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DEVELOPMENT OF OPTIMIZATION PROCEDURE FOR DESIGN OF PACKAGE CUSHIONING

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Southwest Research Institute

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CUSHIONING MATERIALS	VIBRATION ISOLATION	TEMPERATURE	INTERPOLATION
	VIBRATION ISOLATORS	TEMPERATURE EFFECTS	EXTRAPOLATION

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

The objective of this project was to develop a computer-aided design procedure which will utilize an optimization technique that will select available materials and define the material or combinations of materials that will provide the protection to a packaged item from the expected shipping environment, at the least cost.

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20. Abstract (Contd.)

The basic cushioning problem is assumed to be one-dimensional and must therefore be solved independently for each of the three orthogonal directions It is recognized that such a formulation is a considerable simplification from reality; however, in order to develop an optimization scheme that can utilize the bulk of presently available data, it is necessary to start from this point.

The most recent design developments for vibration isolation recognize the great utility of the complex modulus of a material for characterizing its vibration isolation properties. Therefore, the complex modulus method is the basis for our mathematical formulation.

A direct mathematical method for shock isolation is being used. It is a relatively simple design approach which can be formulated for mathematical computations by use of the typical cushioning materials design data, which is peak acceleration versus static stress for given drop heights.

Based on the data available, the temperature influence on materials will be utilized in this program. Ambient temperature variations over wide ranges have a significant influence on cushioning material properties. Unfortunately data for such variations are extremely scanty.

FOREWORD

This report prepared by the Southwest Research Institute under contract DAAG17-73-C-0239 describes a computer program for the least cost design of package cushioning systems. The effort was part of a program for the optimum design of packaging systems sponsored through the AMC CAD-E program under project no. 1E662703A090, Design, Analysis and Optimization of Structures. Requests for the program resulting from this work can be directed to Earl C. Steeves or Frank D. Barca at the U. S. Army Natick Laboratories.

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I. INTRODUCTION

The objective of this project was to develop the computer software for a cushion property and cost optimization procedure for the design selection from available package cushioning materials. The design problem relates to the use of existing cushioning materials to protect large quantity supply items from shock and vibration damage. Current state-of-the-art design procedures and criteria were used.

The General Equipment and Packaging Laboratory (GEPL), Natick Laboratories, has the responsibility to design and specify shipping packages for a large number of supply items which are shipped in large quantities. Current design procedures do not use computer-aided design (CAD) techniques; therefore, in the interest of time and economy, it was desirable to incorporate into computer-aided design the procedures and criteria that constitute the current state-of-the-art. Thus, development of new design procedures was not within the scope of work of this project.

The approach used in this project was to implement a computer-aided design (CAD) procedure which can be used to select from the available materials data files the material or materials that will protect the item to be shipped for the least cost. The shipping environments were accounted for in terms of shock vibration. The temperature effects on the package cushioning material properties were allowed for in the stored data. Thus, the CAD program optimizes least cost for the materials that will provide the necessary protection.

II. TECHNICAL DISCUSSION

A. Literature Review

As with any effective research and development program, it was imperative to do a comprehensive literature study prior to and throughout the entire effort. SwRI has conducted a comprehensive literature survey related to the problem of the development of optimization procedure for design of package cushioning. See Bibliography.

As listed in the Bibliography, SwRI reviewed over 114 publications for package cushioning design procedures and materials design data. Some of the publications reviewed were completely unrelated; they were omitted from the Bibliography.

Theory and Practice of Cushion Design - SVM-2, by G. S. Mustin[1]* is probably the best single reference book which provides the most recent package cushioning design data, materials data, and references. The theory of package cushioning design has been advanced more rapidly than the materials data that can be used in a practical manner with the theory.

SwRI project team personnel spent many hours of telephone contact with people associated with package cushioning materials trying to ascertain the availability and to obtain materials data related to both shock and vibration.

Table I illustrates the organizations contacted and the data supplied.

The Engineering Design Handbook Package and Pack Engineering[2] provides information about both shock and vibration environments.

The MIL-STD-810B, Military Standard, Environmental Test Methods[3], provides information about how packages are tested to specific shock and vibration conditions. Although the test conditions do not exactly duplicate what a package would be subjected to in actual shipment, the test conditions are intended to approximate actual shipping conditions.

