INFLUENCE OF VARIOUS FACTORS ON CUSHION LOADING RATE

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ABSTRACT

INFLUENCE OF VARIOUS FACTORS ON
CUSHION LOADING RATE

By

Karl Sheu

The physical properties of many plastic cushion foams vary with the rate of load applied. This means that the loading rate will affect its performance. Thus, loading rate should be considered as one of the design criteria for package-cushion design. This study was intended to evaluate some factors which would influence the loading rate of cushions under test condition and in practice.

INFLUENCE OF VARIOUS FACTORS ON CUSHION LOADING RATE

By

In-Laang Karl Sheu

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INTRODUCTION

Foamed polymeric materials possess properties which make them applicable as impact absorbers. They can undergo large compressive deformation and absorb relatively large amounts of energy during deformation. However, the mechanical properties of many cushioning foams vary with the rate of loading applied; i.e., they exhibit rate-dependent behavior. The rate-dependence can be due to various factors, such as the structure of foams, compression of gas in closed cells as well as the rupture of closed-cell walls.

The generally accepted dynamic testing methods of cushioning materials, for example ASTM Test Method D1596, more or less ignore the cushioning quality of the container itself and some other factors which could cause the change of loading rate. A series of analyses was proposed for studying loading rate and investigating those variables which could affect loading rate. Among them are:

1. Effect of drop height on loading rate.
2. Effect of variation of cushion thickness on loading rate.
3. Effect of container variation on loading rate.
4. Effect of temperature variation on loading rate.
5. Effect of shape variation of cushioning materials on loading rate.

No consideration was given to humidity, difference in manufacturing process, or other possible variables.

In this study, emphasis would be placed on the interrelation of loading rate in different types of tests rather than on the correlation of mechanical behavior of foams with their material properties. Besides, this study was not intended to be a thorough evaluation of shock response or loading rate of the package tested, but only comparison which would indicate those factors that could contribute the change of loading rate. Nor was it intended to make a quantitative study of the effect of those factors.

TESTING PROCEDURE

Selection of Sample

Almost all the package-cushion foams available are rate-dependent and are in many different densities, shapes, thickness, etc., and can be in the form of molded, die-cut or extruded pads. In this test, Dow Ethafoam 220(2.2 PCF), an extruded material, was used.

Sample Conditioning

For each single loading test in the series, a new sample must be used. After cutting the samples were exposed at least for seven days in a humidity room (70±2°F, 50±2 percent R.H. and good air circulation). This program makes sure that the cushioning materials would approach equilibrium moisture content from the previous condition.

Dynamic Loading Test

The basic equipment required consists of a shock machine, a dummy load, and acceleration measuring and recording equipment. The procedure followed is to construct a dummy load, instrument this load and package it in a variety of ways depending on the factors to be observed. It was intended only to observe the effect of drop height on loading rate in this test. No container was used here.

The dummy load used by School of Packaging is an 8 x 8 inch wooden block. With the cushion size set at 8 x 8 inches the cushion loadings are accompanied by use of metal plates resting on the cushions. Discrete weights of metal plates were used to encompass the useful cushion-loading range. The determination of optimum stress loading in the block was purely empirical. The weight of test block and metal plates was 39.25 pounds.

A fixture was secured over the block and made immovable by setting a nut above the bar and one below it. This restrained the block from moving upward away from the table and restrained the bar from moving towards the table, which would increase the stress on the block during shock. An accelerometer was mounted in the block so that transient acceleration pulse applied to the block in a vertical direction could be monitored. The impact in the test was measured by using a coupler in conjunction with the accelerometer. The output from the accelerometer was fed into a storage oscilloscope. The peak "G" level and the duration of the impact pulse were recorded.

In the drop test, the beginning drop height was 4 inches and was increased by 4 inches on each successive drop until 24 inches was reached. After each drop, each cushioning material was replaced by a new one before making the next drop. This was felt to be more realistic, since it eliminated the possible cumulative effect of repeated impacts on the same cushion.

