15.25                 | 111.5 112.623  |
| 60          | 1            | 73              |                 | 29.5               | 0.01            | 0.11        | 0.057       | 0.014        | 1.929824 |        | 25                 | 5.5                   | 111.5 114.4006 |
| 61          | 1            | 89.5            |                 | 28.25              | 0.02            | 0.166       | 0.101       | 0.045        | 1.643564 |        | 41.5               | 4.25                  | 111.5 119.0485 |
| 62          | 1            | 43.5            |                 | 21.25              | 0.12            | 0.37        | 0.2         | 0.045        | 2.012422 |        | -4.5               | -2.75                 | 111.5 111.6246 |
| 63          | 1            | 49.5            |                 | 22.75              | 0.09            | 0.324       | 0.161       | 0.03         | 2.15625  |        | 1.5                | -1.25                 | 111.5 111.5170 |
| 64          | 1            | 49.5            |                 | 11.75              | 0.11            | 0.345       | 0.16        | 0.024        | 2.744525 |        | 1.5                | -12.25                | 111.5 112.1809 |
| 65          | 1            | 53.25           |                 | 16.5               | 0.05            | 0.376       | 0.137       | 0.024        | 2.744525 |        | 5.25               | -17.5                 | 111.5 112.9870 |
| 66          | 1            | 55              |                 | 14.75              | 0.02            | 0.13        | 0.087       | 0.029        | 1.494252 |        | 7                  | -9.25                 | 111.5 112.1017 |
| 67          | 1            | 38.75           |                 | 6                  | 0.12            | 0.235       | 0.153       | 0.079        | 1.487341 |        | -9.25              | -18                   | 111.5 113.3217 |
| 68          | 1            | 38              |                 | 20                 | 0.03            | 0.205       | 0.105       | 0.02         | 1.952380 |        | -10                | -4                    | 111.5 112.0189 |
| 69          | 1            | 42.5            |                 | 29.5               | 0.02            | 0.21        | 0.081       | 0.025        | 2.592592 |        | -5.5               | 5.5                   | 111.5 111.7709 |
| 70          | 1            | 54              |                 | 22.25              | 0.01            | 0.113       | 0.072       | 0.019        | 1.569444 |        | 6                  | -1.75                 | 111.5 111.6750 |
| 71          | 1            | 52              |                 | 24.5               | 0.01            | 0.119       | 0.03        | 0.018        | 1.4875   |        | 4                  | 0.5                   | 111.5 111.5728 |
| 72          | 1            | 61.5            |                 | 10.75              | 0.01            | 0.141       | 0.084       | 0.016        | 1.678571 |        | 13.5               | -13.25                | 111.5 113.0931 |
| 73          | 1            | 23.5            |                 | 10.75              | 0.02            | 0.188       | 0.049       | 0.019        | 3.836734 |        | -24.5              | -13.25                | 111.5 114.9263 |
| 74          | 1            | 24.5            |                 | 6.5                | 0.03            | 0.134       | 0.096       | 0.041        | 1.395333 |        | -29.5              | -17.5                 | 111.5 115.2855 |
| 75          | 1            | 34.75           |                 | 22.5               | 0.17            | 0.352       | 0.275       | 0.037        | 1.128    |        | -23.25             | -1.5                  | 111.5 113.9081 |
| 76          | 1            | 38.5            |                 | 20.5               | 0.1             | 0.426       | 0.082       | 0.038        | 5.195121 |        | -19.5              | -3.75                 | 111.5 113.2544 |
| 77          | 1            | 29.5            |                 | 26.5               | 0.03            | 0.192       | 0.072       | 0.019        | 2.666666 |        | -18.5              | 2.5                   | 111.5 113.0519 |
| 78          | 1            | 30.5            |                 | 16.5               | 0.06            | 0.224       | 0.161       | 0.035        | 1.391304 |        | -17.5              | -7.5                  | 111.5 113.1138 |
| 79          | 1            | 27.5            |                 | 9.75               | 0.04            | 0.219       | 0.182       | 0.03         | 1.203296 |        | -20.5              | -15.25                | 111.5 114.3899 |
| 80          | 1            | 31              |                 | 46.25              | 0.14            | 0.35        | 0.15        | 0.038        | 2.333333 |        | -17                | 22.25                 | 111.5 114.9622 |
| 81          | 1            | 35.5            |                 | 46                 | 0.11            | 0.36        | 0.127       | 0.045        | 2.834645 |        | -12.5              | 22                    | 111.5 114.3950 |
| 82          | 1            | 76.5            |                 | 22                 | 0.16            | 0.352       | 0.12        | 0.08         | 2.933333 |        | 28.5               | -2                    | 111.5 115.1021 |
| 83          | 1            | 73              |                 | 20.75              | 0.03            | 0.172       | 0.128       | 0.033        | 1.34375  |        | 31                 | -3.25                 | 111.5 115.7748 |
| 84          | 1            | 72.5            |                 | 7.5                | 0.02            | 0.204       | 0.089       | 0.038        | 2.292134 |        | 24.5               | -16.5                 | 111.5 115.3462 |
| 85          | 1            | 75              |                 | 45.25              | 0.05            | 0.174       | 0.093       | 0.027        | 1.860215 |        | 27                 | 21.25                 | 111.5 116.6739 |
| 86          | 1            | 52              |                 | 43.25              | 0.07            | 0.161       | 0.121       | 0.051        | 1.330578 |        | 4                  | 19.25                 | 111.5 113.2201 |
| 87          | 1            | 64              |                 | 37.5               | 0.08            | 0.236       | 0.074       | 0.02         | 3.189184 |        | 16                 | 13.5                  | 111.5 113.4482 |
| 88          | 1            | 67              |                 | 26.25              | 0.05            | 0.17        | 0.151       | 0.03         | 1.297709 |        | 19                 | 2.25                  | 111.5 113.1296 |
| 89          | 1            | 64.5            |                 | 41                 | 0.07            | 0.225       | 0.116       | 0.033        | 1.939655 |        | 16.5               | 17                    | 111.5 113.9890 |
| 90          | 1            | 43.25           |                 | 38                 | 0.23            | 0.47        | 0.2         | 0.038        | 2.35     |        | -9.75              | 14                    | 111.5 112.7976 |
| 91          | 1            | 37.5            |                 | 43                 | 0.05            | 0.148       | 0.062       | 0.035        | 1.804878 |        | 19                 | 14                    | 111.5 113.5935 |
| 92          | 1            | 28.25           |                 | 38                 | 0.04            | 0.218       | 0.137       | 0.022        | 1.591240 |        | -19.75             | 1.25                  | 111.5 114.0978 |
| 93          | 1            | 44.75           |                 | 25.25              | 0.02            | 0.127       | 0.075       | 0.022        | 1.693333 |        | -13.25             | 1.25                  | 111.5 112.2914 |
| 94          | 1            | 38.5            |                 | 36                 | 0.13            | 0.309       | 0.162       | 0.06         | 1.907407 |        | -9.5               | 12                    | 111.5 112.5455 |
| 95          | 1            | 34.75           |                 | 32.75              | 0.05            | 0.199       | 0.093       | 0.032        | 2.133784 |        | -13.25             | 8.75                  | 111.5 112.6249 |
| 96          | 1            | 32.25           |                 | 42.5               | 0.02            | 0.179       | 0.092       | 0.032        | 1.945652 |        | -15.75             | 18.5                  | 111.5 114.1164 |
| 97          | 1            | 42              |                 | 23                 | 0.02            | 0.144       | 0.095       | 0.025        | 1.515789 |        | 6                  | -1                    | 111.5 111.6857 |
| 98          | 1            | 31              |                 | 44.25              | 0.05            | 0.203       | 0.098       | 0.025        | 2.071428 |        | -17                | 20.25                 | 111.5 114.5919 |
| 99          | 1            | 41.5            |                 | 40                 | 0.11            | 0.336       | 0.07        | 0.032        | 4.8      |        | -6.5               | 18                    | 111.5 112.8295 |
| 100         | 1            | 55.5            |                 | 46.5               | 0.02            | 0.209       | 0.145       | 0.02         | 1.441379 |        | 7.5                | 22.5                  | 111.5 113.9945 |
| 101         | 1            | 79              |                 | 41.5               | 0.01            | 0.134       | 0.094       | 0.013        | 1.425501 |        | 31                 | 17.5                  | 111.5 113.0448 |
| 102         | 1            | 86              |                 | 40.5               | 0.01            | 0.078       | 0.1         | 0.02         | 0.78     |        | 38                 | 16.5                  | 111.5 118.9474 |
| 103         | 1            | 79.75           |                 | 30.5               | 0.01            | 0.173       | 0.064       | 0.02         | 2.703125 |        | 31.75              | 4.25                  | 111.5 116.0102 |
| 104         | 1            | 75.75           |                 | 26.25              | 0.03            | 0.178       | 0.074       | 0.021        | 1.507277 |        | 27.75              | 2.25                  | 111.5 114.9233 |

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

| IRMS<br>MM | THN X    | THN Y    | PNCT<br>N° (°) | ATION<br>Y° (°) | COORDINATE<br>Z° (°) | DEPTH<br>R° (°) | X <sub>0</sub> | Y <sub>0</sub> | PRESENTED<br>MM. | AREA<br>MIN. |
|------------|----------|----------|----------------|-----------------|----------------------|-----------------|----------------|----------------|------------------|--------------|
| 53         | 0.116591 | 0.192825 | 0.058295       | 0.046412        | 0.5                  | 0.512536        | 12.94170       | 21.40358       | 0.013612         | 0.002152     |
| 54         | 0.134529 | 0.190592 | 0.062264       | 0.045291        | 0.5                  | 0.513424        | 14.93273       | 21.15470       | 0.013462         | 0.002789     |
| 55         | 0.171130 | 0.21247  | 0.083565       | 0.10613         | 0.5                  | 0.518767        | 19.66143       | 23.5733        | 0.004093         | 0.001087     |
| 56         | -0.02017 | 0.188340 | -0.01008       | 0.044170        | 0.5                  | 0.508940        | 2.34991        | 20.90562       | 0.003794         | 0.000854     |
| 57         | 0.022421 | 0.174837 | 0.011210       | 0.087443        | 0.5                  | 0.507712        | 2.488789       | 19.41255       | 0.009507         | 0.002171     |
| 58         | 0.038686 | 0.147942 | 0.044843       | 0.073991        | 0.5                  | 0.507430        | 9.955156       | 16.42600       | 0.008975         | 0.001310     |
| 59         | 0.049327 | 0.136771 | 0.024663       | 0.058335        | 0.5                  | 0.505257        | 5.475336       | 15.18161       | 0.012934         | 0.000801     |
| 60         | 0.224215 | 0.049327 | 0.112107       | 0.024663        | 0.5                  | 0.513007        | 24.88789       | 5.475336       | 0.005556         | 0.000707     |
| 61         | 0.372197 | 0.038116 | 0.186098       | 0.019058        | 0.5                  | 0.533650        | -41.31390      | 4.230941       | 0.003457         | 0.000937     |
| 62         | -0.04035 | 0.02466  | -0.02017       | -0.01233        | 0.5                  | 0.500558        | -4.47982       | -2.73766       | 0.020742         | 0.002522     |
| 63         | 0.019452 | 0.01121  | 0.006726       | 0.00560         | 0.5                  | 0.500076        | 1.493273       | -1.24439       | 0.017501         | 0.002160     |
| 64         | 0.013452 | 0.10986  | 0.005726       | -0.05493        | 0.5                  | 0.503053        | 1.493273       | -1.24439       | 0.028521         | 0.002480     |
| 65         | 0.047085 | -0.15695 | 0.023542       | -0.07847        | 0.5                  | 0.506668        | 5.226457       | -17.4215       | 0.016205         | 0.001034     |
| 66         | 0.062780 | -0.08295 | 0.031390       | -0.04147        | 0.5                  | 0.502698        | 6.56809        | -9.20852       | 0.005364         | 0.001196     |
| 67         | -0.08295 | -0.16143 | -0.04147       | -0.08071        | 0.5                  | 0.508169        | -9.20852       | -17.9192       | 0.011815         | 0.003971     |
| 68         | -0.08968 | -0.03587 | -0.04484       | -0.01793        | 0.5                  | 0.502327        | -9.95515       | -3.98206       | 0.011667         | 0.000740     |
| 69         | -0.04932 | 0.049327 | -0.02466       | 0.00784         | 0.5                  | 0.501215        | -5.47533       | 5.475336       | 0.006222         | 0.000740     |
| 70         | 0.053811 | -0.01569 | 0.017937       | 0.002242        | 0.5                  | 0.500784        | 5.973094       | -1.74215       | 0.004093         | 0.000688     |
| 71         | 0.035874 | 0.004434 | 0.060538       | -0.05941        | 0.5                  | 0.500326        | 3.982062       | 0.497757       | 0.004321         | 0.000653     |
| 72         | 0.121076 | -0.11833 | -0.10366       | -0.05941        | 0.5                  | 0.507144        | 13.43946       | -13.1905       | 0.004861         | 0.000551     |
| 73         | -0.21923 | -0.11833 | -0.10366       | -0.05941        | 0.5                  | 0.515364        | -24.3901       | -13.1905       | 0.008187         | 0.000827     |
| 74         | -0.21076 | -0.15695 | -0.10366       | -0.07847        | 0.5                  | 0.516375        | -23.3946       | -17.4215       | 0.005691         | 0.001741     |
| 75         | -0.20852 | -0.01343 | -0.10426       | -0.00622        | 0.5                  | 0.507367        | -19.4125       | -3.73318       | 0.035738         | 0.003756     |
| 76         | -0.17433 | -0.03353 | -0.08395       | -0.011210       | 0.5                  | 0.510790        | -23.1457       | -1.49327       | 0.020469         | 0.001825     |
| 77         | -0.16591 | 0.02421  | -0.07847       | -0.03363        | 0.5                  | 0.507237        | -17.4215       | -7.46639       | 0.012281         | 0.001215     |
| 78         | -0.15695 | -0.06726 | -0.09192       | -0.06838        | 0.5                  | 0.512959        | -20.4080       | -15.1816       | 0.013934         | 0.002083     |
| 79         | -0.18385 | -0.13677 | -0.07623       | -0.099775       | 0.5                  | 0.515525        | -16.3237       | 22.15022       | 0.028657         | 0.003111     |
| 80         | -0.15246 | 0.19551  | -0.05605       | 0.098654        | 0.5                  | 0.512713        | -12.4439       | 21.90134       | 0.019014         | 0.002376     |
| 81         | -0.11210 | 0.197309 | 0.127802       | -0.00896        | 0.5                  | 0.516153        | 28.37219       | -1.99103       | 0.015556         | 0.003535     |
| 82         | 0.253605 | -0.01793 | 0.194013       | -0.01457        | 0.5                  | 0.519169        | 30.86098       | -3.23542       | 0.007071         | 0.001356     |
| 83         | 0.278026 | -0.02914 | 0.194013       | -0.01457        | 0.5                  | 0.517247        | 24.39013       | -16.4260       | 0.004093         | 0.000762     |
| 84         | 0.219730 | -0.14738 | 0.109865       | -0.07399        | 0.5                  | 0.523201        | 26.87892       | 21.15470       | 0.014404         | 0.002248     |
| 85         | 0.242152 | 0.190582 | 0.11076        | 0.06432         | 0.5                  | 0.507713        | 3.982062       | 19.16367       | 0.010676         | 0.003381     |
| 86         | 0.035874 | 0.172645 | 0.071749       | 0.060538        | 0.5                  | 0.508736        | 15.92825       | 13.43946       | 0.031113         | 0.002636     |
| 87         | 0.143497 | 0.121076 | 0.083201       | 0.010089        | 0.5                  | 0.507307        | 13.91479       | 2.239910       | 0.012934         | 0.002287     |
| 88         | 0.170403 | 0.020179 | 0.073991       | 0.076233        | 0.5                  | 0.511161        | 16.42600       | 16.92376       | 0.0164           | 0.002419     |
| 89         | 0.147982 | 0.152406 | -0.04372       | 0.062780        | 0.5                  | 0.505819        | -9.70627       | 13.93721       | 0.020330         | 0.003806     |
| 90         | -0.08744 | 0.15560  | -0.04708       | 0.095201        | 0.5                  | 0.503388        | -10.4529       | 18.91479       | 0.011112         | 0.002627     |
| 91         | -0.09417 | 0.170403 | -0.04856       | 0.062780        | 0.5                  | 0.511649        | -19.5614       | 13.93721       | 0.014142         | 0.001224     |
| 92         | -0.17713 | 0.15560  | -0.05941       | 0.05605         | 0.5                  | 0.503549        | -13.1905       | 1.244394       | 0.007071         | 0.001224     |
| 93         | -0.11833 | 0.011210 | -0.04260       | 0.053811        | 0.5                  | 0.504688        | -9.45739       | 11.94618       | 0.016853         | 0.003272     |
| 94         | -0.08520 | 0.07623  | -0.03941       | 0.039297        | 0.5                  | 0.505044        | -13.1905       | 8.710762       | 0.012153         | 0.001954     |
| 95         | -0.11833 | 0.078475 | -0.07062       | 0.032954        | 0.5                  | 0.511732        | -5.47533       | 18.41704       | 0.004381         | 0.000869     |
| 96         | -0.14125 | 0.15914  | -0.02690       | -0.00448        | 0.5                  | 0.500743        | -5.97309       | -0.99551       | 0.006222         | 0.001080     |
| 97         | -0.05381 | -0.00336 | -0.07623       | 0.030807        | 0.5                  | 0.505961        | -6.47085       | 15.92825       | 0.008642         | 0.001915     |
| 98         | -0.15246 | 0.181614 | -0.02914       | 0.071746        | 0.5                  | 0.511186        | 7.466367       | 22.39910       | 0.027278         | 0.000744     |
| 99         | -0.05829 | 0.201743 | 0.034632       | 0.100846        | 0.5                  | 0.524864        | 30.86098       | 17.42152       | 0.005983         | 0.000580     |
| 100        | 0.067264 | 0.201743 | 0.134013       | 0.078475        | 0.5                  | 0.533396        | 37.82459       | 16.42600       | 0.003899         | 0.000997     |
| 101        | 0.278026 | 0.156950 | 0.170403       | 0.073991        | 0.5                  | 0.533396        | 37.82459       | 16.42600       | 0.003899         | 0.000997     |
| 102        | 0.308007 | 0.147982 | 0.147982       | 0.073991        | 0.5                  | 0.533396        | 37.82459       | 16.42600       | 0.003899         | 0.000997     |
| 103        | 0.234753 | 0.038116 | 0.147982       | 0.019058        | 0.5                  | 0.520225        | 31.60762       | 4.230941       | 0.002430         | 0.000449     |
| 104        | 0.248823 | 0.070174 | 0.134439       | 0.010089        | 0.5                  | 0.515351        | 27.62556       | 2.239910       | 0.011112         | 0.001310     |



TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CAGED CHARGE TEST (CONTINUED).

[illegible]

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CAGED CHARGE TEST (CONTINUED).

| FRAG<br>No. | SHEET<br>No. | SHEET<br>X (in) | SHEET<br>Y (in) | POSITION<br>Y (in) | MASS<br>(grs) | LEN<br>(in) | R/D<br>(in) | THIC<br>(in) | L/D   | X (in) | Y (in) | Z (in)   | PATH<br>R (in) |
|-------------|--------------|-----------------|-----------------|--------------------|---------------|-------------|-------------|--------------|-------|--------|--------|----------|----------------|
| 105         | 1            | 71              | 26.25           | 0.01               | 0.117         | 0.103       | 0.019       | 1.135922     | 23    | 2.25   | 111.5  | 113.8697 |                |
| 106         | 1            | 69              | 20              | 0.07               | 0.242         | 0.109       | 0.045       | 2.220183     | 15    | -4     | 111.5  | 112.5755 |                |
| 107         | 1            | 67              | 12.5            | 0.08               | 0.318         | 0.166       | 0.018       | 1.915662     | 19    | -11.5  | 111.5  | 113.6903 |                |
| 108         | 1            | 65              | 5.5             | 0.02               | 0.129         | 0.13        | 0.029       | 0.992307     | 17    | -18.5  | 111.5  | 114.2956 |                |
| 109         | 1            | 7.5             | 8.5             | 0.16               | 0.305         | 0.131       | 0.088       | 2.328244     | -40.5 | -15.5  | 112    | 120.1020 |                |
| 110         | 1            | 11              | 8               | 0.29               | 0.453         | 0.227       | 0.051       | 1.995594     | -37   | -16    | 112    | 119.0336 |                |
| 111         | 1            | 14              | 8               | 0.31               | 0.3           | 0.206       | 0.085       | 1.456310     | -34   | -16    | 112    | 118.1355 |                |
| 112         | 1            | 21.5            | 8.5             | 0.15               | 0.302         | 0.151       | 0.076       | 1.492307     | 2     | -26.5  | 112    | 116.1319 |                |
| 113         | 1            | 27.5            | 45.25           | 0.11               | 0.291         | 0.195       | 0.176       | 1.823232     | -20.5 | 21.25  | 112    | 115.8266 |                |
| 114         | 1            | 29.5            | 10              | 0.28               | 0.361         | 0.138       | 0.06        | 1.823232     | -18.5 | -14    | 112    | 114.3776 |                |
| 115         | 1            | 29.5            | 44.25           | 0.01               | 0.146         | 0.088       | 0.027       | 1.654090     | 20.25 | 20.25  | 112    | 115.3500 |                |
| 116         | 1            | 34.5            | 41.25           | 0.77               | 0.503         | 0.236       | 0.103       | 2.131355     | -13.5 | 17.25  | 112    | 114.1219 |                |
| 117         | 1            | 45              | 40              | 0.04               | 0.21          | 0.137       | 0.054       | 1.510791     | -3    | 16     | 112    | 113.1768 |                |
| 118         | 1            | 57              | 34              | 0.01               | 0.21          | 0.07        | 0.039       | 1.573770     | 9     | 10     | 112    | 112.8051 |                |
| 119         | 1            | 69              | 5               | 0.09               | 0.328         | 0.143       | 0.032       | 2.201342     | 21    | -19    | 112    | 115.5248 |                |
| 120         | 1            | 74              | 1               | 0.17               | 0.31          | 0.226       | 0.059       | 1.371681     | 26    | -23    | 112    | 117.2561 |                |
| 121         | 1            | 69              | 17              | 0.06               | 0.217         | 0.186       | 0.039       | 1.166666     | 20    | -7     | 112    | 113.9868 |                |
| 122         | 1            | 71.5            | 36.5            | 0.01               | 0.376         | 0.033       | 0.005       | 1.139993     | 28.5  | 12.5   | 112    | 115.1195 |                |
| 123         | 1            | 13.5            | 44.5            | 0.18               | 0.422         | 0.179       | 0.048       | 2.357541     | -34.5 | 20.5   | 112    | 118.9726 |                |
| 124         | 1            | 15.5            | 20              | 0.03               | 0.143         | 0.104       | 0.033       | 1.3175       | -4    | -4     | 112    | 116.6886 |                |
| 125         | 1            | 22.5            | 9               | 0.03               | 0.174         | 0.127       | 0.031       | 1.370078     | -25.5 | -15    | 112    | 115.6414 |                |
| 126         | 1            | 20.5            | 30              | 0.71               | 0.48          | 0.305       | 0.09        | 1.573770     | -27.5 | 6      | 112    | 115.4826 |                |
| 127         | 1            | 26              | 27.5            | 0.03               | 0.13          | 0.109       | 0.035       | 1.192660     | -22   | 3.5    | 112    | 114.1939 |                |
| 128         | 1            | 28.5            | 40              | 0.43               | 0.434         | 0.198       | 0.036       | 2.494949     | -19.5 | 16     | 112    | 114.8052 |                |
| 129         | 1            | 33              | 45              | 0.05               | 0.214         | 0.172       | 0.024       | 1.244186     | -15   | 21     | 112    | 114.9347 |                |
| 130         | 1            | 41.5            | 30              | 0.16               | 0.316         | 0.196       | 0.057       | 1.612244     | -6.5  | 6      | 112.5  | 112.8472 |                |
| 131         | 1            | 33              | 45.75           | 0.01               | 0.121         | 0.077       | 0.024       | 1.571428     | 1     | -10    | 112.5  | 115.0187 |                |
| 132         | 1            | 43              | 10.75           | 0.05               | 0.184         | 0.17        | 0.036       | 1.082352     | 0     | 14.5   | 112.5  | 113.2370 |                |
| 133         | 1            | 43              | 30.5            | 0.07               | 0.259         | 0.158       | 0.034       | 1.639240     | -1    | 4      | 112.5  | 112.5755 |                |
| 134         | 1            | 47              | 28              | 0.01               | 0.128         | 0.11        | 0.024       | 1.163636     | 13    | 4.25   | 112.5  | 113.4305 |                |
| 135         | 1            | 61              | 28              | 1.42               | 0.603         | 0.4         | 0.129       | 1.5075       | 4.75  | 16     | 112.5  | 113.3289 |                |
| 136         | 1            | 52.75           | 37.5            | 0.02               | 0.199         | 0.122       | 0.029       | 1.631147     | 15.5  | 13.5   | 112.5  | 114.3623 |                |
| 137         | 1            | 63.5            | 37.5            | 0.17               | 0.44          | 0.207       | 0.049       | 1.444344     | 16.5  | 16     | 112.5  | 114.8237 |                |
| 138         | 1            | 64.5            | 40              | 0.11               | 0.44          | 0.179       | 0.031       | 1.634931     | 18    | -9     | 112.5  | 114.2858 |                |
| 139         | 1            | 66              | 15              | 0.06               | 0.155         | 0.125       | 0.032       | 2.025641     | 29    | 15.5   | 112.5  | 117.2070 |                |
| 140         | 1            | 77              | 34.5            | 0.02               | 0.158         | 0.079       | 0.032       | 2.025641     | 31    | 14.5   | 112.5  | 117.5903 |                |
| 141         | 1            | 77              | 38.5            | 0.11               | 0.295         | 0.142       | 0.082       | 2.077464     | 34    | -0.5   | 112.5  | 116.6940 |                |
| 142         | 1            | 79              | 23.5            | 0.01               | 0.166         | 0.103       | 0.028       | 1.811650     | -47   | 19     | 112.5  | 118.3271 |                |
| 143         | 1            | 82              | 37.75           | 0.11               | 0.203         | 0.168       | 0.039       | 1.208333     | -9.5  | 11.5   | 112.5  | 113.4845 |                |
| 144         | 1            | 82              | 41              | 0.07               | 0.217         | 0.141       | 0.031       | 1.539007     | -29.5 | 15     | 113    | 116.3863 |                |
| 145         | 1            | 38.7            | 35.5            | 0.03               | 0.238         | 0.085       | 0.03        | 3.060606     | 14.5  | 14.5   | 113    | 113.0739 |                |
| 146         | 1            | 34              | 27              | 0.01               | 0.113         | 0.082       | 0.015       | 1.378048     | 15.5  | 1.25   | 113    | 114.0649 |                |
| 147         | 1            | 47.5            | 35              | 0.2                | 0.373         | 0.194       | 0.064       | 1.922680     | -0.5  | -4     | 113    | 117.5117 |                |
| 148         | 1            | 50.5            | 38.5            | 0.02               | 0.171         | 0.08        | 0.031       | 2.1375       | 33    | 14     | 113    | 117.9915 |                |
| 149         | 1            | 53.5            | 25.25           | 0.06               | 0.337         | 0.192       | 0.028       | 1.755208     | -36   | 14     | 113.5  | 119.8326 |                |
| 150         | 1            | 53.5            | 23.5            | 0.12               | 0.316         | 0.142       | 0.053       | 2.225302     | -23.5 | 23.5   | 113.5  | 117.0664 |                |
| 151         | 1            | 60              | 20              | 0.06               | 0.245         | 0.114       | 0.051       | 2.19122      | 19.5  | 19.5   | 113.5  | 115.6384 |                |
| 152         | 1            | 61              | 32              | 0.17               | 0.261         | 0.25        | 0.046       | 1.044        | -21   | -7     | 113.5  | 116.8021 |                |
| 153         | 1            | 61              | 34              | 0.19               | 0.3           | 0.288       | 0.035       | 1.041666     | 19.5  | 19.5   | 113.5  | 116.8021 |                |
| 154         | 1            | 52              | 47.5            | 0.06               | 0.22          | 0.107       | 0.057       | 2.056074     | 19.5  | 19.5   | 113.5  | 116.8021 |                |
| 155         | 1            | 63              | 17              | 0.07               | 0.193         | 0.11        | 0.052       | 1.718181     | 19.5  | 19.5   | 113.5  | 116.8021 |                |
| 156         | 1            | 67.5            | 43.5            | 0.07               | 0.328         | 0.131       | 0.051       | 2.503816     | 19.5  | 19.5   | 113.5  | 116.8021 |                |

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASSED CHARGE TEST (CONTINUED).

| FRAG. NO. | THIN X    | THIN Y   | PENETRATION<br>X (in) | Y (in)   | COORDINATE<br>Z (in) | DEPTH<br>R (in) | NO        | Y <sub>0</sub> | PRESENTED<br>MAX. | AREA<br>MIN. |
|-----------|-----------|----------|-----------------------|----------|----------------------|-----------------|-----------|----------------|-------------------|--------------|
| 105       | 0.206279  | 0.020179 | 0.103199              | 0.010099 | 0.5                  | 0.510636        | 22.89686  | 2.239910       | 0.004039          | 0.000564     |
| 106       | 0.194529  | 0.035547 | 0.067264              | -0.01793 | 0.5                  | 0.504823        | 14.93273  | -3.98206       | 0.012039          | 0.002249     |
| 107       | 0.170403  | 0.10313  | 0.085501              | -0.05156 | 0.5                  | 0.509822        | 18.91479  | -11.4484       | 0.034570          | 0.001956     |
| 108       | 0.152466  | -0.18541 | 0.076233              | -0.08235 | 0.5                  | 0.512536        | 16.52376  | -18.4170       | 0.005364          | 0.001205     |
| 109       | -0.36160  | -0.13839 | -0.36160              | -0.13839 | 1                    | 1.072339        | -40.1383  | -15.3616       | 0.014142          | 0.004080     |
| 110       | -0.33035  | -0.14295 | -0.33035              | -0.14295 | 1                    | 1.062800        | -36.6596  | -15.8571       | 0.044230          | 0.004979     |
| 111       | -0.30357  | -0.14295 | -0.30357              | -0.14295 | 1                    | 1.054781        | -38.6964  | -15.8571       | 0.028368          | 0.008037     |
| 112       | -0.29660  | -0.13839 | -0.29660              | -0.13839 | 1                    | 1.036967        | -26.2633  | -15.3616       | 0.012153          | 0.003863     |
| 113       | -0.18303  | 0.189732 | -0.18303              | 0.189732 | 1                    | 1.034166        | -20.3169  | 21.06026       | 0.004419          | 0.002873     |
| 114       | -0.16517  | -0.125   | -0.16517              | -0.125   | 1                    | 1.021229        | -18.3348  | -13.875        | 0.036299          | 0.006033     |
| 115       | -0.16741  | 0.180803 | -0.16741              | 0.180803 | 1                    | 1.029910        | -18.5825  | 20.06913       | 0.002890          | 0.000532     |
| 116       | -0.12053  | 0.154017 | -0.12053              | 0.154017 | 1                    | 1.018945        | -13.3794  | 17.05598       | 0.058149          | 0.011907     |
| 117       | -0.02678  | 0.142857 | -0.02678              | 0.142857 | 1                    | 1.010507        | -2.97321  | 15.85714       | 0.005761          | 0.001481     |
| 118       | 0.080357  | 0.069295 | 0.080357              | 0.069295 | 1                    | 1.007188        | 8.913642  | 9.910714       | 0.001994          | 0.000370     |
| 119       | 0.1875    | -0.16964 | 0.1875                | -0.16964 | 1                    | 1.031472        | 20.8125   | -18.9303       | 0.021876          | 0.002134     |
| 120       | 0.232142  | -0.20535 | 0.232142              | -0.20535 | 1                    | 1.046329        | 25.76785  | -22.7946       | 0.022412          | 0.004265     |
| 121       | 0.178571  | -0.0625  | 0.178571              | -0.0625  | 1                    | 1.017739        | 19.82142  | -6.9375        | 0.011966          | 0.002150     |
| 122       | 0.209821  | 0.111507 | 0.209821              | 0.111507 | 1                    | 1.027352        | 23.29017  | 12.38639       | 0.015556          | 0.000206     |
| 123       | -0.30809  | 0.183035 | -0.30809              | 0.183035 | 1                    | 1.062256        | -34.1919  | 20.31636       | 0.029169          | 0.003317     |
| 124       | -0.29017  | -0.03571 | -0.29017              | -0.03571 | 1                    | 1.041863        | -32.2098  | -9.8660        | 0.007527          | 0.001341     |
| 125       | -0.27767  | -0.13392 | -0.27767              | -0.13392 | 1                    | 1.034298        | -25.2723  | -14.8660       | 0.061353          | 0.011505     |
| 126       | -0.24553  | 0.053571 | -0.24553              | 0.053571 | 1                    | 1.031095        | -27.2544  | -5.946423      | 0.006667          | 0.001795     |
| 127       | -0.19642  | 0.03125  | -0.19642              | 0.03125  | 1                    | 1.019548        | -21.8035  | 3.46875        | 0.038832          | 0.006770     |
| 128       | -0.17410  | 0.142857 | -0.17410              | 0.142857 | 1                    | 1.025047        | -19.3259  | 15.85714       | 0.016205          | 0.001817     |
| 129       | -0.13392  | 0.1875   | -0.13392              | 0.1875   | 1                    | 1.026203        | -14.8660  | 20.8125        | 0.021834          | 0.003938     |
| 130       | -0.05777  | 0.053333 | -0.05777              | 0.053333 | 1.5                  | 1.504629        | -6.41333  | 5.92           | 0.003241          | 0.000642     |
| 131       | -0.08833  | 0.193333 | -0.08833              | 0.193333 | 1.5                  | 1.533583        | -9.86666  | -13.0733       | 0.010803          | 0.002113     |
| 132       | 0.008833  | -0.11777 | 0.008833              | -0.11777 | 1.5                  | 1.510426        | 0.986666  | 0              | 0.015014          | 0.002102     |
| 133       | -0.008833 | 0.053333 | -0.008833             | 0.053333 | 1.5                  | 1.501007        | -0.986666 | -0.986666      | 0.003241          | 0.000607     |
| 134       | 0.115555  | 0.037777 | 0.115555              | 0.037777 | 1.5                  | 1.511044        | 12.82666  | 4.193333       | 0.085623          | 0.019317     |
| 135       | 0.042222  | 0.142222 | 0.042222              | 0.142222 | 1.5                  | 1.516417        | 4.686666  | 15.78666       | 0.006763          | 0.000781     |
| 136       | 0.137777  | 0.12     | 0.137777              | 0.12     | 1.5                  | 1.524831        | 15.29333  | 13.32          | 0.026986          | 0.004422     |
| 137       | 0.146666  | 0.142222 | 0.146666              | 0.142222 | 1.5                  | 1.530983        | 16.28     | 15.78666       | 0.025091          | 0.002673     |
| 138       | 0.12      | 0.18     | 0.12                  | 0.18     | 1.5                  | 1.523811        | 17.76     | -8.98          | 0.011966          | 0.003011     |
| 139       | 0.257777  | 0.137777 | 0.257777              | 0.137777 | 1.5                  | 1.562761        | 28.61333  | 15.29333       | 0.004861          | 0.000984     |
| 140       | 0.275555  | 0.108349 | 0.275555              | 0.108349 | 1.5                  | 1.567871        | 30.58666  | 14.30666       | 0.010434          | 0.002900     |
| 141       | 0.275555  | -0.00444 | 0.275555              | -0.00444 | 1.5                  | 1.555920        | 30.58666  | -0.49333       | 0.002778          | 0.000468     |
| 142       | 0.302222  | 0.122222 | 0.302222              | 0.122222 | 1.5                  | 1.577695        | 33.54666  | 13.56666       | 0.008642          | 0.003831     |
| 143       | -0.41777  | 0.168889 | -0.41777              | 0.168889 | 1.5                  | 1.545262        | -46.3733  | 18.74666       | 0.017564          | 0.002509     |
| 144       | -0.08444  | 0.102222 | -0.08444              | 0.102222 | 1.5                  | 1.513127        | -9.37333  | 11.34666       | 0.007778          | 0.000980     |
| 145       | -0.12444  | -0.01777 | -0.12444              | -0.01777 | 1.5                  | 1.511805        | -13.8133  | 11.34666       | 0.005185          | 0.000688     |
| 146       | -0.10777  | 0.132743 | -0.10777              | 0.132743 | 2                    | 2.059970        | -23.0840  | 14.73451       | 0.024307          | 0.004170     |
| 147       | 0.022123  | 0.128318 | 0.022123              | 0.128318 | 2                    | 2.016889        | 2.455752  | 14.24336       | 0.005018          | 0.000909     |
| 148       | 0.137169  | -0.06442 | 0.137169              | -0.06442 | 2                    | 2.016889        | 15.22666  | 1.227876       | 0.016668          | 0.001384     |
| 149       | 0.247777  | -0.00544 | 0.247777              | -0.00544 | 2                    | 2.069503        | 27.50442  | -0.49115       | 0.017611          | 0.002953     |
| 150       | 0.233195  | -0.03544 | 0.233195              | -0.03544 | 2                    | 2.079853        | 31.4362   | -3.92920       | 0.009151          | 0.001904     |
| 151       | 0.232035  | 0.070744 | 0.232035              | 0.070744 | 2                    | 2.088345        | 32.41592  | 7.958407       | 0.028746          | 0.005066     |
| 152       | -0.31713  | 0.133649 | -0.31713              | 0.133649 | 2.5                  | 2.540307        | -35.2070  | 13.69162       | 0.017387          | 0.004926     |
| 153       | -0.14096  | 0.207048 | -0.14096              | 0.207048 | 2.5                  | 2.577733        | -15.6475  | 22.98297       | 0.008187          | 0.002121     |
| 154       | -0.13022  | -0.06197 | -0.13022              | -0.06197 | 2.5                  | 2.547102        | 20.53744  | -6.84581       | 0.010471          | 0.002380     |
| 155       | 0.171805  | 0.171805 | 0.171805              | 0.171805 | 2.5                  | 2.572785        | 19.07048  | 19.07048       | 0.010676          | 0.001660     |

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CAGED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | CIN,2<br>RVS. | RVS<br>D/G <sup>2</sup> /in <sup>2</sup> | THOR<br>(ft/sec) | THOR<br>(ft/sec) | THOR<br>(ft/sec) | THOR<br>(ft/sec) | THOR<br>(ft/sec) | THOR<br>(ft/sec) | THOR<br>(ft/sec) | Vel.<br>(ft/sec) | Screen<br>Locations<br>Y1 | Vel.<br>(ft/sec) | MV<br>lb-sec | MV<br>lb-sec |
|-------------|---------------|------------------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|------------------|---------------------------|------------------|--------------|--------------|
| 105         | 0.002379      | 4.212777                                 | 1776.660         | 454.4962         | 1115.578         | 0.001763         |                  |                  |                  | 4 1115.578       | 1                         | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 106         | 0.001714      | 9.756225                                 | 922.6502         | 261.2672         | 591.9587         | 0.002837         |                  |                  |                  | 3 591.9587       | 1                         | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 107         | 0.018263      | 4.380222                                 | 1647.999         | 214.4548         | 1031.227         | 0.005648         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 108         | 0.003265      | 6.047885                                 | 1297.440         | 423.5878         | 860.5140         | 0.001178         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 109         | 0.009111      | 17.56005                                 | 981.7015         | 386.4705         | 684.0860         | 0.007493         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 110         | 0.024605      | 11.78619                                 | 1468.091         | 295.9363         | 876.7140         | 0.017402         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 111         | 0.018209      | 17.03002                                 | 995.1757         | 386.4705         | 690.8261         | 0.014662         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 112         | 0.008008      | 18.72970                                 | 996.7831         | 379.6519         | 638.2175         | 0.006554         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 113         | 0.003546      | 28.19841                                 | 568.0692         | 389.5746         | 478.8324         | 0.003273         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 114         | 0.021166      | 13.22854                                 | 1261.307         | 328.9251         | 794.8164         | 0.015236         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 115         | 0.001706      | 5.858769                                 | 2310.303         | 651.5191         | 1480.911         | 0.001013         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 116         | 0.035039      | 21.98206                                 | 839.6038         | 255.5815         | 547.5956         | 0.038868         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 117         | 0.033621      | 11.04447                                 | 1354.258         | 489.0264         | 921.6423         | 0.00524          |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 118         | 0.001182      | 8.457079                                 | 1724.355         | 487.8213         | 1106.088         | 0.000757         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 119         | 0.012005      | 7.456476                                 | 2036.211         | 355.4511         | 1195.831         | 0.007369         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 120         | 0.013339      | 12.74451                                 | 1301.341         | 374.9807         | 838.1611         | 0.009755         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 121         | 0.007098      | 8.500025                                 | 1737.885         | 479.7056         | 1108.795         | 0.004554         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 122         | 0.007881      | 1.268728                                 | 8171.707         | 319.5995         | 4245.853         | 0.007905         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 123         | 0.016249      | 11.08132                                 | 1535.794         | 300.8013         | 918.2979         | 0.011316         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 124         | 0.004351      | 6.89403                                  | 2004.770         | 667.4952         | 1336.133         | 0.007244         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 125         | 0.004434      | 19.48698                                 | 937.3124         | 573.0133         | 1331.288         | 0.002734         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 126         | 0.006434      | 19.48698                                 | 937.3124         | 573.0133         | 1331.288         | 0.002734         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 127         | 0.004231      | 7.040278                                 | 1887.381         | 705.4240         | 1296.405         | 0.007662         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 128         | 0.022831      | 18.03359                                 | 965.5530         | 260.2284         | 612.8907         | 0.018043         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 129         | 0.003011      | 5.548606                                 | 2516.858         | 487.7607         | 1502.309         | 0.005142         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 130         | 0.012886      | 12.41620                                 | 1752.904         | 485.1757         | 1119.040         | 0.012258         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 131         | 0.001941      | 5.145492                                 | 3401.842         | 1011.075         | 2206.459         | 0.001510         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 132         | 0.006458      | 7.741649                                 | 2491.361         | 729.3614         | 1605.664         | 0.005496         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 133         | 0.003058      | 7.727640                                 | 2592.594         | 565.4172         | 1579.006         | 0.007567         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 134         | 0.001924      | 5.146530                                 | 3347.501         | 953.8316         | 2150.666         | 0.001472         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 135         | 0.051970      | 27.32321                                 | 953.0326         | 294.7365         | 626.4096         | 0.060900         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 136         | 0.003772      | 5.301073                                 | 3482.654         | 690.3453         | 2086.499         | 0.002857         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 137         | 0.015704      | 10.032489                                | 1983.176         | 510.9049         | 1746.940         | 0.014513         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 138         | 0.014892      | 7.203952                                 | 2804.134         | 522.8779         | 1663.506         | 0.011393         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 139         | 0.007488      | 8.011806                                 | 2352.296         | 835.6832         | 1593.969         | 0.006547         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 140         | 0.002923      | 6.842093                                 | 2790.667         | 839.4962         | 1810.081         | 0.002478         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 141         | 0.006667      | 16.47796                                 | 1376.304         | 526.8761         | 951.5905         | 0.007166         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 142         | 0.001829      | 6.160277                                 | 3063.473         | 806.3042         | 1934.891         | 0.001324         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 143         | 0.006237      | 16.03270                                 | 1289.518         | 730.6279         | 995.0732         | 0.006812         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 144         | 0.010036      | 6.47438                                  | 2959.647         | 637.7341         | 1823.718         | 0.008740         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 145         | 0.004379      | 6.850137                                 | 4737.905         | 1052.943         | 2920.424         | 0.017633         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 146         | 0.002937      | 3.404631                                 | 2034.009         | 542.2584         | 1268.133         | 0.003016         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 147         | 0.002864      | 6.747490                                 | 3448.113         | 957.9784         | 2403.045         | 0.003016         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 148         | 0.002864      | 6.747490                                 | 3448.113         | 957.9784         | 2403.045         | 0.003016         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 149         | 0.004035      | 6.647080                                 | 3724.358         | 576.9649         | 2150.361         | 0.008833         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 150         | 0.010282      | 11.67004                                 | 2343.501         | 814.1967         | 1478.848         | 0.012149         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 151         | 0.005538      | 10.85376                                 | 2424.064         | 748.5866         | 1588.825         | 0.006526         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 152         | 0.016436      | 10.05531                                 | 2632.545         | 716.0932         | 1674.313         | 0.019487         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 153         | 0.011156      | 17.03002                                 | 1930.755         | 769.2366         | 1374.989         | 0.017085         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 154         | 0.005154      | 11.64001                                 | 2624.528         | 954.1044         | 1738.816         | 0.007343         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 155         | 0.006675      | 10.48537                                 | 2736.914         | 1058.718         | 1422.819         | 0.009215         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |
| 156         | 0.006168      | 11.34855                                 | 2649.120         | 705.4773         | 1777.298         | 0.008517         |                  |                  |                  | 0 0              | -99                       | 0.00E+00         | 0.00E+00     | 0.00E+00     |





TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | SHEET<br>No. | SHEET<br>X (in) | SHEET<br>Y (in) | MASS<br>(grams) | LEN<br>(in) | WID<br>(in) | THIC<br>(in) | L/D      | X (in) | POSITION<br>Y (in) | COORDINATES.<br>Z (in) | PATH<br>R (in) |
|-------------|--------------|-----------------|-----------------|-----------------|-------------|-------------|--------------|----------|--------|--------------------|------------------------|----------------|
| 157         | 5            | 80              | 47.5            | 0.02            | 0.102       | 0.091       | 0.024        | 1.259259 | 32     | 23.5               | 113.5                  | 120.2435       |
| 158         | 6            | 42              | 22.5            | 0.36            | 0.406       | 0.254       | 0.044        | 1.598425 | -6     | -1.5               | 114                    | 114.1676       |
| 159         | 6            | 61              | 40.25           | 0.18            | 0.35        | 0.159       | 0.045        | 2.201257 | 13     | 16.25              | 114                    | 115.8838       |
| 160         | 6            | 58              | 43.75           | 0.22            | 0.321       | 0.235       | 0.054        | 1.365957 | 10     | 19.75              | 114                    | 116.1295       |
| 161         | 6            | 40.25           | 33              | 0.06            | 0.129       | 0.1         | 0.055        | 1.29     | -7.75  | 9                  | 114                    | 114.6170       |
| 162         | 7            | 5               | 32.5            | 0.41            | 0.596       | 0.186       | 0.046        | 3.204301 | -43    | 8.5                | 114.5                  | 122.6030       |
| 163         | 7            | 28.5            | 46              | 0.18            | 0.312       | 0.2         | 0.049        | 1.56     | -19.5  | 22                 | 114.5                  | 118.2137       |
| 164         | 7            | 59.5            | 44.75           | 0.1             | 0.296       | 0.146       | 0.053        | 2.027397 | 11.5   | 20.75              | 114.5                  | 116.9318       |
| 165         | 8            | 34              | 42.5            | 0.13            | 0.288       | 0.175       | 0.077        | 1.645714 | -14    | 18.5               | 115                    | 117.3168       |
| 166         | 9            | 4               | 47              | 0.24            | 0.326       | 0.228       | 0.056        | 1.172651 | -44    | 23                 | 115.5                  | 125.7189       |
| 167         | 9            | 78.5            | 40.25           | 0.05            | 0.145       | 0.125       | 0.049        | 1.16     | 30.5   | 16.25              | 115.5                  | 120.5593       |
| 168         | 10           | 70.25           | 46              | 0.3             | 0.512       | 0.146       | 0.047        | 3.506949 | 22.25  | 22                 | 116                    | 120.1460       |
| 169         | 11           | 15              | 1               | 0.37            | 0.369       | 0.246       | 0.049        | 1.5      | -33    | -23                | 116.5                  | 123.2487       |
| 170         | 12           | 23.5            | 1               | 0.1             | 0.333       | 0.213       | 0.026        | 1.563380 | -24.5  | 8                  | 117                    | 121.7302       |
| 171         | 12           | 60              | 32              | 0.25            | 0.345       | 0.188       | 0.049        | 2.053571 | 12     | -11.5              | 111.5                  | 114.2300       |
| 172         | 1            | 70              | 12.5            | 0.08            | 0.267       | 0.132       | 0.032        | 2.022727 | 22     | -17.5              | 111.5                  | 117.0448       |
| 173         | 1            | 79              | 6.5             | 0.01            | 0.108       | 0.073       | 0.031        | 1.479452 | 31     | 21                 | 111.5                  | 113.4826       |
| 174         | 1            | 45.75           | 45              | 0.01            | 0.198       | 0.175       | 0.019        | 1.131428 | -2.25  | 5.5                | 111.5                  | 111.7709       |
| 175         | 1            | 42.5            | 29.5            | 0.02            | 0.151       | 0.07        | 0.02         | 2.157142 | -5.5   | 22                 | 111.5                  | 114.3350       |
| 176         | 1            | 35.5            | 46              | 0.08            | 0.271       | 0.184       | 0.03         | 1.472826 | -12.5  |                    |                        |                |

Total Mass = 17.43

Total Impulse Over Target at 9 ft. (4x8 Sheet) = 1.288192 lb-sec

Average Specific Impulse (at center) = 0.297095 psia-in

(based on curved target surface calculation)

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | TRN X     | TRN Y     | PENET RATION |          | COORDINATE | DEPTH    | Xs       | Ys       | PRESENTED | AREA     |
|-------------|-----------|-----------|--------------|----------|------------|----------|----------|----------|-----------|----------|
|             |           |           | X" (in)      | Y" (in)  | Z" (in)    | R" (in)  |          |          | MMX.      | MIN.     |
| 157         | 0.281938  | 0.207048  | 0.704845     | 0.517621 | 2.5        | 2.648535 | 31.29515 | 22.98237 | 0.006493  | 0.001525 |
| 158         | -0.052263 | -0.013115 | -0.15789     | -0.03947 | 3          | 3.004411 | -5.84210 | -1.46052 | 0.063642  | 0.006897 |
| 159         | 0.114035  | 0.142543  | 0.342105     | 0.427631 | 3          | 3.049574 | 12.65789 | 15.82236 | 0.031113  | 0.004000 |
| 160         | 0.087719  | 0.173245  | 0.263157     | 0.519735 | 3          | 3.056039 | 9.736842 | 19.23026 | 0.031690  | 0.005331 |
| 161         | -0.06798  | 0.078947  | -0.20394     | 0.236842 | 3          | 3.016237 | -7.54605 | 8.763157 | 0.008485  | 0.003617 |
| 162         | -0.37554  | 0.074235  | -1.31441     | 0.259825 | 3.5        | 3.747690 | -41.6855 | 8.240174 | 0.069329  | 0.005350 |
| 163         | -0.17030  | 0.192139  | -0.59606     | 0.672489 | 3.5        | 3.613521 | -18.9039 | 21.32751 | 0.028579  | 0.004487 |
| 164         | 0.100436  | 0.181222  | 0.351528     | 0.634279 | 3.5        | 3.574336 | 11.14847 | 20.11572 | 0.014676  | 0.002627 |
| 165         | -0.12179  | 0.160869  | -0.48695     | 0.643473 | 4          | 4.080587 | -13.5130 | 17.85652 | 0.013132  | 0.003511 |
| 166         | -0.38095  | 0.199134  | -1.71428     | 0.896103 | 4.5        | 4.898140 | -42.2857 | 22.10383 | 0.033336  | 0.003726 |
| 167         | 0.284069  | 0.140632  | 1.188311     | 0.633116 | 4.5        | 4.697118 | 29.31168 | 15.61688 | 0.007937  | 0.002682 |
| 168         | 0.191810  | 0.169655  | 0.959051     | 0.948275 | 5          | 5.178707 | 21.29094 | 21.05172 | 0.049649  | 0.004557 |
| 169         | -0.28326  | -0.19742  | -1.55793     | -1.08583 | 5.5        | 5.818609 | -31.4420 | -21.9141 | 0.048841  | 0.005691 |
| 170         | -0.20940  | -0.19658  | -1.25641     | -1.17949 | 6          | 6.242576 | -23.2435 | -21.8205 | 0.029917  | 0.002335 |
| 171         | 0.102564  | 0.068376  | 0.615384     | 0.410256 | 6          | 6.045412 | 11.38461 | 7.589743 | 0.039686  | 0.005636 |
| 172         | 0.127309  | -0.10313  | 0.098654     | -0.05156 | 0.5        | 0.512242 | 21.90134 | -11.4484 | 0.019446  | 0.002330 |
| 173         | 0.278026  | -0.15695  | 0.139013     | -0.07847 | 0.5        | 0.524864 | 30.86098 | -17.4215 | 0.002509  | 0.000720 |
| 174         | -0.02017  | 0.188340  | -0.01008     | 0.094170 | 0.5        | 0.508390 | -2.23991 | 20.90582 | 0.004093  | 0.000392 |
| 175         | -0.04932  | 0.049327  | -0.02466     | 0.024663 | 0.5        | 0.501215 | -5.47533 | 5.475336 | 0.007778  | 0.001030 |
| 176         | -0.11210  | 0.197309  | -0.03605     | 0.098654 | 0.5        | 0.512713 | -12.4439 | 21.90134 | 0.020742  | 0.002296 |

Total Imp

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASSED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | (IN) <sup>2</sup><br>AVG. | AVG<br>Q (gr/in <sup>2</sup> ) | THOR<br>(ft/sec)<br>(max) | THOR<br>(ft/sec)<br>(min) | THOR<br>(ft/sec)<br>(avg) | V<br>lb-sec | MV<br>lb-sec | Vel. Screen<br>Locations<br>X <sub>i</sub> Y <sub>i</sub> | (1-4) | VEL.<br>(fps) | MV<br>lb-sec<br>-10+-7.5 | MV<br>lb-sec<br>-7.5+-5 |
|-------------|---------------------------|--------------------------------|---------------------------|---------------------------|---------------------------|-------------|--------------|-----------------------------------------------------------|-------|---------------|--------------------------|-------------------------|
| 157         | 0.004003                  | 4.995474                       | 5124.931                  | 1731.395                  | 3428.163                  | 0.004694    |              |                                                           |       |               |                          |                         |
| 158         | 0.035269                  | 10.20709                       | 3575.379                  | 675.3317                  | 2125.355                  | 0.052384    |              | 4                                                         | 99    | 0             | 0.00E+00                 | 0.00E+00                |
| 159         | 0.017257                  | 10.25225                       | 3555.184                  | 763.3414                  | 2159.264                  | 0.026610    |              | 2                                                         | 1     | 2             | 2125.355                 | 0.00E+00                |
| 160         | 0.018510                  | 11.88511                       | 3105.746                  | 815.7979                  | 1960.772                  | 0.029533    |              | 3                                                         | 99    | 0             | 0.00E+00                 | 0.00E+00                |
| 161         | 0.006051                  | 9.914491                       | 3033.327                  | 1600.475                  | 2316.901                  | 0.009517    |              | 3                                                         | 99    | 0             | 0.00E+00                 | 0.00E+00                |
| 162         | 0.037340                  | 10.98006                       | 4081.751                  | 597.6958                  | 2339.723                  | 0.065677    |              | -99                                                       | 99    | 0             | 0.00E+00                 | 0.00E+00                |
| 163         | 0.016530                  | 10.88678                       | 3787.852                  | 944.9834                  | 2366.418                  | 0.029163    |              | 1                                                         | 99    | 0             | 0.00E+00                 | 0.00E+00                |
| 164         | 0.009652                  | 11.55787                       | 3542.271                  | 975.0344                  | 2258.652                  | 0.015463    |              | 3                                                         | 99    | 0             | 0.00E+00                 | 0.00E+00                |
| 165         | 0.003321                  | 15.62162                       | 2956.419                  | 1099.233                  | 2027.826                  | 0.018048    |              | 2                                                         | 99    | 0             | 0.00E+00                 | 0.00E+00                |
| 166         | 0.019531                  | 12.28791                       | 4305.013                  | 1148.688                  | 2726.851                  | 0.044806    |              | -99                                                       | 99    | 0             | 0.00E+00                 | 0.00E+00                |
| 167         | 0.005309                  | 9.416688                       | 4611.250                  | 2049.806                  | 3927.528                  | 0.011391    |              | 4                                                         | 99    | 0             | 0.00E+00                 | 0.00E+00                |
| 168         | 0.027103                  | 11.06857                       | 5118.995                  | 853.7007                  | 2986.348                  | 0.061338    |              | 4                                                         | 99    | 0             | 0.00E+00                 | 0.00E+00                |
| 169         | 0.027266                  | 9.902240                       | 5971.799                  | 1191.068                  | 3581.434                  | 0.066205    |              | 1                                                         | -99   | 0             | 3.61E-02                 | 0.00E+00                |
| 170         | 0.016126                  | 6.200960                       | 9180.894                  | 1356.069                  | 5268.482                  | 0.036070    |              | 3                                                         | 99    | 0             | 0.00E+00                 | 0.00E+00                |
| 171         | 0.022661                  | 11.03201                       | 5572.043                  | 1289.131                  | 3430.587                  | 0.058719    |              | 4                                                         | -99   | 0             | 0.00E+00                 | 0.00E+00                |
| 172         | 0.010888                  | 7.347268                       | 1204.581                  | 245.3664                  | 724.9740                  | 0.003970    |              | 4                                                         | -99   | 0             | 0.00E+00                 | 5.99E-04                |
| 173         | 0.001614                  | 6.193077                       | 1256.337                  | 492.6743                  | 874.5061                  | 0.000598    |              | 4                                                         | 99    | 0             | 0.00E+00                 | 0.00E+00                |
| 174         | 0.002243                  | 4.457536                       | 1772.129                  | 305.5355                  | 1038.832                  | 0.000711    |              | 2                                                         | 99    | 0             | 0.00E+00                 | 0.00E+00                |
| 175         | 0.004404                  | 4.540949                       | 1685.923                  | 370.1498                  | 1028.036                  | 0.001407    |              | 2                                                         | 1     | 2             | 1028.036                 | 0.00E+00                |
| 176         | 0.011519                  | 6.944802                       | 1265.193                  | 242.8124                  | 754.0031                  | 0.004129    |              | 2                                                         | 99    | 0             | 0.00E+00                 | 0.00E+00                |
| Total Imp   |                           |                                |                           |                           |                           |             |              |                                                           |       |               | 0.138                    | 0.084                   |

TABLE E-1. FRAGMENT DATA FROM THE 2.7 POUND CASED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | MV<br>lb-sec<br>-5+-2.5 | MV<br>lb-sec<br>-2.5-0 | MV<br>lb-sec<br>Chg. Ht. | MV<br>lb-sec<br>0+2.5 | MV<br>lb-sec<br>2.5+5 | MV<br>lb-sec<br>5+7.5 | MV<br>lb-sec<br>7.5+10 |
|-------------|-------------------------|------------------------|--------------------------|-----------------------|-----------------------|-----------------------|------------------------|
| 157         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 0.00E+00              | 0.00E+00              | 0.00E+00              | 4.69E-03               |
| 158         | 0.00E+00                | 0.00E+00               | 5.24E-02                 | 0.00E+00              | 0.00E+00              | 0.00E+00              | 0.00E+00               |
| 159         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 0.00E+00              | 0.00E+00              | 2.66E-02              | 0.00E+00               |
| 160         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 0.00E+00              | 0.00E+00              | 2.95E-02              | 0.00E+00               |
| 161         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 9.52E-03              | 0.00E+00              | 0.00E+00              | 0.00E+00               |
| 162         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 6.57E-02              | 0.00E+00              | 0.00E+00              | 0.00E+00               |
| 163         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 0.00E+00              | 0.00E+00              | 0.00E+00              | 2.92E-02               |
| 164         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 0.00E+00              | 0.00E+00              | 0.00E+00              | 1.55E-02               |
| 165         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 0.00E+00              | 0.00E+00              | 1.80E-02              | 0.00E+00               |
| 166         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 0.00E+00              | 0.00E+00              | 0.00E+00              | 4.48E-02               |
| 167         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 0.00E+00              | 0.00E+00              | 1.14E-02              | 0.00E+00               |
| 168         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 0.00E+00              | 0.00E+00              | 0.00E+00              | 6.13E-02               |
| 169         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 0.00E+00              | 0.00E+00              | 0.00E+00              | 0.00E+00               |
| 170         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 0.00E+00              | 0.00E+00              | 0.00E+00              | 0.00E+00               |
| 171         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 5.87E-02              | 0.00E+00              | 0.00E+00              | 0.00E+00               |
| 172         | 3.97E-03                | 0.00E+00               | 0.00E+00                 | 0.00E+00              | 0.00E+00              | 0.00E+00              | 0.00E+00               |
| 173         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 0.00E+00              | 0.00E+00              | 0.00E+00              | 0.00E+00               |
| 174         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 0.00E+00              | 0.00E+00              | 0.00E+00              | 7.11E-04               |
| 175         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 1.41E-03              | 0.00E+00              | 0.00E+00              | 0.00E+00               |
| 176         | 0.00E+00                | 0.00E+00               | 0.00E+00                 | 0.00E+00              | 0.00E+00              | 0.00E+00              | 4.13E-03               |
| Total Imp   | 0.057                   | 0.043                  | 0.211                    | 0.208                 | 0.104                 | 0.214                 | 0.227                  |

## **APPENDIX F**

### **Fragment Data from the 2.4 Pound Cased Charge Test**

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASSED CHARGE TEST.