Since the acceleration levels for shock for package cushioning materials are in the form of parametric curves, consideration was given

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*Superscript numbers in parentheses denote References which are listed on Page 182 of this report.

TABLE I

MATERIALS DATA CONTACTS

Organization	Material Data Sought	Data Supplied
Sinclair Koppers Company	Expanded polystyrene (Molded DYLITE®)	Room temp. G_m vs. σ_{st}, some transmissibility.
Nopco Chemical Div. of Diamond-Shamrock Company	Polyurethane	None
U. S. Forest Products Lab	Anything available	None
Du Pont Company	Polyurethane	Nothing outside of that in 304
Package Evaluation Lab, Wright-Patterson AFB	Anything available	Only what is in 304. Some data on Air Cap, SD-240. Transmissibility data being developed under current contract.
Dow Chemicals	Expanded Polyethylene	Some additional data to 304
Michigan State Univ., School of Packaging	Anything available	None
Goodyear Tire Co. Foam Prods. Div.	Urethane Cushions	None
Owens-Corning Fiberglass Corp.	Fiberglass	None
Armour & Co.	Polyurethane Rubberized Hair	None
Flextron Industries	Curled Hair	None
3M Company	Polyester	None
Kimberly-Clark Corp.	Cellulose Wadding	None

TABLE I (Contd.)

MATERIALS DATA CONTACTS

Organization	Material Data Sought	Data Supplied
The Williamson Company	Polyvinyl Chloride	None
Union Carbide Corp.	Polyester, Polyether	None
B. F. Goodrich Chemical Co.	Polyurethane	None
Continental Felt Co.	Felt	None
Armstrong Cork Company	Cork	None
Chicago Curled Hair Co.	Curled Hair	None
Stearns and Foster Co.	Cellulose Wadding	None
Boeing Aerospace Co.	Polyurethane Foam	None (Classified)
Sheller-Globe Corp.	Polyurethane	None
GAF Corp.	Felt	Not useful
National Bureau of Standards	Anything available	None
Plastics Technical Evaluation Center, Picatinny Arsenal	Anything available	Numerous Reports
Janesville Cotton Mills	Curled Hair (Hairkore)	None
Blocksom & Co.	Rubberized Curled Hair	Very little data
Goodyear Aerospace Corp.	Fiberglass	None
Tenneco Chemicals, Inc. (Houston)	Polyurethane	None

to determine the best way to tabulate the voluminous shock data. An interpolation procedure was developed based upon "Digital Computer Program EMI 494 Aerodynamic Interpolation"(4).

Since there has been much concern about using package cushioning materials to protect against shock damage, most of the available materials performance data for protection against shock are found in MIL-HDBK-304, Package Cushioning Design(5).

The report "Vibration Testing of Resilient Package Cushioning Materials"(6) provided the most useable vibration data. There is very little vibration data available. The lack of good frequency response and phase angle data for package cushioning materials according to the varying parameters, i.e.,

- Density (lb/ft^3)
- Static Stress ($lb/in.^2$)
- Thickness (in.)
- Temperature (°F),

is hindering the effective use of the CAD program that was developed.

Some vibration data were obtained from the report "Resilient Cushioning Materials"(7). The vibration data for package cushioning needed some standard form of presentation. In this CAD Program, the vibration-related parameters for each material that were standardized are:

- Storage modulus, E_r, as a function of temperature and frequency
- Loss tangent, $\tan \delta$, as a function of temperature and frequency.

Shock data were obtained from the report "Test Results on Air Cap SD-240 Cushioning Material"(8). Frequency response vibration data were not available.

For those materials included in the initial ten materials cataloged that did not have available actual data related to the performance of the material under shock and vibration environments, an estimate of the physical parameters was made and so indicated in the materials information tabulation (Section C).

It is recommended that shock data (i.e., peak acceleration, g) generated for use with the CAD Program be in the parametric curve form used in MIL-HDBK-304; that is, with the parameters:

- Drop height (in.)
- Static Stress (lb/in.^{2})
- Material thickness (in.)
- Environmental Temperature (°F)
- Material Density (lb/ft^3)

It is recommended that vibration data (i.e., storage modulus, E_r, and loss tangent, $\tan \delta$) for use with this CAD Program be obtained from frequency response curves with phase angle plots for the parameters:

- Material Density (lb/ft^3)
- Static Stress (lb/in.^{2})
- Material Thickness (in.)
- Environmental Temperature (°F)

It is our understanding that additional materials performance data under vibration conditions are being generated under contract for Wright-Patterson AFB, titled "Package Cushioning Materials Testing." Data from that work are not available.