Test Calculation

The peak acceleration and the duration time received by the oscilloscope were recorded. The method of calculation of loading rate is shown in Appendix I. A loading rate list was thus obtained and made the comparison readily available.

DATA PRESENTATION

A literature review showed that no data have been available to evaluate the effect of drop height on loading rate. Actual laboratory work was done to calculate the loading rate.

Effect of Drop Height

The test method was described in the previous part. The peak acceleration and duration time are presented in Table 1, along with the values of loading rate.

Table 1. Loading Rates for Various Drop Heights

Drop Height in Inches	Shock in g's	Duration in msec	Loading Rate in 10^6 lbs/min
4	21	20	4.94
8	27	22	5.78
12	35	22	7.50
16	43	22	9.20
20	61	20	14.36
24	78	18	20.40

The following analyses of the other influencing factors were derived from the existing data. The most common type of data is the "cushion curve." The cushion curve shows what peak acceleration will be transmitted by various thickness of cushion for different values of static stress. A considerable number of cushion curves have been generated. The solution for cushion loading rate, however, requires the values of peak acceleration and duration time for each drop.

The school of Packaging has run extensive drop tests for cushioning materials in the past several years. Some data are in the form ready for use. Cushion curves with acceleration-time records of the shock prepared by Forest Products Laboratory (FPL) can be also used for the analysis. The FPL employed different measuring systems from that used by the School of Packaging. It is not intended here to evaluate the variation of test measuring devices. However, comparison of the results for the purpose of evaluating each influencing factor must be based on the same measuring instruments to eliminate instrument variation.

Effect of Cushion Thickness

An arm type package drop tester was used to conduct the drop tests (8). A drop height of 30 inches was set for all cushioning materials. Both A-flute and B-flute boxes were used. The weight of the dummy load was 11.5 pounds. The test data and loading rates are shown in Table 2. Although the concentration was on plastic foams in this study, there are many cushioning applications for corrugated board loaded as a cushioning pad. Corresponding test results for currugated pads are presented in Appendix II.

Other test data developed at MSU (7) were expressed in peak acceleration and velocity. The conversion of these data into the form of peak acceleration and duration time

Table 2. Loading Rates for Various Thickness of Foams

Cushioning Material	Thickness in Inches	Box Used*	Shock in g's	Duration in msec	Loading Rate in 10^7 lbs/min
Dow Ethafoam	1	A	89.7	6.0	2.06
Dow Ethafoam	2	A	67.8	7.0	1.37
Delvatex Type K	1	A	81.2	6.0	1.87
Delvatex Type K	2	A	55.4	7.5	1.02
Swedish Crucible Expanded PS	2	B	90.5	6.0	2.08
Swedish Crucible Expanded PS	3	B	75.2	6.0	1.73
Swedish Crucible Expanded PS	4	B	70.4	7.5	1.29
Leewood PE 13	2	B	83.3	6.0	1.92
Leewood PE 13	3	B	76.5	6.0	1.76
Leewood 7B Polyurethane	2	B	61.0	8.0	1.05
Leewood 7B Polyurethane	3	B	51.5	9.0	0.79
Toyad NF Chemfoam	2	A	49.1	11.0	0.62
Toyad NF Chemfoam	3	A	32.0	13.0	0.34

*Box used: A = A-flute box

B = B-flute box

is required. A means of doing this is described in reference 12. If it is supposed that the rebound velocity was 20 percent of the impact velocity, then the velocity change would be 120 percent of the impact velocity. The duration time which corresponds to a specific drop can be computed from these equations:

$$A_m \times 386.4 \times \tau \times 10^{-3} = \Delta V$$

$$\Delta V = 1.2 \times V$$

where:

A_m = peak acceleration,

τ = duration time, msec,

V = impact velocity, inches/sec, and

ΔV = velocity change, inches/sec.

Therefore, τ can be obtained through the equation:

$$\tau = \frac{1.2 \times V \times 10^{3}}{386.4 \times A_m}$$

The thickness of cushioning material, container used, shock, duration time, and the corresponding loading rate are shown in Table 3 for those cushions examined in reference 7.

