MAR 1 1968

SC-DR-67-3003
February 1968

Development Report

NORMAL AND ABNORMAL ENVIRONMENTS
EXPERIENCED BY CARGO ON A
FLATBED TRUCK

MASTER

J. T. Foley, 1541
Sandia Laboratory, Albuquerque

SANDIA LABORATORIES

OPERATED FOR THE UNITED STATES ATOMIC ENERGY COMMISSION BY SANDIA CORPORATION | ALBUQUERQUE, NEW MEXICO; LIVERMORE, CALIFORNIA

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Issued by Sandia Corporation,
a prime contractor to the
United States Atomic Energy Commission

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

SC-DR-67-3003

NORMAL AND ABNORMAL ENVIRONMENTS EXPERIENCED BY CARGO
ON A FLATBED TRUCK

J. T. Foley, 1541
Sandia Laboratory, Albuquerque

February 1968

Approved by:

P. J. Jones 1/17/68
for T. B. Lane, 1540

ABSTRACT

The Environmental Data Analysis (EDA) group at Sandia Corporation was invited by Beech Aircraft personnel to accompany them on an over-the-road test of a flatbed truck. Environmental measurements obtained by the EDA group are presented.

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

TABLE OF CONTENTS

	<u>Page</u>
Introduction	5
Background	5
Test Procedures	6
Data Reduction	10
Data Analyses	10
Normal Environments	10
Long-Duration Phenomena	10
Transient Phenomena	10
Abnormal Environments	11
Long-Duration Phenomena	11
Transient Phenomena	11
Conclusions	13
Recommendations	14
List of References	15
Appendix A - Normal Conditions	17
Appendix B - Abnormal Conditions	29

LIST OF ILLUSTRATIONS

Figure

1.	Truck Used in Tests	6
2.	Load in Truck Tests	6
3.	Beech Instrumentation	7
4.	ELI 31 Sampler on Truck Bed	7
5.	Pickup Location on Truck Bed to Rear of Load	7
6.	Loading Dock and Railroad Track Employed in Tests	9
7.	Dirt Road and Desert Brush in Area Where Tests Were Conducted	9
8.	Typical Cattle Guard Over Which Environments Were Sampled	9

10

11

12

13

14

15

16

NORMAL AND ABNORMAL ENVIRONMENTS EXPERIENCED BY CARGO ON A FLATBED TRUCK

Introduction

This report categorizes and presents the data samples taken at the input-to-cargo interface by Sandia during Beech Aircraft truck tests. The potential effects of these environments on general cargo are discussed. Data presented in this report will be placed in the Sandia Corporation Environmental Data Bank.

Background

Beech Aircraft Corporation, Boulder, Colorado, was engaged in determining the dynamic environment experienced by a Dewar flask during shipment of the flask from Amarillo, Texas, to White Sands Proving Ground, New Mexico.

During its search for background data on truck transport dynamic environment, Beech learned of the existence of the Sandia Corporation Environmental Data Bank through a paper on Preliminary Analysis of Truck Transport Environment presented at a DOD Shock and Vibration Symposium.¹

Mr. H. R. Williamson, Chief of Engineering-Testing at Beech, visited the EDA group at Sandia and, during his visits to the Sandia Environmental Data Bank to obtain descriptive data concerning the dynamic environment experienced by cargo in over-the-road transport, saw the ELI 31 portable environmental sampler.

Since Beech was planning an over-the-road evaluation of the environment experienced by its Dewar flask mount, Mr. Williamson invited us to accompany Beech personnel on the test and to take our recorder and sample the environments experienced during their tests. We felt this would be an opportunity to extend our data on truck transport environmental phenomena for the Sandia Corporation Environmental Data Bank.²

In return for this invitation, the EDA group furnished Beech with magnetic tape dubs of the data taken with our recorder.

Test Procedures

Truck: The truck used in the tests was a flatbed Ford F600, Beech A/C No. C. 99 (Figure 1).

Load: The load on the truck consisted of a distributed mass-model of a Beech liquid helium Dewar flask which was, in turn, mounted on an isolated (mitigating) pallet (Figure 2).

Figure 1. Truck Used in Tests

Figure 2. Load in Truck Tests

Instrumentation: Beech instrumentation used was the shock level trigger type located at the flask/pallet interface (Figure 3).

Sandia instrumentation used by EDA personnel was the ELI 31 portable environmental sampler used in conjunction with piezoelectric transducers (Figure 4). The Sandia transducers were located ahead of and behind the truck/load interface on main members of the truck bed (Figure 5).

Figure 3. Beech Instrumentation

Figure 4. ELI 31 Sampler on Truck Bed

Figure 5. Pickup Location on Truck Bed to Rear of Load

Since there were seven additional channels available on the ELI 31 recorder, we donated these channels to Beech A/C personnel for locating pickups on the Dewar mount and on their distributed mass model as they desired. Table I lists all pickup locations and associated instrumentation information.

TABLE I

Truck Test Instrumentation Directory

Test Dates:
1/23-24, 1967

Ch No.	Pickup Mod No. (Endevco)	S/N	Calibrate Values on Data Tape			Location in Test
			1	(g) 2	3	
1	2213E	NB78	0-2	0-4	0-8	V - Truck bed, aft of pallet
2	2213E	NB79	0-2	0-4	0-8	L - Truck bed, aft of pallet
3	2213E	NB81	0-2	0-4	0-8	V - Truck bed, fwd of pallet
4	2213E	NB83	0-2	0-4	0-8	L - Truck bed, fwd of pallet
5	2213E	NB85	0-2	0-4	0-8	T - Truck bed, fwd of pallet
6	2213E	NB86	0-2	0-4	0-8	L - Left rear, Dewar mount
7	2235	DC45	0-4.4	0-8.7	0-18	V - Left rear, Dewar mount
8	2235	DC46	0-4.1	0-8.2	0-17	T - Right front, Dewar mount
9	2235	CB65	0-4.3	0-8.6	0-18	V - Right front, Dewar mount
10	2235	CB66	0-4.0	0-8.0	0-16.8	L - Top of Dewar dummy
11	2235	CB68	0-4.0	0-8.0	0-16.8	T - Top of Dewar dummy
12	2235	FB96	0-4.2	--	--	V - Top of Dewar dummy
13	--	--	--	--	--	480 cps servo time base
14	--	--	--	--	--	Voice channel