| FRAG<br>NUM | SHEET<br>No. | SHEET<br>X (in) | SHEET<br>Y (in) | MASS<br>(grams) | LEN<br>(in) | WID<br>(in) | THIC<br>(in) | L/D      | X (in) | Y (in) | POSITION<br>COORDINATES.<br>Z (in) | PATH<br>R (in) |
|-------------|--------------|-----------------|-----------------|-----------------|-------------|-------------|--------------|----------|--------|--------|------------------------------------|----------------|
| 1           | 30           | 47.25           | 30              | 5.71            | 1.038       | 0.559       | 0.167        | 1.856887 | -0.75  | -23    | 126                                | 128.0842       |
| 2           | 29           | 94.5            | 17.5            | 4.19            | 1.769       | 1.524       | 0.216        | 1.160761 | 46.5   | -6.5   | 125.5                              | 133.9953       |
| 3           | 27           | 52              | 11.5            | 7.06            | 0.865       | 0.6         | 0.211        | 1.441666 | 4      | -12.5  | 124.5                              | 125.1898       |
| 4           | 27           | 14              | 2.75            | 1.75            | 0.659       | 0.295       | 0.174        | 2.233898 | -34    | -21.25 | 124.5                              | 130.7968       |
| 5           | 27           | 49              | 29              | 7.3             | 1.141       | 0.469       | 0.263        | 2.432835 | 1      | 5      | 124.5                              | 124.6043       |
| 6           | 26           | 95              | 17.5            | 2.85            | 0.718       | 0.442       | 0.194        | 1.624434 | 47     | -6.5   | 124                                | 132.7676       |
| 7           | 26           | 49              | 18              | 10.88           | 1.15        | 0.694       | 0.23         | 1.657060 | 1      | -6     | 124                                | 124.1491       |
| 8           | 25           | 51.25           | 10.5            | 0.64            | 0.382       | 0.259       | 0.105        | 1.474903 | 3.25   | -13.5  | 123.5                              | 124.2781       |
| 9           | 22           | 60              | 12.5            | 4.5             | 0.789       | 0.295       | 0.145        | 2.674576 | 12     | -11.5  | 122                                | 123.1269       |
| 10          | 21           | 24              | 4               | 4.28            | 0.861       | 0.475       | 0.244        | 1.812631 | -24    | 7      | 121.5                              | 125.4521       |
| 11          | 21           | 62              | 31              | 3.6             | 0.724       | 0.407       | 0.211        | 1.778869 | 14     | -21    | 121                                | 126.4199       |
| 12          | 20           | 78              | 3               | 3.25            | 0.655       | 0.435       | 0.192        | 1.505747 | 30     | -13    | 121                                | 121.7127       |
| 13          | 20           | 50              | 11              | 2.09            | 0.571       | 0.428       | 0.158        | 1.934112 | 26.5   | -14    | 121                                | 124.6565       |
| 14          | 20           | 74.5            | 10              | 10.16           | 1.326       | 0.468       | 0.249        | 2.833333 | 32     | 1.5    | 121                                | 125.1688       |
| 15          | 20           | 80              | 25.5            | 2.6             | 0.692       | 0.418       | 0.223        | 1.655502 | -24    | -13    | 121                                | 124.0403       |
| 16          | 20           | 24              | 11              | 0.8             | 0.516       | 0.32        | 0.131        | 1.6125   | 3.5    | -15.5  | 120.5                              | 121.5432       |
| 17          | 19           | 51.5            | 8.5             | 12.66           | 1.694       | 1.605       | 0.194        | 1.055451 | -17.5  | -19.25 | 120.5                              | 123.2763       |
| 18          | 19           | 30.5            | 4.75            | 0.11            | 0.449       | 0.141       | 0.025        | 3.184397 | -30    | -7     | 120.5                              | 124.3754       |
| 19          | 19           | 18              | 17              | 4.17            | 0.786       | 0.429       | 0.25         | 1.832167 | -36    | -6     | 120.5                              | 125.9057       |
| 20          | 19           | 12              | 18              | 2.3             | 0.716       | 0.41        | 0.152        | 1.746341 | 29     | -16.75 | 120                                | 124.5855       |
| 21          | 18           | 77              | 7.25            | 0.95            | 0.641       | 0.279       | 0.11         | 2.297491 | 33.5   | -17    | 119.5                              | 125.2657       |
| 22          | 17           | 81.5            | 13.5            | 12.12           | 1.989       | 0.541       | 0.205        | 3.676524 | 11     | -10.5  | 119.5                              | 120.4636       |
| 23          | 17           | 59              | 9               | 0.32            | 0.351       | 0.16        | 0.115        | 2.19375  | -41.4  | -12    | 119.5                              | 127.0362       |
| 24          | 17           | 6.6             | 12              | 3.46            | 0.84        | 0.447       | 0.191        | 1.879194 | -19.75 | -15    | 119.5                              | 122.0463       |
| 25          | 17           | 28.25           | 9               | 11.7            | 1.465       | 0.786       | 0.224        | 1.863867 | -34.5  | -20.5  | 119.5                              | 126.0585       |
| 26          | 17           | 13.5            | 3.5             | 1.88            | 0.735       | 0.448       | 0.132        | 1.640625 | -19    | -16    | 119                                | 121.5647       |
| 27          | 17           | 23              | 8               | 1.78            | 0.641       | 0.414       | 0.125        | 1.548309 | 2      | -3.5   | 119                                | 119.0682       |
| 28          | 16           | 50              | 20.5            | 0.16            | 0.212       | 0.191       | 0.058        | 1.109947 | -11    | 12.5   | 119                                | 120.1592       |
| 29          | 16           | 37              | 36.5            | 2.35            | 0.73        | 0.323       | 0.235        | 2.218844 | 37.5   | -18    | 118.5                              | 125.5886       |
| 30          | 16           | 85.5            | 6               | 4.83            | 1.021       | 0.463       | 0.16         | 2.611940 | 0      | 0      | 118                                | 118            |
| 31          | 15           | 48              | 24              | 2.33            | 0.875       | 0.395       | 0.16         | 2.611940 | -14    | -12    | 118.5                              | 119.9260       |
| 32          | 15           | 48              | 12              | 0.94            | 1.25        | 1.117       | 0.452        | 1.119068 | -37    | -16.5  | 118.5                              | 125.2337       |
| 33          | 15           | 34              | 12              | 1.36            | 1.588       | 1.381       | 1.14         | 1.149891 | -36    | -22.5  | 118.5                              | 125.8749       |
| 34          | 15           | 11              | 7.5             | 1.87            | 0.662       | 0.352       | 0.151        | 1.880681 | 31     | -9.5   | 118.5                              | 122.8556       |
| 35          | 15           | 12              | 1.5             | 2.53            | 0.931       | 0.314       | 0.116        | 2.964969 | 0      | 0      | 118.5                              | 118.5          |
| 36          | 15           | 79              | 14.5            | 0.52            | 0.337       | 0.2         | 0.12         | 1.685    | -36    | 2      | 118                                | 123.3855       |
| 37          | 15           | 48              | 24              | 0.52            | 0.337       | 0.2         | 0.12         | 1.685    | 37.5   | -18    | 118                                | 125.1169       |
| 38          | 15           | 48              | 12              | 2.5             | 0.766       | 0.413       | 0.171        | 1.854721 | 30     | -3.5   | 118                                | 121.8041       |
| 39          | 14           | 85.5            | 6               | 0.64            | 0.306       | 0.255       | 0.13         | 1.1      | -36.5  | -16    | 118                                | 124.2779       |
| 40          | 14           | 78              | 20.5            | 2.5             | 0.711       | 0.361       | 0.204        | 1.969529 | -39    | 0      | 118                                | 119.3251       |
| 41          | 14           | 11.5            | 9               | 5.58            | 1.536       | 1.402       | 0.182        | 1.095577 | -16.5  | -6.5   | 118                                | 125.1728       |
| 42          | 14           | 9               | 24              | 6.36            | 1.474       | 1.212       | 0.209        | 2.267307 | -26.5  | -9.5   | 117.5                              | 122.9735       |
| 43          | 14           | 31.5            | 17.5            | 5.94            | 1.179       | 0.52        | 0.088        | 2.443902 | 31.5   | -2.5   | 117.5                              | 121.2950       |
| 44          | 14           | 12.5            | 2               | 0.6             | 0.501       | 0.205       | 0.176        | 2.929712 | 12.5   | 0      | 117.5                              | 118.4395       |
| 45          | 14           | 21.5            | 14.5            | 2.8             | 0.917       | 0.313       | 0.065        | 1.881578 | 30     | -13.25 | 116.5                              | 125.2350       |
| 46          | 13           | 79.5            | 6               | 0.35            | 0.286       | 0.152       | 0.062        | 4.169491 | 44     | -12.5  | 116.5                              | 125.1579       |
| 47          | 13           | 78              | 21.5            | 1.08            | 1.476       | 0.354       | 0.069        | 4.169491 | 0      | -22.25 | 116                                | 120.7313       |
| 48          | 13           | 60.5            | 32              | 0.34            | 0.276       | 0.198       | 0.062        | 1.393939 | 25     |        |                                    |                |
| 49          | 13           | 72              | 24              | 14.51           | 1.449       | 0.795       | 0.218        | 1.598425 |        |        |                                    |                |
| 50          | 13           | 92              | 10.75           | 2.16            | 0.609       | 0.381       | 0.191        | 1.598425 |        |        |                                    |                |
| 51          | 11           | 92              | 11.5            | 1.6             | 0.595       | 0.289       | 0.163        | 2.058823 |        |        |                                    |                |
| 52          | 11           | 48              | 24              | 0.58            | 0.506       | 0.288       | 0.064        | 1.756944 |        |        |                                    |                |
| 53          | 11           | 48              | 24              | 0.58            | 0.506       | 0.288       | 0.064        | 1.756944 |        |        |                                    |                |
| 54          | 10           | 73              | 1.75            | 0.48            | 0.511       | 0.173       | 0.068        | 2.854748 |        |        |                                    |                |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

| FIRIG<br>NUM | TRN X    | TRN Y    | PENET<br>X' (in) | PENET<br>Y' (in) | COORDINATE<br>Z' (in) | DEPTH<br>R' (in) | Xo       | Yo       | PRESENTED<br>MAX. | AREA<br>MIN. | (IN) <sup>2</sup><br>AVG. |
|--------------|----------|----------|------------------|------------------|-----------------------|------------------|----------|----------|-------------------|--------------|---------------------------|
| 1            | -0.00595 | -0.18253 | -0.08328         | -2.73809         | 15                    | 15.24811         | -0.66071 | -20.2619 | 0.237513          | 0.042789     | 0.140151                  |
| 2            | 0.370517 | -0.10179 | 5.372509         | -0.75093         | 14.5                  | 15.48153         | 41.12749 | -5.74900 | 0.026802          | 0.018423     | 0.022613                  |
| 3            | 0.032128 | -0.05140 | 0.433734         | -1.35542         | 13.5                  | 13.57480         | 3.566265 | -11.1445 | 0.260265          | 0.063486     | 0.161876                  |
| 4            | -0.27309 | -0.17068 | -3.68674         | -2.30421         | 13.5                  | 14.18278         | -30.3132 | -18.9457 | 0.078231          | 0.020656     | 0.049443                  |
| 5            | 0.008032 | 0.040160 | 0.108433         | 0.542168         | 13.5                  | 13.51131         | 0.891566 | 4.457831 | 0.215904          | 0.049765     | 0.132835                  |
| 6            | 0.37032  | -0.05241 | 4.927419         | -0.68145         | 13                    | 13.91918         | 42.07258 | -5.81854 | 0.114271          | 0.030875     | 0.072573                  |
| 7            | 0.008064 | -0.04838 | 0.104838         | -0.62903         | 13                    | 13.01563         | 0.895161 | 5.37096  | 0.367955          | 0.073591     | 0.220773                  |
| 8            | 0.026315 | -0.10931 | 0.328947         | -1.36639         | 12.5                  | 12.57876         | 2.921052 | -12.1936 | 0.047411          | 0.013031     | 0.030221                  |
| 9            | 0.098360 | -0.09426 | 1.081967         | -1.03688         | 11                    | 11.10161         | 0.91803  | -18.2716 | 0.136442          | 0.038666     | 0.087554                  |
| 10           | -0.19753 | -0.16460 | -2.07407         | -1.72839         | 10.5                  | 10.84154         | -21.9259 | -18.2716 | 0.136442          | 0.038666     | 0.087554                  |
| 11           | 0.15226  | 0.057613 | 1.209876         | 0.604938         | 10.5                  | 10.58677         | 12.79012 | 6.395061 | 0.132713          | 0.038677     | 0.085131                  |
| 12           | 0.247933 | -0.17355 | 2.479338         | -1.73553         | 10                    | 10.44792         | 27.52066 | -19.2644 | 0.131666          | 0.038595     | 0.085131                  |
| 13           | 0.016528 | -0.10743 | 0.165289         | -1.07438         | 10                    | 10.05890         | 1.834710 | -11.9256 | 0.102892          | 0.028471     | 0.065681                  |
| 14           | 0.219008 | -0.11570 | 2.190082         | -1.15702         | 10                    | 10.30219         | 24.30991 | -12.8429 | 0.317386          | 0.059599     | 0.188493                  |
| 15           | 0.264462 | 0.012396 | 2.644628         | 0.123966         | 10                    | 10.34453         | 29.35537 | 1.376033 | 0.090690          | 0.029225     | 0.059358                  |
| 16           | -0.19834 | -0.10743 | -1.98347         | -1.07438         | 10                    | 10.25126         | -22.0165 | -11.9256 | 0.047502          | 0.012059     | 0.029780                  |
| 17           | 0.029045 | -0.12863 | 0.275933         | -1.22199         | 9.5                   | 9.582244         | 3.224066 | -14.2780 | 0.507605          | 0.058131     | 0.282868                  |
| 18           | -0.14522 | -0.15975 | -1.37966         | -1.51763         | 9.5                   | 9.718883         | -16.1203 | -17.7323 | 0.034225          | 0.001905     | 0.018065                  |
| 19           | -0.24896 | -0.05809 | -2.36514         | -0.55186         | 9.5                   | 9.805532         | -27.6348 | -6.44813 | 0.129744          | 0.041267     | 0.085506                  |
| 20           | -0.29875 | -0.04979 | -2.83817         | -0.47302         | 9.5                   | 9.926176         | -33.1618 | -5.52697 | 0.117700          | 0.024986     | 0.071343                  |
| 21           | 0.241666 | -0.13958 | 2.175            | -1.25625         | 9                     | 9.343917         | 26.825   | -15.4937 | 0.067177          | 0.011528     | 0.039352                  |
| 22           | 0.280334 | -0.14225 | 2.382845         | -1.20920         | 8.5                   | 8.910113         | 31.11715 | -15.7907 | 0.459878          | 0.047398     | 0.253638                  |
| 23           | 0.092050 | -0.08786 | 0.782426         | -0.74686         | 8.5                   | 8.568546         | 10.21757 | -9.75313 | 0.021644          | 0.007091     | 0.014367                  |
| 24           | -0.34644 | -0.10041 | -2.94476         | -0.85355         | 8.5                   | 8.036051         | -38.4552 | -11.1464 | 0.140908          | 0.032039     | 0.086474                  |
| 25           | 0.15527  | -0.12552 | 1.779661         | -1.06694         | 8.5                   | 8.681121         | -18.3451 | -13.9330 | 0.406286          | 0.062121     | 0.234203                  |
| 26           | -0.28870 | -0.17154 | -2.45397         | -1.45815         | 8.5                   | 8.966505         | -32.0460 | -19.0418 | 0.110784          | 0.019895     | 0.063430                  |
| 27           | 0.15966  | -0.13445 | 1.27731          | -1.07563         | 8                     | 8.172423         | -17.7226 | -14.9243 | 0.110765          | 0.021600     | 0.066182                  |
| 28           | 0.016806 | -0.02941 | 0.13453          | -0.23529         | 8                     | 8.004588         | 1.865546 | -3.26470 | 0.021457          | 0.005870     | 0.013664                  |
| 29           | -0.09243 | 0.105042 | -0.73949         | 0.840336         | 8                     | 8.077934         | -10.2605 | 11.65966 | 0.077784          | 0.025040     | 0.051412                  |
| 30           | 0.316455 | -0.15189 | 2.373417         | -1.13924         | 7.5                   | 7.948646         | 35.12558 | -16.8607 | 0.183268          | 0.036737     | 0.110032                  |
| 31           | 0.11814  | -0.10126 | -0.88607         | -0.75949         | 7                     | 7.590254         | -13.1139 | 0        | 0.113273          | 0.020712     | 0.066993                  |
| 32           | -0.31223 | -0.13924 | -2.34177         | -1.04430         | 7.5                   | 7.926188         | -34.6582 | -11.2405 | 0.016176          | 0.005849     | 0.011012                  |
| 33           | -0.30379 | -0.18987 | -2.27348         | -1.42405         | 7.5                   | 7.966768         | -33.7215 | -21.0759 | 0.096329          | 0.021972     | 0.059150                  |
| 34           | 0.261603 | -0.08016 | 1.962025         | -0.60126         | 7.5                   | 7.775671         | 29.03797 | -8.89873 | 0.169651          | 0.021138     | 0.095394                  |
| 35           | 0.30508  | 0.016949 | -2.13559         | 0.118644         | 7.5                   | 7.5              | 0        | 0        | 0.033706          | 0.012002     | 0.022854                  |
| 36           | 0.31796  | -0.15254 | 2.224576         | -1.06779         | 7                     | 7.319483         | -33.8644 | 1.881355 | 0.113720          | 0.025386     | 0.069553                  |
| 37           | 0.254237 | -0.02965 | 1.779661         | -0.20762         | 7                     | 7.422191         | 35.27542 | -16.9322 | 0.038294          | 0.016268     | 0.027281                  |
| 38           | -0.30350 | -0.13559 | -2.16525         | -0.94915         | 7                     | 7.225669         | 28.22033 | -3.29237 | 0.095324          | 0.027350     | 0.061347                  |
| 39           | 0.33050  | 0        | 2.16525          | -0.94915         | 7                     | 7.368451         | -34.3347 | -15.0508 | 0.238482          | 0.028257     | 0.133370                  |
| 40           | -0.13983 | -0.05508 | -2.31355         | -0.98559         | 7                     | 7.372418         | -36.6864 | 0        | 0.041433          | 0.033562     | 0.037497                  |
| 41           | -0.30084 | -0.18644 | -2.97881         | -1.30508         | 7                     | 7.078612         | -15.5211 | -6.11440 | 0.221072          | 0.039189     | 0.130130                  |
| 42           | -0.22553 | -0.08085 | -2.10593         | -0.52553         | 7                     | 7.425509         | -33.9940 | -20.6949 | 0.053035          | 0.009315     | 0.031175                  |
| 43           | 0.268085 | -0.15319 | 1.46595          | -0.52553         | 6.5                   | 6.683352         | -25.0340 | -8.97446 | 0.129748          | 0.023751     | 0.073749                  |
| 44           | 0.255319 | -0.02127 | 1.742553         | -0.99574         | 6.5                   | 6.802793         | 29.75744 | -17.0042 | 0.032028          | 0.009519     | 0.020774                  |
| 45           | 0.106382 | 0.068085 | 0.691489         | 0.442553         | 6.5                   | 6.709941         | 28.34042 | -2.36170 | 0.094390          | 0.005691     | 0.050040                  |
| 46           | 0.204255 | 0        | 1.659574         | -0.13829         | 6.5                   | 6.551641         | 11.80851 | 7.557446 | 0.042656          | 0.009582     | 0.026119                  |
| 47           | 0.377682 | -0.11373 | 2.07253          | -0.62555         | 6.5                   | 6.634205         | 22.67234 | 0        | 0.517732          | 0.077892     | 0.297812                  |
| 48           | 0.377682 | -0.10729 | 2.07253          | -0.59012         | 5.5                   | 5.912383         | 41.92274 | -12.6244 | 0.087965          | 0.027588     | 0.057777                  |
| 49           | 0.377682 | -0.10729 | 2.07253          | -0.59012         | 5.5                   | 5.908742         | 41.92274 | -11.9098 | 0.076353          | 0.020916     | 0.048634                  |
| 50           | 0.215517 | -0.19181 | 1.077586         | -0.95905         | 5.5                   | 5.5              | 0        | 0        | 0.053708          | 0.008916     | 0.031312                  |
| 51           | 0.215517 | -0.19181 | 1.077586         | -0.95905         | 5.5                   | 5.203938         | 23.92241 | -21.2909 | 0.054906          | 0.007306     | 0.031106                  |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CAGED CHARGE TEST (CONTINUED).

[illegible]



TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CAGED CHARGE TEST (CONTINUED).

| FIRSIG | MV                | MV                   | MV               | MV              | MV       |
|--------|-------------------|----------------------|------------------|-----------------|----------|
| TALIM  | lb-sec<br>-2,-5-0 | Csq. Ht.<br>0.00E+00 | lb-sec<br>0+-2.5 | lb-sec<br>2-5+5 | MV       |
| 1      | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 7.5+11   |
| 2      | 2.55E-01          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 3      | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 4      | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 5      | 0.00E+00          | 0.00E+00             | 9.62E-01         | 0.00E+00        | 0.00E+00 |
| 6      | 4.98E-01          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 7      | 1.50E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 8      | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 9      | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 10     | 0.00E+00          | 0.00E+00             | 4.88E-01         | 0.00E+00        | 0.00E+00 |
| 12     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 13     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 14     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 15     | 0.00E+00          | 3.40E-01             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 16     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 17     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 18     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 19     | 4.79E-01          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 20     | 3.57E-01          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 23     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 24     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 25     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 26     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 27     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 28     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 29     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 30     | 0.00E+00          | 4.58E-02             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 31     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 2.45E-01        | 0.00E+00 |
| 32     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 33     | 0.00E+00          | 2.61E-01             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 34     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 35     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 36     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 37     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 38     | 0.00E+00          | 8.70E-02             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 39     | 0.00E+00          | 2.86E-01             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 40     | 0.00E+00          | 2.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 41     | 0.00E+00          | 2.60E-01             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 42     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 43     | 0.00E+00          | 2.38E-01             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 44     | 5.47E-01          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 45     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 46     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 47     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 48     | 0.00E+00          | 1.60E-01             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 49     | 0.00E+00          | 0.00E+00             | 7.16E-02         | 0.00E+00        | 0.00E+00 |
| 50     | 0.00E+00          | 1.20E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 51     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 52     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 53     | 0.00E+00          | 8.67E-02             | 0.00E+00         | 0.00E+00        | 0.00E+00 |
| 54     | 0.00E+00          | 0.00E+00             | 0.00E+00         | 0.00E+00        | 0.00E+00 |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASSED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | SHEET<br>No. | SHEET<br>X (in) | SHEET<br>POSITION<br>Y (in) | MASS<br>(grams) | LEN<br>(in) | WID<br>(in) | THIC<br>(in) | L/D      | X (in) | FOOT<br>Y (in) | COORDINATES.<br>Z (in) | PATH<br>R (in) |
|-------------|--------------|-----------------|-----------------------------|-----------------|-------------|-------------|--------------|----------|--------|----------------|------------------------|----------------|
| 55          | 10           | 76              | 21                          | 1.6             | 0.638       | 0.384       | 0.159        | 1.661456 | 28     | -3             | 116                    | 119.3691       |
| 56          | 10           | 55              | 27                          | 1.84            | 0.644       | 0.384       | 0.138        | 1.672063 | 7      | 3              | 116                    | 116.2497       |
| 57          | 10           | 18.25           | 6                           | 0.57            | 0.466       | 0.203       | 0.106        | 2.295566 | -24.75 | -18            | 116                    | 121.0993       |
| 58          | 10           | 19.5            | 29                          | 2.19            | 0.736       | 0.428       | 0.142        | 1.719626 | -28.5  | 5              | 116                    | 119.5543       |
| 59          | 10           | 43              | 19                          | 1.37            | 0.505       | 0.437       | 0.141        | 1.155606 | -5     | -5             | 116                    | 116.2153       |
| 60          | 10           | 20              | 15                          | 1.6             | 0.579       | 0.342       | 0.125        | 1.692982 | -24    | -9             | 116                    | 119.6703       |
| 61          | 9            | 71.5            | 17.5                        | 0.99            | 0.444       | 0.259       | 0.104        | 1.714285 | 23.5   | -22.5          | 115.5                  | 119.9947       |
| 62          | 9            | 78.5            | 17.5                        | 2.11            | 0.756       | 0.403       | 0.163        | 1.875930 | 30.5   | -6.5           | 115.5                  | 119.6359       |
| 63          | 9            | 75.5            | 34                          | 0.46            | 0.466       | 0.213       | 0.133        | 2.187793 | 27.5   | -3             | 115.5                  | 118.7665       |
| 64          | 9            | 77.5            | 34                          | 0.79            | 0.443       | 0.272       | 0.113        | 1.628676 | 29.5   | 10             | 115.5                  | 119.6265       |
| 65          | 9            | 53              | 45                          | 0.44            | 0.441       | 0.198       | 0.11         | 2.227272 | 5      | 21             | 115.5                  | 117.5          |
| 66          | 9            | 35              | 8.5                         | 1.96            | 0.946       | 0.241       | 0.121        | 3.925311 | -13    | -15.5          | 115.5                  | 117.2582       |
| 67          | 9            | 30.5            | 17.5                        | 0.53            | 0.51        | 0.225       | 0.08         | 2.266666 | -17.5  | -6.5           | 115.5                  | 116.9489       |
| 68          | 9            | 82              | 24                          | 1.77            | 0.654       | 0.368       | 0.149        | 1.777173 | 34     | 0              | 115.5                  | 120.4003       |
| 69          | 8            | 72              | 24                          | 1.07            | 0.579       | 0.32        | 0.103        | 1.809375 | 24     | 0              | 115                    | 117.0854       |
| 70          | 8            | 70              | 24                          | 0.32            | 0.394       | 0.224       | 0.126        | 1.759928 | 22     | 0              | 115                    | 116.4001       |
| 71          | 8            | 30              | 24                          | 1.4             | 0.605       | 0.458       | 0.112        | 1.320960 | -18    | -13            | 115                    | 121.2023       |
| 72          | 8            | 12              | 11                          | 3.73            | 1.079       | 0.473       | 0.142        | 2.281183 | -36    | -18            | 115                    | 116.7871       |
| 73          | 8            | 38.5            | 6                           | 2.97            | 1.199       | 0.318       | 0.11         | 3.770440 | -9.5   | -17.5          | 115                    | 116.3335       |
| 74          | 8            | 46.5            | 6.5                         | 1.41            | 0.751       | 0.31        | 0.106        | 2.422580 | -1.5   | -17.5          | 115                    | 116.3410       |
| 75          | 8            | 50              | 5.5                         | 2.7             | 0.771       | 0.39        | 0.142        | 1.976923 | 22.5   | -9             | 115                    | 117.5255       |
| 76          | 8            | 70.5            | 15                          | 0.48            | 0.561       | 0.225       | 0.074        | 2.493333 | 25     | -13            | 115                    | 119.4350       |
| 77          | 8            | 73              | 5.5                         | 0.29            | 0.323       | 0.21        | 0.082        | 1.538095 | 29.5   | -10.75         | 115                    | 120.1731       |
| 78          | 8            | 75              | 11                          | 0.13            | 0.283       | 0.211       | 0.062        | 1.341232 | 33     | -19.75         | 115                    | 120.3307       |
| 79          | 8            | 81              | 13.25                       | 0.1             | 0.291       | 0.122       | 0.083        | 1.449979 | 33.5   | 11.5           | 115                    | 117.5850       |
| 80          | 8            | 81.5            | 35.5                        | 0.41            | 0.355       | 0.245       | 0.03         | 1.590487 | -19    | -15.5          | 114.5                  | 117.7162       |
| 81          | 8            | 29              | 6.5                         | 0.1             | 0.324       | 0.205       | 0.125        | 1.541114 | -19    | -20            | 114.5                  | 115.2356       |
| 82          | 7            | 72              | 4                           | 1.88            | 0.581       | 0.377       | 0.151        | 1.046988 | 0      | -13            | 114.5                  | 120.0427       |
| 83          | 7            | 72              | 11                          | 1.96            | 1.582       | 1.511       | 0.075        | 0.971153 | 30     | -20            | 114.5                  | 117.2625       |
| 84          | 7            | 73              | 4                           | 0.5             | 0.303       | 0.312       | 0.073        | 1.818713 | 15.5   | -20            | 114.5                  | 116.8514       |
| 85          | 7            | 63.5            | 4                           | 0.24            | 0.311       | 0.171       | 0.034        | 1.641025 | 12     | -7             | 114.5                  | 118.5717       |
| 86          | 7            | 60              | 4                           | 0.07            | 0.256       | 0.156       | 0.115        | 2.874418 | -30    | -12            | 114.5                  | 119.3587       |
| 87          | 7            | 18              | 17                          | 0.8             | 0.619       | 0.715       | 0.08         | 1.27     | -31.5  | -8             | 114.5                  | 117.4702       |
| 88          | 7            | 16.5            | 12                          | 0.48            | 0.491       | 0.241       | 0.125        | 1.962555 | -25    | -4.5           | 114.5                  | 116.3206       |
| 89          | 7            | 23              | 16                          | 0.61            | 0.473       | 0.241       | 0.165        | 1.206185 | -20    | 2              | 114.5                  | 117.4318       |
| 90          | 7            | 22              | 19.5                        | 0.14            | 0.294       | 0.194       | 0.082        | 1.26     | -19.5  | 12             | 114.5                  | 115.3050       |
| 91          | 7            | 22              | 36                          | 0.72            | 0.545       | 0.276       | 0.1          | 1.974637 | -11    | -8             | 114.5                  | 115.2106       |
| 92          | 7            | 37              | 16                          | 1.11            | 1.735       | 0.337       | 0.092        | 5.148367 | 6.5    | 11             | 114.5                  | 117.1374       |
| 93          | 7            | 57.5            | 36                          | 0.5             | 0.576       | 0.194       | 0.117        | 2.963072 | -24    | 0              | 114                    | 121.1486       |
| 94          | 7            | 74              | 17                          | 0.5             | 0.453       | 0.244       | 0.086        | 1.856557 | 41     | 0              | 114                    | 116.1034       |
| 95          | 7            | 37              | 27                          | 0.36            | 0.511       | 0.174       | 0.091        | 2.936781 | 27     | 0              | 114                    | 114.0049       |
| 96          | 7            | 73              | 27                          | 1.41            | 0.673       | 0.309       | 0.145        | 2.177993 | -3     | 0              | 114                    | 122.8342       |
| 97          | 7            | 73              | 27                          | 4.28            | 1.053       | 0.365       | 0.163        | 2.884731 | -44    | -11.5          | 114                    | 118.4409       |
| 98          | 7            | 75              | 27                          | 1.54            | 0.706       | 0.269       | 0.15         | 1.691449 | -31.5  | -10            | 114                    | 116.3128       |
| 99          | 7            | 75              | 11.5                        | 0.95            | 0.455       | 0.269       | 0.1          | 2.24     | -24.5  | 10.5           | 114                    | 117.9063       |
| 100         | 7            | 18              | 12.5                        | 0.46            | 0.448       | 0.12        | 0.104        | 3.541666 | -26    | -11            | 114                    | 117.4502       |
| 101         | 7            | 18              | 12.5                        | 0.33            | 0.425       | 0.12        | 0.131        | 1.644736 | -26    | -11            | 114                    | 115.1564       |
| 102         | 7            | 18.5            | 17                          | 0.57            | 0.5         | 0.304       | 0.131        | 1.644736 | -26    | -11            | 114                    | 115.1564       |
| 103         | 7            | 23.5            | 17                          | 0.57            | 0.5         | 0.304       | 0.131        | 1.644736 | -26    | -11            | 114                    | 115.1564       |
| 104         | 7            | 18.5            | 34.5                        | 0.16            | 0.229       | 0.146       | 0.081        | 2.016464 | -26    | -11            | 114                    | 115.1564       |
| 105         | 7            | 22              | 39.5                        | 0.46            | 0.502       | 0.248       | 0.129        | 3.069934 | -26    | -11            | 114                    | 115.1564       |
| 106         | 7            | 36              | 13                          | 3.69            | 1.307       | 0.423       | 0.129        | 3.069934 | -26    | -11            | 114                    | 115.1564       |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CAGED CHARGE TEST (CONTINUED).

| FRAG NO. | TEN X    | TEN Y    | PENET X (in) | PENET Y (in) | COORDINATE Z (in) | DEPTH R (in) | Xo       | Yo        | PRESENTED MMK. | AREA MIN. | CIN:4 AVG. |
|----------|----------|----------|--------------|--------------|-------------------|--------------|----------|-----------|----------------|-----------|------------|
| 55       | 0.241379 | -0.05566 | 1.20696      | -0.12931     | 5                 | 5.145223     | 26.79310 | -2.87068  | 0.078273       | 0.019507  | 0.048890   |
| 56       | 0.061344 | 0.025662 | 0.301724     | 0.129310     | 5                 | 5.010764     | 6.698275 | 2.870689  | 0.103712       | 0.022224  | 0.062968   |
| 57       | -0.25646 | -0.15517 | -1.26332     | -0.77586     | 5                 | 5.219801     | -28.4676 | -17.2241  | 0.041827       | 0.009514  | 0.025671   |
| 58       | -0.24568 | 0.043103 | -1.22944     | 0.215517     | 5                 | 5.153206     | -27.2715 | -4.784482 | 0.119415       | 0.023039  | 0.071227   |
| 59       | -0.04310 | -0.04310 | -0.21551     | -0.21551     | 5                 | 5.009280     | -4.78448 | -4.78448  | 0.075578       | 0.021101  | 0.048340   |
| 60       | -0.24137 | -0.07753 | -1.20693     | -0.36793     | 5                 | 5.158206     | -26.7931 | -8.61206  | 0.099564       | 0.021494  | 0.060523   |
| 61       | 0.203463 | -0.19480 | 0.915584     | -0.87662     | 4.5               | 4.675121     | 22.58441 | -21.6233  | 0.074045       | 0.017343  | 0.045694   |
| 62       | 0.264069 | -0.05627 | 1.08311      | -0.25324     | 4.5               | 4.661139     | 29.31168 | -6.24675  | 0.100690       | 0.021709  | 0.061200   |
| 63       | 0.238095 | -0.02597 | 1.071478     | -0.11688     | 4.5               | 4.627269     | 26.42857 | -2.89311  | 0.026902       | 0.007678  | 0.017290   |
| 64       | 0.255411 | 0.086580 | 1.149350     | 0.369610     | 4.5               | 4.660772     | 28.35064 | 9.610389  | 0.047269       | 0.013871  | 0.030570   |
| 65       | 0.043290 | 0.181818 | 0.194805     | 0.918181     | 4.5               | 4.577922     | 4.805194 | 20.18181  | 0.031113       | 0.007760  | 0.019437   |
| 66       | -0.11255 | -0.13419 | -0.50649     | -0.60389     | 4.5               | 4.568503     | -12.4935 | -14.8961  | 0.125998       | 0.016116  | 0.071057   |
| 67       | -0.15151 | -0.05627 | -0.68181     | -0.25324     | 4.5               | 4.558399     | -16.8181 | -6.24675  | 0.051532       | 0.006089  | 0.029807   |
| 68       | 0.294322 | 0        | 1.324675     | 0            | 4.5               | 4.690923     | 32.67532 | 0         | 0.092401       | 0.021051  | 0.056726   |
| 69       | 0.208695 | 0        | 0.834782     | 0            | 4                 | 4.086179     | 23.16521 | 0         | 0.080805       | 0.014374  | 0.047590   |
| 70       | 0.191304 | 0        | 0.765217     | 0            | 4                 | 4.072537     | 21.23478 | 0         | 0.019754       | 0.006317  | 0.013036   |
| 71       | -0.15652 | 0        | -0.62508     | 0            | 4                 | 4.048701     | -17.3739 | -12.5478  | 0.009720       | 0.017999  | 0.057615   |
| 72       | -0.31304 | -0.1304  | -1.25217     | -0.45217     | 4                 | 4.215732     | -34.7478 | -17.3739  | 0.210018       | 0.019267  | 0.115605   |
| 73       | -0.08260 | -0.15652 | -0.33043     | -0.62608     | 4                 | 4.062163     | -9.16956 | -16.8913  | 0.103468       | 0.014604  | 0.059036   |
| 74       | 0.01304  | -0.15217 | -0.05217     | -0.60869     | 4                 | 4.046385     | -1.44792 | -16.8913  | 0.131467       | 0.024213  | 0.077840   |
| 75       | 0.017391 | -0.15217 | 0.069565     | -0.60869     | 4                 | 4.046385     | 1.930434 | -16.8913  | 0.050454       | 0.006655  | 0.028555   |
| 76       | 0.195652 | -0.07826 | 0.782508     | -0.31304     | 4                 | 4.087844     | 21.71739 | -8.68695  | 0.027509       | 0.006983  | 0.017246   |
| 77       | 0.217391 | -0.16086 | 0.869565     | -0.64347     | 4                 | 4.143694     | 24.13043 | -17.8565  | 0.016303       | 0.003573  | 0.009941   |
| 78       | 0.256521 | -0.11304 | 1.026036     | -0.45217     | 4                 | 4.154192     | 28.47391 | -12.5478  | 0.010955       | 0.003367  | 0.007161   |
| 79       | 0.286956 | -0.09347 | 1.147826     | -0.37391     | 4                 | 4.178195     | 31.85217 | 11.1      | 0.036423       | 0.008983  | 0.023703   |
| 80       | 0.291304 | 0.1      | 1.165217     | 0.4          | 4                 | 4.185418     | 32.33478 | 14.9608   | 0.025928       | 0.002400  | 0.014164   |
| 81       | -0.16521 | -0.13479 | -0.66086     | -0.53913     | 3.5               | 3.600148     | -18.3391 | -19.3886  | 0.123210       | 0.026508  | 0.074859   |
| 82       | -0.16593 | -0.17467 | -0.58078     | -0.61135     | 3.5               | 3.522486     | -18.4192 | -12.5026  | 0.051856       | 0.009637  | 0.055301   |
| 83       | 0        | 0        | 0            | 0            | 3.5               | 3.669427     | 29.08246 | -19.3886  | 0.051856       | 0.012835  | 0.032346   |
| 84       | 0.262008 | -0.17467 | 0.917030     | -0.61135     | 3.5               | 3.584444     | 15.02620 | -19.3886  | 0.025573       | 0.006002  | 0.015787   |
| 85       | 0.155371 | -0.17467 | 0.473799     | -0.61135     | 3.5               | 3.571876     | 11.63318 | -11.6331  | 0.054111       | 0.002126  | 0.003070   |
| 86       | 0.104803 | -0.17467 | 0.366812     | -0.61135     | 3.5               | 3.624462     | -29.0929 | -6.78602  | 0.046670       | 0.009799  | 0.028235   |
| 87       | -0.26700 | -0.06113 | -0.96288     | -0.21347     | 3.5               | 3.648519     | -30.5371 | -11.6331  | 0.056004       | 0.010276  | 0.033140   |
| 88       | -0.27510 | -0.10480 | -0.76419     | -0.24454     | 3.5               | 3.580792     | -24.2358 | -7.75545  | 0.037958       | 0.010031  | 0.023945   |
| 89       | -0.21034 | -0.06986 | -0.61135     | -0.13755     | 3.5               | 3.555653     | -19.3886 | -4.36244  | 0.016753       | 0.004653  | 0.010703   |
| 90       | -0.17467 | -0.07930 | -0.74475     | -0.13755     | 3.5               | 3.589621     | -25.2052 | 1.938964  | 0.056915       | 0.006823  | 0.031864   |
| 91       | -0.22707 | 0.017467 | -0.59606     | 0.366812     | 3.5               | 3.569292     | -18.3039 | 11.63319  | 0.056004       | 0.010276  | 0.033140   |
| 92       | -0.17030 | -0.10480 | -0.53624     | -0.24454     | 3.5               | 3.524607     | -10.6637 | -7.75545  | 0.033848       | 0.004976  | 0.049412   |
| 93       | -0.04606 | -0.06986 | 0.136889     | 0.36624      | 3.5               | 3.521723     | 6.301310 | 10.66375  | 0.033241       | 0.006752  | 0.019996   |
| 94       | 0.056768 | 0.06069  | 0.136889     | 0.36624      | 3.5               | 3.582465     | 32.2663  | -6.78602  | 0.045223       | 0.008585  | 0.026304   |
| 95       | -0.20460 | -0.06113 | -0.73362     | -0.21347     | 3.5               | 3.582465     | 32.2663  | 0         | 0.030771       | 0.005479  | 0.018175   |
| 96       | 0.353649 | 0        | 1.078947     | 0            | 3                 | 3.198122     | 39.92105 | 0         | 0.075638       | 0.016236  | 0.045367   |
| 97       | 0.192482 | 0        | 0.578447     | 0            | 3                 | 3.055352     | 21.42105 | 0         | 0.204244       | 0.031616  | 0.117930   |
| 98       | 0.008771 | 0        | 0.026315     | 0            | 3                 | 3.000103     | -2.92105 | 0         | 0.101515       | 0.016967  | 0.032742   |
| 99       | -0.02631 | 0        | -0.02631     | 0            | 3                 | 3.232479     | -42.8421 | -12.1710  | 0.049263       | 0.016240  | 0.05752    |
| 100      | -0.38596 | -0.10964 | -1.15789     | -0.32894     | 3                 | 3.116866     | -29.2105 | -11.1373  | 0.035780       | 0.007986  | 0.021883   |
| 101      | -0.26315 | -0.10887 | -0.78947     | -0.30263     | 3                 | 3.123524     | -30.6710 | -9.73684  | 0.024681       | 0.006039  | 0.015360   |
| 102      | -0.21491 | -0.06113 | -0.82394     | -0.26315     | 3                 | 3.074323     | -23.8552 | -6.81578  | 0.039783       | 0.010423  | 0.025103   |
| 103      | -0.21491 | -0.06113 | -0.64473     | -0.19421     | 3                 | 3.131744     | -31.6447 | 10.22368  | 0.010285       | 0.005434  | 0.007860   |
| 104      | -0.28508 | 0.092105 | -0.85526     | 0.278315     | 3                 | 3.103452     | -25.3157 | 15.09210  | 0.044174       | 0.007127  | 0.025610   |
| 105      | -0.22807 | 0.135364 | -0.68421     | 0.407894     | 3                 | 3.030431     | -11.6842 | -10.2105  | 0.222500       | 0.021960  | 0.122330   |
| 106      | -0.10526 | -0.09649 | -0.31578     | -0.28947     |                   |              |          |           |                |           |            |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | AVG AREAL THOR<br>( $\text{in}^2$ ) | THOR<br>(ft/sec) | V<br>(ft/sec) | THOR<br>(ft/sec) | V<br>(ft/sec) | THOR<br>(ft/sec) | V<br>(ft/sec) | Vel. Screen Locations<br>$X_1$ | Vel.<br>(fps) | MV<br>lb-sec<br>-11+-7.5 | MV<br>lb-sec<br>-7.5+-5 | MV<br>lb-sec<br>-5+-2.5 |
|-------------|-------------------------------------|------------------|---------------|------------------|---------------|------------------|---------------|--------------------------------|---------------|--------------------------|-------------------------|-------------------------|
| 55          | 32.72618                            | 2042.196         | 720.3271      | 1381.261         | 0.151309      |                  |               | 4                              | 8             | 1381.261                 | 0.00E+00                | 0.00E+00                |
| 56          | 29.22053                            | 2226.499         | 701.2222      | 1463.830         | 0.184407      |                  |               | 3                              | 3             | 1463.830                 | 0.00E+00                | 0.00E+00                |
| 57          | 22.20402                            | 2798.035         | 921.6015      | 1859.818         | 0.072579      |                  |               | 1                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 58          | 30.60606                            | 2225.532         | 647.8760      | 1436.704         | 0.214434      |                  |               | 1                              | 1             | 1436.704                 | 0.00E+00                | 0.00E+00                |
| 59          | 28.34091                            | 2190.328         | 841.3082      | 1515.818         | 0.142180      |                  |               | 2                              | 6             | 1515.818                 | 0.00E+00                | 0.00E+00                |
| 60          | 26.43332                            | 2450.669         | 776.1706      | 1613.416         | 0.176741      |                  |               | 1                              | 5             | 1613.416                 | 0.00E+00                | 0.00E+00                |
| 61          | 21.66564                            | 2613.134         | 879.8916      | 1746.483         | 0.118377      |                  |               | 4                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 62          | 34.47702                            | 1861.317         | 598.9383      | 1225.127         | 0.176984      |                  |               | 4                              | 8             | 1225.127                 | 0.00E+00                | 0.00E+00                |
| 63          | 26.60397                            | 2156.239         | 841.9693      | 1499.104         | 0.047212      |                  |               | 4                              | 8             | 1499.104                 | 0.00E+00                | 0.00E+00                |
| 64          | 25.84213                            | 2205.352         | 879.2913      | 1542.322         | 0.083420      |                  |               | 4                              | 4             | 1542.322                 | 0.00E+00                | 0.00E+00                |
| 65          | 22.63682                            | 2466.317         | 870.4914      | 1658.404         | 0.050260      |                  |               | 3                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 66          | 27.59340                            | 2292.628         | 490.3478      | 1391.487         | 0.186726      |                  |               | 2                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 67          | 17.78050                            | 3121.648         | 778.0792      | 1349.863         | 0.170754      |                  |               | 2                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 68          | 31.20213                            | 2000.535         | 659.7092      | 1330.122         | 0.161189      |                  |               | 4                              | 6             | 1330.122                 | 0.00E+00                | 0.00E+00                |
| 69          | 22.48367                            | 2379.316         | 651.7353      | 1515.526         | 0.111024      |                  |               | 4                              | 4             | 1515.526                 | 0.00E+00                | 0.00E+00                |
| 70          | 24.54704                            | 2040.389         | 867.6983      | 1454.043         | 0.031856      |                  |               | 4                              | 4             | 1454.043                 | 0.00E+00                | 0.00E+00                |
| 71          | 24.29909                            | 2219.041         | 626.2711      | 1422.656         | 0.136363      |                  |               | 2                              | 2             | 1422.656                 | 0.00E+00                | 0.00E+00                |
| 72          | 32.26487                            | 1914.391         | 418.2932      | 1166.942         | 0.297855      |                  |               | 1                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 73          | 25.90646                            | 2254.839         | 375.8770      | 1315.359         | 0.267467      |                  |               | 2                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 74          | 23.88365                            | 2311.602         | 532.3075      | 1421.954         | 0.137270      |                  |               | 2                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 75          | 30.83243                            | 1856.513         | 521.9426      | 1169.226         | 0.195410      |                  |               | 3                              | 8             | 1858.742                 | 0.00E+00                | 0.00E+00                |
| 76          | 16.80957                            | 3049.924         | 667.5607      | 1858.742         | 0.061084      |                  |               | 4                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 77          | 16.81501                            | 2852.808         | 1050.907      | 1936.557         | 0.038450      |                  |               | 4                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 78          | 13.07660                            | 3525.034         | 1128.800      | 2326.917         | 0.020710      |                  |               | 4                              | 8             | 2326.917                 | 0.00E+00                | 0.00E+00                |
| 79          | 13.96365                            | 3198.084         | 1320.154      | 2359.119         | 0.015467      |                  |               | 4                              | 8             | 2359.119                 | 0.00E+00                | 0.00E+00                |
| 80          | 17.29689                            | 2848.313         | 957.6902      | 1903.001         | 0.053418      |                  |               | 4                              | 4             | 1903.001                 | 0.00E+00                | 0.00E+00                |
| 81          | 7.559905                            | 6005.331         | 1008.019      | 3506.675         | 0.024008      |                  |               | 1                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 82          | 26.44949                            | 1871.327         | 591.1535      | 1231.240         | 0.166908      |                  |               | 3                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 84          | 15.45780                            | 2792.005         | 941.5387      | 1866.772         | 0.030674      |                  |               | 3                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 83          | 35.44220                            | 1597.704         | 274.3621      | 936.0332         | 0.125608      |                  |               | 3                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 86          | 7.217146                            | 4939.185         | 1086.637      | 1860.815         | 0.064985      |                  |               | 4                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 87          | 24.92976                            | 2002.172         | 567.2617      | 1284.717         | 0.070364      |                  |               | 3                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 88          | 17.00003                            | 2641.570         | 819.3610      | 1730.475         | 0.056869      |                  |               | 1                              | 5             | 1284.717                 | 0.00E+00                | 0.00E+00                |
| 89          | 25.42177                            | 1867.679         | 688.3970      | 1278.038         | 0.053375      |                  |               | 1                              | 5             | 1730.475                 | 0.00E+00                | 0.00E+00                |
| 90          | 13.07958                            | 3027.587         | 1158.430      | 2093.008         | 0.020061      |                  |               | 1                              | 5             | 1278.038                 | 0.00E+00                | 0.00E+00                |
| 91          | 18.82682                            | 2561.640         | 521.8930      | 1541.769         | 0.063334      |                  |               | 1                              | 1             | 1541.769                 | 0.00E+00                | 0.00E+00                |
| 92          | 21.72564                            | 2198.035         | 616.2137      | 1407.109         | 0.069363      |                  |               | 1                              | 1             | 1407.109                 | 0.00E+00                | 0.00E+00                |
| 93          | 22.46387                            | 2317.644         | 756.1242      | 1766.984         | 0.097806      |                  |               | 2                              | 6             | 1286.984                 | 0.00E+00                | 0.00E+00                |
| 94          | 25.00408                            | 1934.279         | 585.2504      | 1259.764         | 0.043125      |                  |               | 3                              | 3             | 1259.764                 | 0.00E+00                | 0.00E+00                |
| 95          | 18.58419                            | 2468.049         | 703.8236      | 1548.939         | 0.054393      |                  |               | 1                              | 5             | 1588.939                 | 0.00E+00                | 0.00E+00                |
| 96          | 19.86102                            | 2167.516         | 594.1932      | 1380.854         | 0.034034      |                  |               | 93                             | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 97          | 30.67366                            | 1490.342         | 463.1411      | 974.2417         | 0.094049      |                  |               | 4                              | 4             | 974.2417                 | 0.00E+00                | 0.00E+00                |
| 98          | 36.29261                            | 1337.534         | 390.0838      | 813.8090         | 0.244332      |                  |               | 3                              | 3             | 813.8090                 | 0.00E+00                | 0.00E+00                |
| 99          | 25.99533                            | 1704.646         | 445.5970      | 1075.121         | 0.113357      |                  |               | 2                              | 2             | 1075.121                 | 0.00E+00                | 0.00E+00                |
| 100         | 29.00568                            | 1505.482         | 654.9912      | 1080.236         | 0.070280      |                  |               | -93                            | 5             | 1315.172                 | 0.00E+00                | 0.00E+00                |
| 101         | 21.02002                            | 1965.549         | 644.7958      | 1315.172         | 0.041420      |                  |               | 1                              | 5             | 1301.475                 | 0.00E+00                | 0.00E+00                |
| 102         | 21.48337                            | 1931.082         | 671.8692      | 1301.475         | 0.029404      |                  |               | 1                              | 5             | 1096.239                 | 0.00E+00                | 0.00E+00                |
| 103         | 26.68995                            | 1604.793         | 587.6655      | 1056.239         | 0.050286      |                  |               | 1                              | 1             | 1398.811                 | 0.00E+00                | 0.00E+00                |
| 104         | 20.35582                            | 1727.201         | 1070.422      | 1349.811         | 0.015323      |                  |               | 1                              | 1             | 0                        | 0.00E+00                | 0.00E+00                |
| 105         | 17.93312                            | 2318.273         | 590.2019      | 1454.237         | 0.045799      |                  |               | 1                              | 0             | 0                        | 0.00E+00                | 0.00E+00                |
| 106         | 30.18886                            | 1506.120         | 282.8224      | 944.4717         | 0.238606      |                  |               | 2                              | 6             | 944.4717                 | 0.00E+00                | 0.00E+00                |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | lb-sec<br>-2.5-0 | lb-sec<br>Orig. Ht. | lb-sec<br>0+2.5 | lb-sec<br>2.5+5 | lb-sec<br>5+.5 | lb-sec<br>7.5+11 |
|-------------|------------------|---------------------|-----------------|-----------------|----------------|------------------|
| 55          | 0.00E+00         | 1.51E-01            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 56          | 0.00E+00         | 1.84E-01            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 57          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 58          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 59          | 1.42E-01         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 60          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 61          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 62          | 1.77E-01         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 63          | 0.00E+00         | 4.72E-02            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 64          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 65          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 66          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 67          | 7.08E-02         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 68          | 0.00E+00         | 1.61E-01            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 69          | 0.00E+00         | 1.11E-01            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 70          | 0.00E+00         | 3.19E-02            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 71          | 0.00E+00         | 1.34E-01            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 72          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 73          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 74          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 75          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 76          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 77          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 78          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 79          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 80          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 81          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 82          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 83          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 84          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 85          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 86          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 87          | 7.04E-02         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 88          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 89          | 5.34E-02         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 90          | 2.01E-02         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 91          | 0.00E+00         | 6.38E-02            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 92          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 93          | 9.78E-02         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 94          | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 95          | 5.44E-02         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 96          | 0.00E+00         | 3.40E-02            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 97          | 0.00E+00         | 9.40E-02            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 98          | 0.00E+00         | 2.44E-01            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 99          | 0.00E+00         | 1.13E-01            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 100         | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 101         | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 102         | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 103         | 5.03E-02         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 104         | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 105         | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |
| 106         | 0.00E+00         | 0.00E+00            | 0.00E+00        | 0.00E+00        | 0.00E+00       | 0.00E+00         |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASSED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | SHEET<br>No. | SHEET<br>X (in) | SHEET<br>Y (in) | PRSS<br>(g sec) | LEN<br>(in) | MID<br>(in) | THIC<br>(in) | L/D      | X (in) | Y (in) | Z (in) | PATH<br>R (in) |
|-------------|--------------|-----------------|-----------------|-----------------|-------------|-------------|--------------|----------|--------|--------|--------|----------------|
| 107         | 6            | 40              | 18.5            | 0.59            | 0.49        | 0.279       | 0.11         | 1.756272 | -8     | -5.5   | 114    | 114.4126       |
| 108         | 6            | 50.5            | 17              | 0.37            | 0.356       | 0.204       | 0.02         | 1.745098 | 2.5    | -7     | 114    | 114.2420       |
| 109         | 6            | 51.25           | 41.25           | 0.29            | 0.299       | 0.214       | 0.089        | 1.397196 | 3.25   | 17.25  | 114    | 115.3435       |
| 110         | 6            | 36.5            | 20.5            | 0.69            | 0.582       | 0.3         | 0.086        | 1.94     | -11.5  | -3.5   | 114    | 114.6320       |
| 111         | 6            | 67              | 16              | 0.11            | 0.309       | 0.178       | 0.064        | 1.730337 | 19     | -8     | 114    | 115.8490       |
| 112         | 6            | 67              | 20              | 0.73            | 0.615       | 0.243       | 0.09         | 2.530864 | 19     | -4     | 114    | 115.6416       |
| 113         | 6            | 66.5            | 7.5             | 0.41            | 0.426       | 0.236       | 0.072        | 1.805084 | 18.5   | -16.5  | 114    | 115.6640       |
| 114         | 6            | 74              | 9               | 0.36            | 0.474       | 0.334       | 0.055        | 1.419161 | 28     | -15    | 114    | 117.8855       |
| 115         | 6            | 77              | 77              | 0.6             | 0.549       | 0.284       | 0.085        | 1.929577 | 29     | -15    | 114    | 118.5833       |
| 116         | 6            | 81              | 27.5            | 0.11            | 0.202       | 0.125       | 0.08         | 1.616    | 33     | 3.5    | 114    | 118.7318       |
| 117         | 6            | 83              | 15              | 0.11            | 0.202       | 0.111       | 0.078        | 1.819819 | 35     | -9     | 114    | 119.5909       |
| 118         | 3            | 18              | 24              | 5.95            | 1.372       | 0.563       | 0.153        | 2.436944 | -30    | 0      | 112.5  | 116.4313       |
| 119         | 5            | 24              | 6.5             | 0.14            | 0.257       | 0.201       | 0.055        | 1.278606 | -24    | -17.5  | 113.5  | 117.3222       |
| 120         | 5            | 24              | 12              | 0.36            | 0.363       | 0.288       | 0.075        | 1.260416 | -24    | -12    | 113.5  | 116.6286       |
| 121         | 5            | 25              | 20              | 0.87            | 0.565       | 0.411       | 0.074        | 1.374695 | -23    | -4     | 113.5  | 115.8760       |
| 122         | 5            | 28              | 15              | 1.18            | 0.651       | 0.392       | 0.1          | 1.660714 | -20    | -9     | 113.5  | 115.5995       |
| 123         | 5            | 23              | 32              | 0.32            | 0.413       | 0.17        | 0.063        | 2.429411 | -25    | 6      | 113.5  | 116.4957       |
| 124         | 5            | 30              | 20.5            | 0.44            | 0.408       | 0.262       | 0.08         | 1.557251 | -18    | -3.5   | 113.5  | 115.2757       |
| 125         | 5            | 28              | 26.5            | 0.87            | 0.6         | 0.24        | 0.1          | 2.5      | -20    | 2.5    | 113.5  | 115.2757       |
| 126         | 5            | 35.5            | 1               | 0.15            | 0.261       | 0.161       | 0.049        | 1.621118 | -12.5  | -23    | 113.5  | 116.4796       |
| 127         | 5            | 36              | 25.5            | 8.21            | 1.579       | 0.56        | 0.138        | 2.817857 | -12    | 1.5    | 113.5  | 114.1424       |
| 128         | 5            | 41.5            | 2.5             | 1.01            | 0.56        | 0.273       | 0.125        | 2.051482 | -6.5   | -1.5   | 113.5  | 115.7011       |
| 129         | 5            | 41.5            | 11.5            | 0.72            | 0.552       | 0.32        | 0.092        | 1.725    | -6.5   | -12.5  | 113.5  | 114.3711       |
| 130         | 5            | 45.5            | 19.5            | 1.46            | 0.72        | 0.336       | 0.101        | 2.142857 | -2.5   | -4.5   | 113.5  | 113.6166       |
| 131         | 5            | 54.5            | 7.5             | 0.21            | 0.219       | 0.18        | 0.06         | 1.216666 | 6.5    | -16.5  | 113.5  | 114.8771       |
| 132         | 5            | 52.5            | 6               | 0.9             | 0.482       | 0.324       | 0.127        | 1.487654 | 9.5    | -19    | 113.5  | 115.3104       |
| 133         | 5            | 57.5            | 7.5             | 0.27            | 0.366       | 0.194       | 0.045        | 1.866597 | 9.5    | -16.5  | 113.5  | 115.0858       |
| 134         | 5            | 59              | 5.75            | 0.2             | 0.241       | 0.2         | 0.066        | 1.205    | 11     | -18.25 | 113.5  | 115.4829       |
| 135         | 5            | 59.5            | 13              | 0.69            | 0.491       | 0.381       | 0.095        | 1.288713 | 11.5   | -11    | 113.5  | 114.6102       |
| 136         | 5            | 65              | 21              | 0.32            | 0.4         | 0.245       | 0.045        | 1.632653 | 17     | -3     | 113.5  | 114.8052       |
| 137         | 5            | 69              | 13              | 0.49            | 0.51        | 0.281       | 0.081        | 1.814946 | 21     | -11    | 113.5  | 115.9493       |
| 138         | 5            | 70.5            | 11.5            | 0.79            | 0.745       | 0.094       | 0.094        | 1.491228 | 22.5   | -12.5  | 113.5  | 116.3819       |
| 139         | 5            | 71.5            | 14.5            | 0.38            | 0.36        | 0.114       | 0.084        | 1.722488 | 23.5   | -9.5   | 113.5  | 116.2959       |
| 140         | 5            | 70              | 1               | 0.29            | 0.3         | 0.212       | 0.088        | 1.415094 | 22     | -23    | 113.5  | 117.8781       |
| 141         | 5            | 71              | 6.5             | 0.26            | 0.355       | 0.209       | 0.07         | 1.706730 | 29     | -17.5  | 113.5  | 118.4461       |
| 142         | 5            | 79              | 7               | 0.16            | 0.236       | 0.191       | 0.056        | 1.235602 | 30     | -17    | 113.5  | 118.6222       |
| 143         | 5            | 80              | 8               | 0.37            | 0.491       | 0.184       | 0.065        | 2.668478 | 32     | -16    | 113.5  | 119.0052       |
| 144         | 5            | 75.5            | 44              | 0.25            | 0.49        | 0.294       | 0.067        | 2.094017 | 27.5   | -20    | 113    | 121.6758       |
| 145         | 5            | 4.5             | 12              | 0.33            | 0.353       | 0.294       | 0.078        | 1.217687 | -49.5  | -12    | 113    | 119.4001       |
| 146         | 5            | 12              | 15.5            | 6.04            | 1.174       | 0.434       | 0.168        | 2.705069 | -25.5  | -8.5   | 113    | 115.8458       |
| 147         | 5            | 22.5            | 25              | 0.9             | 0.65        | 0.407       | 0.062        | 1.537051 | -25    | 1      | 113    | 116.5761       |
| 148         | 5            | 23              | 10              | 0.4             | 0.529       | 0.211       | 0.091        | 2.507109 | -45.5  | -14    | 113    | 122.4561       |
| 149         | 5            | 2.5             | 11.5            | 0.02            | 0.121       | 0.111       | 0.05         | 1.090090 | -20    | -12.5  | 113    | 122.4561       |
| 150         | 5            | 28              | 4               | 0.18            | 0.362       | 0.154       | 0.057        | 2.350649 | -20    | -20    | 113    | 116.4840       |
| 151         | 5            | 25              | 5               | 0.36            | 0.32        | 0.248       | 0.061        | 1.290322 | -23    | -19    | 113    | 115.8717       |
| 152         | 5            | 29              | 13              | 0.52            | 0.452       | 0.21        | 0.068        | 2.152380 | -19    | -11    | 113    | 115.1129       |
| 153         | 5            | 37              | 14              | 0.67            | 0.371       | 0.274       | 0.125        | 1.354014 | -21    | -10    | 113    | 115.3684       |
| 154         | 5            | 32.5            | 14              | 0.34            | 0.641       | 0.343       | 0.044        | 1.868804 | -15.5  | -10    | 113    | 114.4566       |
| 155         | 5            | 39              | 5               | 0.23            | 0.34        | 0.258       | 0.093        | 1.317829 | -12    | -19    | 113    | 115.2128       |
| 156         | 5            | 31.5            | 29              | 0.65            | 0.511       | 0.382       | 0.088        | 1.532156 | -16.5  | 5      | 113    | 114.3076       |
| 157         | 5            | 40.5            | 12.5            | 0.14            | 0.27        | 0.215       | 0.073        | 1.255813 | -7.5   | -11.5  | 113    | 113.8310       |
| 158         | 5            | 40.5            | 41.5            | 0.76            | 0.51        | 0.3         | 0.123        | 1.7      | -7.5   | 17.5   | 113    | 114.5927       |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | TAN X    | TAN Y    | PENET<br>X°(in) | PENET<br>RATON<br>Y°(in) | COORDINATE<br>Z°(in) | DEPTH<br>R°(in) | Xo       | Yo       | PRESENTED<br>MAX. | AREA<br>MIN. | (IN) <sup>2</sup><br>AVG. |          |
|-------------|----------|----------|-----------------|--------------------------|----------------------|-----------------|----------|----------|-------------------|--------------|---------------------------|----------|
| 107         | -0.07017 | -0.04824 | -0.21052        | -0.14473                 |                      | 3               | 3.010858 | -7.78347 | -5.35526          | 0.041720     | 0.009365                  | 0.025543 |
| 108         | 0.021929 | -0.06140 | 0.065789        | -0.18421                 |                      | 3               | 3.006370 | 2.434210 | -6.81578          | 0.143901     | 0.008084                  | 0.075993 |
| 109         | 0.028508 | 0.151315 | 0.085526        | 0.453947                 |                      | 3               | 3.035355 | 3.164473 | 16.79605          | 0.025345     | 0.007544                  | 0.016444 |
| 110         | -0.10087 | -0.03070 | -0.30263        | -0.09210                 |                      | 3               | 3.016632 | -11.1973 | -3.40789          | 0.062408     | 0.009221                  | 0.035815 |
| 111         | 0.165666 | -0.07017 | 0.5             | -0.21052                 |                      | 3               | 3.048658 | 18.5     | -7.78947          | 0.013369     | 0.002778                  | 0.008073 |
| 112         | 0.165666 | -0.03508 | 0.5             | -0.10526                 |                      | 3               | 3.043202 | 18.5     | -3.89473          | 0.063092     | 0.009232                  | 0.036162 |
| 113         | 0.162280 | -0.14473 | 0.486842        | -0.43421                 |                      | 3               | 3.070106 | 18.01315 | -16.0657          | 0.044294     | 0.007486                  | 0.025890 |
| 114         | 0.228070 | -0.13157 | 0.684210        | -0.39473                 |                      | 3               | 3.120613 | 28.23684 | -14.6052          | 0.050913     | 0.005907                  | 0.028410 |
| 115         | 0.254385 | -0.13157 | 0.763157        | -0.39473                 |                      | 3               | 3.124522 | 32.13157 | 3.407894          | 0.009723     | 0.003850                  | 0.006786 |
| 116         | 0.289473 | 0.030701 | 0.868421        | 0.092105                 |                      | 3               | 3.147130 | 34.07894 | -8.76315          | 0.010969     | 0.004235                  | 0.007602 |
| 117         | 0.307017 | -0.07894 | 0.921052        | -0.23684                 |                      | 3               | 3.152417 | -29.6    | 0                 | 0.271992     | 0.030331                  | 0.151161 |
| 118         | -0.26666 | 0        | -0.4            | 0                        |                      | 1.5             | 1.552417 | -29.6    | 0                 | 0.271992     | 0.030331                  | 0.151161 |
| 119         | -0.21145 | -0.15418 | -0.52863        | -0.38546                 |                      | 2.5             | 2.584189 | -23.4713 | -17.1145          | 0.019799     | 0.004237                  | 0.012018 |
| 120         | -0.21145 | -0.10572 | -0.52863        | -0.26431                 |                      | 2.5             | 2.568913 | -23.4713 | -11.7356          | 0.036299     | 0.007499                  | 0.021899 |
| 121         | -0.20264 | -0.03524 | -0.50660        | -0.08810                 |                      | 2.5             | 2.552335 | -22.4933 | -3.91189          | 0.091449     | 0.011977                  | 0.051713 |
| 122         | -0.17621 | -0.07529 | -0.44052        | -0.19823                 |                      | 2.5             | 2.546245 | -19.5594 | -8.80176          | 0.091785     | 0.014099                  | 0.052942 |
| 123         | -0.22026 | 0.070484 | -0.55066        | 0.176211                 |                      | 2.5             | 2.565984 | -24.4493 | 7.823788          | 0.039509     | 0.006026                  | 0.022768 |
| 124         | -0.15859 | -0.03083 | -0.39647        | -0.07709                 |                      | 2.5             | 2.532417 | -17.6035 | -3.42290          | 0.042781     | 0.008388                  | 0.025585 |
| 125         | -0.17621 | 0.02206  | -0.44052        | 0.055066                 |                      | 2.5             | 2.539113 | -19.5594 | 2.444933          | 0.067672     | 0.011278                  | 0.039475 |
| 126         | -0.11013 | 0.020264 | -0.27533        | -0.50660                 |                      | 2.5             | 2.565630 | -12.2246 | -22.4933          | 0.023811     | 0.004470                  | 0.014141 |
| 127         | -0.10572 | 0.013215 | -0.26431        | 0.030359                 |                      | 2.5             | 2.514150 | -11.7356 | 1.466960          | 0.462762     | 0.040469                  | 0.251616 |
| 128         | -0.05726 | -0.18942 | -0.14317        | -0.47356                 |                      | 2.5             | 2.548482 | -6.35682 | -21.0264          | 0.062850     | 0.014029                  | 0.038439 |
| 129         | -0.05726 | -0.11013 | -0.14317        | -0.27533                 |                      | 2.5             | 2.519187 | -6.35682 | -12.2246          | 0.060874     | 0.010145                  | 0.035510 |
| 130         | 0.05726  | -0.03964 | -0.05506        | -0.09911                 |                      | 2.5             | 2.502570 | -2.44493 | -4.0088           | 0.112441     | 0.015723                  | 0.064107 |
| 131         | 0.05726  | -0.14537 | 0.14317         | -0.36343                 |                      | 2.5             | 2.530332 | 6.356828 | -16.1365          | 0.027224     | 0.007458                  | 0.017341 |
| 132         | 0.083700 | -0.15859 | 0.209251        | -0.39647                 |                      | 2.5             | 2.534930 | 9.290748 | -17.6035          | 0.055123     | 0.014524                  | 0.034823 |
| 133         | 0.083700 | -0.14537 | 0.242290        | -0.40198                 |                      | 2.5             | 2.543677 | 10.75770 | -17.8480          | 0.023571     | 0.006455                  | 0.015013 |
| 134         | 0.096916 | -0.16079 | 0.253303        | -0.24229                 |                      | 2.5             | 2.524453 | 11.24669 | -10.7577          | 0.056496     | 0.010931                  | 0.033713 |
| 135         | 0.101321 | -0.09691 | 0.317621        | -0.06607                 |                      | 2.5             | 2.528750 | 16.62555 | -2.93392          | 0.055313     | 0.006222                  | 0.030768 |
| 136         | 0.149779 | -0.02643 | 0.374449        | -0.06607                 |                      | 2.5             | 2.553950 | 20.53744 | -10.7577          | 0.047054     | 0.007473                  | 0.027264 |
| 137         | 0.185022 | -0.09691 | 0.462555        | -0.24229                 |                      | 2.5             | 2.563478 | 22.00440 | -12.2246          | 0.065372     | 0.012049                  | 0.038710 |
| 138         | 0.198237 | -0.11013 | 0.495594        | -0.27533                 |                      | 2.5             | 2.561584 | 22.98237 | -9.29074          | 0.035188     | 0.008210                  | 0.021899 |
| 139         | 0.207048 | -0.08370 | 0.517621        | -0.30925                 |                      | 2.5             | 2.596434 | 21.51541 | -22.4933          | 0.025633     | 0.007519                  | 0.016576 |
| 140         | 0.193832 | -0.20264 | 0.484581        | -0.50660                 |                      | 2.5             | 2.608946 | 28.36123 | -17.1145          | 0.028891     | 0.005636                  | 0.017294 |
| 141         | 0.255506 | -0.15418 | 0.638766        | -0.38546                 |                      | 2.5             | 2.608946 | 28.36123 | -17.1145          | 0.028891     | 0.005636                  | 0.017294 |
| 142         | 0.264217 | -0.14977 | 0.660792        | -0.37444                 |                      | 2.5             | 2.612825 | 29.33920 | -16.6255          | 0.022224     | 0.005273                  | 0.013748 |
| 143         | 0.281938 | -0.14096 | 0.704845        | -0.35242                 |                      | 2.5             | 2.621261 | 31.29515 | -15.6475          | 0.044277     | 0.005861                  | 0.025069 |
| 144         | 0.242290 | 0.176211 | 0.605726        | 0.440528                 |                      | 2.5             | 2.609783 | 26.89427 | 19.55947          | 0.029024     | 0.003968                  | 0.016496 |
| 145         | -0.38495 | -0.10619 | -0.76991        | -0.21238                 |                      | 2               | 2.153572 | -42.7300 | -11.7876          | 0.032908     | 0.007170                  | 0.020039 |
| 146         | -0.31858 | -0.07522 | -0.63716        | -0.15044                 |                      | 2               | 2.104427 | -35.3628 | -8.34955          | 0.279654     | 0.040018                  | 0.153836 |
| 147         | -0.22566 | 0.008849 | -0.45132        | 0.017699                 |                      | 2               | 2.050368 | -25.0486 | 0.982300          | 0.112913     | 0.010770                  | 0.061841 |
| 148         | -0.22123 | -0.12389 | -0.44247        | -0.24778                 |                      | 2               | 2.063294 | -24.5575 | -13.7522          | 0.034191     | 0.005881                  | 0.020036 |
| 149         | -0.40265 | -0.11061 | -0.80530        | -0.22123                 |                      | 2               | 2.167364 | -44.6946 | -12.2787          | 0.003111     | 0.001285                  | 0.002969 |
| 150         | -0.17699 | -0.17699 | -0.35398        | -0.35398                 |                      | 2               | 2.061700 | -19.6460 | -19.6460          | 0.024563     | 0.003867                  | 0.014215 |
| 151         | -0.20353 | -0.16814 | -0.40707        | -0.33628                 |                      | 2               | 2.068526 | -22.5929 | -18.6637          | 0.045905     | 0.008750                  | 0.027328 |
| 152         | -0.16814 | -0.09734 | -0.33628        | -0.19469                 |                      | 2               | 2.037398 | -18.6637 | -10.8053          | 0.037748     | 0.005678                  | 0.021713 |
| 153         | -0.18564 | -0.08843 | -0.37168        | -0.17699                 |                      | 2               | 2.041928 | -20.6283 | -9.82300          | 0.041692     | 0.014047                  | 0.027969 |
| 154         | -0.13716 | -0.08849 | -0.27433        | -0.17699                 |                      | 2               | 2.026471 | -15.2256 | -9.82300          | 0.087044     | 0.011406                  | 0.049225 |
| 155         | -0.10619 | -0.16814 | -0.21238        | -0.33628                 |                      | 2               | 2.039165 | -11.7876 | -18.6637          | 0.019237     | 0.005261                  | 0.012249 |
| 156         | -0.14601 | 0.044247 | -0.29203        | 0.088495                 |                      | 2               | 2.023145 | -16.2079 | 4.911504          | 0.057454     | 0.009834                  | 0.013574 |
| 157         | -0.06637 | -0.10176 | -0.13274        | -0.20353                 |                      | 2               | 2.014708 | -7.36725 | -11.2964          | 0.020245     | 0.005473                  | 0.012859 |
| 158         | -0.06637 | 0.154867 | -0.13274        | 0.309734                 |                      | 2               | 2.028190 | -7.36725 | 17.19026          | 0.048062     | 0.011591                  | 0.029826 |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CAGED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | AVG<br>D(gr/in <sup>2</sup> ) | PREAL<br>THOR V<br>(ft/sec) | THOR V<br>(ft/sec) | THOR V<br>(ft/sec) | THOR V<br>(ft/sec) | Vel.<br>(fps) | MV<br>lb-sec | MV<br>lb-sec | MV<br>lb-sec | MV<br>lb-sec | MV<br>lb-sec |
|-------------|-------------------------------|-----------------------------|--------------------|--------------------|--------------------|---------------|--------------|--------------|--------------|--------------|--------------|
|             |                               |                             |                    |                    |                    |               |              |              |              |              |              |
| 107         | 23.03794                      | 1801.214                    | 587.4391           | 1154.326           | 0.046244           | 6             | 1154.326     | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 108         | 4.868868                      | 6461.769                    | 745.6525           | 3603.711           | 0.091289           | 7             | 3603.711     | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 109         | 17.63458                      | 2124.255                    | 856.0436           | 1450.149           | 0.029586           | 3             | 0            | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 110         | 19.26552                      | 2169.502                    | 517.0608           | 1343.281           | 0.063458           | 2             | 6            | 1343.281     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 111         | 13.62459                      | 2729.221                    | 839.9641           | 1784.592           | 0.013440           | 4             | 8            | 1784.592     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 112         | 20.16665                      | 2110.611                    | 499.3831           | 1304.997           | 0.065223           | 4             | 8            | 1304.997     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 113         | 15.83611                      | 2511.642                    | 662.0640           | 1586.853           | 0.044544           | 4             | 0            | 0.00E+00     | 4.45E-02     | 0.00E+00     | 0.00E+00     |
| 114         | 12.67130                      | 3097.974                    | 615.9083           | 1656.941           | 0.045769           | 4             | 0            | 0.00E+00     | 4.57E-02     | 0.00E+00     | 0.00E+00     |
| 115         | 18.92045                      | 2244.956                    | 554.8641           | 1359.910           | 0.057507           | 4             | 0            | 0.00E+00     | 5.75E-02     | 0.00E+00     | 0.00E+00     |
| 116         | 14.73425                      | 2351.594                    | 1173.995           | 1762.794           | 0.012069           | 4             | 0            | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 117         | 14.46850                      | 2409.668                    | 1180.360           | 1795.014           | 0.013518           | 4             | 0            | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 118         | 55.39252                      | 855.7165                    | 165.1326           | 510.4246           | 0.186963           | 1             | 1            | 1762.794     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 119         | 11.64868                      | 2701.241                    | 849.9347           | 1775.588           | 0.017019           | 1             | 1            | 1795.014     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 120         | 15.98194                      | 2131.122                    | 653.0919           | 1392.107           | 0.033358           | 1             | 0            | 510.4246     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 121         | 16.82345                      | 2142.257                    | 466.4005           | 1304.328           | 0.077692           | 1             | 0            | 1392.107     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 122         | 22.28829                      | 1706.150                    | 418.6311           | 1062.390           | 0.085829           | 1             | 0            | 1304.328     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 123         | 14.05463                      | 2426.762                    | 592.3387           | 1509.550           | 0.033072           | 1             | 0            | 1062.390     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 124         | 17.19753                      | 2008.750                    | 591.9001           | 1300.325           | 0.039172           | 2             | 0            | 1509.550     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 125         | 22.03885                      | 1702.565                    | 444.1097           | 1079.337           | 0.063933           | 1             | 0            | 1300.325     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 126         | 10.60744                      | 2929.817                    | 835.6170           | 1882.717           | 0.019335           | 1             | 0            | 1079.337     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 127         | 32.62906                      | 1327.322                    | 213.4545           | 770.3883           | 0.433035           | 2             | 0            | 0            | 1.93E-02     | 0.00E+00     | 0.00E+00     |
| 128         | 26.27503                      | 1444.178                    | 468.9887           | 956.5836           | 0.066147           | 2             | 0            | 2770.3883    | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 129         | 20.27574                      | 1801.758                    | 469.9841           | 1135.871           | 0.055992           | 2             | 0            | 0            | 6.61E-02     | 0.00E+00     | 0.00E+00     |
| 130         | 22.77438                      | 1671.632                    | 383.1620           | 1027.397           | 0.102698           | 2             | 0            | 0            | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 131         | 12.10952                      | 2490.932                    | 943.2835           | 1717.107           | 0.024688           | 2             | 0            | 1027.397     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 132         | 25.84457                      | 1423.472                    | 523.4937           | 923.4859           | 0.059985           | 3             | 0            | 0            | 0.00E+00     | 2.47E-02     | 0.00E+00     |
| 133         | 10.30356                      | 3094.975                    | 642.6223           | 1868.799           | 0.034545           | 3             | 0            | 0            | 0.00E+00     | 6.00E-02     | 0.00E+00     |
| 134         | 13.32166                      | 2328.255                    | 881.4057           | 1604.830           | 0.021975           | 3             | 0            | 0            | 0.00E+00     | 3.45E-02     | 0.00E+00     |
| 135         | 20.46548                      | 1761.671                    | 513.5331           | 1137.802           | 0.053751           | 3             | 0            | 0            | 0.00E+00     | 2.20E-02     | 0.00E+00     |
| 136         | 10.40035                      | 3089.315                    | 600.1041           | 1844.709           | 0.040415           | 3             | 0            | 1137.802     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 137         | 17.97229                      | 2002.800                    | 503.8761           | 1253.398           | 0.042047           | 4             | 0            | 1844.709     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 138         | 20.40783                      | 1796.257                    | 505.2853           | 1150.771           | 0.062242           | 4             | 0            | 1253.398     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 139         | 17.51195                      | 1953.278                    | 655.7628           | 1304.520           | 0.033419           | 4             | 0            | 0            | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 140         | 17.49478                      | 1905.518                    | 754.5112           | 1332.514           | 0.028457           | 4             | 0            | 1304.520     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 141         | 15.03395                      | 2270.479                    | 671.8461           | 1471.162           | 0.026188           | 4             | 0            | 0            | 2.65E-02     | 0.00E+00     | 0.00E+00     |
| 142         | 11.63732                      | 2687.100                    | 913.5682           | 1800.394           | 0.019721           | 4             | 0            | 0            | 0.00E+00     | 2.62E-02     | 0.00E+00     |
| 143         | 14.75896                      | 2408.739                    | 528.6445           | 1468.691           | 0.037205           | 4             | 0            | 0            | 0.00E+00     | 1.97E-02     | 0.00E+00     |
| 144         | 15.15484                      | 2346.872                    | 527.7136           | 1437.292           | 0.024601           | 4             | 0            | 0            | 0.00E+00     | 3.72E-02     | 0.00E+00     |
| 145         | 16.46747                      | 1812.970                    | 578.1618           | 1195.566           | 0.027012           | 4             | 0            | 0            | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 146         | 37.78959                      | 1002.214                    | 233.1801           | 617.6973           | 0.255436           | 1             | 0            | 517.6973     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 147         | 14.55328                      | 2075.736                    | 356.2714           | 1216.004           | 0.074928           | 1             | 0            | 1216.004     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 148         | 19.96370                      | 1563.983                    | 417.7546           | 990.8688           | 0.027136           | 1             | 0            | 0            | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 149         | 9.096935                      | 2542.808                    | 1310.545           | 1926.677           | 0.002638           | 1             | 0            | 0            | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 150         | 12.66208                      | 2220.010                    | 554.9192           | 1387.465           | 0.017098           | 1             | 0            | 0            | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 151         | 13.17318                      | 2115.146                    | 610.2045           | 1362.675           | 0.033586           | 1             | 0            | 0            | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 152         | 15.19776                      | 1927.601                    | 465.6345           | 1196.618           | 0.027035           | 1             | 0            | 0            | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 153         | 24.04020                      | 1223.038                    | 540.8690           | 881.9536           | 0.040456           | 1             | 0            | 1196.618     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 154         | 9.09568                       | 1638.468                    | 356.8650           | 997.6666           | 0.064207           | 2             | 0            | 881.9536     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 155         | 18.77629                      | 1525.173                    | 576.8624           | 1051.018           | 0.015550           | 2             | 0            | 6997.6666    | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 156         | 19.30245                      | 1580.339                    | 422.4708           | 1001.405           | 0.044565           | 2             | 0            | 0            | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 157         | 14.77502                      | 1812.421                    | 679.5609           | 1245.991           | 0.016208           | 2             | 0            | 1001.405     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 158         | 25.48047                      | 1231.671                    | 423.8830           | 827.7772           | 0.043072           | 2             | 0            | 1245.991     | 0.00E+00     | 0.00E+00     | 0.00E+00     |



