

AD-A119 676

COLD REGIONS RESEARCH AND ENGINEERING LAB HANOVER NH
DECELERATION OF PROJECTILES IN SNOW, (U)
AUG 82 D G ALBERT, P W RICHMOND

F/G 8/12

UNCLASSIFIED

CRREL-82-20

NL

[or]
AD
Sub-e



END
DATE
FILMED
11-82
DTIC

CRREL

REPORT 82-20



US Army Corps
of Engineers

Cold Regions Research &
Engineering Laboratory

12

Deceleration of projectiles in snow

AD A119676

DTIC FILE COPY



SEP 26 1982

82 09 27 018

*For conversion of SI metric units to U.S./
British customary units of measurement
consult ASTM Standard E380, Metric Prac-
tice Guide, published by the American Socie-
ty for Testing and Materials, 1916 Race St.,
Philadelphia, Pa. 19103.*

*Cover: M374 81-mm projectile after impact
into a snow target. Aluminum foil
was used to protect snow sample
from winds caused by motion of the
centrifuge arm.*

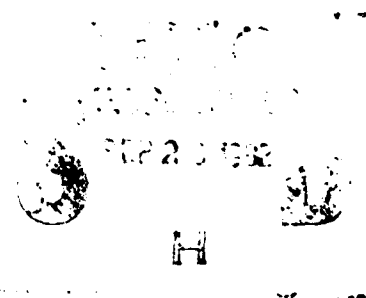


CRREL Report 82-20

August 1982

Deceleration of projectiles in snow

Donald G. Albert and Paul W. Richmond III



Prepared for
OFFICE OF THE CHIEF OF ENGINEERS
Approved for public release; distribution unlimited.

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER CRREL Report 82-20	2. GOVT ACCESSION NO. A119676	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) DECELERATION OF PROJECTILES IN SNOW		5. TYPE OF REPORT & PERIOD COVERED
		6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Donald G. Albert and Paul W. Richmond III		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Cold Regions Research and Engineering Laboratory Hanover, New Hampshire 03755		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS DA Project 4A762730AT42, Tech Area B, Work Units 2 and 9
11. CONTROLLING OFFICE NAME AND ADDRESS Office of the Chief of Engineers Washington, D.C. 20314		12. REPORT DATE August 1982
		13. NUMBER OF PAGES 34
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS. (of this report) Unclassified
		15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for public release; distribution unlimited.		
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Centrifuge Penetration tests Mortars Projectiles Mortar shells Snow Nylon Styrofoam Penetration		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Instrumented M374 projectiles were launched into snow, nylon, and Styrofoam targets using a 10.7-m radius centri- fuge. For snow of 410-kg/m ³ density, the 3.1-kg test projectile experienced decelerations of approximately 220, 400, and 550 m/s ² (at a depth of 0.1 m) for initial impact velocities of 15, 30 and 46 m/s respectively. These values dis- agree with values predicted from a simple hydrodynamic drag force approximation. The decelerations measured for snow targets were always greater than those measured for nylon shaving targets (of density 120 kg/m ³) indicating that this material is not a good analog for snow of the density used in these tests.		

PREFACE

This report was prepared by Donald G. Albert, Geophysicist, Geophysical Sciences Branch, Research Division, and Paul W. Richmond III, Mechanical Engineer, Applied Research Branch, Experimental Engineering Division, U.S. Army Cold Regions Research and Engineering Laboratory. Funding was provided by DA Project 4A762730AT42, Technical Area B, Work Unit 2, *Cold Regions Performance of Seismic-Acoustic Sensor Systems* and Work Unit 9, *Fuze Action in Snow*.

The authors acknowledge the assistance of George Aitken, Glenn Durell, Dennis Farrell, Gregor Fellers, and Gary Decoff of CRREL and the many personnel at Sandia Laboratories who made this study possible. Dr. George Swinzow and David Cole of CRREL provided many useful comments on an earlier version of this report. The authors also thank Dr. Malcom Mellor and Jacqueline Richter of CRREL, and A. Garcia of U.S. Army Armament Research and Development Command (ARRADCOM) for technical reviews.

The contents of this report are not to be used for advertising or promotional purposes. Citation of brand names does not constitute an official endorsement or approval of the use of such commercial products.

CONTENTS

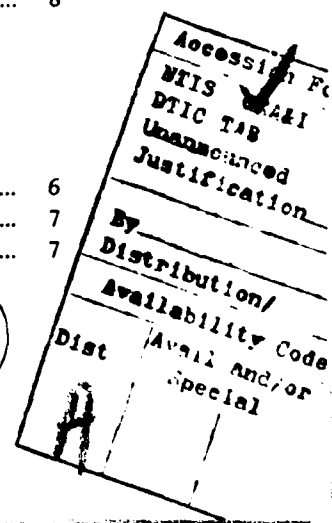
	Page
Abstract	i
Preface	ii
Introduction.....	1
Test procedure	1
Data reduction.....	4
Results	6
Conclusions.....	8
Recommendations for future work	9
Literature cited	9
Appendix A. Graphs of measured acceleration vs penetration depth	11
Appendix B. Listing of data for each impact	15

ILLUSTRATIONS

Figure		
1.	View of the 10.7-m centrifuge at Sandia Laboratories, Albuquerque, New Mexico ..	2
2.	Close-up view of instrumented M524 fuze and M374 81-mm projectile	2
3.	Preparation of the snow target	3
4.	Snow target, with aluminum foil windscreen in place, positioned in stand prior to test	3
5.	Close-up view of test projectile mounted on centrifuge arm	4
6.	Acceleration vs time for 30-m/s impact of projectile into 390-kg/m ³ density snow target	5
7.	Acceleration vs time response of projectile, suspended by a string, to hammer tap ..	5
8.	Amplitude vs frequency curve from data in Figure 7	5
9.	Acceleration vs penetration depth into snow	7
10.	Acceleration vs penetration depth into snow, nylon, and Styrofoam	7
11.	Acceleration vs penetration depth into snow—a comparison of measured and theoretical values	8

TABLES

Table		
1.	Impacts into snow	6
2.	Impacts into nylon	7
3.	Impacts into Styrofoam	7



DECELERATION OF PROJECTILES IN SNOW

Donald G. Albert and Paul W. Richmond III

INTRODUCTION

Snow greatly reduces the effectiveness of impact-fuzed projectiles. In order to obtain maximum effectiveness on a winter battlefield, to design new fuzes and to evaluate current equipment, detailed knowledge of the snow penetration process is required. Fuze performance under various impact conditions can be studied by both direct and reverse ballistic test procedures (Lascher et al. 1975). The direct test subjects the fuzed projectile to realistic launch accelerations, but has the problem of accurately locating the point of impact and requires telemetry to obtain data from on-board transducers. The reverse ballistic technique, where the target is fired into a stationary projectile, has the advantage of allowing instrumentation in the projectile to be directly wired to recording equipment. However, this technique is difficult to use with snow because of its compressibility (Todisco et al. 1980).

The centrifugal launch method used here to test impact-fuzed projectiles is unique in that it provides advantages normally found in both of the above techniques. Sensors in the projectile are directly wired to recording equipment, and the target is not accelerated as in the reverse ballistic technique. The point of impact is also easily controlled using this method.

These tests provided measurements of the deceleration of a projectile when it hits a snow target. The deceleration data were smoothed by using a low pass digital filter and integrated to obtain depth of penetration. The data were then compared with a modified hydrodynamic drag equation (Kornhauser 1969) that has been used to describe fuze impact

into both snow and mud. Kovacs (1971) and Davis (1975) also used similar equations to analyze fuze performance.

TEST PROCEDURE

The centrifuge facility used for these tests (Fig. 1) is located at the Sandia Laboratories in Albuquerque, New Mexico. Otts (1973) described the centrifuge and gave an example of its use as an impact testing machine. It has a 10.7-m radius and is capable of subjecting a test item to tangential velocities up to 164 m/s.

An inert M374 81-mm projectile with an M524 fuze was used in these tests. The fuze was instrumented by replacing the striker and explosive train with a piezoresistive accelerometer mounted on an aluminum plug (Fig. 2). The instrumentation lead was run through the projectile body and out of the tail section. The mass of the projectile was 6.2 kg.

Targets made from snow, nylon shavings (a candidate material to simulate snow), and Styrofoam panels were used in these tests. The snow targets were prepared by sifting snow through a 6-mm mesh screen into 610-mm square by 150-mm deep boxes constructed of 50-mm thick Styrofoam (Fig. 3). These targets were then aged at least 24 hours to allow the snow to sinter. Snow densities of about 400 kg/m³ were obtained. The nylon targets were prepared by pouring 10-mm long nylon shavings into the 150-mm deep Styrofoam boxes. A piece of cheesecloth was placed over the surface of the shavings to keep them in place when the box was turned on its side for the



Figure 1. View of the 10.7-m centrifuge at Sandia Laboratories, Albuquerque, New Mexico.

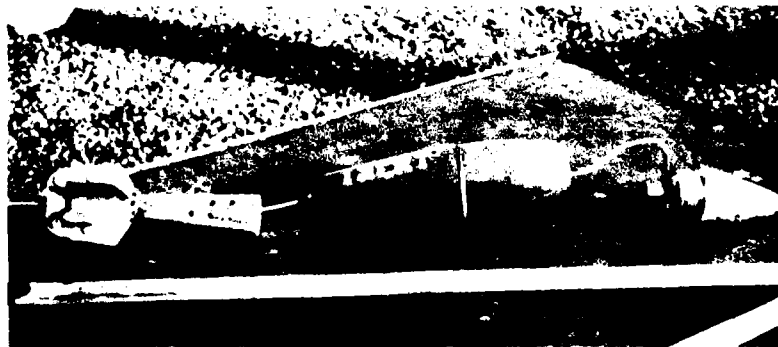


Figure 2. Close-up view of instrumented M524 fuze and M374 81-mm projectile.



Figure 3. Preparation of the snow target.



Figure 4. Snow target, with aluminum foil windscreen in place, positioned in stand prior to test.

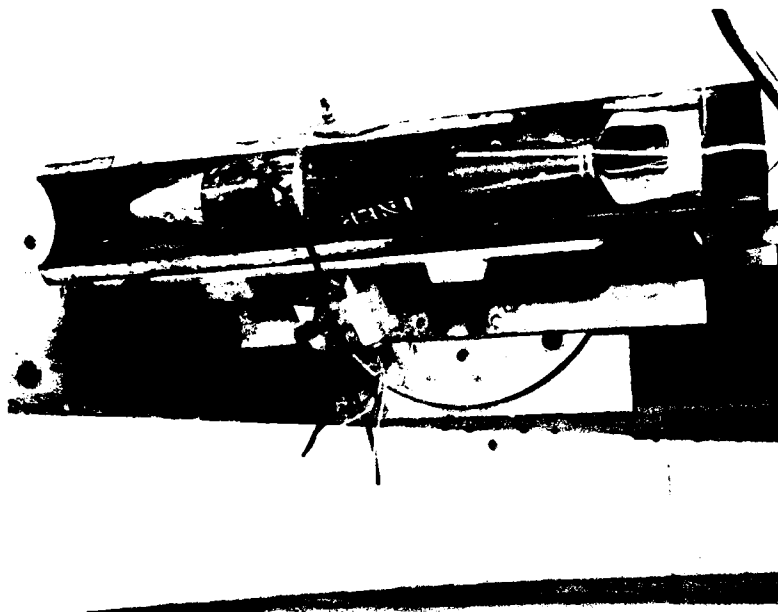


Figure 5. Close-up view of test projectile mounted on centrifuge arm. Note steel cable holding projectile to arm and explosive cable-cutter used to release projectile.

test. Three 50-mm thick panels of Styrofoam were placed in the target boxes for a third series of tests. The Styrofoam targets were used to check the operation of the measuring equipment.

The target box was placed in a rigid stand located on a tangent to the arc made by the centrifuge arm and positioned to ensure a near normal impact (Fig. 4). An aluminum foil wind screen was placed 150 mm in front of the snow target to protect the snow surface from wind damage. Alternating layers of Styrofoam and plywood were placed behind the target to stop the projectile.

The instrumented projectile was mounted on the centrifuge as shown in Figure 5. When the centrifuge achieved the desired velocity, the projectile was released so that it hit the target. The accelerometer output was amplified and recorded on an analog tape recorder. The frequency response of this system was flat to 5 kHz. Data were obtained for impact velocities ranging from 15 to 90 m/s (50 to 300 ft/s). Preliminary results from this experiment have been presented by Fulton (1979) and by Aitken et al. (1980).

DATA REDUCTION

The test data were digitized for computer analysis using a sampling rate of 40 kHz. Input signals of known acceleration values were used to calibrate the system.

A typical acceleration vs time signal for a snow impact at 30 m/s is shown in Figure 6. Projectile impacts with the wind screen, the snow surface, and the barrier behind the snow target are identified in the figure. The travel times between these impacts were used to verify the identifications given in the figure.

The signal was passed through a zero phase low pass digital filter with a cutoff frequency of 5 kHz, corresponding to the bandwidth of the analog recording equipment. The filter removes any high frequency noise produced by the digitizing process (Otnes and Enochson 1978) without introducing time shifts to the signal. This latter property of the filter is quite important. Computer programs to apply digital Butterworth filters to signals are readily available (Stearns 1975); however, these filters will introduce a frequency-dependent phase shift, which causes the output signal to be delayed in time by an amount proportional to the frequency of each component. To remove the phase shift, the filter was first applied to the signal, obtaining a phase-shifted, filtered output. The filter output was then reversed and the signal passed through the filter again. This procedure has two effects: 1) the final output will not be phase (or time) shifted, since the phase shift caused by the second pass will be the negative of the phase shift caused by the first pass, and 2) the final

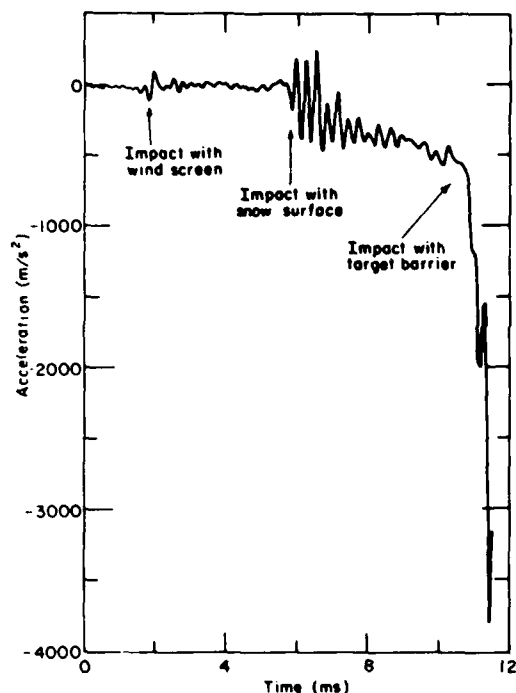


Figure 6. Acceleration vs time for 30-m/s impact of projectile into 390-kg/m³ density snow target.