- Notes:
1. Calibrate values given here are exact settings.
 2. Cal is 50 cps square wave with base at zero.
 3. Base of square wave is zero.
 4. V = vertical axis
 5. L = longitudinal axis
 6. T = transverse axis

Sandia Instruments: ELI 31 recorder system
Dictaphone
Citizen's band transceivers

The following Beech personnel conducted the tests: H. R. Williamson, Chief, Engineering Testing; R. L. Greeno, Test Engineer, Environmental Group; and C. L. Baese, Project Engineer, LM Conditioning Unit. The author operated the ELI 31 recorder.

The general test procedure was to drive over the route chosen by Beech, isolate certain conditions which might produce unique dynamic environments, and sample the events. The route started at the Lindey Liquid Helium Plant in Amarillo, Texas, and continued west to the Texas/New Mexico border on U. S. 66. Events sampled along this route as being normal environments experienced were as follows:

1. Backing up to loading dock across RR tracks (Figure 6). (Vibran)
2. Driving to weighing station over a series of RR tracks. (Vibran and Spectra)
3. Going into a dip at 15 mph. (Vibran)
4. Driving from a low, level road to a raised road. (Vibran)
5. Driving onto bad overpass at 50-55 mph. (Vibran)
6. Driving on heavily patched asphalt highway at 50 mph. (Vibran)
7. Driving on access road parallel to interstate highway. (Vibran)
8. Driving on smooth blacktop, 4-lane interstate highway at 50, 55, and 35 mph. (Vibran)
9. Driving in paved construction zone at 45 and 55 mph. (Vibran)
10. Driving on rough blacktop at 60 mph. (Vibran)

Figure 6. Loading Dock and Railroad Track Employed in Tests

Samples taken in a second series were of unusual situations which might occur along the route and which could produce severe environmental inputs. These were as follows:

1. Colliding with loading dock. (Spectra)
2. Driving over RR tracks at high speed, 45 and 50 mph. (Spectra)
3. Driving with two wheels on shoulder at 45 mph. (Vibran)
4. Driving completely on shoulder at 45 mph. (Vibran)
5. Driving off road in desert brush (Figure 7). (Vibran)
6. Driving into a dip at 50 mph. (Vibran)
7. Driving on median of interstate highway (turning around). (Vibran)
8. Hitting potholes in a truck stop at 45-50 mph. (Spectra)
9. Driving on dirt road at 45 mph. (Vibran)
10. Running over a cattle guard at 45 mph (Figure 8). (Spectra)

Figure 7. Dirt Road and Desert Brush in Area Where Tests Were Conducted

Figure 8. Typical Cattle Guard Over Which Environments Were Sampled

Data Reduction

The descriptive terms, Vibran and/or Spectra, indicate the data reduction format selected to portray the event. Descriptions of the manner in which these reductions are accomplished, as well as examples of the standard formats, are contained in Sandia Corporation Engineering Manual Procedure S-49, paragraphs 2.3, 2.5, and 2.6, and Figures A-7, A-8, A-9, and A-10.

Technical descriptions of the data reduction systems are contained in References 3 and 4.

The data reduction was performed by Division 7335 as a part of test request No. T-12317. Computer time required for this reduction was 8 hours and 13 minutes.

Data Analyses

Normal Environments

Long-Duration Phenomena -- Program Vidar was utilized to analyze the Vibran data reductions obtained from the normal environments of long duration. The following functions were performed:

1. The vertical axis was selected as being the axis in which maximum acceleration levels were detected.
2. The Vibran data from the two truck-bed vertical pickup locations were combined into a composite acceleration density description of the dynamic environment for each of the normal events sampled. Tables A-I through A-X in Appendix A present the resultant description of each of the ten events measured.
3. The tabulation of frequency of occurrence of road types presented in Table II of Reference 2 was used as a guide to obtain weighting factors for each of the ten events. These weighting factors were then applied in the production of a composite acceleration probability density description of the environment produced in the vertical axis at the truck/load interface. Table A-XI gives the resultant acceleration probability description of a trip, in which these ten road types would be encountered. Table A-XII lists the weighting factors that were applied to each road type when generating the composite environment description.

Transient Phenomena -- One normal event, considered to be sufficiently transient to warrant analysis in terms of shock spectra, was the crossing of railroad tracks at slow speed. Figure A-1 of Appendix A presents the vertical g-time history of this event; Figure A-2 presents the resultant shock spectra produced, assuming that the responding single-degree-of-freedom systems had critical damping ratios of 0, 0.03, and 0.10.

In general, we interpret spectra presentations of transient truck transport environments taken at the payload/truckbed interface in the following manner:

1. Shock spectra picture the response severity on cargo systems.
2. The 0.03 damping spectrum is an estimate of the response severity produced on nonisolated cargo systems.

3. The 0.10 damping spectrum is an estimate of the response severity produced on isolated or mitigated cargo systems.
4. The 0.0 spectrum is an estimate of the upper limit of response severity which may be achieved in the first application of a series of pulses of the type from which spectra were obtained regardless of the damping which may be present in the system.
5. Cargo responses greater than those predicted for 0.0 damping indicate that it is questionable as to whether the system under consideration approximates a single-degree-of-freedom system.

The shock spectra shown in Figure A-2 are those derived for the pickup location at the rear location on the truck bed. These spectra envelop the spectra obtained at the forward location on the truck bed and are, therefore, considered to represent the greatest vertical axis response severity relative to location of cargo on the truck bed.

Abnormal Environments

Long-Duration Phenomena -- The following events were considered to occur over a period of time which precluded their interpretation as transient phenomena:

1. Driving with two wheels on shoulder at 45 mph.
2. Driving completely on shoulder at 45 mph.
3. Driving off the road in desert brush.
4. Driving into a dip at 50 mph.
5. Turning around on the median of a 4-lane highway.
6. Driving on a dirt road at 45 mph.