Effect of Cushion Shape

The only available information about the effect of cushion shape on loading rate was derived from references 13 and 14. The tests were conducted on urethane foams and expressed as curves of acceleration-time records. Single-wall 200 pound test B-flute corrugated boxes were used. Each package was dropped 24 inches to land flatwise on the bottom of the box. The relevant figures are summarized in Table 4.

Table 3. Loading Rates for Various Thickness of Firm Reclaimed Polyurethane

Thickness in Inches	Plate Weight in lbs.	V in inches/sec	Shock in g's	Duration in msec	Loading Rate in 10^6 lbs/min
1.983	4.0	152.7	54.3	7.3	4.29
1.983	4.5	150.8	54.5	7.2	4.89
1.983	5.0	152.7	54.9	7.2	5.49
1.983	5.5	152.8	56.1	7.0	6.33
1.983	6.0	152.7	59.7	6.6	7.83
1.983	6.5	153.3	61.5	6.5	8.85
1.983	7.0	151.5	61.8	6.3	9.86
1.983	7.5	152.0	61.4	6.4	10.40
1.983	10.0	152.7	72.9	5.4	19.44
1.983	15.0	151.6	90.4	4.3	45.41
2.041	4.0	152.2	51.9	7.6	3.93
2.041	4.5	151.9	54.3	7.2	4.86
2.041	5.0	153.5	53.0	7.5	5.09
2.041	5.5	152.8	54.8	7.2	6.03
2.041	6.0	153.5	59.0	6.7	7.61
2.041	6.5	152.6	60.7	6.5	8.73
2.041	7.0	152.4	60.6	6.5	9.41
2.041	7.5	151.8	61.8	6.4	10.41
2.041	10.0	152.8	67.7	5.8	16.80
2.041	15.0	153.0	84.8	4.7	34.46

The corresponding figures for corrugated board are presented in Appendix III.

Table 4. Loading Rates for Various Shapes of Urethane Foam

Shape of Foam	Dummy Load in lbs	Shock in g's	Time in msec	Loading Rate in 10^5 lbs/min
Side Pads	4.0	32.9	24.0	6.58
" "	7.8	21.4	30.8	6.50
" "	20.6	22.9	36.0	15.72
" "	34.0	32.9	36.0	37.28
" "	43.5	43.1	31.1	72.34
Corner Pads	4.0	22.5	31.0	3.48
" "	7.8	14.3	42.3	3.18
" "	13.7	19.3	42.9	7.40
" "	20.6	35.0	39.0	22.18
" "	39.2	56.3	35.0	75.66

Effect of Container

The container effect is observed to be an important factor in the performance of cushioned packages utilizing the side pads and corner pads for cushion application (13, 14). Either single-wall 200 pound test B-flute boxes or cleated plywood boxes were used. Each package was dropped flatwise from a height of 24 inches. The relevant data are shown in Table 5.

Table 5. Loading Rates for Urethane Foam Using Two Different Containers

Cushion Shape	Container Used*	Dummy Load in lbs.	Shock in g's	Time in msec	Loading Rate in 10^5 lbs/min
Side Pads	C	4.0	32.9	24.0	6.58
" "	P	4.0	37.9	33.0	8.10
" "	C	7.8	21.4	30.8	6.50
" "	P	7.8	21.0	32.0	6.14
" "	C	20.6	22.9	36.0	15.72
" "	P	20.6	16.4	42.0	9.66
" "	C	34.0	32.9	36.0	37.28
" "	P	34.0	18.6	49.1	15.46
" "	C	43.5	43.1	31.1	72.34
" "	P	43.5	23.6	44.0	28.00
Corner Pads	C	4.0	22.5	31.0	3.48
" "	P	4.0	23.8	32.0	3.58
" "	C	7.8	14.3	42.3	3.18
" "	P	7.8	15.0	38.0	3.72
" "	C	13.7	19.3	42.9	7.40
" "	P	13.7	17.9	42.3	6.96
" "	C	20.6	35.0	39.0	22.18
" "	P	20.6	20.0	39.0	12.68
" "	C	39.2	56.3	35.0	75.66
" "	P	39.2	43.8	36.0	57.24

*Container Used: C = Corrugated Box

P = Plywood Box

DISCUSSION

Although so far the factors which affect the loading rate are not completely known, it is evident that drop height, cushion thickness, container type, and cushion shape do influence the loading rate. The effect of temperature will be discussed later on.

