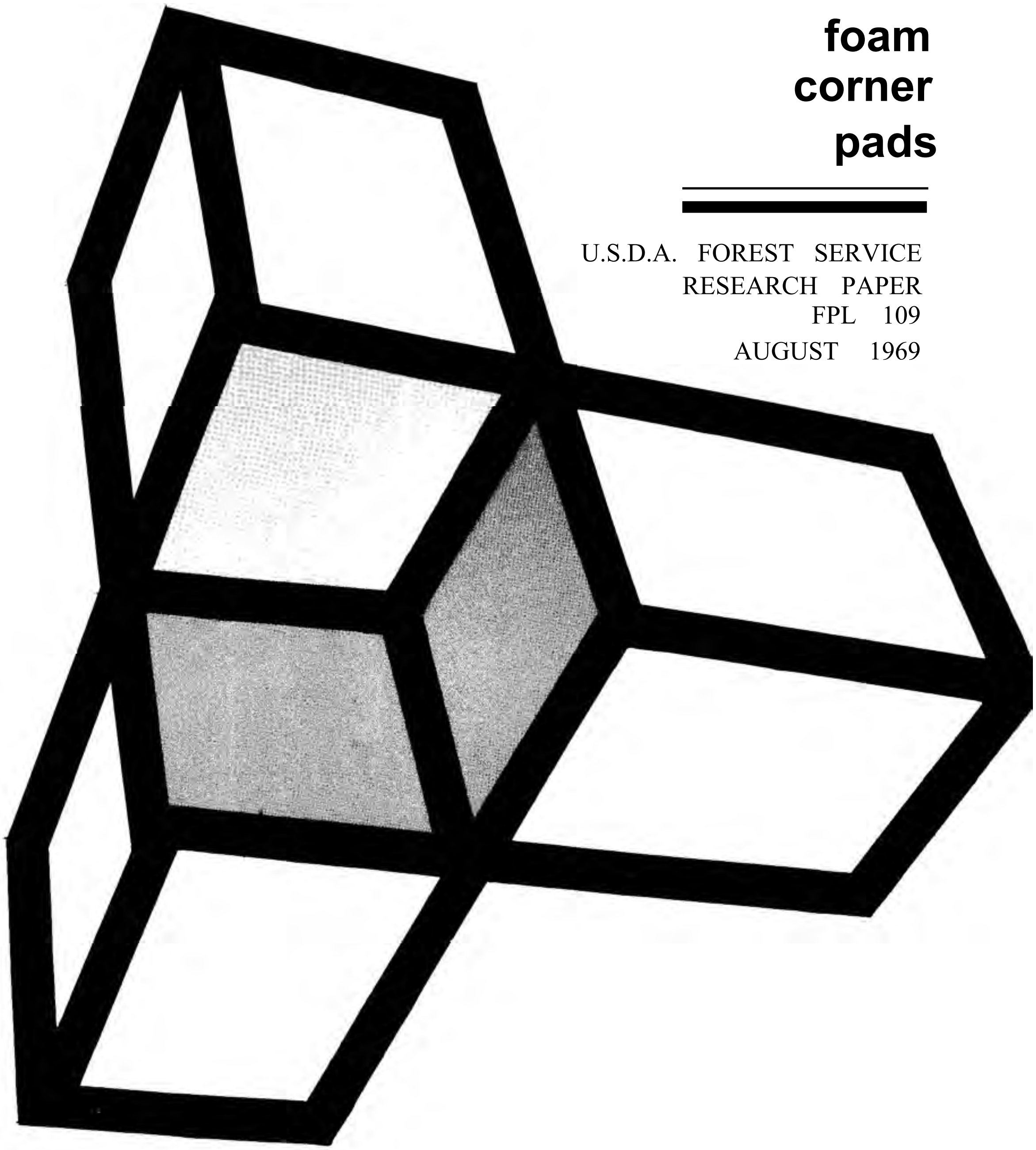
CONTAINER EFFECTS IN CUSHIONED PACKAGES:

urethane foam corner pads

U.S.D.A. FOREST SERVICE
RESEARCH PAPER
FPL 109
AUGUST 1969



U.S. Department of Agriculture/Forest Service/Forest Products Laboratory/Madison, Wis.

ABSTRACT

Available package cushioning design data generally are based on the response of cushions alone, ignoring effects that the container may have on the shocks experienced by the contents of cushioned packages.

In this study a direct relationship was indicated between rigidity of the outer container and the severity of shock to contents. Cushioning applied as corner pads produced results similar to those in a previous study of side-pad cushioning of the same kind and amount.

Specimen packages loaded for optimum flat-drop performance performed at least as well when dropped in the edgewise and cornenvise orientations.

CONTAINER EFFECTS IN CUSHIONED PACKAGES: urethane foam corner pads

By C. A. JORDAN: Engineer

Forest Products Laboratory [2]
Forest Service
U.S. Department of Agriculture

INTRODUCTION

Side pads and corner pads are used in two common methods of applying cushioning material for shock protection of fragile articles in shipping boxes when the articles are rectangular hexahedrons or are readily given this form by boxing or blocking. The side-pad method was studied in a previous investigation.[3] Corner pads were used in the work reported here. (A third method, complete enclosure of the article by cushioning, also may lie employed, but either of the other methods generally utilizes the cushioning material more efficiently.)

Shock protection by cushioned packages often is specified only on the basis of the peak response to dynamic compression of an unconfined pad of the particular cushioning material used. This ignores possible effects of the shipping container on the shock transmitted to the packaged article and may seriously under- or overestimate the severity of that shock.

The major objective of this study was to extend the basic knowledge of package cushioning performance into an area that more nearly resembles the conditions of use--ina cushioned package. The work reported here closely parallels that involving urethane foam side pads.[3] The kind and amount of cushioning material used in each specimen package were the same in both studies; only the method of application was different. The same two kinds of boxes (wood-cleated plywood and single-wall regular slotted corrugated fiberboard) were used, and two different kinds (double-wall and triple-wall regular slotted corrugated fiberboard boxes) were added. Again, only the initial impact was studied.

[1] The author gratefully acknowledges the assistance of John D. Wiese, Engineering Technician, who performed the tests and handled the instrumentation for this study.

[2] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

[3] Jordan, C. A. Container Effects in Cushioned Packages: Urethane Foam Cushioning Applied as Side Pads. U.S. Forest Serv. Res. Pap. FPL 91. Forest Products Laboratory, Madison, Wis. 1968.

MATERIALS

All specimen boxes were 13-inch cubes, inside. The style A wood-cleated plywood boxes (fig. 1) were made from 1/4-inch Douglas-fir plywood and 5/8- by 1-1/4-inch ponderosa pine cleat stock. The three kinds of corrugated fiberboard boxes were all regular slotted style (fig. 2), some made from single-wall, some from double-wall, and some from triple-wall board (fig. 3). The single-wall was a 200-pound test B-flute board with nominal 40-pound facings and a 26.5-pound corrugating medium. The double-wall was A-B flute commercial fiberboard of 350-pound burst rating. The triple-wall had a C-B-A flute arrangement and complied with specification PPP-B-640.

The cushioning material was selected from a single nominal 3-inch-thick sheet of urethane foam from the same four-sheet shipment that supplied cushion pads for the earlier study.[3] The foam had a density of 2 pounds per cubic foot. A single sheet was used because dynamic compression response varied much less within a single sheet than it did between sheets.

Each corner pad (fig, 4) used three 2-1/2-by 2-1/2- by 3-inch blocks of urethane foam One of the smaller faces of each block was glued with sodium silicate to one of the outer faces of a corner structure made from B-flute corrugated fiberboard. The scored and folded structure was held in box-corner form by a 1/2-inch-wide glued flap. When placing the corner pads around the 7-inch cube dummy load in the specimen boxes, the thickness of the fiberboard in these corner structures was accommodated by compression of the urethane foam Therefore, these specimen packages were somewhat more tightly packed than those in the earlier study.[3]

With the package resting on the bottom of its container, the dummy load was supported by four 2-1/2-inch-square pads, one under each corner, as shown in figure 5.

In evaluating the dynamic compression characteristics of the cushion material alone, test specimens consisted for four 2-1/2- by 2-1/2-by 3-inch pads arranged as shown in figure 5.[4]

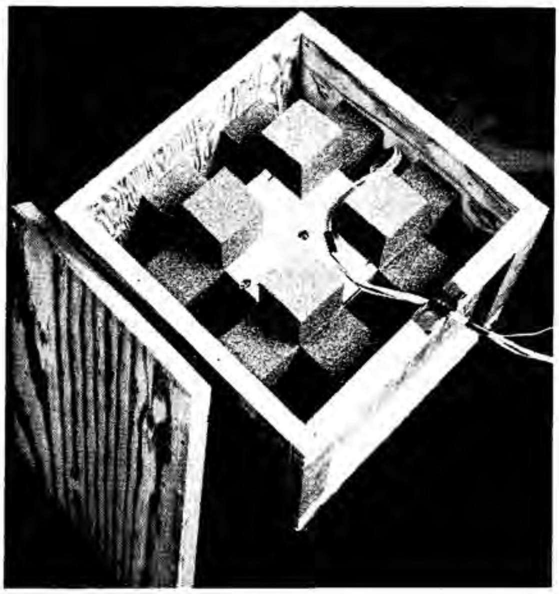


Figure I.--One of the Mood-Cleated plywood boxes with the cover removed, showing the dummy load positioned and supported by the urethane foam corner pads.

(M 134 371)

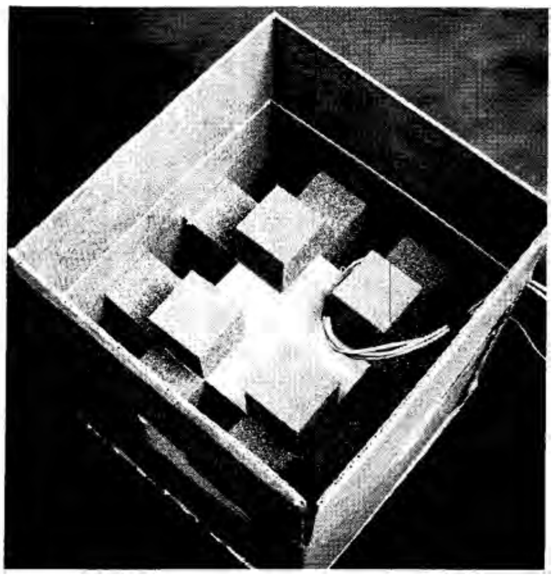


Figure 2.--One of the single-wall corrugated fiberboard boxes with top flaps open, showing the dummy load positioned and supported by the urethane foam corner pads. All of the fiberboard boxes were regular slotted style. (M 134 372)

[4] A significant difference in dynamic compressive response was found for four 2-1/2-inch-square pads arranged as shown as compared to a single 5-Inch-square pad.