(CONTINUED).

| FRAG | MV       | MV       | MV       | MV       | MV       | MV       | MV       |
|------|----------|----------|----------|----------|----------|----------|----------|
| NUM  | lb-sec   | lb-sec   | lb-sec   | lb-sec   | lb-sec   | lb-sec   | lb-sec   |
|      | -2.5-0   | Chg. Ht. |          | 0x2.5    | 2.5x5    | 5x7.5    | 7.5x11   |
| 107  | 4.82E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 108  | 9.13E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 109  | 0.13E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.96E-02 | 0.00E+00 |
| 110  | 0.00E+00 | 6.35E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 111  | 1.34E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 112  | 6.52E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 113  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 114  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 115  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 116  | 0.00E+00 | 1.21E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 117  | 0.00E+00 | 1.87E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 118  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 119  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 120  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 121  | 7.77E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 122  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 123  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.31E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 124  | 0.00E+00 | 3.92E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 125  | 0.00E+00 | 6.39E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 126  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 127  | 0.00E+00 | 4.33E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 128  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 129  | 1.03E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 130  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 131  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 132  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 133  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 134  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 135  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 136  | 0.00E+00 | 4.04E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 137  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 138  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 139  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 140  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 141  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 142  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 143  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 144  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 145  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 146  | 2.55E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 147  | 0.00E+00 | 7.49E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 148  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 149  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 150  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 151  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 152  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 153  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 154  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 155  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 156  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.46E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 157  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 158  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.31E-02 | 0.00E+00 |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | SHEET<br>No. | SHEET<br>X (in) | SHEET<br>Y (in) | POSITION<br>Y (in) | MASS<br>(grams) | LEN<br>(in) | WID<br>(in) | THIC<br>(in) | L/D      | POSTION<br>X (in) | POSTION<br>Y (in) | COORDINATES<br>2 (in) | PATH<br>R (in) |
|-------------|--------------|-----------------|-----------------|--------------------|-----------------|-------------|-------------|--------------|----------|-------------------|-------------------|-----------------------|----------------|
| 159         | 4            | 36.5            | 23              | 0.4                | 0.32            | 0.234       | 0.234       | 0.1          | 1.941537 | -9.5              | -1                | 113                   | 113.4020       |
| 160         | 3            | 36.5            | 35              | 0.42               | 0.275           | 0.252       | 0.252       | 0.082        | 1.091269 | -9.5              | 11                | 112.5                 | 113.4250       |
| 161         | 4            | 36              | 2.5             | 2.25               | 0.298           | 0.489       | 0.489       | 0.131        | 1.631901 | -12               | -21.5             | 113                   | 115.6514       |
| 162         | 4            | 29.5            | 5.5             | 1.5                | 0.876           | 0.27        | 0.27        | 0.08         | 3.244444 | -18.5             | -18.5             | 113                   | 115.9692       |
| 163         | 4            | 44              | 12              | 0.34               | 0.34            | 0.303       | 0.303       | 0.066        | 1.103896 | -4                | -4                | 113                   | 113.7057       |
| 164         | 4            | 45              | 19.5            | 0.73               | 0.628           | 0.283       | 0.283       | 0.088        | 2.213081 | -3                | -4.5              | 112                   | 113.1293       |
| 165         | 4            | 50              | 24.5            | 0.31               | 0.337           | 0.189       | 0.189       | 0.137        | 1.783068 | 2                 | 0.5               | 113                   | 113.0188       |
| 166         | 4            | 59              | 5.5             | 1.08               | 0.698           | 0.358       | 0.358       | 0.082        | 1.933220 | 11                | -18.5             | 113                   | 115.0315       |
| 167         | 4            | 57              | 12              | 1.2                | 0.574           | 0.312       | 0.312       | 0.156        | 1.833743 | 43                | -12               | 112                   | 121.4889       |
| 168         | 4            | 56              | 14.5            | 0.41               | 0.46            | 0.204       | 0.204       | 0.145        | 2.254901 | 8                 | -9.5              | 113                   | 113.6804       |
| 169         | 4            | 56              | 14.5            | 0.31               | 0.559           | 0.295       | 0.295       | 0.155        | 1.694915 | 8                 | -9.5              | 113                   | 113.6804       |
| 170         | 4            | 73              | 5               | 2.3                | 0.296           | 0.228       | 0.228       | 0.074        | 1.293245 | 11                | -18               | 113                   | 114.5560       |
| 171         | 4            | 73              | 5               | 0.41               | 0.558           | 0.248       | 0.248       | 0.134        | 2.440775 | 25                | -18               | 113                   | 117.2817       |
| 172         | 4            | 62.5            | 14              | 0.46               | 0.526           | 0.293       | 0.293       | 0.081        | 1.735221 | 14.5              | -10               | 113                   | 114.3645       |
| 173         | 4            | 64.5            | 7               | 0.21               | 0.291           | 0.204       | 0.204       | 0.088        | 1.426470 | 18.5              | -17               | 113                   | 115.4567       |
| 174         | 4            | 66.5            | 6               | 0.09               | 0.099           | 0.061       | 0.061       | 0.051        | 1.622950 | 13                | -17               | 113                   | 115.9105       |
| 175         | 4            | 66              | 7               | 1.02               | 0.306           | 0.071       | 0.071       | 0.071        | 2.054823 | 7                 | -19               | 113                   | 115.6805       |
| 176         | 4            | 55              | 5               | 0.02               | 0.395           | 0.21        | 0.21        | 0.052        | 1.880752 | 32.5              | -31               | 113                   | 118.0942       |
| 177         | 4            | 80.5            | 13              | 0.02               | 0.111           | 0.069       | 0.069       | 0.048        | 1.603695 | 31                | -4                | 113                   | 117.2433       |
| 178         | 4            | 79              | 20              | 2.45               | 0.893           | 0.573       | 0.573       | 0.093        | 1.659851 | 16                | -5                | 113                   | 114.2365       |
| 179         | 4            | 64              | 24              | 0.75               | 0.778           | 0.32        | 0.32        | 0.069        | 2.386503 | 13                | -8.5              | 113                   | 114.0624       |
| 180         | 4            | 61              | 15.5            | 0.9                | 0.642           | 0.27        | 0.27        | 0.262        | 2.377777 | 3.5               | -19               | 113                   | 113.1083       |
| 181         | 4            | 51.5            | 20.5            | 0.18               | 0.3             | 0.226       | 0.226       | 0.045        | 1.327433 | 0                 | -9.5              | 113                   | 114.5862       |
| 182         | 4            | 48              | 33.5            | 0.48               | 0.552           | 0.251       | 0.251       | 0.076        | 2.139203 | 10.5              | 9.5               | 113                   | 113.8337       |
| 183         | 4            | 58.5            | 27.5            | 0.16               | 0.365           | 0.175       | 0.175       | 0.055        | 2.085714 | 31.5              | 9.5               | 113                   | 117.3605       |
| 184         | 4            | 79.5            | 8               | 0.19               | 0.371           | 0.166       | 0.166       | 0.064        | 2.234939 | 31.5              | -16               | 113                   | 118.3944       |
| 185         | 4            | 70.5            | 40              | 0.36               | 0.361           | 0.276       | 0.276       | 0.061        | 1.380434 | 22.5              | 16                | 113                   | 116.3239       |
| 186         | 4            | 77              | 4               | 0.35               | 0.384           | 0.249       | 0.249       | 0.039        | 1.542168 | 29                | -20               | 113                   | 118.3638       |
| 187         | 4            | 75              | 5.5             | 0.28               | 0.32            | 0.178       | 0.178       | 0.062        | 1.757752 | 27                | -18.5             | 113                   | 117.6445       |
| 188         | 4            | 58.5            | 34              | 0.21               | 0.327           | 0.187       | 0.187       | 0.082        | 1.175653 | 10.5              | 10                | 113                   | 113.9265       |
| 189         | 4            | 48              | 40              | 0.43               | 0.636           | 0.326       | 0.326       | 0.055        | 1.577015 | 1                 | 16                | 113                   | 114.1315       |
| 190         | 4            | 45              | 24.5            | 0.84               | 0.404           | 0.177       | 0.177       | 0.114        | 1.08777  | -3                | 0.5               | 113                   | 113.0403       |
| 191         | 4            | 52              | 4               | 0.44               | 0.454           | 0.227       | 0.227       | 0.057        | 1.96426  | 4                 | -20               | 113                   | 114.8259       |
| 192         | 4            | 20.5            | 13.5            | 4.29               | 1.21            | 0.616       | 0.616       | 0.135        | 1.96426  | -27.5             | -5.5              | 112.5                 | 115.9428       |
| 193         | 3            | 21              | 7.5             | 0.34               | 0.376           | 0.305       | 0.305       | 0.065        | 1.207779 | -26               | -18.5             | 112.5                 | 116.6483       |
| 194         | 3            | 26              | 9.5             | 0.12               | 0.228           | 0.139       | 0.139       | 0.065        | 1.640287 | -22               | -14.5             | 112.5                 | 115.5443       |
| 195         | 3            | 30              | 3               | 2.71               | 0.859           | 0.375       | 0.375       | 0.161        | 2.290666 | -18               | -21               | 112.5                 | 115.8501       |
| 196         | 3            | 27.5            | 14.5            | 0.1                | 0.218           | 0.176       | 0.176       | 0.056        | 1.236636 | -20.5             | -9.5              | 112.5                 | 114.7464       |
| 197         | 3            | 15.5            | 31              | 0.42               | 0.367           | 0.275       | 0.275       | 0.106        | 1.934545 | -32.5             | 7                 | 112.5                 | 117.3044       |
| 198         | 3            | 18              | 35.25           | 0.21               | 0.358           | 0.216       | 0.216       | 0.088        | 1.657407 | -30               | 11.25             | 112.5                 | 116.9735       |
| 199         | 3            | 26              | 34.75           | 0.17               | 0.315           | 0.186       | 0.186       | 0.069        | 1.635548 | -22               | 10.75             | 112.5                 | 115.1383       |
| 200         | 3            | 32              | 38.5            | 1.05               | 0.778           | 0.353       | 0.353       | 0.124        | 2.203966 | -16               | 14.5              | 112.5                 | 114.5534       |
| 201         | 3            | 42              | 24.5            | 0.36               | 0.465           | 0.29        | 0.29        | 0.059        | 1.660714 | -6                | 0.5               | 112.5                 | 112.6404       |
| 202         | 3            | 40.5            | 12              | 3.8                | 1.025           | 0.55        | 0.55        | 0.178        | 1.863636 | -12               | -12               | 112.5                 | 113.3865       |
| 203         | 3            | 53.5            | 23.5            | 0.26               | 0.475           | 0.24        | 0.24        | 0.044        | 1.973166 | 5.5               | 4.5               | 112.5                 | 112.7247       |
| 204         | 3            | 53              | 37.75           | 0.19               | 0.445           | 0.19        | 0.19        | 0.053        | 2.342105 | 5                 | 13.75             | 112.5                 | 113.4473       |
| 205         | 3            | 64              | 38              | 0.31               | 0.433           | 0.234       | 0.234       | 0.074        | 1.950427 | 16                | 14                | 112.5                 | 114.4917       |
| 206         | 3            | 77              | 12              | 0.38               | 0.505           | 0.292       | 0.292       | 0.055        | 1.779452 | 24                | -12               | 112.5                 | 116.7957       |
| 207         | 3            | 81              | 21              | 0.42               | 0.371           | 0.225       | 0.225       | 0.069        | 1.643808 | 33                | -13               | 112.5                 | 117.2765       |
| 208         | 3            | 86              | 12.5            | 0.47               | 0.4             | 0.301       | 0.301       | 0.068        | 1.329903 | 39                | -11.5             | 112.5                 | 119.3009       |
| 209         | 3            | 64              | 20.5            | 0.15               | 0.496           | 0.17        | 0.17        | 0.045        | 2.917647 | 16                | -3.5              | 112.5                 | 113.6854       |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASSED CHARGE TEST (CONTINUED).

| FRIG<br>NUM | TAN X    | TAN Y    | PENET<br>Y'(in) | PATION<br>Y'(in) | COORDINATE<br>Z'(in) | DEPTH<br>P'(in) | Xo       | Yo       | PRESENTED<br>MAX. | AREA<br>MIN. | (IN) <sup>2</sup><br>AVG. |
|-------------|----------|----------|-----------------|------------------|----------------------|-----------------|----------|----------|-------------------|--------------|---------------------------|
| 159         | -0.08407 | -0.00884 | -0.16314        | -0.01769         | 2                    | 2.007133        | -9.33185 | -0.98230 | 0.031113          | 0.009723     | 0.020418                  |
| 160         | -0.08444 | 0.09777  | -0.12666        | 0.14666          | 1.5                  | 1.512486        | -9.37333 | 10.85333 | 0.039840          | 0.011879     | 0.025860                  |
| 161         | -0.10619 | -0.19026 | -0.21238        | -0.38053         | 2                    | 2.046927        | -11.7876 | -21.1194 | 0.133599          | 0.021931     | 0.077765                  |
| 162         | -0.16371 | -0.16371 | -0.32743        | -0.32743         | 2                    | 2.052906        | -18.1725 | -18.1725 | 0.145846          | 0.013319     | 0.079582                  |
| 163         | -0.03539 | -0.10619 | -0.07079        | -0.21238         | 2                    | 2.012431        | -3.92920 | -11.7876 | 0.007070          | 0.007778     | 0.023924                  |
| 164         | -0.02654 | 0.03982  | -0.05309        | -0.07964         | 2                    | 2.002289        | -2.94690 | -4.42035 | 0.064525          | 0.009041     | 0.036783                  |
| 165         | 0.017699 | 0.004424 | 0.03598         | 0.008849         | 2                    | 2.000332        | 1.964601 | 0.491150 | 0.017600          | 0.007155     | 0.012378                  |
| 166         | 0.097945 | -0.16371 | 0.194590        | -0.32743         | 2                    | 2.035956        | 10.80530 | -18.1725 | 0.102448          | 0.012035     | 0.057241                  |
| 167         | 0.380530 | -0.10619 | 0.761061        | -0.21238         | 2                    | 2.150424        | 42.23893 | -11.7876 | 0.059834          | 0.016261     | 0.038047                  |
| 168         | 0.070796 | -0.08407 | 0.141592        | -0.16314         | 2                    | 2.012043        | 7.859407 | -9.33185 | 0.023603          | 0.007440     | 0.015521                  |
| 169         | 0.097945 | -0.16371 | 0.141592        | -0.16314         | 2                    | 2.012043        | 7.859407 | -9.33185 | 0.023603          | 0.007440     | 0.015521                  |
| 170         | 0.097945 | -0.16371 | 0.141592        | -0.16314         | 2                    | 2.012043        | 7.859407 | -9.33185 | 0.023603          | 0.007440     | 0.015521                  |
| 171         | 0.221238 | -0.16371 | 0.141592        | -0.16314         | 2                    | 2.012043        | 7.859407 | -9.33185 | 0.023603          | 0.007440     | 0.015521                  |
| 172         | 0.129318 | -0.08843 | 0.141592        | -0.16314         | 2                    | 2.012043        | 7.859407 | -9.33185 | 0.023603          | 0.007440     | 0.015521                  |
| 173         | 0.146017 | -0.15044 | 0.141592        | -0.16314         | 2                    | 2.012043        | 7.859407 | -9.33185 | 0.023603          | 0.007440     | 0.015521                  |
| 174         | 0.163716 | -0.15044 | 0.141592        | -0.16314         | 2                    | 2.012043        | 7.859407 | -9.33185 | 0.023603          | 0.007440     | 0.015521                  |
| 175         | 0.153292 | -0.15044 | 0.141592        | -0.16314         | 2                    | 2.012043        | 7.859407 | -9.33185 | 0.023603          | 0.007440     | 0.015521                  |
| 176         | 0.061946 | -0.16371 | 0.141592        | -0.16314         | 2                    | 2.012043        | 7.859407 | -9.33185 | 0.023603          | 0.007440     | 0.015521                  |
| 177         | 0.287610 | -0.03734 | 0.141592        | -0.09734         | 2                    | 2.012043        | 7.859407 | -9.33185 | 0.023603          | 0.007440     | 0.015521                  |
| 178         | 0.274336 | -0.03539 | 0.141592        | -0.09339         | 2                    | 2.012043        | 7.859407 | -9.33185 | 0.023603          | 0.007440     | 0.015521                  |
| 179         | 0.141592 | 0.04247  | 0.141592        | -0.04247         | 2                    | 2.012043        | 7.859407 | -9.33185 | 0.023603          | 0.007440     | 0.015521                  |
| 180         | 0.115044 | -0.07522 | 0.141592        | -0.07522         | 2                    | 2.012043        | 7.859407 | -9.33185 | 0.023603          | 0.007440     | 0.015521                  |
| 181         | 0.030973 | -0.03097 | 0.141592        | -0.03097         | 2                    | 2.012043        | 7.859407 | -9.33185 | 0.023603          | 0.007440     | 0.015521                  |
| 182         | 0        | -0.16814 | 0.18540         | -0.33628         | 2                    | 2.028074        | 0        | -18.6637 | 0.026719          | 0.010904     | 0.018312                  |
| 183         | 0.092920 | 0.084070 | 0.16914         | 0.16914          | 2                    | 2.015640        | 10.31415 | 9.331858 | 0.049127          | 0.004667     | 0.017890                  |
| 184         | 0.278761 | 0.030973 | 0.557522        | -0.061946        | 2                    | 2.077177        | 30.94247 | 3.338053 | 0.022628          | 0.006763     | 0.027945                  |
| 185         | 0.278761 | -0.14159 | 0.557522        | -0.29318         | 2                    | 2.095477        | 30.94247 | -15.7168 | 0.023092          | 0.003983     | 0.013537                  |
| 186         | 0.199115 | 0.141592 | 0.398230        | 0.263185         | 2                    | 2.058830        | 23.10176 | 15.71681 | 0.045905          | 0.007349     | 0.026627                  |
| 187         | 0.256637 | -0.17699 | 0.519274        | -0.35398         | 2                    | 2.034935        | 28.49637 | -19.6460 | 0.030249          | 0.007089     | 0.016669                  |
| 188         | 0.238938 | -0.16371 | 0.473776        | -0.32743         | 2                    | 2.082205        | 26.52212 | -18.1725 | 0.035128          | 0.006806     | 0.020967                  |
| 189         | 0.092920 | 0.084070 | 0.185340        | 0.175991         | 2                    | 2.016398        | 10.31415 | 9.623008 | 0.019920          | 0.004995     | 0.012457                  |
| 190         | 0.008649 | 0.141592 | -0.05309        | 0.283185         | 2                    | 2.027026        | 0.982300 | 15.71681 | 0.060813          | 0.005242     | 0.033029                  |
| 191         | -0.02654 | 0.004424 | -0.07079        | -0.33393         | 2                    | 2.000724        | -2.94690 | 0.491150 | 0.046670          | 0.015975     | 0.033791                  |
| 192         | 0.035392 | -0.10619 | -0.07079        | -0.21238         | 1.5                  | 1.545904        | -27.1333 | -5.42666 | 0.247132          | 0.007538     | 0.033791                  |
| 193         | -0.24444 | -0.04883 | -0.34666        | -0.07333         | 1.5                  | 1.545177        | -25.5523 | -16.28   | 0.040687          | 0.004093     | 0.023860                  |
| 194         | -0.23111 | -0.14666 | -0.34666        | -0.07333         | 1.5                  | 1.545177        | -25.5523 | -16.28   | 0.040687          | 0.004093     | 0.023860                  |
| 195         | -0.19555 | -0.12883 | -0.23333        | -0.19333         | 1.5                  | 1.540591        | -21.7066 | -14.3066 | 0.014360          | 0.004093     | 0.009227                  |
| 196         | -0.18222 | -0.18666 | -0.23333        | -0.19333         | 1.5                  | 1.544668        | -17.776  | -20.72   | 0.130929          | 0.024539     | 0.077734                  |
| 197         | -0.18222 | -0.18666 | -0.23333        | -0.19333         | 1.5                  | 1.544668        | -17.776  | -20.72   | 0.130929          | 0.024539     | 0.077734                  |
| 198         | -0.28883 | 0.06222  | -0.43333        | 0.09333          | 1.5                  | 1.529952        | -20.2246 | -9.37333 | 0.038900          | 0.003568     | 0.008729                  |
| 199         | -0.28883 | 0.06222  | -0.43333        | 0.09333          | 1.5                  | 1.529952        | -20.2246 | -9.37333 | 0.038900          | 0.003568     | 0.008729                  |
| 200         | -0.19555 | 0.09555  | -0.23333        | 0.14333          | 1.5                  | 1.559647        | -23.6    | 11.1     | 0.018562          | 0.004562     | 0.011986                  |
| 201         | -0.14222 | 0.12883  | -0.23333        | 0.14333          | 1.5                  | 1.535118        | -21.7066 | 10.60666 | 0.020989          | 0.004197     | 0.012593                  |
| 202         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.527379        | -15.7866 | 14.30666 | 0.065866          | 0.010497     | 0.038182                  |
| 203         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.502146        | -5.92    | 0.493333 | 0.047461          | 0.006022     | 0.026741                  |
| 204         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.502146        | -5.92    | 0.493333 | 0.047461          | 0.006022     | 0.026741                  |
| 205         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.511820        | -7.4     | -11.84   | 0.166057          | 0.029837     | 0.097447                  |
| 206         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.511820        | -7.4     | -11.84   | 0.166057          | 0.029837     | 0.097447                  |
| 207         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.502989        | 5.426666 | 4.44     | 0.045963          | 0.004257     | 0.025110                  |
| 208         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.502989        | 5.426666 | 4.44     | 0.045963          | 0.004257     | 0.025110                  |
| 209         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.512631        | 4.933333 | 13.54666 | 0.025481          | 0.003321     | 0.014401                  |
| 210         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.512631        | 4.933333 | 13.54666 | 0.025481          | 0.003321     | 0.014401                  |
| 211         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.526550        | 15.78666 | 14.31133 | 0.065866          | 0.010497     | 0.038182                  |
| 212         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.526550        | 15.78666 | 14.31133 | 0.065866          | 0.010497     | 0.038182                  |
| 213         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.532276        | 28.61133 | -11.84   | 0.054742          | 0.005463     | 0.023924                  |
| 214         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.532276        | 28.61133 | -11.84   | 0.054742          | 0.005463     | 0.023924                  |
| 215         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.563713        | 32.56    | -2.96    | 0.036293          | 0.008305     | 0.023924                  |
| 216         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.563713        | 32.56    | -2.96    | 0.036293          | 0.008305     | 0.023924                  |
| 217         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.590667        | 37.49333 | -11.3466 | 0.041544          | 0.009139     | 0.025341                  |
| 218         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.590667        | 37.49333 | -11.3466 | 0.041544          | 0.009139     | 0.025341                  |
| 219         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.515812        | 15.78666 | -3.45333 | 0.025938          | 0.002352     | 0.014140                  |
| 220         | -0.05333 | 0.00444  | -0.21333        | 0.19333          | 1.5                  | 1.515812        | 15.78666 | -3.45333 | 0.025938          | 0.002352     | 0.014140                  |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASSED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | RUG      | APRHL    | THOR<br>(in) | THOR<br>(ft/sec) | V<br>(ft/sec) | THOR<br>(ft/sec) | V<br>(ft/sec) | MV<br>(ft/sec) | Vel.<br>Screen Locations<br>(ft) | Y1        | Y2        | MV<br>1b-sec | MV<br>1b-sec | MV<br>1b-sec | MV<br>1b-sec |
|-------------|----------|----------|--------------|------------------|---------------|------------------|---------------|----------------|----------------------------------|-----------|-----------|--------------|--------------|--------------|--------------|
| Digr/in2    | in2      | in2      | in2          | in2              | in2           | in2              | in2           | in2            | in2                              | in2       | in2       | in2          | in2          | in2          | in2          |
| 159         | 19.59009 | 1427.329 | 536.5706     | 1011.950         | 0.027713      | 0.027713         | 0.027713      | 0.027713       | 0.027713                         | 0.027713  | 0.027713  | 0.027713     | 0.027713     | 0.027713     | 0.027713     |
| 160         | 16.24105 | 1339.664 | 540.5762     | 940.1204         | 0.027033      | 0.027033         | 0.027033      | 0.027033       | 0.027033                         | 0.027033  | 0.027033  | 0.027033     | 0.027033     | 0.027033     | 0.027033     |
| 161         | 28.93305 | 1182.947 | 305.0821     | 744.0149         | 0.114613      | 0.114613         | 0.114613      | 0.114613       | 0.114613                         | 0.114613  | 0.114613  | 0.114613     | 0.114613     | 0.114613     | 0.114613     |
| 162         | 18.4829  | 1716.135 | 285.0958     | 1010.615         | 0.102761      | 0.102761         | 0.102761      | 0.102761       | 0.102761                         | 0.102761  | 0.102761  | 0.102761     | 0.102761     | 0.102761     | 0.102761     |
| 163         | 14.21126 | 1953.145 | 571.1937     | 1262.169         | 0.029381      | 0.029381         | 0.029381      | 0.029381       | 0.029381                         | 0.029381  | 0.029381  | 0.029381     | 0.029381     | 0.029381     | 0.029381     |
| 164         | 19.64564 | 1568.105 | 359.1431     | 963.6242         | 0.0180161     | 0.0180161        | 0.0180161     | 0.0180161      | 0.0180161                        | 0.0180161 | 0.0180161 | 0.0180161    | 0.0180161    | 0.0180161    | 0.0180161    |
| 165         | 25.04424 | 1124.290 | 572.3957     | 848.3429         | 0.018005      | 0.018005         | 0.018005      | 0.018005       | 0.018005                         | 0.018005  | 0.018005  | 0.018005     | 0.018005     | 0.018005     | 0.018005     |
| 166         | 18.95733 | 1674.202 | 335.9517     | 1005.077         | 0.074318      | 0.074318         | 0.074318      | 0.074318       | 0.074318                         | 0.074318  | 0.074318  | 0.074318     | 0.074318     | 0.074318     | 0.074318     |
| 167         | 31.53911 | 1076.616 | 405.3230     | 741.0693         | 0.060885      | 0.060885         | 0.060885      | 0.060885       | 0.060885                         | 0.060885  | 0.060885  | 0.060885     | 0.060885     | 0.060885     | 0.060885     |
| 168         | 28.34694 | 1082.166 | 455.2519     | 768.7093         | 0.023157      | 0.023157         | 0.023157      | 0.023157       | 0.023157                         | 0.023157  | 0.023157  | 0.023157     | 0.023157     | 0.023157     | 0.023157     |
| 169         | 31.20190 | 1029.369 | 393.3338     | 711.9518         | 0.034579      | 0.034579         | 0.034579      | 0.034579       | 0.034579                         | 0.034579  | 0.034579  | 0.034579     | 0.034579     | 0.034579     | 0.034579     |
| 170         | 15.22150 | 1803.763 | 637.7267     | 1220.745         | 0.025909      | 0.025909         | 0.025909      | 0.025909       | 0.025909                         | 0.025909  | 0.025909  | 0.025909     | 0.025909     | 0.025909     | 0.025909     |
| 171         | 41.47876 | 873.6524 | 233.5275     | 583.5900         | 0.091898      | 0.091898         | 0.091898      | 0.091898       | 0.091898                         | 0.091898  | 0.091898  | 0.091898     | 0.091898     | 0.091898     | 0.091898     |
| 172         | 12.65937 | 2280.232 | 395.6366     | 1337.935         | 0.037556      | 0.037556         | 0.037556      | 0.037556       | 0.037556                         | 0.037556  | 0.037556  | 0.037556     | 0.037556     | 0.037556     | 0.037556     |
| 173         | 18.04753 | 1694.362 | 416.5151     | 1055.438         | 0.033240      | 0.033240         | 0.033240      | 0.033240       | 0.033240                         | 0.033240  | 0.033240  | 0.033240     | 0.033240     | 0.033240     | 0.033240     |
| 174         | 17.37289 | 1596.930 | 651.2207     | 1124.075         | 0.016161      | 0.016161         | 0.016161      | 0.016161       | 0.016161                         | 0.016161  | 0.016161  | 0.016161     | 0.016161     | 0.016161     | 0.016161     |
| 175         | 8.654653 | 2400.620 | 1459.737     | 1930.179         | 0.077678      | 0.077678         | 0.077678      | 0.077678       | 0.077678                         | 0.077678  | 0.077678  | 0.077678     | 0.077678     | 0.077678     | 0.077678     |
| 176         | 16.40659 | 1862.378 | 362.2482     | 1112.313         | 0.077678      | 0.077678         | 0.077678      | 0.077678       | 0.077678                         | 0.077678  | 0.077678  | 0.077678     | 0.077678     | 0.077678     | 0.077678     |
| 177         | 11.81486 | 2402.839 | 525.1453     | 1463.992         | 0.020046      | 0.020046         | 0.020046      | 0.020046       | 0.020046                         | 0.020046  | 0.020046  | 0.020046     | 0.020046     | 0.020046     | 0.020046     |
| 178         | 8.615945 | 2537.704 | 1933.255     | 1945.479         | 0.002663      | 0.002663         | 0.002663      | 0.002663       | 0.002663                         | 0.002663  | 0.002663  | 0.002663     | 0.002663     | 0.002663     | 0.002663     |
| 179         | 21.65675 | 1515.470 | 277.8248     | 846.6477         | 0.150403      | 0.150403         | 0.150403      | 0.150403       | 0.150403                         | 0.150403  | 0.150403  | 0.150403     | 0.150403     | 0.150403     | 0.150403     |
| 180         | 16.23600 | 1893.547 | 307.7359     | 1100.641         | 0.056516      | 0.056516         | 0.056516      | 0.056516       | 0.056516                         | 0.056516  | 0.056516  | 0.056516     | 0.056516     | 0.056516     | 0.056516     |
| 181         | 47.84138 | 691.1526 | 353.2034     | 522.4783         | 0.032194      | 0.032194         | 0.032194      | 0.032194       | 0.032194                         | 0.032194  | 0.032194  | 0.032194     | 0.032194     | 0.032194     | 0.032194     |
| 182         | 10.66121 | 2618.157 | 631.0505     | 1624.603         | 0.020021      | 0.020021         | 0.020021      | 0.020021       | 0.020021                         | 0.020021  | 0.020021  | 0.020021     | 0.020021     | 0.020021     | 0.020021     |
| 183         | 17.17627 | 1759.105 | 397.6012     | 1078.353         | 0.035438      | 0.035438         | 0.035438      | 0.035438       | 0.035438                         | 0.035438  | 0.035438  | 0.035438     | 0.035438     | 0.035438     | 0.035438     |
| 184         | 12.28972 | 2293.112 | 554.5973     | 1423.855         | 0.015597      | 0.015597         | 0.015597      | 0.015597       | 0.015597                         | 0.015597  | 0.015597  | 0.015597     | 0.015597     | 0.015597     | 0.015597     |
| 185         | 14.03461 | 2060.247 | 551.4725     | 1305.860         | 0.018907      | 0.018907         | 0.018907      | 0.018907       | 0.018907                         | 0.018907  | 0.018907  | 0.018907     | 0.018907     | 0.018907     | 0.018907     |
| 186         | 13.51974 | 2107.706 | 533.4746     | 1320.590         | 0.032549      | 0.032549         | 0.032549      | 0.032549       | 0.032549                         | 0.032549  | 0.032549  | 0.032549     | 0.032549     | 0.032549     | 0.032549     |
| 187         | 18.74697 | 1595.101 | 537.3059     | 1066.203         | 0.025549      | 0.025549         | 0.025549      | 0.025549       | 0.025549                         | 0.025549  | 0.025549  | 0.025549     | 0.025549     | 0.025549     | 0.025549     |
| 188         | 13.35408 | 2099.863 | 613.2284     | 1356.545         | 0.026005      | 0.026005         | 0.026005      | 0.026005       | 0.026005                         | 0.026005  | 0.026005  | 0.026005     | 0.026005     | 0.026005     | 0.026005     |
| 189         | 16.85676 | 1662.126 | 588.9976     | 1125.561         | 0.016183      | 0.016183         | 0.016183      | 0.016183       | 0.016183                         | 0.016183  | 0.016183  | 0.016183     | 0.016183     | 0.016183     | 0.016183     |
| 190         | 13.01925 | 2245.628 | 357.2682     | 1301.448         | 0.038314      | 0.038314         | 0.038314      | 0.038314       | 0.038314                         | 0.038314  | 0.038314  | 0.038314     | 0.038314     | 0.038314     | 0.038314     |
| 191         | 26.81728 | 1166.334 | 495.0967     | 800.7157         | 0.040057      | 0.040057         | 0.040057      | 0.040057       | 0.040057                         | 0.040057  | 0.040057  | 0.040057     | 0.040057     | 0.040057     | 0.040057     |
| 192         | 13.02103 | 2196.233 | 463.2271     | 1309.733         | 0.040057      | 0.040057         | 0.040057      | 0.040057       | 0.040057                         | 0.040057  | 0.040057  | 0.040057     | 0.040057     | 0.040057     | 0.040057     |
| 193         | 31.22717 | 936.9769 | 180.8793     | 538.3284         | 0.164166      | 0.164166         | 0.164166      | 0.164166       | 0.164166                         | 0.164166  | 0.164166  | 0.164166     | 0.164166     | 0.164166     | 0.164166     |
| 194         | 14.24946 | 1629.328 | 436.5522     | 1032.440         | 0.024033      | 0.024033         | 0.024033      | 0.024033       | 0.024033                         | 0.024033  | 0.024033  | 0.024033     | 0.024033     | 0.024033     | 0.024033     |
| 195         | 13.00518 | 1616.861 | 630.8217     | 1123.841         | 0.009233      | 0.009233         | 0.009233      | 0.009233       | 0.009233                         | 0.009233  | 0.009233  | 0.009233     | 0.009233     | 0.009233     | 0.009233     |
| 196         | 34.85219 | 820.5388 | 233.7343     | 527.1269         | 0.097805      | 0.097805         | 0.097805      | 0.097805       | 0.097805                         | 0.097805  | 0.097805  | 0.097805     | 0.097805     | 0.097805     | 0.097805     |
| 197         | 11.45591 | 1798.703 | 649.0203     | 1223.862         | 0.008379      | 0.008379         | 0.008379      | 0.008379       | 0.008379                         | 0.008379  | 0.008379  | 0.008379     | 0.008379     | 0.008379     | 0.008379     |
| 198         | 21.14689 | 1133.225 | 446.4741     | 789.8499         | 0.022712      | 0.022712         | 0.022712      | 0.022712       | 0.022712                         | 0.022712  | 0.022712  | 0.022712     | 0.022712     | 0.022712     | 0.022712     |
| 199         | 18.16212 | 1300.163 | 453.8891     | 877.0382         | 0.012409      | 0.012409         | 0.012409      | 0.012409       | 0.012409                         | 0.012409  | 0.012409  | 0.012409     | 0.012409     | 0.012409     | 0.012409     |
| 200         | 13.4988  | 1650.745 | 433.7023     | 1072.248         | 0.012480      | 0.012480         | 0.012480      | 0.012480       | 0.012480                         | 0.012480  | 0.012480  | 0.012480     | 0.012480     | 0.012480     | 0.012480     |
| 201         | 27.43986 | 989.6602 | 249.6420     | 619.6511         | 0.044545      | 0.044545         | 0.044545      | 0.044545       | 0.044545                         | 0.044545  | 0.044545  | 0.044545     | 0.044545     | 0.044545     | 0.044545     |
| 202         | 13.46199 | 1706.032 | 362.6909     | 1034.361         | 0.025494      | 0.025494         | 0.025494      | 0.025494       | 0.025494                         | 0.025494  | 0.025494  | 0.025494     | 0.025494     | 0.025494     | 0.025494     |
| 203         | 38.99546 | 248.6627 | 201.4532     | 475.1580         | 0.123621      | 0.123621         | 0.123621      | 0.123621       | 0.123621                         | 0.123621  | 0.123621  | 0.123621     | 0.123621     | 0.123621     | 0.123621     |
| 204         | 10.35415 | 2126.755 | 357.0492     | 1241.932         | 0.022107      | 0.022107         | 0.022107      | 0.022107       | 0.022107                         | 0.022107  | 0.022107  | 0.022107     | 0.022107     | 0.022107     | 0.022107     |
| 205         | 13.19337 | 1737.085 | 378.8097     | 1056.847         | 0.019571      | 0.019571         | 0.019571      | 0.019571       | 0.019571                         | 0.019571  | 0.019571  | 0.019571     | 0.019571     | 0.019571     | 0.019571     |
| 206         | 16.24978 | 1456.973 | 367.2661     | 927.1193         | 0.019571      | 0.019571         | 0.019571      | 0.019571       | 0.019571                         | 0.019571  | 0.019571  | 0.019571     | 0.019571     | 0.019571     | 0.019571     |
| 207         | 12.75269 | 1847.542 | 350.2659     | 1068.904         | 0.028540      | 0.028540         | 0.028540      | 0.028540       | 0.028540                         | 0.028540  | 0.028540  | 0.028540     | 0.028540     | 0.028540     | 0.028540     |
| 208         | 18.62307 | 1280.938 | 442.7714     | 861.9547         | 0.024783      | 0.024783         | 0.024783      | 0.024783       | 0.024783                         | 0.024783  | 0.024783  | 0.024783     | 0.024783     | 0.024783     | 0.024783     |
| 209         | 18.54636 | 1319.515 | 423.8639     | 871.6924         | 0.028049      | 0.028049         | 0.028049      | 0.028049       | 0.028049                         | 0.028049  | 0.028049  | 0.028049     | 0.028049     | 0.028049     | 0.028049     |
| 210         | 10.60798 | 2104.587 | 347.9185     | 1246.247         | 0.012593      | 0.012593         | 0.012593      | 0.012593       | 0.012593                         | 0.012593  | 0.012593  | 0.012593     | 0.012593     | 0.012593     | 0.012593     |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND Cased Charge Test (Continued).

| FRAG | MV         | MV       | MV       | MV       | MV       | MV       | MV       |
|------|------------|----------|----------|----------|----------|----------|----------|
| NUM  | lb-sec     | lb-sec   | Chg. Ht. | lb-sec   | lb-sec   | lb-sec   | lb-sec   |
| 159  | 0.00E+00   | 2.77E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 160  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 161  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 162  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 163  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 164  | -4.82E-02  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 165  | 0.00E+00   | 1.80E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 166  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 167  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 168  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 169  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 170  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 171  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 172  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 173  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 174  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 175  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 176  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 177  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 178  | 2.66E-03   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 179  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 1.50E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 180  | \$5.65E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 181  | 0.00E+00   | 3.22E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 182  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 183  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 184  | 0.00E+00   | 1.56E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 185  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 186  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 187  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 188  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 189  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 190  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 191  | 0.00E+00   | 4.60E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 192  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 193  | 1.64E-01   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 194  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 195  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 196  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 197  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 198  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 2.27E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 199  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.26E-02 | 0.00E+00 | 0.00E+00 |
| 200  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.25E-02 | 0.00E+00 | 0.00E+00 |
| 201  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.45E-02 | 0.00E+00 |
| 202  | 0.00E+00   | 2.55E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 203  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 204  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 2.21E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 205  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.37E-02 | 0.00E+00 |
| 206  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.96E-02 | 0.00E+00 |
| 207  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 208  | 0.00E+00   | 2.48E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 209  | 0.00E+00   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 210  | 0.00E+00   | 1.26E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASSED CHARGE TEST (CONTINUED).