Close examination of the drop testing data revealed that loading rate varies with drop height. The higher the drop height is, the higher loading rate the cushion will experience. This is due to the high peak acceleration and short duration time the cushion is subjected to when dropped from a considerable height. For one case, the loading rate at 24-inches drop is almost four times as large as the one at 4-inches drop. For this reason, adequate consideration of the drop height is necessary.

Another influencing factor is the cushion thickness. The shock level and duration time experienced at various thickness indicates that loading rate decreases with the increase of cushion thickness. This can be related to the general idea that thick cushioning material tends to give more protection on product than thin cushioning material; i.e., it can decrease the loading rate on the cushion and eliminate the product damage. While overpackaging or underpackaging are equally undesirable, a further investigation of the influence of cushion thickness is essential.

The third factor arises from the consideration of cushion shape. It is obvious from the test data that corner pads experienced substantial lower loading rates than side pads. In drop testing, some kinds of cushion shape may prove to be more protective than other shapes of the same material. The reason is that some configurations tend to distribute the force (or energy) received throughout the whole cushion and hence decrease the loading rate. Every change in dimension and geometric configuration should be thoroughly examined for possible loading rate change.

The fourth factor involved the consideration of the effect of the type of container. The container effect was found to be an important factor in determining the severity and the duration of shock experienced by the contents of a cushioned package during rough handling. As shown in Table 5, the advantage of heavily loaded cleated plywood boxes is evident. However, plywood boxes have somewhat less shock protection for the light loads than did the single-wall fiberboard boxes. This result would lead to an assumption of possible differences in shock level and duration time and in the resistance to downward movement of the dummy load provided by friction between the cushion and the vertical side panels of the container. The difference at high static stress for packages involving fiberboard boxes and plywood boxes could be attributed to the energy absorption by the containers themselves. This example reveals the complexity of container problem.

Unfortunately, it is not possible to obtain the information regarding the temperature effect on loading rate. However, temperature does have some influence on loading rate. Some work has been done on determining the effect of temperature extremes on the properties of package-cushioning materials. Most of the programs devoted to such research involved static testing, while others included dynamic loading on the materials. The results of these tests performed on various samples of PE foam, vinyl foam, and latex foam are mostly in the forms as load versus deflection at room temperature, low temperature, and elevated temperature.

Dynamic testing data in reference 5 revealed that for a given static stress on a specific thickness of a typical flexible polyurethane cushioning material, higher peak acceleration and shorter duration time would be obtained for a drop test at -65°F than for one at room temperature (70°F). Some plastic foams, such as flexible polyurethane and polyvinyl chloride foams, appear to increase in stiffness continuously from 60°F to -50°F, becoming almost rigid at 30°F. Also rubber and rubber-bonded materials in general appear to increase peak acceleration with a decrease in temperature. However, the effect of temperature on the package, the foam and container, is quite another story. It is to be noted that the change of loading rate is not simply the combination of the changes on the cushion and container. All presentations to define loading rate change at temperature extremes must be examined carefully.

No attempt is made here to evaluate the cumulative degradation of the package protection caused by repeated package impact, as would be experienced in service. Neither is there any attempt to evaluate creep effect that might alter the cushion loading rate after extended storage periods during which the cushions support the dead weight of the content. It must be borne in mind, however, that the load-compression curve and dynamic response of some cushioning foams are sensitive to previous compression history of the foams, exhibiting a decreasing stiffness and load-bearing capacity with an increasing number of compression cycles. Not all cushion foams exhibit such a property. Some foams are almost completely free from the effect of a previous compression history. Two examples (8) are shown in Table 6.