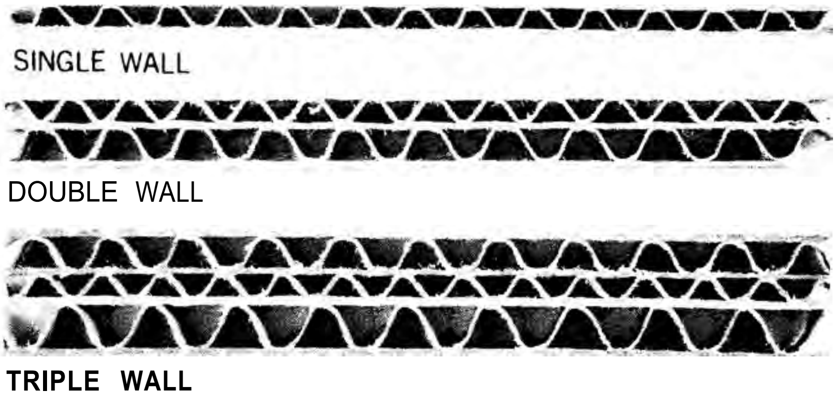


Figure 3.--Cross sections of the three constructions of corrugated fiberboard used to make specimen boxes. (M 134 373)

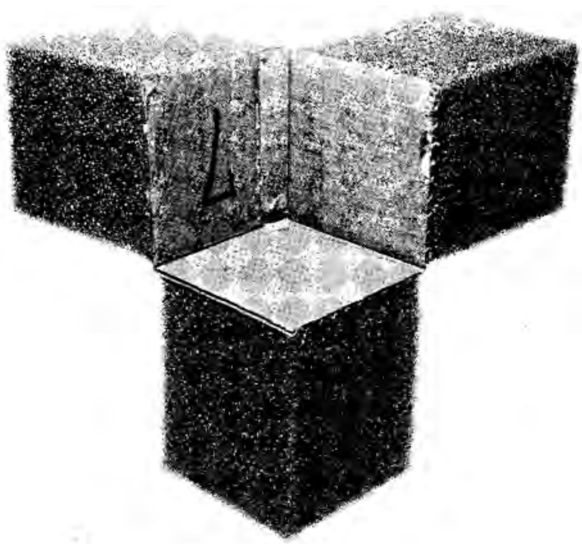


Figure 4.--One of the corner pads used in this study. (M l34 377)

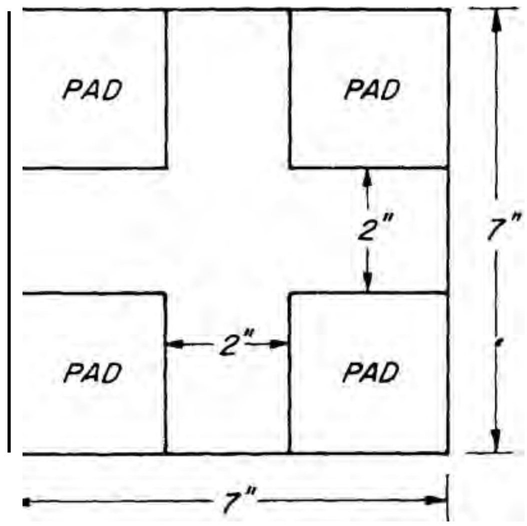


Figure 5.--Arrangement of corner pads for package drop tests and tests of cushions alone. (M 136 744)

METHOD

Complete cushioned packages were dropped to land flatwise on the bottom of the box, diagonally edgewise on a bottom edge, or diagonally cornerwise on a bottom corner. All four kinds of boxes mere dropped diagonally edgewise and diagonally cornerwise; only the single-wall fiberboard and cleated plywood boxes were dropped flatwise. Each package contained the dummy load positioned by eight corner pads, one at each corner. Within the dummy load were three piezo-resistive accelerometers mounted in mutually perpendicular array around the approximate center of gravity of the load. One of the accelerometers was alined vertically and the other two horizontally, regardless of package drop orientation. Their output, along with a 1,000-cycles-per-second sawtooth timing signal and a signal to indicate the instant of initial contact between package and impact surface, were recorded on magnetic tape. These were recorded later on paper using a light-beam oscillograph. The time-base was stretched suitably by proper manipulation of recording and playback speeds. Weights of the dummy load were chosen to cover the useful cushion-load range and extend into the regions of overload and underload.

Each specimen package was dropped only once, soon after the dummy load and cushions were inserted in the box. Thus, no attempt was made to evaluate cumulative degradation of the package protection caused by repeated impacts or cushion-creep effects as might develop during extended storage.

In addition to the package drop tests, the response to dynamic compression of the cushions by themselves was determined using the Forest Products Laboratory's pendulum-impact cushion test apparatus. The procedure was essentially that of ASTM Method D-1596-64, except that only one impact was made against each specimen. The same recording techniques as used for the package drop were employed.

Package drop tests and corresponding pendulum tests of cushions were made using dummy loads and pendulum heads weighing 4, 7, 10.5, and 20 pounds. These weights, divided by the 25-square-inch cushionbearing area (four 2-1/2-inch-square pads), gave static stress values of 0.16, 0.28, 0.42, and 0.80 pound per square inch. To obtain data for a static stress of 0.082 pound per square inch, the 4-pound dummy load and pendulum head were used with four 3-1/2-inch-square cushions.

The vertical drop height was 24 inches in the package tests. In the pendulum tests the drop height was adjusted to give an average velocity of 136 inches per second (equivalent to the velocity attained in a 24-inch free fall) over an inch of essentially horizontal travel just preceding contact.

RESULTS AND DISCUSSION

The results of the package drop tests and of the corresponding impact tests of the cushions by themselves are expressed both as peak acceleration of the load resulting from the applied shock and as undamped shock spectra.[3] Peak acceleration data are presented as peak acceleration-static stress ($\underline{G_m\text{-W/A}}$) curves (figs. 6, 7, and 8). The peak acceleration data are also presented in table 1, along with information on the variability of the observed peak acceleration values.

Figure 6 shows $\underline{G_m\text{-W/A}}$ curves for 24-inch flatwise drops of packages using wood-cleated plywood boxes and B-flute corrugated boxes and for the cushions by themselves. There is good similarity between these curves and those shown in figure 7 of the previous report.[3] Both show a common crossover point in the 0.20 to 0.25 p.s.i. static stress range, and there is also agreement in the arrangement or vertical order of the curves on both sides of the crossover point. The shock protection advantage of cleated plywood boxes for heavier loads again is evident. With corner pads, however, the plywood boxes provided somewhat less shock protection for the lighter loads than did the single-wall fiberboard boxes. This unexpected result led to investigations of possible differences in impact velocity and in the resistance to downward movement of the dummy load provided by only the pads bearing against the vertical sides of the load in the two kinds of boxes (see Appendix). The higher impact velocity and the greater frictional drag on the vertical sides of the load that were observed for the plywood boxes could explain the spread at low static stress between the curves in figure 6.

The divergence at the higher static stress end between the curve for the cushion alone and for packages involving fiberboard boxes is attributed to energy absorption by the bottom flaps of these boxes.

Peak acceleration-static stress curves for edgewise and cornerwise package drops as well as for flatwise impacts of the cushions by themselves are shown in figures 7 and 8. In the edgewise and cornerwise package impacts, there are two important ways in which the container may absorb part of the energy of the descending dummy load. One is by crushing of the impacting edge or corner of the box. The other is by bending of box panels that back up the working cushions (those on the underside of the load, which act to stop downward motion of the load). Thus, peak acceleration of the load in these tests should relate directly to box panel stiffness and to the crushing resistance of the box edges and corners. The plywood panels were the stiffest, followed by triple-wall, double-wall, and single-wall fiberboard, in that order. Crushing resistance of box edges and corners also should follow this order. The curves in both figures 7 and 8 show this order at the low static stress end (W/A = 0.082) and,

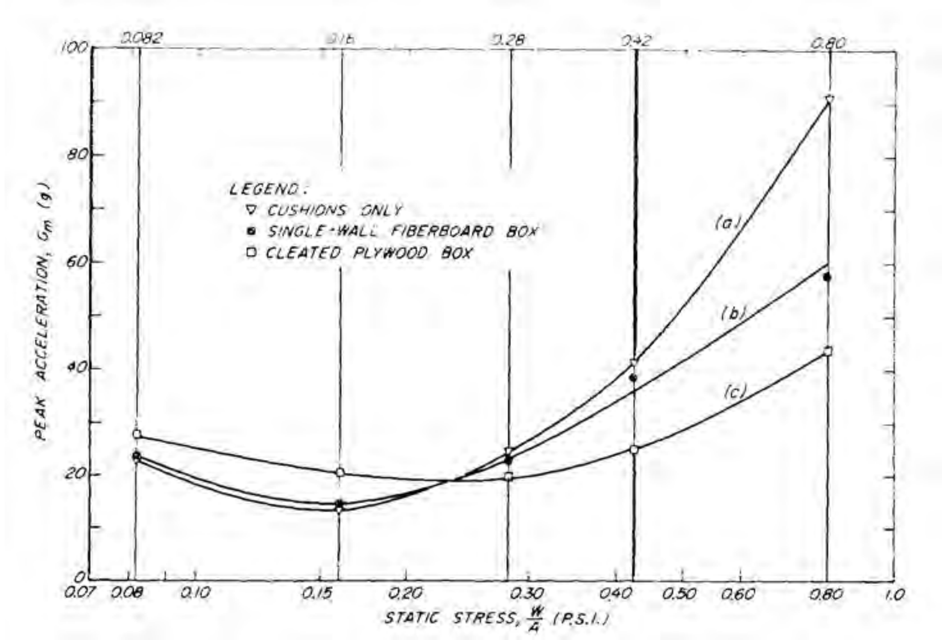


Figure 6.--Peak acceleration-static stress (G_m –W/A) curves for: (a) Urethane foam cushions only; and flatwise drop of cushioned load in (b) single-wall fiberboard box; and (c) cleated plywood box. (M 136 746)