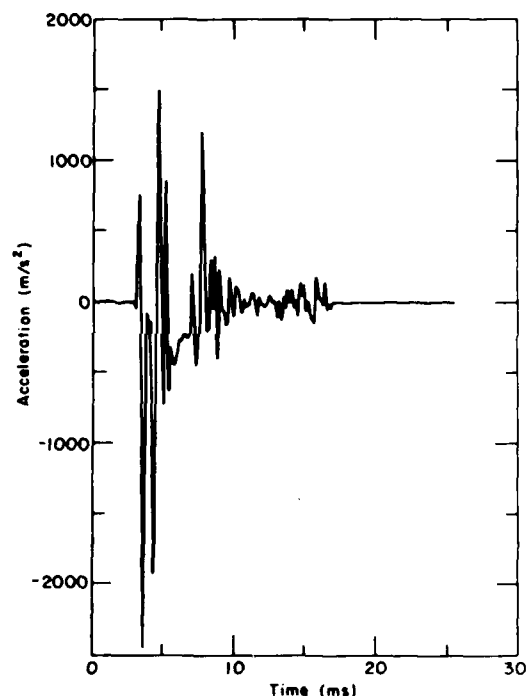


Figure 7. Acceleration vs time response of projectile, suspended by a string, to hammer tap.

amplitude response of the filter will be the square of the amplitude response of a single filter operation. After filtering, however, some high frequency noise superimposed on the snow impact signal was still visible. This noise cannot be attributed to the digitizing process and therefore must have some physical cause.

A possible source of this high frequency noise is resonant vibration of the projectile. A test was conducted to ascertain whether or not the resonant frequency of the projectile was of the same order as the high frequency noise on the data traces. The projectile was suspended from a string attached to its tail and then tapped with a hammer. The output from the accelerometer was then digitized and is shown in Figure 7. The amplitude vs frequency plot obtained from the Fourier transform of this signal is shown in Figure 8. The peak amplitude is around 1.5 kHz, with a significant amount of power located at frequencies up to about 3.5 kHz, suggesting that resonant vibration of the projectile could be the cause of the noise on the data traces. In most cases, it was found that a low pass filter with a cutoff frequency of around 1 kHz was sufficient to remove this high frequency noise. For the higher impact

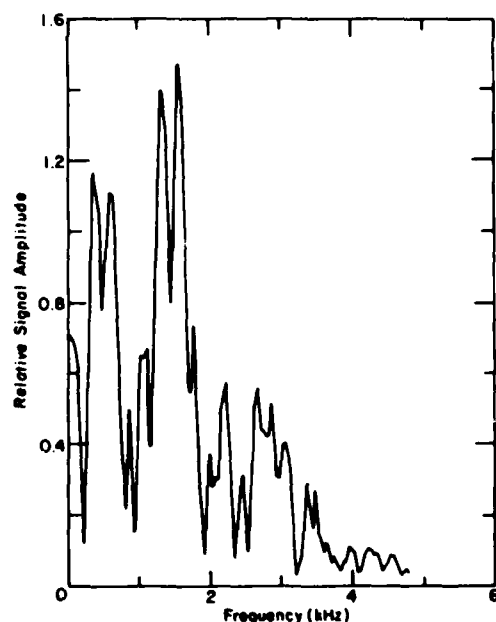


Figure 8. Amplitude vs frequency curve from data in Figure 7.

velocities, however, the low pass filtering procedure did not give usable results even if a lower cutoff frequency was used.

The poorer quality of the data at higher impact velocities is due to two factors. First, as the impact velocity increases, the amplitude of the resonant vibrations increases, thereby decreasing the signal-to-noise ratio. This effect is analogous to increasing the force of the hammer blow in the experiment discussed above. Second, the data are degraded because the impacting time interval decreases significantly. For a given impact velocity V_o , the number of significant data points N obtained during an impact with a target of thickness d is limited by the bandwidth of the recording instrument B and is given by

$$N = \frac{d}{V_o} B. \quad (1)$$

For this experiment $B \approx 5$ kHz and $d = 0.15$ m. For a relatively low impact velocity of 30 m/s, N is 25, but for a high velocity of 90 m/s the number of data points is reduced to only eight. It is difficult to accurately define the deceleration of the projectile with only eight data points available for the event. With noise superimposed on the signal, accurate measurement of the deceleration with this limited number of data points becomes impossible.

After filtering to remove the noise, the deceleration data were integrated to obtain curves of depth of penetration as a function of time. The penetration vs time data and the original deceleration vs time data were then used to construct deceleration vs penetration curves at velocities from 15 to 46 m/s.

RESULTS

Test parameters for the projectile impacts into snow are listed in Table 1. Acceleration vs penetration graphs are shown in Figure A1, and the measured values are given in Appendix B. All of the graphs show a nearly linear relationship between the deceleration and the penetration, with larger deceleration values at a given penetration for higher initial impact velocities. The variation between the individual tests shown in the graphs can be used to estimate the accuracy of the deceleration measurements at about ± 50 m/s² (or ± 5 g's). The slight variations in the initial conditions did not show a consistent relationship with the measured deceleration values.

At an initial velocity of 61 m/s (200 ft/s), the shape of the curve (Fig. A1e) becomes much different from the curves for lower velocity tests. The signal processing techniques used to reduce the data were

Table 1. Impacts into snow.

Test no.	Impact velocity (m/s)	Impact velocity (ft/s)	Density (kg/m ³)	Notes	Filter frequency (Hz)
79-09	15	49	380	-	500
79-10	16	51	390	-	500
79-12	16	51	410	-	500
79-15	23	75	410	-	700
79-16	23	74	420	-	700
79-17	24	79	430	-	700
79-06	30	99	410	-	750
79-08	30	99	390	-	750
79-18	30	99	440	-	750
79-21	45	149	430	-	1000
79-24	45	149	410	-	1000
79-22	61	200	410	-	1000
79-25	61	199	420	-	1000
79-26	61	201	400	A	1000
79-23	76	250	420	-	1000
79-27	90	294	400	-	1000
79-28	92	301	420	-	1000

A. Target tipped.

no longer able to remove the effects of the projectile resonating as it hit the snow target. The bandwidth of the recording system would have to be increased to allow higher velocity data to be analyzed.

A graph of the averages of the individual tests is shown in Figure 9. The deceleration values for a penetration of 0.08 m or greater (after the resonating caused by the impact with the snow surface has died down) show a monotonic increase with respect to the initial impact velocity. Note, however, that the deceleration curve for an initial velocity of 23 m/s (75 ft/s) is not significantly different from the curve for 31 m/s (100 ft/s) within the estimated accuracy of the measurements. Thus this experiment can only resolve differences greater than about 15 m/s (50 ft/s) between the initial impact velocities.

The parameters for the impacts into nylon are listed in Table 2, and graphs of acceleration vs distance are given in Figure A2. The projectile experienced a nearly constant deceleration after impact. In addition, there was no measurable difference in deceleration after impacts at 15 and 30 m/s (50 and 100 ft/s). Again, the records of the higher impact velocity tests are not reliable because of the bandwidth limitations. Although both wet and dry nylon shavings were used, no significant differences between the two conditions were found.

Table 3 lists the test parameters for impacts of the projectile into Styrofoam. Graphs of acceleration vs distance are shown in Figure A3. The values of deceleration increased monotonically as a function of

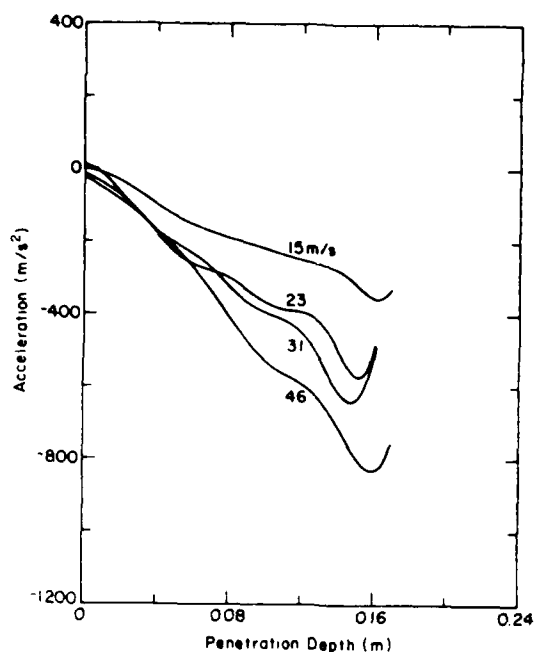


Figure 9. Acceleration vs penetration depth into snow. Average value for impact velocities of 15 through 46 m/s (50 through 150 ft/s). Three separate impacts were averaged to produce these curves, except for the curve of 46 m/s, which is the average of two tests.

Table 2. Impacts into nylon.

Test no.	Impact velocity		Density	Notes	Filter frequency
	(m/s)	(ft/s)	(kg/m ³)		(Hz)
79-11	15	49	90 wet	-	500
79-13	15	49	140 dry	-	500
79-07	30	100	99 dry	A	750
79-19	30	100	170 wet, frozen	A	750
79-20	30	98	160 wet	B	750
79-29	59	195	180 wet	-	1000
79-30	61	201	90 dry	-	1000
79-31	91	299	90 dry	B	1000
79-32	87	287	150 wet	A	1000

A. Target slumped.

B. Accelerometer Damaged during test.

penetration depth. The measurements at 15 and 31 m/s (50 and 100 ft/s) are the only reliable ones for the reasons discussed above. For these tests, as with nylon, there is very little difference between the decelerations caused at these two impact velocities.

Table 3. Impacts into Styrofoam.

Test no.	Impact velocity		Density	Filter frequency
	(m/s)	(ft/s)	(kg/m ³)	(Hz)
79-14	15	50	32	1000
79-33	28	93	32	1000
79-02	30	100	32	1000
79-03	30	100	32	1000
79-04	59	193	32	1000
79-05	92	301	32	1000

Figure 10 shows a comparison of the average acceleration values measured for all three materials with an initial impact velocity of 31 m/s (100 ft/s). This graph shows striking differences in the decelerations caused by the different materials. Nylon caused much lower values of deceleration when compared with snow, while Styrofoam caused much larger values. In addition, the deceleration caused by nylon leveled off at a constant value after a penetration of a few centimeters, while the decelerations increased with depth for the other two materials. Nylon has been used by the U.S. Air Force to simulate snow for

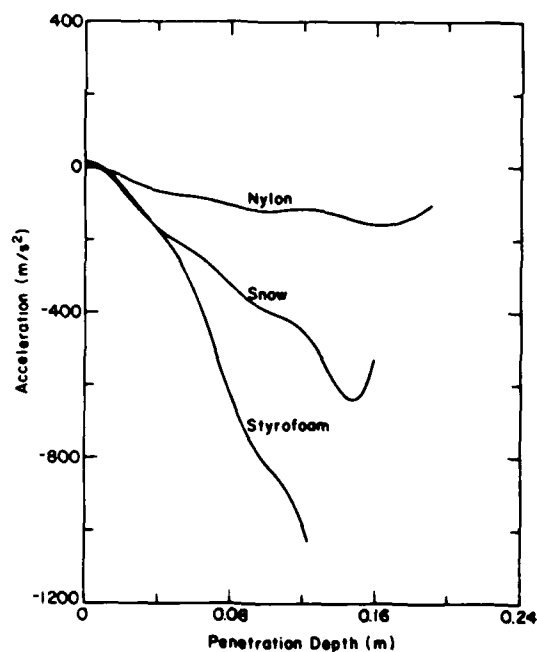


Figure 10. Acceleration vs penetration depth into snow, nylon, and Styrofoam at an impact velocity of 31 m/s (100 ft/s).

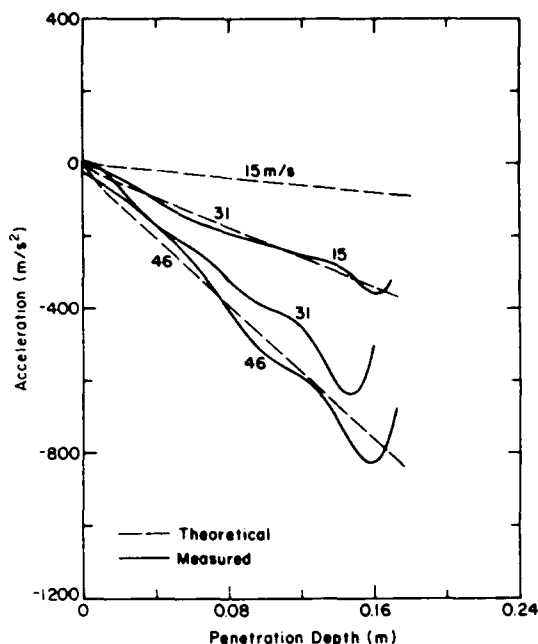


Figure 11. Acceleration vs penetration depth into snow—a comparison of measured and theoretical values.

missile nose cone impacts*. These measurements, however, show that the characteristic shape of the acceleration vs penetration depth curves as well as the magnitude of the values for nylon and snow of this density are markedly different, suggesting that different processes are involved in causing the deceleration.

A hydrodynamic drag force equation has been used by several investigators (Brennan et al. 1980) as a basis for determining fuze performance against water, snow, or mud targets. The equation is

$$F = \frac{1}{2} C_D \rho V_o^2 A, \quad (2)$$

where F = drag force on projectile
 C_D = drag coefficient
 ρ = target density
 V_o = projectile velocity
 A = projectile area.