One interesting result has been pointed out by Wilson (15) that both static and dynamic tests have established that there is a significant increase in the effective stiffness of a cushion when it is enclosed. This increase must be considered when designing protective packaging. The energy absorbed by a cushion increases when the lateral expansion of the cushion is restrained. This measure must be adopted in cushion testing because the generally accepted testing methods deal with the materials only rather than considering the whole package as a complete system.

So far, no direct evidence supports the assumption for the calculation of loading rate made in Appendix I. One recent report by Notle (16) indicated that the approximation

Table 6. Influence of Compression History on Loading Rate

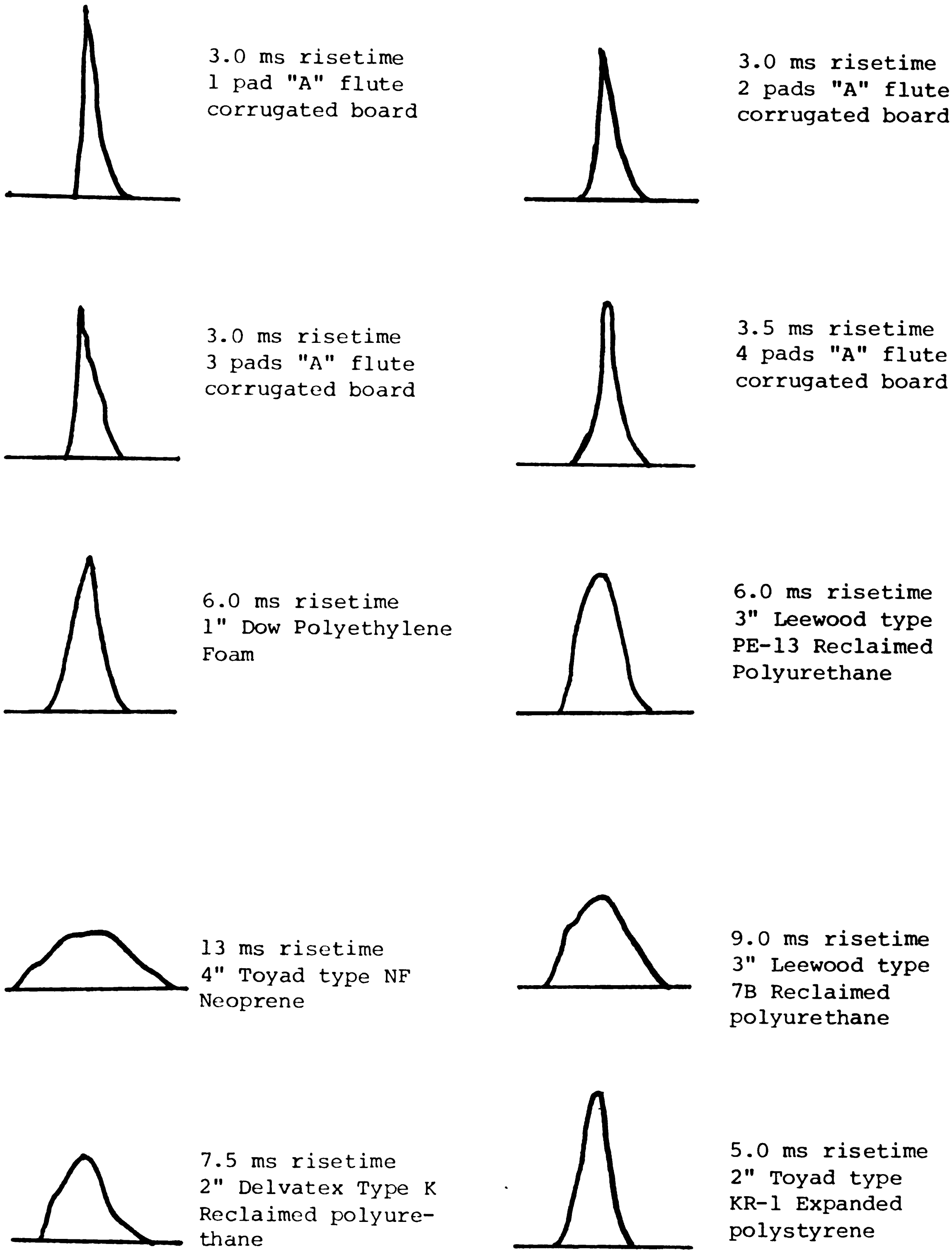
Cushioning Material	Drop No.	Shock in g's	Time in msec	Loading Rate in 10^6 lbs/min
Leewood 7B 2" Polyurethane	1	61.1	8.0	1.05
"	2	61.1	8.0	1.05
"	3	61.1	8.0	1.05
"	4	61.1	8.0	1.05
"	5	61.1	8.0	1.05
"	10	61.1	8.0	1.05
"	15	61.1	8.0	1.05
"	20	61.1	8.0	1.05
"	25	61.1	8.0	1.05
Toyad NF 2" Chemfoam	1	49.1	11.0	0.62
"	2	50.9	11.0	0.64
"	3	55.9	11.0	0.70
"	4	57.2	11.0	0.72
"	5	57.2	11.0	0.72
"	10	58.4	11.0	0.73
"	15	59.7	11.0	0.75
"	20	60.9	11.0	0.76
"	25	60.9	10.5	0.80