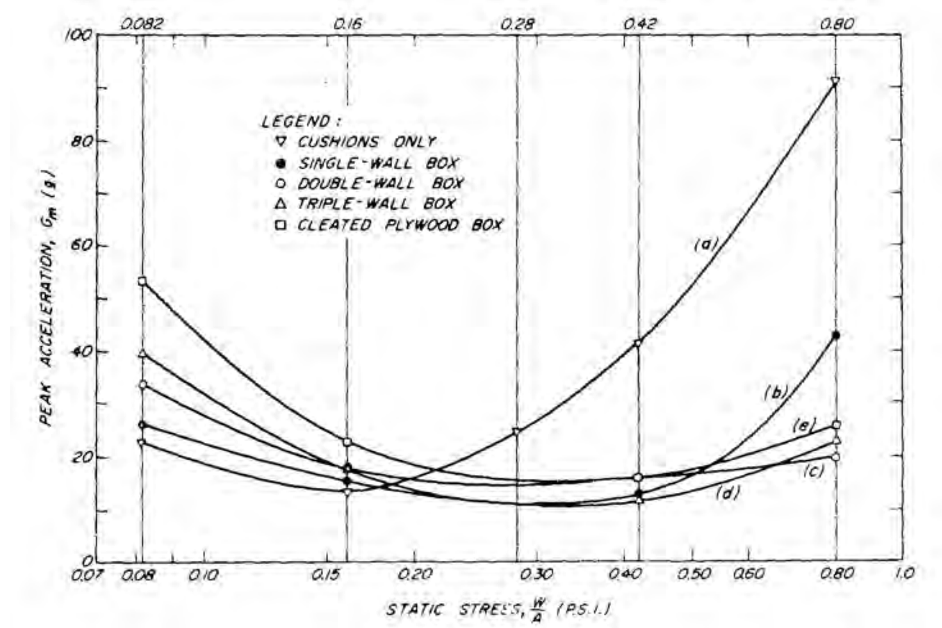


Figure 7.--Peak acceleration-static stress (G_m –W/A) curves for: (a) Urethane foam cushions alone in flatwise compression, and edgewise drops of cushioned load in (b) single-wall fiberboard box; (c) double-wall fiberboard box; (d) triple-wall fiberboard box; and (e) cleated plywood box. (M 136 747)

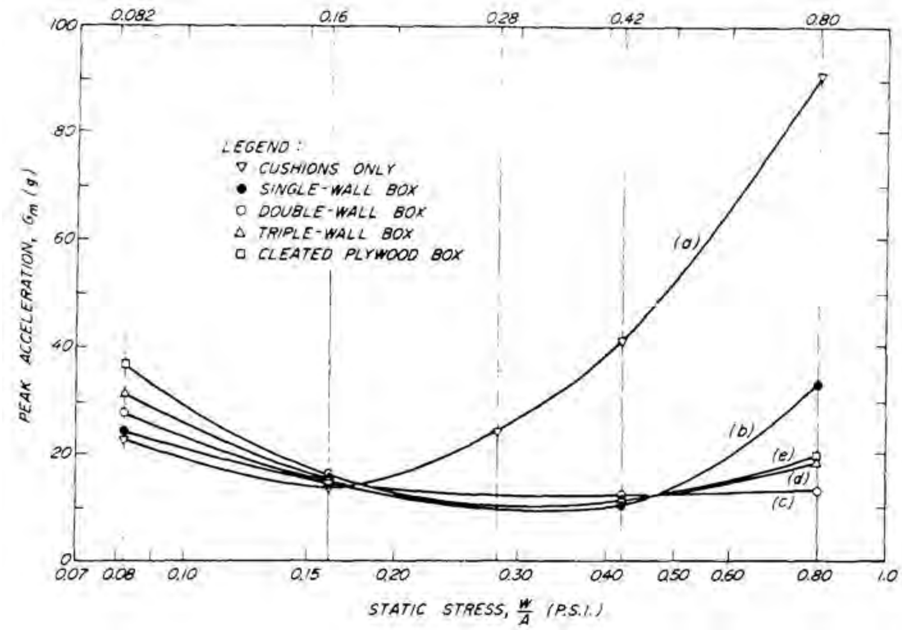


Figure 8.--Peak acceleration-static stress (G_m-W/A) curves for: (a) Urethane foam cushions alone in flatwise compression, and cornerwise drops of cushioned load in (b) single-wall fiberboard box; (c) double-wall fiberboard box; (d) triple-wall fiberboard box; and (e) cleated plywood box. (M 136 748)

except for the single-wall box,[5] at the high static stress end (W/A = 0.080), as well. An important thing to note about the curves in figures 7 and 8 is that when these packages contained a load that gave optimum performance in the flat drop (fig. 6), the flat-drop peak acceleration was not likely to be exceeded when the boxes were dropped on an edge or corner.

Figures 9 through 21 show typical digitized acceleration-time records of the shocks experienced by the dummy load in 24-inch drop tests of the experimental cushioned packages. The undamped shock spectrum for each of these experimental shocks also is shown. The shock spectrum shows the damage potential of a given shockwhen that shock is applied to packaged mechanical articles. Figures 22-24 show curves for the same types of data for tests of cushions alone.

If every article to be packaged was a rigid, unyielding structure throughout, like the dummy loads in the experimental packages of this study, there would he no need for the shock spectra. The peak acceleration of all parts of such articles would be the same as the peak acceleration of the applied shock.

Many articles that must be cushioned for shipment, however, are assemblies consisting of a fairly rigid main structure to which are attached individual parts or subassemblies that often are the most damage-prone elements of the entire article. Because of their own inertia and the resilience of their attachment to the main structure, the motion of these elements during an eternally applied shock will differ from the motion of the main structure. Each will respond at its own natural frequency, and the maximum acceleration it will experience will be shown by the value of the appropriate shock spectrum at that natural frequency.

---

[5] The single-wall box was overloaded by the 20-pound load associated with a static stress of 0.80. Breaking of the backup panels and crushing of the struck corner or edge reduced the available stopping distance to the point where bottoming of the load was occurring.

Table 1.--Peak acceleration data for experimental impacts

Type of specimen and test	Static stress	Average peak acceleration of load	Estimated standard deviation	Estimated standard error of mean
	P.s.i.	g.		
Single-wall box Flatwise drop	0.082	[1]23.40	0.42	0.21
	.16	14.57	.55	.32
	[2].28	[1]22.58	3.36	1.68
	.42	36.83	5.72	3.30
	.80	57.70	3.61	2.08
Edgewise drop	.082	26.23	.21	.12
	.16	15.20	.51	.29
	.42	12.60	.27	.16
	.80	42.67	5.84	3.37
Cornerwise drop	.082	24.17	.76	.44
	.16	14.40	.72	.42
	.42	10.43	.68	.39
	.80	33.20	5.31	3.07
Double-wall box Edgewise drop	.082	33.87	.69	.40
	.16	17.50	1.25	.72
	.42	15.27	.80	.46
	.80	19.83	.66	.38
Cornerwise drop	.082	27.53	1.03	.59
	.16	14.77	.07	.04
	.42	12.30	.70	.40
	.80	13.13	.61	.35
Triple-wall box Edgewise drop	.082	39.80	1.52	.87
	.16	17.17	1.41	.81
	.42	15.10	1.84	1.06
	.80	22.83	1.89	1.09
Cornerwise drop	.082	31.40	.76	.44
	.16	15.10	.27	.16
	.42	11.50	.52	.30
	.80	18.53	1.77	.98
Cleated plywood box Flatwise drop	0.82	[1]27.30	.64	.32
	.16	20.37	3.33	1.92
	[2].28	[1]19.40	1.75	.88
	.42	24.67	3.87	2.23
	.80	43.30	.99	.57
Edgewise drop	.082	53.30	2.38	1.37
	.16	22.63	1.22	.70
	.42	15.70	.53	.31
	.80	25.80	1.48	.85
Cornerwise drop	.082	36.63	1.21	.70
	.16	15.77	.30	.18
	.42	11.27	.44	.25
	.80	19.53	1.34	.77
Cushions only Pendulum impact	.082	22.35	1.11	.45
	.16	13.50	1.40	.81
	[2].28	24.40	1.20	.69
	.42	41.17	2.75	1.59
	.80	90.93	7.50	4.33

[1] These results are averages for four replicates; all other package test results are averages of three replicates. The results far pads only are averages of six replicates.

[2] Tests were made at this static stress value only to determine additional data for flatwise drops.

CONCLUSIONS

1. No particular advantage or disadvantage of corner pad swith respect to side pads was found.

2. At the extremes of the load range studied, the severity of shock experienced by the package contents in the edgewise and cornerwise drops bears a direct relationship to box-panel stiffness.

3. Specimen packages loaded for optimum flat-drop performance performed at least as well when dropped in the edgewise and cornerwise orientations.

4. Strength of box panels was a factor in preventing bottoming of the load in edgewise and cornerwise package impacts.

5. The previously noted flat-drop advantage of heavily loaded cleated plywood boxes again was evident.

6. The container effect again was found to be an important factor in determining the severity of the shocks experienced by the contents of a cushioned package during rough handling.