Kornhauser (1969) claimed that eq 2 produces con-

*Personal communication with H. Rarrick, Sandia Laboratories, 1978.

servative estimates of fuze performance, i.e. the calculated force is lower than the actual force. However, no test data for snow targets were available to verify this hypothesis. When calculating forces on point detonating devices, the drag coefficient C_D is 1, so eq 2 reduces to the equation for the stagnation pressure for a body traveling in a fluid medium.

Data from impacts into snow are compared with predictions made using eq 2 in Figure 11. For low velocities (15-30 m/s), this equation predicts lower values for deceleration than were measured. At 46 m/s, there is close agreement between the calculated and the measured deceleration values. The experimental data above this velocity are severely degraded by noise but were used to estimate deceleration values. These estimated values are less than values calculated using eq 2.

As shown in Figure 11, the predictions made using eq 2 are not in agreement with the measured data, and the agreement at 46 m/s must be regarded as fortuitous. This comparison shows that treating snow as a simple fluid by eq 2 is invalid and a theory which more accurately models the behavior of snow is needed.

CONCLUSIONS

These experiments have demonstrated the utility of the centrifugal launching method for measuring the deceleration of a projectile caused by impact with a compressible material. The measurements were estimated to have an accuracy of $\pm 50 \text{ m/s}^2$ for initial impact velocities of 15-46 m/s.

The data show that for a projectile impacting into snow the deceleration increases as the initial impact velocity increases. Projectiles launched into targets prepared from nylon shavings undergo much less deceleration than those launched into snow targets. In addition, the deceleration appears to be independent of penetration depth for nylon targets. Of all of the materials tested, Styrofoam targets caused the largest deceleration of the impacting projectiles. This penetration resistance of the Styrofoam targets is probably caused by the cohesive forces between the individual particles of the material.

Past theoretical work on deceleration of projectiles has treated snow in a very simplified manner. The data from these experiments do not agree with predictions made using these simplified theories (see Fig. 11). In addition, these measurements show that nylon shavings are not suitable as an experimental analog for snow (see Fig. 10).

RECOMMENDATIONS FOR FUTURE WORK

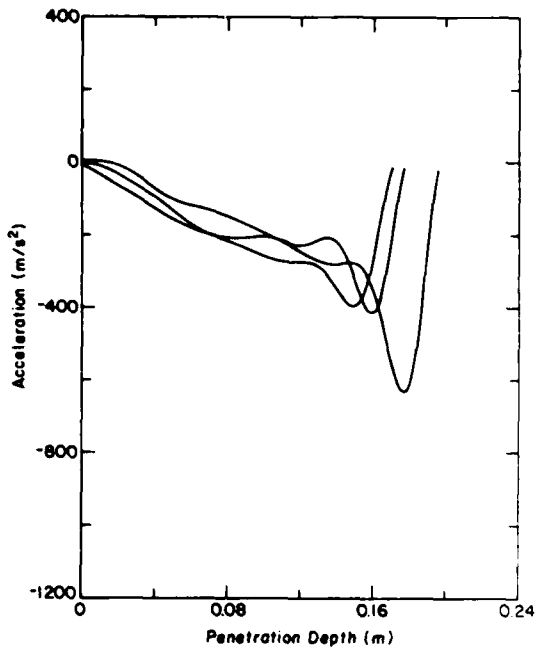
Future tests should be conducted with higher bandwidth instrumentation to provide sufficient data for analysis at higher impact velocities. It is estimated that a recording bandwidth of 40 kHz would be adequate for impact velocities of up to 240 m/s. Deconvolution and other methods of pulse compression could also be used to eliminate the resonant noise from the data once the bandwidth has been increased.

Future testing should also include deeper targets so that a steady-state penetration condition can be achieved. The use of a simple projectile shape (e.g., cylindrical or conical) would also allow the fundamental response of snow to an impact to be evaluated so that differences between different types of projectiles could eventually be accounted for. Snow of different initial densities should also be investigated in future tests.

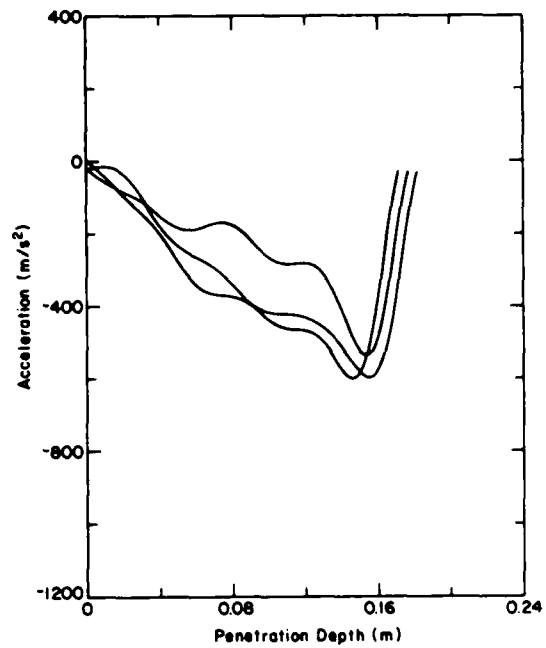
LITERATURE CITED

- Aitken, G.W., P.W. Richmond III and D.G. Albert (1980) Impact fuze performance in snow. *Army Science Conference Proceedings, 17-20 June 1980, West Point, New York*, vol. 1, p. 31-45.
- Brennan, R.X., Y.K. Carignan, B.L. Schulman and F. Cotton (1980) Fuze impact response catalog. U.S. Army Armament Research and Development Command Special Publication ARLCD-SP-80001.
- Davis, H.J. (1975) Impact sensors for use with electronic fuzes. Harry Diamond Laboratories, HDL-TR-1728.
- Fulton, D.L. (1979) Impact into snow tests for CRREL (U.S. Army) on mortar rounds. Sandia Laboratories Environmental Test Report R-422334.
- Kornhauser, M. (1969) Prediction of firing depths of impact fuzes. Degradation Effects Program, Methodology and Evaluation Working Group Report no. 4, AD856947.
- Kovacs, J.E. (1971) Experimental and predicted firing depths of point initiating impact fuzes impacting sand, mud, water and snow (confidential report). Picatinny Arsenal, PA-TR-4095.
- Lascher, F.R., R. Parisse and B.L. Schulman (1975) Terminal ballistic technology overview paper. *Proceedings of the Fuze/Munitions Environment Characterization Symposium, October 7-9*, vol. 2. Dover, New Jersey: U.S. Army Armament Command, Picatinny Arsenal.
- Otnes, R.K. and L. Enochson (1978) *Applied time series analysis*. New York: John Wiley and Sons.
- Otto, J.V. (1973) Impact testing with the 35-foot centrifuge. *Shock and Vibration Bulletin*, vol. 44, no. 3, p. 125-132.
- Stearns, S.D. (1975) *Digital signal analysis*. Rochelle Park, New Jersey: Hayden Book Co.
- Todisco, A., D. Henderson, J. Hollowell, F. Cotton and A. Garcia (1980) Fuze impact mechanics. U.S. Army Armament Research and Development Command Report ARLCD-CR-80003.

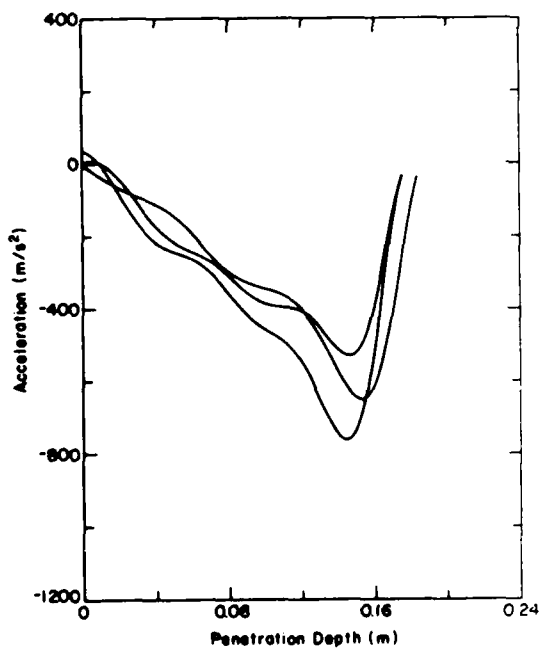
APPENDIX A. GRAPHS OF MEASURED ACCELERATION VS PENETRATION DEPTH.



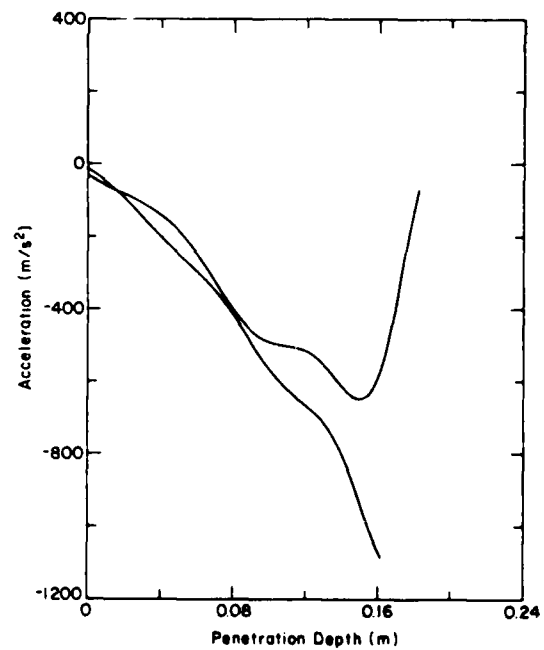
a. Impact velocity 15 m/s (50 ft/s).



b. Impact velocity 23 m/s (75 ft/s).

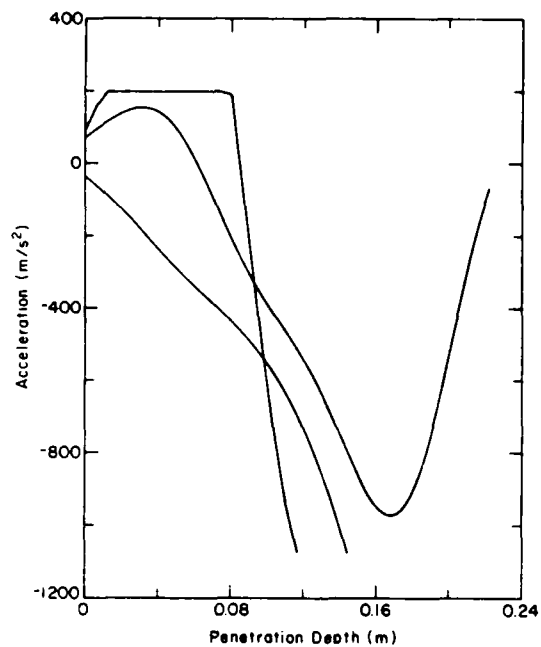


c. Impact velocity 31 m/s (100 ft/s).

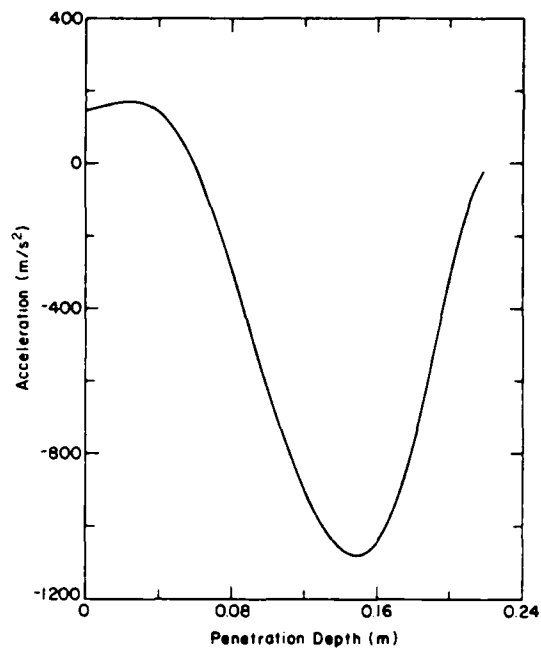


d. Impact velocity 46 m/s (150 ft/s).

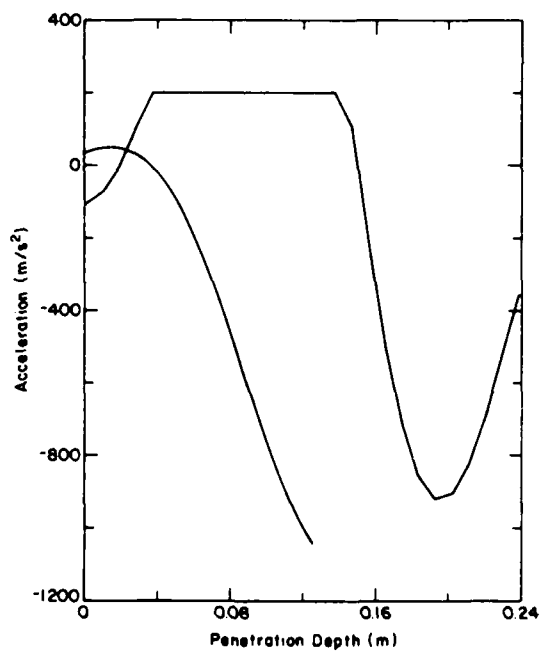
Figure A1. Acceleration vs penetration depth into snow. Each line corresponds to one of the test impacts listed in Table B1.



e. Impact velocity 61 m/s (200 ft/s).

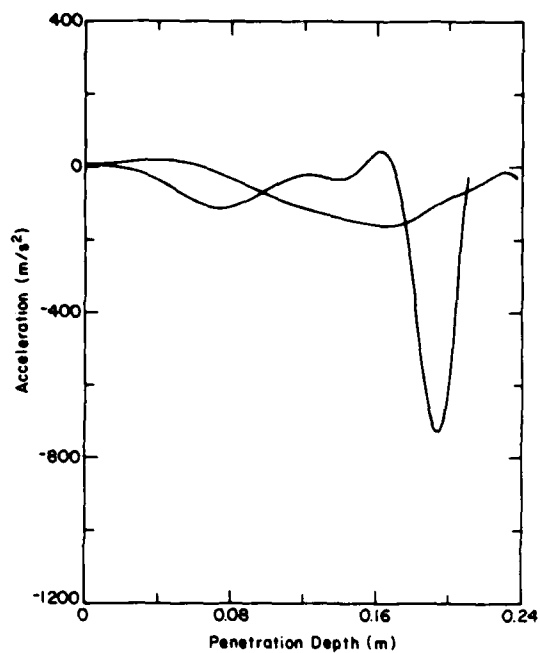


f. Impact velocity 76 m/s (250 ft/s).