of irregular loading by intervals of constant stress rate to predict creep and relaxation of polyurethane. Stressing which varies with time in an irregular manner can be approximated by intervals of constant rate. This gives some implication that the approximation of irregular loading by constant loading rate as used in Appendix I could be a reasonable one because dynamic testing is a fast procedure, in which the duration time is expressed in milliseconds.

Obviously, each cushioning material exhibits a characteristic shape of the shock pulse. The shock shape is essentially the way in which the amplitude changes with time. The shape of the shock pulse is dependent on the energy dissipated during the impact, which in turn depends on the package, the contents, as well as the surface the package strikes. Figure 1 (8) illustrates the shock pulses received by the dummy load during flat drop tests. These pictures were hand duplicates of polaroid photograph of oscilloscope traces. For certain shapes the shock pulse, especially those centrally symmetric pulses, the calculation of loading rate may be closer to the approximation used in Appendix I than those with irregular shapes.

The interpretation of data calls for an exercise of judgment, and differences of opinion would arise even if all of the figures were available. For one thing, it is important to note the damping effect of cushioning material. This phenomenon may cause the complex shapes of the shock pulse and result in change of the loading rate. The determination of the values of peak acceleration and duration time requires careful consideration.

In conducting a test to determine the loading rate, the package is subjected to an impact on a rigid surface. Ideally, surfaces on which packages might be dropped range from concrete floors, truck beds, to identical packages. Each of these surfaces will result in a different shock. Thus, each will impose a different loading rate. In actual distribution,



Source: Redrawn from reference 8, p. 14.

Figure 1. Typical package flat drop test shock pulses.

containers usually rebound to some extent immediately after a flat drop. This phenomenon causes the increase of peak acceleration experienced by the item. No attempt has been made in this study to investigate the loading rate under such conditions.

CONCLUSIONS

In review, the loading rate under dynamic test is in the range of 10^5 to 10^7 pounds per minute. This is a tremendously high value. Some cushions either broke down or bottomed out under high loading rates. Not only did the physical properties of cushioning materials have significant changes, but also the shock responses of the packages exhibit extraordinary behavior under such conditions. However, little work has been done in this area. This probably goes unnoticed in many cases because conventional methods do not stress either the importance of loading rate or the factors which affect loading rate.

Generally, the conventional testing methods, those employing the dynamic testing principal, seek to:

1. simulate as nearly as possible, with a compact and simple device, the effects of rough handling and drop on a cushioned product;

2. record as accurately as possible the results of the tests;

3. determine to varying degrees of accuracy the possible effects of complex dynamic responses and their usefulness as design criteria.

Further study is recommended to investigate the possible quantitative relationships between loading rate and those influencing factors. It would be possible to obtain

more accurate results using electronic differentiator and automatic recording instruments in future cushion evaluations. The differentiator would automatically determine the slope of each point along the curve and locate the maximum slope which is the loading rate. It is believed that more accurate and applicable information can be obtained through this approach.