| FRAG<br>No. | SHEET<br>No. | SHEET<br>POSITION<br>X (in) | SHEET<br>POSITION<br>Y (in) | WTS<br>(grams) | LEN<br>(in) | MID<br>(in) | THI<br>(in) | L/D       | RATIO | POST<br>Y (in) | COM<br>Y (in) | COM<br>Z (in) | COM<br>R (in) |
|-------------|--------------|-----------------------------|-----------------------------|----------------|-------------|-------------|-------------|-----------|-------|----------------|---------------|---------------|---------------|
| 211         | 3            | 1                           | 10.5                        | 0.3            | 0.361       | 0.297       | 0.034       | 1.215-403 |       | -47            | -7.5          | 112.5         | 122.1535      |
| 212         | 3            | 2                           | 11                          | 0.04           | 0.226       | 0.174       | 0.043       | 1.238-500 |       | -46            | -13           | 112.5         | 122.2944      |
| 213         | 3            | 15.5                        | 25                          | 0.06           | 0.274       | 0.223       | 0.041       | 1.201-744 |       | -42.5          | 1             | 112.5         | 117.1046      |
| 214         | 3            | 16                          | 16                          | 0.02           | 0.563       | 0.39        | 0.085       | 1.443-603 |       | -29            | 8             | 112.5         | 116.4527      |
| 215         | 3            | 17                          | 15                          | 1.16           | 0.595       | 0.437       | 0.144       | 1.3615-66 |       | -31            | -22.5         | 112.5         | 118.8423      |
| 216         | 3            | 21                          | 6.5                         | 0.04           | 0.267       | 0.185       | 0.063       | 1.443-643 |       | -27            | -17.5         | 112.5         | 117.0106      |
| 217         | 3            | 21                          | 21                          | 0.04           | 0.194       | 0.114       | 0.05        | 1.4210-52 |       | -45            | -1            | 112.5         | 121.1703      |
| 218         | 3            | 12                          | 46                          | 0.18           | 0.337       | 0.182       | 0.062       | 1.8516-40 |       | -46            | 27            | 112.5         | 120.1509      |
| 219         | 3            | 15.5                        | 40                          | 0.02           | 0.205       | 0.112       | 0.046       | 1.830-557 |       | -32.5          | 16            | 112.5         | 118.1044      |
| 220         | 3            | 20                          | 41                          | 0.09           | 0.326       | 0.138       | 0.044       | 2.3623-18 |       | -28            | 17            | 112.5         | 117.1718      |
| 221         | 3            | 20.25                       | 43.5                        | 0.02           | 0.21        | 0.123       | 0.026       | 1.623-906 |       | -27.75         | 19.5          | 112.5         | 117.5013      |
| 222         | 3            | 24                          | 36                          | 0.03           | 0.225       | 0.126       | 0.023       | 1.7857-14 |       | -24            | 12            | 112.5         | 115.6552      |
| 223         | 3            | 25                          | 36                          | 0.04           | 0.214       | 0.113       | 0.041       | 1.6461-53 |       | -23            | 12            | 112.5         | 115.4523      |
| 224         | 3            | 29                          | 24.5                        | 0.12           | 0.388       | 0.256       | 0.062       | 1.5156-25 |       | -19            | 0.5           | 112.5         | 114.0942      |
| 225         | 3            | 24.5                        | 24.5                        | 0.12           | 0.279       | 0.19        | 0.056       | 1.468-21  |       | -22.5          | 5.5           | 112.5         | 114.8596      |
| 226         | 3            | 28.5                        | 17.5                        | 0.08           | 0.189       | 0.171       | 0.045       | 1.1052-3  |       | -19.5          | -6.5          | 112.5         | 114.3623      |
| 227         | 3            | 32.5                        | 16                          | 0.08           | 0.393       | 0.109       | 0.036       | 3.6055-04 |       | -15.5          | 8             | 112.5         | 113.8441      |
| 228         | 3            | 34                          | 20.5                        | 0.12           | 0.35        | 0.05        | 0.026       | 1.5254-23 |       | -11            | -3.5          | 112.5         | 113.4217      |
| 229         | 3            | 31.5                        | 32.75                       | 0.02           | 0.13        | 0.118       | 0.035       | 1.118     |       | -18.5          | 8.25          | 112.5         | 114.0397      |
| 230         | 3            | 37.5                        | 0.75                        | 0.28           | 0.461       | 0.173       | 0.059       | 2.347-39  |       | -10.5          | -23.25        | 112.5         | 124.1501      |
| 231         | 3            | 36                          | 14                          | 0.25           | 0.429       | 0.277       | 0.05        | 1.5437-26 |       | -12            | -10           | 112.5         | 113.4305      |
| 232         | 3            | 36                          | 29                          | 0.09           | 0.383       | 0.128       | 0.07        | 1.4153-84 |       | -9             | 5             | 112           | 112.7208      |
| 233         | 3            | 33                          | 33                          | 0.09           | 0.574       | 0.311       | 0.205       | 1.8456-59 |       | -6             | 12            | 112           | 112.8007      |
| 234         | 3            | 42                          | 36                          | 0.01           | 0.152       | 0.093       | 0.047       | 1.8313-25 |       | -13            | 17            | 112           | 114.2716      |
| 235         | 3            | 33                          | 41                          | 0.1            | 0.341       | 0.073       | 0.03        | 1.2430-84 |       | -16            | 16            | 112           | 113.1415      |
| 236         | 3            | 47                          | 40                          | 0.02           | 0.184       | 0.105       | 0.025       | 1.5619-04 |       | -9.5           | -9.5          | 112           | 113.6859      |
| 237         | 3            | 47.5                        | 43.5                        | 0.23           | 0.431       | 0.159       | 0.089       | 2.7106-31 |       | -0.75          | 5             | 112           | 112.0716      |
| 238         | 3            | 48.25                       | 28                          | 0.59           | 0.36        | 0.347       | 0.052       | 2.7624-33 |       | 4.5            | 5             | 112           | 112.2509      |
| 239         | 3            | 54                          | 30                          | 1.3            | 0.985       | 0.478       | 0.098       | 2.5058-20 |       | 8.5            | 5             | 112           | 112.7231      |
| 240         | 3            | 42.75                       | 14.5                        | 0.04           | 0.153       | 0.151       | 0.036       | 1.0523-80 |       | 9.5            | -25           | 112           | 113.1804      |
| 241         | 3            | 56.5                        | 37.25                       | 2.28           | 0.553       | 0.423       | 0.143       | 1.5555-55 |       | 12             | -11.5         | 112           | 113.2765      |
| 242         | 3            | 12.5                        | 60                          | 0.66           | 0.312       | 0.167       | 0.09        | 1.9728-81 |       | 12             | -14           | 112           | 113.5077      |
| 243         | 3            | 60                          | 10                          | 0.21           | 0.292       | 0.164       | 0.082       | 1.0977-44 |       | 14.5           | -8.5          | 112           | 113.2541      |
| 244         | 3            | 15.5                        | 15.5                        | 0.56           | 0.532       | 0.3         | 0.089       | 1.7733-33 |       | 16             | 6             | 112           | 113.2960      |
| 245         | 3            | 13                          | 13                          | 1.05           | 0.562       | 0.405       | 0.108       | 1.3875-54 |       | 14             | 18            | 112           | 114.2923      |
| 246         | 3            | 64                          | 42                          | 0.19           | 0.334       | 0.31        | 0.036       | 1.0677-41 |       | 19.5           | -6.75         | 112           | 113.8650      |
| 247         | 3            | 67.5                        | 17.25                       | 0.5            | 0.435       | 0.287       | 0.041       | 2.5214-72 |       | 22             | -17           | 112           | 115.3933      |
| 248         | 3            | 70                          | 1                           | 0.14           | 0.411       | 0.163       | 0.046       | 1.4044-94 |       | 20             | 4             | 112           | 113.9413      |
| 249         | 3            | 68                          | 20                          | 0.08           | 0.25        | 0.178       | 0.039       | 1.7393-17 |       | 21             | 13.5          | 112           | 114.7486      |
| 250         | 3            | 69                          | 37.5                        | 0.13           | 0.372       | 0.214       | 0.064       | 1.9170-73 |       | 23             | 10.5          | 112           | 114.8183      |
| 251         | 3            | 34.5                        | 34.5                        | 1.84           | 0.786       | 0.41        | 0.052       | 1.8366-43 |       | 22.5           | -16           | 112           | 115.3527      |
| 252         | 3            | 70.5                        | 8                           | 0.19           | 0.371       | 0.202       | 0.074       | 1.5692-30 |       | 22             | -23           | 112           | 115.4345      |
| 253         | 3            | 70                          | 1                           | 0.2            | 0.306       | 0.195       | 0.085       | 1.6679-53 |       | 22.5           | 14            | 112           | 115.0923      |
| 254         | 3            | 70.5                        | 30                          | 0.6            | 0.432       | 0.259       | 0.105       | 1.0186-44 |       | 25             | 9             | 112           | 115.1065      |
| 255         | 3            | 13                          | 13                          | 1.63           | 0.601       | 0.59        | 0.072       | 1.4768-51 |       | 26             | -13.5         | 112           | 115.7681      |
| 256         | 3            | 10.5                        | 10.5                        | 0.26           | 0.319       | 0.216       | 0.04        | 1.7586-20 |       | 24             | 8.25          | 112           | 114.8492      |
| 257         | 3            | 32.5                        | 32.5                        | 0.03           | 0.204       | 0.116       | 0.04        | 1.7586-20 |       | 24             | 8.25          | 112           | 115.2458      |
| 258         | 3            | 75                          | 26                          | 0.03           | 0.354       | 0.308       | 0.104       | 1.1493-50 |       | 27.5           | -4            | 112           | 115.3680      |
| 259         | 3            | 75.5                        | 20                          | 0.27           | 0.269       | 0.189       | 0.054       | 1.4232-80 |       | 28             | -13.5         | 112           | 115.7680      |
| 260         | 3            | 74                          | 10.5                        | 0.26           | 0.2         | 0.16        | 0.03        | 1.25      |       | 28             | 15            | 112           | 115.1116      |
| 261         | 3            | 74                          | 39                          | 0.92           | 0.707       | 0.356       | 0.071       | 2.1687-11 |       | 27             | 15            | 112           | 115.1116      |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | TIN X    | TIN Y     | PERIT<br>X° (in) | PERIT<br>Y° (in) | COORDINATE<br>Z° (in) | DEPTH<br>R° (in) | Vo       | Vo        | PRESENTED<br>MRX. | APER<br>MIN. | (IN)<br>AVG. |
|-------------|----------|-----------|------------------|------------------|-----------------------|------------------|----------|-----------|-------------------|--------------|--------------|
| 211         | -0.41777 | -0.06666  | -0.62666         | -0.1             | 1.5                   | 1.628714         | -46.3733 | -7.4      | 0.031534          | 0.006464     | 0.018399     |
| 212         | -0.40698 | -0.11555  | -0.61333         | -0.17333         | 1.5                   | 1.629792         | -45.3866 | -12.8266  | 0.024861          | 0.001032     | 0.002947     |
| 213         | -0.29888 | 0.00888   | -0.43333         | 0.13333          | 1.5                   | 1.581395         | -32.0666 | 0.986666  | 0.024967          | 0.007381     | 0.016174     |
| 214         | -0.25727 | -0.07111  | -0.38666         | -0.10666         | 1.5                   | 1.552703         | -28.6133 | -7.89333  | 0.064190          | 0.012710     | 0.048450     |
| 215         | -0.27555 | -0.1      | -0.41333         | -0.3             | 1.5                   | 1.584564         | -30.5966 | -22.2     | 0.062659          | 0.015164     | 0.038912     |
| 216         | -0.24    | -0.15555  | -0.36            | -0.23333         | 1.5                   | 1.560142         | -26.64   | -17.2666  | 0.017285          | 0.004078     | 0.010692     |
| 217         | -0.4     | -0.00888  | -0.6             | -0.01333         | 1.5                   | 1.615604         | -44.4    | -0.98666  | 0.012445          | 0.001603     | 0.007024     |
| 218         | -0.32    | 0.19555   | -0.48            | 0.23333          | 1.5                   | 1.602012         | -35.52   | 21.70666  | 0.022582          | 0.004154     | 0.013368     |
| 219         | -0.28888 | 0.14222   | -0.43333         | 0.21333          | 1.5                   | 1.575845         | -32.0666 | 15.79666  | 0.004321          | 0.000758     | 0.002540     |
| 220         | -0.24688 | 0.15111   | -0.37333         | 0.25666          | 1.5                   | 1.562291         | -27.6266 | 16.77333  | 0.015130          | 0.002147     | 0.009028     |
| 221         | -0.24666 | 0.17333   | -0.37333         | 0.25666          | 1.5                   | 1.566894         | -27.38   | 19.24     | 0.005983          | 0.000740     | 0.003362     |
| 222         | -0.21333 | 0.10666   | -0.32            | 0.16             | 1.5                   | 1.542076         | -23.68   | 11.84     | 0.010145          | 0.001037     | 0.005591     |
| 223         | -0.20444 | 0.10666   | -0.30666         | 0.16             | 1.5                   | 1.539364         | -22.6433 | 11.84     | 0.007588          | 0.001453     | 0.004521     |
| 224         | -0.16888 | 0.04444   | -0.25333         | 0.06666          | 1.5                   | 1.531256         | -18.7266 | 0.493333  | 0.026346          | 0.004209     | 0.015278     |
| 225         | -0.2     | 0.04888   | -0.3             | 0.07333          | 1.5                   | 1.531462         | -22.2    | 5.426666  | 0.016668          | 0.003345     | 0.010006     |
| 226         | -0.17333 | -0.05777  | -0.26            | -0.08666         | 1.5                   | 1.524831         | -19.24   | -6.41333  | 0.013828          | 0.003292     | 0.008560     |
| 227         | -0.13777 | -0.07111  | -0.20666         | -0.10666         | 1.5                   | 1.517922         | -15.2333 | -7.89333  | 0.011112          | 0.001583     | 0.006347     |
| 228         | -0.12444 | -0.03111  | -0.18666         | -0.04666         | 1.5                   | 1.512290         | -13.8133 | -3.45333  | 0.035900          | 0.002666     | 0.013283     |
| 229         | -0.14666 | 0.07777   | -0.22            | 0.11666          | 1.5                   | 1.520529         | -18.28   | 8.633333  | 0.004444          | 0.000864     | 0.002654     |
| 230         | -0.14777 | -0.20666  | -0.62666         | -0.31            | 1.5                   | 1.654935         | -46.3733 | -22.94    | 0.036914          | 0.004724     | 0.020819     |
| 231         | -0.09333 | -0.08888  | -0.14            | -0.13333         | 1.5                   | 1.512407         | -10.36   | -9.866666 | 0.038892          | 0.004532     | 0.021712     |
| 232         | -0.10714 | 0.044642  | -0.10714         | 0.044642         | 1                     | 1.006713         | -11.8378 | 4.955357  | 0.032225          | 0.006129     | 0.019177     |
| 233         | -0.09035 | 0.030357  | -0.09035         | 0.030357         | 1                     | 1.006436         | -8.9164  | 8.91642   | 0.029375          | 0.016705     | 0.020340     |
| 234         | -0.05357 | 0.107142  | -0.05357         | 0.107142         | 1                     | 1.007149         | -5.94642 | 11.83285  | 0.002102          | 0.000511     | 0.001307     |
| 235         | -0.13992 | 0.151785  | -0.13992         | 0.151785         | 1                     | 1.020282         | -14.8664 | 16.84821  | 0.025928          | 0.002281     | 0.014104     |
| 236         | -0.00892 | 0.142857  | -0.00892         | 0.142857         | 1                     | 1.010132         | -0.99107 | 15.85714  | 0.006763          | 0.000948     | 0.003856     |
| 237         | -0.00446 | 0.174107  | -0.00446         | 0.174107         | 1                     | 1.010559         | -0.49553 | 19.32589  | 0.025345          | 0.005233     | 0.015289     |
| 238         | 0.002332 | 0.035714  | 0.002332         | 0.035714         | 1                     | 1.000640         | 0.24767  | 3.954285  | 0.043235          | 0.012748     | 0.028031     |
| 239         | 0.040178 | 0.053571  | 0.040178         | 0.053571         | 1                     | 1.002239         | 4.95871  | 5.946428  | 0.031413          | 0.003266     | 0.017340     |
| 240         | 0.053571 | 0.167410  | 0.053571         | 0.167410         | 1                     | 1.015330         | 5.946428 | 13.58258  | 0.103183          | 0.010366     | 0.056724     |
| 241         | 0.075892 | -0.08492  | 0.075892         | -0.08492         | 1                     | 1.006456         | 8.424107 | -9.41517  | 0.008642          | 0.001956     | 0.005244     |
| 242         | 0.084821 | 0.118303  | 0.084821         | 0.118303         | 1                     | 1.010559         | 9.415178 | 13.13169  | 0.151217          | 0.032863     | 0.092040     |
| 243         | 0.107142 | -0.107142 | 0.107142         | -0.107142        | 1                     | 1.010951         | 11.83285 | -11.3973  | 0.057042          | 0.008820     | 0.032931     |
| 244         | 0.107142 | -0.125    | 0.107142         | -0.125           | 1                     | 1.013461         | 11.83285 | -13.875   | 0.019930          | 0.005594     | 0.012757     |
| 245         | 0.12464  | -0.07589  | 0.12464          | -0.07589         | 1                     | 1.011197         | 14.87053 | 8.42410   | 0.048943          | 0.006187     | 0.028565     |
| 246         | 0.142857 | -0.04357  | 0.142857         | -0.04357         | 1                     | 1.011572         | 15.85714 | -5.94642  | 0.075624          | 0.014532     | 0.045078     |
| 247         | 0.125    | 0.160714  | 0.125            | 0.160714         | 1                     | 1.020516         | 13.875   | 17.83928  | 0.041053          | 0.004464     | 0.022754     |
| 248         | 0.174107 | -0.06026  | 0.174107         | -0.06026         | 1                     | 1.016831         | 19.32589 | -6.63973  | 0.045755          | 0.008940     | 0.027348     |
| 249         | 0.19423  | -0.15173  | 0.19423          | -0.15173         | 1                     | 1.030350         | 21.80357 | -16.8482  | 0.026560          | 0.002649     | 0.014845     |
| 250         | 0.179571 | 0.035714  | 0.179571         | 0.035714         | 1                     | 1.018446         | 19.82142 | 3.954285  | 0.013527          | 0.002489     | 0.008003     |
| 251         | 0.1875   | 0.120535  | 0.1875           | 0.120535         | 1                     | 1.024541         | 20.8125  | 13.87946  | 0.025928          | 0.002718     | 0.014323     |
| 252         | 0.205357 | 0.09375   | 0.205357         | 0.09375          | 1                     | 1.025163         | 22.73464 | 10.40625  | 0.089167          | 0.018604     | 0.053846     |
| 253         | 0.20892  | -0.14285  | 0.20892          | -0.14285         | 1                     | 1.023934         | 23.29410 | -15.8571  | 0.028421          | 0.003983     | 0.016202     |
| 254         | 0.196489 | -0.20535  | 0.196489         | -0.20535         | 1                     | 1.023594         | 21.80357 | -22.7946  | 0.021022          | 0.005083     | 0.013051     |
| 255         | 0.200892 | 0.125     | 0.200892         | 0.125            | 1                     | 1.027610         | 23.29410 | 13.875    | 0.048905          | 0.010803     | 0.070923     |
| 256         | 0.23214  | -0.08035  | 0.23214          | -0.08035         | 1                     | 1.027759         | 24.77678 | -8.9164   | 0.120751          | 0.001086     | 0.070923     |
| 257         | 0.23214  | -0.13053  | 0.23214          | -0.13053         | 1                     | 1.033643         | 25.76785 | -13.8794  | 0.037012          | 0.008534     | 0.024174     |
| 258         | 0.21485  | 0.073660  | 0.21485          | 0.073660         | 1                     | 1.045350         | 23.78571 | 8.176333  | 0.050560          | 0.009313     | 0.030243     |
| 259         | 0.241071 | 0.017857  | 0.241071         | 0.017857         | 1                     | 1.043802         | 26.75942 | 1.982142  | 0.03640           | 0.011845     | 0.050546     |
| 260         | 0.245335 | -0.03571  | 0.245335         | -0.03571         | 1                     | 1.030421         | 27.25446 | -3.96478  | 0.038992          | 0.007907     | 0.013344     |
| 261         | 0.232142 | -0.12053  | 0.232142         | -0.12053         | 1                     | 1.030643         | 25.76785 | -13.8794  | 0.040443          | 0.010112     | 0.012540     |
| 262         | 0.136429 | 0.133928  | 0.136429         | 0.133928         | 1                     | 1.037867         | 31.80357 | 14.86666  | 0.100791          | 0.010121     | 0.059546     |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CAGED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | AVG<br>Digr/in2 | REHL<br>THOR | V<br>(ft/sec) | THOR<br>V<br>(ft/sec) | V<br>(ft/sec) | THOR<br>V<br>(ft/sec) | THOR<br>V<br>(ft/sec) | Vol.<br>Screen<br>Locations<br>(ft-sec) | VEL.<br>(ft/sec) | MV<br>10-sec | MV<br>1b-sec | MV<br>1b-sec | MV<br>1b-sec |
|-------------|-----------------|--------------|---------------|-----------------------|---------------|-----------------------|-----------------------|-----------------------------------------|------------------|--------------|--------------|--------------|--------------|
| 211         | 15.79012        | 1529.509     | 465.9566      | 937.7328              | 0.020493      |                       |                       | -94                                     | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 212         | 17.9469         | 2117.192     | 662.3841      | 1389.788              | 0.002854      |                       |                       | -93                                     | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 213         | 16.07470        | 1984.723     | 555.1545      | 933.9309              | 0.017255      |                       |                       | 1                                       | 369.9799         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 214         | 18.98839        | 1323.977     | 322.1271      | 924.0524              | 0.052031      |                       |                       | 1                                       | 316.0524         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 215         | 29.81061        | 909.3952     | 313.7833      | 611.5918              | 0.048572      |                       |                       | -93                                     | 0                | 4.38E-02     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 216         | 13.10610        | 1670.936     | 565.6344      | 1113.315              | 0.010719      |                       |                       | -94                                     | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 217         | 5.694210        | 3430.744     | 737.8308      | 2064.317              | 0.005709      |                       |                       | -94                                     | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 218         | 13.46432        | 1725.034     | 494.5841      | 1104.809              | 0.013615      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 219         | 9.967916        | 2561.536     | 694.8834      | 1628.209              | 0.008224      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 220         | 9.967916        | 2561.536     | 694.8834      | 1628.209              | 0.008224      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 221         | 5.948623        | 3255.354     | 679.4588      | 1962.407              | 0.002693      |                       |                       | 1                                       | 2062.169         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 222         | 9.365306        | 3528.758     | 637.5800      | 2032.169              | 0.004076      |                       |                       | 1                                       | 1472.077         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 223         | 8.945944        | 2263.023     | 661.1317      | 1472.077              | 0.004076      |                       |                       | 1                                       | 1103.908         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 224         | 13.74506        | 1659.396     | 413.3920      | 1039.394              | 0.014344      |                       |                       | 1                                       | 1417.259         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 225         | 11.99176        | 1800.034     | 539.7824      | 1169.908              | 0.003611      |                       |                       | 1                                       | 1101.593         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 226         | 9.345323        | 2113.971     | 720.5467      | 1417.259              | 0.007762      |                       |                       | -1                                      | 1810.654         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 227         | 12.60288        | 1788.085     | 414.7008      | 1101.593              | 0.006032      |                       |                       | -1                                      | 1646.434         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 228         | 6.222851        | 3170.213     | 451.0944      | 1810.654              | 0.014976      |                       |                       | -93                                     | 0                | 2.13E-02     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 229         | 7.534213        | 2547.049     | 745.8139      | 1646.434              | 0.002254      |                       |                       | -94                                     | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 230         | 13.44685        | 1834.599     | 342.5565      | 1113.573              | 0.021347      |                       |                       | 1                                       | 1164.332         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 231         | 11.51403        | 1941.405     | 387.7584      | 1164.332              | 0.019829      |                       |                       | 1                                       | 715.8963         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 232         | 15.12194        | 1111.598     | 320.1737      | 715.8963              | 0.019623      |                       |                       | 1                                       | 362.1946         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 233         | 38.89865        | 496.4337     | 229.3436      | 362.1946              | 0.000826      |                       |                       | 1                                       | 1407.686         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 234         | 7.651020        | 1793.747     | 621.6263      | 1207.686              | 0.000826      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 235         | 5.186393        | 2569.024     | 593.5213      | 1278.104              | 0.003458      |                       |                       | 1                                       | 567.3242         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 236         | 18.96705        | 934.1482     | 286.1546      | 610.1519              | 0.012114      |                       |                       | 1                                       | 319.0740         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 237         | 12.05514        | 810.6271     | 324.0213      | 567.3242              | 0.022416      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 238         | 21.11072        | 1384.540     | 753.5673      | 819.0740              | 0.011776      |                       |                       | 1                                       | 1715.360         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 239         | 12.11072        | 1384.540     | 753.5673      | 819.0740              | 0.011776      |                       |                       | 1                                       | 567.3242         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 240         | 22.91763        | 869.2169     | 153.9821      | 511.5945              | 0.045534      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 241         | 7.547460        | 1830.043     | 600.6763      | 1215.360              | 0.003329      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 242         | 30.20405        | 652.3867     | 207.6517      | 430.6197              | 0.081847      |                       |                       | 1                                       | 575.6445         | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 243         | 20.04158        | 923.5447     | 227.7443      | 673.4592              | 0.025011      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 244         | 16.46117        | 992.1226     | 332.7458      | 637.4592              | 0.007604      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 245         | 19.60405        | 931.4367     | 244.6006      | 583.5737              | 0.023527      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 246         | 9.34343         | 1647.194     | 350.1161      | 1039.700              | 0.037524      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 247         | 18.23711        | 463.1838     | 264.5521      | 637.3754              | 0.021442      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 248         | 18.23711        | 463.1838     | 264.5521      | 637.3754              | 0.021442      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 249         | 9.585883        | 1633.441     | 244.8214      | 444.6014              | 0.003623      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 250         | 9.983459        | 1534.041     | 430.9734      | 931.5074              | 0.005361      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 251         | 9.076143        | 1746.549     | 321.7470      | 1034.193              | 0.054704      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 252         | 34.83930        | 595.0509     | 113.7046      | 347.279               | 0.050118      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 253         | 11.12661        | 1413.178     | 323.7136      | 863.4190              | 0.011747      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 254         | 15.32164        | 1022.136     | 373.6744      | 741.4473              | 0.010096      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 255         | 18.26193        | 975.8764     | 299.3058      | 623.0762              | 0.025465      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 256         | 22.98237        | 842.9474     | 256.0837      | 514.0130              | 0.059403      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 257         | 15.10366        | 1110.122     | 363.5191      | 736.0307              | 0.017656      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 258         | 8.598767        | 1714.752     | 505.3104      | 1110.011              | 0.019459      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 259         | 20.66849        | 834.5807     | 335.0733      | 537.3107              | 0.021311      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 260         | 11.56333        | 1374.125     | 413.1047      | 773.1153              | 0.016504      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 261         | 10.2803         | 1453.793     | 514.9431      | 930.6160              | 0.017560      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |
| 262         | 16.58952        | 1117.127     | 194.5343      | 556.2169              | 0.041459      |                       |                       | 1                                       | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |



TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CAGED CHARGE TEST (CONTINUED).

| FRIG | RV       | RV       | RV       | RV       | RV       | RV       |
|------|----------|----------|----------|----------|----------|----------|
| NUM  | 1b-sec   | 1b-sec   | 1b-sec   | 1b-sec   | 1b-sec   | 1b-sec   |
|      | -2.5-0   | Chd. Ht. | 1b-sec   | 1b-sec   | 1b-sec   | 1b-sec   |
| 211  | 2.05E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 212  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 213  | 0.00E+00 | 1.73E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 214  | 5.20E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 215  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 216  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 217  | 0.00E+00 | 5.71E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 218  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 219  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 220  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 221  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 222  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 223  | 0.00E+00 | 1.49E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 224  | 0.00E+00 | 1.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 225  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 226  | 7.76E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 227  | 6.03E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 228  | 0.00E+00 | 1.49E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 229  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 230  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 231  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 232  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 233  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 234  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 235  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 236  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 237  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 238  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 239  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 240  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 241  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 242  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 243  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 244  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 245  | 2.25E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 246  | 3.74E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 247  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 248  | 2.14E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 249  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 250  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 251  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 252  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 253  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 254  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 255  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 256  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 257  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 258  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 259  | 0.00E+00 | 2.13E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 260  | 1.65E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 261  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 262  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND Cased CHARGE TEST (CONTINUED).

| FRAG<br>NUM | SHEET<br>No. | SHEET<br>X (in) | SHEET<br>Y (in) | POSITION<br>Y (in) | WTS<br>(grams) | LEN<br>(in) | WID<br>(in) | THIC<br>(in) | L/D      | POST<br>X (in) | POST<br>Y (in) | COORDINATES<br>Z (in) | PATH<br>R (in) |
|-------------|--------------|-----------------|-----------------|--------------------|----------------|-------------|-------------|--------------|----------|----------------|----------------|-----------------------|----------------|
| 263         | 2            | 69.5            | 44.25           | 44.25              | 0.76           | 0.563       | 0.265       | 0.083        | 2.124523 | 21.5           | 20.25          | 112                   | 115.8289       |
| 264         | 2            | 81              | 12              | 12                 | 0.39           | 0.412       | 0.192       | 0.092        | 2.051370 | 33             | -12            | 112                   | 117.3754       |
| 265         | 2            | 75              | 43.5            | 43.5               | 0.14           | 0.152       | 0.106       | 0.034        | 1.433462 | 27             | 19.5           | 112                   | 116.8471       |
| 266         | 2            | 91              | 15              | 15                 | 0.2            | 0.245       | 0.209       | 0.029        | 1.122448 | 33             | 9              | 112                   | 117.1067       |
| 267         | 2            | 73              | 44.5            | 44.5               | 0.15           | 0.202       | 0.145       | 0.04         | 1.33103  | 31             | 20.5           | 112                   | 118.0057       |
| 268         | 2            | 82.5            | 40              | 40                 | 1.12           | 0.463       | 0.461       | 0.086        | 1.017353 | 34.5           | 16             | 112                   | 118.2403       |
| 269         | 2            | 91              | 25.5            | 25.5               | 0.3            | 0.286       | 0.227       | 0.082        | 1.25311  | 43             | 1.5            | 112                   | 119.9402       |
| 270         | 18           | 77.25           | 77.25           | 77.25              | 11.7           | 1.465       | 0.786       | 0.274        | 1.863967 | 29             | 53.25          | 120                   | 134.4491       |
| 271         | 14           | 85.5            | 6               | 6                  | 2.5            | 0.711       | 0.361       | 0.204        | 1.965729 | 37.5           | -18            | 118                   | 125.1169       |
| 272         | 10           | 18.25           | 6               | 6                  | 2.18           | 0.736       | 0.429       | 0.142        | 1.713426 | -29.75         | -18            | 116                   | 121.0993       |
| 273         | 10           | 43              | 19              | 19                 | 1.6            | 0.579       | 0.342       | 0.125        | 1.632482 | -5             | -5             | 115.5                 | 117.6          |
| 274         | 9            | 53              | 45              | 45                 | 1.96           | 0.946       | 0.541       | 0.121        | 3.95311  | 5              | 21             | 115                   | 116.2871       |
| 275         | 8            | 38.5            | 6               | 6                  | 1.41           | 0.751       | 0.31        | 0.106        | 2.422580 | -9.5           | -18            | 114.5                 | 119.3587       |
| 276         | 2            | 16.5            | 12              | 12                 | 0.61           | 0.473       | 0.241       | 0.125        | 1.962655 | 31.5           | -12            | 114                   | 112.9402       |
| 277         | 6            | 22              | 39.5            | 39.5               | 3.69           | 1.307       | 0.423       | 0.129        | 3.083834 | -26            | 15.5           | 114                   | 112.9402       |
| 278         | 5            | 51.25           | 41.25           | 41.25              | 0.69           | 0.582       | 0.312       | 0.086        | 1.94     | 3.25           | 17.25          | 114                   | 115.3435       |
| 279         | 4            | 59              | 5.5             | 5.5                | 1.2            | 0.574       | 0.312       | 0.156        | 1.837443 | 11             | -18.5          | 113                   | 113.6404       |
| 280         | 4            | 59              | 14.5            | 14.5               | 0.71           | 0.553       | 0.295       | 0.155        | 1.894315 | 8              | -9.5           | 113                   | 114.6841       |
| 281         | 4            | 59              | 8               | 8                  | 2.3            | 0.852       | 0.348       | 0.199        | 2.443775 | 11             | -16            | 113                   | 114.6841       |
| 282         | 4            | 79.5            | 8               | 8                  | 0.36           | 0.381       | 0.276       | 0.061        | 1.340434 | 31.5           | -16            | 113                   | 116.3444       |
| 283         | 4            | 52              | 4               | 4                  | 4.29           | 1.21        | 0.616       | 0.135        | 1.954385 | 7              | -20            | 113                   | 114.8254       |
| 284         | 3            | 19              | 16              | 16                 | 1.16           | 0.595       | 0.437       | 0.144        | 1.361556 | -7             | -4             | 112.5                 | 116.4527       |

Total Impulse Over Target at 9 ft. (4.8 Sheet) 336.687 lb-sec  
Average Specific Impulse (at center) 10.492 psi-sec  
(based on curved target surface calculation)

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASSED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | TAN X    | TAN Y    | PENET<br>X (in) | PENET<br>Y (in) | COORDINATE<br>Z (in) | DEPTH<br>R (in) | No       | %        | PRESENTED<br>MM. | MMEM<br>MIN. | UNDA<br>RUG. |
|-------------|----------|----------|-----------------|-----------------|----------------------|-----------------|----------|----------|------------------|--------------|--------------|
| 263         | 0.191964 | 0.180803 | 0.191964        | 0.180803        | 1                    | 1.034135        | 21.30303 | 20.06919 | 0.071224         | 0.019500     | 0.040962     |
| 264         | 0.294642 | -0.10714 | 0.294642        | -0.10714        | 1                    | 1.047335        | 32.70535 | -11.4928 | 0.032973         | 0.007363     | 0.020168     |
| 265         | 0.241071 | 0.174107 | 0.241071        | 0.174107        | 1                    | 1.043277        | 26.75392 | 19.32589 | 0.032028         | 0.007164     | 0.019596     |
| 266         | 0.294642 | -0.08035 | 0.294642        | -0.08035        | 1                    | 1.045536        | 32.70535 | -8.91964 | 0.053644         | 0.006349     | 0.029997     |
| 267         | 0.276785 | 0.183035 | 0.276785        | 0.183035        | 1                    | 1.053618        | 30.72321 | 20.31696 | 0.029163         | 0.005776     | 0.017472     |
| 268         | 0.306035 | 0.142857 | 0.306035        | 0.142857        | 1                    | 1.056074        | 34.13136 | 15.85714 | 0.101300         | 0.018575     | 0.059338     |
| 269         | 0.383928 | 0.013392 | 0.383928        | 0.013392        | 1                    | 1.071251        | 42.61607 | 1.408607 | 0.028457         | 0.008159     | 0.018403     |
| 270         | 0.241668 | 0.44375  | 2.175           | 3.99375         | 3                    | 10.08368        | 76.8235  | 49.25675 | 0.406285         | 0.062121     | 0.234203     |
| 271         | 0.317796 | -0.15254 | 2.224576        | -1.06773        | 7                    | 7.472191        | 35.27542 | -16.9322 | 0.099324         | 0.027450     | 0.061337     |
| 272         | -0.25646 | -0.15517 | -1.28232        | -0.77586        | 5                    | 5.219301        | -28.4676 | -17.2241 | 0.119415         | 0.023039     | 0.071227     |
| 273         | -0.04310 | -0.04310 | -0.21551        | -0.21551        | 5                    | 5.009230        | -4.78448 | -0.78448 | 0.099564         | 0.021494     | 0.060519     |
| 274         | 0.043290 | 0.181818 | 0.194805        | 0.819181        | 4.5                  | 4.577322        | 4.805194 | 20.18181 | 0.125993         | 0.016116     | 0.071057     |
| 275         | -0.08260 | -0.15652 | -0.33043        | -0.62808        | 4                    | 4.062183        | -9.16956 | -17.3739 | 0.103468         | 0.014604     | 0.059036     |
| 276         | -0.27510 | -0.10480 | -0.96288        | -0.36681        | 3.5                  | 3.648519        | -30.5371 | -11.6331 | 0.037953         | 0.010031     | 0.023995     |
| 277         | -0.22607 | 0.135964 | -0.68421        | 0.407394        | 3                    | 3.103952        | -25.3157 | 15.09210 | 0.222500         | 0.021960     | 0.122230     |
| 278         | 0.029503 | 0.151315 | 0.085526        | 0.453947        | 3                    | 3.035355        | 3.164473 | 16.79605 | 0.062403         | 0.009221     | 0.035415     |
| 279         | 0.097345 | -0.16371 | 0.194690        | -0.32743        | 2                    | 2.035356        | 10.80530 | -13.1725 | 0.059834         | 0.016251     | 0.038047     |
| 280         | 0.070796 | -0.08407 | 0.141592        | -0.16814        | 2                    | 2.012043        | 7.058407 | -9.33185 | 0.035630         | 0.009879     | 0.022755     |
| 281         | 0.097345 | -0.14159 | 0.194690        | -0.28313        | 2                    | 2.029309        | 10.80530 | -15.7168 | 0.089901         | 0.020949     | 0.055450     |
| 282         | 0.273761 | -0.14159 | 0.557522        | -0.28313        | 2                    | 2.085407        | 30.94247 | -15.7168 | 0.045905         | 0.007343     | 0.026627     |
| 283         | 0.035398 | -0.17699 | 0.070796        | -0.35398        | 2                    | 2.042317        | 3.923403 | -13.6460 | 0.247182         | 0.007528     | 0.137980     |
| 284         | -0.25777 | -0.07111 | -0.38666        | -0.10666        | 1.5                  | 1.557703        | -20.6133 | -7.83333 | 0.062653         | 0.015164     | 0.113842     |

Total

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASSED CHARGE TEST (CONTINUED).

| FRAG<br>NUM | AVG AREAL<br>Digr/in2 | THOR<br>V<br>(ft/sec) | THOR<br>V<br>(ft/sec) | THOR<br>V<br>(ft/sec) | MV<br>lb-sec | Vol. Screen<br>Locations<br>X <sub>1</sub> | Y <sub>1</sub> | VEL.<br>(ft/sec) | MV<br>lb-sec | MV<br>lb-sec | MV<br>lb-sec | MV<br>lb-sec |       |       |
|-------------|-----------------------|-----------------------|-----------------------|-----------------------|--------------|--------------------------------------------|----------------|------------------|--------------|--------------|--------------|--------------|-------|-------|
|             |                       | (max)                 | (min)                 | (avg)                 |              |                                            |                |                  |              |              |              |              |       |       |
| 263         | 18.59901              | 998.2342              | 237.4978              | 617.8860              | 0.032149     | 4                                          | 99             | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |       |       |
| 264         | 19.33705              | 933.2983              | 303.1717              | 618.2353              | 0.016507     | 4                                          | -1             | 8 618.2353       | 0.00E+00     | 0.00E+00     | 1.65E-02     | 0.00E+00     |       |       |
| 265         | 7.144065              | 1962.379              | 639.2773              | 1300.278              | 0.012463     | 4                                          | 99             | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |       |       |
| 266         | 6.667290              | 2214.709              | 446.9311              | 1330.820              | 0.018223     | 4                                          | -1             | 8 1330.820       | 0.00E+00     | 0.00E+00     | 1.87E-02     | 0.00E+00     |       |       |
| 267         | 8.584833              | 1750.087              | 519.5067              | 1134.797              | 0.011654     | 4                                          | 99             | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |       |       |
| 268         | 18.68590              | 987.3913              | 276.6836              | 632.0375              | 0.043465     | 4                                          | 99             | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |       |       |
| 269         | 16.78581              | 1034.309              | 405.2623              | 719.7868              | 0.014784     | 3                                          | 1              | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |       |       |
| 270         | 49.95646              | 2615.896              | 639.6292              | 1627.782              | 1.303911     | 4                                          | 0              | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |       |       |
| 271         | 40.75815              | 2229.813              | 874.1562              | 1551.985              | 0.265649     | 4                                          | -99            | 0                | 0.00E+00     | 2.17E-01     | 0.00E+00     | 0.00E+00     |       |       |
| 272         | 30.60606              | 2247.063              | 654.1453              | 1450.607              | 0.216509     | 1                                          | -1             | 6 1578.353       | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |       |       |
| 273         | 26.43332              | 2397.403              | 759.3023              | 1578.353              | 0.172900     | 2                                          | 99             | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |       |       |
| 274         | 27.53340              | 2296.171              | 491.1058              | 1349.638              | 0.187015     | 2                                          | -99            | 0                | 0.00E+00     | 1.38E-01     | 0.00E+00     | 0.00E+00     |       |       |
| 275         | 23.89365              | 2318.359              | 533.8635              | 1476.111              | 0.137671     | 1                                          | -1             | 5 1293.417       | 0.00E+00     | 0.00E+00     | 5.40E-02     | 0.00E+00     |       |       |
| 276         | 25.42177              | 1890.153              | 696.6806              | 1293.417              | 0.054018     | 1                                          | 99             | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |       |       |
| 277         | 30.18886              | 1635.257              | 287.9531              | 961.6053              | 0.242937     | 1                                          | 99             | 0                | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |       |       |
| 278         | 19.25552              | 2179.593              | 519.4659              | 1349.529              | 0.063753     | 3                                          | -99            | 0                | 5.84E-02     | 0.00E+00     | 0.00E+00     | 0.00E+00     |       |       |
| 279         | 31.53911              | 1033.534              | 389.0312              | 711.2829              | 0.053437     | 3                                          | -1             | 7 711.3518       | 0.00E+00     | 0.00E+00     | 3.46E-02     | 0.00E+00     |       |       |
| 280         | 31.20190              | 1029.369              | 393.3338              | 711.3518              | 0.034574     | 3                                          | -99            | 0                | 0.00E+00     | 9.04E-02     | 0.00E+00     | 0.00E+00     |       |       |
| 281         | 41.47876              | 858.9415              | 299.5849              | 574.7632              | 0.090350     | 3                                          | -99            | 0                | 0.00E+00     | 3.30E-02     | 0.00E+00     | 0.00E+00     |       |       |
| 282         | 13.51974              | 2135.782              | 540.5808              | 1318.181              | 0.032982     | 4                                          | -99            | 0                | 0.00E+00     | 9.30E-02     | 0.00E+00     | 0.00E+00     |       |       |
| 283         | 31.22717              | 1150.364              | 222.0735              | 680.2190              | 0.201553     | 3                                          | -99            | 0                | 2.02E-01     | 0.00E+00     | 0.00E+00     | 0.00E+00     |       |       |
| 284         | 29.61061              | 895.6466              | 309.0443              | 602.3455              | 0.047833     | 1                                          | -1             | 5 602.3455       | 0.00E+00     | 0.00E+00     | 0.00E+00     | 0.00E+00     |       |       |
| -----       |                       |                       |                       |                       |              |                                            |                |                  |              |              |              | 4.665        | 7.943 | 7.523 |
| Total       |                       |                       |                       |                       |              |                                            |                |                  |              |              |              |              |       |       |

TABLE F-1. FRAGMENT DATA FROM THE 2.4 POUND CASSED CHARGE TEST (CONTINUED).

| FRHG  | MV       | MV       | MV       | MV       | MV       | MV       | MV       |
|-------|----------|----------|----------|----------|----------|----------|----------|
| NUM   | lb-sec   | lb-sec   | Chg. Ht. | lb-sec   | lb-sec   | lb-sec   | lb-sec   |
| 263   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.21E-02 |
| 264   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 265   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.25E-02 |
| 266   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 267   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.17E-02 |
| 268   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.85E-02 | 0.00E+00 |
| 269   | 0.00E+00 | 1.48E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.30E+00 |
| 270   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 271   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 272   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 273   | 1.73E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.87E-01 |
| 274   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 275   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 276   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.43E-01 | 0.00E+00 |
| 277   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.38E-02 | 0.00E+00 |
| 278   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 279   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 280   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 281   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 282   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 283   | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 284   | 4.78E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| Total | 5.706    | 5.545    | 2.090    | 0.777    | 0.734    |          | 1.696    |

## **APPENDIX G**

**Calculations of Horizontal Blast Impulse Distributions and  
Blast and Fragment Impulse Distributions**

TABLE G-1. CALCULATIONS OF HORIZONTAL BLAST IMPULSE DISTRIBUTIONS AND  
BLAST AND FRAGMENT IMPULSE DISTRIBUTIONS.

| r<br>(in) | 2.373 Lb. Chg. at 6 in.           |                                 |                              |                             | 2.373 Lb. Chg. at 12 in.          |                                 |                              |                             | 2.373 Lb. Chg. at 18 in.          |                                 |                              |                             |
|-----------|-----------------------------------|---------------------------------|------------------------------|-----------------------------|-----------------------------------|---------------------------------|------------------------------|-----------------------------|-----------------------------------|---------------------------------|------------------------------|-----------------------------|
|           | Chg. Only<br>Impulse<br>(psi-sec) | Chg+Frq<br>Impulse<br>(psi-sec) | Total<br>Impulse<br>(lb-sec) | Cumul.<br>Total<br>(lb-sec) | Chg. Only<br>Impulse<br>(psi-sec) | Chg+Frq<br>Impulse<br>(psi-sec) | Total<br>Impulse<br>(lb-sec) | Cumul.<br>Total<br>(lb-sec) | Chg. Only<br>Impulse<br>(psi-sec) | Chg+Frq<br>Impulse<br>(psi-sec) | Total<br>Impulse<br>(lb-sec) | Cumul.<br>Total<br>(lb-sec) |
| 0.00      | 3381.00                           | 3401.00                         | 8.30                         | 8.30                        | 991.20                            | 999.82                          | 2.52                         | 2.52                        | 516.40                            | 521.44                          | 1.32                         | 1.32                        |
| 0.90      | 3242.00                           | 3261.96                         | 22.10                        | 30.40                       | 981.40                            | 990.00                          | 7.34                         | 9.86                        | 514.30                            | 519.33                          | 3.91                         | 5.24                        |
| 1.80      | 2875.00                           | 2894.85                         | 30.68                        | 61.08                       | 952.80                            | 961.36                          | 11.66                        | 21.52                       | 507.80                            | 512.80                          | 6.39                         | 11.63                       |
| 2.70      | 2392.00                           | 2411.67                         | 34.24                        | 95.32                       | 908.20                            | 916.68                          | 15.31                        | 36.63                       | 497.30                            | 502.26                          | 8.70                         | 20.32                       |
| 3.60      | 1903.00                           | 1922.43                         | 32.10                        | 129.52                      | 851.10                            | 859.47                          | 18.19                        | 55.02                       | 483.30                            | 488.20                          | 10.79                        | 31.11                       |
| 4.50      | 1474.00                           | 1493.13                         | 32.10                        | 161.63                      | 785.90                            | 794.15                          | 20.28                        | 75.30                       | 466.20                            | 471.02                          | 12.63                        | 43.74                       |
| 5.40      | 1128.00                           | 1146.79                         | 29.13                        | 190.76                      | 716.50                            | 724.60                          | 21.65                        | 96.95                       | 446.60                            | 451.34                          | 14.22                        | 57.96                       |
| 6.30      | 862.20                            | 880.62                          | 25.97                        | 216.73                      | 646.60                            | 654.54                          | 22.39                        | 119.34                      | 425.20                            | 429.84                          | 15.54                        | 73.50                       |
| 7.20      | 662.40                            | 680.41                          | 23.00                        | 239.73                      | 578.80                            | 586.56                          | 22.62                        | 141.96                      | 402.60                            | 407.14                          | 16.60                        | 90.10                       |
| 8.10      | 514.10                            | 531.69                          | 20.36                        | 260.09                      | 513.20                            | 522.78                          | 22.44                        | 164.40                      | 379.30                            | 383.73                          | 17.42                        | 107.52                      |
| 9.00      | 404.00                            | 421.16                          | 18.10                        | 278.19                      | 456.80                            | 464.40                          | 21.98                        | 186.38                      | 355.90                            | 360.22                          | 18.01                        | 125.53                      |
| 9.90      | 322.00                            | 338.72                          | 16.19                        | 294.39                      | 404.10                            | 411.31                          | 21.32                        | 207.70                      | 332.60                            | 337.01                          | 18.41                        | 143.94                      |
| 10.80     | 260.40                            | 276.68                          | 14.60                        | 308.98                      | 357.20                            | 364.22                          | 20.53                        | 228.23                      | 310.40                            | 314.50                          | 18.63                        | 162.56                      |
| 11.70     | 213.60                            | 229.45                          | 13.28                        | 322.26                      | 315.90                            | 322.23                          | 19.69                        | 247.92                      | 288.80                            | 292.79                          | 18.71                        | 181.27                      |
| 12.60     | 177.80                            | 193.22                          | 12.18                        | 334.44                      | 279.90                            | 286.55                          | 18.82                        | 266.73                      | 268.40                            | 272.23                          | 18.67                        | 199.94                      |
| 13.50     | 150.10                            | 165.11                          | 11.29                        | 345.73                      | 248.50                            | 254.97                          | 17.96                        | 284.70                      | 249.20                            | 252.98                          | 18.53                        | 218.47                      |
| 14.40     | 128.50                            | 143.10                          | 10.55                        | 356.28                      | 221.40                            | 227.69                          | 17.13                        | 301.83                      | 231.20                            | 234.88                          | 18.32                        | 236.79                      |
| 15.30     | 111.40                            | 125.61                          | 9.95                         | 366.23                      | 197.90                            | 204.02                          | 16.36                        | 318.19                      | 214.60                            | 218.18                          | 18.06                        | 254.85                      |
| 16.20     | 97.87                             | 111.70                          | 9.46                         | 375.69                      | 177.70                            | 183.66                          | 15.63                        | 333.82                      | 199.30                            | 202.78                          | 17.76                        | 272.61                      |
| 17.10     | 86.99                             | 100.45                          | 9.06                         | 384.75                      | 160.20                            | 166.00                          | 14.96                        | 348.78                      | 185.20                            | 188.59                          | 17.44                        | 290.05                      |
| 18.00     | 78.22                             | 91.32                           | 8.75                         | 393.50                      | 145.10                            | 150.75                          | 14.37                        | 363.14                      | 172.40                            | 175.70                          | 17.10                        | 307.15                      |
| 18.90     | 71.09                             | 83.85                           | 8.50                         | 402.00                      | 132.20                            | 137.70                          | 13.83                        | 376.97                      | 160.70                            | 163.92                          | 16.77                        | 323.92                      |
| 19.80     | 65.28                             | 77.72                           | 8.32                         | 410.32                      | 121.00                            | 126.36                          | 13.34                        | 390.31                      | 150.10                            | 153.23                          | 16.44                        | 340.35                      |
| 20.70     | 60.52                             | 72.64                           | 8.10                         | 418.51                      | 111.30                            | 116.52                          | 12.92                        | 403.23                      | 140.50                            | 143.55                          | 16.12                        | 356.47                      |
| 21.60     | 56.62                             | 68.44                           | 8.05                         | 426.60                      | 102.90                            | 107.99                          | 12.55                        | 415.78                      | 131.80                            | 134.78                          | 15.81                        | 372.28                      |
| 22.50     | 53.41                             | 64.94                           | 8.04                         | 434.65                      | 95.69                             | 100.66                          | 12.24                        | 428.02                      | 123.90                            | 126.81                          | 15.54                        | 387.82                      |
| 23.40     | 50.77                             | 62.02                           | 8.06                         | 442.69                      | 89.45                             | 94.30                           | 11.97                        | 439.99                      | 116.90                            | 119.74                          | 15.29                        | 403.11                      |
| 24.30     | 48.62                             | 59.60                           | 8.11                         | 450.73                      | 84.04                             | 88.77                           | 11.76                        | 451.75                      | 110.60                            | 113.37                          | 15.06                        | 418.17                      |
| 25.20     | 46.86                             | 57.59                           | 8.19                         | 458.86                      | 79.38                             | 84.00                           | 11.58                        | 463.33                      | 104.90                            | 107.60                          | 14.86                        | 433.03                      |
| 26.10     | 45.43                             | 55.91                           | 8.29                         | 467.05                      | 75.34                             | 79.86                           | 11.45                        | 474.78                      | 99.79                             | 102.43                          | 14.69                        | 447.72                      |
| 27.00     | 44.30                             | 54.55                           | 8.42                         | 475.34                      | 71.87                             | 76.29                           | 11.36                        | 486.15                      | 95.24                             | 97.82                           | 14.55                        | 462.26                      |
| 27.90     | 43.40                             | 53.42                           | 8.57                         | 483.75                      | 68.88                             | 73.20                           | 11.31                        | 497.45                      | 91.19                             | 93.71                           | 14.44                        | 476.70                      |
| 28.80     | 42.72                             | 52.52                           | 8.74                         | 492.39                      | 66.31                             | 70.53                           | 11.24                        | 508.74                      | 87.58                             | 90.05                           | 14.35                        | 491.06                      |
| 29.70     | 42.22                             | 51.81                           | 8.93                         | 501.07                      | 64.12                             | 68.25                           | 11.30                        | 520.05                      | 84.37                             | 86.79                           | 14.31                        | 505.36                      |
| 30.60     | 41.87                             | 51.26                           | 9.14                         | 510.00                      | 62.26                             | 66.31                           | 11.35                        | 531.40                      | 81.54                             | 83.91                           | 14.24                        | 519.65                      |
| 31.50     | 41.67                             | 50.86                           | 9.37                         | 519.14                      | 60.68                             | 64.64                           | 11.43                        | 542.83                      | 79.04                             | 81.36                           | 14.20                        | 533.94                      |
| 32.40     | 41.59                             | 50.60                           | 9.62                         | 528.51                      | 59.37                             | 63.25                           | 11.53                        | 554.36                      | 76.84                             | 79.11                           | 14.33                        | 548.27                      |
| 33.30     | 41.62                             | 50.45                           | 9.89                         | 538.13                      | 58.29                             | 62.09                           | 11.67                        | 566.03                      | 74.93                             | 77.15                           | 14.40                        | 562.67                      |
| 34.20     | 41.75                             | 50.41                           | 10.17                        | 548.02                      | 57.42                             | 61.15                           | 11.83                        | 577.86                      | 73.26                             | 75.44                           | 14.49                        | 577.16                      |
| 35.10     | 41.97                             | 50.46                           | 10.47                        | 558.19                      | 56.73                             | 60.39                           | 12.02                        | 589.89                      | 71.83                             | 73.97                           | 14.62                        | 591.78                      |
| 36.00     | 42.27                             | 50.60                           | 56.29                        | 614.48                      | 56.21                             | 59.80                           | 66.53                        | 656.41                      | 70.61                             | 72.71                           | 60.89                        | 672.67                      |

Impulse over 6x6 = 614.48 lb-sec Impulse over 6x6 = 656.41 lb-sec Impulse over 6x6 = 672.67 lb-sec

TABLE G-1. CALCULATIONS OF HORIZONTAL BLAST IMPULSE DISTRIBUTIONS AND  
BLAST AND FRAGMENT IMPULSE DISTRIBUTIONS (CONTINUED).

| r<br>(in.)                                                                                                     | 0.5666 Lb. Chg. at 6 in.          |                                 |                              |                             | 0.5666 Lb. Chg. at 12 in.         |                                 |                              |                             | 0.5666 Lb. Chg. at 18 in.         |                                 |                              |                             |
|----------------------------------------------------------------------------------------------------------------|-----------------------------------|---------------------------------|------------------------------|-----------------------------|-----------------------------------|---------------------------------|------------------------------|-----------------------------|-----------------------------------|---------------------------------|------------------------------|-----------------------------|
|                                                                                                                | Chg. Only<br>Impulse<br>(psi-sec) | Chgt+Frq<br>Impulse<br>(lb-sec) | Total<br>Impulse<br>(lb-sec) | Cumul.<br>Total<br>(lb-sec) | Chg. Only<br>Impulse<br>(psi-sec) | Chgt+Frq<br>Impulse<br>(lb-sec) | Total<br>Impulse<br>(lb-sec) | Cumul.<br>Total<br>(lb-sec) | Chg. Only<br>Impulse<br>(psi-sec) | Chgt+Frq<br>Impulse<br>(lb-sec) | Total<br>Impulse<br>(lb-sec) | Cumul.<br>Total<br>(lb-sec) |
| 0.00                                                                                                           | 886.70                            | 1806.40                         | 4.59                         | 4.59                        | 286.70                            | 659.84                          | 1.67                         | 1.67                        | 157.10                            | 365.64                          | 0.93                         | 0.93                        |
| 0.50                                                                                                           | 851.70                            | 1804.68                         | 13.47                        | 18.06                       | 284.20                            | 656.44                          | 4.94                         | 6.61                        | 156.50                            | 364.65                          | 2.76                         | 3.69                        |
| 1.00                                                                                                           | 759.00                            | 1764.59                         | 21.17                        | 39.23                       | 276.20                            | 646.58                          | 8.03                         | 14.64                       | 154.70                            | 361.70                          | 4.54                         | 8.23                        |
| 1.50                                                                                                           | 636.50                            | 1663.64                         | 27.25                        | 66.48                       | 264.00                            | 631.03                          | 10.88                        | 25.52                       | 151.80                            | 356.92                          | 6.24                         | 14.47                       |
| 2.00                                                                                                           | 511.50                            | 1530.01                         | 31.87                        | 98.35                       | 248.30                            | 610.81                          | 13.45                        | 38.97                       | 147.90                            | 350.50                          | 7.85                         | 22.32                       |
| 2.50                                                                                                           | 401.00                            | 1391.40                         | 35.42                        | 133.77                      | 230.40                            | 587.39                          | 15.73                        | 54.70                       | 143.10                            | 342.61                          | 9.34                         | 31.66                       |
| 3.00                                                                                                           | 311.10                            | 1265.22                         | 38.31                        | 172.07                      | 211.30                            | 561.93                          | 17.72                        | 72.42                       | 137.70                            | 333.66                          | 10.71                        | 42.37                       |
| 3.50                                                                                                           | 241.40                            | 1158.01                         | 40.83                        | 212.91                      | 192.10                            | 535.71                          | 19.45                        | 91.87                       | 131.80                            | 323.83                          | 11.96                        | 54.34                       |
| 4.00                                                                                                           | 188.80                            | 1069.77                         | 43.16                        | 256.07                      | 173.50                            | 509.59                          | 20.94                        | 112.81                      | 125.60                            | 313.43                          | 13.09                        | 67.43                       |
| 4.50                                                                                                           | 149.40                            | 997.79                          | 45.38                        | 301.45                      | 155.90                            | 484.12                          | 22.24                        | 135.05                      | 119.20                            | 302.64                          | 14.10                        | 81.53                       |
| 5.00                                                                                                           | 120.10                            | 939.50                          | 47.51                        | 348.96                      | 139.80                            | 459.95                          | 23.37                        | 158.42                      | 112.80                            | 291.73                          | 15.01                        | 96.54                       |
| 5.50                                                                                                           | 98.19                             | 889.08                          | 49.58                        | 398.53                      | 125.30                            | 437.29                          | 24.37                        | 182.79                      | 106.50                            | 280.86                          | 15.82                        | 112.36                      |
| 6.00                                                                                                           | 81.72                             | 847.05                          | 51.57                        | 450.10                      | 112.50                            | 416.33                          | 25.25                        | 208.04                      | 100.50                            | 270.30                          | 16.54                        | 128.90                      |
| 6.50                                                                                                           | 69.27                             | 810.63                          | 53.34                        | 503.60                      | 101.20                            | 396.93                          | 26.05                        | 234.09                      | 94.67                             | 259.95                          | 17.18                        | 146.08                      |
| 7.00                                                                                                           | 59.80                             | 778.56                          | 55.34                        | 558.94                      | 91.39                             | 379.16                          | 26.78                        | 260.87                      | 89.23                             | 250.06                          | 17.76                        | 163.84                      |
| 7.50                                                                                                           | 52.56                             | 749.91                          | 57.11                        | 616.05                      | 82.93                             | 362.92                          | 27.46                        | 288.33                      | 84.17                             | 240.65                          | 18.28                        | 182.12                      |
| 8.00                                                                                                           | 46.99                             | 723.99                          | 58.81                        | 674.86                      | 75.68                             | 348.09                          | 28.05                        | 316.42                      | 79.51                             | 231.75                          | 18.76                        | 200.88                      |
| 8.50                                                                                                           | 42.71                             | 700.30                          | 60.43                        | 735.29                      | 69.49                             | 334.55                          | 28.70                        | 345.12                      | 75.25                             | 223.39                          | 19.20                        | 220.08                      |
| 9.00                                                                                                           | 39.43                             | 678.49                          | 61.98                        | 797.27                      | 64.25                             | 322.20                          | 29.27                        | 374.39                      | 71.40                             | 215.56                          | 19.61                        | 239.69                      |
| 9.50                                                                                                           | 36.92                             | 658.30                          | 63.47                        | 860.73                      | 59.85                             | 310.92                          | 29.83                        | 404.23                      | 67.95                             | 208.28                          | 20.00                        | 259.69                      |
| 10.00                                                                                                          | 35.02                             | 639.50                          | 64.89                        | 925.62                      | 56.11                             | 300.59                          | 30.38                        | 434.60                      | 64.88                             | 201.51                          | 20.33                        | 280.02                      |
| 10.50                                                                                                          | 33.61                             | 621.93                          | 66.25                        | 991.87                      | 53.02                             | 291.14                          | 30.91                        | 465.51                      | 61.82                             | 194.90                          | 20.63                        | 300.65                      |
| 11.00                                                                                                          | 32.60                             | 605.46                          | 67.56                        | 1059.43                     | 50.47                             | 282.48                          | 31.44                        | 496.95                      | 58.86                             | 188.53                          | 20.90                        | 321.55                      |
| 11.50                                                                                                          | 31.92                             | 589.98                          | 68.82                        | 1128.25                     | 48.38                             | 274.52                          | 31.96                        | 528.91                      | 56.11                             | 182.49                          | 21.14                        | 342.69                      |
| 12.00                                                                                                          | 31.30                             | 575.41                          | 70.03                        | 1198.28                     | 46.71                             | 267.21                          | 32.46                        | 561.38                      | 53.56                             | 176.80                          | 21.37                        | 364.07                      |
| 12.50                                                                                                          | 31.31                             | 561.66                          | 71.21                        | 1269.49                     | 45.38                             | 260.48                          | 32.91                        | 594.29                      | 51.18                             | 171.39                          | 21.58                        | 385.64                      |
| 13.00                                                                                                          | 31.30                             | 546.67                          | 72.34                        | 1341.83                     | 43.65                             | 253.55                          | 33.20                        | 627.58                      | 48.97                             | 166.28                          | 21.77                        | 407.42                      |
| 13.50                                                                                                          | 31.46                             | 536.39                          | 73.44                        | 1415.28                     | 41.89                             | 246.81                          | 33.64                        | 661.22                      | 46.90                             | 161.43                          | 21.95                        | 429.37                      |
| 14.00                                                                                                          | 31.76                             | 524.76                          | 74.52                        | 1489.79                     | 40.25                             | 240.39                          | 33.98                        | 695.20                      | 44.97                             | 156.82                          | 22.11                        | 451.48                      |
| 14.50                                                                                                          | 31.76                             | 513.75                          | 75.35                        | 1565.15                     | 38.71                             | 234.26                          | 34.29                        | 729.49                      | 43.17                             | 152.46                          | 22.26                        | 473.74                      |
| 15.00                                                                                                          | 30.77                             | 501.89                          | 76.17                        | 1641.32                     | 37.27                             | 228.41                          | 34.59                        | 764.08                      | 41.47                             | 148.30                          | 22.41                        | 496.15                      |
| 15.50                                                                                                          | 30.05                             | 490.73                          | 76.95                        | 1718.27                     | 35.91                             | 222.82                          | 34.86                        | 798.95                      | 39.89                             | 144.35                          | 22.54                        | 518.69                      |
| 16.00                                                                                                          | 28.95                             | 479.97                          | 77.67                        | 1795.94                     | 34.63                             | 217.47                          | 35.12                        | 834.07                      | 38.39                             | 140.58                          | 22.66                        | 541.35                      |
| 16.50                                                                                                          | 27.64                             | 469.59                          | 78.36                        | 1874.30                     | 33.42                             | 212.35                          | 35.37                        | 869.44                      | 36.99                             | 136.93                          | 22.77                        | 564.12                      |
| 17.00                                                                                                          | 27.11                             | 459.58                          | 79.00                        | 1953.30                     | 32.28                             | 207.45                          | 35.62                        | 905.04                      | 35.67                             | 133.57                          | 22.88                        | 587.00                      |
| 17.50                                                                                                          | 26.40                             | 449.93                          | 79.61                        | 2032.91                     | 31.20                             | 202.75                          | 35.82                        | 940.85                      | 34.43                             | 130.30                          | 22.98                        | 609.98                      |
| 18.00                                                                                                          | 25.70                             | 440.64                          | 80.19                        | 2113.10                     | 30.18                             | 198.24                          | 36.02                        | 976.88                      | 33.26                             | 127.19                          | 23.07                        | 633.05                      |
| 18.50                                                                                                          | 25.02                             | 431.67                          | 80.73                        | 2193.83                     | 29.21                             | 193.92                          | 36.22                        | 1013.09                     | 32.15                             | 124.20                          | 23.16                        | 656.21                      |
| 19.00                                                                                                          | 24.37                             | 423.02                          | 81.26                        | 2275.09                     | 28.29                             | 189.77                          | 36.40                        | 1049.50                     | 31.11                             | 121.36                          | 23.24                        | 679.45                      |
| 19.50                                                                                                          | 23.73                             | 414.69                          | 81.75                        | 2356.83                     | 27.42                             | 185.78                          | 36.58                        | 1086.07                     | 30.12                             | 118.62                          | 23.32                        | 702.77                      |
| 20.00                                                                                                          | 23.12                             | 406.65                          | 82.23                        | 2439.06                     | 26.60                             | 181.96                          | 36.76                        | 1123.03                     | 29.18                             | 116.01                          | 23.40                        | 726.17                      |
| Impulse over 6x6 = 2809.23 lb-sec      Impulse over 6x6 = 1288.50 lb-sec      Impulse over 6x6 = 831.83 lb-sec |                                   |                                 |                              |                             |                                   |                                 |                              |                             |                                   |                                 |                              |                             |
| Impulse over 3x3 = 1103.48 lb-sec      Impulse over 3x3 = 518.20 lb-sec      Impulse over 3x3 = 336.07 lb-sec  |                                   |                                 |                              |                             |                                   |                                 |                              |                             |                                   |                                 |                              |                             |



## **APPENDIX H**

### **Severe Dynamic Environments (Krauthammer) Code Output**

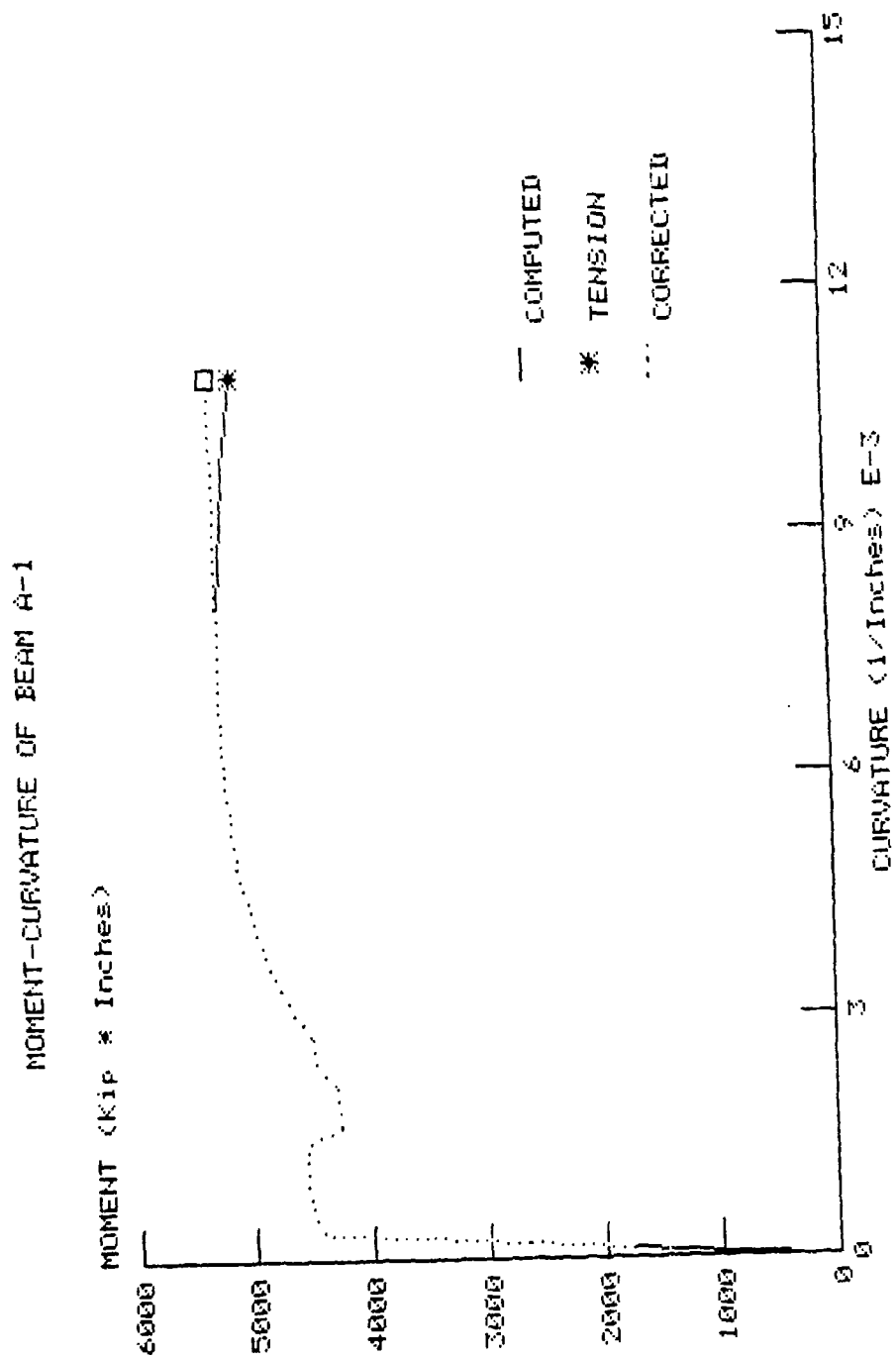


Figure H-1.1. Moment-Curvature of Beam A-1.