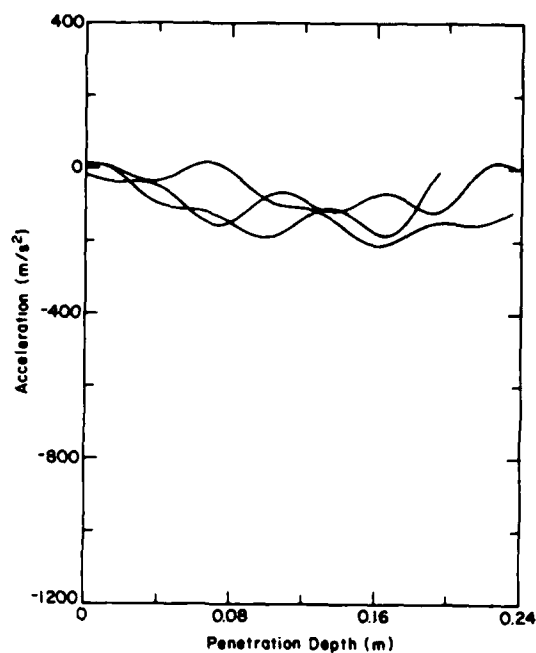


g. Impact velocity 91 m/s (300 ft/s).

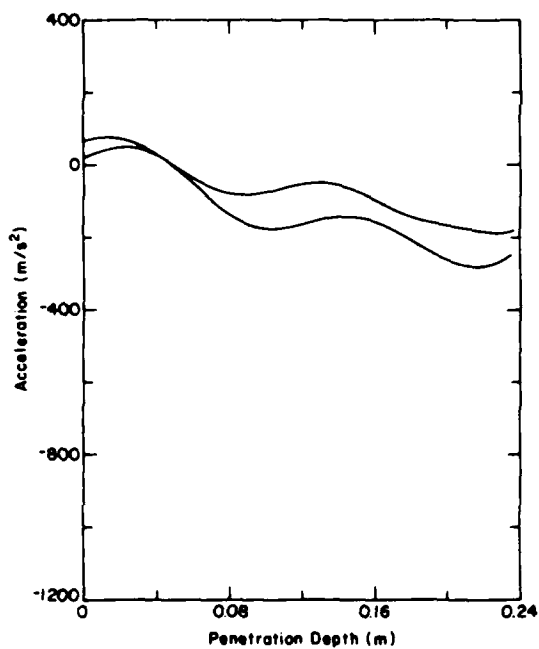
Figure A1 (cont'd). Acceleration vs penetration depth into snow.



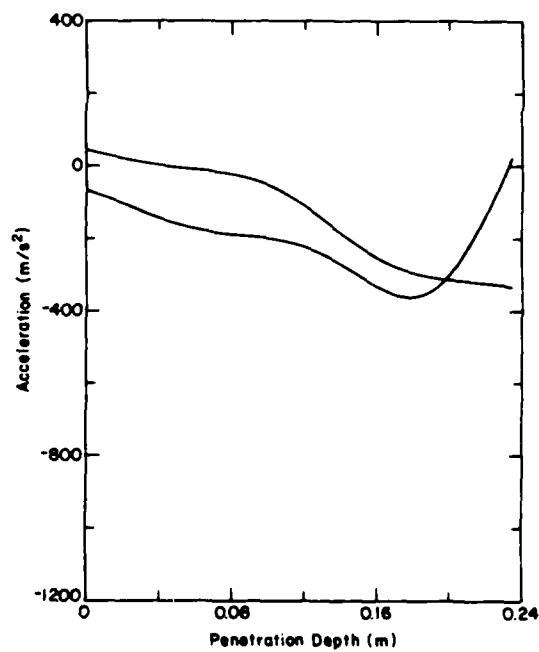
a. Impact velocity 15 m/s (50 ft/s).



b. Impact velocity 31 m/s (100 ft/s).

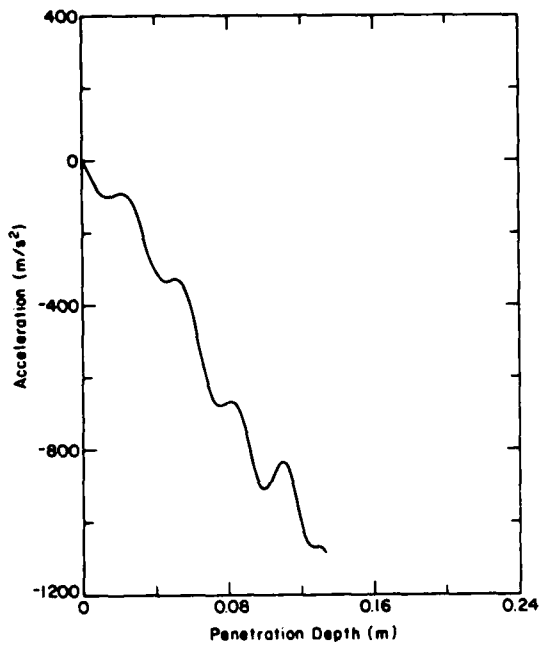


c. Impact velocity 61 m/s (200 ft/s).

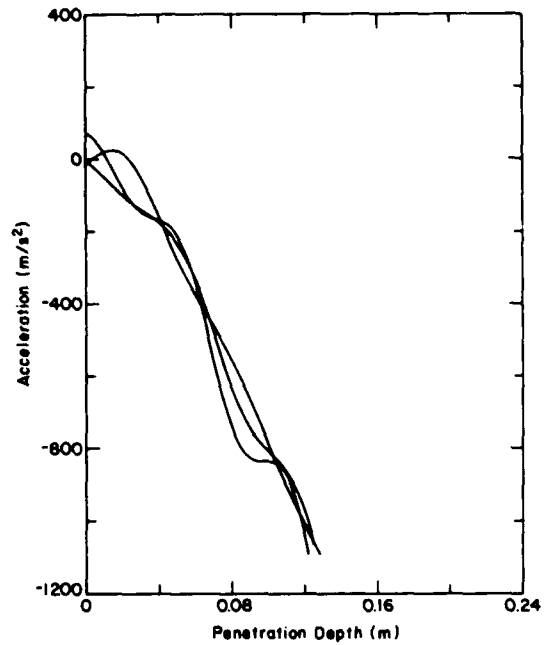


d. Impact velocity 91 m/s (300 ft/s).

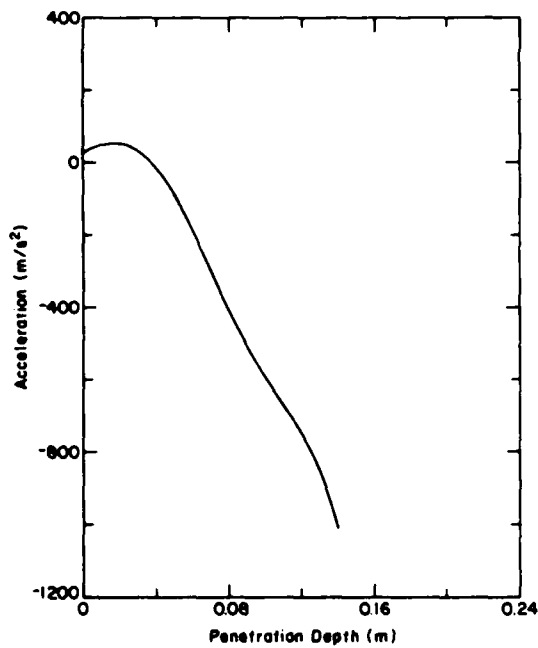
Figure A2. Acceleration vs penetration depth into nylon. Each line corresponds to one of the test impacts listed in Table B1.



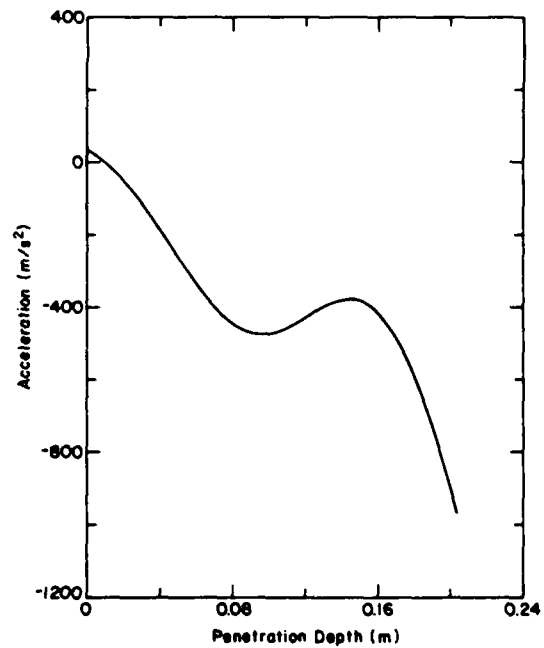
a. Impact velocity 15 m/s (50 ft/s).



b. Impact velocity 31 m/s (100 ft/s).



c. Impact velocity 59 m/s (193 ft/s)



d. Impact velocity 92 m/s (301 ft/s).

Figure A3. Acceleration vs penetration depth into Styrofoam. Each line corresponds to one of the test impacts listed in Table B1.

APPENDIX B. LISTING OF DATA FOR EACH IMPACT

Table B1. Time (TIME), acceleration (ACCEL), velocity (VEL), and penetration depth (DIST) values are listed for each impact. The data are listed in the same order in which the measurements were obtained. For a listing of these impacts by target material and impact velocity see Tables 1, 2, and 3.

TEST NO. 79-01
MATERIAL: STYROFOAM
DENSITY: 0.032 G/CC
IMPACT VELOCITY: 100. FT/S 30.5 M/S
SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 48
LOW PASS FILTER CUTOFF: 1000. HZ
COMMENTS: BAD DATA

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E+00	-0.150000E+02	0.304800E+02	0.000000E+00
0.400000E+00	-0.519510E+02	0.304429E+02	0.121918E-01
0.800000E+00	-0.273223E+03	0.305441E+02	0.243944E-01
0.120000E+01	0.388136E+03	0.306858E+02	0.366388E-01
0.160000E+01	0.118733E+03	0.307978E+02	0.489390E-01
0.200000E+01	-0.197543E+03	0.307735E+02	0.612573E-01
0.240000E+01	-0.143340E+03	0.306944E+02	0.735502E-01
0.280000E+01	0.446518E+02	0.306777E+02	0.858222E-01
0.320000E+01	0.110275E+02	0.307028E+02	0.980982E-01

TEST NO. 79-02
MATERIAL: STYROFOAM
DENSITY: 0.032 G/CC
IMPACT VELOCITY: 100. FT/S 30.5 M/S
SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 80
LOW PASS FILTER CUTOFF: 1000. HZ
COMMENTS:

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E+00	-0.938377E+01	0.304800E+02	0.000000E+00
0.400000E+00	-0.258471E+02	0.304844E+02	0.121924E-01
0.800000E+00	-0.105384E+02	0.304965E+02	0.243978E-01
0.120000E+01	-0.129607E+03	0.304843E+02	0.365803E-01
0.160000E+01	-0.271564E+03	0.303837E+02	0.487516E-01
0.200000E+01	-0.388734E+03	0.302507E+02	0.608800E-01
0.240000E+01	-0.483433E+03	0.300751E+02	0.729463E-01
0.280000E+01	-0.606834E+03	0.298567E+02	0.849341E-01
0.320000E+01	-0.748542E+03	0.295860E+02	0.968244E-01
0.360000E+01	-0.887922E+03	0.292582E+02	0.108595E-00
0.400000E+01	-0.101114E+04	0.288779E+02	0.120224E-00
0.440000E+01	-0.112608E+04	0.284500E+02	0.131691E-00
0.480000E+01	-0.124124E+04	0.279775E+02	0.142977E-00
0.520000E+01	-0.147910E+04	0.274424E+02	0.154264E-00
0.560000E+01	-0.195710E+04	0.267646E+02	0.164915E-00
0.600000E+01	-0.191257E+04	0.259711E+02	0.175458E-00
0.640000E+01	-0.623548E+03	0.253451E+02	0.185717E-00

TEST NO. 79-03
MATERIAL: STYROFOAM
DENSITY: 0.032 G/CC
IMPACT VELOCITY: 100. FT/S 30.5 M/S
SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 84
LOW PASS FILTER CUTOFF: 1000. HZ
COMMENTS:

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E+00	-0.520758E+01	0.304800E+02	0.000000E+00
0.400000E+00	-0.656244E+02	0.304663E+02	0.121900E-01
0.800000E+00	-0.121598E+03	0.304283E+02	0.243696E-01
0.120000E+01	-0.164100E+03	0.303711E+02	0.365300E-01
0.160000E+01	-0.229540E+03	0.302538E+02	0.486638E-01
0.200000E+01	-0.352113E+03	0.301795E+02	0.607600E-01
0.240000E+01	-0.536919E+03	0.300046E+02	0.727980E-01
0.280000E+01	-0.694550E+03	0.297589E+02	0.847517E-01
0.320000E+01	-0.793870E+03	0.294458E+02	0.965985E-01
0.360000E+01	-0.853330E+03	0.291296E+02	0.108317E-00
0.400000E+01	-0.972511E+03	0.287675E+02	0.119898E-00
0.440000E+01	-0.111840E+04	0.283338E+02	0.131321E-00
0.480000E+01	-0.138599E+04	0.278216E+02	0.142556E-00
0.520000E+01	-0.151642E+04	0.272406E+02	0.153570E-00
0.560000E+01	-0.181115E+04	0.265850E+02	0.164339E-00
0.600000E+01	-0.244135E+04	0.257744E+02	0.174812E-00
0.640000E+01	-0.464338E+04	0.247241E+02	0.184909E-00
0.680000E+01	-0.105113E+04	0.239455E+02	0.194633E-00

Table B1 (cont'd).