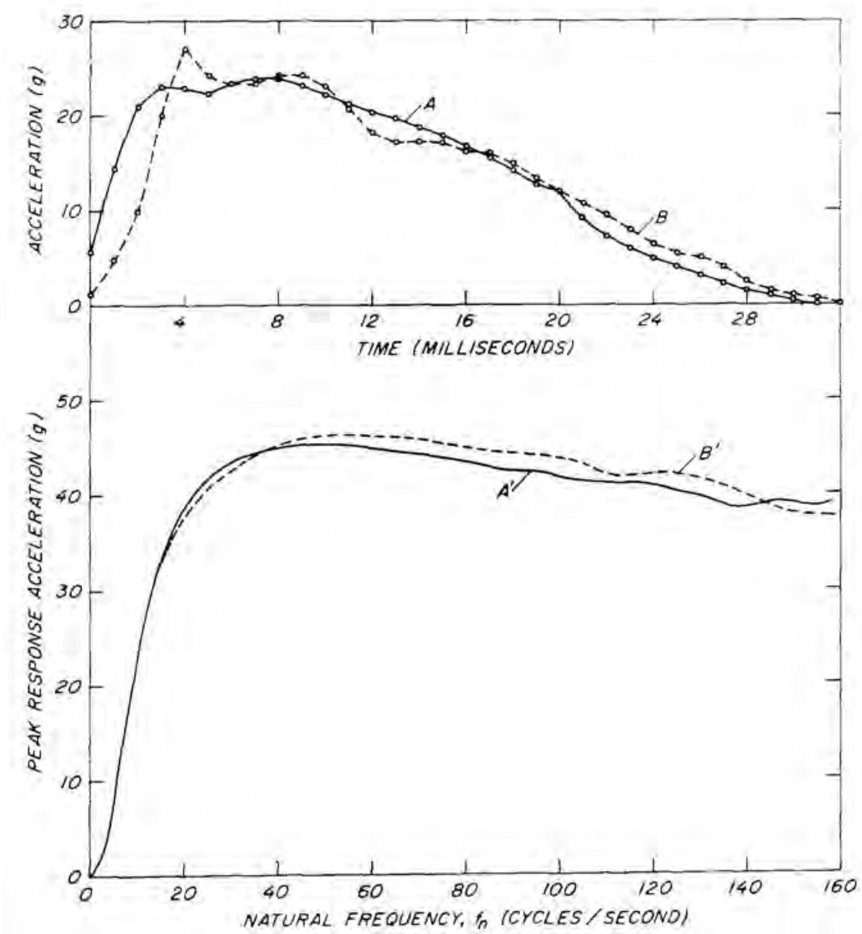


Figure 9.--The upper two curves are digitized acceleration-time records of the shock experienced by the dummy load cushioned with urethane foam corner pads (static stress = 0.082 p.s.i. in a single-wall corrugated fiberboard box, A, and in a cleated plywood box, B, each dropped 24 inches to land flatwise onto the bottom of the box. A' and B' are corresponding undamped shock spectra. (M 136 754)

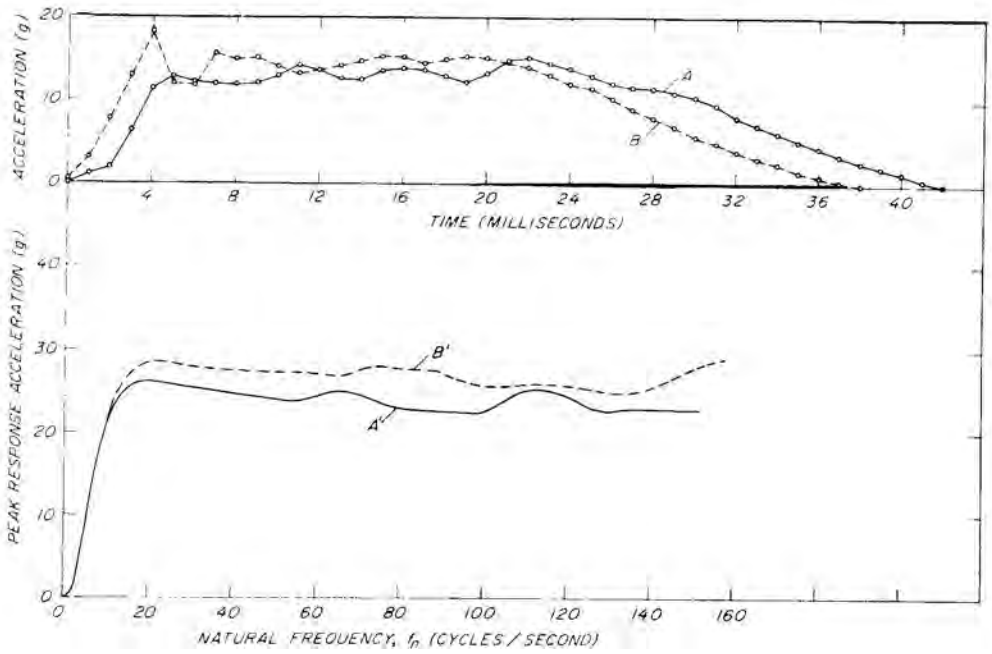


Figure 10.--The upper two curves are digitized acceleration-time records of the shock experienced by the dummy load cushioned with urethane foam corner pads (static stress = 0.16 p.s.i.) in a single wall corrugated fiberboard box, A, and in a cleated plywood box, B, each dropped 24 inches to land flatwise onto the bottom of the box. A' and B' are corresponding undamped shock spectra. (M 136 753)

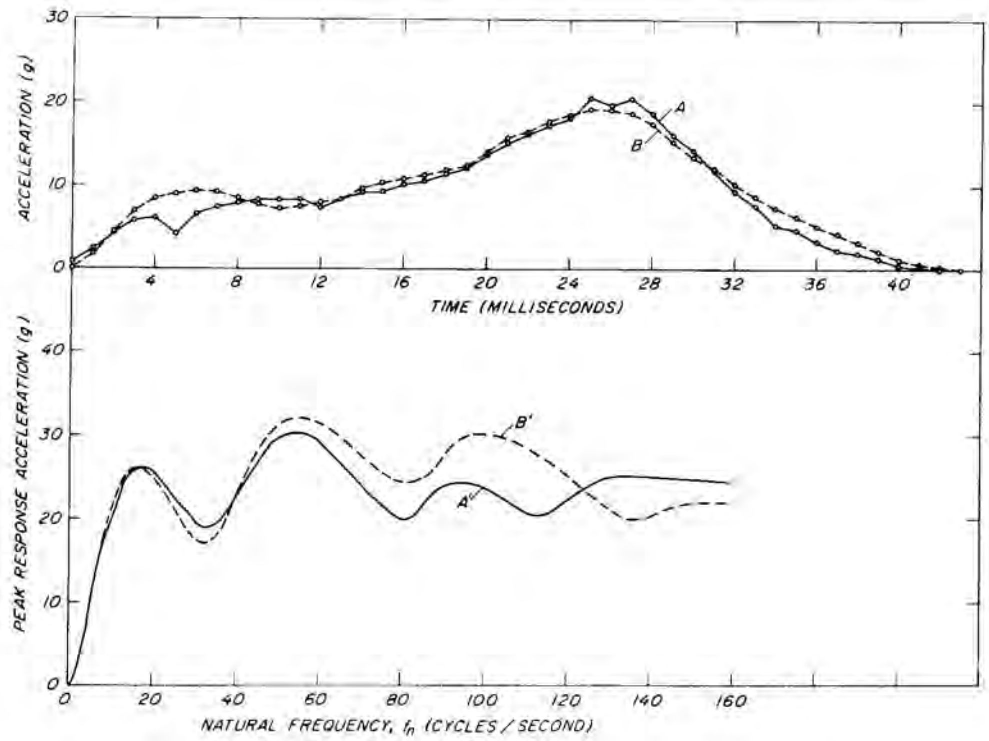


Figure 11 .--The upper two curves are digitized acceleration-time records of the shock experienced by the dummy load cushioned with urethane foam corner pads (static stress = 0.28 p.s.i.) in a single-wall corrugated fiberboard box, A, and in a cleated plywood box, B, each dropped 24 inches to land flatwise on the bottom of the box. A' and B' are corresponding undamped shock spectra. (M 136 750)

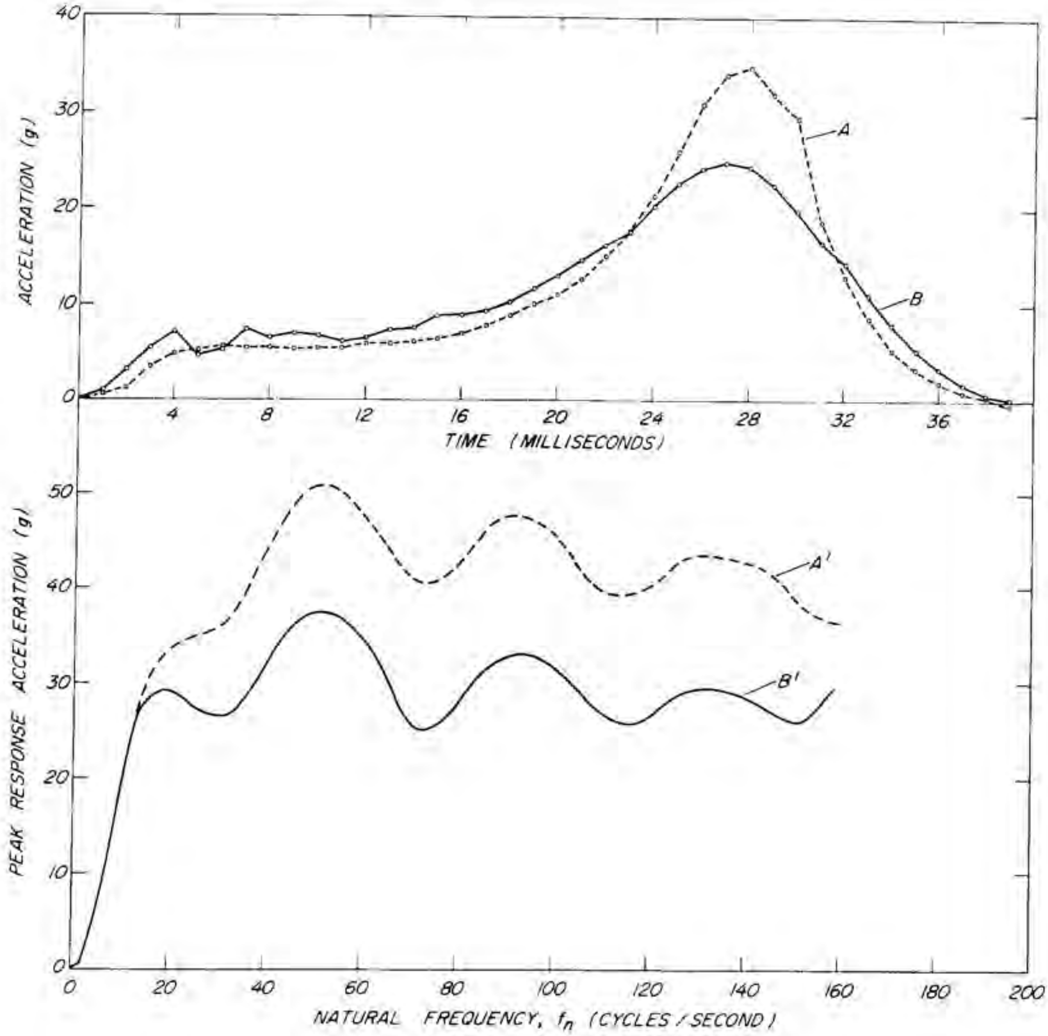


Figure 12.--The upper two curves are digitized acceleration-time records of the shock experienced by the dummy load cushioned with urethane foam corner pads (static stress = 0.42 p.s.i.) in a single-wall corrugated fiberboard box, A, and in a cleated plywood box, B, each dropped 24 inches to land flatwise on the bottom of the box. A' and B' are corresponding undamped shock spectra.