Program Vidar was utilized to analyze these events in the following manner:

1. Vidar reductions of the vertical axis pickup locations were combined to provide a description of the "input to load environment" for each event. Tables B-I through B-VI provide these analyses.
2. A probability description was derived of the environment that would be experienced if all these events occurred in a trip where each event was considered equally likely to occur. Table B-VII provides this description.

Transient Phenomena -- Four events in the abnormal category evaluated as transient phenomena were (1) collision with loading docks, (2) crossing railroad tracks at high speed, (3) crossing a cattle guard at high and low speeds, and (4) hitting pot holes at high speed.

1. Collision With Loading Dock

Collision with a loading dock has a characteristic which separates this event from other truck transport phenomena evaluated in these tests. The longitudinal, not the vertical, axis produces the greatest response severity. Figure B-1 shows the g-time history of this event, and Figure B-2 shows the derived shock spectra from a truck bed location.

An additional data reduction, Figure B-3, is taken from the test data obtained in this event to illustrate an "applicability test" of shock spectra. The mitigating pallet/load system on the truck was known to have a natural frequency of the order of 10 cps. The shock spectrum of Figure B-2 for 0.10 damping indicates that the peak response of a 10-cps single-degree-of-freedom system should be of the order of 1.5 g. Figure B-3 is the actual g-time history of

the longitudinal response of the mitigating pallet load, measured during the test event. The measured system peak response was ≈ 1.5 g, indicating that the assumption that this pallet system approximates a single degree of freedom with 0.10 damping is reasonable.

Figures B-4 and B-5 are g-time histories and shock spectra, respectively, taken at the second longitudinal pickup location on the truck bed during the test. These are included to illustrate that there appears to be little, if any, effect of truck bed location on the resultant longitudinal shock.

Figures B-6 and B-7 are included for the sake of completeness to describe the resulting vertical axis environment produced by this collision event. Only the rearward location time history and spectra are shown, since, in the case of vertical axis environment, the rearward location produced the greater response severity.

2. Crossing Railroad Tracks at High Speeds (45-50 mph)

Figures B-8 and B-9 show the g-time history and spectra obtained at a speed of 45 mph. Figures B-10 and B-11 present data taken at 50 mph to illustrate that small high-speed variations appear to have little effect on the response severity. As in other environmental events of this nature, shocks at aft location on the truck bed are the most severe, and the vertical axis is, again, the "governing" axis.

Response severity during high-speed crossings of railroad tracks, however, may not be consistent for all possible cargo systems. A comparison with shock spectra obtained when crossing tracks slowly from a stop (Figures A-1 and A-2) indicates that low-speed crossings may have a greater response severity for low natural-frequency cargo systems and that high-speed crossings have a greater response severity for high natural-frequency cargo systems.

The g-time histories of railroad crossings (Figures B-8 and B-10) indicate that the characteristic environment is one of repetitive shock. For this reason, it would appear that the initial environment would best be represented by the 0 damping spectrum, followed in turn by either the 0.03 or 0.10 damping spectrum, depending upon whether a mitigated or non-mitigated cargo system is being evaluated.

3. Crossing a Cattle Guard at High and Low Speeds

Figures B-12, B-13, B-14, and B-15 present the g-time histories and spectra obtained during cattle-guard crossings from the rearward (vertical) truck-bed location. Both the time histories and spectra indicate a remarkable similarity to railroad crossings. As a result of the comparison, our present interpretation is that this environment is not unique and that its potential effects on cargo are the same as those effects produced in crossing railroad tracks.

4. Hitting Pot Holes at High Speed

The pot holes encountered in this test were in the unpaved parking area of a truck stop. They consisted of depressions caused by truck wheels standing when the surface was wet, wheel spin, and ruts formed under the same conditions, as well as ridged ground irregularities produced by general wind and water action. Access to this area was directly off the main paved highway and transition was very abrupt. For a considerable distance leading to this

area, the paved highway was very smooth blacktop, straight and level, with a posted 60-mph speed limit. This situation made it possible for a vehicle to approach this truck stop at a high rate of speed and turn into this abrupt collection of irregularities with little or no reduction in its highway velocity. A nominal velocity of 45 mph was chosen for sampling this event.

It may be of interest to note that this was the only abnormal environment sampled in which a qualitative experience in relation to the material on the truck bed was noted. During this event, the ELI 31 recording system (weight, 90 pounds), which was resting on a foam plastic pad, separated from the pad and came to rest on the truck floor, moving a distance of about 3 feet in the plane of the truck bed. Vertical height traversed by the recorder was estimated to be of the order of 2 to 4 inches. This vertical travel estimate was inferred from passenger response in the truck cab.

Figures B-16 and B-17 present the g-time history and spectra obtained during this event. Again, the vertical axis and the aft location on the truck bed produced the governing severity of response.

A comparison of response severity for this event with all other events sampled in these tests indicates that pot holes and bumps are potentially the most severe transient vertical environment that cargo will encounter in truck transport.

Conclusions

Data sampling performed during these tests appears to have accomplished the following:

1. Our data bank store of environmental descriptions of the dynamic inputs to cargo during normal over-the-road operations was extended to include data in the 2-ton truck category.
2. Certain near-accident events were measured which, to our knowledge, have not been previously described in quantitative terms which relate to potential effects on cargo.
3. Our analysis of transient phenomena has led us to postulating a ranking of these transient phenomena in terms of response severity. The results indicate that pot holes or bumps produce the most severe vertical axis environment, and collisions with objects such as loading docks produce the most severe longitudinal environment.
4. Speed appears to produce differing response severity on cargo; low speeds have greater effect on low natural-frequency cargo, high speeds have greater effect on high natural-frequency cargo.
5. Some events are not unique in the dynamic sense, as exemplified by the remarkable similarity of environment encountered on railroad tracks and cattle guards.
6. Location of cargo on the truck bed has an effect on the severity of vertical inputs to cargo, with cargo located over or near the rear wheels getting the roughest ride.
7. Location of cargo on the truck bed appears to have little, if any, effect on longitudinal shocks that may be imposed on the cargo.