TEST NO. 79-04
 MATERIAL: STYROFOAM
 DENSITY: 0.032 G/CC
 IMPACT VELOCITY: 193. FT/S 58.8 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 57
 LOW PASS FILTER CUTOFF: 1000. HZ
 COMMENTS: ROUND HIT STEEL.

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	-0.293649E 02	0.588264E 02	0.000000E 00
0.400000E 00	-0.497614E 02	0.588454E 02	0.235000E -01
0.800000E 00	-0.672759E 02	0.588468E 02	0.470739E -01
0.120000E 01	-0.305018E 03	0.587745E 02	0.706011E -01
0.160000E 01	-0.345259E 03	0.586026E 02	0.947795E -01
0.200000E 01	-0.725419E 03	0.583476E 02	0.117472E 00
0.240000E 01	-0.101551E 04	0.580074E 02	0.140374E 00
0.280000E 01	-0.161003E 04	0.574901E 02	0.163653E 00
0.320000E 01	-0.206823E 04	0.567457E 02	0.186704E 00
0.360000E 01	-0.161453E 04	0.559667E 02	0.200239E 00
0.400000E 01	-0.574350E 03	0.555283E 02	0.231524E 00
0.440000E 01	-0.147054E 02	0.554358E 02	0.253710E 00

TEST NO. 79-05
 MATERIAL: STYROFOAM
 DENSITY: 0.032 G/CC
 IMPACT VELOCITY: 301. FT/S 91.7 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 56
 LOW PASS FILTER CUTOFF: 1000. HZ
 COMMENTS: BAD DATA

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	-0.322955E 02	0.174488E 02	0.000000E 00
0.400000E 00	-0.165388E 03	0.172338E 02	0.366062E -01
0.800000E 00	-0.422166E 03	0.160333E 02	0.733344E -01
0.120000E 01	-0.460699E 03	0.141799E 02	0.108964E 00
0.160000E 01	-0.352852E 03	0.125277E 02	0.146502E 00
0.200000E 01	-0.549823E 03	0.106622E 02	0.182069E 00
0.240000E 01	-0.134805E 04	0.067077E 02	0.210102E 00
0.280000E 01	-0.196802E 04	0.499514E 01	0.255464E 00
0.320000E 01	-0.141821E 04	0.179333E 02	0.299129E 00
0.360000E 01	-0.104337E 04	0.885713E 01	0.308536E 00
0.400000E 01	-0.210848E 03	0.883359E 01	0.362297E 00

TEST NO. 79-06
 MATERIAL: SNOW
 DENSITY: 0.410 G/CC
 IMPACT VELOCITY: 93. FT/S 30.2 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 77
 LOW PASS FILTER CUTOFF: 750. HZ
 COMMENTS:

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	-0.314947E 01	0.301752E 01	0.000000E 00
0.400000E 00	-0.418837E 02	0.301663E 01	0.120368E -01
0.800000E 00	-0.767951E 02	0.301423E 01	0.241369E -01
0.120000E 01	-0.103538E 03	0.301081E 01	0.361809E -01
0.160000E 01	-0.138755E 03	0.300583E 01	0.482142E -01
0.200000E 01	-0.195856E 03	0.299920E 01	0.603224E -01
0.240000E 01	-0.262651E 03	0.299000E 01	0.722042E -01
0.280000E 01	-0.313091E 03	0.297842E 01	0.841416E -01
0.320000E 01	-0.338247E 03	0.296533E 01	0.960294E -01
0.360000E 01	-0.356645E 03	0.295114E 01	0.107863E 00
0.400000E 01	-0.398547E 03	0.293647E 01	0.117639E 00
0.440000E 01	-0.483835E 03	0.291846E 01	0.131351E 00
0.480000E 01	-0.596966E 03	0.289734E 01	0.146685E 00
0.520000E 01	-0.555807E 03	0.287119E 01	0.154524E 00
0.560000E 01	-0.540014E 03	0.284731E 01	0.165561E 00
0.600000E 01	-0.242654E 03	0.283189E 01	0.177315E 00
0.640000E 01	-0.797360E 01	0.282711E 01	0.188629E 00

TEST NO. 79-07
 MATERIAL: DRY NYLON
 DENSITY: 0.699 G/CC
 IMPACT VELOCITY: 100. FT/S 30.5 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 43
 LOW PASS FILTER CUTOFF: 750. HZ
 COMMENTS: TARGET SLUMPED.

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	-0.157934E 02	0.304400E 01	0.000000E 00
0.400000E 00	-0.346033E 02	0.304549E 01	0.121001E -01
0.800000E 00	-0.359554E 02	0.304549E 01	0.243749E -01
0.120000E 01	-0.436349E 02	0.304307E 01	0.365139E -01
0.160000E 01	-0.402268E 02	0.304150E 01	0.487254E -01
0.200000E 01	-0.131116E 03	0.303733E 01	0.606489E -01
0.240000E 01	-0.155120E 03	0.303314E 01	0.732214E -01
0.280000E 01	-0.127228E 03	0.302863E 01	0.853355E -01
0.320000E 01	-0.300111E 03	0.302214E 01	0.972255E -01
0.360000E 01	-0.156434E 03	0.301857E 01	0.107790E 00
0.400000E 01	-0.798563E 03	0.301155E 01	0.121337E 00
0.440000E 01	-0.117711E 03	0.301133E 01	0.134431E 00
0.480000E 01	-0.110072E 03	0.300664E 01	0.145467E 00
0.520000E 01	-0.783499E 03	0.300020E 01	0.157465E 00
0.560000E 01	-0.701370E 03	0.299465E 01	0.167445E 00
0.600000E 01	-0.100010E 03	0.298900E 01	0.181455E 00
0.640000E 01	-0.120000E 03	0.298333E 01	0.194463E 00
0.680000E 01	-0.127711E 03	0.297777E 01	0.205492E 00
0.720000E 01	-0.127711E 03	0.297777E 01	0.217492E 00
0.760000E 01	-0.147410E 03	0.297777E 01	0.231512E 00
0.800000E 01	-0.177410E 03	0.297777E 01	0.244537E 00

Table B1 (cont'd).

TEST NO. 79-08
MATERIAL: 540
DENSITY: 0.390 G/CC
IMPACT VELOCITY: 33.0 F/MS 30.2 M/S
SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 74
LOW PASS FILTER CUTOFF: 750. HZ
COMMENTS: NO. ACCEL. M/S**2 VEL. M/S DIST.

[illegible]

TEST NO. 74-20
MATERIAL: 540
DENSITY: 6.345 G/CC
IMPACT VELOCITY: 4.5 F/MS 14.8 M/S
SAMPLING RATE: 10000. Hz NO. OF DATA POINTS: 14
LOW PASS FILTER CUTOFF: 500. Hz
COMMENTS: 10000. Hz 14.8 M/S DIST.

C	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	[	\	]	^	_	`	{		}	~	DEL	ESC	SP	CR	LF	VT	FF	FE	BS	HT	BT	BTB	BT7	BT15	BT31	BT63	BT127	BT255	BT511	BT1023	BT2047	BT4095	BT8191	BT16383	BT32767	BT65535	BT131071	BT262143	BT524287	BT1048575	BT2097151	BT4194303	BT8388607	BT16777215	BT33554431	BT67108863	BT134217727	BT268435455	BT536870911	BT1073741823	BT2147483647	BT4294967295	BT8589934591	BT17179869183	BT34359738367	BT68719476735	BT137438953471	BT274877906943	BT549755813887	BT1099511627775	BT2199023255551	BT4398046511103	BT8796093022207	BT17592186044415	BT35184372088831	BT70368744177663	BT140737480355327	BT281474960710655	BT562949921421311	BT1125899842842623	BT2251799685685247	BT4503599371370495	BT9007198742740991	BT18014397484481983	BT36028794968963967	BT72057589937927935	BT144115179875855871	BT288230359751711743	BT576460719503423487	BT1152921439006846975	BT2305842878013693951	BT4611685756027387903	BT9223371516054775807	BT18446743032109551715	BT36893486064219103431	BT73786972128438206863	BT14757394425687641371	BT29514788851375282743	BT59029577702754565487	BT118059155405509130975	BT236118310811018261951	BT472236621622036523903	BT94447324324407304787	BT188894648648814609555	BT377789297297629211111	BT75557859459525842223	BT1511157191191056844447	BT3022314382382113728895	BT60446287647642274579	BT120892575295285491559	BT241785150590570983119	BT483570301181141966239	BT967140602362283932479	BT193428120472456764955	BT386856240944913529911	BT773712481889827059823	BT1547424963779654119647	BT3094849927559308239295	BT618969985511861647859	BT1237939971037323375919	BT2475879942074646751839	BT4951759884149329303679	BT9903519768298658615359	BT19807039536597317231119	BT39614079073194634462239	BT7922815814638926892459	BT15845639229278853784919	BT31691278458557707569839	BT63382556917115415139679	BT12676513383423083077359	BT25353026766846166154719	BT50706053533692332319439	BT10141210706738466462879	BT20282421413476932925759	BT40564842826953865851519	BT81129685653911731711039	BT16225937137823463542079	BT32451874275646927084159	BT64903748551293854167831	BT12980749102587709356655	BT25961498205175418713311	BT5192299641035483742663	BT10384592882070967485267	BT20769185764141934970535	BT4153837152828386984087	BT83076743056567739681755	BT166153486113135479373511	BT33230697222629495874303	BT66461394445258991756607	BT13292278889051799733215	BT26584557778103598466431	BT53169115556207196932863	BT10633823113241439386727	BT21267646226482878773545	BT42535292452965757547091	BT85070584905971515094183	BT170141169811954303188367	BT3402823396239086063767	BT6805646792478172127535	BT13611293584956344244711	BT27222587169928688489423	BT54445174339857377978847	BT10889034867971555575775	BT2177806973594311115155	BT435561394718862222222	BT871122789437724444444	BT174224578867488888888	BT348449157734977777777	BT696898315469955555555	BT139379663099911111111	BT278759326199822222222	BT557518652399644444444	BT111503730479368888888	BT223007460958737777777	BT446014921917475555555	BT892029843834951111111	BT1784059676669902222222	BT3568119353339804444444	BT713623870667960888888	BT1427247741335921777777	BT2854495482671843555555	BT5708990965343687111111	BT1141798173067377422222	BT228359634613549444444	BT456719269227098888888	BT913438538454197777777	BT182687716890795555555	BT365375433781591111111	BT730750867563182222222	BT1461501735126364444444	BT2923003470252728888888	BT584600694050545777777
---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	---	--	---	---	-----	-----	----	----	----	----	----	----	----	----	----	-----	-----	------	------	------	-------	-------	-------	--------	--------	--------	--------	---------	---------	---------	----------	----------	----------	-----------	-----------	-----------	-----------	------------	------------	------------	-------------	-------------	-------------	--------------	--------------	--------------	--------------	---------------	---------------	---------------	----------------	----------------	----------------	-----------------	-----------------	-----------------	-----------------	------------------	------------------	------------------	-------------------	-------------------	-------------------	--------------------	--------------------	--------------------	--------------------	---------------------	---------------------	---------------------	----------------------	----------------------	----------------------	-----------------------	-----------------------	-----------------------	-----------------------	------------------------	------------------------	------------------------	------------------------	------------------------	------------------------	-------------------------	-------------------------	-------------------------	------------------------	-------------------------	-------------------------	------------------------	--------------------------	--------------------------	------------------------	-------------------------	-------------------------	-------------------------	-------------------------	-------------------------	-------------------------	-------------------------	--------------------------	--------------------------	-------------------------	--------------------------	--------------------------	--------------------------	--------------------------	---------------------------	---------------------------	--------------------------	---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	--------------------------	---------------------------	---------------------------	--------------------------	---------------------------	----------------------------	---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	----------------------------	--------------------------	--------------------------	---------------------------	---------------------------	---------------------------	---------------------------	--------------------------	-------------------------	-------------------------	-------------------------	-------------------------	-------------------------	-------------------------	-------------------------	-------------------------	-------------------------	-------------------------	-------------------------	-------------------------	--------------------------	--------------------------	-------------------------	--------------------------	--------------------------	--------------------------	--------------------------	-------------------------	-------------------------	-------------------------	-------------------------	-------------------------	-------------------------	--------------------------	--------------------------	-------------------------

Table B1 (cont'd).