(M 136 749)

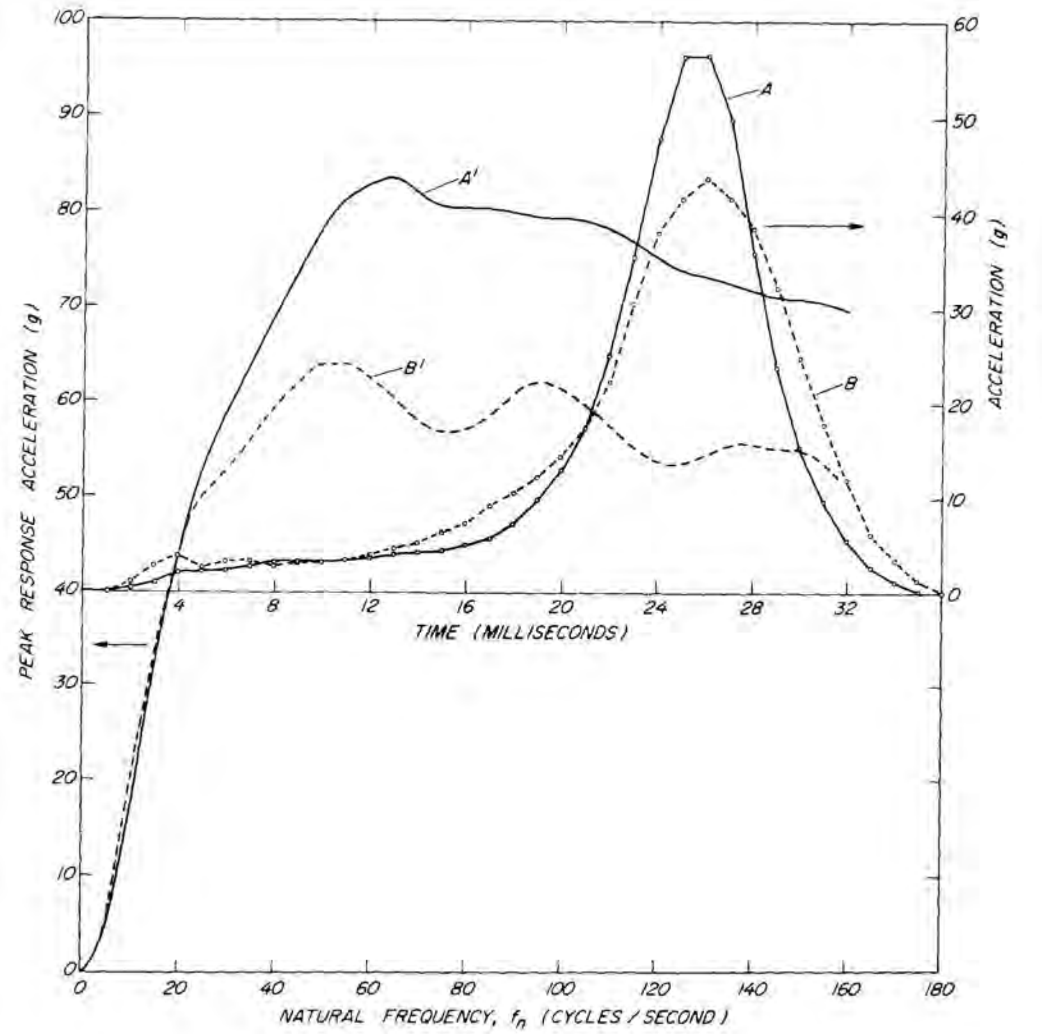


Figure 13.--The two curves referenced to the upper set of coordinates are the digitized acceleration-time records of the shock experienced by the dummy load cushioned with urethane foam corner pads (static stress = 0.80 p.s.i.) in a single-wall corrugated fiberboard box, A, and in a cleated plywood box, B, each dropped 24 inches to land flatwise on the bottom of the box. A' and B' are corresponding undamped shock spectra.

(M 139 751)

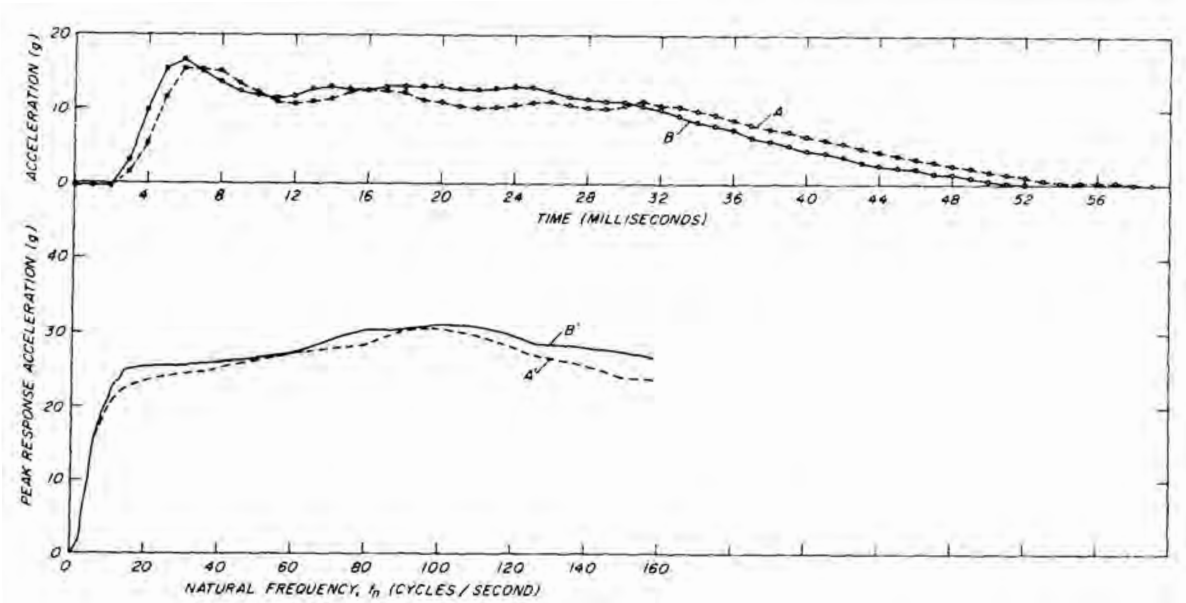


Figure 14.--The upper two curves are digitized acceleration-time records of the shock experienced by the dummy load cushioned with urethane foam corner pads (nominal static stress = 0.16 p.s.i.) in a single-wall corrugated fiberboard box, A, and in a double-wall corrugated fiberboard box, B, each dropped 24 inches in a diagonal orientation to land on a bottom edge of the box. A' and B' are corresponding undamped shock spectra.

(M 136 740)

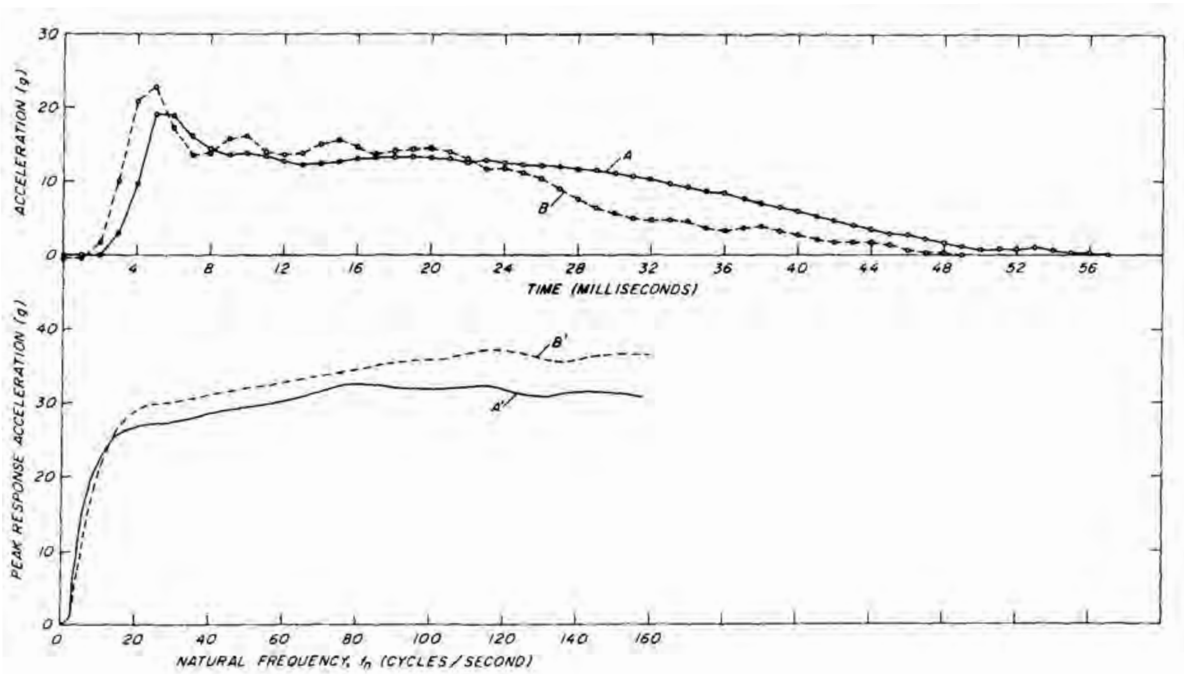


Figure 15.--The upper two curves are digitized acceleration-time records of the shock experienced by the dummy load cushioned with urethane foam corner pads (nominal static stress = 0.16 p.s.i.) in a triple-wall corrugated fiberboard box, A, and in a cleated plywood box, B, each dropped 24 inches in a diagonal orientation to land on a bottom edge of the box. A' and B' are corresponding undamped shock spectra. (M 136 752)