8. Certain "unusual" events were sampled which permitted us to extend our store of environmental descriptions of dynamic inputs to cargo experienced during off-road operations.
9. Except for off-road operation in bumpy terrain, it appears that long-duration phenomena encountered in normal situations is more severe than the long-duration phenomena encountered in what we considered to be unusual events in this test.

Recommendations

The data obtained in these investigations consist exclusively of acceleration amplitudes. For maximum use in data interpretation and application, it is recommended that apparent weight measurements be obtained, using either the actual truck upon which these acceleration measurements were obtained, or a similar truck of the same load rating and configuration. Of particular interest in this respect would be apparent weight measurements in the 0-to-10-cps region (Reference 5).

LIST OF REFERENCES

1. Foley, J. T., Preliminary Analysis of Data Obtained in the Joint Army/AEC/Sandia Test of Truck Transport Environment, paper presented February 1966 and published in Part 5 of Shock and Vibration Bulletin #35, pp. 57-70.
2. Foley, J. T., An Environmental Research Study, paper presented at 1967 IES Symposium, April 1967, published in IES 1967 Proceedings, pp. 363-373.
3. Murfin, W. B., Automated Digital Shock Data Reduction System, paper presented in February 1967 and published in Part 6, Shock and Vibration Bulletin, #36, pp. 21-36.
4. Department 7180, Vibration Analysis for Weapon Development Test Programs, Sandia Corporation report, SC-DR-321-61, April 1962.
5. Foley, J. T., The Environment Experienced by Cargo on a Flat Bed Tractor-Trailer Combination, SC-RR-66-677, December 1966.

APPENDIX A

NORMAL CONDITIONS

TABLE A-I

Normal Conditions
(Vertical axis, forward and aft locations)

Backing Up to Loading Dock Across Railroad Tracks

ACCELERATION DISTRIBUTION, PERCENT

O-PEAK ACCELERATION, G	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
3.2											
2.3											
1.65											
1.2											
0.86											
0.62											
0.45											
0.32									0.60		
0.23									4.22		
0.17	0.73								9.72		
0.12	3.58	1.77						1.20	19.96	0.50	
0.10	95.69	98.22	99.99	99.99	99.99	99.99	99.99	99.99	98.80	65.50	99.50

No. of Peaks
Counted

139 113 260 315 651 783 1171 1650 2528 3345 4568

Total No. of Peaks Counted: 15,523

Driving Away From Dock Onto Pavement

ACCELERATION DISTRIBUTION, PERCENT

O-PEAK ACCELERATION, G	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
3.2											
2.3											
1.65											
1.2											
0.86											
0.62											
0.45											
0.32									1.15		
0.23									9.61		
0.17									18.50		
0.12	0.65								2.64	21.64	
0.10	99.35	99.99	99.99	99.99	99.99	99.99	99.99	99.99	97.36	49.20	99.99

No. of Peaks
Counted

161 111 221 368 1041 1170 1203 1676 2587 3222 4682

Total No. of Peaks Counted: 16,442

TABLE A-II

Normal Conditions
(Vertical axis, forward and aft locations)

Driving to Weighing Station Over First Set of Railroad Tracks

ACCELERATION DISTRIBUTION, PERCENT

O-PEAK ACCELERATION, G	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
3.2											
2.3											
1.65											
1.2											
0.86											
0.62	3.36										
0.45	3.36										
0.32	4.97	3.25							0.70		
0.23	16.70	10.88	2.35				0.27		0.79	1.45	0.10
0.17	13.31	18.47	1.97	0.20	0.77	0.21	0.78	0.15	2.32	3.85	0.60
0.12	28.34	31.51	9.79	3.80	2.88	1.31	2.25	0.96	9.51	10.30	2.54
0.10	29.97	35.85	85.89	96.00	96.34	98.48	96.70	98.89	87.33	83.65	96.71

Frequency CPS	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
No. of Peaks Counted	60	92	255	474	1278	1509	1441	2285	2737	3506	4935

Total No. of Peaks Counted: 18,572

Driving to Weighing Station Over Second Set of Railroad Tracks

ACCELERATION DISTRIBUTION, PERCENT

O-PEAK ACCELERATION, G	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
3.2											
2.3											
1.65											
1.2											
0.86	1.65										
0.62	3.35	1.03							0.30		
0.45	11.70	3.13	1.18						0.34	0.79	0.10
0.32	13.35	8.32	1.54						0.98	1.48	0.30
0.23	18.35	15.58	2.31	0.47	0.40	0.75	0.05	0.63	1.57	4.19	1.10
0.17	13.35	17.70	4.21	0.90	1.49	0.98	0.54	0.96	3.36	6.28	2.60
0.12	13.30	20.80	12.75	3.13	4.26	3.62	2.16	3.23	8.48	13.20	6.45
0.10	25.00	33.29	77.99	95.50	93.79	94.66	97.24	95.22	85.23	73.81	89.40

Frequency CPS	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
No. of Peaks Counted	60	96	259	444	1048	1338	1574	2151	2907	3565	4918

Total No. of Peaks Counted: 18,360

TABLE A-III

Normal Conditions
(Vertical axis, forward and aft locations)

Going Into a Dip at Low Speed

ACCELERATION DISTRIBUTION, PERCENT

3.2											
2.3											
1.65											
1.2											
0.86											
0.62											
0.45											
0.32	5.40	2.40									
0.23	17.55	22.60									
0.17	24.30	26.20							0.89		
0.12	16.20	20.25	6.21	0.69	0.09				1.52	7.73	0.40
0.10	36.45	28.60	93.85	99.31	99.91	99.99	99.99	99.99	98.48	91.37	99.60
Frequency CPS	0- 5	5- 10	10- 20	20- 30	30- 45	45- 60	60- 87	87- 125	125- 175	175- 250	250- 350