TEST NO. 79-10

MATERIAL: SNOW

DENSITY: 0.390 G/CC

IMPACT VELOCITY: 51. FT/S

15.5 M/S

SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 132

LOW PASS FILTER CUTOFF: 500. HZ

COMMENTS:

TIME, MS	ACCEL, M/S**2	VFL, M/S	DIST, M
0.000000E+00	-0.067382E+01	0.155448E+02	0.000000E+00
0.400000E+00	-0.223086E+02	0.155394E+02	0.621703E-01
0.800000E+00	-0.420045E+02	0.155265E+02	0.124304E-01
0.120000E+01	-0.616848E+02	0.155058E+02	0.186371E-01
0.160000E+01	-0.803597E+02	0.154773E+02	0.248340E-01
0.200000E+01	-0.988826E+02	0.154415E+02	0.310179E-01
0.240000E+01	-0.118095E+03	0.153981E+02	0.371861E-01
0.280000E+01	-0.137402E+03	0.153470E+02	0.433353E-01
0.320000E+01	-0.155166E+03	0.152864E+02	0.494626E-01
0.360000E+01	-0.170209E+03	0.152232E+02	0.555551E-01
0.400000E+01	-0.182693E+03	0.151526E+02	0.616403E-01
0.440000E+01	-0.193637E+03	0.150773E+02	0.676864E-01
0.480000E+01	-0.203951E+03	0.149977E+02	0.737315E-01
0.520000E+01	-0.214396E+03	0.149141E+02	0.796640E-01
0.560000E+01	-0.225495E+03	0.148261E+02	0.855632E-01
0.600000E+01	-0.237806E+03	0.147355E+02	0.914422E-01
0.640000E+01	-0.250883E+03	0.146357E+02	0.973118E-01
0.680000E+01	-0.262762E+03	0.145329E+02	0.103352E+00
0.720000E+01	-0.270827E+03	0.144261E+02	0.109944E+00
0.760000E+01	-0.273911E+03	0.143170E+02	0.114792E+00
0.800000E+01	-0.274267E+03	0.142073E+02	0.120067E+00
0.840000E+01	-0.277951E+03	0.140971E+02	0.126158E+00
0.880000E+01	-0.282730E+03	0.139834E+02	0.133177E+00
0.920000E+01	-0.289314E+03	0.138667E+02	0.141281E+00
0.960000E+01	-0.296658E+03	0.137234E+02	0.150380E+00
1.000000E+02	-0.304722E+03	0.135710E+02	0.160379E+00
0.103000E+02	-0.313475E+03	0.134151E+02	0.171171E+00
0.104000E+02	-0.318608E+03	0.132734E+02	0.182652E+00
0.108000E+02	-0.314758E+03	0.131292E+02	0.194733E+00
0.112000E+02	-0.187418E+03	0.131692E+02	0.164955E+00
0.116000E+02	-0.542785E+02	0.131219E+02	0.164955E+00

TEST NO. 79-11

MATERIAL: DRY NYLON

DENSITY: 0.390 G/CC

IMPACT VELOCITY: 49. FT/S

14.9 M/S

SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 160

LOW PASS FILTER CUTOFF: 500. HZ

COMMENTS:

TIME, MS	ACCEL, M/S**2	VFL, M/S	DIST, M
0.000000E+00	0.971551E+01	0.149352E+02	0.000000E+00
0.400000E+00	0.694141E+01	0.149366E+02	0.597479E-01
0.800000E+00	0.258602E+01	0.149405E+02	0.119507E-01
0.120000E+01	-0.217133E+01	0.149416E+02	0.179266E-01
0.160000E+01	-0.762351E+01	0.149337E+02	0.239922E-01
0.200000E+01	-0.154959E+02	0.149342E+02	0.298777E-01
0.240000E+01	-0.273386E+02	0.149257E+02	0.358496E-01
0.280000E+01	-0.430349E+02	0.149117E+02	0.418173E-01
0.320000E+01	-0.607778E+02	0.148910E+02	0.477780E-01
0.360000E+01	-0.782133E+02	0.148632E+02	0.537280E-01
0.400000E+01	-0.934647E+02	0.148287E+02	0.596676E-01
0.440000E+01	-0.104990E+03	0.147884E+02	0.655912E-01
0.480000E+01	-0.111150E+03	0.147465E+02	0.714988E-01
0.520000E+01	-0.110625E+03	0.147009E+02	0.773879E-01
0.560000E+01	-0.105290E+03	0.146579E+02	0.832591E-01
0.600000E+01	-0.906876E+02	0.146149E+02	0.891142E-01
0.640000E+01	-0.752728E+02	0.145554E+02	0.949555E-01
0.680000E+01	-0.592240E+02	0.145033E+02	0.100078E+00
0.720000E+01	-0.441328E+02	0.144533E+02	0.106603E+00
0.760000E+01	-0.316601E+02	0.144033E+02	0.113233E+00
0.800000E+01	-0.239187E+02	0.143533E+02	0.120000E+00
0.840000E+01	-0.225356E+02	0.144033E+02	0.126993E+00
0.880000E+01	-0.268653E+02	0.144481E+02	0.135619E+00
0.920000E+01	-0.329301E+02	0.144814E+02	0.144399E+00
0.960000E+01	-0.334047E+02	0.144677E+02	0.152719E+00
0.100000E+02	-0.233660E+02	0.144510E+02	0.160574E+00
0.104000E+02	0.137249E+01	0.144510E+02	0.168454E+00
0.108000E+02	0.314157E+01	0.144510E+02	0.176123E+00
0.112000E+02	0.418141E+01	0.144510E+02	0.183716E+00
0.116000E+02	-0.449523E+01	0.144510E+02	0.191122E+00
0.120000E+02	-0.139820E+01	0.144510E+02	0.198459E+00
0.124000E+02	-0.156462E+01	0.143564E+02	0.205721E+00
0.128000E+02	-0.189687E+01	0.141646E+02	0.212921E+00
0.132000E+02	-0.729670E+01	0.139010E+02	0.220061E+00
0.136000E+02	-0.680914E+01	0.136122E+02	0.227141E+00
0.140000E+02	-0.438673E+01	0.133944E+02	0.234161E+00
0.144000E+02	-0.133505E+01	0.132704E+02	0.241121E+00

Table B1 (cont'd).

TEST NO. 79-12
 MATERIAL: SNOW
 DENSITY: 0.410 G/CC
 IMPACT VELOCITY: 51. FT/S 15.5 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 149
 LOW PASS FILTER CUTOFF: 500. HZ
 COMMENTS:

TIME, MS	ACCEL, M/S**2	VFL, M/S	DIST, M
0.000000E+00	0.876591E+01	0.155448E+02	0.000000E+00
0.400000E+00	0.674983E+01	0.155448E+02	0.621857E-02
0.800000E+00	0.193850E+01	0.155448E+02	0.124382E-01
0.120000E+01	-0.685158E+01	0.155448E+02	0.186580E-01
0.160000E+01	-0.210662E+02	0.155436E+02	0.248767E-01
0.200000E+01	-0.407642E+02	0.155313E+02	0.310919E-01
0.240000E+01	-0.534318E+02	0.155105E+02	0.373006E-01
0.280000E+01	-0.446659E+02	0.154808E+02	0.434991E-01
0.320000E+01	-0.100963E+03	0.154435E+02	0.496841E-01
0.360000E+01	-0.111740E+03	0.154008E+02	0.558531E-01
0.400000E+01	-0.119432E+03	0.153545E+02	0.620042E-01
0.440000E+01	-0.127180E+03	0.153052E+02	0.681362E-01
0.480000E+01	-0.135757E+03	0.152255E+02	0.742478E-01
0.520000E+01	-0.144316E+03	0.151455E+02	0.803378E-01
0.560000E+01	-0.161325E+03	0.151336E+02	0.864035E-01
0.600000E+01	-0.175421E+03	0.150663E+02	0.924535E-01
0.640000E+01	-0.190202E+03	0.149932E+02	0.984537E-01
0.680000E+01	-0.205031E+03	0.149141E+02	0.104433E+00
0.720000E+01	-0.219574E+03	0.148292E+02	0.110386E+00
0.760000E+01	-0.234345E+03	0.147384E+02	0.116300E+00
0.800000E+01	-0.250248E+03	0.146415E+02	0.122176E+00
0.840000E+01	-0.266102E+03	0.145382E+02	0.128012E+00
0.880000E+01	-0.282812E+03	0.144292E+02	0.133806E+00
0.920000E+01	-0.298207E+03	0.143168E+02	0.139555E+00
0.960000E+01	-0.314879E+03	0.142045E+02	0.145259E+00
0.100000E+02	-0.327965E+03	0.140932E+02	0.150918E+00
0.104000E+02	-0.336435E+03	0.139775E+02	0.156533E+00
0.108000E+02	-0.345527E+03	0.138439E+02	0.162098E+00
0.112000E+02	-0.475853E+03	0.136755E+02	0.167603E+00
0.116000E+02	-0.585166E+03	0.134626E+02	0.173032E+00
0.120000E+02	-0.636590E+03	0.132154E+02	0.178368E+00
0.124000E+02	-0.572820E+03	0.129694E+02	0.183694E+00
0.128000E+02	-0.385648E+03	0.127744E+02	0.188751E+00
0.132000E+02	-0.147182E+03	0.126682E+02	0.193836E+00
0.136000E+02	-0.439767E+01	0.126437E+02	0.198897E+00
0.140000E+02	-0.224570E+03	0.148680E+02	0.216763E+00
0.144000E+02	-0.238615E+03	0.147753E+02	0.222692E+00
0.148000E+02	-0.222233E+03	0.146771E+02	0.228582E+00
0.152000E+02	-0.236549E+03	0.145737E+02	0.234432E+00
0.156000E+02	-0.274394E+03	0.144657E+02	0.240240E+00
0.160000E+02	-0.385633E+03	0.143537E+02	0.246004E+00
0.164000E+02	-0.503463E+03	0.142362E+02	0.251722E+00
0.168000E+02	-0.533414E+03	0.141091E+02	0.257392E+00
0.172000E+02	-0.374332E+03	0.139675E+02	0.263007E+00
0.176000E+02	-0.404407E+03	0.138110E+02	0.268563E+00
0.180000E+02	-0.339401E+03	0.136495E+02	0.274055E+00
0.184000E+02	-0.319818E+03	0.135044E+02	0.279485E+00
0.188000E+02	-0.185547E+03	0.134015E+02	0.284864E+00
0.192000E+02	-0.556574E+02	0.133553E+02	0.290213E+00

TEST NO. 79-13
 MATERIAL: WET NYLON
 DENSITY: 0.140 G/CC
 IMPACT VELOCITY: 47 FT/S 14.4 M/S
 SAMPLING RATE: 10000 Hz NO. OF DATA POINTS: 207
 LOW PASS FILTER CUTOFF: 500. HZ
 COMMENTS:

[illegible]

TEST NO. 79114
MATERIAL: STYROFOAM
DENSITY: 0.032 G/CC
IMPACT VELOCITY: 50. FT/S 10. M/S
SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 724
LOW PASS FILTER CUTOFF: 1000. HZ
COMMENTS: BAD DATA

[illegible]

Table B1 (cont'd).

TEST NO. 79-15
 MATERIAL: SNOW
 DENSITY: 0.410 G/CC
 IMPACT VELOCITY: 75. FT/S 22.4 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 94
 LOW PASS FILTER CUTOFF: 700. HZ
 COMMENTS:

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E+00	-0.193406E+02	0.228600E+00	0.000000E+00
0.400000E+00	-0.548129E+02	0.225449E+00	0.914140E+00
0.800000E+00	-0.791779E+02	0.228178E+00	0.182742E+00
0.120000E+01	-0.101765E+03	0.227818E+00	0.273044E+00
0.160000E+01	-0.134025E+03	0.227340E+00	0.364081E+00
0.200000E+01	-0.169172E+03	0.226740E+00	0.455033E+00
0.240000E+01	-0.186736E+03	0.226020E+00	0.544157E+00
0.280000E+01	-0.179354E+03	0.225200E+00	0.636616E+00
0.320000E+01	-0.166483E+03	0.224200E+00	0.726589E+00
0.360000E+01	-0.177852E+03	0.223013E+00	0.816791E+00
0.400000E+01	-0.217178E+03	0.222312E+00	0.905704E+00
0.440000E+01	-0.260645E+03	0.222169E+00	0.994764E+00
0.480000E+01	-0.281730E+03	0.221075E+00	0.108342E+00
0.520000E+01	-0.278111E+03	0.221944E+00	0.117162E+00
0.560000E+01	-0.239051E+03	0.221813E+00	0.125738E+00
0.600000E+01	-0.2346964E+03	0.221756E+00	0.134666E+00
0.640000E+01	-0.451286E+03	0.221506E+00	0.143337E+00
0.680000E+01	-0.534447E+03	0.221347E+00	0.151837E+00
0.720000E+01	-0.484729E+03	0.221187E+00	0.160445E+00
0.760000E+01	-0.526478E+03	0.221033E+00	0.168895E+00
0.800000E+01	-0.405146E+02	0.220974E+00	0.177294E+00

TEST NO. 79-16
 MATERIAL: SNOW
 DENSITY: 0.420 G/CC
 IMPACT VELOCITY: 74. FT/S 22.6 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 94
 LOW PASS FILTER CUTOFF: 700. HZ
 COMMENTS:

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E+00	-0.213408E+02	0.225552E+00	0.000000E+00
0.400000E+00	-0.408042E+02	0.225478E+00	0.902113E+00
0.800000E+00	-0.865927E+02	0.225222E+00	0.180157E+00
0.120000E+01	-0.128008E+03	0.224792E+00	0.273655E+00
0.160000E+01	-0.175577E+03	0.224159E+00	0.360167E+00
0.200000E+01	-0.213881E+03	0.223365E+00	0.449685E+00
0.240000E+01	-0.205701E+03	0.222273E+00	0.538821E+00
0.280000E+01	-0.352111E+03	0.220944E+00	0.627470E+00
0.320000E+01	-0.395633E+03	0.219439E+00	0.715562E+00
0.360000E+01	-0.374134E+03	0.218014E+00	0.803065E+00
0.400000E+01	-0.393146E+03	0.216486E+00	0.889937E+00
0.440000E+01	-0.423678E+03	0.214947E+00	0.976238E+00
0.480000E+01	-0.456728E+03	0.213073E+00	0.106182E+00
0.520000E+01	-0.466514E+03	0.211221E+00	0.114668E+00
0.560000E+01	-0.472538E+03	0.209347E+00	0.123280E+00
0.600000E+01	-0.507204E+03	0.207460E+00	0.131415E+00
0.640000E+01	-0.534571E+03	0.205524E+00	0.139669E+00
0.680000E+01	-0.534571E+03	0.203597E+00	0.147832E+00
0.720000E+01	-0.5300244E+03	0.201682E+00	0.155950E+00
0.760000E+01	-0.525571E+03	0.199779E+00	0.164019E+00
0.800000E+01	-0.289152E+02	0.197847E+00	0.171841E+00

TEST NO. 79-17
 MATERIAL: SNOW
 DENSITY: 0.430 G/CC
 IMPACT VELOCITY: 79. FT/S 24.1 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 93
 LOW PASS FILTER CUTOFF: 700. HZ
 COMMENTS:

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E+00	-0.177900E+02	0.240730E+00	0.000000E+00
0.400000E+00	-0.120700E+02	0.240770E+00	0.966148E+00
0.800000E+00	-0.438412E+02	0.240657E+00	0.192188E+00
0.120000E+01	-0.432477E+02	0.240417E+00	0.288807E+00
0.160000E+01	-0.167911E+03	0.239890E+00	0.384876E+00
0.200000E+01	-0.125550E+03	0.239148E+00	0.481676E+00
0.240000E+01	-0.2257415E+03	0.238121E+00	0.576126E+00
0.280000E+01	-0.2833431E+03	0.237441E+00	0.671161E+00
0.320000E+01	-0.4233940E+03	0.235432E+00	0.765741E+00
0.360000E+01	-0.4773479E+03	0.234446E+00	0.859800E+00
0.400000E+01	-0.4093370E+03	0.232433E+00	0.953264E+00
0.440000E+01	-0.421732E+03	0.231186E+00	0.104680E+00
0.480000E+01	-0.4244141E+03	0.229774E+00	0.113882E+00
0.520000E+01	-0.4435945E+03	0.227778E+00	0.122667E+00
0.560000E+01	-0.4666777E+03	0.225559E+00	0.132044E+00
0.600000E+01	-0.519435E+03	0.222422E+00	0.141844E+00
0.640000E+01	-0.5841210E+03	0.221018E+00	0.149967E+00
0.680000E+01	-0.555255E+03	0.219441E+00	0.154787E+00
0.720000E+01	-0.495225E+03	0.217277E+00	0.167520E+00
0.760000E+01	-0.4922587E+03	0.215514E+00	0.176180E+00
0.800000E+01	-0.155554E+02	0.215477E+00	0.184407E+00

Table B1 (cont'd).