LOAD-DEFLECTION FOR BEAM A-1

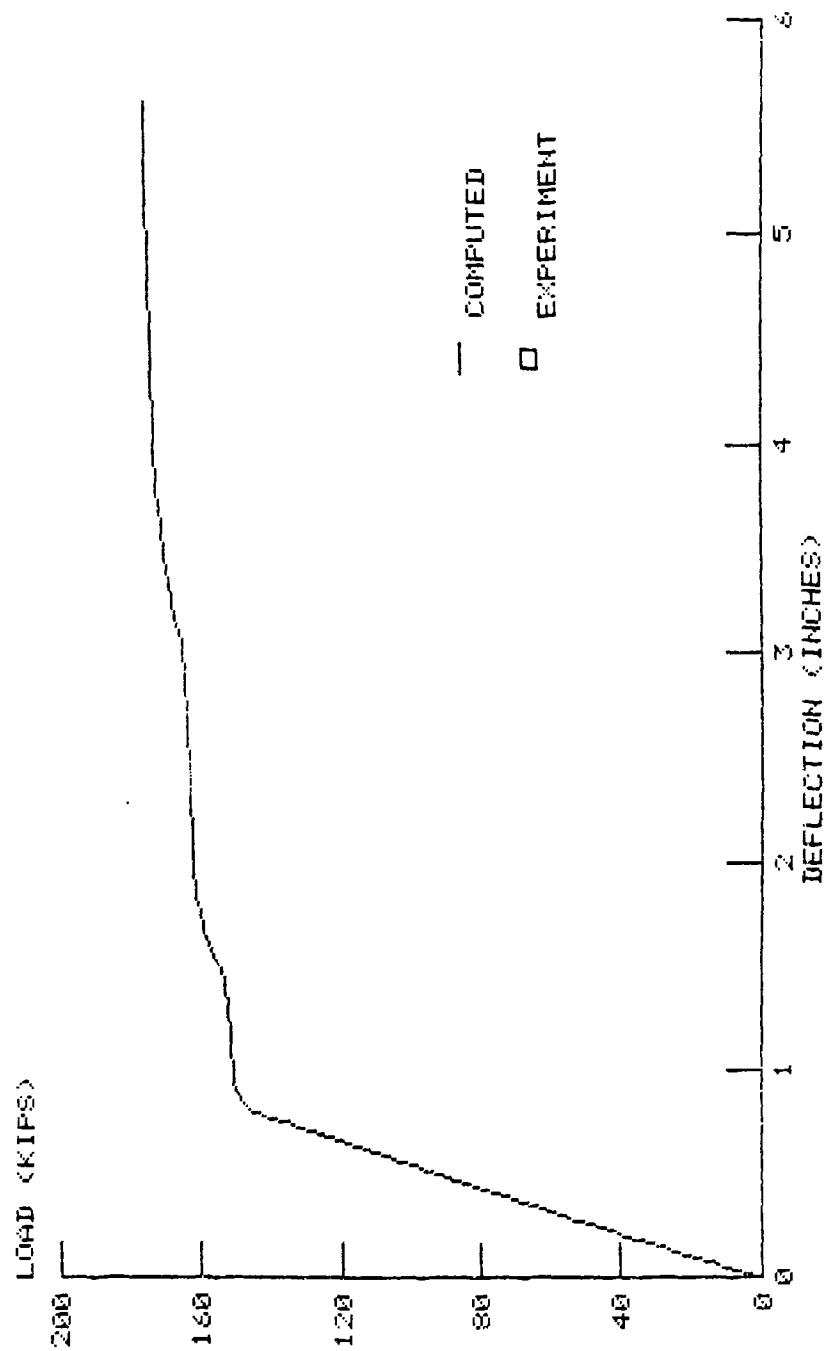


Figure H-2. Load Deflection for Beam A-1.

Air Blast of AFESC Case A1  
 191 LB C-4, 25.8 Inch Standoff  
 FORCING FUNCTION (KIPS)

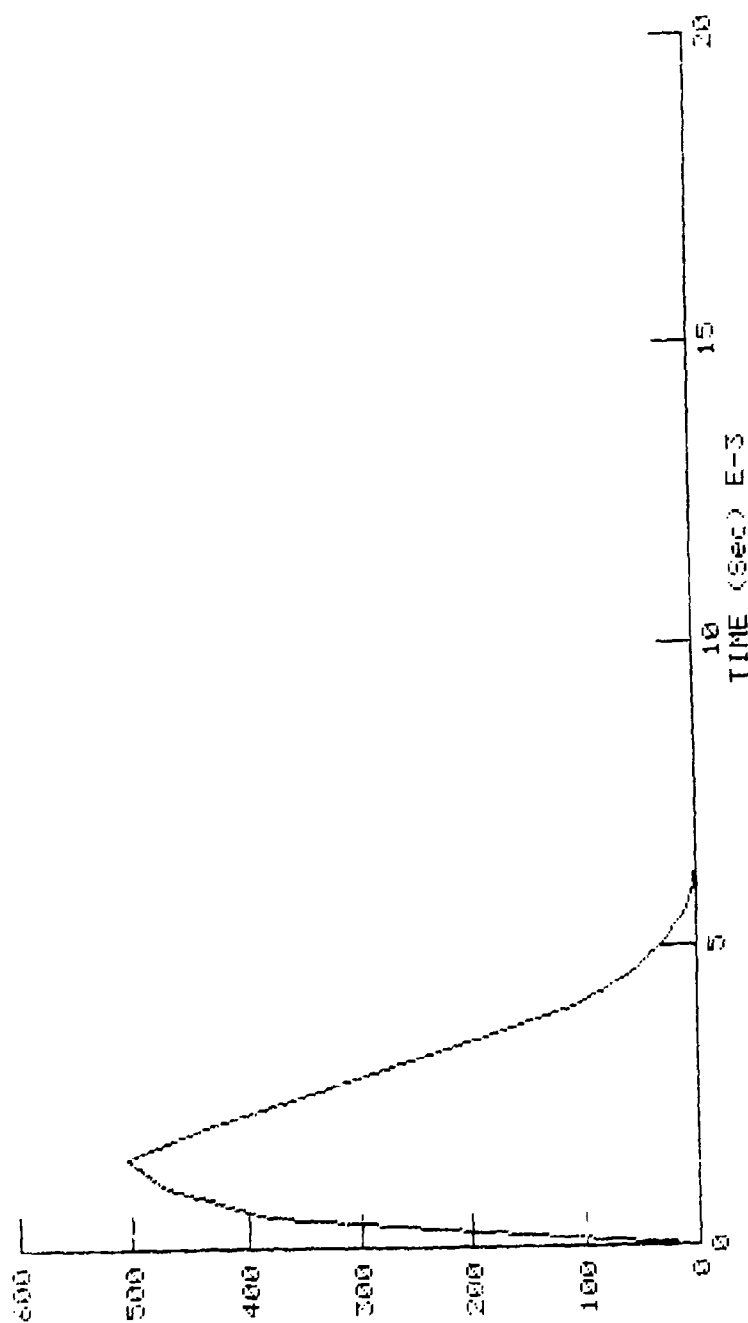


Figure H-3. Air Blast of AFESC Case A-1;  
 191 Pound C-4, 25.8 Inch Standoff; Forcing Function, Time.

Air Blast Of AFESC Case A1  
 191 LB C-4, 25.8 Inch Standoff

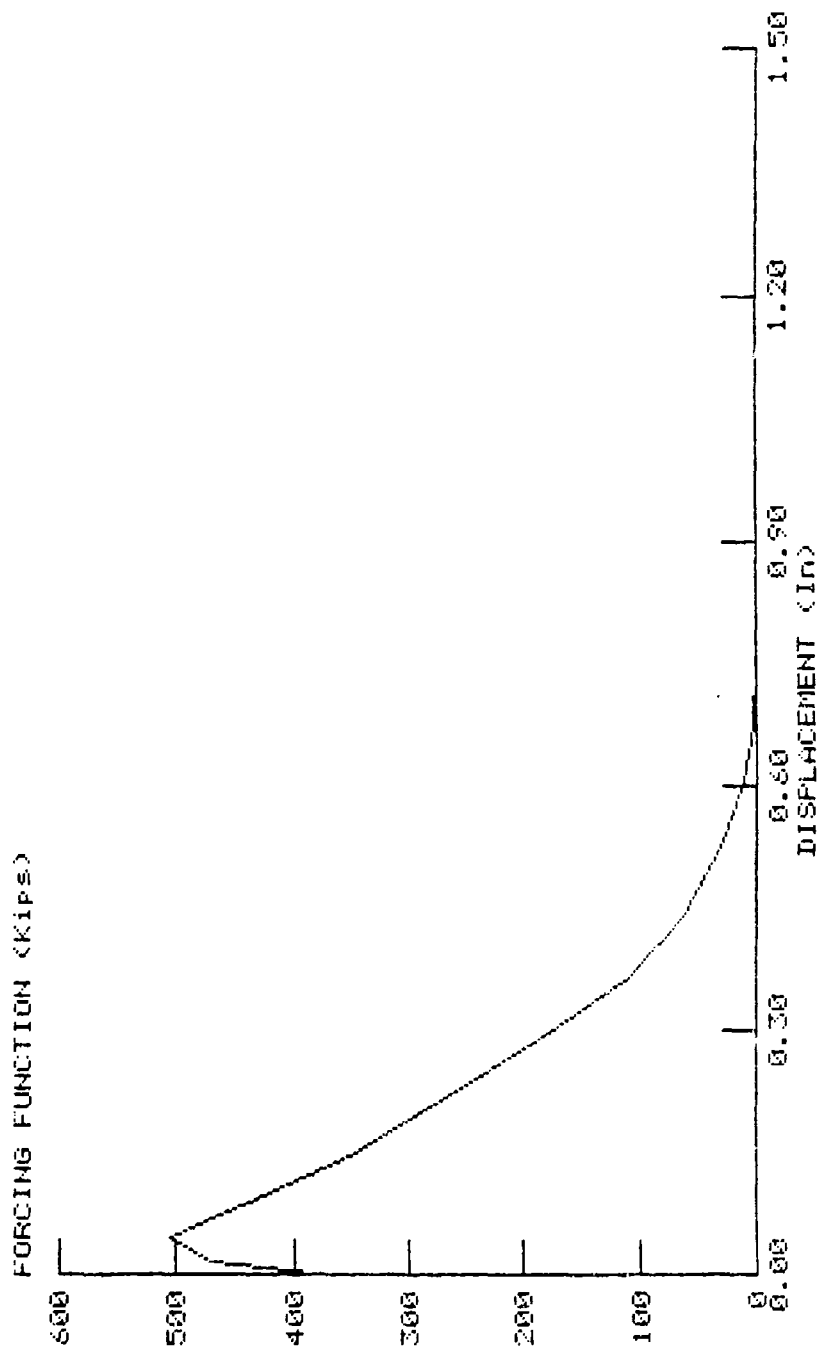


Figure H-4. Air Blast of AFESC Case A-1;  
 191 Pound C-4, 25.8 Inch Standoff; Forcing Function, Disp.

Air Blast of AFESC Case A1  
191 LB C-4, 25.8 Inch Standoff

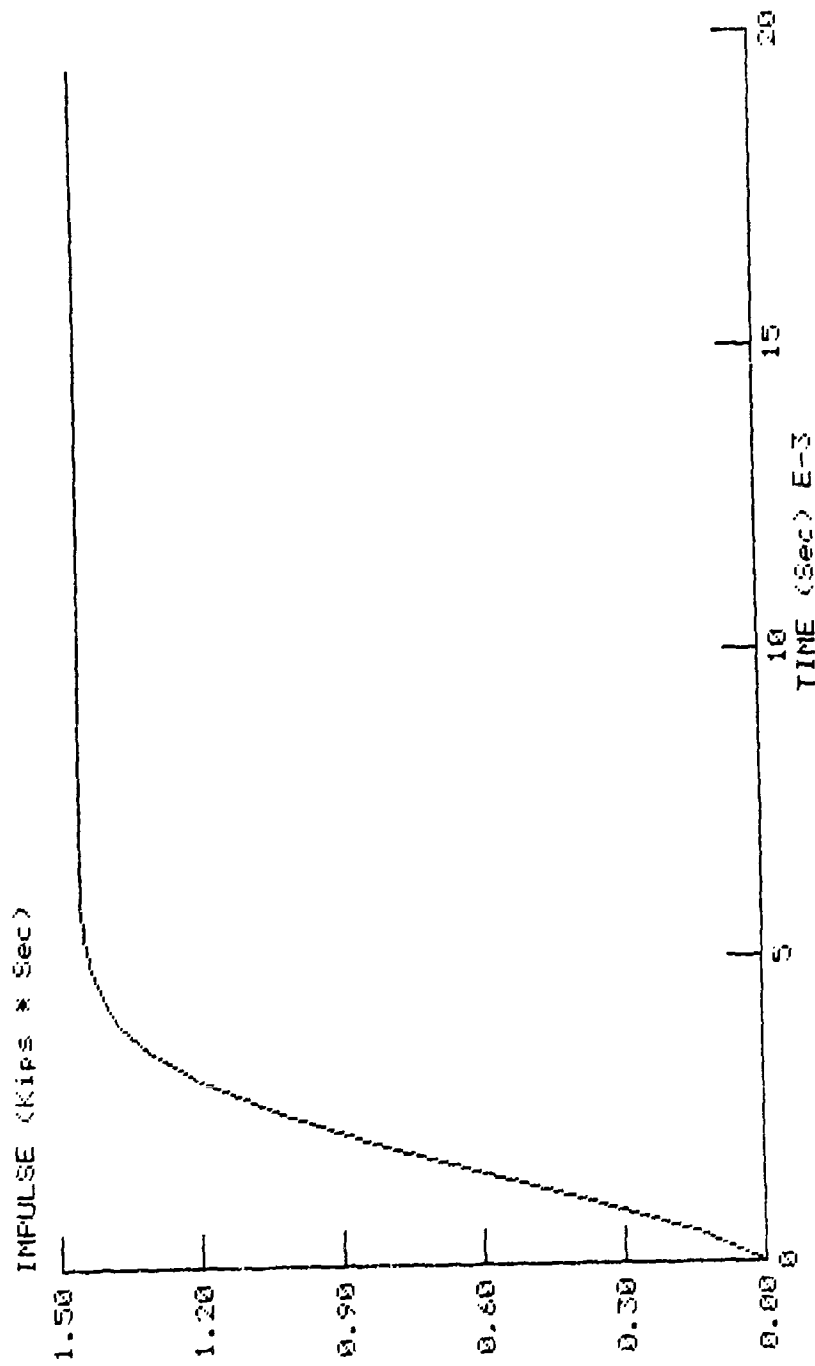


Figure H-5. Air Blast of AFESC Case A-1;  
191 Pound C-4, 25.8 Inch Standoff; Impulse, Time.

Air Blast Of AFESC Case A1  
 191 LB C-4, 25.8 Inch Standoff

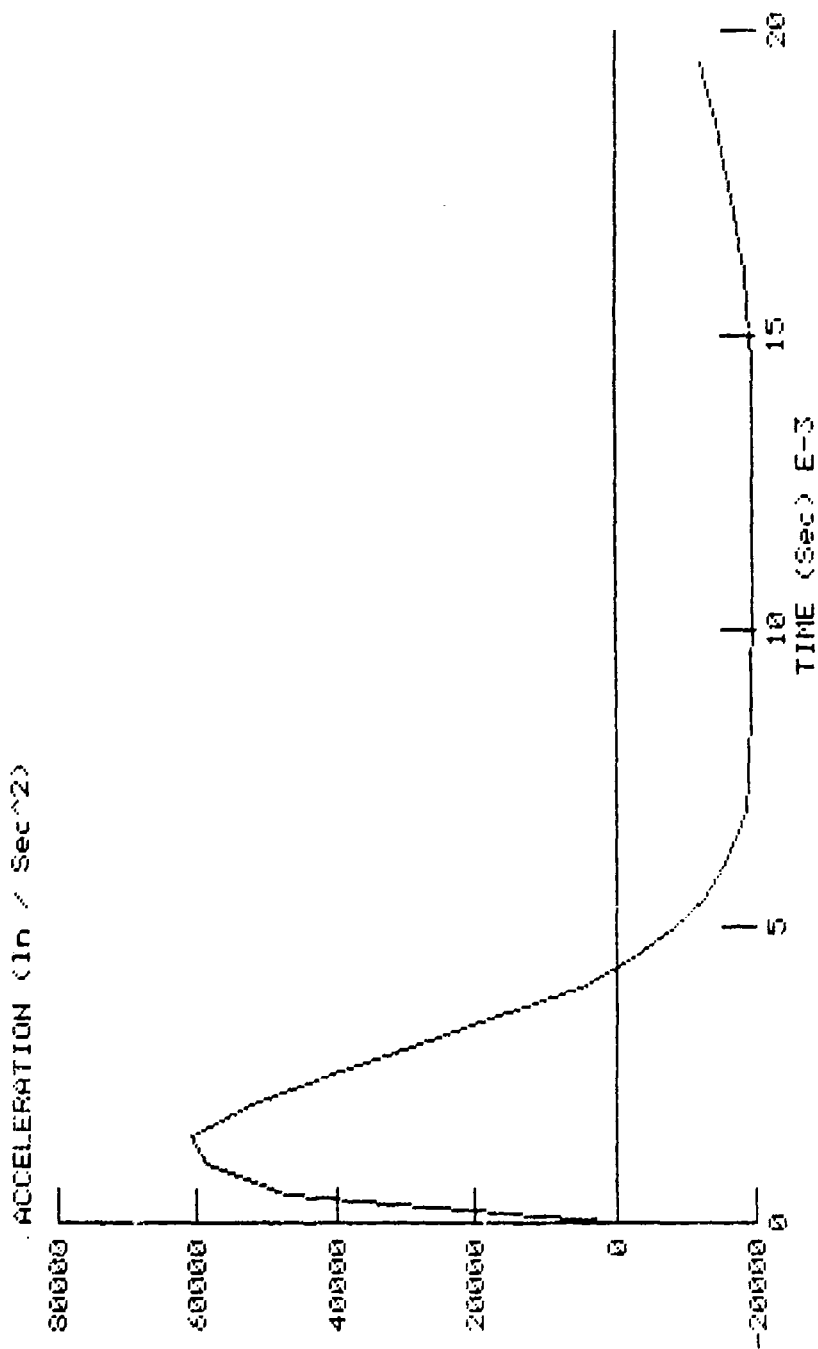


Figure H-6. Air Blast of AFESC Case A-1;  
 191 Pound C-4, 25.8 Inch Standoff; Acceleration, Time.

Air Blast of AFESC Case A1  
 191 LB C-4, 25.8 Inch Standoff

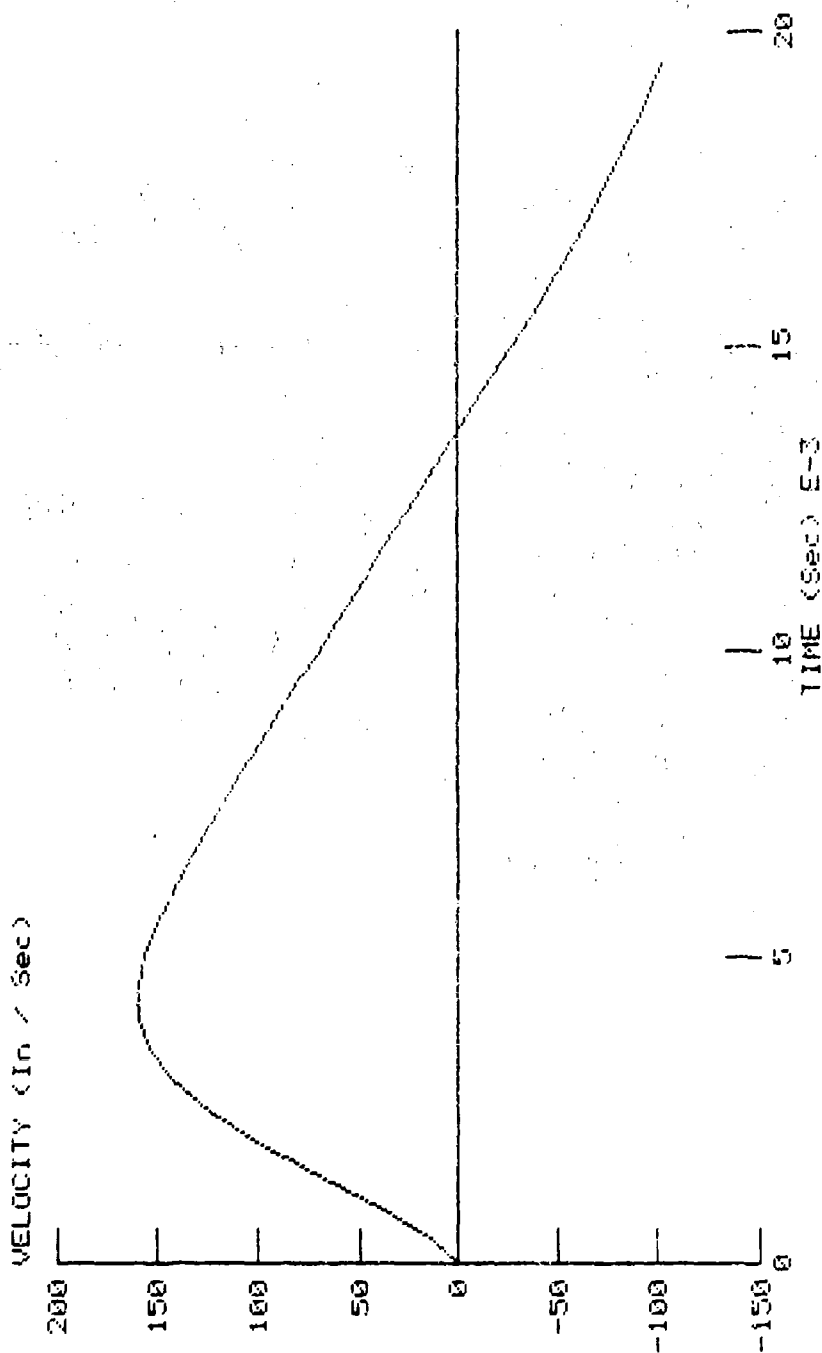


Figure H-7. Air Blast of AFESC Case A-1;  
 191 Pound C-4, 25.8 Inch Standoff; Velocity, Time.



Air Blast Of AFESC Case A1  
191 LB C-4, 25.8 Inch Standoff

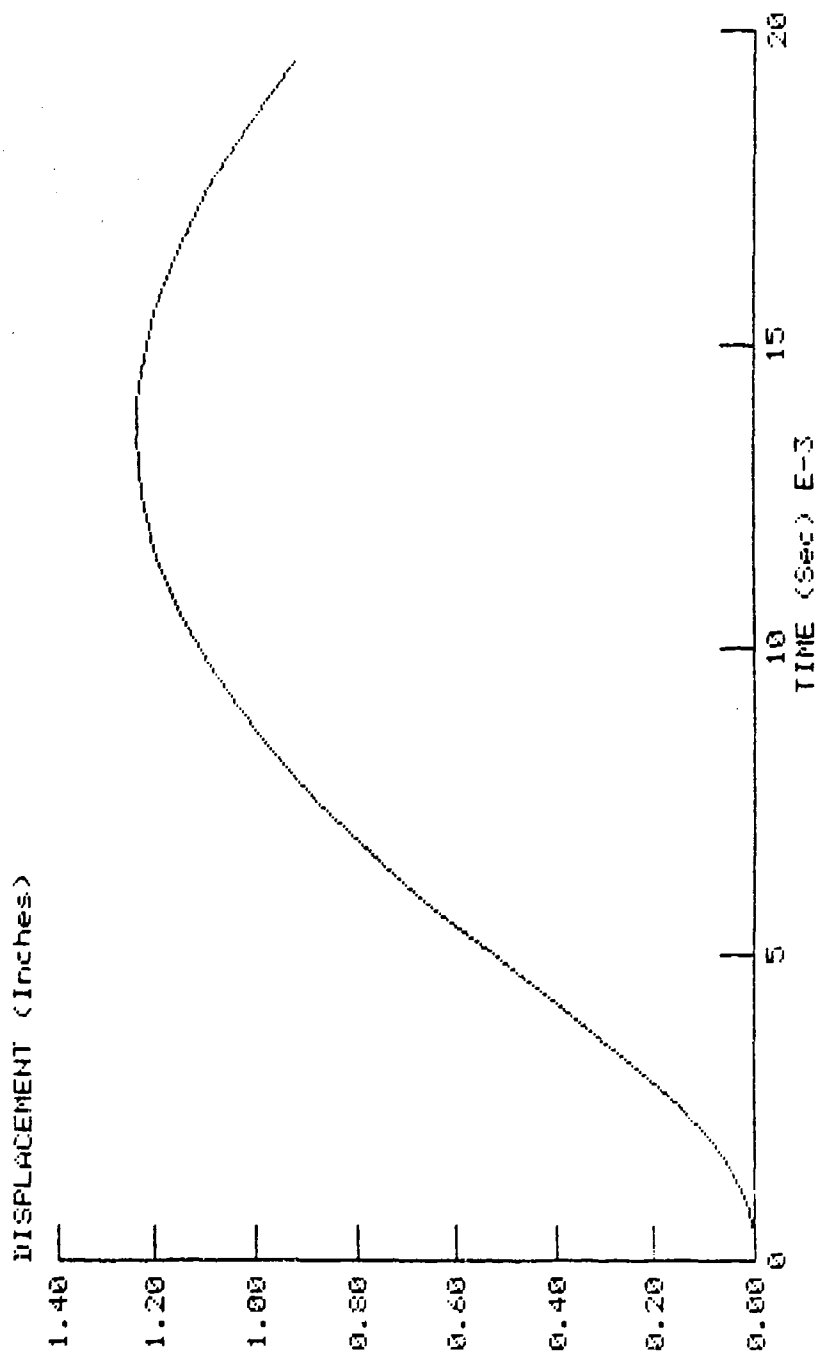


Figure H-8. Air Blast of AFESC Case A-1;  
191 Pound C-4, 25.8 Inch Standoff; Displacement, Time.

Air Blast Of AFESC Case A1  
 191 LB C-4, 25.8 Inch Standoff  
 PLASTIC DISP. (Inches)

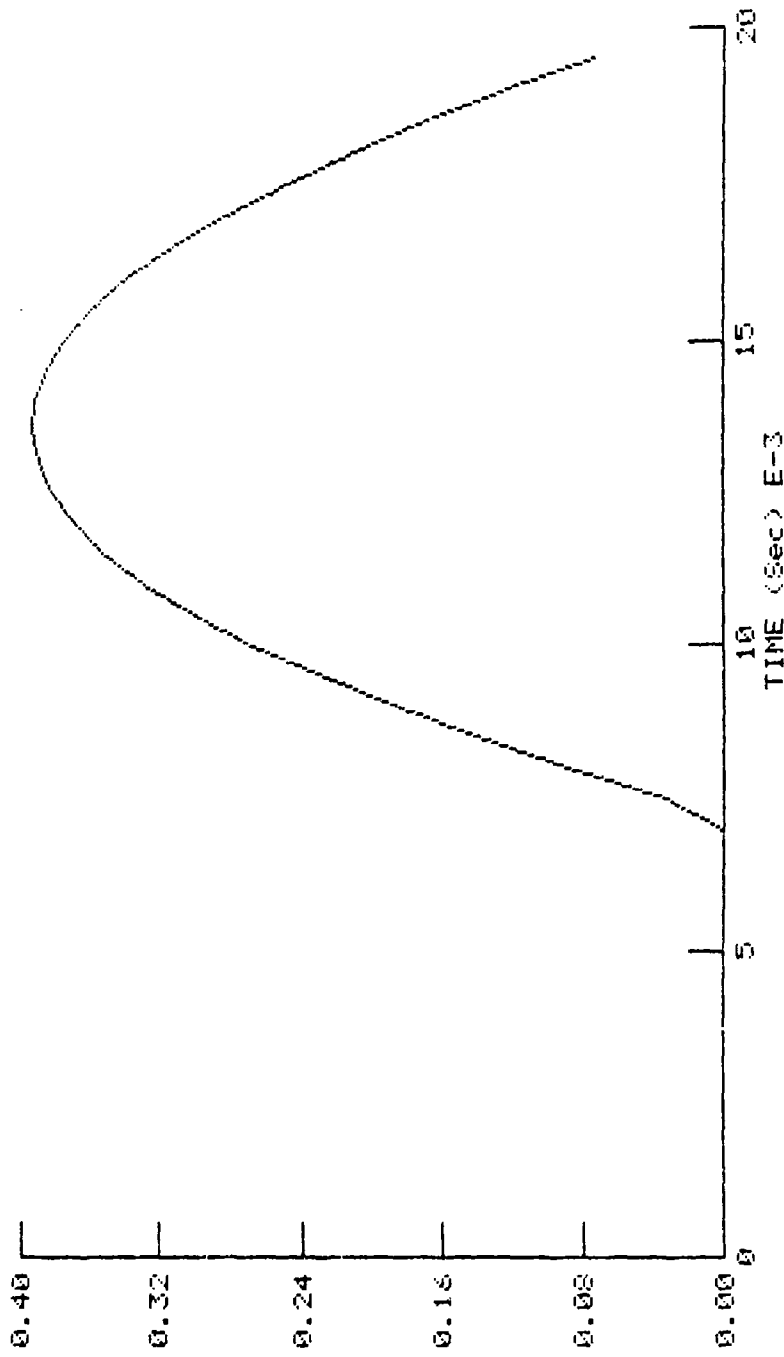


Figure H-9. Air Blast of AFESC Case A-1;  
 191 Pound C-4, 25.8 Inch Standoff; Plast. Disp., Time

Air Blast Of AFESC Case A1  
 191 LB C-4, 25.8 Inch Standoff

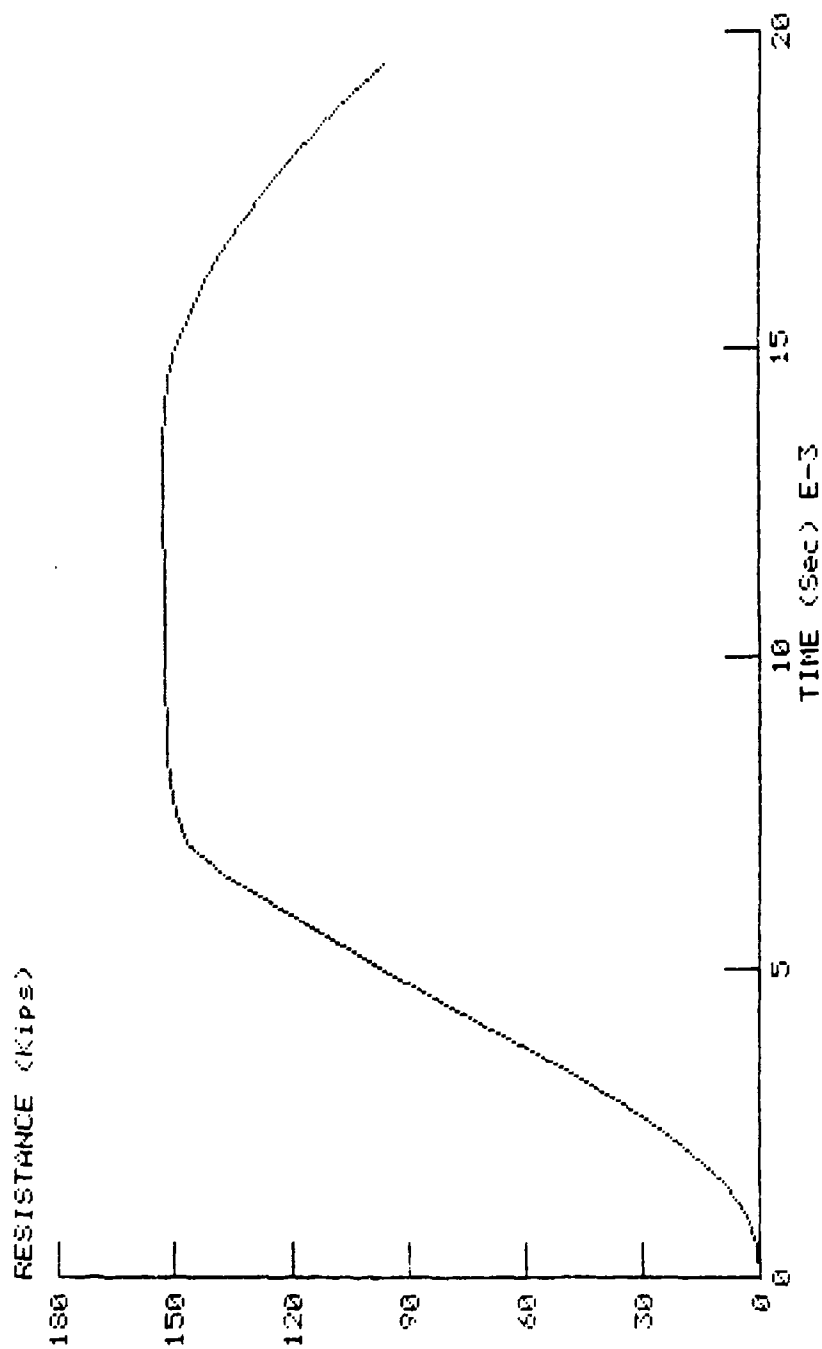


Figure H-10. Air Blast of AFESC Case A-1;  
 191 Pound C-4, 25.8 Inch Standoff; Resistance, Time.

Air Blast Of AFESC Case A1  
191 LB C-4, 25.8 Inch Standoff

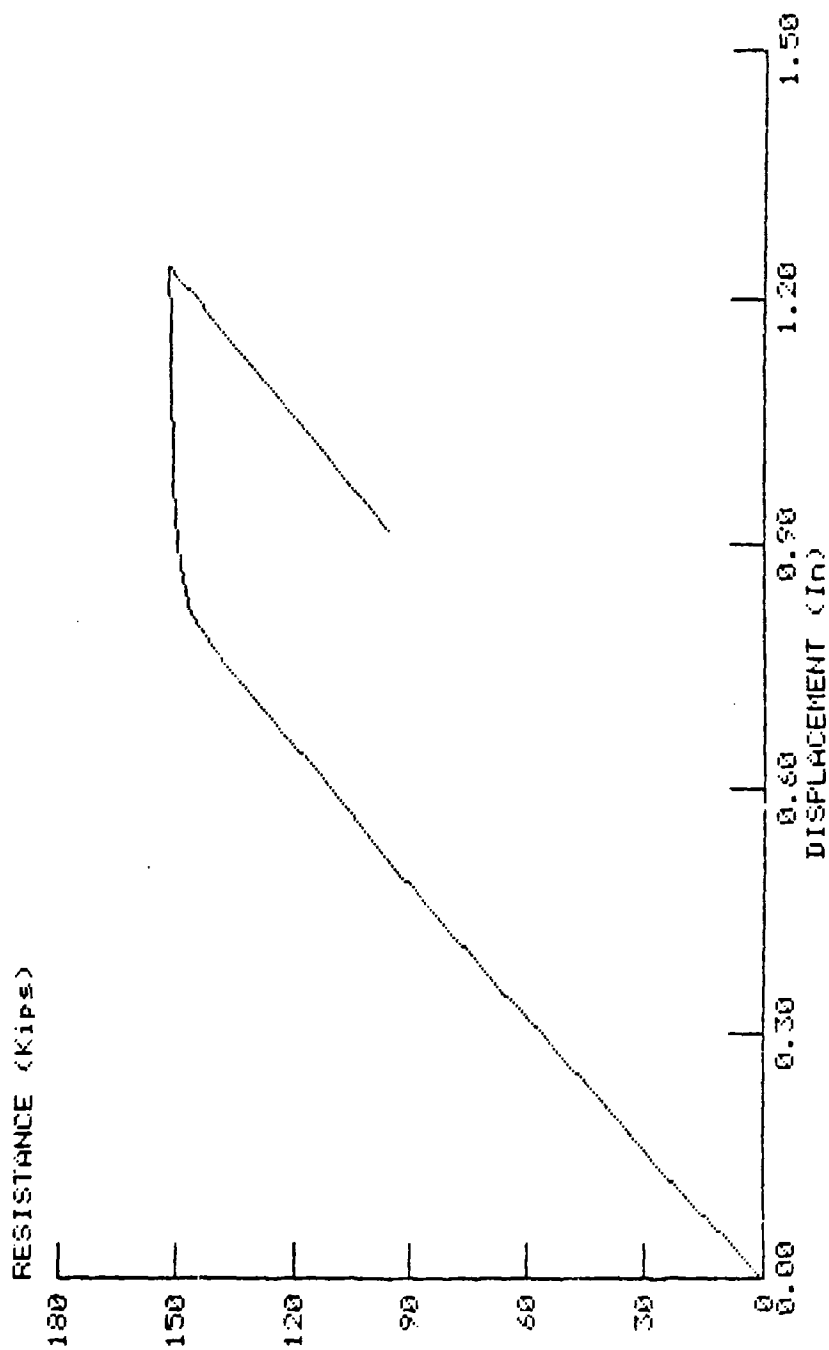


Figure H-11. Air Blast of AFESC Case A-1;  
191 Pound C-4, 25.8 Inch Standoff; Resistance, Disp.

Air Blast of AFESC Case A1  
 191 LB C-4, 25.8 Inch Standoff

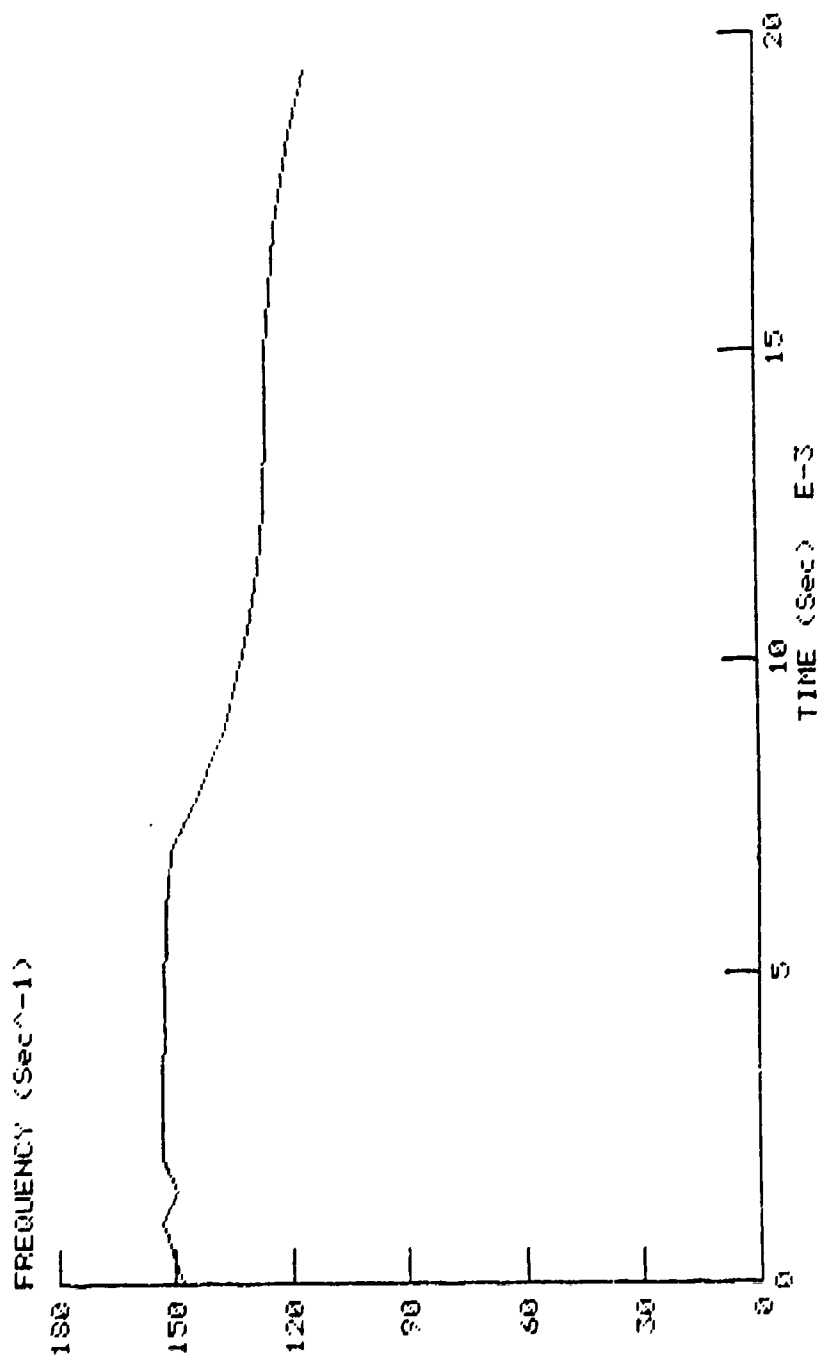


Figure H-12. Air Blast of AFESC Case A-1;  
 191 Pound C-4, 25.8 Inch Standoff; Frequency, Time.

Air Blast Of AFESC Case A1  
191 LB C-4, 25.8 Inch Standoff

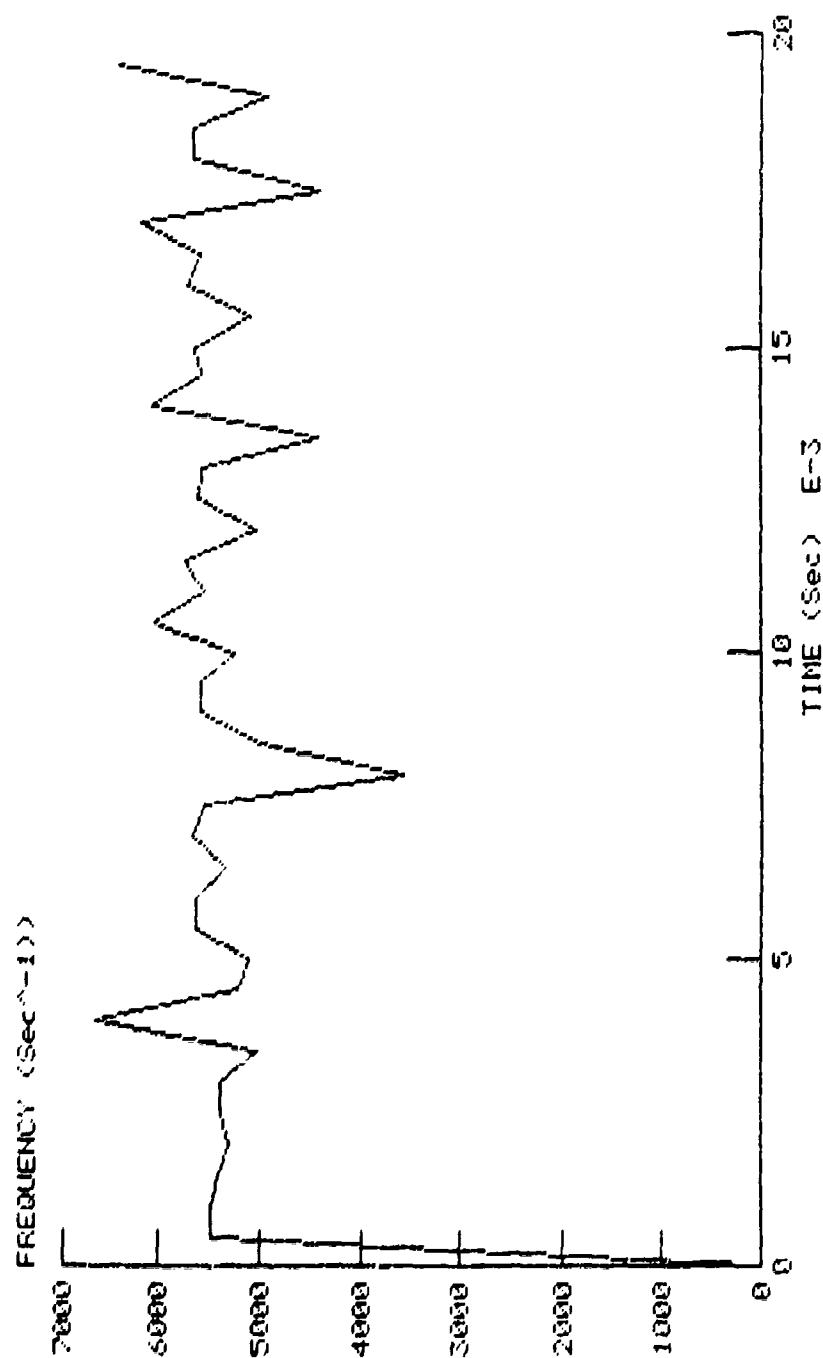


Figure H-12. Air Blast of AFESC Case A-1;  
191 Pound C-4, 25.8 Inch Standoff; Frequency Time (Continued).

Air Blast Of AFESC Case A1  
 191 LB C-4, 25.8 Inch Standoff  
 SHEAR DISP. (Inches)

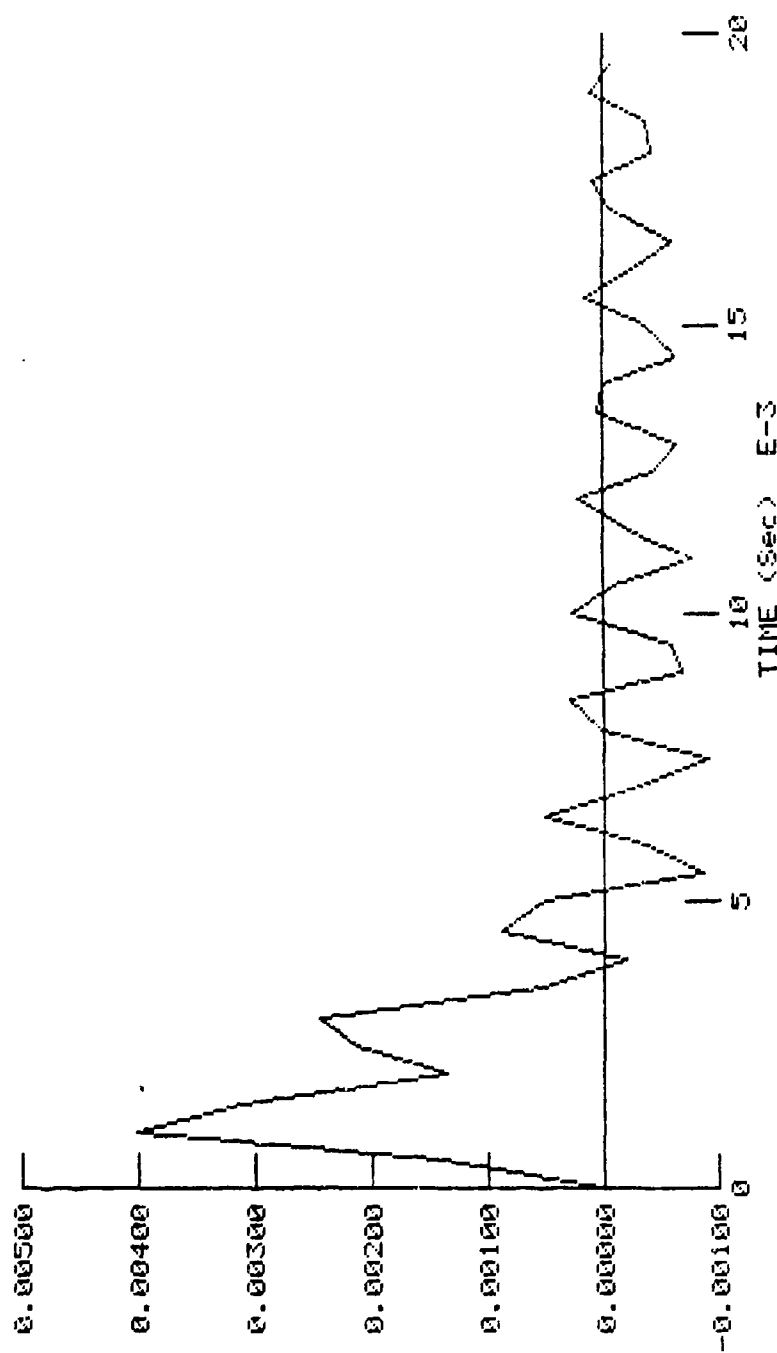


Figure H-13. Air Blast of AFESC Case A-1;  
 191 Pound C-4, 25.8 Inch Standoff; Shear Disp., Time

Air Blast Of AFESC Case A1  
 191 LB C-4, 25.8 Inch Standoff

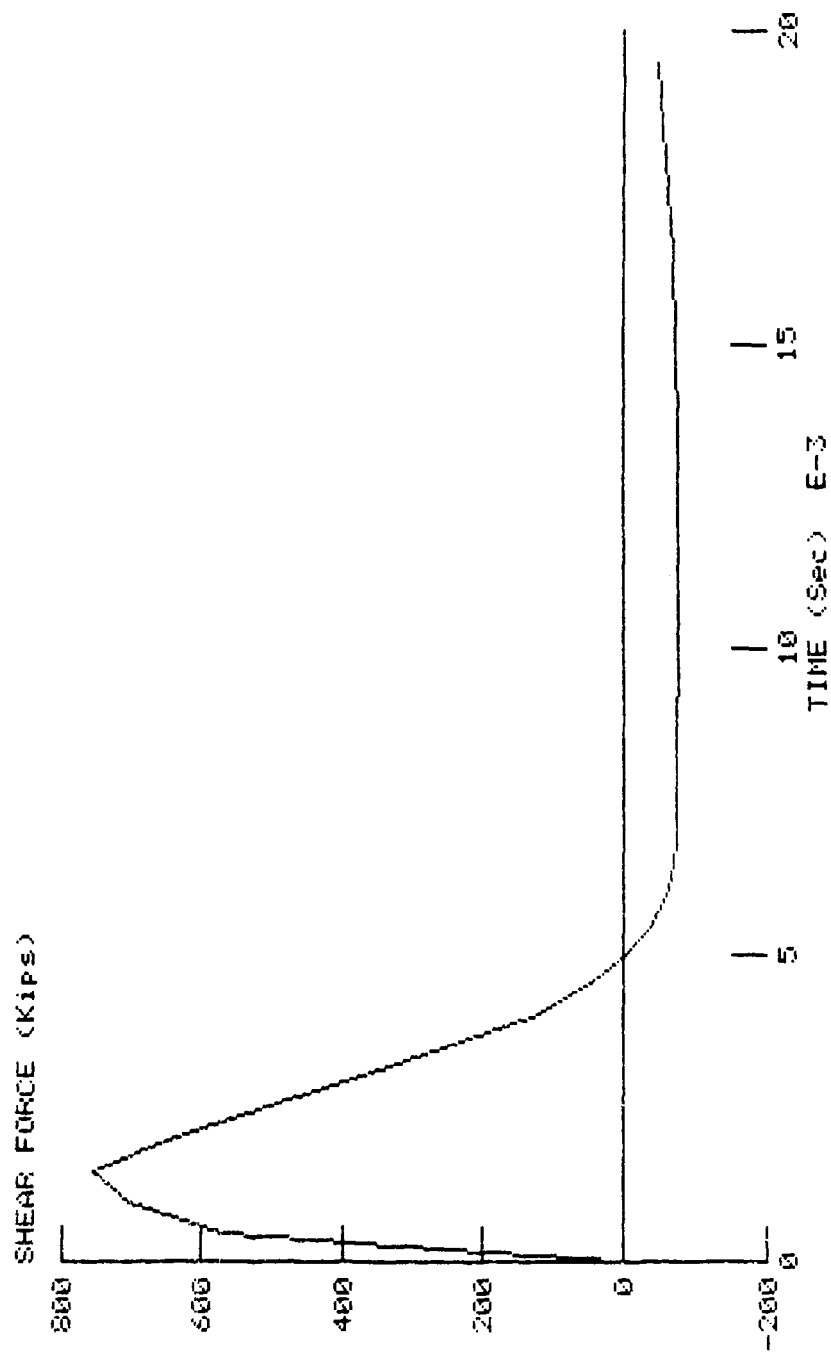


Figure H-14. Air Blast of AFESC Case A-1;  
 191 Pound C-4, 25.8 Inch Standoff; Shear Force, Time.



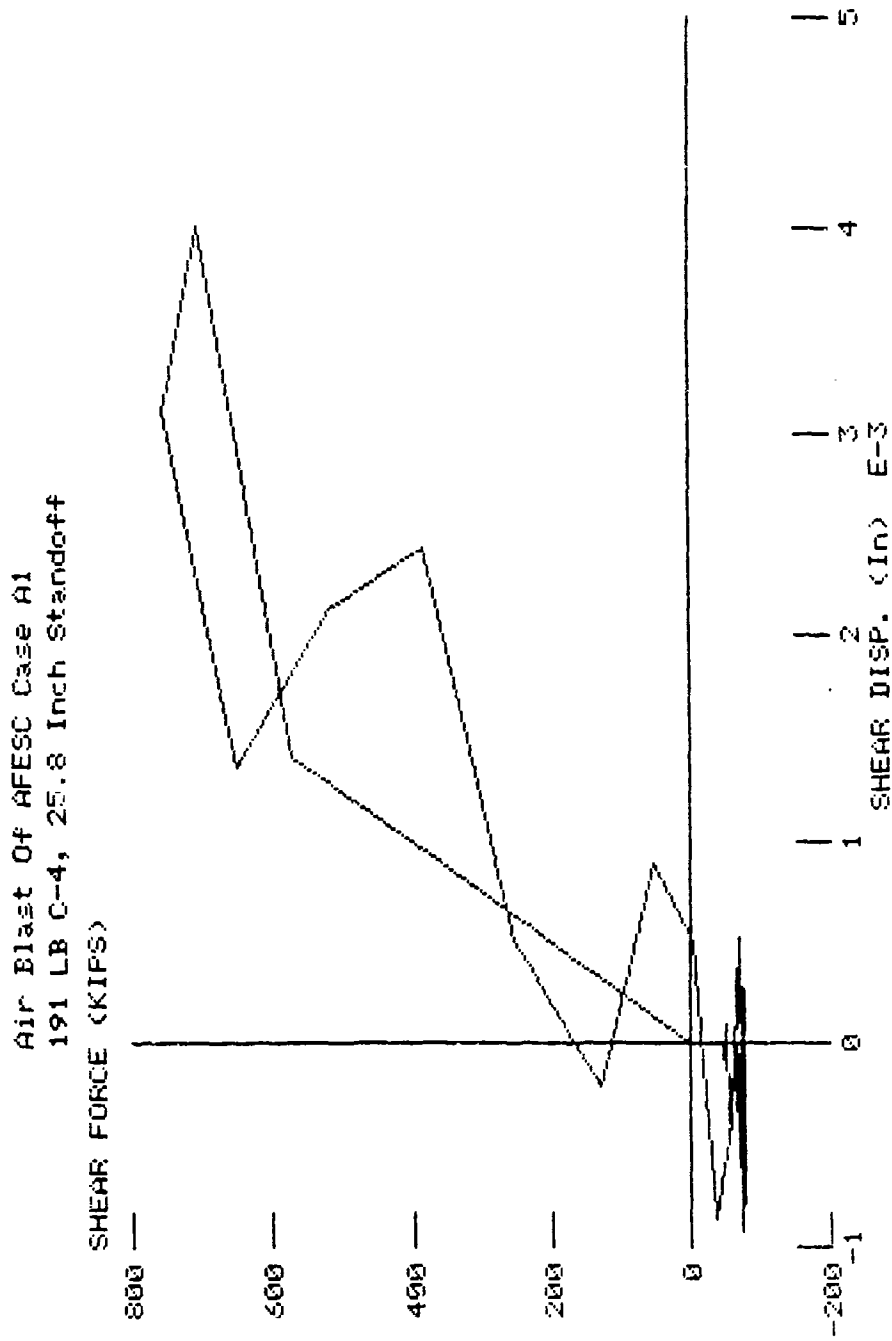


Figure H-15. Air Blast of AFESC Case A-1;  
191 Pound C-4, 25.8 Inch Standoff; Shear Force, Shear Disp.