No. of Peaks
Counted

74 84 292 431 1227 1555 1819 2379 3063 3485 5311

Total No. of Peaks Counted: 19,720

TABLE A-IV

Normal Conditions
(Vertical axis, forward and aft locations)

Driving From Low, Level Road to Raised Road

ACCELERATION DISTRIBUTION, PERCENT

3.2											
2.3											
1.65											
1.2											
0.86											
0.62										0.20	
0.45										1.75	
0.32										5.20	
0.23										0.15	6.55
0.17										1.17	9.91
0.12	3.52	1.58							0.19	4.54	18.51
0.10	96.47	98.41	99.99	99.99	99.99	99.99	99.99	99.99	99.99	94.15	57.88
Frequency CPS	0- 5	5- 10	10- 20	20- 30	30- 45	45- 60	60- 87	87- 125	125- 175	175- 250	250- 350

No. of Peaks
Counted

114 126 264 317 627 544 1162 1709 2639 3311 4416

Total No. of Peaks Counted: 15,229

TABLE A-V

Normal Conditions
(Vertical axis, forward and aft locations)

Driving Onto Overpass at 50-55 mph

ACCELERATION DISTRIBUTION, PERCENT

3.2												
2.3												
1.65												
1.2												
0.86												
0.62												
0.45									3.50	1.06		
0.32		3.34	0.41						7.60	9.06		
0.23	17.58	9.98	0.41						12.90	25.06		
0.17	13.54	18.91	2.02	0.76	0.34		0.25		22.20	21.92	0.45	
0.12	10.82	21.11	3.24	5.28	6.77	0.60	0.85	0.30	20.85	18.54	3.55	
0.10	58.11	46.66	93.97	93.96	92.94	99.40	98.91	99.70	32.95	24.41	96.10	
Frequency CPS	0- 5	5- 10	10- 20	20- 30	30- 45	45- 60	60- 87	87- 125	125- 175	175- 250	250- 350	

No. of Peaks
Counted

74 90 248 398 635 809 1257 1643 2625 3247 4748

Total No. of Peaks Counted: 15,376

Driving Off Overpass at 50-55 mph

ACCELERATION DISTRIBUTION, PERCENT

3.2												
2.3											0.32	
1.65											3.71	
1.2											0.71	
0.86										0.30	0.00	
0.62										9.29	0.00	
0.45										0.15	38.55	0.09
0.32	2.12	2.15	0.44							7.44	30.40	1.51
0.23	5.13	11.93	1.31	0.51	0.77				2.23	0.05	23.00	14.45
0.17	14.87	16.28	5.62	1.51	1.58	1.30	9.65	0.61	20.06	4.15	23.83	
0.12	15.99	31.55	8.17	9.33	9.18	16.94	31.40	14.25	20.00	1.90	24.39	
0.10	61.68	38.03	84.46	88.60	88.47	81.81	56.77	85.09	29.24	1.00	29.79	
Frequency CPS	0- 5	5- 10	10- 20	20- 30	30- 45	45- 60	60- 87	87- 125	125- 175	175- 250	250- 350	

No. of Peaks
Counted

94 92 232 396 642 945 1039 1865 2792 2991 2534

Total No. of Peaks Counted: 13,622

Total No. of Peaks Counted: 15,886

TABLE A-VII

Normal Conditions
(Vertical axis, forward and aft locations)

Driving On Access Road Parallel to Interstate Highway

ACCELERATION DISTRIBUTION, PERCENT											
O-PEAK ACCELERATION, G	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
3.2											
2.3											
1.65											
1.2			0.47								
0.86			0.47							0.45	
0.62		0.90	0.89							3.66	
0.45		3.50	0.89					0.08	3.19	15.57	
0.32	2.79	9.65	0.89		0.48			0.00	13.13	23.75	
0.23	12.51	19.30	4.98	0.26	2.79		1.13	3.11	23.15	22.59	1.65
0.17	15.28	15.80	7.69	5.95	7.39	1.91	3.85	9.13	19.36	14.24	6.49
0.12	22.23	15.80	17.68	21.27	18.08	14.49	10.96	10.25	15.79	8.99	21.01
0.10	47.24	35.05	66.08	72.57	71.27	83.65	84.06	77.43	25.38	10.85	70.81
Frequency CPS	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
No. of Peaks Counted	72	114	221	419	610	836	1166	1358	2541	3223	4711
Total No. of Peaks Counted: 15,271											

ACCELERATION DISTRIBUTION, PERCENT											
O-PEAK ACCELERATION, G	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
3.2											
2.3											
1.65											
1.2										0.05	
0.86										1.03	
0.62										15.36	
0.45										2.96	28.01
0.32	3.85	3.46					0.10		22.93	23.46	0.77
0.23	2.56	8.06					5.43	0.11	38.93	15.55	9.87
0.17	14.12	17.28	0.81		0.33	1.79	19.04	3.52	20.28	7.91	19.98
0.12	21.82	27.57	2.49	1.99	4.84	14.99	25.99	17.87	9.90	4.42	25.16
0.10	57.70	43.68	96.70	98.01	94.84	83.17	49.49	78.45	5.01	4.12	44.22
Frequency CPS	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
No. of Peaks Counted	78	87	242	404	642	939	1035	1716	2547	3097	4798
Total No. of Peaks Counted: 15,585											

TABLE A-VIII

Normal Conditions
(Vertical axis, forward and aft locations)

Driving On Interstate Highway at 50-55 mph

ACCELERATION DISTRIBUTION, PERCENT

O-PEAK ACCELERATION, G	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
3.2											
2.3											
1.65											
1.2											
0.86											
0.62										0.25	
0.45		3.47	0.46						1.35	5.95	
0.32	1.35	13.78	5.63			0.10			13.09	21.44	0.20
0.23	12.15	18.09	16.52	5.21	1.80	0.36	0.69	0.05	31.63	25.94	3.11
0.17	10.80	14.66	23.56	10.67	7.30	5.72	3.17	1.31	21.74	17.45	12.52
0.12	27.00	19.81	22.18	18.64	16.83	13.13	13.42	7.42	16.71	14.01	23.47
0.10	48.65	30.18	31.61	65.42	74.12	80.64	82.72	91.17	15.48	14.97	60.70
Frequency CPS	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350