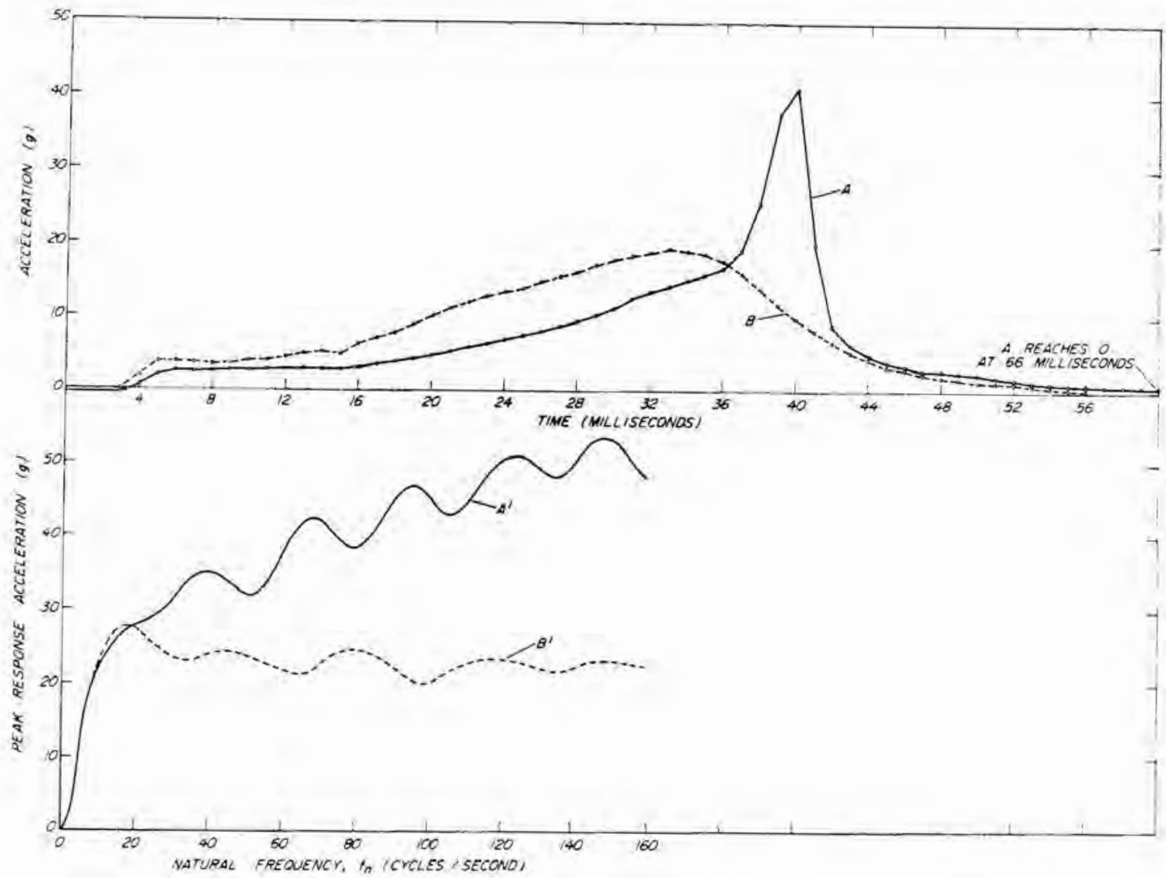


Figure 16.--The upper two curves are digitized acceleration-time records of the shock experienced by the dummy load cushioned with urethane foam corner pads (nominal static stress = 0.80 p.s.i.) in a single-wall corrugated fiberboard box, A, and in a double-wall corrugated fiberboard box, B, each dropped 24 inches in a diagonal orientation to land on a bottom edge of the box. A' and B' are corresponding undamped shock spectra. Note the sharp rise (spike) in the acceleration-time curve (A) for the single-wall box, beginning at about 37 milliseconds. This is an indication that the load actually bottomed in this test. The effect of this bottoming can be seen in the shock spectrum A', which shows a generally increasing peak response acceleration as systems with higher and higher natural frequencies are (theoretically) subjected to it.

(M 136 755)

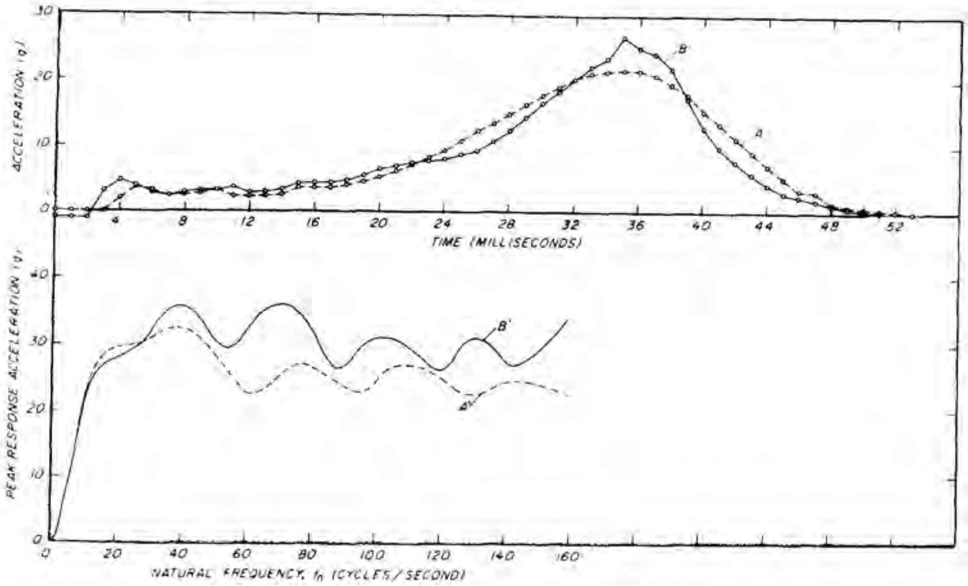


Figure 17.--The upper two curves are digitized acceleration-time records of the shock experienced by the dummy load cushioned with urethane foam corner pads (nominal static stress = 0.80 p.s.i.) in a triple-wall corrugated fiberboard box, A, and in a cleated plywood box, B, each dropped 24 inches in a diagonal orientation to land on a bottom edge of the box. A' and B' are corresponding undamped shock spectra.

(M 136 759)

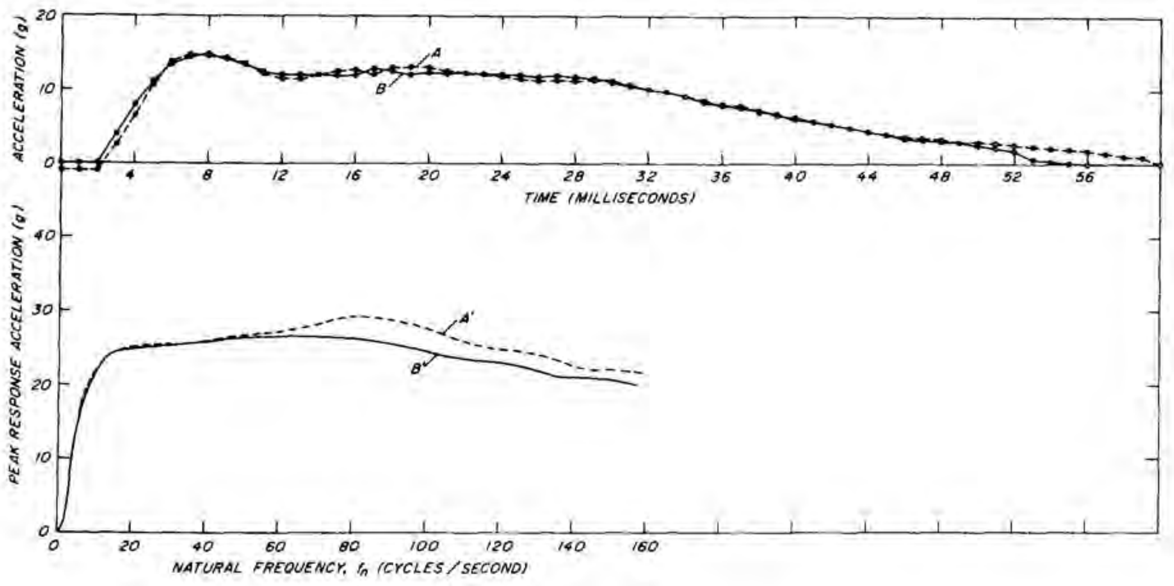


Figure 18.--The upper two curves are digitized acceleration-time records of the shock experienced by the dummy load cushioned with urethane foam corner pads (nominal static stress = 0.16 p.s.i.) in a single-wall corrugated fiberboard box, A, and in a double-wall corrugated fiberboard box, B, each dropped 24 inches in a diagonal orientation to land on a bottom corner of the box. A' and B' are corresponding undamped shock spectra.