APPENDICES

APPENDIX I

CALCULATION OF LOADING RATE FROM SHOCK PULSES

APPENDIX I

CALCULATION OF LOADING RATE FROM SHOCK PULSES

The shock pulse generated in a drop is generally an approximate half-sine wave (Figure I.1). The amplitude of a shock is commonly measured in "g's" (acceleration of gravity). The horizontal axis represents the length of time or duration of shock. By definition, loading rate is the force applied over certain periods; i.e., pounds per minute in this study. For dynamic testing, loading rate can be best represented by the maximum slope of the shock pulse.

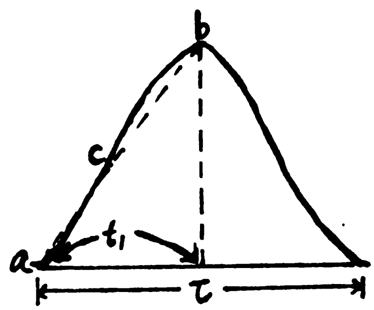


Figure I.1. Sine wave.

The slopes of the curve at point a and point b are approximately equal to zero. The slope reaches maximum at point c. Thus, the slope at c can be used to represent the loading rate. Since slope varies along the curve, an approximation for the loading rate can be reached by plotting a straight line between point a and point b. The slope of the straight line could be regarded as the slope of the curve at point c; i.e., the approximate value of the loading rate. Therefore, the loading rate is equal to

$$R = \frac{A_m \times W}{t_1} \times 60 \times 10^3$$

where:

R = loading rate, in lbs/min.,

t_1 = duration time between a and b, in msec.,

W = weight on the cushion, in lbs., and

A_m = peak acceleration divided by acceleration of gravity.

Generally, shock data are reported in the form of peak acceleration and total duration time rather in partial duration time as t_1 in the curve. Therefore, a second approximation is required. A simple solution could be obtained by assuming the partial duration time t_1 equal to one half of the total duration time; i.e.,

$$t_1 = \frac{\tau}{2}$$

where τ is the total duration time in msec.

Accordingly, loading rate from dynamic testing could be computed from the equation:

$$R = \frac{W \times A_m}{t_1} \times 10^3 \times 60$$

$$= \frac{W \times A_m}{\tau} \times 1.2 \times 10^4$$

APPENDIX II

INFLUENCE OF THICKNESS OF CORRUGATED PADS ON LOADING RATE

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INFLUENCE OF THICKNESS OF CORRUGATED PADS ON LOADING RATE

The four groups of data presented here (8) were derived by utilizing instrumented dummy loads cushioned with A-flute 200 pound test corrugated pads. A-flute containers were used. Each package was dropped 25 times. Only drop 1 was recorded here.

Group 1 used one corrugated pad placed so that the flutes ran at right angles to the flutes directly beneath. This meant that the dummy load was cushioned by three layers of corrugated board (two flap layers and one pad). Each layer of board had the flutes running at right angles to the layers adjacent to it.

Group 2, 3, and 4 used two, three, and four pads, respectively. In each case, the flutes were placed at right angles to those in the adjacent layers.

The weight of the dummy load was 11.5 pounds. Table II.1 shows that loading rate decreases as the thickness increases (or the number of pads used increases).

Table II.1. Loading Rates for Corrugated Boxes with Various Thickness

Group	Shock in g's	Duration in msec	Loading Rate in 10^6 lbs/min
1	123	3.0	5.64
2	141	3.0	6.49
3	103	3.0	4.74
4	85	3.0	3.36

Group 2 is exceptional, possibly due to experimental error.