TEST NO. 79-18
 MATERIAL: SNOW
 DENSITY: 0.440 G/CC
 IMPACT VELOCITY: 99. FT/S 30.2 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 74
 LOW PASS FILTER CUTOFF: 750. HZ
 COMMENTS:

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	0.381434E 02	0.301752E 02	0.000000E 00
0.400000E 00	-0.222875E 02	0.301802E 02	0.120718E -01
0.800000E 00	-0.121506E 03	0.301518E 02	0.241395E -01
0.120000E 01	-0.203859E 03	0.300855E 02	0.361880E -01
0.160000E 01	-0.242405E 03	0.299950E 02	0.482045E -01
0.200000E 01	-0.265647E 03	0.298937E 02	0.601825E -01
0.240000E 01	-0.313722E 03	0.297789E 02	0.721176E -01
0.280000E 01	-0.365074E 03	0.296393E 02	0.840021E -01
0.320000E 01	-0.444839E 03	0.294725E 02	0.958252E -01
0.360000E 01	-0.482747E 03	0.292867E 02	0.107577E 00
0.400000E 01	-0.540467E 03	0.290836E 02	0.119252E 00
0.440000E 01	-0.654427E 03	0.286461E 02	0.130939E 00
0.480000E 01	-0.760830E 03	0.285606E 02	0.142322E 00
0.520000E 01	-0.698192E 03	0.282610E 02	0.153686E 00
0.560000E 01	-0.387827E 03	0.280374E 02	0.164941E 00
0.600000E 01	-0.452421E 02	0.279564E 02	0.176136E 00

TEST NO. 79-19
 MATERIAL: WET FROZEN NYLON
 DENSITY: 0.170 G/CC
 IMPACT VELOCITY: 100. FT/S 30.5 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 79
 LOW PASS FILTER CUTOFF: 750. HZ
 COMMENTS: TARGET MAY HAVE SLUMPED.

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	0.152274E 02	0.304830E 02	0.000000E 00
0.400000E 00	0.259999E 01	0.304844E 02	0.121931E -01
0.800000E 00	-0.432410E 02	0.304773E 02	0.243861E -01
0.120000E 01	-0.895730E 02	0.304502E 02	0.365722E -01
0.160000E 01	-0.109158E 03	0.304395E 02	0.487443E -01
0.200000E 01	-0.112926E 03	0.303651E 02	0.608993E -01
0.240000E 01	-0.130339E 03	0.303172E 02	0.730359E -01
0.280000E 01	-0.166018E 03	0.302582E 02	0.851514E -01
0.320000E 01	-0.184648E 03	0.301861E 02	0.972405E -01
0.360000E 01	-0.175007E 03	0.301119E 02	0.109300E 00
0.400000E 01	-0.135237E 03	0.300436E 02	0.121332E 00
0.440000E 01	-0.111237E 03	0.300014E 02	0.133341E 00
0.480000E 01	-0.128903E 03	0.299547E 02	0.145333E 00
0.520000E 01	-0.170136E 03	0.298949E 02	0.157303E 00
0.560000E 01	-0.181938E 03	0.298227E 02	0.169247E 00
0.600000E 01	-0.123929E 03	0.297592E 02	0.181162E 00
0.640000E 01	-0.287606E 02	0.297290E 02	0.193059E 00

TEST NO. 79-20
 MATERIAL: WET NYLON
 DENSITY: 0.160 G/CC
 IMPACT VELOCITY: 98. FT/S 29.9 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 138
 LOW PASS FILTER CUTOFF: 750. HZ
 COMMENTS: ACCELEROMETER DAMAGED.

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	0.816523E 01	0.298704E 02	0.000000E 00
0.400000E 00	0.727323E 01	0.298745E 02	0.119490E -01
0.800000E 00	-0.185655E 02	0.298726E 02	0.238987E -01
0.120000E 01	-0.354840E 02	0.298609E 02	0.358456E -01
0.160000E 01	-0.190331E 02	0.298490E 02	0.477873E -01
0.200000E 01	0.111339E 02	0.298477E 02	0.597262E -01
0.240000E 01	0.134837E 02	0.298539E 02	0.716665E -01
0.280000E 01	-0.247448E 02	0.298526E 02	0.836083E -01
0.320000E 01	-0.739374E 02	0.298326E 02	0.955459E -01
0.360000E 01	-0.100883E 03	0.297967E 02	0.107472E 00
0.400000E 01	-0.108355E 03	0.297547E 02	0.119382E 00
0.440000E 01	-0.125878E 03	0.297085E 02	0.131275E 00
0.480000E 01	-0.166264E 03	0.296506E 02	0.143147E 00
0.520000E 01	-0.205302E 03	0.295757E 02	0.154993E 00
0.560000E 01	-0.210691E 03	0.294912E 02	0.166807E 00
0.600000E 01	-0.182543E 03	0.294119E 02	0.178587E 00
0.640000E 01	-0.153500E 03	0.293345E 02	0.190338E 00
0.680000E 01	-0.148544E 03	0.292856E 02	0.202064E 00
0.720000E 01	-0.155653E 03	0.292246E 02	0.213766E 00
0.760000E 01	-0.146015E 03	0.291635E 02	0.225443E 00
0.800000E 01	-0.120064E 03	0.291102E 02	0.237097E 00
0.840000E 01	-0.114287E 03	0.290645E 02	0.248732E 00
0.880000E 01	-0.143896E 03	0.290135E 02	0.260348E 00
0.920000E 01	-0.155807E 03	0.289518E 02	0.271941E 00
0.960000E 01	-0.935844E 02	0.288936E 02	0.283511E 00
1.000000E 01	-0.245935E 02	0.288784E 02	0.295065E 00
1.040000E 01	-0.129005E 03	0.288556E 02	0.306613E 00
1.080000E 01	-0.498135E 03	0.287397E 02	0.318137E 00
1.120000E 01	-0.972333E 03	0.284645E 02	0.329582E 00
1.160000E 01	-0.940949E 03	0.283087E 02	0.340893E 00
1.200000E 01	-0.551770E 03	0.277769E 02	0.352761E 00
1.240000E 01	-0.654801E 02	0.276608E 02	0.363142E 00

Table B1 (cont'd).

TEST NO. 79-21
 MATERIAL: SNOW
 DENSITY: 0.430 G/CC
 IMPACT VELOCITY: 149. FT/S 45.4 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 55
 LOW PASS FILTER CUTOFF: 1000. HZ

COMMENTS:

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	-0.305529E 02	0.454152E 02	0.000000E 00
0.400000E 00	-0.774267E 02	0.453933E 02	0.181623E -01
0.800000E 00	-0.126744E 03	0.453630E 02	0.363121E -01
0.120000E 01	-0.212356E 03	0.452868E 02	0.544411E -01
0.160000E 01	-0.344443E 03	0.451763E 02	0.725353E -01
0.200000E 01	-0.462564E 03	0.450130E 02	0.905746E -01
0.240000E 01	-0.503293E 03	0.448176E 02	0.108541E -00
0.280000E 01	-0.536259E 03	0.446116E 02	0.126427E -00
0.320000E 01	-0.638227E 03	0.443770E 02	0.144226E 00
0.360000E 01	-0.572610E 03	0.441237E 02	0.161926E 00
0.400000E 01	-0.165121E 03	0.439703E 02	0.179539E 00

TEST NO. 79-22
 MATERIAL: SNOW
 DENSITY: 0.410 G/CC
 IMPACT VELOCITY: 200. FT/S 61.0 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 51
 LOW PASS FILTER CUTOFF: 1000. HZ

COMMENTS:

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	0.759347E 02	0.609600E 02	0.000000E 00
0.400000E 00	0.150845E 03	0.610066E 02	0.243923E -01
0.800000E 00	0.101811E 03	0.610633E 02	0.488069E -01
0.120000E 01	-0.129151E 03	0.610617E 02	0.732348E -01
0.160000E 01	-0.368814E 03	0.609594E 02	0.976419E -01
0.200000E 01	-0.553839E 03	0.607754E 02	0.121991E -00
0.240000E 01	-0.814264E 03	0.605042E 02	0.146250E -00
0.280000E 01	-0.979653E 03	0.601358E 02	0.170380E 00
0.320000E 01	-0.700633E 03	0.597844E 02	0.194361E 00
0.360000E 01	-0.161511E 03	0.596135E 02	0.218233E 00

TEST NO. 79-23
 MATERIAL: SNOW
 DENSITY: 0.430 G/CC
 IMPACT VELOCITY: 250. FT/S 76.2 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 42
 LOW PASS FILTER CUTOFF: 1000. HZ

COMMENTS:

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	0.151524E 03	0.762000E 02	0.000000E 00
0.400000E 00	0.172565E 03	0.762669E 02	0.304930E -01
0.800000E 00	-0.277049E 02	0.763063E 02	0.610101E -01
0.120000E 01	-0.488997E 03	0.762071E 02	0.915186E -01
0.160000E 01	-0.922309E 03	0.759195E 02	0.119499E -00
0.200000E 01	-0.108244E 04	0.755064E 02	0.152236E 00
0.240000E 01	-0.739712E 03	0.751241E 02	0.182358E 00
0.280000E 01	-0.994543E 02	0.749608E 02	0.212367E 00

TEST NO. 79-24
 MATERIAL: SNOW
 DENSITY: 0.410 G/CC
 IMPACT VELOCITY: 149. FT/S 45.4 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 59
 LOW PASS FILTER CUTOFF: 1000. HZ

COMMENTS:

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	-0.117074E 02	0.454152E 02	0.000000E 00
0.400000E 00	-0.852575E 02	0.453967E 02	0.181633E -01
0.800000E 00	-0.181593E 03	0.453436E 02	0.363125E -01
0.120000E 01	-0.270734E 03	0.452527E 02	0.544329E -01
0.160000E 01	-0.365285E 03	0.451264E 02	0.725098E -01
0.200000E 01	-0.497431E 03	0.449547E 02	0.905276E -01
0.240000E 01	-0.617670E 03	0.447311E 02	0.108466E -00
0.280000E 01	-0.695506E 03	0.444674E 02	0.126386E 00
0.320000E 01	-0.852137E 03	0.441627E 02	0.144034E 00
0.360000E 01	-0.109258E 04	0.437716E 02	0.161624E 00
0.400000E 01	-0.961125E 03	0.433404E 02	0.179045E 00
0.440000E 01	-0.268050E 03	0.430866E 02	0.196321E 00

Table B1 (cont'd).

TEST NO. 79-25

MATERIAL: SNOW
 DENSITY: 0.420 G/CC
 IMPACT VELOCITY: 199. FT/S 60.7 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 51
 LOW PASS FILTER CUTOFF: 1000. HZ

COMMENTS:

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	-0.350527E 02	0.606552E 02	0.000000E 00
0.400000E 00	-0.148743E 03	0.606197E 02	0.242564E -01
0.800000E 00	-0.282413E 03	0.605373E 02	0.484886E -01
0.120000E 01	-0.399702E 03	0.603964E 02	0.726759E -01
0.160000E 01	-0.529365E 03	0.602119E 02	0.967992E -01
0.200000E 01	-0.738244E 03	0.599620E 02	0.120836E 00
0.240000E 01	-0.107968E 04	0.596723E 02	0.144754E 00
0.280000E 01	-0.139572E 04	0.590995E 02	0.168498E 00
0.320000E 01	-0.116138E 04	0.585630E 02	0.192027E 00
0.360000E 01	-0.309811E 03	0.582623E 02	0.215381E 00

TEST NO. 79-26

MATERIAL: SNOW
 DENSITY: 0.400 G/CC
 IMPACT VELOCITY: 201. FT/S 61.3 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 44
 LOW PASS FILTER CUTOFF: 1000. HZ
 COMMENTS: TARGET TIPPED 10-15 DEGREES FROM VERTICAL.

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	0.979033E 02	0.612648E 02	0.000000E 00
0.400000E 00	0.489557E 03	0.613726E 02	0.245225E -01
0.800000E 00	0.822622E 03	0.616499E 02	0.491226E -01
0.120000E 01	0.412450E 03	0.619239E 02	0.738425E -01
0.160000E 01	-0.546374E 03	0.619309E 02	0.986195E -01
0.200000E 01	-0.115454E 04	0.615378E 02	0.123315E 00
0.240000E 01	-0.445232E 03	0.610437E 02	0.147838E 00
0.280000E 01	-0.306593E 03	0.609416E 02	0.172217E 00

TEST NO. 79-27

MATERIAL: SNOW
 DENSITY: 0.400 G/CC
 IMPACT VELOCITY: 204. FT/S 89.6 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 40
 LOW PASS FILTER CUTOFF: 1000. HZ
 COMMENTS: LOST IN SCREEN.

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	0.374769E 02	0.896112E 02	0.000000E 00
0.400000E 00	-0.634643E 03	0.896261E 02	0.358478E -01
0.800000E 00	-0.348197E 03	0.895663E 02	0.716906E -01
0.120000E 01	-0.460962E 03	0.893735E 02	0.107475E 00
0.160000E 01	-0.112205E 04	0.869128E 02	0.143125E 00
0.200000E 01	-0.868007E 03	0.884986E 02	0.178604E 00
0.240000E 01	-0.291319E 03	0.882646E 02	0.213950E 00

TEST NO. 79-28

MATERIAL: SNOW
 DENSITY: 0.420 G/CC
 IMPACT VELOCITY: 301. FT/S 91.7 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 42
 LOW PASS FILTER CUTOFF: 1000. HZ

COMMENTS:

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	-0.104738E 03	0.917448E 02	0.000000E 00
0.400000E 00	0.252536E 03	0.917550E 02	0.366955E -01
0.800000E 00	0.101440E 04	0.920388E 02	0.734384E -01
0.120000E 01	0.114970E 04	0.924811E 02	0.110335E 00
0.160000E 01	0.106259E 03	0.927574E 02	0.147395E 00
0.200000E 01	-0.486224E 03	0.925775E 02	0.184475E 00
0.240000E 01	-0.692400E 03	0.922335E 02	0.221434E 00
0.280000E 01	-0.445479E 02	0.920652E 02	0.258290E 00

Table B1 (cont'd).