(M 136 757)

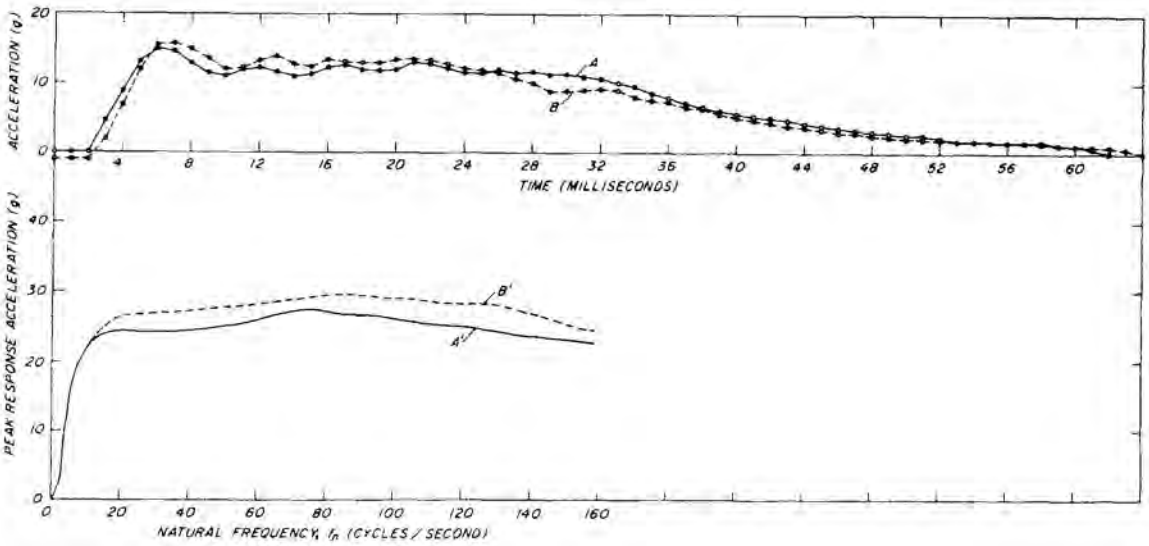


Figure 19.--The upper two curves are digitized acceleration-time records of the shock experienced by the dummy load, cushioned with urethane foam corner pads (nominal static stress = 0.16 p.s.i.), in a triple-wall corrugated fiberboard box, A, and in a cleated plywood box, B, each dropped 24 inches in a diagonal orientation to—land on a bottom corner of the box. A' and B' are corresponding undamped shock spectra.

(M 136 756)

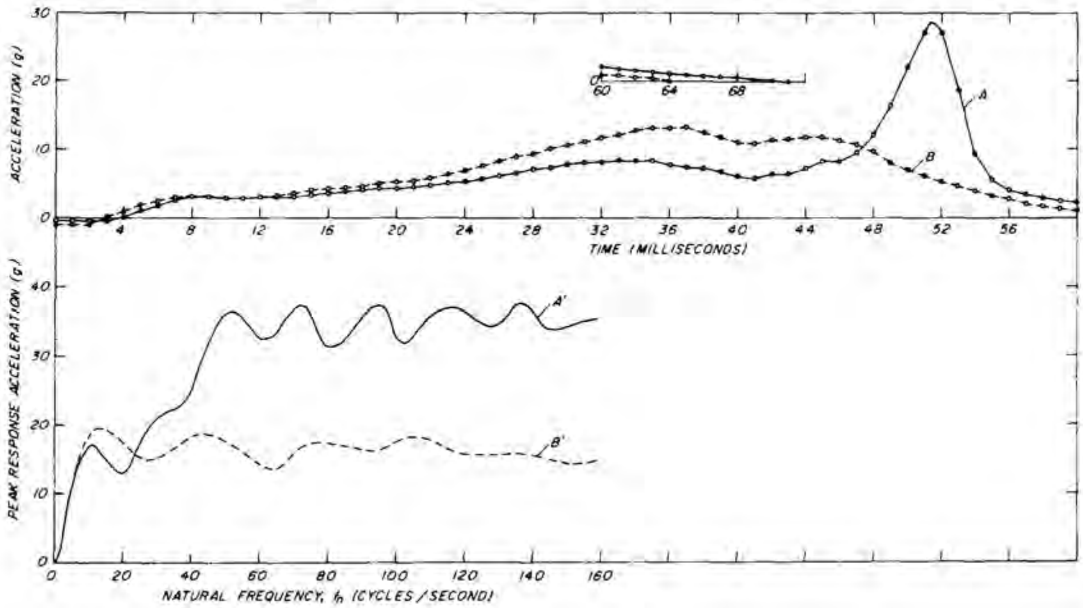


Figure 20.--The upper two curves are digitized acceleration-time records of the shock experienced by the dummy load, cushioned with urethane foam corner pads (nominal static stress = 0.80 p.s.i.), in a single-wall corrugated fiberboard box, A, and in a double-wall corrugated fiberboard box, B, each dropped 24 inches in a diagonal orientation to land on a bottom corner of the box. A' and B' are corresponding undamped shock spectra. As in the edgewise drop (fig. 16), the sharp rise, beginning at about 46 milliseconds, in the curve for the single-wall box indicates bottoming of the load. However, in the cornerwise drop (fig. 20) the bottoming was not as hard as in the edgewise drop (fig. 16). (M 136 742)

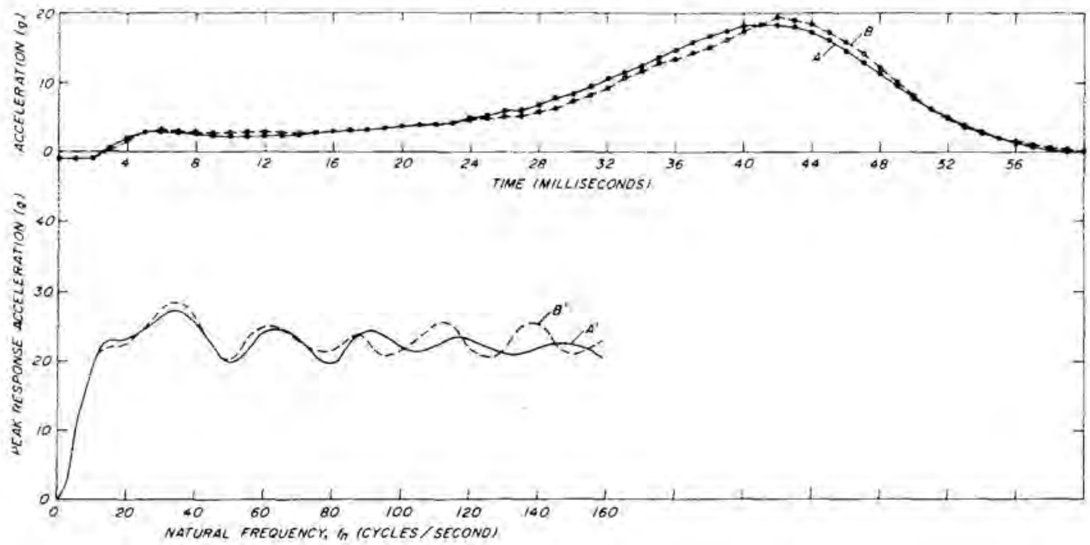


Figure 21.--The upper two curves are digitized acceleration-time records of the shock experienced by the dummy load, cushioned with urethane foam corner pads (nominal static stress = 0.80 p.s.i.), in a triple-wall corrugated fiberboard box, A, and in a cleated plywood box, B, each dropped 24 inches in a diagonal orientation to land on a bottom corner of the—box. A' and B' are corresponding undamped shock spectra.

(M 136 741)

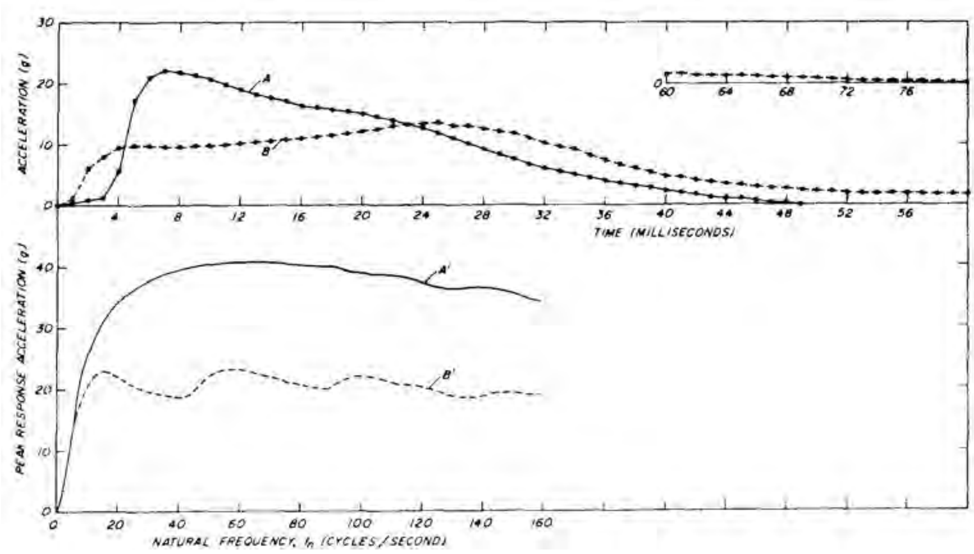


Figure 22.--Each of the upper two curves is a digitized acceleration-time record of the shock experienced by the pendulum head in an impact test of the cushion by itself. The static stress (weight of pendulum divided by area of cushion) was 0.081 p.s.i. for curve A and 0. 159 p.s.i. for curve B. A' and B' are corresponding undamped shock spectra. Curves A and A' are comparable with the curves in figure 9, because of close similarity of static stress. Similarly, curves B and B' are comparable with the curves in figure 10.

(M 136 743)