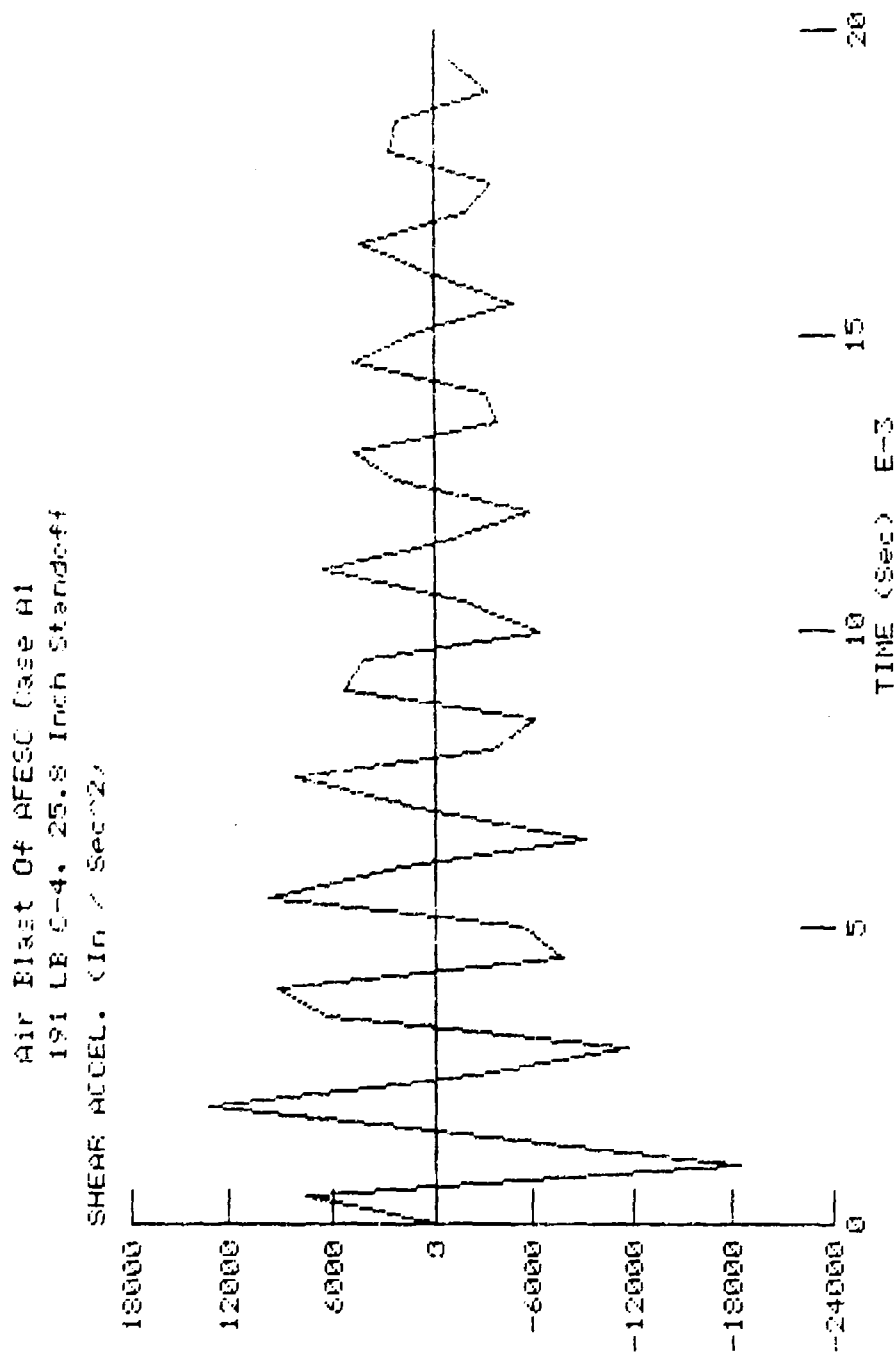


Figure H-16. Air Blast of AFESC Case A-1;  
191 Pound C-4, 25.8 Inch Standoff; Shear Accel., Time

Air Blast Of AFESC Case A1  
 191 LB C-4, 25.8 Inch Standoff  
 SHEAR VELOCITY (In / Sec)

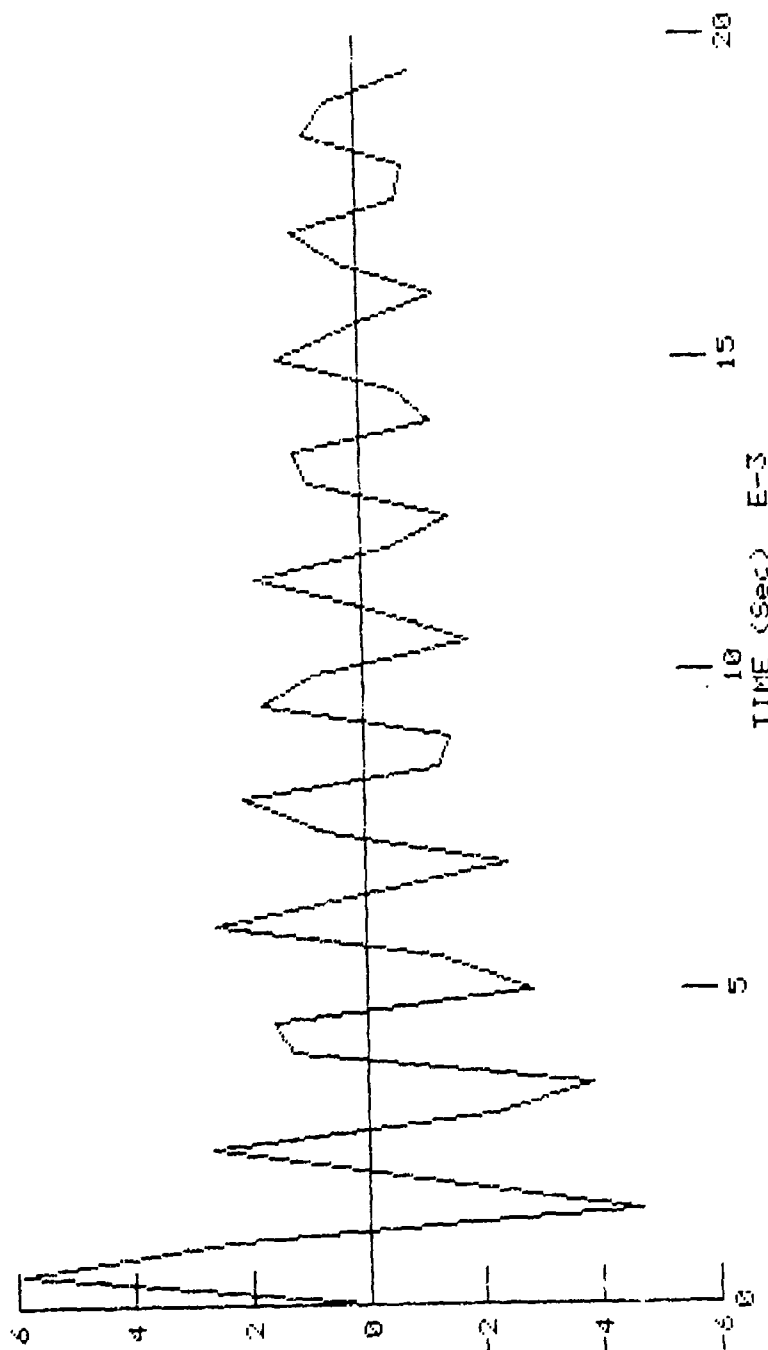


Figure H-17. Air Blast of AFESC Case A-1;  
 191 Pound C-4, 25.8 Inch Standoff; Shear Velocity, Time.

Air Blast Of AFESC Case A1  
 191 LB C-4, 25.8 Inch Standoff

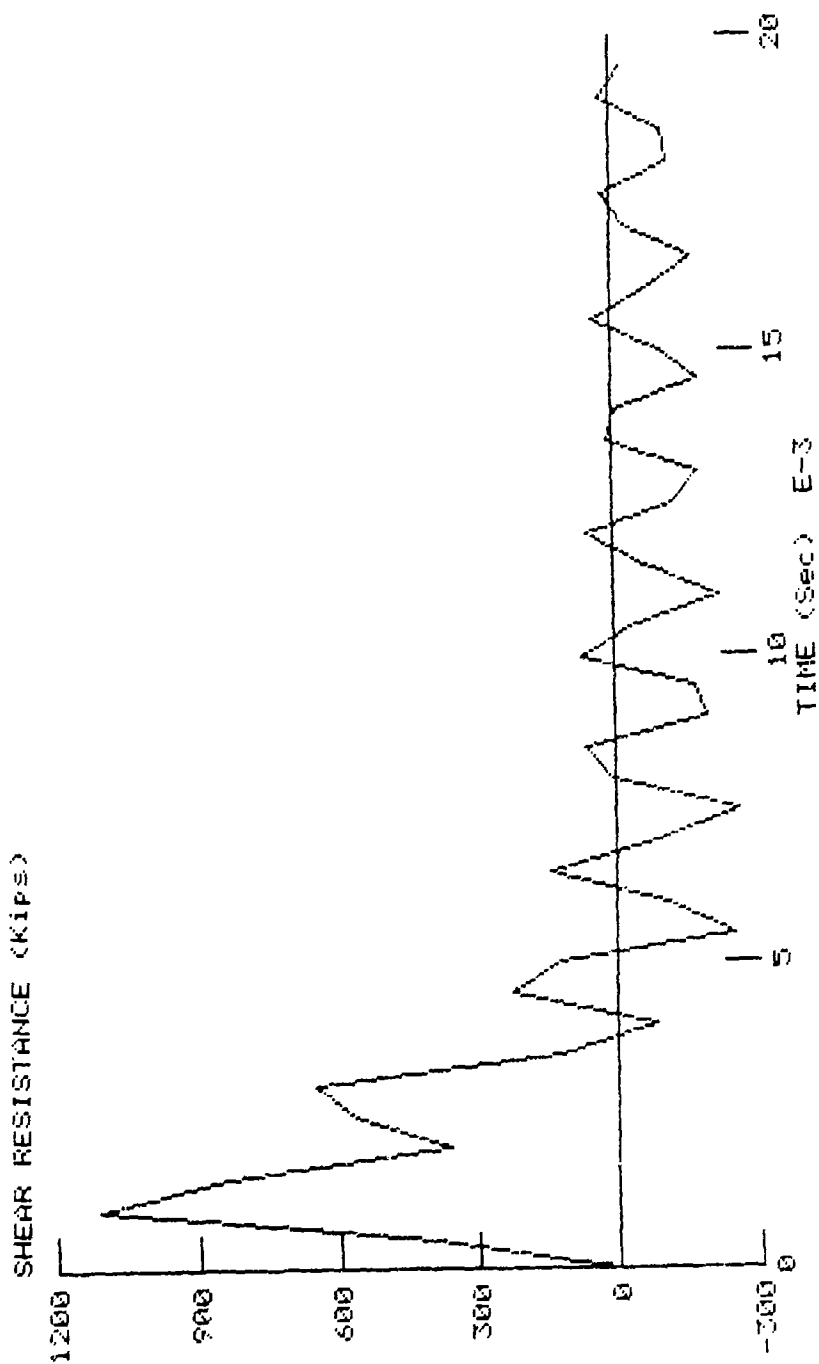


Figure H-18. Air Blast of AFESC Case A-1;  
 191 Pound C-4, 25.8 Inch Standoff; Shear Resistance, Time.

Air Blast Of AFESC Case A1  
 191 LB C-4, 25.8 Inch Standoff

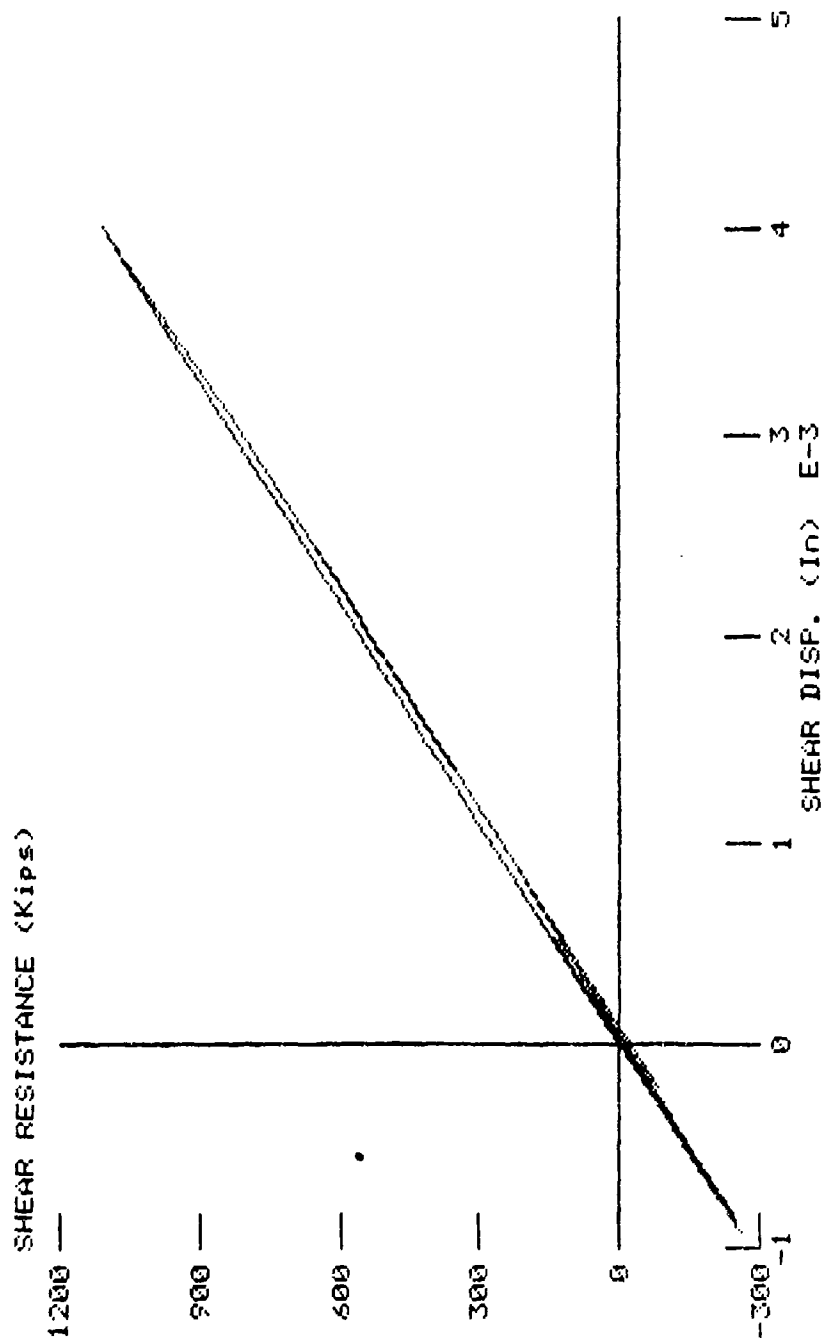


Figure H-19. Air Blast of AFESC Case A-1;  
 191 Pound C-4, 25.8 Inch Standoff; Shear Resistance, Shear Disp.

**APPENDIX I**

**REICON Code Output**

TABLE I-1. CALCULATIONS ON A CONCRETE BEAM, AFESC CASE1-2.4 POUND AT 6 INCHES.

PAGE 1  
3 27 1990 9 37 20 57

CALCULATIONS ON A CONCRETE BEAM  
AFESC CASE1--2.4 LB. AT 6 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. (A) 28.000000  
BEAM OR PLATE THICKNESS, IN. (H) 4.000000  
LENGTH TO WIDTH RATIO, DIMENSIONLESS (CM) 0.88999999  
MASS PER UNIT AREA, LBS-SEC.500/IN.CUBED (SMALL) 0.88999999E-03  
POWER FROM PRESSURE-LAMBDA CURVE (FM) 0.82999999  
UNIFORM PRESSURE LOAD, PSI. (PU) 0.00000000E+00  
PRESSURE DECAY, DIMENSIONLESS (ALPHA) 3.40000001  
PRESSURE DURATION, SEC. (TMD) 0.23500000E-03  
SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED (F), 2.00000000  
WAVE FUNCTION: 1=GENERAL, 2=SQUARE (WVFN) 1.00000000  
WEIGHT VECTOR: 0=VERT, 1=EXP BLM, -1=EXP AB (SMALL) 0.00000000E+00  
REINFORCEMENT DENSITY, LB.-SEC.50./IN.SQ. (RHOR) 0.73390000E-03  
CONCRETE COMPRESSIVE STRENGTH, PSI. (SIGCR) 5000.0000  
REINFORCED STEEL YIELD STRESS, PSI. (SIGHR) 65000.0000  
REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS (CD) 0.24999999E-02  
REINFORCING DISTANCE, IN. (D) 3.30000000  
DIAMETER OF EXPLOSIVE, IN. (BIGD) 2.50000000  
PRESSURE INTERCEPT ON P-LAMBDA CURVE (SMALL) 5.00000000  
EXPLOSIVE HEIGHT, LBS. (BIGH) 2.40000001  
LENGTH OF EXPLOSIVE, IN. (BIGL) 8.14999996  
X 1 OF EXPLOSIVE, IN. (CX1) 28.00000000  
X 2 OF EXPLOSIVE, IN. (CX2) 28.00000000  
Y 1 OF EXPLOSIVE, IN. (CY1) 20.90000000  
Y 2 OF EXPLOSIVE, IN. (CY2) 29.10000000  
Z 1 OF EXPLOSIVE, IN. (CZ1) 6.00000000  
Z 2 OF EXPLOSIVE, IN. (CZ2) 6.00000000  
SHEAR STIFFNESS REINFORCEMENT RATIO (Q1) 0.49999999E-04  
ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (SMALL) 2.00000000  
TIME INCREMENT, SEC. (TINC) 0.99999999E-04  
TIME MAXIMUM, SEC. (TMAX) 0.10000000  
TIME STEP INTERVAL PER PRINTED LINE, SEC. (TPRINT) 0.50000000E-03  
CRITICAL TIME, SEC. (TCR) 0.12000000E-02  
NO VALUE OF THE ORIGINAL HINGE LOCATION, KHO, WAS FOUND IN THE INTERVAL CO, R.  
IT IS ASSUMED TO BE THE VALUE OF H.

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN. (B) 24.92000000  
HINGE MOMENT, IN.-LBS./IN. (BIGM) 1562.1230  
WEIGHT PER UNIT AREA, LBS./IN.SQ. (W) 0.34721902

TABLE I-1. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA1-2.4 POUND AT 6 INCHES  
(Continued).

| ORIGINAL HINGE LOCATION, IN.                                       |                 |                                                        |                       |                          |                         |                           |                         |  |  |
|--------------------------------------------------------------------|-----------------|--------------------------------------------------------|-----------------------|--------------------------|-------------------------|---------------------------|-------------------------|--|--|
| CLAMPED-SUPPORTED                                                  |                 | GENERAL TIME FUNCTION                                  |                       | VERTICAL WALL            |                         | BLAST LOAD                |                         |  |  |
| CALCULATIONS ON A CONCRETE BEAM                                    |                 | LOCALIZED SHEAR FAILURE CALCULATION                    |                       | PAGE 2                   |                         |                           |                         |  |  |
| AF ESC CASEA1-2.4 LB. AT 6 IN.                                     |                 | GENERAL TIME FUNCTION                                  |                       | 3 27 1990 5 37 22 93     |                         |                           |                         |  |  |
| CLAMPED-SUPPORTED                                                  |                 | GENERAL TIME FUNCTION                                  |                       | BLAST LOAD               |                         |                           |                         |  |  |
| BREACH RADIUS 1 BAR                                                |                 | I CRITICAL                                             |                       |                          |                         |                           |                         |  |  |
| 1.0000000                                                          | 2.5754113       | 1.0438719                                              |                       |                          |                         |                           |                         |  |  |
| 10.7500001                                                         | 1.0372064       | 1.0438719                                              |                       |                          |                         |                           |                         |  |  |
| BREACH BY LOCALIZED SHEAR FAILURE AT BREACH RADIUS OF 10.75000 IN. |                 |                                                        |                       |                          |                         |                           |                         |  |  |
| CALCULATIONS ON A CONCRETE BEAM                                    |                 | FLEXURAL RESPONSE INCLUDING NO LOCALIZED SHEAR FAILURE |                       | PAGE 3                   |                         |                           |                         |  |  |
| AF ESC CASEA1-2.4 LB. AT 6 IN.                                     |                 |                                                        |                       | 3 27 1990 9 37 26 12     |                         |                           |                         |  |  |
| CLAMPED-SUPPORTED                                                  |                 | GENERAL TIME FUNCTION                                  |                       | BLAST LOAD               |                         |                           |                         |  |  |
| TIME (SECONDS)                                                     | THEIA (RADIANS) | MIDPT. VEL. (IN./SEC.)                                 | MIDPT. DELTA (INCHES) | PRESSURE WORK (IN.-LBS.) | PLASTIC WORK (IN.-LBS.) | KINETIC ENERGY (IN.-LBS.) | HINGE LOCATION (INCHES) |  |  |
| 0.0000000E+00                                                      | 0.0000000E+00   | 0.0000000E+00                                          | 0.0000000E+00         | 0.0000000E+00            | 0.0000000E+00           | 0.0000000E+00             | 28.000000               |  |  |
| 0.4999999E-02                                                      | 0.1215534E-02   | 501.60373                                              | 0.23003580            | 106007.45                | 2558.5308               | 103498.927                | 28.000000               |  |  |
| 0.9999999E-03                                                      | 0.1711336E-01   | 494.95178                                              | 0.47317470            | 106007.45                | 5329.5322               | 100677.92                 | 28.000000               |  |  |
| 0.1999999E-02                                                      | 0.2589241E-01   | 486.29364                                              | 0.72498757            | 106007.45                | 8063.5405               | 97943.914                 | 28.000000               |  |  |
| 0.1999999E-02                                                      | 0.3458216E-01   | 481.64789                                              | 0.96747458            | 106007.45                | 10750.557               | 95246.898                 | 28.000000               |  |  |
| 0.2499999E-02                                                      | 0.4309412E-01   | 474.95591                                              | 1.2066355             | 106007.45                | 13450.580               | 92566.875                 | 28.000000               |  |  |
| 0.3000000E-02                                                      | 0.5151630E-01   | 468.34396                                              | 1.444104              | 106007.45                | 16041.611               | 89363.844                 | 28.000000               |  |  |
| 0.3000000E-02                                                      | 0.5982049E-01   | 461.69202                                              | 1.677044              | 106007.45                | 18629.650               | 87377.805                 | 28.000000               |  |  |
| 0.4000000E-02                                                      | 0.6807211E-01   | 455.04014                                              | 1.9041124             | 106007.45                | 21178.697               | 84828.758                 | 28.000000               |  |  |
| 0.4999999E-01                                                      | 0.7607211E-01   | 448.38809                                              | 2.1303194             | 106007.45                | 23690.750               | 82316.703                 | 28.000000               |  |  |
| 0.4999999E-02                                                      | 0.8401916E-01   | 441.73602                                              | 2.3525505             | 106007.45                | 26165.811               | 79841.641                 | 28.000000               |  |  |
| 0.5999999E-02                                                      | 0.9189841E-01   | 435.08392                                              | 2.5717554             | 106007.45                | 28603.877               | 77403.578                 | 28.000000               |  |  |
| 0.5999999E-02                                                      | 0.9955846E-01   | 428.43182                                              | 2.7976344             | 106007.45                | 31004.951               | 75002.500                 | 28.000000               |  |  |
| 0.6499999E-02                                                      | 0.10714355      | 421.77375                                              | 3.0001874             | 106007.45                | 33369.031               | 72638.422                 | 28.000000               |  |  |
| 0.6499999E-02                                                      | 0.11462194      | 415.12766                                              | 3.2094142             | 106007.45                | 35636.117               | 70111.336                 | 28.000000               |  |  |
| 0.7499999E-02                                                      | 0.12197553      | 408.47559                                              | 3.4153149             | 106007.45                | 37906.211               | 68021.242                 | 28.000000               |  |  |
| 0.7499999E-02                                                      | 0.12921134      | 401.82349                                              | 3.6178894             | 106007.45                | 40231.312               | 65768.141                 | 28.000000               |  |  |
| 0.8499999E-02                                                      | 0.13632137      | 395.17139                                              | 3.8171384             | 106007.45                | 42455.422               | 63552.031                 | 28.000000               |  |  |
| 0.8499999E-02                                                      | 0.14332360      | 388.51332                                              | 4.0130606             | 106007.45                | 44634.535               | 61372.918                 | 28.000000               |  |  |
| 0.9499999E-02                                                      | 0.15070205      | 381.86722                                              | 4.2058575             | 106007.45                | 46776.656               | 59230.797                 | 28.000000               |  |  |
| 0.9499999E-02                                                      | 0.15896172      | 375.21512                                              | 4.3948285             | 106007.45                | 48881.785               | 57125.668                 | 28.000000               |  |  |
| 0.1049999E-01                                                      | 0.16360159      | 368.56305                                              | 4.5806725             | 106007.45                | 50949.918               | 55057.535                 | 28.000000               |  |  |
| 0.1049999E-01                                                      | 0.17012468      | 361.91095                                              | 4.7634912             | 106007.45                | 52981.059               | 53026.395                 | 28.000000               |  |  |
| 0.1149999E-01                                                      | 0.17652799      | 355.25885                                              | 4.9427838             | 106007.45                | 54975.207               | 51032.246                 | 28.000000               |  |  |
| 0.1149999E-01                                                      | 0.18281250      | 348.60678                                              | 5.1187501             | 106007.45                | 56932.359               | 49075.094                 | 28.000000               |  |  |
| 0.1249999E-01                                                      | 0.18897322      | 341.95468                                              | 5.2913904             | 106007.45                | 58852.520               | 47154.934                 | 28.000000               |  |  |
| 0.1299999E-01                                                      | 0.19502518      | 335.30261                                              | 5.4607048             | 106007.45                | 60735.687               | 45271.766                 | 28.000000               |  |  |



TABLE I-1. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA1-2.4 POUND AT 6 INCHES  
(Continued).

|               |            |           |           |           |           |           |           |
|---------------|------------|-----------|-----------|-----------|-----------|-----------|-----------|
| 0.1349998E-01 | 0.20095332 | 328.65051 | 5.6268328 | 106007.45 | 62501.859 | 45425.534 | 28.000000 |
| 0.1399998E-01 | 0.20676269 | 321.95841 | 5.7895553 | 106007.45 | 64391.039 | 41616.414 | 28.000000 |
| 0.1449998E-01 | 0.21245329 | 315.34634 | 5.9468318 | 106007.45 | 66163.227 | 39844.227 | 28.000000 |
| 0.1499998E-01 | 0.21802506 | 308.63424 | 6.1047015 | 106007.45 | 67946.422 | 38109.031 | 28.000000 |
| 0.1549998E-01 | 0.22347806 | 302.04218 | 6.2573857 | 106007.45 | 69536.625 | 36410.828 | 28.000000 |
| 0.1599998E-01 | 0.22881229 | 295.39008 | 6.4067440 | 106007.45 | 71257.836 | 34749.617 | 28.000000 |
| 0.1649998E-01 | 0.23402771 | 288.73798 | 6.5527759 | 106007.45 | 72882.047 | 33125.406 | 28.000000 |
| 0.1699998E-01 | 0.23912436 | 282.08531 | 6.6954823 | 106007.45 | 74469.266 | 31538.187 | 28.000000 |
| 0.1749998E-01 | 0.24410221 | 275.43381 | 6.8340618 | 106007.45 | 76019.492 | 29987.961 | 28.000000 |

MINIMUM DEFLECTION = 9.685946 RT TIME = 0.3830075E-01

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT WAS FRACTURED

TABLE I-2. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA2-2.4 POUND AT 12 INCHES.

PAGE 1

CALCULATIONS ON A CONCRETE BEAM  
AFESC CASEA2-2.4 LB. AT 12 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. (D) 28.000000  
BEAM OR PLATE THICKNESS, IN. (H) 1.000000  
LENGTH TO WIDTH RATIO, DIMENSIONLESS (LW) 0.08595939  
WEISS PER UNIT AREA, LBS-SEC.500/IN.CUBED (SMALL) 0.08659937E-03  
POWER FROM PRESSURE-LAMBDA CURVE (CF) 1.8000000  
UNIFORM PRESSURE LOAD, PSI. (F1) 0.0000000E+00  
PRESSURE DEGR., DIMENSIONLESS (ALPHA) 3.5000000  
PRESSURE DURATION, SEC. (TAU) 0.2020000E-03  
SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED (F) 2.0000000  
WAVE FUNCTION 1=GENERAL, 2=SOURCE (WAVEF) 1.0000000  
WEIGHT VECTOR 0=VERT, 1=EXP BLM, -1=EXP NO (SMALL) 0.0000000E+00  
REINFORCEMENT DENSITY, LB.-SEC.50./IN.SQ (RHOR) 0.73390000E-03  
CONCRETE COMPRESSIVE STRENGTH, PSI. (SIGMAC) 5080.10000  
REINFORCED STEEL YIELD STRESS, PSI. (SIGMAK) 65900.0000  
REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS (U) 0.24597999E-02  
REINFORCING DISTANCE, IN. (D) 3.3000000  
DIAMETER OF EXPLOSIVE, IN. (BIGD) 2.5000000  
PRESSURE INTERCEPT ON P-LAMBDA CURVE (SMALL) 5.8000000  
EXPLOSIVE WEIGHT, LBS. (BIGH) 2.4000001  
LENGTH OF EXPLOSIVE, IN. (BIGL) 6.1999996  
X 1 OF EXPLOSIVE, IN. (EX1) 28.000000  
X 2 OF EXPLOSIVE, IN. (EX2) 28.000000  
Y 1 OF EXPLOSIVE, IN. (EY1) 20.900000  
Y 2 OF EXPLOSIVE, IN. (EY2) 19.100000  
Z 1 OF EXPLOSIVE, IN. (EZ1) 12.000000  
Z 2 OF EXPLOSIVE, IN. (EZ2) 12.000000  
SHAPE: STRIP REINFORCEMENT RATIO (U) 0.4599999E-04  
ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (SMALL) 2.8000000  
TIME INCREMENT, SEC. (THICK) 0.99999937E-04  
TIME MAXIMUM, SEC. (THIN) 0.10000000  
TIME STEP INTERVAL PER PRINTED LINE, SEC. (TPRINT) 0.5000000E-03  
CRITICAL TIME, SEC. (CTCR) 0.1200001E-02  
NO VALUE OF THE ORIGINAL HINGE LOCATION, AND, WAS FOUND IN THE INTERVAL (C.A.).  
IT IS ASSUMED TO BE THE VALUE OF A.

COMPUTED CONSTANT PRUFS  
BEAM HALF WIDTH, IN. (D) 28.000000  
HINGE MOMENT, IN.-LBS./IN. (BIGM) 1564.1230  
WEIGHT PER UNIT AREA, LBS./IN.SQ. (U) 0.3472190E

TABLE I-2. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA2-2.4 POUND AT 12 INCHES (Continued).

[illegible]

TABLE I-2. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA2-2.4 POUND AT 12 INCHES  
(Continued).

|               |           |           |           |            |            |             |            |
|---------------|-----------|-----------|-----------|------------|------------|-------------|------------|
| 0.1599999E-01 | 0.2097979 | 141.45341 | 2.6489522 | -6.659.141 | -6.195.793 | 6.751.4375  | 29.0000000 |
| 0.1599999E-01 | 0.1387992 | 134.48279 | 3.4751237 | -6.659.141 | -6.195.887 | 5.943.7535  | 29.0000000 |
| 0.1599999E-01 | 0.1387992 | 139.15336 | 3.1400645 | -6.659.141 | -6.195.874 | 5.752.8654  | 29.0000000 |
| 0.1649999E-01 | 0.1388319 | 129.15336 | 3.082792  | -6.659.141 | -6.201.278 | -6.52.8711  | 29.0000000 |
| 0.1649999E-01 | 0.1388319 | 129.15336 | 3.082792  | -6.659.141 | -6.201.278 | 3.988.6588  | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | 3.288.4578  | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | 2.534.2283  | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | 2.151.0156  | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | 1.641.7852  | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | 1.169.5469  | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | 7.34.20878  | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | 3.26.94647  | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | -25.210937  | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | -3.41.47556 | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | -6.26.75088 | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | -887.83125  | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | -1100.5283  | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | -1278.6133  | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | -1415.9191  | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | -1518.2227  | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | -1543.5291  | 29.0000000 |
| 0.1749999E-01 | 0.1393324 | 109.17938 | 3.9181059 | -6.659.141 | -6.208.444 | -1611.6633  | 29.0000000 |

MINIMUM DEFLECTION = 4.3500429 RT TIME = 0.2569996E-01  
ON EXTENSIVE INDICATES THAT A REINFORCING ELEMENT WAS FRACTURED

TABLE I-3. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA3-2.4 POUND AT 18 INCHES.

PAGE 1

3 27 1990 9 43 7 97

CALCULATIONS ON A CONCRETE BEAM

AFESC CASEA3--2.4 LB. AT 18 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. (R) 29.000000  
 BEAM OR PLATE THICKNESS, IN. (H) 4.000000  
 LENGTH TO HINGE LOCATION, DIMENSIONLESS (X) 0.68999999  
 MASS PER UNIT AREA, LBS.-SEC. 500./IN. CUBED (SMALL) 0.090999997E-03  
 POWER FROM PRESSURE-LAMBDA CURVE (F) 1.1500000  
 UNIFORM PRESSURE LOAD, PSI. (P) 0.00000000E+00  
 PRESSURE DECAY, DIMENSIONLESS (ALPHA) 4.30000002  
 PRESSURE DURATION, SEC. (TAU) 0.20199999E-03  
 SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED (F) 2.0000000  
 SHAPE FUNCTION: 1=GENERAL, 2=SQUARE (SHAPEFN) 1.0000000  
 WEIGHT VECTOR: 0=VERT, 1=EXP BUL, -1=EXP AB (SMALL) 0.00000000E+00  
 REINFORCEMENT DENSITY, LB.-SEC. 50./IN. IN. 4 (RHO) 0.73390000E-03  
 CONCRETE COMPRESSIVE STRENGTH, PSI. (SIGMAC) 5000.0000  
 REINFORCED STEEL YIELD STRESS, PSI. (SIGMAHY) 65000.0000  
 REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS (R) 0.24999999E-02  
 REINFORCING DISTANCE, IN. (D) 3.3000000  
 DIAMETER OF EXPLOSIVE, IN. (BIGD) 2.5000000  
 PRESSURE INTERCEPT ON P-LAMBDA CURVE (SMALL) 5.8000000  
 EXPLOSIVE WEIGHT, LBS. (BIGW) 2.4000001  
 LENGTH OF EXPLOSIVE, IN. (BIGL) 8.1999996  
 X 1 OF EXPLOSIVE, IN. (EX1) 28.0000000  
 X 2 OF EXPLOSIVE, IN. (EX2) 28.0000000  
 Y 1 OF EXPLOSIVE, IN. (EY1) 20.9000000  
 Y 2 OF EXPLOSIVE, IN. (EY2) 29.1000000  
 Z 1 OF EXPLOSIVE, IN. (EZ1) 18.0000000  
 Z 2 OF EXPLOSIVE, IN. (EZ2) 18.0000000  
 SHEAR STIRRUP REINFORCEMENT RATIO (R) 0.49999999E-04  
 ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (SMALL) 2.0000000  
 TIME INCREMENT, SEC. (TIMCR) 0.99999997E-04  
 TIME MINIMUM, SEC. (TMIN) 0.10000000  
 TIME STEP INTERVAL PER PRINTED LINE, SEC. (TPRINT) 0.50000002E-03  
 CRITICAL TIME, SEC. (TCR) 0.12000001E-02

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN. (R) 24.920000  
 HINGE MOMENT, IN.-LBS./IN. (BIGM) 1562.1230  
 WEIGHT PER UNIT AREA, LBS./IN. SQ. (W) 0.34721902  
 ORIGINAL HINGE LOCATION, IN. (X) 25.836185

CLAMPED-SUPPORTED

GENERAL TIME FUNCTION

VERTICAL WALL

BLAST LOAD

TABLE I-3. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA3-2.4 POUND AT 18 INCHES  
(Continued).

| CALCULATIONS ON A CONCRETE BEAM |                    |                           |                          |                             |                            |                              |                            |           |  | LOCALIZED SHEAR FAILURE CALCULATION                   |                |                |                |           | BLAST LOAD |                |                |           |  |
|---------------------------------|--------------------|---------------------------|--------------------------|-----------------------------|----------------------------|------------------------------|----------------------------|-----------|--|-------------------------------------------------------|----------------|----------------|----------------|-----------|------------|----------------|----------------|-----------|--|
| AFESC CASEA3-2.4 LB. AT 18 IN.  |                    |                           |                          |                             |                            |                              |                            |           |  | VERTICAL WALL                                         |                |                |                |           | BLAST LOAD |                |                |           |  |
| CLAMPED-SUPPORTED               |                    |                           |                          |                             |                            |                              |                            |           |  | GENERAL TIME FUNCTION                                 |                |                |                |           | BLAST LOAD |                |                |           |  |
| EMERGENCY RADIUS (BAR)          |                    |                           |                          |                             |                            |                              |                            |           |  | I CRITICAL                                            |                |                |                |           | BLAST LOAD |                |                |           |  |
| 1.00000000                      |                    |                           |                          |                             |                            |                              |                            |           |  | 1.0438719                                             |                |                |                |           | BLAST LOAD |                |                |           |  |
| CALCULATIONS ON A CONCRETE BEAM |                    |                           |                          |                             |                            |                              |                            |           |  | FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE |                |                |                |           | BLAST LOAD |                |                |           |  |
| AFESC CASEA3-2.4 LB. AT 18 IN.  |                    |                           |                          |                             |                            |                              |                            |           |  | VERTICAL WALL                                         |                |                |                |           | BLAST LOAD |                |                |           |  |
| CLAMPED-SUPPORTED               |                    |                           |                          |                             |                            |                              |                            |           |  | GENERAL TIME FUNCTION                                 |                |                |                |           | BLAST LOAD |                |                |           |  |
| TIME<br>(SECONDS)               | THETA<br>(RADIANS) | MIDPT. VEL.<br>(IN./SEC.) | MIDPT. DELTA<br>(INCHES) | PRESSURE WORK<br>(IN.-LBS.) | PLASTIC WORK<br>(IN.-LBS.) | KINETIC ENERGY<br>(IN.-LBS.) | MIDGE LOCATION<br>(INCHES) |           |  |                                                       |                |                |                |           |            |                |                |           |  |
| 0.00000000E+00                  | 0.00000000E+00     | 0.00000000E+00            | 0.00000000E+00           | 0.00000000E+00              | 0.00000000E+00             | 0.00000000E+00               | 0.00000000E+00             | 25.836185 |  | 0.00000000E+00                                        | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 25.836185 |            | 0.00000000E+00 | 0.00000000E+00 | 25.836185 |  |
| 0.49999997E-03                  | 0.00000000E+00     | 232.43315                 | 0.10624950               | 25519.523                   | 1261.4432                  | 24256.080                    | 26.230852                  |           |  | 25519.523                                             | 1261.4432      | 24256.080      | 26.230852      |           |            | 25519.523      | 1261.4432      | 24256.080 |  |
| 0.99999993E-03                  | 0.00000000E+00     | 232.43315                 | 0.2226405                | 25519.523                   | 2598.3772                  | 22921.146                    | 26.663355                  |           |  | 25519.523                                             | 2598.3772      | 22921.146      | 26.663355      |           |            | 25519.523      | 2598.3772      | 22921.146 |  |
| 0.14999997E-02                  | 0.12498875E-01     | 232.43315                 | 0.3068659                | 25519.523                   | 3892.4600                  | 21627.062                    | 27.037046                  |           |  | 25519.523                                             | 3892.4600      | 21627.062      | 27.037046      |           |            | 25519.523      | 3892.4600      | 21627.062 |  |
| 0.19999994E-02                  | 0.16523283E-01     | 221.87385                 | 0.46265191               | 25519.523                   | 5145.7603                  | 20373.764                    | 28.0000000                 |           |  | 25519.523                                             | 5145.7603      | 20373.764      | 28.0000000     |           |            | 25519.523      | 5145.7603      | 20373.764 |  |
| 0.24999997E-02                  | 0.10426027E-01     | 215.22783                 | 0.57782874               | 25519.523                   | 6361.1724                  | 19158.352                    | 28.0000000                 |           |  | 25519.523                                             | 6361.1724      | 19158.352      | 28.0000000     |           |            | 25519.523      | 6361.1724      | 19158.352 |  |
| 0.30000000E-02                  | 0.14209491E-01     | 208.57581                 | 0.67787875               | 25519.523                   | 7539.5923                  | 17979.932                    | 28.0000000                 |           |  | 25519.523                                             | 7539.5923      | 17979.932      | 28.0000000     |           |            | 25519.523      | 7539.5923      | 17979.932 |  |
| 0.35000003E-02                  | 0.17875165E-01     | 201.92378                 | 0.78050459               | 25519.523                   | 8681.0155                  | 16838.504                    | 28.0000000                 |           |  | 25519.523                                             | 8681.0155      | 16838.504      | 28.0000000     |           |            | 25519.523      | 8681.0155      | 16838.504 |  |
| 0.40000007E-02                  | 0.21421353E-01     | 195.27176                 | 0.87960348               | 25519.523                   | 9785.4531                  | 15754.070                    | 28.0000000                 |           |  | 25519.523                                             | 9785.4531      | 15754.070      | 28.0000000     |           |            | 25519.523      | 9785.4531      | 15754.070 |  |
| 0.44999998E-02                  | 0.24849156E-01     | 188.61374                 | 0.9757637                | 25519.523                   | 10852.894                  | 14666.630                    | 28.0000000                 |           |  | 25519.523                                             | 10852.894      | 14666.630      | 28.0000000     |           |            | 25519.523      | 10852.894      | 14666.630 |  |
| 0.49999993E-02                  | 0.28157373E-01     | 181.56771                 | 1.0684233                | 25519.523                   | 11883.341                  | 13536.183                    | 28.0000000                 |           |  | 25519.523                                             | 11883.341      | 13536.183      | 28.0000000     |           |            | 25519.523      | 11883.341      | 13536.183 |  |
| 0.54999993E-02                  | 0.31348003E-01     | 175.31569                 | 1.157441                 | 25519.523                   | 12876.756                  | 12542.728                    | 28.0000000                 |           |  | 25519.523                                             | 12876.756      | 12542.728      | 28.0000000     |           |            | 25519.523      | 12876.756      | 12542.728 |  |
| 0.59999993E-02                  | 0.34419248E-01     | 168.66367                 | 1.2437389                | 25519.523                   | 13833.258                  | 11686.266                    | 28.0000000                 |           |  | 25519.523                                             | 13833.258      | 11686.266      | 28.0000000     |           |            | 25519.523      | 13833.258      | 11686.266 |  |
| 0.64999993E-02                  | 0.37371704E-01     | 162.01166                 | 1.3194077                | 25519.523                   | 14752.727                  | 10766.797                    | 28.0000000                 |           |  | 25519.523                                             | 14752.727      | 10766.797      | 28.0000000     |           |            | 25519.523      | 14752.727      | 10766.797 |  |
| 0.69999993E-02                  | 0.40205380E-01     | 155.35963                 | 1.3907706                | 25519.523                   | 15635.203                  | 9884.3203                    | 28.0000000                 |           |  | 25519.523                                             | 15635.203      | 9884.3203      | 28.0000000     |           |            | 25519.523      | 15635.203      | 9884.3203 |  |
| 0.74999993E-02                  | 0.42920263E-01     | 148.70761                 | 1.4517674                | 25519.523                   | 16480.686                  | 9036.8379                    | 28.0000000                 |           |  | 25519.523                                             | 16480.686      | 9036.8379      | 28.0000000     |           |            | 25519.523      | 16480.686      | 9036.8379 |  |
| 0.79999993E-02                  | 0.45551636E-01     | 142.05559                 | 1.5044583                | 25519.523                   | 17289.176                  | 8230.3477                    | 28.0000000                 |           |  | 25519.523                                             | 17289.176      | 8230.3477      | 28.0000000     |           |            | 25519.523      | 17289.176      | 8230.3477 |  |
| 0.84999993E-02                  | 0.48052206E-01     | 135.40356                 | 1.5498630                | 25519.523                   | 18060.674                  | 7458.8496                    | 28.0000000                 |           |  | 25519.523                                             | 18060.674      | 7458.8496      | 28.0000000     |           |            | 25519.523      | 18060.674      | 7458.8496 |  |
| 0.89999993E-02                  | 0.50522064E-01     | 128.75154                 | 1.5898630                | 25519.523                   | 18795.178                  | 6724.3457                    | 28.0000000                 |           |  | 25519.523                                             | 18795.178      | 6724.3457      | 28.0000000     |           |            | 25519.523      | 18795.178      | 6724.3457 |  |
| 0.94999993E-02                  | 0.5291348E-01      | 122.09953                 | 1.619413                 | 25519.523                   | 19492.689                  | 6026.8340                    | 28.0000000                 |           |  | 25519.523                                             | 19492.689      | 6026.8340      | 28.0000000     |           |            | 25519.523      | 19492.689      | 6026.8340 |  |
| 0.99999993E-02                  | 0.54712304E-01     | 115.44750                 | 1.6471913                | 25519.523                   | 20153.207                  | 5366.3164                    | 28.0000000                 |           |  | 25519.523                                             | 20153.207      | 5366.3164      | 28.0000000     |           |            | 25519.523      | 20153.207      | 5366.3164 |  |
| 0.10499997E-01                  | 0.56715077E-01     | 108.79548                 | 1.6680222                | 25519.523                   | 20776.732                  | 4742.7910                    | 28.0000000                 |           |  | 25519.523                                             | 20776.732      | 4742.7910      | 28.0000000     |           |            | 25519.523      | 20776.732      | 4742.7910 |  |
| 0.10999997E-01                  | 0.58598457E-01     | 102.14146                 | 1.6807568                | 25519.523                   | 21363.266                  | 4156.2578                    | 28.0000000                 |           |  | 25519.523                                             | 21363.266      | 4156.2578      | 28.0000000     |           |            | 25519.523      | 21363.266      | 4156.2578 |  |
| 0.11499997E-01                  | 0.6036360E-01      | 95.491440                 | 1.6901657                | 25519.523                   | 21912.805                  | 3606.7187                    | 28.0000000                 |           |  | 25519.523                                             | 21912.805      | 3606.7187      | 28.0000000     |           |            | 25519.523      | 21912.805      | 3606.7187 |  |
| 0.11999997E-01                  | 0.62008371E-01     | 88.835417                 | 1.6970157                | 25519.523                   | 22425.352                  | 3094.1719                    | 28.0000000                 |           |  | 25519.523                                             | 22425.352      | 3094.1719      | 28.0000000     |           |            | 25519.523      | 22425.352      | 3094.1719 |  |
| 0.12499997E-01                  | 0.63535883E-01     | 82.187393                 | 1.70162485               | 25519.523                   | 22900.904                  | 2618.6191                    | 28.0000000                 |           |  | 25519.523                                             | 22900.904      | 2618.6191      | 28.0000000     |           |            | 25519.523      | 22900.904      | 2618.6191 |  |
| 0.12999997E-01                  | 0.64944131E-01     | 75.535370                 | 1.70494556               | 25519.523                   | 23379.465                  | 2180.0586                    | 28.0000000                 |           |  | 25519.523                                             | 23379.465      | 2180.0586      | 28.0000000     |           |            | 25519.523      | 23379.465      | 2180.0586 |  |
| 0.13499997E-01                  | 0.66233354E-01     | 68.883354                 | 1.7073503                | 25519.523                   | 23741.607                  | 1778.4902                    | 28.0000000                 |           |  | 25519.523                                             | 23741.607      | 1778.4902      | 28.0000000     |           |            | 25519.523      | 23741.607      | 1778.4902 |  |
| 0.13999997E-01                  | 0.67404246E-01     | 62.231331                 | 1.7084246E-01            | 25519.523                   | 24105.607                  | 1413.9150                    | 28.0000000                 |           |  | 25519.523                                             | 24105.607      | 1413.9150      | 28.0000000     |           |            | 25519.523      | 24105.607      | 1413.9150 |  |
| 0.14499997E-01                  | 0.6846126E-01      | 55.579308                 | 1.7086126E-01            | 25519.523                   | 24433.189                  | 1086.3340                    | 28.0000000                 |           |  | 25519.523                                             | 24433.189      | 1086.3340      | 28.0000000     |           |            | 25519.523      | 24433.189      | 1086.3340 |  |
| 0.14999997E-01                  | 0.6939932E-01      | 48.927288                 | 1.7086932E-01            | 25519.523                   | 24723.779                  | 795.74414                    | 28.0000000                 |           |  | 25519.523                                             | 24723.779      | 795.74414      | 28.0000000     |           |            | 25519.523      | 24723.779      | 795.74414 |  |
| 0.15499997E-01                  | 0.70203526E-01     | 42.275269                 | 1.7086932E-01            | 25519.523                   | 24977.375                  | 542.14844                    | 28.0000000                 |           |  | 25519.523                                             | 24977.375      | 542.14844      | 28.0000000     |           |            | 25519.523      | 24977.375      | 542.14844 |  |
| 0.15999997E-01                  | 0.70899052E-01     | 35.623245                 | 1.70899052E-01           | 25519.523                   | 25193.379                  | 325.54492                    | 28.0000000                 |           |  | 25519.523                                             | 25193.379      | 325.54492      | 28.0000000     |           |            | 25519.523      | 25193.379      | 325.54492 |  |

TABLE I-3. CALCULATIONS ON A CONCRETE BEAM, AFSC CASEA3-2.4 POUND AT 18 INCHES  
(Continued).

|                |                |           |           |           |            |            |            |
|----------------|----------------|-----------|-----------|-----------|------------|------------|------------|
| 0.16499974E-01 | 0.81475767E-01 | 28.971224 | 2.2813220 | 25519.523 | 25.375.530 | 145.93555  | 28.0000000 |
| 0.16999974E-01 | 0.8193737E-01  | 22.319195 | 2.2941446 | 25519.523 | 25.316.205 | 3.3183594  | 28.0000000 |
| 0.17499974E-01 | 0.8227902E-01  | 15.667164 | 2.3036413 | 25519.523 | 25.621.890 | -102.30664 | 28.0000000 |
| 0.17999974E-01 | 0.8249327E-01  | 9.0151377 | 2.3098116 | 25519.523 | 25.690.461 | -170.93750 | 28.0000000 |
| 0.18499974E-01 | 0.8259467E-01  | 2.3631105 | 2.3126564 | 25519.523 | 25.722.100 | -202.57617 | 28.0000000 |

MAXIMUM DEFLECTION = 2.3128629 AT TIME = 0.18699976E-01

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

TABLE I-4. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA4 .8 POUND AT 7 INCHES.

PAGE 1

3 27 1990 9 45 5 40

CALCULATIONS ON A CONCRETE BEAM

AFESC CASEA4--2.8 LB. AT 7 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. (XD 28.000000  
 BEAM OR PLATE THICKNESS, IN. (XD 1.000000  
 LENGTH TO MATH RATIO, DIMENSIONLESS (XD 0.89599999  
 MASS PER UNIT AREA, LBS.-SEC.SQ./IN.CUBED (CNDLND 0.096599997E-03  
 POWER FROM PRESSURE-LAMBDA CURVE (FND 1.0000000  
 UNIFORM PRESSURE LOAD, PSI. (CND 0.00000000E+00  
 PRESSURE AREA, DIMENSIONLESS (ALPHND 3.40000001  
 PRESSURE DURATION, SEC. (FND 0.24500000E-03  
 SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED (F 2.00000000  
 SHAPE FUNCTION: 1=SEMI-ELL, 2=SHORE (CND 1.00000000  
 WEIGHT VECTING DEPERT, 1=EXP.BLM., 2=EXP. RB (CNDLND 0.08000000E+00  
 REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.SQ. (RHOR 0.73390000E-03  
 CONCRETE COMPRESSIVE STRENGTH, PSI. (CNDLND 5000.0000  
 REINFORCED STEEL YIELD STRESS, PSI. (CNDLND 6500.0000  
 REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS (CD 0.24599999E-02  
 REINFORCING DISTANCE, IN. (CD 3.30000000  
 DIAMETER OF EXPLOSIVE, IN. (B1LD) 3.25000000  
 PRESSURE INTERCEPT ON P-LAMBDA CURVE (CNDLND 5.00000000  
 EXPLOSIVE WEIGHT, LBS. (B1GD 2.80000000  
 LENGTH OF ENVELOPE, IN. (B1LD) 5.13000001  
 X 1 OF EXPLOSIVE, IN. (E4D) 28.0000000  
 X 2 OF EXPLOSIVE, IN. (E4D) 28.0000000  
 Y 1 OF EXPLOSIVE, IN. (E4D) 23.4000000  
 Y 2 OF EXPLOSIVE, IN. (E4D) 27.7999999  
 Z 1 OF EXPLOSIVE, IN. (E2D) 7.0000000  
 Z 2 OF EXPLOSIVE, IN. (E2D) 7.0000000  
 SHEAR STRIP REINFORCEMENT RATIO (CND 0.49999999E-04  
 ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (CNDLND 2.00000000  
 TIME INCREMENT, SEC. (TIMCR) 0.99999997E-04  
 TIME MAXIMUM, SEC. (FMRK) 0.10000000  
 TIME STEP INTERVAL PER PRINTED LINE, SEC. (TPRINT) 0.50000002E-03  
 CRITICAL TIME, SEC. (TCR) 0.120000001E-02

U VALUE OF THE ORIGIN HINGE LOCATION, XHD, WAS FOUND IN THE INTERVAL (CND).  
 ASSUMED TO BE THE VALUE OF ...

CONSTANT VALUES

AM HALF WIDTH, IN (B) 24.920000  
 LONG POWER, IN.-L (B1GND) 5542.1230  
 WEIGHT PER UNIT AREA (CD 0.59721902



TABLE I-4. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA4-2.8 POUND AT 7 INCHES  
(Continued).

| ORIGINAL HINGE LOCATION, IN.                                                          |                 | CHD 28.000000         |                       | BLAST LOAD                |                         |
|---------------------------------------------------------------------------------------|-----------------|-----------------------|-----------------------|---------------------------|-------------------------|
| CLAMPED-SUPPORTED                                                                     |                 | GENERAL TIME FUNCTION |                       | VERTICAL WALL             |                         |
| CALCULATIONS ON A CONCRETE BEAM LOCALIZED SHEAR FAILURE CALCULATION                   |                 |                       |                       |                           |                         |
| AFESC CASEA4-2.8 LB. AT 7 IN.                                                         |                 |                       |                       |                           |                         |
| CLAMPED-SUPPORTED                                                                     |                 | GENERAL TIME FUNCTION |                       | VERTICAL WALL             |                         |
| BREACH RADIUS                                                                         | I BAR           | I CRITICAL            |                       |                           |                         |
| 1.000000                                                                              | 2.0044239       | 1.0438719             |                       |                           |                         |
| 9.5000010                                                                             | 1.0326266       | 1.0438719             |                       |                           |                         |
| BREACH BY LOCALIZED SHEAR FAILURE AT BREACH RADIUS OF 9.50000 IN.                     |                 |                       |                       |                           |                         |
| CALCULATIONS ON A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE |                 |                       |                       |                           |                         |
| AFESC CASEA4-2.8 LB. AT 7 IN.                                                         |                 |                       |                       |                           |                         |
| CLAMPED-SUPPORTED                                                                     |                 | GENERAL TIME FUNCTION |                       | VERTICAL WALL             |                         |
| TIME (SECONDS)                                                                        | THETA (RADIANS) | MOVT. VEL. (IN./SEC.) | DISPL. DELTA (INCHES) | PRESSURE WORK (C.N.-LBS.) | PLASTIC WORK (IN.-LBS.) |
| 0.0000000E+00                                                                         | 0.7000000E+00   | 0.0000000E+00         | 0.0000000E+00         | 0.0000000E+00             | 0.0000000E+00           |
| 0.4999997E-02                                                                         | 0.7134355E-02   | 436.34702             | 0.19373619            | 80932.406                 | 2221.5291               |
| 0.9999993E-03                                                                         | 0.1467668E-01   | 430.29495             | 0.1654670             | 80932.406                 | 4632.9639               |
| 0.9999997E-02                                                                         | 0.2250111E-01   | 423.64265             | 0.63003117            | 80932.406                 | 7007.4053               |
| 0.1999999E-02                                                                         | 0.3000677E-01   | 416.95078             | 0.64018944            | 80932.406                 | 9344.8535               |
| 0.24999997E-02                                                                        | 0.3753764E-01   | 410.33668             | 1.0470221             | 80932.406                 | 11645.309               |
| 0.30000003E-02                                                                        | 0.4466172E-01   | 403.68658             | 1.2405283             | 80932.406                 | 13908.270               |
| 0.35000003E-02                                                                        | 0.5181102E-01   | 397.03452             | 1.4307086             | 80932.406                 | 16324.713               |
| 0.40000007E-02                                                                        | 0.5894153E-01   | 390.38242             | 1.6179229             | 80932.406                 | 18824.713               |
| 0.44999930E-02                                                                        | 0.6575325E-01   | 383.73035             | 1.8010910             | 80932.406                 | 20477.193               |
| 0.49999930E-02                                                                        | 0.7230325E-01   | 377.07825             | 2.012632              | 80932.406                 | 22392.482               |
| 0.54999931E-02                                                                        | 0.7832032E-01   | 370.42615             | 2.218192              | 80932.406                 | 24671.178               |
| 0.59999933E-02                                                                        | 0.8372588E-01   | 363.77408             | 2.401743              | 80932.406                 | 26712.680               |
| 0.64999936E-02                                                                        | 0.8852226E-01   | 357.12158             | 2.5819433             | 80932.406                 | 28717.167               |
| 0.69999939E-02                                                                        | 0.9290303E-01   | 350.46388             | 2.7588410             | 80932.406                 | 30684.703               |
| 0.74999947E-02                                                                        | 0.9690394E-01   | 343.81761             | 2.9324131             | 80932.406                 | 32615.225               |
| 0.79999939E-02                                                                        | 0.10080325      | 337.16571             | 3.1026590             | 80932.406                 | 34508.754               |
| 0.84999930E-02                                                                        | 0.11677067      | 330.51361             | 3.2695787             | 80932.406                 | 36365.283               |
| 0.89999922E-02                                                                        | 0.12811331      | 323.86154             | 3.4331227             | 80932.406                 | 38184.832               |
| 0.94999913E-02                                                                        | 0.13947850      | 317.20944             | 3.5934401             | 80932.406                 | 39987.379               |
| 0.99999905E-02                                                                        | 0.15074222      | 310.55737             | 3.7503819             | 80932.406                 | 41712.434               |
| 0.10499990E-01                                                                        | 0.15947850      | 303.90527             | 3.9034793             | 80932.406                 | 43421.496               |
| 0.10999989E-01                                                                        | 0.16475557      | 297.25317             | 4.0542870             | 80932.406                 | 45093.066               |
| 0.11499988E-01                                                                        | 0.15004468      | 290.60110             | 4.2012510             | 80932.406                 | 46727.671               |
| 0.11999987E-01                                                                        | 0.15517460      | 283.94901             | 4.3448887             | 80932.406                 | 48325.223               |
| 0.12499986E-01                                                                        | 0.16018571      | 277.29694             | 4.4851989             | 80932.406                 | 49885.812               |
| 0.12999985E-01                                                                        | 0.16507806      | 270.64484             | 4.6221857             | 80932.406                 | 51409.406               |
| 0.13499984E-01                                                                        | 0.16985117      | 263.99274             | 4.7568574             | 80932.406                 | 52897.184               |
| 0.13999983E-01                                                                        | 0.17451219      | 257.34064             | 4.8891291             | 80932.406                 | 54349.703               |
| 0.14499982E-01                                                                        | 0.17906121      | 250.68854             | 5.0190008             | 80932.406                 | 55767.168               |
| 0.14999981E-01                                                                        | 0.18350923      | 244.03644             | 5.1474725             | 80932.406                 | 57149.727               |
| 0.15499980E-01                                                                        | 0.18785725      | 237.38434             | 5.2745442             | 80932.406                 | 58497.287               |
| 0.15999979E-01                                                                        | 0.19210527      | 230.73224             | 5.4002159             | 80932.406                 | 59819.846               |
| 0.16499978E-01                                                                        | 0.19625329      | 224.08014             | 5.5244876             | 80932.406                 | 61117.405               |
| 0.16999977E-01                                                                        | 0.20030131      | 217.42804             | 5.6473593             | 80932.406                 | 62390.964               |
| 0.17499976E-01                                                                        | 0.20424933      | 210.77594             | 5.7688310             | 80932.406                 | 63640.523               |
| 0.17999975E-01                                                                        | 0.20810735      | 204.12384             | 5.8889027             | 80932.406                 | 64866.082               |
| 0.18499974E-01                                                                        | 0.21186537      | 197.47174             | 6.0075744             | 80932.406                 | 66077.641               |
| 0.18999973E-01                                                                        | 0.21552339      | 190.81964             | 6.1248461             | 80932.406                 | 67272.199               |
| 0.19499972E-01                                                                        | 0.21908141      | 184.16754             | 6.2407178             | 80932.406                 | 68450.758               |
| 0.19999971E-01                                                                        | 0.22253943      | 177.51544             | 6.3551895             | 80932.406                 | 69605.317               |
| 0.20499970E-01                                                                        | 0.22590745      | 170.86334             | 6.4682612             | 80932.406                 | 70739.876               |
| 0.20999969E-01                                                                        | 0.22917547      | 164.21124             | 6.5799329             | 80932.406                 | 71854.435               |
| 0.21499968E-01                                                                        | 0.23234349      | 157.55914             | 6.6902046             | 80932.406                 | 72949.994               |
| 0.21999967E-01                                                                        | 0.23541151      | 150.90704             | 6.8000763             | 80932.406                 | 74025.553               |
| 0.22499966E-01                                                                        | 0.23837953      | 144.25494             | 6.9095480             | 80932.406                 | 75081.112               |
| 0.22999965E-01                                                                        | 0.24124755      | 137.60284             | 7.0186197             | 80932.406                 | 76116.671               |
| 0.23499964E-01                                                                        | 0.24401557      | 130.95074             | 7.1272914             | 80932.406                 | 77132.230               |
| 0.23999963E-01                                                                        | 0.24668359      | 124.29864             | 7.2355631             | 80932.406                 | 78128.789               |
| 0.24499962E-01                                                                        | 0.24925161      | 117.64654             | 7.3434348             | 80932.406                 | 79105.348               |
| 0.24999961E-01                                                                        | 0.25171963      | 110.99444             | 7.4509065             | 80932.406                 | 80061.907               |
| 0.25499960E-01                                                                        | 0.25408765      | 104.34234             | 7.5579782             | 80932.406                 | 81008.466               |
| 0.25999959E-01                                                                        | 0.25635567      | 97.69024              | 7.6646499             | 80932.406                 | 81945.025               |
| 0.26499958E-01                                                                        | 0.25852369      | 91.03814              | 7.7709216             | 80932.406                 | 82861.584               |
| 0.26999957E-01                                                                        | 0.26059171      | 84.38604              | 7.8767933             | 80932.406                 | 83758.143               |
| 0.27499956E-01                                                                        | 0.26255973      | 77.73394              | 7.9822650             | 80932.406                 | 84634.702               |
| 0.27999955E-01                                                                        | 0.26442775      | 71.08184              | 8.0873367             | 80932.406                 | 85491.261               |
| 0.28499954E-01                                                                        | 0.26619577      | 64.42974              | 8.1919084             | 80932.406                 | 86327.820               |
| 0.28999953E-01                                                                        | 0.26786379      | 57.77764              | 8.2960801             | 80932.406                 | 87144.379               |
| 0.29499952E-01                                                                        | 0.26943181      | 51.12554              | 8.4000518             | 80932.406                 | 87940.938               |
| 0.29999951E-01                                                                        | 0.27089983      | 44.47344              | 8.5038235             | 80932.406                 | 88717.497               |
| 0.30499950E-01                                                                        | 0.27226785      | 37.82134              | 8.6073952             | 80932.406                 | 89474.056               |
| 0.30999949E-01                                                                        | 0.27353587      | 31.16924              | 8.7107669             | 80932.406                 | 90210.615               |
| 0.31499948E-01                                                                        | 0.27470389      | 24.51714              | 8.8139386             | 80932.406                 | 90927.174               |
| 0.31999947E-01                                                                        | 0.27577191      | 17.86504              | 8.9169103             | 80932.406                 | 91623.733               |
| 0.32499946E-01                                                                        | 0.27673993      | 11.21294              | 9.0196820             | 80932.406                 | 92300.292               |
| 0.32999945E-01                                                                        | 0.27760795      | 4.56084               | 9.1222537             | 80932.406                 | 92956.851               |
| 0.33499944E-01                                                                        | 0.27837597      | -1.19126              | 9.2246254             | 80932.406                 | 93593.410               |
| 0.33999943E-01                                                                        | 0.27914399      | -7.93936              | 9.3267971             | 80932.406                 | 94210.969               |
| 0.34499942E-01                                                                        | 0.27981201      | -14.78726             | 9.4287688             | 80932.406                 | 94809.528               |
| 0.34999941E-01                                                                        | 0.28037999      | -21.63516             | 9.5305405             | 80932.406                 | 95389.087               |
| 0.35499940E-01                                                                        | 0.28084797      | -28.48306             | 9.6321122             | 80932.406                 | 95939.646               |
| 0.35999939E-01                                                                        | 0.28121595      | -35.33096             | 9.7334839             | 80932.406                 | 96460.205               |
| 0.36499938E-01                                                                        | 0.28148393      | -42.17886             | 9.8346556             | 80932.406                 | 96951.764               |
| 0.36999937E-01                                                                        | 0.28165191      | -49.02676             | 9.9356273             | 80932.406                 | 97413.323               |
| 0.37499936E-01                                                                        | 0.28171989      | -55.87466             | 10.0363990            | 80932.406                 | 97844.882               |
| 0.37999935E-01                                                                        | 0.28168787      | -62.72256             | 10.1369707            | 80932.406                 | 98246.441               |
| 0.38499934E-01                                                                        | 0.28155585      | -69.57046             | 10.2373424            | 80932.406                 | 98618.000               |
| 0.38999933E-01                                                                        | 0.28132383      | -76.41836             | 10.3375141            | 80932.406                 | 98960.559               |
| 0.39499932E-01                                                                        | 0.28099181      | -83.26626             | 10.4374858            | 80932.406                 | 99274.118               |
| 0.39999931E-01                                                                        | 0.28055979      | -90.11416             | 10.5372575            | 80932.406                 | 99558.677               |
| 0.40499930E-01                                                                        | 0.28002777      | -96.96206             | 10.6368292            | 80932.406                 | 99814.236               |
| 0.40999929E-01                                                                        | 0.27939575      | -103.80996            | 10.7362009            | 80932.406                 | 100040.795              |
| 0.41499928E-01                                                                        | 0.27866373      | -110.65786            | 10.8353726            | 80932.406                 | 100237.354              |
| 0.41999927E-01                                                                        | 0.27783171      | -117.50576            | 10.9343443            | 80932.406                 | 100403.913              |
| 0.42499926E-01                                                                        | 0.27689969      | -124.35366            | 11.0331160            | 80932.406                 | 100540.472              |
| 0.42999925E-01                                                                        | 0.27586767      | -131.20156            | 11.1316877            | 80932.406                 | 100647.031              |
| 0.43499924E-01                                                                        | 0.27473565      | -138.04946            | 11.2300594            | 80932.406                 | 100723.590              |
| 0.43999923E-01                                                                        | 0.27350363      | -144.89736            | 11.3282311            | 80932.406                 | 100770.149              |
| 0.44499922E-01                                                                        | 0.27217161      | -151.74526            | 11.4262028            | 80932.406                 | 100786.708              |
| 0.44999921E-01                                                                        | 0.27073959      | -158.59316            | 11.5239745            | 80932.406                 | 100773.267              |
| 0.45499920E-01                                                                        | 0.26920757      | -165.44106            | 11.6215462            | 80932.406                 | 100739.826              |
| 0.45999919E-01                                                                        | 0.26757555      | -172.28896            | 11.7189179            | 80932.406                 | 100676.385              |
| 0.46499918E-01                                                                        | 0.26584353      | -179.13686            | 11.8160896            | 80932.406                 | 100582.944              |
| 0.46999917E-01                                                                        | 0.26401151      | -185.98476            | 11.9130613            | 80932.406                 | 100459.503              |
| 0.47499916E-01                                                                        | 0.26207949      | -192.83266            | 12.0098330            | 80932.406                 | 100306.062              |
| 0.47999915E-01                                                                        | 0.26004747      | -199.68056            | 12.1064047            | 80932.406                 | 100122.621              |
| 0.48499914E-01                                                                        | 0.25791545      | -206.52846            | 12.2027764            | 80932.406                 | 99909.180               |
| 0.48999913E-01                                                                        | 0.25568343      | -213.37636            | 12.2989481            | 80932.406                 | 99665.739               |
| 0.49499912E-01                                                                        | 0.25335141      | -220.22426            | 12.3949198            | 80932.406                 | 99392.298               |
| 0.49999911E-01                                                                        | 0.25091939      | -227.07216            | 12.4906915            | 80932.406                 | 99088.857               |
| 0.50499910E-01                                                                        | 0.24838737      | -233.92006            | 12.5862632            | 80932.406                 | 98755.416               |
| 0.50999909E-01                                                                        | 0.24575535      | -240.76796            | 12.6816349            | 80932.406                 | 98391.975               |
| 0.51499908E-01                                                                        | 0.24302333      | -247.61586            | 12.7768066            | 80932.406                 | 97998.534               |
| 0.51999907E-01                                                                        | 0.24019131      | -254.46376            | 12.8717783            | 80932.406                 | 97575.093               |
| 0.52499906E-01                                                                        | 0.23725929      | -261.31166            | 12.9665499            | 80932.406                 | 97121.652               |
| 0.52999905E-01                                                                        | 0.23422727      | -268.15956            | 13.0611216            | 80932.406                 | 96638.211               |
| 0.53499904E-01                                                                        | 0.23109525      | -275.00746            | 13.1554933            | 80932.406                 | 96124.770               |
| 0.53999903E-01                                                                        | 0.22786323      | -281.85536            | 13.2496650            | 80932.406                 | 95581.329               |
| 0.54499902E-01                                                                        | 0.22453121      | -288.70326            | 13.3436367            | 80932.406                 | 95007.888               |
| 0.54999901E-01                                                                        | 0.22109919      | -295.55116            | 13.4374084            | 80932.406                 | 94404.447               |
| 0.55499900E-01                                                                        | 0.21756717      | -302.39906            | 13.5309801            | 80932.406                 | 93770.006               |
| 0.55999899E-01                                                                        | 0.21393515      | -309.24696            | 13.6243518            | 80932.406                 | 93105.565               |
| 0.56499898E-01                                                                        | 0.21020313      | -316.09486            | 13.7175235            | 80932.406                 | 92411.124               |
| 0.56999897E-                                                                          |                 |                       |                       |                           |                         |