No. of Peaks
Counted

74 116 212 402 618 859 1168 1801 2521 3349 4642

Total No. of Peaks Counted: 15,762

Driving on Level Blacktop Interstate Highway at 35 mph

ACCELERATION DISTRIBUTION, PERCENT

O-PEAK ACCELERATION, G	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
3.2											
2.3											
1.65											
1.2											
0.86											
0.62											
0.45										0.05	
0.32		1.07							0.54	0.90	
0.23	1.16	8.68		0.27	0.34				7.67	11.46	
0.17	2.33	21.75	3.09	4.80	2.73		0.25		16.15	23.41	0.20
0.12	10.47	22.80	16.65	18.64	8.95	1.26	2.72	0.10	22.74	25.50	1.10
0.10	86.04	45.65	80.26	76.40	87.97	98.73	97.03	99.89	52.90	38.68	98.70
Frequency CPS	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350

No. of Peaks
Counted

86 92 258 398 582 872 1141 1738 2475 3237 4720

Total No. of Peaks Counted: 15,599

Normal Conditions
(Vertical axis, forward and aft locations)

ACCELERATION DISTRIBUTION, PERCENT

No. of Peaks Counted											
80	169	221	406	671	822	1138	1759	2598	3163	4641	
Total No. of Peaks Counted:									15,668		

ACCELERATION DISTRIBUTION, PERCENT

No. of Peaks Counted	76	127	220	400	612	848	1157	1779	2537	3345	4732
Total No. of Peaks Counted: 15,833											

TABLE A-X

Normal Conditions
(Vertical axis, forward and aft locations)

Driving On Rough Blacktop at 60 mph

ACCELERATION DISTRIBUTION, PERCENT

O-PEAK ACCELERATION, G											
3.2											
2.3											
1.65											
1.2									0.05		
0.86									1.32		
0.62									6.44		
0.45								2.24	12.04	1.24	
0.32		3.47	2.91		0.15		0.25		9.57	10.53	7.65
0.23		10.32	5.44	4.22	3.71	0.80	1.85	0.21	25.76	6.92	17.83
0.17	3.29	14.64	18.72	10.39	8.73	5.45	11.30	1.95	21.50	3.66	18.70
0.12	5.52	20.70	20.39	20.05	19.38	20.35	22.55	13.70	19.31	2.64	19.96
0.10	91.19	50.82	52.47	65.35	68.03	73.35	64.10	84.11	21.67	56.40	34.57
Frequency CPS	0- 5	5- 10	10- 20	20- 30	30- 45	45- 60	60- 87	87- 125	125- 175	175- 250	250- 350

No. of Peaks
Counted

91 116 240 404 594 894 1092 1823 2760 2910 4652

Total No. of Peaks Counted: 15,576

TABLE A-XI

Composite of All Normal Situations
(Vertical axis, forward and aft locations)

PROBABILITY OF OCCURRENCE, PERCENT											
O-PEAK ACCELERATION, g	3.2										
	2.3										
	1.65									0.06	
	1.2			0.01						0.01	0.01
	0.86	0.21		0.01						0.50	0.00
	0.62	0.86	0.20	0.02					0.02	4.47	0.00
	0.45	1.93	0.92	0.19					1.39	11.22	0.21
	0.32	2.76	3.67	0.93		0.04		0.04	9.39	13.50	1.50
	0.23	7.85	10.14	2.47	1.05	0.87	0.24	0.60	0.19	18.14	12.71
	0.17	9.55	14.38	6.48	3.43	2.83	1.46	3.12	0.90	14.53	8.67
	0.12	13.86	19.63	12.12	8.98	7.28	6.63	7.47	5.25	13.33	8.83
	0.10	62.99	51.03	77.76	86.54	88.97	91.67	88.77	93.65	43.19	40.10
Frequency CPS	0- 5	5- 10	10- 20	20- 30	30- 45	45- 60	60- 87	87- 125	125- 175	175- 250	250- 350

No. of Peaks
Counted

Note: Acceleration distributions less
than 0.01% are not reported.

Total No. of Peaks Counted: 273,995

TABLE A-XII

Normal Conditions
Frequency of Occurrence

Weight applied to road types for deriving composite descriptions
of environment:

Event	Weight
1. Backing up to dock	1
2. Crossing railroad tracks	8
3. Dip	2
4. Low level to high	2
5. Overpass	1
6. Asphalt road at 50 mph	10
7. Access road	1.5
8. Four-lane highway	1.5
9. Construction zone	1.0
10. Blacktop at 60 mph	10

Figure A-1. Driving Across Railroad Tracks at Stockyards - Vertical, Aft on Truck Bed (Channel 1)

Figure A-2. Driving Across Railroad Tracks at Stockyards - Vertical, Aft on Truck Bed (Channel 1)

APPENDIX B

ABNORMAL CONDITIONS

TABLE B-I

Abnormal Conditions
(Vertical axis, forward and aft locations)

Driving With Two Wheels on Shoulder at 45 mph

ACCELERATION DISTRIBUTION, PERCENT

O-PEAK ACCELERATION, g	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
3.2											
2.3											
1.65											
1.2											
0.86										0.05	
0.62										0.84	
0.45		1.83							0.41	0.06	
0.32	1.50	3.61	0.92	0.76	0.14			0.05	3.71	18.48	
0.23	16.67	16.41	8.60	2.52	0.94	0.37	2.27	0.97	15.16	23.10	1.59
0.17	15.13	24.57	17.13	8.97	8.02	5.06	5.94	2.39	23.40	16.97	8.41
0.12	15.15	16.33	28.82	21.75	24.54	12.86	14.22	9.86	23.03	13.15	19.88
0.10	51.55	37.29	44.57	66.00	66.37	81.71	77.62	86.72	34.20	20.43	70.12
Frequency CPS	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
No. of Peaks Counted	66	110	222	400	636	847	1161	1764	2542	3248	4659