TEST NO. 79-29
 MATERIAL: WET NYLON
 DENSITY: 0.180 G/CC
 IMPACT VELOCITY: 195. FT/S
 SAMPLING RATE: 10000. HZ
 LOW PASS FILTER CUTOFF: 1000. HZ
 NO. OF DATA POINTS: 76
 COMMENTS:

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	0.225173E 02	0.594367E 02	0.000000E 00
0.400000E 00	0.494291E 02	0.594523E 02	0.237773E -01
0.800000E 00	-0.193792E 01	0.594644E 02	0.475612E -01
0.120000E 01	-0.104921E 03	0.594433E 02	0.713440E -01
0.160000E 01	-0.172712E 03	0.593855E 02	0.951106E -01
0.200000E 01	-0.167413E 03	0.593156E 02	0.118851E 00
0.240000E 01	-0.143981E 03	0.592540E 02	0.142564E 00
0.280000E 01	-0.168325E 03	0.591935E 02	0.166254E 00
0.320000E 01	-0.235364E 03	0.591132E 02	0.189916E 00
0.360000E 01	-0.283039E 03	0.590078E 02	0.213541E 00
0.400000E 01	-0.251221E 03	0.589979E 02	0.237121E 00
0.440000E 01	-0.151379E 03	0.588170E 02	0.260663E 00
0.480000E 01	-0.166170E 03	0.587614E 02	0.284179E 00
0.520000E 01	-0.475651E 03	0.586438E 02	0.307663E 00
0.560000E 01	-0.726337E 03	0.583872E 02	0.331072E 00
0.600000E 01	-0.368937E 03	0.581492E 02	0.354374E 00

TEST NO. 79-30
 MATERIAL: DRY NYLON
 DENSITY: 0.090 G/CC
 IMPACT VELOCITY: 201. FT/S
 SAMPLING RATE: 10000. HZ
 LOW PASS FILTER CUTOFF: 1000. HZ
 NO. OF DATA POINTS: 67
 COMMENTS:

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	0.706373E 02	0.612648E 02	0.000000E 00
0.400000E 00	0.661668E 02	0.612945E 02	0.245119E -01
0.800000E 00	-0.297242E 01	0.613084E 02	0.490333E -01
0.120000E 01	-0.713204E 02	0.612922E 02	0.735542E -01
0.160000E 01	-0.183233E 02	0.612602E 02	0.980647E -01
0.200000E 01	-0.520065E 02	0.612344E 02	0.122563E 00
0.240000E 01	-0.669717E 02	0.612125E 02	0.147053E 00
0.280000E 01	-0.125247E 03	0.611744E 02	0.171531E 00
0.320000E 01	-0.165239E 03	0.611152E 02	0.195989E 00
0.360000E 01	-0.186110E 03	0.610448E 02	0.220421E 00
0.400000E 01	-0.168826E 03	0.609707E 02	0.244824E 00
0.440000E 01	0.141923E 02	0.609339E 02	0.269203E 00
0.480000E 01	0.215312E 03	0.608861E 02	0.293584E 00
0.520000E 01	0.956675E 02	0.610580E 02	0.317994E 00

TEST NO. 79-31
 MATERIAL: DRY NYLON
 DENSITY: 0.180 G/CC
 IMPACT VELOCITY: 299. FT/S
 SAMPLING RATE: 10000. HZ
 LOW PASS FILTER CUTOFF: 1000. HZ
 NO. OF DATA POINTS: 43
 COMMENTS: ACCELEROMETER DAMAGED.

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	-0.629311E 02	0.911352E 02	0.000000E 00
0.400000E 00	-0.136034E 03	0.910955E 02	0.364470E -01
0.800000E 00	-0.183156E 03	0.910301E 02	0.728727E -01
0.120000E 01	-0.204776E 03	0.909530E 02	0.109269E 00
0.160000E 01	-0.286802E 03	0.908572E 02	0.145632E 00
0.200000E 01	-0.362808E 03	0.907230E 02	0.181049E 00
0.240000E 01	-0.169307E 03	0.906056E 02	0.218213E 00
0.280000E 01	0.191964E 03	0.906134E 02	0.254452E 00
0.320000E 01	0.180946E 03	0.907041E 02	0.290715E 00

TEST NO. 79-32
 MATERIAL: WET NYLON
 DENSITY: 0.150 G/CC
 IMPACT VELOCITY: 287. FT/S
 SAMPLING RATE: 10000. HZ
 LOW PASS FILTER CUTOFF: 1000. HZ
 NO. OF DATA POINTS: 57
 COMMENTS: TARGET SLUMPED.

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	0.480433E 02	0.874776E 02	0.000000E 00
0.400000E 00	0.865005E 01	0.874887E 02	0.349937E -01
0.800000E 00	-0.117602E 02	0.874876E 02	0.699892E -01
0.120000E 01	-0.609461E 02	0.874753E 02	0.104082E 00
0.160000E 01	-0.181200E 03	0.874743E 02	0.139964E 00
0.200000E 01	-0.296230E 03	0.873325E 02	0.174318E 00
0.240000E 01	-0.316939E 03	0.872049E 02	0.209827E 00
0.280000E 01	-0.341577E 03	0.870743E 02	0.244687E 00
0.320000E 01	-0.353831E 03	0.869375E 02	0.279488E 00
0.360000E 01	-0.271614E 03	0.868087E 02	0.314236E 00
0.400000E 01	-0.109386E 03	0.867317E 02	0.348042E 00
0.440000E 01	-0.324481E 01	0.867134E 02	0.383629E 00

Table B1 (cont'd).

TEST NO. 79-33
 MATERIAL: STYROFOAM
 DENSITY: 0.032 G/CC
 IMPACT VELOCITY: 93. FI/S 28.3 M/S
 SAMPLING RATE: 10000. HZ NO. OF DATA POINTS: 97
 LOW PASS FILTER CUTOFF: 1000. HZ
 COMMENTS: BAD DATA

TIME, MS	ACCEL, M/S**2	VEL, M/S	DIST, M
0.000000E 00	0.732338E 02	0.283464E 02	0.000000E 00
0.400000E 00	-0.295971E 01	0.283603E 02	0.113428E -01
0.800000E 00	-0.107036E 03	0.283401E 02	0.226847E -01
0.120000E 01	-0.159058E 03	0.282844E 02	0.340103E -01
0.160000E 01	-0.186944E 03	0.282165E 02	0.453109E -01
0.200000E 01	-0.294211E 03	0.281241E 02	0.565803E -01
0.240000E 01	-0.509040E 03	0.279657E 02	0.678010E -01
0.280000E 01	-0.725554E 03	0.277166E 02	0.789401E -01
0.320000E 01	-0.830095E 03	0.274013E 02	0.899649E -01
0.360000E 01	-0.839270E 03	0.270651E 02	0.100858E 00
0.400000E 01	-0.892607E 03	0.267237E 02	0.111617E 00
0.440000E 01	-0.109915E 04	0.263298E 02	0.122230E 00
0.480000E 01	-0.131975E 04	0.258412E 02	0.132667E 00
0.520000E 01	-0.120750E 04	0.253210E 02	0.142898E 00
0.560000E 01	-0.672621E 03	0.249358E 02	0.152943E 00
0.600000E 01	-0.105044E 03	0.247872E 02	0.162880E 00
0.640000E 01	0.127857E 03	0.248035E 02	0.172795E 00
0.680000E 01	0.735431E 02	0.248436E 02	0.182727E 00
0.720000E 01	-0.103110E 03	0.248460E 02	0.192668E 00
0.760000E 01	-0.274535E 03	0.247669E 02	0.202593E 00
0.800000E 01	-0.212049E 03	0.246599E 02	0.212477E 00
0.840000E 01	-0.891428E 01	0.246148E 02	0.222330E 00

Table B2 (cont'd).

SNOW 150 FPS		2 TESTS				
TIME, MS		ACCEL, M/S**2	VEL, M/S		DIST, M	
0.000000E 00	00	-0.211342E 02	0.454152E 02	02	0.000000E 00	00
0.400000E 00	00	-0.613421E 02	0.453950E 02	02	0.181628E -01	-01
0.800000E 00	00	-0.154169E 03	0.453483E 02	02	0.363123E -01	-01
0.120000E 01	01	-0.241546E 03	0.452697E 02	02	0.544570E -01	-01
0.160000E 01	01	-0.354864E 03	0.451513E 02	02	0.725225E -01	-01
0.200000E 01	01	-0.480008E 03	0.449838E 02	02	0.905511E -01	-01
0.240000E 01	01	-0.560402E 03	0.447738E 02	02	0.108503E -00	-00
0.280000E 01	01	-0.615943E 03	0.445395E 02	02	0.126366E 00	00
0.320000E 01	01	-0.745167E 03	0.442698E 02	02	0.144130E 00	00
0.360000E 01	01	-0.832645E 03	0.439476E 02	02	0.161175E 00	00
0.400000E 01	01	-0.563123E 03	0.436553E 02	02	0.179292E 00	00

SNOW 200 FPS		2 TESTS				
TIME, MS		ACCEL, M/S**2	VEL, M/S		DIST, M	
0.000000E 00	00	0.204410E 02	0.608076E 02	02	0.000000E 00	00
0.400000E 00	00	0.105098E 01	0.608131E 02	02	0.243243E -01	-01
0.800000E 00	00	-0.303018E 02	0.607983E 02	02	0.486477E -01	-01
0.120000E 01	01	-0.264432E 03	0.607290E 02	02	0.729553E -01	-01
0.160000E 01	01	-0.449040E 03	0.605856E 02	02	0.972205E -01	-01
0.200000E 01	01	-0.646042E 03	0.603687E 02	02	0.121413E -00	-00
0.240000E 01	01	-0.946972E 03	0.600532E 02	02	0.145502E 00	00

NYLON 100 FPS		3 TESTS				
TIME, MS		ACCEL, M/S**2	VEL, M/S		DIST, M	
0.000000E 00	00	0.256408E 01	0.302768E 02	02	0.000000E 00	00
0.400000E 00	00	-0.821003E 01	0.302762E 02	02	0.121107E -01	-01
0.800000E 00	00	-0.325873E 02	0.302683E 02	02	0.242199E -01	-01
0.120000E 01	01	-0.562306E 02	0.302503E 02	02	0.363239E -01	-01
0.160000E 01	01	-0.694715E 02	0.302248E 02	02	0.484190E -01	-01
0.200000E 01	01	-0.777337E 02	0.301454E 02	02	0.605031E -01	-01
0.240000E 01	01	-0.906585E 02	0.301619E 02	02	0.725747E -01	-01
0.280000E 01	01	-0.106697E 03	0.301224E 02	02	0.846317E -01	-01
0.320000E 01	01	-0.115532E 03	0.300776E 02	02	0.966718E -01	-01
0.360000E 01	01	-0.113843E 03	0.300314E 02	02	0.108694E 00	00
0.400000E 01	01	-0.111149E 03	0.299866E 02	02	0.120697E 00	00
0.440000E 01	01	-0.111827E 03	0.299411E 02	02	0.132682E 00	00
0.480000E 01	01	-0.135880E 03	0.298906E 02	02	0.144649E 00	00
0.520000E 01	01	-0.151260E 03	0.298331E 02	02	0.156594E 00	00
0.560000E 01	01	-0.154254E 03	0.297714E 02	02	0.168515E 00	00
0.600000E 01	01	-0.135821E 03	0.297127E 02	02	0.180411E 00	00
0.640000E 01	01	-0.101421E 03	0.296650E 02	02	0.192287E 00	00

STYROFOAM 100 FPS		3 TESTS				
TIME, MS		ACCEL, M/S**2	VEL, M/S		DIST, M	
0.000000E 00	00	0.195465E 02	0.297688E 02	02	0.000000E 00	00
0.400000E 00	00	-0.142457E 02	0.297712E 02	02	0.119084E -01	-01
0.800000E 00	00	-0.796408E 02	0.297530E 02	02	0.238140E -01	-01
0.120000E 01	01	-0.150732E 03	0.297068E 02	02	0.357069E -01	-01
0.160000E 01	01	-0.229349E 03	0.296313E 02	02	0.475754E -01	-01
0.200000E 01	01	-0.345043E 03	0.295181E 02	02	0.594068E -01	-01
0.240000E 01	01	-0.508481E 03	0.293485E 02	02	0.711821E -01	-01
0.280000E 01	01	-0.675659E 03	0.291107E 02	02	0.828760E -01	-01
0.320000E 01	01	-0.790435E 03	0.288154E 02	02	0.944625E -01	-01
0.360000E 01	01	-0.866231E 03	0.284846E 02	02	0.105923E 00	00
0.400000E 01	01	-0.950133E 03	0.281230E 02	02	0.117246E 00	00

A facsimile catalog card in Library of Congress MARC format is reproduced below.

Albert, Donald G.

Deceleration of projectiles in snow / by Donald G. Albert and Paul W. Richmond III. Hanover, N.H.: U.S. Cold Regions Research and Engineering Laboratory; Springfield, Va.: available from National Technical Information Service, 1982.

iii, 34 p., illus.; 28 cm. (CRREL Report 82-20.)

Prepared for Office of the Chief of Engineers by Corps of Engineers, U.S. Army Cold Regions Research and Engineering Laboratory under DA Project 4A762730 AT42.

Bibliography: p. 9.

1. Centrifuge. 2. Mortars. 3. Mortar shells.
4. Nylon. 5. Penetration. 6. Penetration tests.
7. Projectiles. 8. Snow. 9. Styrofoam.

Albert, Donald G.

Deceleration of projectiles in snow.
1982.

(Card 2)

I. Richmond, Paul W., III. II. United States. Army. Corps of Engineers. III. Army Cold Regions Research and Engineering Laboratory, Hanover, N.H. IV. Series: CRREL Report 82-20.