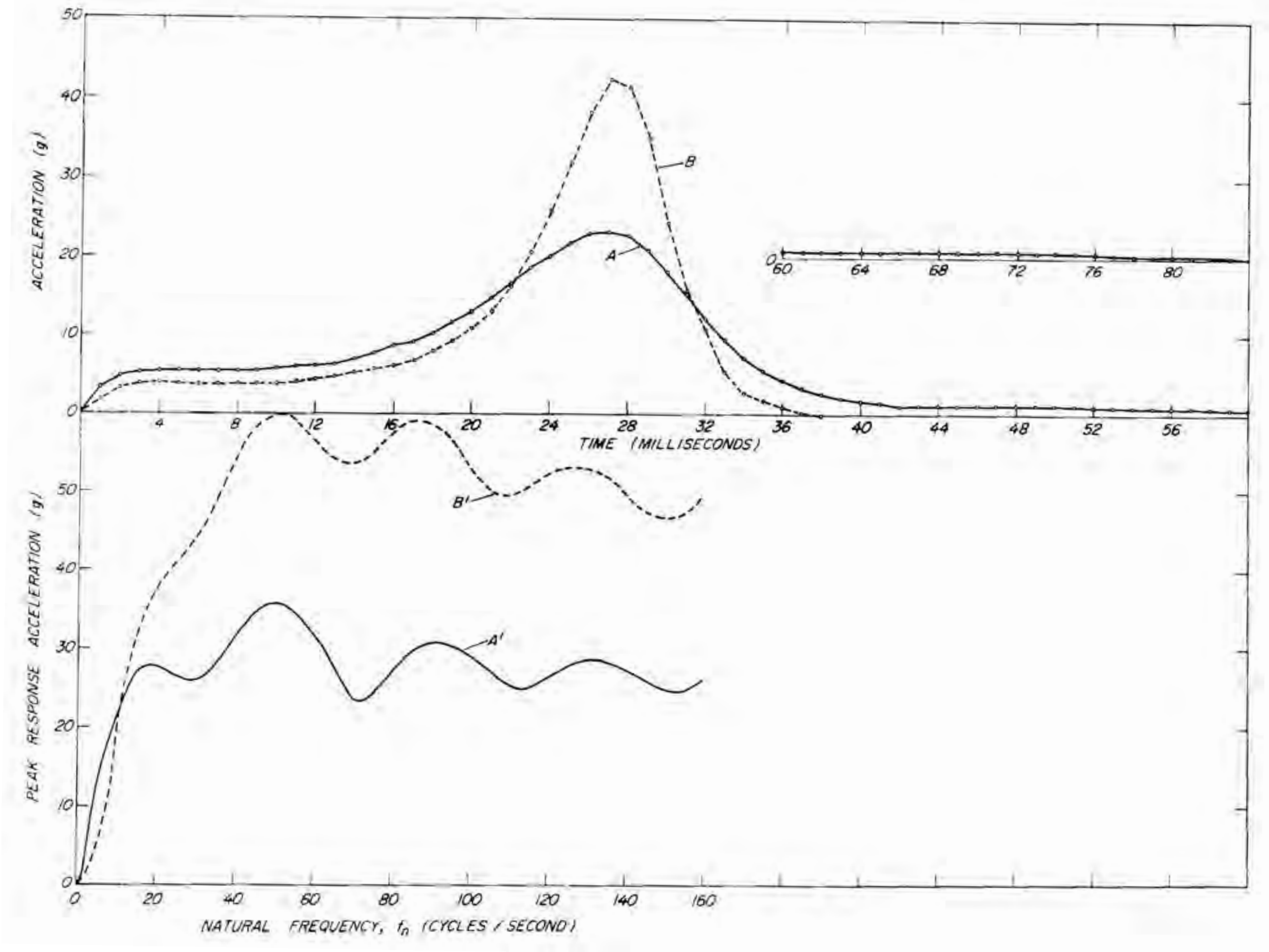


Figure 23.--Each of the upper two curves is a digitized acceleration-time record of the shock experienced by the pendulum head in an impact test of the cushion by itself. The static stress (weight of pendulum divided by area of cushion) was 0.28 p.s.i. for curve A, and 0.42 p.s.i. for curve B. A' and B' are corresponding undamped shock spectra. Curves A and A' are comparable with the curves in figure I I, because the same static stress applies. Likewise, curves B and B' are comparable with the curves in figure 12.

(M 136 758)

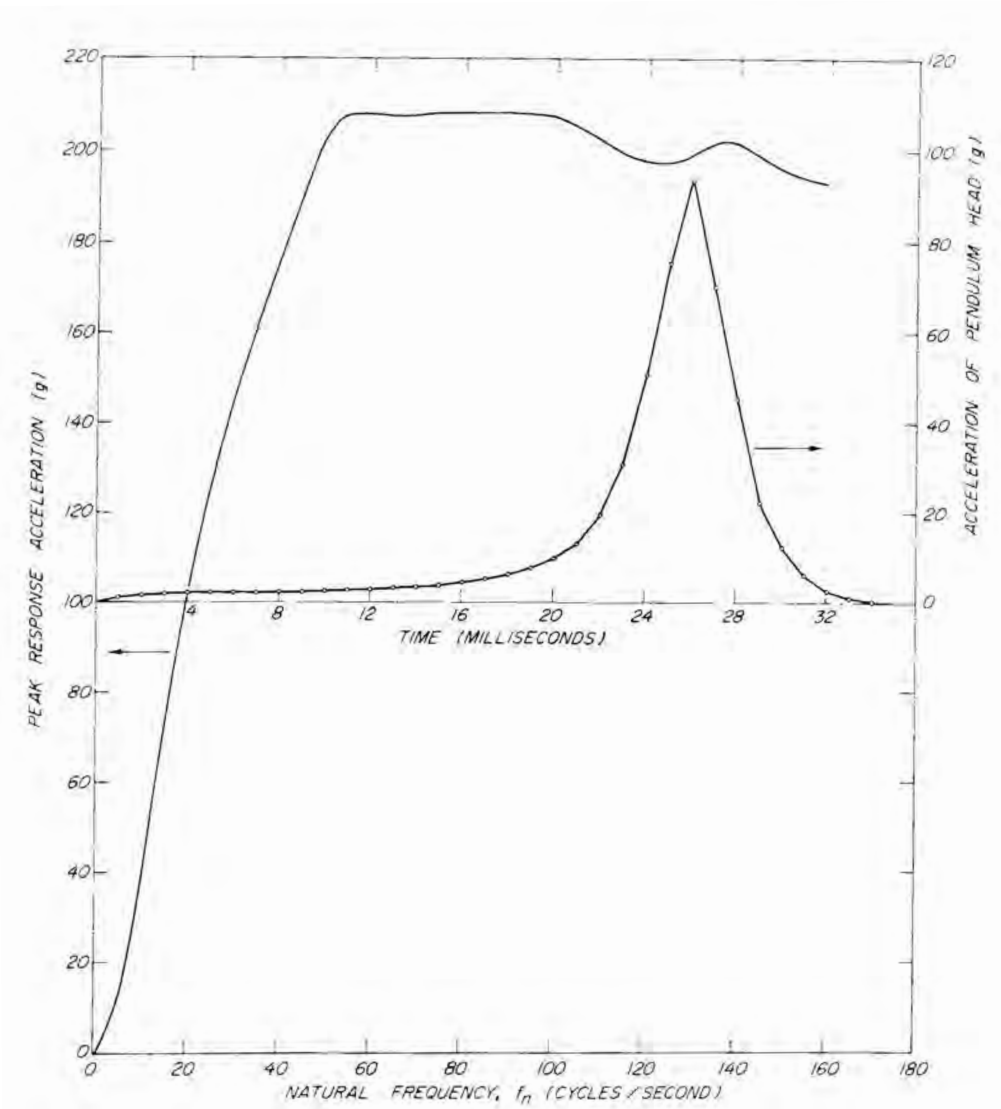


Figure 24.--The curve for the upper set of coordinates is the digitized acceleration-time record of the shock experienced by the pendulum head in an impact test of the cushion by itself. The static stress (weight of pendulum divided by area of cushion) was 0.80 p.s.i. The curve for the lower set of coordinates is the corresponding undamped shock spectrum. These curves are comparable, because of the similar static stress, to the curves in figure 13.

(M 136 745)

APPENDIX

Higher observed peak acceleration of the 4-pound load in flat drops of packages with cleated plywood boxes than in flat drops of packages with single-wall fiberboard boxes raised questions about possible differences in impact velocity. The cleated plywood box with 4-pound load weighed about 15 pounds. The single-wall fiberboard box with 4-pound load weighed about 6 pounds. Overall outside length and width dimensions were 14.75 inches for the cleated plywood box and 13.4 inches for the single-wall fiberboard box. Both differences (weight and overall size) could be expected to influence impact velocity, but in opposite ways.

A method of measuring impact velocity of dropped packages was devised, not in time to be used on the specimen packages of this study, however. It was used later to measure impact velocity of packages utilizing single-wall fiberboard and cleated plywood boxes, both with a 4-pound load.

The method employed a 6-foot length of 1/4-inch-wide magnetic recording tape on which had been recorded an oscillating signal, having an approximately triangular waveform, at 10 cycles per inch of tape length. One end of this tape was securely fastened at the top center of the package as it rested on the drop table. Then the tape was threaded across the face and over the top of a tape playback head mounted on a bracket directly above the package center. The free end was allowed to hang. The playback head was connected to the tape recorder, as were the terminals of the start-of-collision circuit and a timing oscillator operating at 1,000 cycles per second. While the package was falling, it pulled the tape across the face of the playback head which produced an oscillating signal having steadily increasing frequency. Each one-tenth inch of package fall produced one cycle of recorded signal. The elapsed time, in seconds, to complete the last five cycles was determined from the timing signal. Dividing the one-half-inch distance by this value of time gave the average velocity over the last one-half inch of fall.

Using this method, impact velocities of 133.3 and 130.1 inches per second were determined for the cleated plywood and single-wall fiberboard boxes, respectively, each with the 4-pound load and each dropped flatwise a measured 24 inches.

This difference in impact velocity could be expected to result in higher peak acceleration of the load in the plywood box than in the single-wall fiberboard box when both contained the 4-pound load.

Next, the four pads bearing against the bottom of the box were removed and, with the top of the box open, weights were superimposed incrementally on the 4-pound dummy load (supported by only the cushion pressure against its vertical sides) until the load started to slip downward. This occurred when superimposed load reached 5.6 pounds for the single-wall fiberboard box and 8.1 pounds for the cleated plywood box. This difference is attributed mainly to differences in the stiffness of the sides of the two kinds of boxes. More of the side cushion pressure was relieved by bending (bulging) of sides in the fiberboard than in the plywood box. Thus, there are two factors (higher impact velocity and greater side-cushion drag) that could contribute to higher peak acceleration in the plywood than in the fiberboard boxes during flat drops with the lightest load.

ABOUT THE FOREST SERVICE. . . .

As our Nation grows, people expect and need more from their forests--more wood; more water, fish and wildlife; more recreation and natural beauty; more special forest products and forage. The Forest Service of the U.S. Department of Agriculture helps to fulfill these expectations and needs through three major activities:

* Conducting forest and range research at over 75 locations ranging from Puerto Rico to Alaska to Hawaii.

* Participating with all State forestry agencies in cooperative programs to protect, improve, and wisely use our Country's 395 million acres of State, local, and private forest lands.

* Managing and protecting the 187-million acre National Forest System.

The Forest Service does this by encouraging use of the new knowledge that research scientists develop: by setting an example in managing, under sustained yield, the National Forests and Grasslands for multiple use purposes: and by cooperating with all States and with private citizens in their efforts to achieve better management, protection, and use of forest resources.

Traditionally, Forest Service people have been active members of the communities and towns in which they live and work. They strive to secure for all, continuous benefits from the Country's forest resources.

For more than 60 years, the Forest Service has been serving the Nation as a leading natural resource conservation agency.