Total No. of Peaks Counted: 15,655

TABLE B-II

Abnormal Conditions
(Vertical axis, forward and aft locations)

Driving With Four Wheels on Shoulder at 45 mph

ACCELERATION DISTRIBUTION, PERCENT

O-PEAK ACCELERATION, g	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
3.2											
2.3											
1.65											
1.2											
0.86											
0.62										1.53	
0.45									0.10	13.10	
0.32		5.20	2.38	1.25				0.34	3.15	17.68	0.20
0.23	2.88	11.33	8.24	3.79	2.98	1.80	4.69	0.58	14.56	21.86	3.05
0.17	11.42	13.07	17.61	11.04	11.07	8.23	8.74	2.64	19.04	16.43	10.10
0.12	24.30	13.07	19.59	24.79	23.82	19.97	19.31	13.47	22.67	12.47	21.14
0.10	61.44	57.39	52.12	59.13	62.14	70.00	66.91	83.27	40.38	16.87	65.57
Frequency CPS	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
No. of Peaks Counted	70	115	255	399	642	827	1171	1737	2567	3241	4643

Total No. of Peaks Counted: 15,667

TABLE B-III

Abnormal Conditions
(Vertical axis, forward and aft locations)

Driving Off Road in Desert Brush

ACCELERATION DISTRIBUTION, PERCENT

O-PEAK ACCELERATION, G	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
3.2	5.89										
2.3	0.00										
1.65	2.94										
1.2	0.00										
0.86	0.00										
0.62	0.00										
0.45	0.00	1.36									
0.32	5.93	9.44					0.52				
0.23	14.68	16.19					10.53		0.42	0.60	0.70
0.17	35.29	24.34	1.76	0.78	0.15		4.69		3.01	5.95	0.00
0.12	14.68	16.20	11.85	3.01	1.92		0.13	0.10	8.81	15.45	0.85
0.10	20.61	32.46	86.39	96.27	97.88	99.90	84.05	99.85	87.71	77.25	99.15

No. of Peaks
Counted

34	74	227	401	622	837	769	1701	2321	3270	4770
----	----	-----	-----	-----	-----	-----	------	------	------	------

Total No. of Peaks Counted: 15,026

TABLE B-IV

Abnormal Conditions
(Vertical axis, forward and aft locations)

Driving Into a Dip at 50 mph

ACCELERATION DISTRIBUTION, PERCENT

O-PEAK ACCELERATION, G	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
3.2											
2.3											
1.65											
1.2											
0.86											
0.62										0.35	
0.45									1.70	5.28	
0.32		4.31	0.44						18.71	18.92	
0.23	1.37	12.94	7.13	1.03	0.66		0.34		35.46	28.01	2.90
0.17	9.46	15.48	18.30	9.61	4.44	2.39	1.50	0.05	23.15	20.22	11.95
0.12	17.59	21.52	20.52	24.22	11.72	12.90	7.53	1.85	12.39	12.92	24.95
0.10	71.63	45.70	53.62	65.14	83.18	84.71	90.69	98.10	8.59	14.20	60.20

No. of Peaks
Counted

74	116	224	396	607	875	1136	1810	2581	3389	4776
----	-----	-----	-----	-----	-----	------	------	------	------	------

Total No. of Peaks Counted: 15,984

TABLE B-V

Abnormal Conditions
(Vertical axis, forward and aft locations)

Driving on Median Between Access Road and Interstate Highway

ACCELERATION DISTRIBUTION, PERCENT

O-PEAK ACCELERATION, G	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
3.2											
2.3											
1.65											
1.2									0.15	3.99	
0.86									0.15	3.99	
0.62		0.81							1.31	16.69	
0.45	1.32	4.79	1.91						11.87	27.45	0.10
0.32	6.66	11.18	10.00		0.15		1.99		28.59	21.61	2.36
0.23	10.67	12.76	17.62	4.95	2.66	2.79	8.04	2.22	29.54	14.13	14.54
0.17	10.72	16.81	16.67	13.65	9.24	7.89	14.26	10.86	14.14	7.64	20.78
0.12	29.30	19.21	19.04	30.93	20.97	24.53	21.79	22.60	7.30	4.04	22.59
0.10	41.33	34.40	34.76	50.52	66.98	64.73	53.86	64.33	7.10	4.40	39.58
Frequency CPS	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350

No. of Peaks
Counted

75 125 210 404 639 860 1105 1795 2558 3139 4668

Total No. of Peaks Counted: 15,578

TABLE B-VI

Abnormal Conditions
(Vertical axis, forward and aft locations)

Driving on Dirt Road at 45 mph

ACCELERATION DISTRIBUTION, PERCENT

O-PEAK ACCELERATION, G	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350
3.2											
2.3											
1.65											
1.2											
0.86								3.13	0.10	2.22	
0.62								13.23	1.40	14.54	
0.45						0.34		0.00		12.70	23.20
0.32	1.37	1.73	1.33	0.73	1.31	0.57	0.00		22.46	23.41	1.95
0.23	0.00	8.58	9.85	8.83	6.70	3.00	0.28	2.29	23.80	17.95	10.50
0.17	15.07	19.85	16.61	16.95	15.86	7.83	3.79	8.39	16.30	8.48	20.69
0.12	23.30	20.67	23.79	21.46	23.88	19.66	13.81	18.94	10.30	4.69	24.25
0.10	60.31	49.13	48.42	52.03	51.97	68.93	65.76	70.43	12.94	5.57	42.51
Frequency CPS	0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250	250-350

No. of Peaks
Counted

73 116 223 419 612 865 733 1757 2647 3220 4604

Total No. of Peaks Counted: 15,269

TABLE B-VII

Composite of all Abnormal Conditions
(Vertical axis, forward and aft locations)

PROBABILITY OF OCCURRENCE, PERCENT											
0-PEAK ACCELERATION, G	3.2										
	*										
	2.3										
	1.65	*									
	1.2										
	0.86									0.05	
	0.62									0.84	
	0.45		1.83						0.41	0.06	
	0.32	1.50	3.61	0.92	0.76	0.14		0.05	3.71	18.48	
	0.23	16.67	16.41	8.60	2.52	0.94	0.37	2.27	0.97	15.16	23.10
Frequency CPS	0.17	15.13	24.57	17.13	8.97	8.02	5.06	5.94	2.39	23.40	16.97
	0.12	15.15	16.33	28.82	21.75	24.54	12.86	14.22	9.86	23.03	13.15
	0.10	51.55	37.29	44.57	66.00	66.37	81.71	77.62	86.72	34.20	20.43
		0-5	5-10	10-20	20-30	30-45	45-60	60-87	87-125	125-175	175-250
											250-350

* Net acceleration probability distributions
less than 0.01% are not reported.