TABLE I-4. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA4-2.8 POUND AT 7 INCHES  
(Continued).

|                  |            |           |           |           |           |           |           |
|------------------|------------|-----------|-----------|-----------|-----------|-----------|-----------|
| 0.13-0939 8-E-01 | 0.10905162 | 263.94274 | 4.7558451 | 80932.406 | 53836.004 | 26036.398 | 28.000000 |
| 0.13-0939 8-E-01 | 0.11700637 | 257.34067 | 4.861760  | 80932.406 | 53745.517 | 26586.789 | 28.000000 |
| 0.13-0939 8-E-01 | 0.12504235 | 250.68857 | 5.0131860 | 80932.406 | 53736.234 | 26174.172 | 28.000000 |
| 0.13-0939 8-E-01 | 0.13305954 | 244.03698 | 5.1368670 | 80932.406 | 53733.855 | 23796.351 | 28.000000 |
| 0.13-0939 8-E-01 | 0.14107572 | 237.38440 | 5.2372217 | 80932.406 | 53472.484 | 21459.922 | 28.000000 |
| 0.13-0939 8-E-01 | 0.14909190 | 230.73230 | 5.3742514 | 80932.406 | 53774.121 | 21158.285 | 28.000000 |
| 0.13-0939 8-E-01 | 0.15710795 | 224.08022 | 5.4979541 | 80932.406 | 61038.762 | 19833.645 | 28.000000 |
| 0.13-0939 8-E-01 | 0.16512400 | 217.42819 | 5.5983310 | 80932.406 | 61266.410 | 18665.996 | 28.000000 |
| 0.13-0939 8-E-01 | 0.17314005 | 211.77617 | 5.7053823 | 80932.406 | 63387.066 | 17475.340 | 28.000000 |
| 0.13-0939 8-E-01 | 0.18115610 | 204.12415 | 5.8091078 | 80932.406 | 65727.398 | 15205.008 | 28.000000 |
| 0.13-0939 8-E-01 | 0.18917215 | 197.47214 | 5.9095063 | 80932.406 | 68807.078 | 14125.328 | 28.000000 |
| 0.13-0939 8-E-01 | 0.19718820 | 190.82011 | 6.0065799 | 80932.406 | 67849.766 | 13082.641 | 28.000000 |
| 0.13-0939 8-E-01 | 0.20520425 | 184.16809 | 6.1032270 | 80932.406 | 64835.461 | 12076.945 | 28.000000 |
| 0.13-0939 8-E-01 | 0.21322030 | 177.51607 | 6.1907477 | 80932.406 | 69824.156 | 11108.250 | 28.000000 |
| 0.13-0939 8-E-01 | 0.22123635 | 170.86404 | 6.2778430 | 80932.406 | 70755.859 | 10176.547 | 28.000000 |
| 0.13-0939 8-E-01 | 0.22925240 | 164.21202 | 6.3616123 | 80932.406 | 71650.570 | 9281.8359 | 28.000000 |
| 0.13-0939 8-E-01 | 0.23726845 | 157.56000 | 6.4405547 | 80932.406 | 72508.289 | 8424.1172 | 28.000000 |
| 0.13-0939 8-E-01 | 0.24528450 | 150.90797 | 6.5191722 | 80932.406 | 73329.016 | 7603.3905 | 28.000000 |
| 0.13-0939 8-E-01 | 0.25330055 | 144.25595 | 6.5929632 | 80932.406 | 74112.750 | 6819.6562 | 28.000000 |
| 0.13-0939 8-E-01 | 0.26131660 | 137.60394 | 6.6634278 | 80932.406 | 74859.492 | 6072.9141 | 28.000000 |
| 0.13-0939 8-E-01 | 0.26933265 | 130.95182 | 6.7305665 | 80932.406 |           |           |           |

MAXIMUM DEFLECTION = 7.3750262 AT FIRE = 0.3339992E-01

ON ASTERISK INDICATES THAT A REINFORCING ELEMENT WAS FRACTURED

TABLE I-5. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA5-2.8 POUND AT 16 INCHES.

PAGE 1

CALCULATIONS ON A CONCRETE BEAM  
AFESC CASEA5-2.8 LB. AT 16 IN.

3 27 1990 9 45 46 65

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. (R) 28.000000  
BEAM OR PLATE THICKNESS, IN. (H) 4.000000  
LENGTH TO WIDTH RATIO, DIMENSIONLESS (RHO) 0.08999979  
WEISS PER UNIT AREA, LBS.-SEC./IN.<sup>2</sup> (SMALL) 0.08999979E-03  
PRESSURE FROM PRESSURE-LOADING CURVE (FNI) 1.15000000  
UNIT POINT PRESSURE LOAD, PSI (PFI) 0.08000000E+00  
PRESSURE DENSITY, DIMENSIONLESS (CLPFI) 3.00000000  
PRESSURE DURATION, SEC. (TRD) 0.25000001E-03  
SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED (F) 2.00000000  
WAVE FUNCTION: 1=GENERAL, 2=SQUARE (QWVFI) 1.00000000  
HEIGHT VECTOR: 0=VERT, 1=EXP BLM, -1=EXP AB (SMALL) 0.30000000E+00  
REINFORCEMENT DENSITY, LB.-SEC./IN.<sup>2</sup> (RHO) 0.75500000E-03  
CONCRETE COMPRESSIVE STRENGTH, PSI (CSIGMC) 5000.0000  
REINFORCED STEEL YIELD STRESS, PSI (CSIGMR) 6500.0000  
REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS (R) 0.24999999E-02  
REINFORCING DISTANCE, IN. (C) 3.50000000  
DIAMETER OF EXPLOSIVE, IN. (CIGD) 3.75000000  
PRESSURE INTERCEPT ON P-LADING CURVE (SMALL) 5.00000000  
EXPLOSIVE WEIGHT, LBS. (CIGW) 2.80000000  
LENGTH OF EXPLOSIVE, IN. (CIGL) 5.50000001  
X 1 OF EXPLOSIVE, IN. (CX1) 28.000000  
X 2 OF EXPLOSIVE, IN. (CX2) 28.000000  
Y 1 OF EXPLOSIVE, IN. (CY1) 23.400000  
Y 2 OF EXPLOSIVE, IN. (CY2) 27.799999  
Z 1 OF EXPLOSIVE, IN. (CZ1) 16.000000  
Z 2 OF EXPLOSIVE, IN. (CZ2) 16.000000  
SWING STIRRUP REINFORCEMENT RATIO (R) 0.49999999E-04  
ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (CSMALL) 2.00000000  
TIME INCREMENT, SEC. (TINC) 0.99999979E-04  
TIME MAXIMUM, SEC. (THMX) 0.10000000  
TIME STEP INTERVAL PER PRINTED LINE, SEC. (TPRINT) 0.50000002E-03  
CRITICUM TIME, SEC. (CIB) 0.12000001E-02

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN. (R) 28.000000  
BEAM THICKNESS, IN. (H) 4.000000  
WEIGHT PER UNIT AREA, LBS./IN.<sup>2</sup> (RHO) 0.08999979  
ORIGINAL PLATE LOCATION, IN. (X0) 28.675000

CLAMPED-SUPPORTED GENERAL TIME FUNCTION  
VERTICAL WALL ELASTIC LOAD

TABLE I-5. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA5-2.8 POUND AT 16 INCHES  
(Continued).

[illegible]

TABLE I-5. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA5-2.8 POUND AT 16 INCHES  
(Continued).

|               |            |           |           |           |           |            |           |
|---------------|------------|-----------|-----------|-----------|-----------|------------|-----------|
| 0.1699997E-01 | 0.10415415 | 67.656097 | 2.9163163 | 33701.008 | 34436.197 | 1264.6105  | 28.000000 |
| 0.1699997E-01 | 0.10540211 | 61.040082 | 2.9464613 | 33701.008 | 32793.949 | 907.05859  | 28.000000 |
| 0.1799997E-01 | 0.10631287 | 54.352058 | 2.9725002 | 33701.008 | 33114.707 | 586.30078  | 28.000000 |
| 0.1799997E-01 | 0.10724405 | 47.790035 | 3.0028334 | 33701.008 | 33398.473 | 302.53516  | 28.000000 |
| 0.1899997E-01 | 0.10803644 | 41.046016 | 3.0250204 | 33701.008 | 33645.242 | 55.765625  | 28.000000 |
| 0.1899997E-01 | 0.10871005 | 34.395956 | 3.0438014 | 33701.008 | 33855.020 | -154.01172 | 28.000000 |
| 0.1999997E-01 | 0.10935987 | 27.743971 | 3.0594165 | 33701.008 | 34027.805 | -326.79637 | 28.000000 |
| 0.1999997E-01 | 0.10970950 | 21.071942 | 3.0716252 | 33701.008 | 34163.598 | -462.56984 | 28.000000 |
| 0.2099997E-01 | 0.11001816 | 14.419912 | 3.0805085 | 33701.008 | 34262.398 | -561.39062 | 28.000000 |
| 0.2099997E-01 | 0.11021642 | 7.7878861 | 3.0860853 | 33701.008 | 34324.203 | -623.19531 | 28.000000 |
| 0.2199997E-01 | 0.11027829 | 1.1356584 | 3.0882962 | 33701.008 | 34349.016 | -648.00781 | 28.000000 |

MAXIMUM DEFLECTION = 3.088344 RT TIME = 0.2159997E-01

AN APOSTRISK INDICATES THAT A REINFORCING ELEMENT WAS FRACTURED

TABLE I-6. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA6-2.8 POUND AT 23 INCHES.

PAGE 1  
3 27 1990 9 46 43 72

CALCULATIONS ON A CONCRETE BEAM

AFESC CASEA6-2.8 LB. AT 23 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. (XD) 28.000000  
 BEAM OR PLATE THICKNESS, IN. (XD) 4.000000  
 LENGTH TO MOUTH RATIO, DIMENSIONLESS (CND) 0.89999999  
 PRESS PER UNIT AREA, LBS.-SEC.500/IN.CUBED (SHALLD) 0.896599997E-03  
 POWER FROM PRESSURE-LAMBDA CURVE (FND) 1.7500000  
 UNIFORM PRESSURE LOAD, PSI. (FND) 0.00000000E+00  
 PRESSURE RATIO, DIMENSIONLESS (CNLFND) 5.4000001  
 PRESSURE BURSTION, SEC. (TFND) 0.37299999E-03  
 SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED (F) 2.8000000  
 WAVE FUNCTION: 1=GENERAL, 2=SOURCE (CNVFNFD) 1.9000000  
 HEIGHT VECTORS: 0=VERT, 1=EXP BLN, -1=EXP (CNVFNFD) 0.00000000E+00  
 REINFORCEMENT DENSITY, LB.-SEC.50./IN.MM4 (RHOR) 0.72390000E-03  
 CONCRETE COMPRESSIVE STRENGTH, PSI. (SIGMAC) 5000.0000  
 REINFORCED STEEL YIELD STRESS, PSI. (SIGMAK) 65000.000  
 REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS (CD) 0.24999999E-02  
 REINFORCING DISTANCE, IN. (CD) 3.3000000  
 DIAMETER OF EXPLOSIVE, IN. (CBLD) 3.7500000  
 PRESSURE INTERCEPT ON P-LAMBDA CURVE (SHALLD) 5.8000000  
 EXPLOSIVE WEIGHT, LBS. (CBLD) 2.8000000  
 LENGTH OF EXPLOSIVE, IN. (CBLD) 5.6300001  
 X 1 OF EXPLOSIVE, IN. (CX1) 28.000000  
 X 2 OF EXPLOSIVE, IN. (CX2) 28.000000  
 Y 1 OF EXPLOSIVE, IN. (CY1) 23.400000  
 Y 2 OF EXPLOSIVE, IN. (CY2) 27.799999  
 Z 1 OF EXPLOSIVE, IN. (CZ1) 23.000000  
 Z 2 OF EXPLOSIVE, IN. (CZ2) 23.000000  
 SHEAR STRESS REINFORCEMENT RATIO (CQ1) 0.49999999E-04  
 ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (SHALLD) 2.0000000  
 TIME INCREMENT, SEC. (CTIME) 0.99999997E-04  
 TIME MAXIMUM, SEC. (CTIME) 0.10000000  
 TIME STEP INTERVAL PER PRINTED LINE, SEC. (CTIME) 0.50000000E-03  
 CRITICAL TIME, SEC. (CTCR) 0.12000001E-02

COMPUTED CONSTANT VALUES

BEAM HALF AREA, IN. (CD) 24.920000  
 HINGE MOMENT, IN.-LBS./IN. (CBLMD) 1582.1240  
 HEIGHT PER UNIT AREA, LBS./IN.SQ. (CD) 0.34721902  
 ORIGINAL HINGE LOCATION, IN. (CXH) 20.732651

CLAMPED-SUPPORTED

GENERAL TIME FUNCTION

VERTICAL WALL

BLAST LOAD

TABLE I-6. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA6-2.8 POUND AT 23 INCHES  
(Continued).

| LOCALIZED SHEAR FAILURE CALCULATION                                                   |                 |                        |                       |                          |                         |                         |                           |                         |  | PAGE 2     |                    |
|---------------------------------------------------------------------------------------|-----------------|------------------------|-----------------------|--------------------------|-------------------------|-------------------------|---------------------------|-------------------------|--|------------|--------------------|
| AFESC CASEA6--2.8 LB. AT 23 IN.                                                       |                 |                        |                       |                          |                         |                         |                           |                         |  |            |                    |
| CLIPPED-SUPPORTED                                                                     |                 |                        |                       |                          |                         |                         |                           |                         |  |            |                    |
| BREACH RADIUS                                                                         | I BAR           | I CRITICAL             | VERTICAL WALL         |                          |                         |                         |                           |                         |  | BLAST LOAD |                    |
| 1.0000000                                                                             | 0.24826305      | 1.0438719              |                       |                          |                         |                         |                           |                         |  | 3          | 27 1990 9 46 52 29 |
| CALCULATIONS ON A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE |                 |                        |                       |                          |                         |                         |                           |                         |  | PAGE 3     |                    |
| AFESC CASEA6--2.8 LB. AT 23 IN.                                                       |                 |                        |                       |                          |                         |                         |                           |                         |  |            |                    |
| CLIPPED-SUPPORTED                                                                     |                 |                        |                       |                          |                         |                         |                           |                         |  |            |                    |
| TIME (SECONDS)                                                                        | THETA (RADIANS) | ALDPT. VEL. (IN./SEC.) | MIDPT. DELTA (INCHES) | PRESSURE WORK (IN.-LBS.) | PLASTIC WORK (IN.-LBS.) | KINETIC WORK (IN.-LBS.) | KINETIC ENERGY (IN.-LBS.) | HINGE LOCATION (INCHES) |  |            |                    |
| 0.0000000E+00                                                                         | 0.0000000E+00   | 0.0000000E+00          | 0.0000000E+00         | 0.0000000E+00            | 0.0000000E+00           | 0.0000000E+00           | 0.0000000E+00             | 20.732651               |  |            |                    |
| 0.4999999E-02                                                                         | 0.3750732E-02   | 179.42178              | 0.1615329E-01         | 20190.209                | 1168.0712               | 19022.139               | 21.370037                 | 21.370037               |  |            |                    |
| 0.9999998E-02                                                                         | 0.7637620E-02   | 179.42178              | 0.16986418            | 20190.209                | 2397.2327               | 17792.977               | 22.067078                 | 22.067078               |  |            |                    |
| 0.1499997E-02                                                                         | 0.1140162E-01   | 179.42178              | 0.25357507            | 20190.209                | 3550.7485               | 16639.461               | 22.765500                 | 22.765500               |  |            |                    |
| 0.1099996E-02                                                                         | 0.1408453E-01   | 179.42178              | 0.34928602            | 20190.209                | 4635.3013               | 15554.828               | 23.465532                 | 23.465532               |  |            |                    |
| 0.2599995E-02                                                                         | 0.1816527E-01   | 179.42178              | 0.43893897            | 20190.209                | 5637.1167               | 14533.092               | 24.165822                 | 24.165822               |  |            |                    |
| 0.3599994E-02                                                                         | 0.2126121E-01   | 179.42178              | 0.52870792            | 20190.209                | 6621.2686               | 13568.940               | 24.867250                 | 24.867250               |  |            |                    |
| 0.4599993E-02                                                                         | 0.2418744E-01   | 179.42178              | 0.61841087            | 20190.209                | 7532.2698               | 12657.639               | 25.567766                 | 25.567766               |  |            |                    |
| 0.5599992E-02                                                                         | 0.2635754E-01   | 179.42178              | 0.70812982            | 20190.209                | 8395.2471               | 11794.962               | 26.268337                 | 26.268337               |  |            |                    |
| 0.6599991E-02                                                                         | 0.2783591E-01   | 179.42178              | 0.79784077            | 20190.209                | 9213.0308               | 10977.118               | 26.968948                 | 26.968948               |  |            |                    |
| 0.7599990E-02                                                                         | 0.2867016E-01   | 179.42178              | 0.88815331            | 20190.209                | 9989.9420               | 10209.667               | 27.669548                 | 27.669548               |  |            |                    |
| 0.8599989E-02                                                                         | 0.2885291E-01   | 179.42178              | 0.97984077            | 20190.209                | 10728.124               | 9462.0850               | 28.370000                 | 28.370000               |  |            |                    |
| 0.9599988E-02                                                                         | 0.2838529E-01   | 179.42178              | 1.0728381             | 20190.209                | 11425.713               | 8760.4961               | 29.070000                 | 29.070000               |  |            |                    |
| 1.0599987E-02                                                                         | 0.2734452E-01   | 179.42178              | 1.1674103             | 20190.209                | 12094.309               | 8095.9004               | 29.770000                 | 29.770000               |  |            |                    |
| 1.1599986E-02                                                                         | 0.2584673E-01   | 179.42178              | 1.2636554             | 20190.209                | 12721.912               | 7468.2969               | 30.470000                 | 30.470000               |  |            |                    |
| 1.2599985E-02                                                                         | 0.23911448      | 179.42178              | 1.362681              | 20190.209                | 13312.521               | 6877.6875               | 31.170000                 | 31.170000               |  |            |                    |
| 1.3599984E-02                                                                         | 0.21536554      | 179.42178              | 1.466819              | 20190.209                | 13866.139               | 6324.0703               | 31.870000                 | 31.870000               |  |            |                    |
| 1.4599983E-02                                                                         | 0.18729402      | 179.42178              | 1.575012              | 20190.209                | 14382.763               | 5807.4463               | 32.570000                 | 32.570000               |  |            |                    |
| 1.5599982E-02                                                                         | 0.15456819      | 179.42178              | 1.6879.330            | 20190.209                | 14865.394               | 5327.8154               | 33.270000                 | 33.270000               |  |            |                    |
| 1.6599981E-02                                                                         | 0.1175012       | 179.42178              | 1.8074.330            | 20190.209                | 15305.032               | 4885.1768               | 33.970000                 | 33.970000               |  |            |                    |
| 1.7599980E-02                                                                         | 0.075012        | 179.42178              | 1.9310.330            | 20190.209                | 15710.678               | 4479.5312               | 34.670000                 | 34.670000               |  |            |                    |
| 1.8599979E-02                                                                         | 0.02456819      | 179.42178              | 2.0546.330            | 20190.209                | 16079.330               | 4110.8789               | 35.370000                 | 35.370000               |  |            |                    |
| 1.9599978E-02                                                                         | 0.0000000E+00   | 179.42178              | 2.1782.330            | 20190.209                | 16410.990               | 3779.2187               | 36.070000                 | 36.070000               |  |            |                    |
| 2.0599977E-02                                                                         | 0.0000000E+00   | 179.42178              | 2.3018.330            | 20190.209                | 16703.656               | 3484.5527               | 36.770000                 | 36.770000               |  |            |                    |
| 2.1599976E-02                                                                         | 0.0000000E+00   | 179.42178              | 2.4254.330            | 20190.209                | 16963.330               | 3228.8789               | 37.470000                 | 37.470000               |  |            |                    |
| 2.2599975E-02                                                                         | 0.0000000E+00   | 179.42178              | 2.5490.330            | 20190.209                | 17184.010               | 3008.1992               | 38.170000                 | 38.170000               |  |            |                    |
| 2.3599974E-02                                                                         | 0.0000000E+00   | 179.42178              | 2.6726.330            | 20190.209                | 17367.697               | 2822.5117               | 38.870000                 | 38.870000               |  |            |                    |
| 2.4599973E-02                                                                         | 0.0000000E+00   | 179.42178              | 2.7962.330            | 20190.209                | 17514.393               | 2675.8164               | 39.570000                 | 39.570000               |  |            |                    |
| 2.5599972E-02                                                                         | 0.0000000E+00   | 179.42178              | 2.9198.330            | 20190.209                | 17624.094               | 2568.1152               | 40.270000                 | 40.270000               |  |            |                    |
| 2.6599971E-02                                                                         | 0.0000000E+00   | 179.42178              | 3.0434.330            | 20190.209                | 17696.803               | 2493.4062               | 40.970000                 | 40.970000               |  |            |                    |
| 2.7599970E-02                                                                         | 0.0000000E+00   | 179.42178              | 3.1670.330            | 20190.209                | 17735.520               | 2457.6895               | 41.670000                 | 41.670000               |  |            |                    |

MAXIMUM DEFLECTION = 1.5946493 AT TIME = 0.1529998E-01

TABLE 1-6. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEA6-2.8 POUND AT 23 INCHES  
(Continued).

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED







TABLE I-8. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB2-2.4 POUND AT 12 INCHES.

PAGE 1  
3 27 1990 9 51 59 54

CALCULATIONS ON A CONCRETE BEAM  
AFESC CASEB2-2.4 LB. AT 12 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. CD 28.000000  
BEAM OR PLATE THICKNESS, IN. CD 1.000000  
LENGTH TO WIDTH RATIO, DIMENSIONLESS (PR) 0.08999999  
WEISS PER UNIT AREA, LBS.-SEC.500/IN.CURED (SMALL) 0.89059997E-03  
POWER FROM PRESSURE-LAMBDA CURVE (PD) 1.0000000  
UNIFORM PRESSURE LOAD, PSI. (PU) 0.00000000E+00  
PRESSURE DECAY, DIMENSIONLESS (ALPHA) 3.5000000  
PRESSURE DURATION, SEC. (TRD) 0.20200000E-03  
SUPPORT FACTOR: 1-SIMPLY, 2-CLAMPED (C) 2.0000000  
WAVE FUNCTION: 1-GENERAL, 2-SOURCE CURVE (C) 1.0000000  
WEIGHT VECTOR: 0=VERT, 1=EXP BLN, -1=EXP AB (SMALL) 0.00000000E+00  
REINFORCEMENT DENSITY, LB.-SEC.50./IN.SQ. (RHOR) 0.73390000E-03  
CONCRETE COMPRESSIVE STRENGTH, PSI. (SIGNAC) 5000.0000  
REINFORCED STEEL YIELD STRESS, PSI. (SIGNAR) 5000.0000  
REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS (C) 0.99999998E-02  
REINFORCING DISTANCE, IN. (C) 3.3000000  
DIAMETER OF EXPLOSIVE, IN. (BIGD) 2.5000000  
PRESSURE INTERCEPT ON P-LAMBDA CURVE (SMALL) 5.0000000  
EXPLOSIVE WEIGHT, LBS. (BIGW) 2.4000001  
LENGTH OF EXPLOSIVE, IN. (BIGL) 8.1999996  
X 1 OF EXPLOSIVE, IN. (EX1) 28.000000  
X 2 OF EXPLOSIVE, IN. (EX2) 28.000000  
Y 1 OF EXPLOSIVE, IN. (EY1) 20.900000  
Y 2 OF EXPLOSIVE, IN. (EY2) 29.100000  
Z 1 OF EXPLOSIVE, IN. (EZ1) 12.000000  
Z 2 OF EXPLOSIVE, IN. (EZ2) 12.000000  
SHEAR STIRRUP REINFORCEMENT RATIO (C) 0.49999999E-01  
ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (SMALL) 2.0000000  
TIME INCREMENT, SEC. (TINC) 0.99999997E-04  
TIME MAXIMUM, SEC. (THAN) 0.10000000  
TIME STEP INTERVAL PER PRINTED LINE, SEC. (TPRINT) 0.50000002E-03  
CRITICAL TIME, SEC. (TCR) 0.14000000E-02  
NO VALUE OF THE ORIGINAL HINGE LOCATION, XHO, WAS FOUND IN THE INTERVAL (C, D).  
IT IS ASSUMED TO BE THE VALUE OF A.

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN. (C) 24.920000  
HINGE MOMENT, IN.-LBS./IN. (BIGMD) 5082.0205  
WEIGHT PER UNIT AREA, LBS./IN.SQ. (C) 0.34721902

TABLE I-8. CALCULATIONS ON A CONCRETE BEAM, AFESC CASE2-2.4 POUND AT 12 INCHES  
(Continued).

| ORIGINAL HINGE LOCATION, IN.    |  |  |  |  |  |  |  |  |  | CHD 26.000000                                         |  |  |  |  |  |  |  |  |  |
|---------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------------------------------|--|--|--|--|--|--|--|--|--|
| CLAMPED-SUPPORTED               |  |  |  |  |  |  |  |  |  | VERTICAL WALL                                         |  |  |  |  |  |  |  |  |  |
| GENERAL TIME FUNCTION           |  |  |  |  |  |  |  |  |  | BLAST LOAD                                            |  |  |  |  |  |  |  |  |  |
| CALCULATIONS ON A CONCRETE BEAM |  |  |  |  |  |  |  |  |  | LOCALIZED SHEAR FAILURE CALCULATION                   |  |  |  |  |  |  |  |  |  |
| AFESC CRSE#--2.4 LB. AT 12 IN.  |  |  |  |  |  |  |  |  |  | 3 27 1990 9 52 2 67                                   |  |  |  |  |  |  |  |  |  |
| CLAMPED-SUPPORTED               |  |  |  |  |  |  |  |  |  | VERTICAL WALL                                         |  |  |  |  |  |  |  |  |  |
| GENERAL TIME FUNCTION           |  |  |  |  |  |  |  |  |  | BLAST LOAD                                            |  |  |  |  |  |  |  |  |  |
| I CRITICAL                      |  |  |  |  |  |  |  |  |  |                                                       |  |  |  |  |  |  |  |  |  |
| 1.000000 0.79421699 1.7530495   |  |  |  |  |  |  |  |  |  |                                                       |  |  |  |  |  |  |  |  |  |
| CALCULATIONS ON A CONCRETE BEAM |  |  |  |  |  |  |  |  |  | FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE |  |  |  |  |  |  |  |  |  |
| AFESC CRSE#--2.4 LB. AT 12 IN.  |  |  |  |  |  |  |  |  |  | 3 27 1990 9 52 3 17                                   |  |  |  |  |  |  |  |  |  |
| CLAMPED-SUPPORTED               |  |  |  |  |  |  |  |  |  | VERTICAL WALL                                         |  |  |  |  |  |  |  |  |  |
| GENERAL TIME FUNCTION           |  |  |  |  |  |  |  |  |  | BLAST LOAD                                            |  |  |  |  |  |  |  |  |  |
| I CRITICAL                      |  |  |  |  |  |  |  |  |  |                                                       |  |  |  |  |  |  |  |  |  |
| 1.000000 0.79421699 1.7530495   |  |  |  |  |  |  |  |  |  |                                                       |  |  |  |  |  |  |  |  |  |

MAXIMUM DEFLECTION = 1.1479876 AT TIME = 0.60999957E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT WAS FRACTURED

TABLE I-9. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB3-2.4 POUND AT 18 INCHES.

PAGE 1

3 27 1990 9 52 9 92

CALCULATIONS ON A CONCRETE BEAM

AFESC CASEB3-2.4 LB. AT 18 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. (XD) 28.000000  
 BEAM OR PLATE THICKNESS, IN. (XD) 4.000000  
 LENGTH TO WIDTH RATIO, DIMENSIONLESS (XND) 0.8899999999  
 MASS PER UNIT AREA, LBS.-SEC.SQ./IN.CURED (CENHLLD) 0.898599977E-03  
 POWER FROM PRESSURE-LAMBDA CURVE (FND) 1.15000000  
 UNIFORM PRESSURE LOAD, PSI. (PUD) 0.00000000E+00  
 PRESSURE DELAY, DIMENSIONLESS (ALPHAD) 4.30000012  
 PRESSURE DURATION, SEC. (CTPUD) 0.261999999E-03  
 SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED (CF) 2.00000000  
 SHAPE FUNCTION: 1=GENERAL, 2=SQUARE (SHAPEFN) 1.00000000  
 WEIGHT VECTOR: 0=VERT, 1=EXP BLM, -1=EXP NO (CENHLLD) 0.00000000E+00  
 REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.MM-1 (CRHOD) 0.73900000E-03  
 CONCRETE COMPRESSIVE STRENGTH, PSI. (CSIGRCD) 5000.0000  
 REINFORCED STEEL YIELD STRESS, PSI. (CSIGHRD) 65000.0000  
 REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS (CD) 0.99999999E-02  
 REINFORCING DISTANCE, IN. (CD) 3.30000000  
 DIAMETER OF EXPLOSIVE, IN. (CBIGD) 2.50000000  
 PRESSURE INTERCEPT ON P-LAMBDA CURVE (CENHLLD) 5.00000000  
 EXPLOSIVE HEIGHT, LBS. (CBIGD) 2.40000011  
 LENGTH OF EXPLOSIVE, IN. (CBIGD) 0.19999996  
 X 1 OF EXPLOSIVE, IN. (CXID) 28.00000000  
 X 2 OF EXPLOSIVE, IN. (CXID) 28.00000000  
 Y 1 OF EXPLOSIVE, IN. (CYID) 0.90000000  
 Y 2 OF EXPLOSIVE, IN. (CYID) 0.10000000  
 Z 1 OF EXPLOSIVE, IN. (CZID) 18.00000000  
 Z 2 OF EXPLOSIVE, IN. (CZID) 18.00000000  
 SHEAR STRENGTH REINFORCEMENT RATIO (QID) 0.49999999E-04  
 ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (CENHLLD) 2.00000000  
 TIME INTERVAL, SEC. (TINGED) 0.99999997E-04  
 TIME MAXIMUM, SEC. (CTHRD) 0.10000000  
 TIME STEP INTERVAL PER PRINTED LINE, SEC. (CTPINTD) 0.50000002E-03  
 CRITICAL TIME, SEC. (CTCRD) 0.14000000E-02

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN. (XD) 28.000000  
 HINGE MOMENT, IN.-LBS./IN. (BIGRD) 5882.0205  
 WEIGHT PER UNIT AREA, LBS./IN.SQ. (XD) 0.34221902  
 ORIGINAL HINGE LOCATION, IN. (XRD) 26.058931

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL

BLAST LOAD

TABLE I-9. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB3-2.4 POUND AT 18 INCHES  
(Continued).

| CALCULATIONS IN A CONCRETE BEAM |  |  |  |  |                        |  |  |  |  | LOCALIZED SHEAR FAILURE CALCULATION                   |  |  |  |  |                          |  |  |  |  | PAGE 2                  |  |  |  |  |                           |  |  |  |  |                       |  |  |  |  |            |  |  |  |  |
|---------------------------------|--|--|--|--|------------------------|--|--|--|--|-------------------------------------------------------|--|--|--|--|--------------------------|--|--|--|--|-------------------------|--|--|--|--|---------------------------|--|--|--|--|-----------------------|--|--|--|--|------------|--|--|--|--|
| AFESC CASE#—2.4 LB. AT 10 IN.   |  |  |  |  |                        |  |  |  |  |                                                       |  |  |  |  |                          |  |  |  |  |                         |  |  |  |  |                           |  |  |  |  |                       |  |  |  |  |            |  |  |  |  |
| CLAMPED-SUPPORTED               |  |  |  |  | GENERAL TIME FUNCTION  |  |  |  |  | VERTICAL WALL                                         |  |  |  |  | BLAST LOAD               |  |  |  |  |                         |  |  |  |  |                           |  |  |  |  |                       |  |  |  |  |            |  |  |  |  |
| BATCH RADIUS 1 BAR              |  |  |  |  | I CRITICAL             |  |  |  |  |                                                       |  |  |  |  |                          |  |  |  |  |                         |  |  |  |  |                           |  |  |  |  |                       |  |  |  |  |            |  |  |  |  |
| 1.0000000                       |  |  |  |  | 1.7538495              |  |  |  |  |                                                       |  |  |  |  |                          |  |  |  |  |                         |  |  |  |  |                           |  |  |  |  |                       |  |  |  |  |            |  |  |  |  |
| CALCULATIONS IN A CONCRETE BEAM |  |  |  |  |                        |  |  |  |  | FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE |  |  |  |  |                          |  |  |  |  | PAGE 3                  |  |  |  |  |                           |  |  |  |  |                       |  |  |  |  |            |  |  |  |  |
| AFESC CASE#—2.4 LB. AT 10 IN.   |  |  |  |  |                        |  |  |  |  |                                                       |  |  |  |  |                          |  |  |  |  |                         |  |  |  |  |                           |  |  |  |  |                       |  |  |  |  |            |  |  |  |  |
| CLAMPED-SUPPORTED               |  |  |  |  | GENERAL TIME FUNCTION  |  |  |  |  | VERTICAL WALL                                         |  |  |  |  | BLAST LOAD               |  |  |  |  |                         |  |  |  |  |                           |  |  |  |  |                       |  |  |  |  |            |  |  |  |  |
| TIME (SECONDS)                  |  |  |  |  | MIDPT. VEL. (IN./SEC.) |  |  |  |  | MIDPT. DELTA (CMES)                                   |  |  |  |  | PRESSURE WORK (IN.-LBS.) |  |  |  |  | PLASTIC WORK (IN.-LBS.) |  |  |  |  | KINETIC ENERGY (IN.-LBS.) |  |  |  |  | HINGE LOCATION (CMES) |  |  |  |  |            |  |  |  |  |
| 0.0000000E+00                   |  |  |  |  | 0.0000000E+00          |  |  |  |  | 0.0000000E+00                                         |  |  |  |  | 0.0000000E+00            |  |  |  |  | 0.0000000E+00           |  |  |  |  | 0.0000000E+00             |  |  |  |  | 26.098991             |  |  |  |  |            |  |  |  |  |
| 0.0000000E+00                   |  |  |  |  | 0.3856147E-02          |  |  |  |  | 0.10839135                                            |  |  |  |  | 25169.121                |  |  |  |  | 4525.9375               |  |  |  |  | 20643.184                 |  |  |  |  | 28.0000000            |  |  |  |  |            |  |  |  |  |
| 0.0000000E+00                   |  |  |  |  | 0.7356022E-02          |  |  |  |  | 0.21374086                                            |  |  |  |  | 25169.121                |  |  |  |  | 8951.4648               |  |  |  |  | 16217.656                 |  |  |  |  | 28.0000000            |  |  |  |  |            |  |  |  |  |
| 0.0000000E+00                   |  |  |  |  | 0.13560312E-01         |  |  |  |  | 0.30688873                                            |  |  |  |  | 25169.121                |  |  |  |  | 12852.497               |  |  |  |  | 12316.624                 |  |  |  |  | 28.0000000            |  |  |  |  |            |  |  |  |  |
| 0.0000000E+00                   |  |  |  |  | 0.14939947E-02         |  |  |  |  | 0.173.77136                                           |  |  |  |  | 0.38751280               |  |  |  |  | 25169.121               |  |  |  |  | 16229.033                 |  |  |  |  | 8940.0879             |  |  |  |  | 28.0000000 |  |  |  |  |
| 0.0000000E+00                   |  |  |  |  | 0.19393947E-02         |  |  |  |  | 0.148.72140                                           |  |  |  |  | 0.11271897E-01           |  |  |  |  | 25169.121               |  |  |  |  | 6088.0469                 |  |  |  |  | 3760.5039             |  |  |  |  | 28.0000000 |  |  |  |  |
| 0.0000000E+00                   |  |  |  |  | 0.24393947E-02         |  |  |  |  | 0.123.67682                                           |  |  |  |  | 0.45561311               |  |  |  |  | 25169.121               |  |  |  |  | 19081.074                 |  |  |  |  | 21408.617             |  |  |  |  | 28.0000000 |  |  |  |  |
| 0.0000000E+00                   |  |  |  |  | 0.28256777E-01         |  |  |  |  | 0.98.629257                                           |  |  |  |  | 0.51118964               |  |  |  |  | 25169.121               |  |  |  |  | 23211.664                 |  |  |  |  | 1957.4570             |  |  |  |  | 28.0000000 |  |  |  |  |
| 0.0000000E+00                   |  |  |  |  | 0.31794371E-01         |  |  |  |  | 0.55424237                                            |  |  |  |  | 0.58477134               |  |  |  |  | 25169.121               |  |  |  |  | 24190.275                 |  |  |  |  | 678.90625             |  |  |  |  | 28.0000000 |  |  |  |  |
| 0.0000000E+00                   |  |  |  |  | 0.24684631E-01         |  |  |  |  | 0.4653122                                             |  |  |  |  | 25169.121                |  |  |  |  | 25244.271               |  |  |  |  | -75.150391                |  |  |  |  | 28.0000000            |  |  |  |  |            |  |  |  |  |
| 0.0000000E+00                   |  |  |  |  | 0.21527754E-01         |  |  |  |  | 23.486568                                             |  |  |  |  |                          |  |  |  |  |                         |  |  |  |  |                           |  |  |  |  |                       |  |  |  |  |            |  |  |  |  |

MAXIMUM DEFLECTION = 0.60625735 AT TIME = 0.49999990E-02

AN ASTERISK INDICATES THAT A NEIGHBORING ELEMENT WAS FRACTURED

TABLE I-10. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB41-2.8 POUND AT 7 INCHES.

PAGE 1

CALCULATIONS ON A CONCRETE BEAM

AFESC CASEB41-2.8 LB. AT 7 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. (R) 28.000000  
 BEAM OR PLATE THICKNESS, IN. (H) 4.000000  
 LENGTH TO WIDTH RATIO, DIMENSIONLESS (LWD) 0.89999999  
 MASS PER UNIT AREA, LBS.-SEC.SQ./IN.CURED (SMALL) 0.899999997E-03  
 POWER FROM PRESSURE-LAMBDA CURVE (FND) 1.000000  
 UNIFORM PRESSURE LOAD, PSI. (PU) 0.00000000E+00  
 PRESSURE DECAY, DIMENSIONLESS (ALPHA) 3.4000001  
 PRESSURE DURATION, SEC. (TMD) 0.24500000E-03  
 SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED (F) 2.0000000  
 SHAPE FUNCTION: 1=GENERAL, 2=SQUARE (HARVEFN) 1.0000000  
 HEIGHT VECTOR: 0=VERT, 1=EXP BLN, -1=EXP AB (SMALLN) 0.00000000E+00  
 REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.MM4 (CRHOR) 0.73900000E-03  
 CONCRETE COMPRESSIVE STRENGTH, PSI. (SIGNAC) 5000.0000  
 REINFORCED STEEL YIELD STRESS, PSI. (SIGNAC) 65000.000  
 REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS (CD) 0.99999999E-02  
 REINFORCING DISTANCE, IN. (CD) 3.30000000  
 DIAMETER OF EXPLOSIVE, IN. (BIGD) 3.2500000  
 PRESSURE INTERCEPT ON P-LAMBDA CURVE (SMALL) 5.0000000  
 EXPLOSIVE HEIGHT, LBS. (BIGD) 2.8000000  
 LENGTH OF EXPLOSIVE, IN. (BIGD) 5.1300001  
 X 1 OF EXPLOSIVE, IN. (EX1) 28.000000  
 X 2 OF EXPLOSIVE, IN. (EX2) 28.000000  
 Y 1 OF EXPLOSIVE, IN. (Y1) 23.400000  
 Y 2 OF EXPLOSIVE, IN. (Y2) 27.799999  
 Z 1 OF EXPLOSIVE, IN. (EZ1) 7.0000000  
 Z 2 OF EXPLOSIVE, IN. (EZ2) 7.0000000  
 SINKER STEEL RATIO REINFORCEMENT RATIO (TD) 0.99999999E-04  
 ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (SMALL) 2.0000000  
 TIME INCREMENT, SEC. (FINCE) 0.999999997E-04  
 TIME MAXIMUM, SEC. (THRS) 0.10000000  
 TIME STEP INTERVAL PER PRINTED LINE, SEC. (TPRINT) 0.5000002E-03  
 CRITICAL TIME, SEC. (CTCR) 0.14000000E-02

NO VALUE OF THE ORIGINAL HINGE LOCATION, XHO, WAS FOUND IN THE INTERVAL (O,R). IT IS ASSUMED TO BE THE VALUE OF R.

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN. (R) 24.920000  
 HINGE MOMENT, IN.-LBS./IN. (BIGMD) 5882.0235  
 WEIGHT PER UNIT AREA, LBS./IN.SQ. (CD) 0.34721902

TABLE I-10. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB41-2.8 POUND AT 7 INCHES  
(Continued).

| ORIGINAL HINGE LOCATION, IN.                                     |               | CHD 28.000000                                         |                       | BLAST LOAD               |                         |                           |                         |
|------------------------------------------------------------------|---------------|-------------------------------------------------------|-----------------------|--------------------------|-------------------------|---------------------------|-------------------------|
| CLAMPED-SUPPORTED                                                |               | GENERAL TIME FUNCTION                                 |                       | VERTICAL WALL            |                         |                           |                         |
| CALCULATIONS IN A CONCRETE BEAM                                  |               | LOCALIZED SHEAR FAILURE CALCULATION                   |                       | PAGE 2                   |                         |                           |                         |
| AFESC CASEB41-2.8 LB. AT 7 IN.                                   |               | GENERAL TIME FUNCTION                                 |                       | 3 27 1990 9 54 39 76     |                         |                           |                         |
| CLAMPED-SUPPORTED                                                |               | GENERAL TIME FUNCTION                                 |                       | BLAST LOAD               |                         |                           |                         |
| BENCH RADIUS 1 BAR                                               |               | 3 CRITICAL                                            |                       |                          |                         |                           |                         |
| 1.0000000                                                        |               | 1.9530495                                             |                       |                          |                         |                           |                         |
| 4.2999999                                                        |               | 1.7558495                                             |                       |                          |                         |                           |                         |
| BREACH BY LOCALIZED SHEAR FAILURE AT BENCH RADIUS OF 4.30000 IN. |               |                                                       |                       |                          |                         |                           |                         |
| CALCULATIONS IN A CONCRETE BEAM                                  |               | FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE |                       | PAGE 3                   |                         |                           |                         |
| AFESC CASEB41-2.8 LB. AT 7 IN.                                   |               | GENERAL TIME FUNCTION                                 |                       | 3 27 1990 9 54 46 63     |                         |                           |                         |
| CLAMPED-SUPPORTED                                                |               | GENERAL TIME FUNCTION                                 |                       | BLAST LOAD               |                         |                           |                         |
| TIME (SECONDS)                                                   | INTRA (MINI)  | MDIPT. VEL. (IN./SEC.)                                | MDIPT. DELTA (INCHES) | PRESSURE WORK (IN.-LBS.) | PLASTIC WORK (IN.-LBS.) | KINETIC ENERGY (IN.-LBS.) | HINGE LOCATION (INCHES) |
| 0.0000000E+00                                                    | 0.0000000E+00 | 0.0000000E+00                                         | 0.0000000E+00         | 0.0000000E+00            | 0.0000000E+00           | 0.0000000E+00             | 28.000000               |
| 0.4999999E-03                                                    | 0.5851888E-02 | 418.55151                                             | 0.19513729            | 80304.945                | 8172.3472               | 72132.602                 | 28.000000               |
| 0.9999999E-03                                                    | 0.1421963E-01 | 393.50391                                             | 0.39815110            | 80304.945                | 16674.564               | 63630.383                 | 28.000000               |
| 0.1499999E-02                                                    | 0.2102290E-01 | 368.45636                                             | 0.59864123            | 80304.945                | 24652.285               | 55652.660                 | 28.000000               |
| 0.1999999E-02                                                    | 0.2737684E-01 | 343.40876                                             | 0.76660752            | 80304.945                | 32105.512               | 48199.434                 | 28.000000               |
| 0.2499999E-02                                                    | 0.3287503E-01 | 318.36124                                             | 0.93205011            | 80304.945                | 39034.242               | 41270.703                 | 28.000000               |
| 0.3000000E-02                                                    | 0.3874686E-01 | 293.31366                                             | 1.0845688             | 80304.945                | 45138.477               | 34866.469                 | 28.000000               |
| 0.3500000E-02                                                    | 0.4476298E-01 | 268.26608                                             | 1.2255637             | 80304.945                | 51318.215               | 28586.730                 | 28.000000               |
| 0.4000000E-02                                                    | 0.4935815E-01 | 243.21852                                             | 1.3531348             | 80304.945                | 56673.457               | 23631.488                 | 28.000000               |
| 0.4499999E-02                                                    | 0.5244934E-01 | 218.17094                                             | 1.4685322             | 80304.945                | 61504.203               | 18800.742                 | 28.000000               |
| 0.4999999E-02                                                    | 0.5412163E-01 | 193.12338                                             | 1.5714058             | 80304.945                | 65810.453               | 14494.452                 | 28.000000               |
| 0.5499999E-02                                                    | 0.5434663E-01 | 168.07581                                             | 1.6617056             | 80304.945                | 69592.203               | 10712.742                 | 28.000000               |
| 0.5999999E-02                                                    | 0.4846477E-01 | 143.02824                                             | 1.7394816             | 80304.945                | 72849.461               | 7455.4844                 | 28.000000               |
| 0.6499999E-02                                                    | 0.4337938E-01 | 117.98067                                             | 1.8047338             | 80304.945                | 75582.227               | 4722.7187                 | 28.000000               |
| 0.6999999E-02                                                    | 0.3773819E-01 | 92.933105                                             | 1.8514622             | 80304.945                | 77790.492               | 2514.4531                 | 28.000000               |
| 0.7499999E-02                                                    | 0.3175242E-01 | 67.685529                                             | 1.8976669             | 80304.945                | 79474.266               | 830.67963                 | 28.000000               |
| 0.7999999E-02                                                    | 0.2533374E-01 | 42.837975                                             | 1.9253478             | 80304.945                | 80633.539               | -328.59375                | 28.000000               |
| 0.8499999E-02                                                    | 0.1940504E-01 | 17.790421                                             | 1.9405048             | 80304.945                | 81268.320               | -963.37500                | 28.000000               |

MINIMUM DEFLECTION = 1.9436134 AT TIME = 0.8899932E-02  
AN ASTERISK INDICATES THAT A REINFORCING ELEMENT WAS FRACTURED



TABLE I-11. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB4-2.8 POUND AT 7 INCHES.

PAGE 1

5 29 1990 2 22 27 83

CALCULATIONS ON A CONCRETE BEAM

AFESC CASEB4--2.8 LB. AT 7 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. (A) 28.000000  
 BEAM OR PLATE THICKNESS, IN. (CD) 4.000000  
 LENGTH TO WIDTH RATIO, DIMENSIONLESS (AK) 0.88999993  
 MASS PER UNIT AREA, LBS.-SEC.500/IN.CUBED (SHALL) 0.8965997E-03  
 POWER FROM PRESSURE-LAMBDA CURVE (FN) 1.000000  
 UNIFORM PRESSURE LOAD, PSI. (FUD) 0.0000000E+00  
 PRESSURE DECAY, DIMENSIONLESS (HLFHD) 3.4000001  
 PRESSURE DURATION, SEC. (TND) 0.24500000E-03  
 SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED (ED) 2.0000000  
 WAVE FUNCTION: 1=GENERAL, 2=SHAKE (CHVEFD) 1.0000000  
 WEIGHT VECTOR: 0=VERT, 1=EXP BLM, -1=EXP NB (SHALL) 0.0000000E+00  
 REINFORCEMENT DENSITY, LB.-SEC.50./IN.SQ (CRHD) 0.73590000E-03  
 CONCRETE COMPRESSIVE STRENGTH, PSI. (SIGMC) 5000.0000  
 REINFORCED STEEL YIELD STRESS, PSI. (SIGMR) 65000.000  
 REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS (XD) 0.9999999E-02  
 REINFORCING DISTANCE, IN. (CD) 3.3000000  
 DIAMETER OF EXPLOSIVE, IN. (RIND) 4.4000000  
 PRESSURE INTERCEPT ON P-LAMBDA CURVE (SHALL) 5.0000000  
 EXPLOSIVE WEIGHT, LBS. (BLGD) 2.8000000  
 LENGTH OF EXPLOSIVE, IN. (BLGD) 4.4000000  
 X 1 OF EXPLOSIVE, IN. (EXD) 28.000000  
 X 2 OF EXPLOSIVE, IN. (EXD) 28.000000  
 Y 1 OF EXPLOSIVE, IN. (EYD) 25.000000  
 Y 2 OF EXPLOSIVE, IN. (EYD) 25.000000  
 Z 1 OF EXPLOSIVE, IN. (EZD) 2.0000000  
 Z 2 OF EXPLOSIVE, IN. (EZD) 2.0000000  
 SHEAR STIFFNESS REINFORCEMENT RATIO (SHALL) 0.0000000E+04  
 ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (SHALL) 2.0000000  
 TIME INTERVAL, SEC. (TIMD) 0.4999999E-04  
 TIME MAXIMUM, SEC. (TIMD) 0.1000000  
 TIME STEP INTERVAL PER PRINTED LINE, SEC. (TPRIND) 0.5000000E-03  
 CRITICAL TIME, SEC. (TURD) 0.1000000E-02  
 NO VALUE OF THE ORIGINAL HINGE LOCATION, XHU, WAS FOUND IN THE INTERVAL (0,R).  
 IT IS ASSUMED TO BE THE VALUE OF R.

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN. (B) 28.000000  
 HINGE MOMENT, IN.-LBS./IN. (BLMD) 508.00000  
 WEIGHT PER UNIT AREA, LBS./IN.SQ. (CD) 0.3422190E-03  
 ORIGINAL HINGE LOCATION, IN. (ND) 28.000000

CLAMPED-SUPPORTED

GENERAL TIME FUNCTION

VERTICAL MOMENT

BLEST LOAD

TABLE I-11. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB4-2.8 POUND AT 7 INCHES  
(Continued).

| CALCULATIONS ON A CONCRETE BEAM |  |  |  |  |  |  |  |  |  | LOCALIZED SHEAR FAILURE EVALUATION                    |  |  |  | PAGE 2                 |  |  |  |                       |  |  |  |                          |  |  |  |                         |  |  |  |                           |  |  |  |                         |  |  |  |           |  |  |  |
|---------------------------------|--|--|--|--|--|--|--|--|--|-------------------------------------------------------|--|--|--|------------------------|--|--|--|-----------------------|--|--|--|--------------------------|--|--|--|-------------------------|--|--|--|---------------------------|--|--|--|-------------------------|--|--|--|-----------|--|--|--|
| AFESC CASEB4-2.8 LB. AT 7 IN.   |  |  |  |  |  |  |  |  |  | GENERAL TIME FUNCTION                                 |  |  |  | VERTICAL WALL          |  |  |  | BLAST LOAD            |  |  |  |                          |  |  |  |                         |  |  |  |                           |  |  |  |                         |  |  |  |           |  |  |  |
| CLAMPED-SUPPORTED               |  |  |  |  |  |  |  |  |  | I CRITICAL                                            |  |  |  | 1.7530495              |  |  |  |                       |  |  |  |                          |  |  |  |                         |  |  |  |                           |  |  |  |                         |  |  |  |           |  |  |  |
| BRANCH RADIUS                   |  |  |  |  |  |  |  |  |  | I BRN                                                 |  |  |  | 1.4626355              |  |  |  |                       |  |  |  |                          |  |  |  |                         |  |  |  |                           |  |  |  |                         |  |  |  |           |  |  |  |
| 1.00000000                      |  |  |  |  |  |  |  |  |  |                                                       |  |  |  |                        |  |  |  |                       |  |  |  |                          |  |  |  |                         |  |  |  |                           |  |  |  |                         |  |  |  |           |  |  |  |
| CALCULATIONS ON A CONCRETE BEAM |  |  |  |  |  |  |  |  |  | FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE |  |  |  | PAGE 3                 |  |  |  |                       |  |  |  |                          |  |  |  |                         |  |  |  |                           |  |  |  |                         |  |  |  |           |  |  |  |
| AFESC CASEB4-2.8 LB. AT 7 IN.   |  |  |  |  |  |  |  |  |  | GENERAL TIME FUNCTION                                 |  |  |  | VERTICAL WALL          |  |  |  | BLAST LOAD            |  |  |  |                          |  |  |  |                         |  |  |  |                           |  |  |  |                         |  |  |  |           |  |  |  |
| CLAMPED-SUPPORTED               |  |  |  |  |  |  |  |  |  | I CRITICAL                                            |  |  |  | 1.7530495              |  |  |  |                       |  |  |  |                          |  |  |  |                         |  |  |  |                           |  |  |  |                         |  |  |  |           |  |  |  |
| BRANCH RADIUS                   |  |  |  |  |  |  |  |  |  | I BRN                                                 |  |  |  | 1.4626355              |  |  |  |                       |  |  |  |                          |  |  |  |                         |  |  |  |                           |  |  |  |                         |  |  |  |           |  |  |  |
| 1.00000000                      |  |  |  |  |  |  |  |  |  |                                                       |  |  |  |                        |  |  |  |                       |  |  |  |                          |  |  |  |                         |  |  |  |                           |  |  |  |                         |  |  |  |           |  |  |  |
| TIME (SECONDS)                  |  |  |  |  |  |  |  |  |  | TWETA (INCHES)                                        |  |  |  | MIOPF. VEL. (IN./SEC.) |  |  |  | MIOPF. DELTA (INCHES) |  |  |  | PRESSURE WORK (IN.-LBS.) |  |  |  | PLASTIC WORK (IN.-LBS.) |  |  |  | KINETIC ENERGY (IN.-LBS.) |  |  |  | HINGE LOCATION (INCHES) |  |  |  |           |  |  |  |
| 0.00000000E+00                  |  |  |  |  |  |  |  |  |  | 0.00000000E+00                                        |  |  |  | 0.00000000E+00         |  |  |  | 0.00000000E+00        |  |  |  | 0.00000000E+00           |  |  |  | 0.00000000E+00          |  |  |  | 0.00000000E+00            |  |  |  | 0.00000000E+00          |  |  |  | 28.000000 |  |  |  |
| 0.4999997E-03                   |  |  |  |  |  |  |  |  |  | 0.5000000E-02                                         |  |  |  | 322.29959              |  |  |  | 0.15143780            |  |  |  | 49091.484                |  |  |  | 6342.2129               |  |  |  | 42749.273                 |  |  |  | 28.000000               |  |  |  |           |  |  |  |
| 0.9999994E-03                   |  |  |  |  |  |  |  |  |  | 0.1000000E-01                                         |  |  |  | 297.25201              |  |  |  | 0.30632567            |  |  |  | 49091.484                |  |  |  | 12878.916               |  |  |  | 36262.570                 |  |  |  | 28.000000               |  |  |  |           |  |  |  |
| 0.1499991E-02                   |  |  |  |  |  |  |  |  |  | 0.1602463E-01                                         |  |  |  | 272.20444              |  |  |  | 0.49868976            |  |  |  | 49091.484                |  |  |  | 18751.123               |  |  |  | 30300.361                 |  |  |  | 28.000000               |  |  |  |           |  |  |  |
| 0.1999991E-02                   |  |  |  |  |  |  |  |  |  | 0.2066178E-01                                         |  |  |  | 247.15680              |  |  |  | 0.51853007            |  |  |  | 49091.484                |  |  |  | 24228.834               |  |  |  | 24662.650                 |  |  |  | 28.000000               |  |  |  |           |  |  |  |
| 0.2499991E-02                   |  |  |  |  |  |  |  |  |  | 0.2465164E-01                                         |  |  |  | 222.10930              |  |  |  | 0.65584662            |  |  |  | 49091.484                |  |  |  | 29142.051               |  |  |  | 19949.434                 |  |  |  | 28.000000               |  |  |  |           |  |  |  |
| 0.3000000E-02                   |  |  |  |  |  |  |  |  |  | 0.2859425E-01                                         |  |  |  | 197.06174              |  |  |  | 0.84063939            |  |  |  | 49091.484                |  |  |  | 33530.770               |  |  |  | 15560.715                 |  |  |  | 28.000000               |  |  |  |           |  |  |  |
| 0.3500000E-02                   |  |  |  |  |  |  |  |  |  | 0.3168958E-01                                         |  |  |  | 172.01416              |  |  |  | 0.97265357            |  |  |  | 49091.484                |  |  |  | 37394.932               |  |  |  | 11696.492                 |  |  |  | 28.000000               |  |  |  |           |  |  |  |
| 0.4000000E-02                   |  |  |  |  |  |  |  |  |  | 0.3473762E-01                                         |  |  |  | 146.96660              |  |  |  | 0.1038749             |  |  |  | 49091.484                |  |  |  | 40734.719               |  |  |  | 8356.7656                 |  |  |  | 28.000000               |  |  |  |           |  |  |  |
| 0.4499998E-02                   |  |  |  |  |  |  |  |  |  | 0.3713839E-01                                         |  |  |  | 121.91902              |  |  |  | 1.0945725             |  |  |  | 49091.484                |  |  |  | 43549.953               |  |  |  | 5541.5312                 |  |  |  | 28.000000               |  |  |  |           |  |  |  |
| 0.4999998E-02                   |  |  |  |  |  |  |  |  |  | 0.3909187E-01                                         |  |  |  | 96.871460              |  |  |  | 1.1367464             |  |  |  | 49091.484                |  |  |  | 45940.631               |  |  |  | 3250.7930                 |  |  |  | 28.000000               |  |  |  |           |  |  |  |
| 0.5499998E-02                   |  |  |  |  |  |  |  |  |  | 0.4053808E-01                                         |  |  |  | 71.823883              |  |  |  | 1.1663965             |  |  |  | 49091.484                |  |  |  | 47606.930               |  |  |  | 1484.5547                 |  |  |  | 28.000000               |  |  |  |           |  |  |  |
| 0.5999997E-02                   |  |  |  |  |  |  |  |  |  | 0.4165703E-01                                         |  |  |  | 46.776325              |  |  |  | 1.1835228             |  |  |  | 49091.484                |  |  |  | 48848.672               |  |  |  | 242.81250                 |  |  |  | 28.000000               |  |  |  |           |  |  |  |
| 0.6499996E-02                   |  |  |  |  |  |  |  |  |  | 0.4268671E-01                                         |  |  |  | 21.728771              |  |  |  | 1.1835228             |  |  |  | 49091.484                |  |  |  | 49565.918               |  |  |  | -474.43359                |  |  |  | 28.000000               |  |  |  |           |  |  |  |

MAXIMUM DEFLECTION = 1.1891253 AT TIME = 0.65999956F-02

AN ASTERISK INDICATES THAT A PLUMP OR TENSILE ELEMENT HAS FRACTURED

TABLE I-12. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB5-2.8 POUND AT 16 INCHES.