APPENDIX III

LOADING RATES OF SELECTED CREASED CORRUGATED PADS

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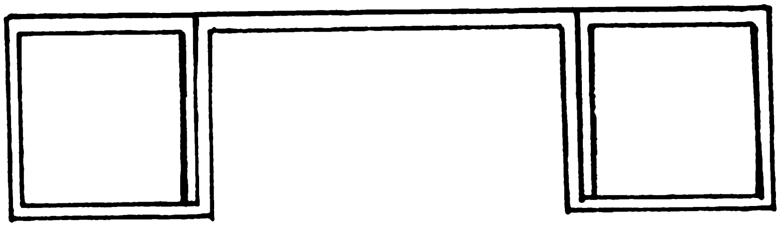
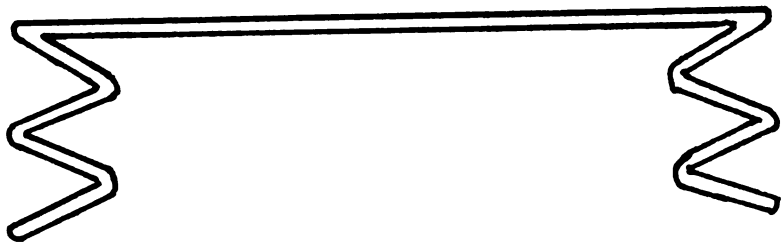
LOADING RATES OF SELECTED CREASED CORRUGATED PADS

The data were based on reference 10. The corrugated boards used in the construction of the test pads were 200 pound test or 275 pound test C-flute board. The three pad styles chosen are presented in Figure III.2. Finished pad dimensions for all pad style were 8" x 8" x 2". Each package was dropped from a height of 30 inches. The package drop tester employed was an L.A.B. spring loaded tester. The test data are shown in Table III.2 and Table III.3.

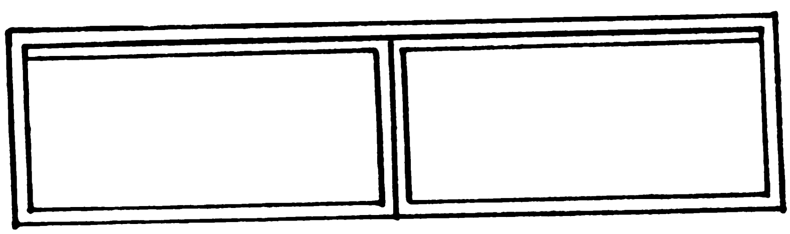
It is interesting to note the loading rate variation under different static stresses. For pad style A, it exhibits considerably high loading rate under low static stress. While under high static stress, 0.304psi or higher, pad style A appears to have lower loading rate as compared with the other two pad styles, especially in the use of 275 pound test board. Apparently, loading rate depends on the stress applied, pad material, and pad style.



STYLE A PAD



STYLE B PAD



STYLE C PAD

Source: Redrawn from reference 10, p. 3.

Figure III.2. Styles of corrugated pads.

Table III.2. Loading Rates for 200 Pound Test Pads with Various Styles

Pad Style	Stress in psi	Dummy Load in lbs	Shock in g's	Duration in msec	Loading Rate in 10^6 lbs/min
A	0.192	12.3	37	10.0	5.46
B	0.192	12.3	28	18.2	2.28
C	0.192	12.3	28	16.4	2.52
A	0.304	19.5	11	13.6	1.90
B	0.304	19.5	16	11.8	3.18
C	0.304	19.5	11	12.7	2.02
A	0.417	26.7	11	17.3	2.04
B	0.417	26.7	12	14.5	2.66
C	0.417	26.7	11	25.0	1.40

Table III.3. Loading Rates for 275 Pound Test Pads with Various Styles

Pad Style	Stress in psi	Dummy Load in lbs	Shock in g's	Duration in msec	Loading Rate in 10^6 lbs/min
A	0.192	12.3	31	10.0	4.20
B	0.192	12.3	30	12.7	3.48
C	0.192	12.3	30	14.5	3.06
A	0.304	19.5	16	10.9	3.44
B	0.304	19.5	11	10.9	2.36
C	0.304	19.5	5	20.0	0.58
A	0.417	26.7	11	12.7	2.78
B	0.417	26.7	11	4.5	7.84
C	0.417	26.7	7	5.5	4.08

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