Total No. of Peaks Counted: 93,179

Figure B-1. Backing Into Loading Dock - Longitudinal, Aft on Truck Bed (Channel 2)

Figure B-2. Backing Into Loading Dock - Longitudinal, Aft on Truck Bed (Channel 2)

Figure B-3. Backing Into Loading Dock - Longitudinal, on Beech Dewar Mount (Channel 6)

Figure B-4. Backing Into Loading Dock -
Longitudinal, Forward on Truck Bed
(Channel 4)

Figure B-5. Backing Into Loading Dock -
Longitudinal, Forward on Truck Bed
(Channel 4)

Figure B-6. Backing Into Loading Dock -
Vertical, Truck Bed Aft of Pallet
(Channel 1)

Figure B-7. Backing Into Loading Dock -
Vertical, Truck Bed Aft of Pallet
(Channel 1)

Figure B-8. Driving Across Railroad Tracks at ≈ 45 mph - Vertical, Aft on Truck Bed (Channel 1)

Figure B-9. Driving Across Railroad Tracks at 45 mph - Vertical, Aft on Truck Bed (Channel 1)

Figure B-10. Driving Across Railroad Tracks at 50 mph - Vertical, Aft on Truck Bed (Channel 1)

Figure B-11. Driving Across Railroad Tracks at 50 mph - Vertical, Aft on Truck Bed (Channel 1)

Figure B-12. Driving Across Cattle Guard at 45 mph - Vertical, Aft on Truck Bed (Channel 1)

Figure B-13. Driving Across Cattle Guard at 45 mph - Vertical, Aft on Truck Bed (Channel 1)

Figure B-14. Driving Across Cattle Guard at Slow Speed - Vertical, Aft on Truck Bed (Channel 1)

Figure B-15. Driving Across Cattle Guard at Slow Speed - Vertical, Aft on Truck Bed (Channel 1)

Figure B-16. Driving Across Pot Holes at Truck Stop -
Vertical, Truck Bed Aft (Channel 1)

Figure B-17. Driving Across Potholes at Truck Stop -
Vertical, Aft on Truck Bed (Channel 1)

DISTRIBUTION:

V. E. Isakson, Program Mgr., LEM
Beech Aircraft Corp.
P. O. Box 631
Boulder, Colorado

R. A. Meldrum
Office, Director of Transportation
Deputy Chief of Staff for Logistics
Dept. of the Army
Washington, D. C. 20545

Robert Kennedy
USA Transportation Engineering Agency
Ft. Eustis, Va. 23604

J. A. Lieberman
Div. of Reactor Development
AEC Headquarters
Washington, D. C. 20545

W. G. Belter
Sanitary Engineering Branch
Div. of Reactor Development
AEC Headquarters
Washington, D. C. 20545

J. A. Sisler
Traffic Management Branch
Div. of Construction
AEC Headquarters
Washington, D. C. 20545

John Langhaar
Atomic Energy Division
E. I. DuPont De Nemours
1007 Market Street
Wilmington, Delaware 19898

Steven H. Brown, Mgr.
Nuclear Service Dept.
National Lead Co.
Nuclear Metals Div.
111 Broadway
New York, N. Y. 10006

R. W. Johnson, Chief
Automotive Engineering Laboratory
U. S. Army Development and Proof Services
Aberdeen Proving Ground, Maryland 21005

L. B. Shappert,
Union Carbide Nuclear Co.
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

J. P. Salter
Royal Armament R & D Establishment
Ministry of Defence
Ft. Halstead
Kent, England

J. E. Rice
Dept. 456G
Goodyear Aerospace Corp.
1210 Massillon Rd.
Akron, Ohio 44306

U. S. Department of Agriculture
Forest Products Laboratory
P. O. Box 5130
Madison, Wisconsin 53705
Attn: W. O. Godshall
Packaging Research
Div. of Wood Engineering

Ministry of Technology
Aircraft Torpedo Development Unit
Helston, Cornwall, England
Attn: H. Robinson

General American Research Division
General American Transportation Corp.
7449 North Natchez Ave.
Miles, Illinois 60648
Attn: Fred Ostrem

W. Paulson
HIC Building - R - P&VE SVE
George Marshall Space Flight Center
National Aeronautics & Space Administration
Huntsville, Alabama 35812

Mechanical Information Division
Oak Ridge National Laboratory
Box X
Oak Ridge, Tennessee 37830

E. K. Snyder
Office of Weapons
Distribution & Transportation Branch
AEC Albuquerque Operations
Sandia Base, New Mexico 87115

W. A. Gardner, 1500
D. M. Olson, 1510
B. E. Arthur, Jr., 1520
T. B. Lane, 1540
E. White, 7331, Attn: R. G. Hamilton
J. V. Otts, 7324
J. A. Mortley, 7334, Attn: F. R. Gustke
J. D. Patrick, 7335, Attn: T. B. Smart
H. R. Willis, 8146, Attn: C. A. Scott
E. A. Paxton, 8232
B. R. Allen, 3421
J. Shunny, 3411
R. S. Gillespie, 3413 (4)
C. H. Sproul, 3428-2 (10)

jk

REPRODUCTION PERMISSION

This report is not to be reproduced in whole or in part without written permission by the manager of the originating department.