PAGE 1

3 27 1990 9 56 21 87

CALCULATIONS ON A CONCRETE BEAM

AFESC CASEB5--2.8 LB. AT 16 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. (H) 28.000000  
 BEAM OR PLATE THICKNESS, IN. (HD) 4.000000  
 LENGTH TO WIDTH RATIO, DIMENSIONLESS (LW) 0.89599999  
 MASS PER UNIT AREA, LBS.-SEC. SQ./IN. CUBED (SMALL) 0.89859937E-03  
 POWER FROM PRESSURE-LAMBDA CURVE (FN) 1.1500000  
 UNIFORM PRESSURE LOAD, PSI (PU) 0.00000000E+00  
 PRESSURE DECAY, DIMENSIONLESS (ALPHA) 3.8000000  
 PRESSURE DURATION, SEC. (TND) 0.2340001E-03  
 SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED (F) 2.0000000  
 SHAPE FUNCTION: 1=GENERAL, 2=SQUARE (CMV/FN) 1.0000000  
 HEIGHT VECTOR: 0=VERT, 1=EXP BLM, -1=EXP AB (SMALL) 0.00000000E+00  
 REINFORCEMENT DENSITY, LB.-SEC. SQ./IN. SQ. (RHOK) 0.73380000E-03  
 CONCRETE COMPRESSIVE STRENGTH, PSI. (CELMAR) 5000.0000  
 REINFORCED STEEL YIELD STRESS, PSI. (CELMAR) 65000.000  
 REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS (CD) 0.9999999E-02  
 REINFORCING DISTANCE, IN. (CBIG) 3.2500000  
 DIAMETER OF EXPLOSIVE, IN. (SMALL) 5.0000000  
 PRESSURE INTERCEPT ON P-LAMBDA CURVE (BIG) 2.8000000  
 EXPLOSIVE HEIGHT, LBS. (BIGL) 5.6300001  
 LENGTH OF EXPLOSIVE, IN. (CEX) 28.000000  
 X 1 OF EXPLOSIVE, IN. (CEX) 28.000000  
 X 2 OF EXPLOSIVE, IN. (CEY) 23.400000  
 Y 1 OF EXPLOSIVE, IN. (CEY) 27.799999  
 Y 2 OF EXPLOSIVE, IN. (CEZ) 16.000000  
 Z 1 OF EXPLOSIVE, IN. (CEZ) 16.000000  
 Z 2 OF EXPLOSIVE, IN. (OT) 0.4999999E-04  
 SHEAR STIRUP REINFORCEMENT RATIO (SMALL) 2.0000000  
 ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (CLNCK) 0.9999999E-04  
 TIME INCREMENT, SEC. (CMAX) 0.1000000  
 TIME MAXIMUM, SEC. (CPRINT) 0.5000002E-03  
 TIME STEP INTERVAL PER PRINTED LINE, SEC. (CTCR) 0.14000000E-02  
 CRITICAL TIME, SEC.

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN. (B) 24.920000  
 HINGE MOMENT, IN.-LBS./IN. (BIGM) 5882.0205  
 WEIGHT PER UNIT AREA, LBS./IN. SQ. (W) 0.34721902  
 ORIGINAL HINGE LOCATION, IN. (XW) 26.879836

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

TABLE I-12. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB5-2.8 POUND AT 16 INCHES  
(Continued).

| CALCULATIONS IN A CONCRETE BEAM LOCALIZED SHEAR FAILURE CALCULATION                   |                    |                           |                          |                             |                            |                              |                            |            |  | PAGE 2               |  |  |  |  |  |  |  |
|---------------------------------------------------------------------------------------|--------------------|---------------------------|--------------------------|-----------------------------|----------------------------|------------------------------|----------------------------|------------|--|----------------------|--|--|--|--|--|--|--|
| AFESC CASES--2.8 LB. AT 16 IN.                                                        |                    |                           |                          |                             |                            |                              |                            |            |  |                      |  |  |  |  |  |  |  |
| CLAMPED-SUPPORTED GENERAL TIME FUNCTION                                               |                    |                           |                          |                             |                            |                              |                            |            |  |                      |  |  |  |  |  |  |  |
| BENCH RADIUS                                                                          | 1 BAR              | I CRITICAL                | VERTICAL WALL            |                             |                            |                              |                            |            |  | 3 27 1990 9 56 28 73 |  |  |  |  |  |  |  |
| 1.0000000                                                                             | 0.4485521          | 1.7538495                 | BLAST LOAD               |                             |                            |                              |                            |            |  |                      |  |  |  |  |  |  |  |
| CALCULATIONS IN A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE |                    |                           |                          |                             |                            |                              |                            |            |  | PAGE 3               |  |  |  |  |  |  |  |
| AFESC CASES--2.8 LB. AT 16 IN.                                                        |                    |                           |                          |                             |                            |                              |                            |            |  |                      |  |  |  |  |  |  |  |
| CLAMPED-SUPPORTED GENERAL TIME FUNCTION                                               |                    |                           |                          |                             |                            |                              |                            |            |  |                      |  |  |  |  |  |  |  |
| TIME<br>(SECONDS)                                                                     | THETA<br>(RADIANS) | MDIPT. VEL.<br>(IN./SEC.) | MDIPT. DELTA<br>(INCHES) | PRESSURE WORK<br>(IN.-LBS.) | PLASTIC WORK<br>(IN.-LBS.) | KINETIC ENERGY<br>(IN.-LBS.) | HINGE LOCATION<br>(INCHES) | BLAST LOAD |  | 3 27 1990 9 56 29 12 |  |  |  |  |  |  |  |
| 0.0000000E+00                                                                         | 0.0000000E+00      | 0.0000000E+00             | 0.0000000E+00            | 0.0000000E+00               | 0.0000000E+00              | 0.0000000E+00                | 26.870836                  |            |  |                      |  |  |  |  |  |  |  |
| 0.4999997E-03                                                                         | 0.44909758E-02     | 262.37720                 | 0.12574732               | 33328.793                   | 5266.2959                  | 28662.496                    | 28.000000                  |            |  |                      |  |  |  |  |  |  |  |
| 0.9999994E-03                                                                         | 0.89819517E-02     | 237.32962                 | 0.25067401               | 33328.793                   | 10498.225                  | 22930.560                    | 28.000000                  |            |  |                      |  |  |  |  |  |  |  |
| 0.1499997E-02                                                                         | 0.11967034E-01     | 212.28206                 | 0.36307696               | 33328.793                   | 15205.658                  | 18123.135                    | 28.000000                  |            |  |                      |  |  |  |  |  |  |  |
| 0.1999994E-02                                                                         | 0.1534146E-01      | 187.23448                 | 0.46295607               | 33328.793                   | 19368.594                  | 13940.199                    | 28.000000                  |            |  |                      |  |  |  |  |  |  |  |
| 0.2499997E-02                                                                         | 0.1853980E-01      | 162.18592                 | 0.55031145               | 33328.793                   | 23047.035                  | 10281.758                    | 28.000000                  |            |  |                      |  |  |  |  |  |  |  |
| 0.3000000E-02                                                                         | 0.22326534E-01     | 137.13934                 | 0.62514305               | 33328.793                   | 28750.430                  | 4538.3633                    | 28.000000                  |            |  |                      |  |  |  |  |  |  |  |
| 0.3500000E-02                                                                         | 0.24951814E-01     | 112.09178                 | 0.68745083               | 33328.793                   | 30875.385                  | 2453.4082                    | 28.000000                  |            |  |                      |  |  |  |  |  |  |  |
| 0.4000000E-02                                                                         | 0.25329815E-01     | 87.044205                 | 0.73723483               | 33328.793                   | 32435.940                  | 892.95312                    | 28.000000                  |            |  |                      |  |  |  |  |  |  |  |
| 0.4499997E-02                                                                         | 0.27660338E-01     | 61.996639                 | 0.77449507               | 33328.793                   | 33471.801                  | -145.00781                   | 28.000000                  |            |  |                      |  |  |  |  |  |  |  |
| 0.4999994E-02                                                                         | 0.28543803E-01     | 36.949081                 | 0.79923153               | 33328.793                   | 33883.266                  | -654.47266                   | 28.000000                  |            |  |                      |  |  |  |  |  |  |  |
| 0.5499997E-02                                                                         | 0.28980149E-01     | 11.901531                 | 0.81144416               | 33328.793                   |                            |                              |                            |            |  |                      |  |  |  |  |  |  |  |

MINIMUM DEFLECTION = 0.0177035 AT TIME = 0.57999376E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT WAS FRACTURED

TABLE I-13. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB6-2.8 POUND AT 23 INCHES.

PAGE 1  
3 27 1990 9 56 52 66

CALCULATIONS ON A CONCRETE BEAM  
AFESC CASEB6--2.8 LB. AT 23 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. (H) 28.000000  
BEAM OR PLATE THICKNESS, IN. (CH) 4.000000  
LENGTH TO WIDTH RATIO, DIMENSIONLESS (CAR) 0.80599999  
MASS PER UNIT AREA, LBS.-SEC.500/IN.CUBED (SMALLH) 0.89659997E-03  
  
POWER FROM PRESSURE-LAMBDA CURVE (CFN) 1.2500000  
UNIFORM PRESSURE LOAD, PSI. (CPD) 0.08000000E+00  
PRESSURE DECAY, DIMENSIONLESS (CALPHA) 5.4000001  
PRESSURE DURATION, SEC. (CTAU) 0.37299999E-03  
  
SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED (CF) 2.0000000  
WAVE FUNCTION: 1=GENERAL, 2=SQUARE (UWAVEFN) 1.0000000  
WEIGHT VECTOR: 0=VERT, 1=EXP BLN, -1=EXP (R) (SMALLN) 0.08000000E+00  
REINFORCEMENT DENSITY, LB.-SEC.50./IN.SQ (CMOR) 0.73390000E-03  
  
CONCRETE COMPRESSIVE STRENGTH, PSI. (CSIGMC) 5000.0000  
REINFORCED STEEL YIELD STRESS, PSI. (CSIGHR) 6500.0000  
REINFORCEMENT RATIO IN TENS/M, DIMENSIONLESS (CD) 0.9999999E-02  
REINFORCING DISTANCE, IN. (CBLG) 3.3000000  
  
DIAMETER OF EXPLOSIVE, IN. (CBGD) 3.2500000  
PRESSURE INTERCEPT ON P-LAMBDA CURVE (SMALLK) 5.8000000  
EXPLOSIVE WEIGHT, LBS. (CBGW) 2.8000000  
LENGTH OF EXPLOSIVE, IN. (CBGL) 5.8300001  
  
X 1 OF EXPLOSIVE, IN. (CX1) 28.000000  
X 2 OF EXPLOSIVE, IN. (CX2) 28.000000  
Y 1 OF EXPLOSIVE, IN. (CY1) 23.400000  
Y 2 OF EXPLOSIVE, IN. (CY2) 27.799999  
  
Z 1 OF EXPLOSIVE, IN. (CZ1) 23.000000  
Z 2 OF EXPLOSIVE, IN. (CZ2) 23.000000  
SHEAR STIRUP REINFORCEMENT RATIO (Q1) 0.4999999E-04  
ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (SMALLD) 2.8000000  
  
TIME INCREMENT, SEC. (CTINC) 0.99999997E-04  
TIME MAXIMUM, SEC. (CTMX) 0.10000000  
TIME STEP INTERVAL PER PRINTED LINE, SEC. (CTPRINT) 0.5000000E-03  
CRITICAL TIME, SEC. (CTCR) 0.14000000E-02  
  
COMPUTED CONSTANT VALUES  
BEAM HALF WIDTH, IN. (CB) 24.920000  
HINGE MOMENT, IN.-LBS./IN. (CBICHM) 5082.0205  
WEIGHT PER UNIT AREA, LBS./IN.SQ. (CH) 0.34721902  
ORIGINAL HINGE LOCATION, IN. (CAR) 21.438419  
  
CLAMPED-SUPPORTED GENERAL TIME FUNCTION : VERTICAL HALL BLAST LOAD

TABLE I-13. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEB6-2.8 POUND AT 23 INCHES  
(Continued).

| CALCULATIONS ON A CONCRETE BEAM LOCALIZED SHEAR FAILURE CALCULATION                   |                |                |                |                |                |                |                |                |                | PAGE 2                    |           |           |           |    |   |    |
|---------------------------------------------------------------------------------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|---------------------------|-----------|-----------|-----------|----|---|----|
| AFESC CASEB6-2.8 LB. AT 23 IN.                                                        |                |                |                |                |                |                |                |                |                | 3                         | 27        | 1990      | 9         | 57 | 0 | 20 |
| CLAMPED-SUPPORTED                                                                     |                |                |                |                |                |                |                |                |                | BLAST LOAD                |           |           |           |    |   |    |
| GENERAL TIME FUNCTION                                                                 |                |                |                |                |                |                |                |                |                | VERTICAL WALL             |           |           |           |    |   |    |
| I CRITICAL                                                                            |                |                |                |                |                |                |                |                |                |                           |           |           |           |    |   |    |
| 1.0000000 0.24033298 1.7538495                                                        |                |                |                |                |                |                |                |                |                |                           |           |           |           |    |   |    |
| CALCULATIONS ON A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE |                |                |                |                |                |                |                |                |                | PAGE 3                    |           |           |           |    |   |    |
| AFESC CASEB6-2.8 LB. AT 23 IN.                                                        |                |                |                |                |                |                |                |                |                | 3                         | 27        | 1990      | 9         | 57 | 0 | 59 |
| CLAMPED-SUPPORTED                                                                     |                |                |                |                |                |                |                |                |                | BLAST LOAD                |           |           |           |    |   |    |
| GENERAL TIME FUNCTION                                                                 |                |                |                |                |                |                |                |                |                | VERTICAL WALL             |           |           |           |    |   |    |
| TIME (SECONDS)                                                                        |                |                |                |                |                |                |                |                |                | KINETIC ENERGY (IN.-LBS.) |           |           |           |    |   |    |
| MIDPT. VEL. (IN./SEC.)                                                                |                |                |                |                |                |                |                |                |                | PLASTIC WORK (IN.-LBS.)   |           |           |           |    |   |    |
| MIDPT. DELTA (INCHES)                                                                 |                |                |                |                |                |                |                |                |                | HINGE LOCATION (INCHES)   |           |           |           |    |   |    |
| 0.00000000E+00                                                                        | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 21.438419                 |           |           |           |    |   |    |
| 0.00000000E+00                                                                        | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 15723.245                 | 3990.4602 | 15723.245 | 23.725282 |    |   |    |
| 0.00000000E+00                                                                        | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 12065.312                 | 7648.3926 | 12065.312 | 26.239417 |    |   |    |
| 0.00000000E+00                                                                        | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 9050.9277                 | 10662.777 | 9050.9277 | 28.000000 |    |   |    |
| 0.00000000E+00                                                                        | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 6569.1826                 | 13144.522 | 6569.1826 | 28.000000 |    |   |    |
| 0.00000000E+00                                                                        | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 4611.9396                 | 15101.771 | 4611.9396 | 28.000000 |    |   |    |
| 0.00000000E+00                                                                        | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 3179.1936                 | 16534.521 | 3179.1936 | 28.000000 |    |   |    |
| 0.00000000E+00                                                                        | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 2270.9277                 | 17442.777 | 2270.9277 | 28.000000 |    |   |    |
| 0.00000000E+00                                                                        | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 0.00000000E+00 | 1867.1680                 | 17826.537 | 1867.1680 | 28.000000 |    |   |    |

TABLE I-14. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC1-2.4 POUND AT 6 INCHES.

CALCULATIONS ON A CONCRETE BEAM  
AFESC CASEC1-2.4 LB. AT 6 IN.

PAGE 1  
3 27 1990 9 59 22 35

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. (H) 28.000000  
BEAM OR PLATE THICKNESS, IN. (H) 4.000000  
LENGTH TO WIDTH RATIO, DIMENSIONLESS (HR) 0.00999999  
WEISS PER UNIT AREA, LBS.-SEC.500/IN.CUBED (SMALL) 0.1078300E-02  
POWER FROM PRESSURE-LAMBDA CURVE (FN) 0.82999998  
UNIFORM PRESSURE LOAD, PSI. (FUD) 0.0000000E+00  
PRESSURE DECAY, DIMENSIONLESS (ALPHA) 3.4000001  
PRESSURE DURATION, SEC. (TAU) 0.23500000E-03  
SUPPORT FACTOR: 1=SIM V, 2=CLAMPED (F) 2.0000000  
WAVE FUNCTION: 1=GENERAL, 2=SQUARE (WAVEFN) 1.0000000  
HEIGHT VECTOR: 0=VERT, 1=EXP BLN, -1=EXP RB (SMALL) 0.0000000E+00  
REINFORCEMENT DENSITY, LB.-SEC.50./IN.<sup>2</sup> (RHO) 0.7339000E-03  
CONCRETE COMPRESSIVE STRENGTH, PSI. (SIGMAC) 5080.0000  
REINFORCED STEEL YIELD STRESS, PSI. (SIGMAK) 65800.000  
REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS (CD) 0.1850000E-01  
REINFORCING DISTANCE, IN. (CD) 3.09999999  
DIAMETER OF EXPLOSIVE, IN. (BIGD) 2.5000000  
PRESSURE INTERCEPT ON P-LAMBDA CURVE (SMALL) 5.0000000  
EXPLOSIVE HEIGHT, LBS. (BIGD) 2.4000001  
LENGTH OF EXPLOSIVE, IN. (BIGL) 8.1999996  
X 1 OF EXPLOSIVE, IN. (EX1) 28.0000000  
X 2 OF EXPLOSIVE, IN. (EX2) 28.0000000  
Y 1 OF EXPLOSIVE, IN. (EY1) 20.9000000  
Y 2 OF EXPLOSIVE, IN. (EY2) 29.1000000  
Z 1 OF EXPLOSIVE, IN. (EZ1) 6.0000000  
Z 2 OF EXPLOSIVE, IN. (EZ2) 6.0000000  
SHEAR STIRRUP REINFORCEMENT RATIO (Q1) 0.0000000E+00  
ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (SMALL) 2.0000000  
TIME INCREMENT, SEC. (TINC) 0.9999999E-04  
TIME MAXIMUM, SEC. (THMX) 0.10000000  
TIME STEP INTERVAL PER PRINTED LINE, SEC. (TPRINT) 0.5000000E-03  
CRITICAL TIME, SEC. (TCK) 0.20999999E-02

NO VALUE OF THE ORIGINAL HINGE LOCATION, XHO, WAS FOUND IN THE INTERVAL (0,X).  
IT IS ASSUMED TO BE THE VALUE OF R.

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN. (CB) 24.320000  
HINGE MOMENT, IN.-LBS./IN. (BIGMD) 8102.1211  
WEIGHT PER UNIT AREA, LBS./IN.<sup>2</sup> (CD) 0.41666669

TABLE I-14. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC1-2.4 POUND AT 6 INCHES  
(Continued).

|                                                                   |               |                                                       |               |                          |                         |                           |                         |
|-------------------------------------------------------------------|---------------|-------------------------------------------------------|---------------|--------------------------|-------------------------|---------------------------|-------------------------|
| ORIGINAL HINGE LOCATION, IN.                                      |               | CHD 28.000000                                         |               | BLAST LOAD               |                         |                           |                         |
| CLAMPED-SUPPORTED                                                 |               | GENERAL TIME FUNCTION                                 |               | VERTICAL WALL            |                         |                           |                         |
| CALCULATIONS IN A CONCRETE BEAM                                   |               | LOCALIZED SHEAR FAILURE CALCULATION                   |               | PAGE 2                   |                         |                           |                         |
| AFESC CASEC1-2.4 LB. AT 6 IN.                                     |               | GENERAL TIME FUNCTION                                 |               | 3 27 1990 9 59 25 15     |                         |                           |                         |
| CLAMPED-SUPPORTED                                                 |               | GENERAL TIME FUNCTION                                 |               | BLAST LOAD               |                         |                           |                         |
| BREACH RADIUS 1 BRK                                               |               | I CRITICAL                                            |               |                          |                         |                           |                         |
| 1.0000000                                                         |               | 2.3317571                                             |               |                          |                         |                           |                         |
| 3.6249993                                                         |               | 2.3317571                                             |               |                          |                         |                           |                         |
| BREACH BY LOCALIZED SHEAR FAILURE AT BREACH RADIUS OF 3.62500 IN. |               |                                                       |               |                          |                         |                           |                         |
| CALCULATIONS IN A CONCRETE BEAM                                   |               | FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE |               | PAGE 3                   |                         |                           |                         |
| AFESC CASEC1-2.4 LB. AT 6 IN.                                     |               | GENERAL TIME FUNCTION                                 |               | 3 27 1990 9 59 28 89     |                         |                           |                         |
| CLAMPED-SUPPORTED                                                 |               | GENERAL TIME FUNCTION                                 |               | BLAST LOAD               |                         |                           |                         |
| TIME (SECONDS)                                                    | INCHES        | IN./SEC.                                              | INCHES        | PRESSURE WORK (IN.-LBS.) | PLASTIC WORK (IN.-LBS.) | KINETIC ENERGY (IN.-LBS.) | HINGE LOCATION (INCHES) |
| 0.0000000E+00                                                     | 0.0000000E+00 | 0.0000000E+00                                         | 0.0000000E+00 | 0.0000000E+00            | 0.0000000E+00           | 0.0000000E+00             | 28.000000               |
| 0.0000000E+00                                                     | 0.0000000E+00 | 394.79163                                             | 0.18589284    | 87468.422                | 10723.620               | 76744.805                 | 28.000000               |
| 0.0000000E+00                                                     | 0.0000000E+00 | 366.04065                                             | 0.37610090    | 87468.422                | 21696.172               | 65772.250                 | 28.000000               |
| 0.0000000E+00                                                     | 0.0000000E+00 | 337.28964                                             | 0.55133347    | 87468.422                | 31839.443               | 55628.977                 | 28.000000               |
| 0.0000000E+00                                                     | 0.0000000E+00 | 308.53864                                             | 0.71339053    | 87468.422                | 41153.434               | 46314.988                 | 28.000000               |
| 0.0000000E+00                                                     | 0.0000000E+00 | 279.78766                                             | 0.86047214    | 87468.422                | 49638.141               | 37830.281                 | 28.000000               |
| 0.0000000E+00                                                     | 0.0000000E+00 | 251.03667                                             | 0.99317819    | 87468.422                | 57293.570               | 30174.852                 | 28.000000               |
| 0.0000000E+00                                                     | 0.0000000E+00 | 222.28569                                             | 1.1115087     | 87468.422                | 64119.719               | 23348.703                 | 28.000000               |
| 0.0000000E+00                                                     | 0.0000000E+00 | 193.53476                                             | 1.2154639     | 87468.422                | 70116.586               | 17351.836                 | 28.000000               |
| 0.0000000E+00                                                     | 0.0000000E+00 | 164.78384                                             | 1.3002478     | 87468.422                | 75284.164               | 12184.258                 | 28.000000               |
| 0.0000000E+00                                                     | 0.0000000E+00 | 136.03291                                             | 1.3602478     | 87468.422                | 79622.484               | 7845.9375                 | 28.000000               |
| 0.0000000E+00                                                     | 0.0000000E+00 | 107.28198                                             | 1.4110785     | 87468.422                | 83131.508               | 4336.9141                 | 28.000000               |
| 0.0000000E+00                                                     | 0.0000000E+00 | 78.531021                                             | 1.4875298     | 87468.422                | 85811.273               | 1657.1484                 | 28.000000               |
| 0.0000000E+00                                                     | 0.0000000E+00 | 49.780064                                             | 1.5196074     | 87468.422                | 87661.742               | -193.32031                | 28.000000               |
| 0.0000000E+00                                                     | 0.0000000E+00 | 21.029110                                             | 1.5373098     | 87468.422                | 88682.937               | -1214.5156                | 28.000000               |

MINIMUM DEFLECTION = 1.5411212 AT TIME = 0.73999949E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT WAS FRACTURED



TABLE I-15. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC2-2.4 POUND AT 12 INCHES.

CALCULATIONS ON A CONCRETE BEAM  
AFESC CASEC2-2.4 LB. AT 12 IN.

INPUT VALUES

|                                               |                        |
|-----------------------------------------------|------------------------|
| PLATE HALF WIDTH OR BEAM HALF SPAN, IN.       | (H) 28.000000          |
| BEAM OR PLATE THICKNESS, IN.                  | (H) 4.000000           |
| LENGTH TO WIDTH RATIO, DIMENSIONLESS          | (H) 0.88999999         |
| MASS PER UNIT AREA, LBS.-SEC./IN.CUBED        | (SMALL) 0.10782999E-02 |
| POWER FROM PRESSURE-LAMBDA CURVE              | (F) 1.000000           |
| UNIFORM PRESSURE LOAD, PSI                    | (CPU) 0.00000000E+00   |
| PRESSURE DECAY, DIMENSIONLESS                 | (ALPHA) 3.500000       |
| PRESSURE DURATION, SEC.                       | (TAU) 0.20200000E-03   |
| SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED           | (E) 2.000000           |
| WAVE FUNCTION: 1=GENERAL, 2=SQUARE            | (WAVEF) 1.000000       |
| WEIGHT VECTOR: 0=VERT, 1=EXP BLM, -1=EXP AB   | (SMALL) 0.00000000E+00 |
| REINFORCEMENT DENSITY, LB.-SEC./IN.AN4        | (PHOR) 0.73390000E-03  |
| CONCRETE COMPRESSIVE STRENGTH, PSI            | (SIGMAC) 5000.0000     |
| REINFORCED STEEL YIELD STRESS, PSI            | (SIGMAR) 6500.0000     |
| REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS | (D) 0.16500000E-01     |
| REINFORCING DISTANCE, IN.                     | (D) 3.8999999          |
| DIAMETER OF EXPLOSIVE, IN.                    | (BIGD) 2.500000        |
| PRESSURE INTERCEPT ON P-LAMBDA CURVE          | (SMALLK) 5.000000      |
| EXPLOSIVE WEIGHT, LBS.                        | (BIGW) 2.4000001       |
| LENGTH OF EXPLOSIVE, IN.                      | (BIGL) 8.1499996       |
| X 1 OF EXPLOSIVE, IN.                         | (EX1) 28.000000        |
| X 2 OF EXPLOSIVE, IN.                         | (EX2) 28.000000        |
| Y 1 OF EXPLOSIVE, IN.                         | (EY1) 20.900000        |
| Y 2 OF EXPLOSIVE, IN.                         | (EY2) 29.100000        |
| Z 1 OF EXPLOSIVE, IN.                         | (EZ1) 12.000000        |
| Z 2 OF EXPLOSIVE, IN.                         | (EZ2) 12.000000        |
| SHEAR STIRRUP REINFORCEMENT RATIO             | (Q1) 0.00000000E+00    |
| ENVIRONMENT FACTOR: 1=SOIL, 2=AIR             | (SMALLR) 2.000000      |
| TIME INCREMENT, SEC.                          | (CTIME) 0.9999999E-04  |
| TIME MAXIMUM, SEC.                            | (TIMEK) 0.10000000     |
| TIME STEP INTERVAL PER PRINTED LINE, SEC.     | (TPRINT) 0.5000000E-03 |
| CRITICAL TIME, SEC.                           | (CTCR) 0.20999999E-02  |

NO VALUE OF THE ORIGINAL HINGE LOCATION, XND, WAS FOUND IN THE INTERVAL (0,R).  
IT IS ASSUMED TO BE THE VALUE OF R.

COMPUTED CONSTANT VALUES

|                                   |                   |
|-----------------------------------|-------------------|
| BEAM HALF WIDTH, IN.              | (B) 24.920000     |
| HINGE MOMENT, IN.-LBS./IN.        | (BIGMD) 8102.1211 |
| WEIGHT PER UNIT AREA, LBS./IN.SQ. | (W) 0.41665509    |

TABLE I-15. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC2-2.4 POUND AT 12 INCHES  
(Continued).

| ORIGINAL HINGE LOCATION, IN.    |                    | CASE 28.000000                                        |                          | VERTICAL WALL               |                            | BLAST LOU                    |                            |
|---------------------------------|--------------------|-------------------------------------------------------|--------------------------|-----------------------------|----------------------------|------------------------------|----------------------------|
| CLAMPED-SUPPORTED               |                    | GENERAL TIME FUNCTION                                 |                          | VERTICAL WALL               |                            | BLAST LOU                    |                            |
| CALCULATIONS IN A CONCRETE BEAM |                    | LOCALIZED SHEAR FAILURE CALCULATION                   |                          |                             |                            |                              |                            |
| AFESC CASEC2-2.4 LB. AT 12 IN.  |                    |                                                       |                          |                             |                            |                              |                            |
| CLAMPED-SUPPORTED               |                    | GENERAL TIME FUNCTION                                 |                          | VERTICAL WALL               |                            | BLAST LOU                    |                            |
| BENCH RADIUS 1 BAR              |                    | I CRITICAL                                            |                          |                             |                            |                              |                            |
| 1.0000000                       |                    | 0.73228115                                            |                          | 2.3317261                   |                            |                              |                            |
| CALCULATIONS IN A CONCRETE BEAM |                    | FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE |                          |                             |                            |                              |                            |
| AFESC CASEC2-2.4 LB. AT 12 IN.  |                    |                                                       |                          |                             |                            |                              |                            |
| CLAMPED-SUPPORTED               |                    | GENERAL TIME FUNCTION                                 |                          | VERTICAL WALL               |                            | BLAST LOU                    |                            |
| TIME<br>(SECONDS)               | THETA<br>(RADIANS) | MIDPT. VEL.<br>(IN./SEC.)                             | MIDPT. DELTA<br>(INCHES) | PRESSURE MARK<br>(IN.-LBS.) | PLASTIC MARK<br>(IN.-LBS.) | KINETIC ENERGY<br>(IN.-LBS.) | HINGE LOCATION<br>(INCHES) |
| 0.0000000E+00                   | 0.0000000E+00      | 0.0000000E+00                                         | 0.0000000E+00            | 0.0000000E+00               | 0.0000000E+00              | 0.0000000E+00                | 26.000000                  |
| 0.4999997E-03                   | 0.4417631E-02      | 255.43737                                             | 0.12445337               | 36563.246                   | 7179.3545                  | 31383.891                    | 26.000000                  |
| 0.9999994E-03                   | 0.8794112E-02      | 226.60607                                             | 0.24438436               | 36563.246                   | 14132.437                  | 24430.809                    | 26.000000                  |
| 0.1499997E-02                   | 0.1254063E-01      | 197.93434                                             | 0.35113943               | 36563.246                   | 20258.219                  | 18507.027                    | 26.000000                  |
| 0.1999999E-02                   | 0.1581052E-01      | 169.18262                                             | 0.44231866               | 36563.246                   | 25550.639                  | 13012.547                    | 26.000000                  |
| 0.2499997E-02                   | 0.1892929E-01      | 140.43089                                             | 0.52032202               | 36563.246                   | 30015.875                  | 8547.3711                    | 26.000000                  |
| 0.2999999E-02                   | 0.2160391E-01      | 111.67916                                             | 0.58334953               | 36563.246                   | 33651.754                  | 4911.4922                    | 26.000000                  |
| 0.3499997E-02                   | 0.2257147E-01      | 82.927599                                             | 0.63200116               | 36563.246                   | 36458.324                  | 2104.9219                    | 26.000000                  |
| 0.3999999E-02                   | 0.21795605E-01     | 54.175640                                             | 0.66627693               | 36563.246                   | 38435.590                  | 127.65625                    | 26.000000                  |
| 0.4499997E-02                   | 0.2450631E-01      | 25.423802                                             | 0.68617678               | 36563.246                   | 39583.559                  | -1020.3125                   | 26.000000                  |

MINIMUM DEFLECTION = 0.63170002 at TIME = 0.49999990E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

TABLE I-16. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC3-2.4 POUND AT 18 INCHES.

PAGE 1

3 27 1530 9 59 49 87

CALCULATIONS ON A CONCRETE BEAM

AFESC CASEC3-2.4 LB. AT 18 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. (XD) 28.000000  
 BEAM OR PLATE THICKNESS, IN. (XD) 4.000000  
 LENGTH TO HATCH RATIO, DIMENSIONLESS (XND) 0.00999999  
 MASS PER UNIT AREA, LBS.-SEC.SQ./IN.-CUBED (SAPHLA) 0.10782999E-02  
 POWER FROM PRESSURE-LAMBDA CURVE (FND) 1.15000000  
 UNIFORM PRESSURE LOAD, PSI. (PU) 0.10000000E+00  
 PRESSURE DECAY, DIMENSIONLESS (ALPHA) 1.30000002  
 PRESSURE DURATION, SEC. (TND) 0.26199999E-03  
 SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED (X) 2.00000000  
 WAVE FUNCTION: 1=GENERAL, 2=SQUARE (XAVEFND) 1.00000000  
 WEIGHT VECTOR: 0=VERT, 1=EXP BLN, -1=EXP AB (SAPHLA) 0.00000000E+00  
 REINFORCEMENT DENSITY, LB.-SEC.SQ./IN.-SQ (CRHO) 0.73390000E-03  
 CONCRETE COMPRESSIVE STRENGTH, PSI. (SIGMA) 5000.0000  
 REINFORCED STEEL YIELD STRESS, PSI. (SIGMA) 65000.0000  
 REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS (XD) 0.16500000E-01  
 REINFORCING DISTANCE, IN. (XD) 3.05999999  
 DIAMETER OF EXPLOSIVE, IN. (CBIGD) 2.50000000  
 PRESSURE INTERCEPT ON P-LAMBDA CURVE (SAPHLA) 5.00000000  
 EXPLOSIVE WEIGHT, LBS. (CBIGM) 2.40000001  
 LENGTH OF EXPLOSIVE, IN. (CBIGL) 0.19999996  
 X 1 OF EXPLOSIVE, IN. (EX1) 28.000000  
 X 2 OF EXPLOSIVE, IN. (EX2) 28.000000  
 Y 1 OF EXPLOSIVE, IN. (EY1) 20.500000  
 Y 2 OF EXPLOSIVE, IN. (EY2) 29.100000  
 Z 1 OF EXPLOSIVE, IN. (EZ1) 18.000000  
 Z 2 OF EXPLOSIVE, IN. (EZ2) 18.000000  
 SHEAR STIFFNESS REINFORCEMENT RATIO (Q1) 0.00000000E+00  
 ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (SAPHLA) 2.00000000  
 TIME INCREMENT, SEC. (ETIMED) 0.9999997E-04  
 TIME MAXIMUM, SEC. (CTMAX) 0.10000000  
 TIME STEP INTERVAL PER PRINTED LINE, SEC. (CTPRINT) 0.50000000E-03  
 CRITICAL TIME, SEC. (CTCK) 0.20999999E-02

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN. (X) 24.920000  
 HINGE MOMENT, IN.-LBS./IN. (BIGM) 8102.1211  
 HEIGHT PER UNIT AREA, LBS./IN.-SQ. (XD) 0.41685509  
 ORIGINAL HINGE LOCATION, IN. (XND) 26.231281

CLAMPED-SUPPORTED GENERAL TIME FUNCTION VERTICAL WALL BLAST LOAD

TABLE I-16. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC3-2.4 POUND AT 18 INCHES  
(Continued).

| CALCULATIONS IN A CONCRETE BEAM |                    |                          |                         | LOCALIZED SHEAR FAILURE CALCULATION                   |                            |                              |                            | PAGE 2              |  |  |  |
|---------------------------------|--------------------|--------------------------|-------------------------|-------------------------------------------------------|----------------------------|------------------------------|----------------------------|---------------------|--|--|--|
| AFESC CASEC3-2.4 LB. AT 18 IN.  |                    |                          |                         | CLAMPED-SUPPORTED                                     |                            |                              |                            | 3 27 1990 10 0 1 29 |  |  |  |
| CLAMPED-SUPPORTED               |                    |                          |                         | GENERAL TIME FUNCTION                                 |                            |                              |                            | BLAST LOUW          |  |  |  |
| BRANCH RADIUS 1 BK              |                    |                          |                         | 1 CRITICAL                                            |                            |                              |                            |                     |  |  |  |
| 1.0000000                       |                    |                          |                         | 0.3639426                                             |                            |                              |                            | 2.3317261           |  |  |  |
| CALCULATIONS IN A CONCRETE BEAM |                    |                          |                         | FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE |                            |                              |                            | PAGE 3              |  |  |  |
| AFESC CASEC3-2.4 LB. AT 18 IN.  |                    |                          |                         | CLAMPED-SUPPORTED                                     |                            |                              |                            | 3 27 1990 10 0 1 35 |  |  |  |
| CLAMPED-SUPPORTED               |                    |                          |                         | GENERAL TIME FUNCTION                                 |                            |                              |                            | BLAST LOUW          |  |  |  |
| TIME<br>(SECONDS)               | THETA<br>(RADIANS) | MDPT. VEL.<br>(IN./SEC.) | MDPT. DELTA<br>(INCHES) | PRESSURE WORK<br>(IN.-LBS.)                           | PLASTIC WORK<br>(IN.-LBS.) | KINETIC ENERGY<br>(IN.-LBS.) | HINGE LOCATION<br>(INCHES) |                     |  |  |  |
| 0.0000000E+00                   | 0.0000000E+00      | 0.0000000E+00            | 0.0000000E+00           | 0.0000000E+00                                         | 0.0000000E+00              | 0.0000000E+00                | 26.231291                  |                     |  |  |  |
| 0.4939999E-03                   | 0.31417271E-02     | 178.78029                | 0.07968357E-01          | 20825.404                                             | 5074.6396                  | 15750.765                    | 26.000000                  |                     |  |  |  |
| 0.9939999E-03                   | 0.64775205E-02     | 150.02656                | 0.17017058              | 20825.404                                             | 9616.6475                  | 11600.757                    | 26.000000                  |                     |  |  |  |
| 0.1439999E-02                   | 0.8498906E-02      | 121.27683                | 0.23799694              | 20825.404                                             | 13729.353                  | 7096.0516                    | 26.000000                  |                     |  |  |  |
| 0.1939999E-02                   | 0.1040083E-01      | 92.525085                | 0.29144743              | 20825.404                                             | 16812.756                  | 4012.6464                    | 26.000000                  |                     |  |  |  |
| 0.2439999E-02                   | 0.11604358E-01     | 63.773323                | 0.33052203              | 20825.404                                             | 19066.857                  | 1758.5469                    | 26.000000                  |                     |  |  |  |
| 0.3000000E-02                   | 0.12686456E-01     | 35.021561                | 0.35522076              | 20825.404                                             | 20491.654                  | 333.75000                    | 26.000000                  |                     |  |  |  |
| 0.3500000E-02                   | 0.13055129E-01     | 6.2698092                | 0.36551960              | 20825.404                                             | 21067.150                  | -261.74609                   | 26.000000                  |                     |  |  |  |

MAXIMUM DEFLECTION = 0.36564749 AT TIME = 0.37000005E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

TABLE I-17. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC4-2.8 POUND AT 7 INCHES.

PAGE 1

CALCULATIONS ON A CONCRETE BEAM

AFESC CASEC4-2.8 LB. AT 7 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. (H) 28.000000  
 BEAM OR PLATE THICKNESS, IN. (H) 4.000000  
 LENGTH TO HINGE POINT, DIMENSIONLESS (H) 0.88999999  
 MASS PER UNIT AREA, LBS.-SEC.500/IN.CURED (SMALL) 0.10782999E-02  
 POWER FROM PRESSURE-LAMBDA CURVE (FND) 1.00000000  
 UNIFORM PRESSURE LOAD, PSI. (FND) 0.00000000E+00  
 PRESSURE DECAY, DIMENSIONLESS (ALPHA) 3.90000001  
 PRESSURE DURATION, SEC. (TND) 0.24500000E-03  
 SUPPORT FACTOR: 1-SIMPLY, 2-CLAMPED (CF) 2.000000  
 SHAPE FUNCTION: 1-GENERAL, 2-SQUARE (URVFN) 1.000000  
 WEIGHT VECTOR: 0=VERT, 1=EXP BAL, -1=EXP AB (SMALL) 0.00000000E+00  
 REINFORCEMENT DENSITY, LB.-SEC.50./IN.<sup>2</sup> (RHOR) 0.73390000E-03  
 CONCRETE COMPRESSIVE STRENGTH, PSI. (SIGMK) 5000.0000  
 REINFORCED STEEL YIELD STRESS, PSI. (SIGMR) 65000.0000  
 REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS (CD) 0.16500000E-01  
 REINFORCING DISTANCE, IN. (CD) 3.09999999  
 DIAMETER OF EXPLOSIVE, IN. (CRGD) 3.25000000  
 PRESSURE INTERCEPT ON P-LAMBDA CURVE (SMALL) 5.00000000  
 EXPLOSIVE WEIGHT, LBS. (CRGD) 2.80000000  
 LENGTH OF EXPLOSIVE, IN. (CRGL) 5.63000001  
 X 1 OF EXPLOSIVE, IN. (CX1) 28.00000000  
 X 2 OF EXPLOSIVE, IN. (CX2) 28.00000000  
 Y 1 OF EXPLOSIVE, IN. (CY1) 23.40000000  
 Y 2 OF EXPLOSIVE, IN. (CY2) 27.79999999  
 Z 1 OF EXPLOSIVE, IN. (CZ1) 7.00000000  
 Z 2 OF EXPLOSIVE, IN. (CZ2) 7.00000000  
 SHEAR STIFFNESS REINFORCEMENT RATIO (CD) 0.00000000E+00  
 ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (SMALL) 2.00000000  
 TIME INCREMENT, SEC. (TINC) 0.99999997E-04  
 TIME MAXIMUM, SEC. (THMX) 0.10000000  
 TIME STEP INTERVAL PER PRINTED LINE, SEC. (TPRINT) 0.50000002E-03  
 CRITICAL TIME, SEC. (CTCR) 0.20999999E-02

NO VALUE OF THE ORIGINAL HINGE LOCATION, XHO, WAS FOUND IN THE INTERVAL (CD, R).  
 IT IS ASSUMED TO BE THE VALUE OF R.

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN. (CR) 24.520000  
 HINGE MOMENT, IN.-LBS./IN. (BLMD) 8102.1211  
 WEIGHT PER UNIT AREA, LBS./IN.<sup>2</sup> (CD) 0.41655509

TABLE I-17. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC4-2.8 POUND AT 7 INCHES  
(Continued).

| ORIGINAL HINGE LOCATION, IN.    |                  | CH# 28.000000                                         |                          | BLAST LOAD                  |                            | PAGE 2                       |                            |
|---------------------------------|------------------|-------------------------------------------------------|--------------------------|-----------------------------|----------------------------|------------------------------|----------------------------|
| CLAMPED-SUPPORTED               |                  | GENERAL TIME FUNCTION                                 |                          | VERTICAL WALL               |                            |                              |                            |
| CALCULATIONS IN A CONCRETE BEAM |                  | LOCALIZED SHEAR FAILURE CALCULATION                   |                          | BLAST 1990                  |                            | 10 0 27 11                   |                            |
| AFESC CASEC4-2.8 LB. AT 7 IN.   |                  | GENERAL TIME FUNCTION                                 |                          | BLAST 1990                  |                            | 3 27 1990 10 0 27 11         |                            |
| CLAMPED-SUPPORTED               |                  | GENERAL TIME FUNCTION                                 |                          | VERTICAL WALL               |                            | PAGE 3                       |                            |
| BENCHMARK RADIIUS I BAR         |                  | I CRITICAL                                            |                          | BLAST 1990                  |                            |                              |                            |
| 1.0000000                       | 1.807665         | 2.331261                                              |                          |                             |                            |                              |                            |
| CALCULATIONS IN A CONCRETE BEAM |                  | FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE |                          |                             |                            |                              |                            |
| AFESC CASEC4-2.8 LB. AT 7 IN.   |                  | GENERAL TIME FUNCTION                                 |                          | BLAST 1990                  |                            | 3 27 1990 10 0 27 49         |                            |
| CLAMPED-SUPPORTED               |                  | GENERAL TIME FUNCTION                                 |                          | VERTICAL WALL               |                            |                              |                            |
| TIME<br>(SECONDS)               | YETH<br>(INCHES) | MDIPT, VEL.<br>(IN./SEC.)                             | MDIPT, DELTA<br>(INCHES) | PRESSURE WORK<br>(IN.-LBS.) | PLASTIC WORK<br>(IN.-LBS.) | KINETIC ENERGY<br>(IN.-LBS.) | HINGE LOCATION<br>(INCHES) |
| 0.0000000E+00                   | 0.0000000E+00    | 0.0000000E+00                                         | 0.0000000E+00            | 0.0000000E+00               | 0.0000000E+00              | 0.0000000E+00                | 28.000000                  |
| 0.4999999E-03                   | 0.5737425E-02    | 340.92096                                             | 0.16064782               | 66653.289                   | 9267.3076                  | 57385.960                    | 28.000000                  |
| 0.9999999E-03                   | 0.11560594E-01   | 312.16919                                             | 0.32352037               | 66653.289                   | 18666.027                  | 47967.262                    | 28.000000                  |
| 0.1999999E-02                   | 0.11884320E-01   | 283.41739                                             | 0.47281694               | 66653.289                   | 27275.441                  | 33377.840                    | 28.000000                  |
| 0.1999999E-02                   | 0.21680633E-01   | 254.66559                                             | 0.60733771               | 66653.289                   | 35035.555                  | 31617.734                    | 28.000000                  |
| 0.4999999E-02                   | 0.27581521E-01   | 225.91379                                             | 0.72748262               | 66653.289                   | 41966.359                  | 24686.940                    | 28.000000                  |
| 0.9000000E-02                   | 0.29754904E-01   | 197.16206                                             | 0.83325154               | 66653.289                   | 48067.963                  | 18585.426                    | 28.000000                  |
| 0.9000000E-02                   | 0.3023022E-01    | 168.41034                                             | 0.92464459               | 66653.289                   | 53340.070                  | 13513.219                    | 28.000000                  |
| 0.9000000E-02                   | 0.3073639E-01    | 139.65862                                             | 1.0016619                | 66653.289                   | 57782.979                  | 8970.3164                    | 28.000000                  |
| 0.9999999E-02                   | 0.30010826E-01   | 110.90688                                             | 1.0643032                | 66653.289                   | 61396.566                  | 5256.7227                    | 28.000000                  |
| 0.4999999E-02                   | 0.28734535E-01   | 82.155121                                             | 1.1125696                | 66653.289                   | 64160.863                  | 2472.4258                    | 28.000000                  |
| 0.5499999E-02                   | 0.48949941E-01   | 55.403366                                             | 1.1464534                | 66653.289                   | 66135.859                  | 517.42563                    | 28.000000                  |
| 0.5999999E-02                   | 0.46641861E-01   | 24.651608                                             | 1.1659721                | 66653.289                   | 67261.562                  | -606.27344                   | 28.000000                  |

SHRINKAGE DEPLETION = 1.1711039 AT TIME = 0.6499999E-02

IN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED

TABLE I-18. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC5-2.8 POUND AT 16 INCHES.

PAGE 1

CALCULATIONS ON A CONCRETE BEAM

AFESC CASEC5--2.8 LB. AT 16 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. (H) 28.000000  
 BEAM OR PLATE THICKNESS, IN. (H) 4.000000  
 LENGTH TO WIDTH RATIO, DIMENSIONLESS (LW) 0.88959999  
 MASS PER UNIT AREA, LBS.-SEC./IN.CUBED (SMALL) 0.10782999E-02

POWER FROM PRESSURE-LAMBDA CURVE (CFH) 1.1500000  
 UNIFORM PRESSURE LOAD, PSI. (CPD) 0.00000000E+00  
 PRESSURE DECAY, DIMENSIONLESS (ALPHA) 3.8000000  
 PRESSURE DURATION, SEC. (TMD) 0.23400001E-03

SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED (E) 2.0000000  
 WAVE FUNCTION: 1=GENERAL, 2=SQUARE (CURVEFN) 1.0000000  
 WEIGHT VECTOR: 0=VERT, 1=EXP BLN, -1=EXP AB (SMALL) 0.00000000E+00  
 REINFORCEMENT DENSITY, LB.-SEC./IN.4H4 (RHOR) 0.73390000E-03

CONCRETE COMPRESSIVE STRENGTH, PSI. (SIGMNC) 5000.0000  
 REINFORCED STEEL YIELD STRESS, PSI. (SIGMNY) 65000.000  
 REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS (RD) 0.16500000E-01  
 REINFORCING DISTANCE, IN. (D) 3.09999999

DIAMETER OF EXPLOSIVE, IN. (BIGD) 3.2500000  
 PRESSURE INTERCEPT ON P-LAMBSON CURVE (SMALL) 5.0000000  
 EXPLOSIVE WEIGHT, LBS. (BIGH) 2.8000000  
 LENGTH OF EXPLOSIVE, IN. (BIGL) 5.6000001

X 1 OF EXPLOSIVE, IN. (EX1) 28.000000  
 X 2 OF EXPLOSIVE, IN. (EX2) 28.000000  
 Y 1 OF EXPLOSIVE, IN. (EY1) 23.400000  
 Y 2 OF EXPLOSIVE, IN. (EY2) 27.799999

Z 1 OF EXPLOSIVE, IN. (EZ1) 16.000000  
 Z 2 OF EXPLOSIVE, IN. (EZ2) 16.000000  
 SHEAR STRESS REINFORCEMENT RATIO (Q) 0.00000000E+00  
 ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (SMALL) 2.8000000

TIME INCREMENT, SEC. (TINGR) 0.9999999E-04  
 TIME MAXIMUM, SEC. (TMAX) 0.10000000  
 TIME STEP INTERVAL PER PRINTED LINE, SEC. (TPRINT) 0.5000000E-03  
 CRITICAL TIME, SEC. (TCR) 0.20999999E-02

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN. (B) 24.920000  
 HINGE MOMENT, IN.-LBS./IN. (BIGMD) 8102.1211  
 WEIGHT PER UNIT AREA, LBS./IN.SQ. (H) 0.41665509  
 ORIGINAL HINGE LOCATION, IN. (XHD) 26.971539

CLAMPED-SUPPORTED GENERAL TIME FUNCTION

VERTICAL WALL

BLNET LOAD

TABLE I-18. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC5-2.8 POUND AT 16 INCHES  
(Continued).

[illegible]

MAXIMUM DEFLECTION = 0.48948020 AT TIME = 0.4200003E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT HAS FRACTURED



TABLE I-19. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC6-2.8 POUND AT 23 INCHES.

PAGE 1

3 27 1990 10 0 49 8

CALCULATIONS ON A CONCRETE BEAM

AFESC CASEC6-2.8 LB. AT 23 IN.

INPUT VALUES

PLATE HALF WIDTH OR BEAM HALF SPAN, IN. (XD) 28.000000  
 BEAM OR PLATE THICKNESS, IN. (XD) 4.000000  
 LENGTH TO WIDTH RATIO, DIMENSIONLESS (XK) 0.86999999  
 MASS PER UNIT AREA, LBS-SEC.500/IN.CUBED (SMALLD) 0.10782999E-02  
 POWER FROM PRESSURE-LAMBDA CURVE (EN) 1.250000  
 UNIFORM PRESSURE LOAD, PSI. (PD) 0.00000000E+00  
 PRESSURE DECAY, DIMENSIONLESS (ALPHA) 5.4000001  
 PRESSURE DURATION, SEC. (TAD) 0.37299999E-03  
 SUPPORT FACTOR: 1=SIMPLY, 2=CLAMPED (F) 2.000000  
 SHAPE FUNCTION: 1=GENERAL, 2=SIMPLE (XARVEF) 1.000000  
 HEIGHT VECTOR: D=VERT, 1=EXP BLM, -1=EXP AB (SMALLD) 0.00000000E+00  
 REINFORCEMENT DENSITY, LB.-SEC.50./IN.SQ. (RHOD) 0.73390000E-03  
 CONCRETE COMPRESSIVE STRENGTH, PSI. (SIGMCC) 5000.0000  
 REINFORCED STEEL YIELD STRESS, PSI. (SIGMRC) 65000.0000  
 REINFORCEMENT RATIO IN TENSION, DIMENSIONLESS (D) 0.18200000E-01  
 REINFORCING DISTANCE, IN. (D) 3.89999999  
 DIAMETER OF EXPLOSIVE, IN. (BIGD) 3.25000000  
 PRESSURE INTERCEPT ON P-LAMBDA CURVE (SMALLD) 5.00000000  
 EXPLOSIVE WEIGHT, LBS. (BIGD) 2.80000000  
 LENGTH OF EXPLOSIVE, IN. (BIGL) 5.6300001  
 X 1 OF EXPLOSIVE, IN. (CX1) 28.000000  
 X 2 OF EXPLOSIVE, IN. (CX2) 28.000000  
 Y 1 OF EXPLOSIVE, IN. (CY1) 23.400000  
 Y 2 OF EXPLOSIVE, IN. (CY2) 27.799999  
 Z 1 OF EXPLOSIVE, IN. (EZ1) 23.000000  
 Z 2 OF EXPLOSIVE, IN. (EZ2) 23.000000  
 SHEAR STRESS REINFORCEMENT RATIO (D) 0.00000000E+00  
 ENVIRONMENT FACTOR: 1=SOIL, 2=AIR (SMALLD) 2.00000000  
 TIME INCREMENT, SEC. (TIMCK) 0.99999997E-04  
 TIME MAXIMUM, SEC. (THMX) 0.10000000  
 TIME STEP INTERVAL PER PRINTED LINE, SEC. (TIPRINT) 0.50000002E-03  
 CRITICAL TIME, SEC. (TCR) 0.28999999E-02

COMPUTED CONSTANT VALUES

BEAM HALF WIDTH, IN. (D) 24.920000  
 HINGE MOMENT, IN.-LBS./IN. (BIGMD) 8102.1211  
 WEIGHT PER UNIT AREA, LBS./IN.SQ. (XD) 0.41665009  
 ORIGINAL HINGE LOCATION, IN. (XD) 21.774929

CLAMPED-SUPPORTED

GENERAL TIME FUNCTION

VERTICAL WALL

BLAST LOAD

TABLE I-19. CALCULATIONS ON A CONCRETE BEAM, AFESC CASEC6-2.8 POUND AT 23 INCHES  
(Continued).

| CALCULATIONS ON A CONCRETE BEAM LOCALIZED SHEAR FAILURE CALCULATION                   |                 |                       |                      |                          |                         |                           |                           |                         |  | PAGE 2               |
|---------------------------------------------------------------------------------------|-----------------|-----------------------|----------------------|--------------------------|-------------------------|---------------------------|---------------------------|-------------------------|--|----------------------|
| AFESC CASEC6-2.8 LB. AT 23 IN.                                                        |                 |                       |                      |                          |                         |                           |                           |                         |  | 3 27 1990 10 0 56 30 |
| CLAMPED-SUPPORTED                                                                     |                 |                       |                      |                          | VERTICAL WALL           |                           |                           |                         |  | BLAST LOAD           |
| GENERAL TIME FUNCTION                                                                 |                 |                       |                      |                          |                         |                           |                           |                         |  |                      |
| BENCH RADIUS 1 BAR 1 CRITICAL                                                         |                 |                       |                      |                          |                         |                           |                           |                         |  |                      |
| 1.000000                                                                              | 0.24017607      | 2.3317261             |                      |                          |                         |                           |                           |                         |  |                      |
| CALCULATIONS ON A CONCRETE BEAM FLEXURAL RESPONSE ASSUMING NO LOCALIZED SHEAR FAILURE |                 |                       |                      |                          |                         |                           |                           |                         |  | PAGE 3               |
| AFESC CASEC6-2.8 LB. AT 23 IN.                                                        |                 |                       |                      |                          |                         |                           |                           |                         |  | 3 27 1990 10 0 56 77 |
| CLAMPED-SUPPORTED                                                                     |                 |                       |                      |                          | VERTICAL WALL           |                           |                           |                         |  | BLAST LOAD           |
| GENERAL TIME FUNCTION                                                                 |                 |                       |                      |                          |                         |                           |                           |                         |  |                      |
| TIME (SECONDS)                                                                        | THETA (RADIANS) | MDPT. VEL. (IN./SEC.) | MDPT. DELTA (INCHES) | PRESSURE WORK (IN.-LBS.) | PLASTIC WORK (IN.-LBS.) | KINETIC ENERGY (IN.-LBS.) | KINETIC ENERGY (IN.-LBS.) | HINGE LOCATION (INCHES) |  |                      |
| 0.00000000E+00                                                                        | 0.00000000E+00  | 0.00000000E+00        | 0.00000000E+00       | 0.00000000E+00           | 0.00000000E+00          | 0.00000000E+00            | 0.00000000E+00            | 21.774529               |  |                      |
| 0.49999997E-03                                                                        | 0.27153003E-02  | 151.15950             | 0.67512698E-01       | 16232.978                | 4386.0005               | 11846.977                 | 11846.977                 | 24.662999               |  |                      |
| 0.99999993E-03                                                                        | 0.58654346E-02  | 115.73785             | 0.14182217           | 16232.978                | 8181.8857               | 8051.0918                 | 8051.0918                 | 28.000000               |  |                      |
| 0.14999997E-02                                                                        | 0.68754630E-02  | 86.986099             | 0.19251315           | 16232.978                | 11105.525               | 5127.4521                 | 5127.4521                 | 28.000000               |  |                      |
| 0.19999999E-02                                                                        | 0.81720809E-02  | 58.234337             | 0.22881827           | 16232.978                | 13159.862               | 3033.1152                 | 3033.1152                 | 28.000000               |  |                      |
| 0.24999997E-02                                                                        | 0.89552673E-02  | 29.462578             | 0.25074747           | 16232.978                | 14464.836               | 1768.0820                 | 1768.0820                 | 28.000000               |  |                      |
| 0.30000000E-02                                                                        | 0.9250295E-02   | 0.73082530            | 0.25830084           | 16232.978                | 14900.626               | 1332.3916                 | 1332.3916                 | 28.000000               |  |                      |

MAXIMUM DEFLECTION = 0.25808638 AT TIME = 0.31000001E-02

AN ASTERISK INDICATES THAT A REINFORCING ELEMENT WAS FRACTURED