B. Mathematical Modeling of Cushioning Material

1. Description of Problem

The basic cushioning problem is illustrated in Figure 1. The outer container as well as the inner item is assumed to be rigid, and the time-dependent input force $P(t)$ is uniformly distributed across the outer container base, and its resultant acts through the center of gravity of the isolated item of weight W. We also assume that the problem is one-dimensional, and must therefore be solved independently for each of the three orthogonal directions. It is recognized that such a formulation is a considerable simplification from reality; however, in order to develop an optimization scheme that can utilize the bulk of presently available data, it is necessary to start from this point.

At the outset we assume that we have the following statement of the problem. The weight W and its dimensions are given. Therefore, the supported area A is also given. The loading from $P(t)$ is given in terms of a power spectral density, or RMS level and discrete spectrum for

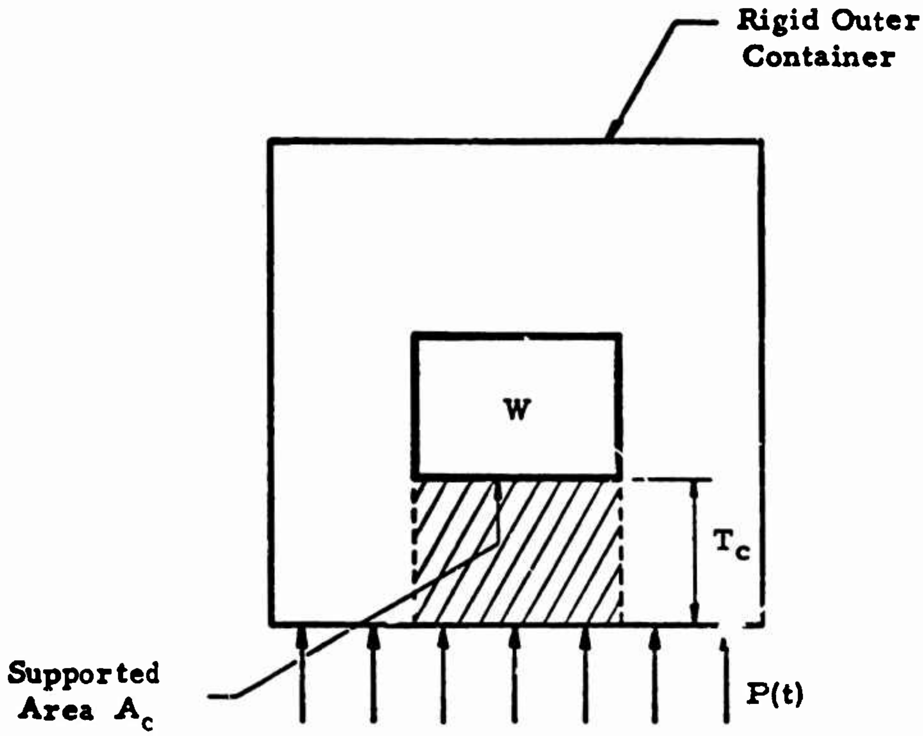

FIGURE 1. CONCEPT OF CUSHIONING PROBLEM

vibration excitation, and is given in terms of an initial drop height h for shock excitation. Finally, we are given the damage criteria for the item. For shock it will be damage fragility rating G_F transmitted to it at the interface, and for vibration it will be maximum RMS vibration level Y_F and possibly an associated power spectrum S_F of acceleration transmitted at the interface. With this information given, we seek a suitable material of thickness T_c that can satisfy the above criteria.

It is recognized that some of the literature considers various forms for the shock excitation including acceleration pulses, velocity pulses, etc. However, most of the design information appears to be presented in terms of equivalent drop height, and since a transformation to this parameter can be accomplished in any case, we use it as the most feasible design parameter.

2. Vibration Isolation at Room Temperature

The most recent design developments[1] recognize the great utility of the complex modulus of a material for characterizing its vibration isolation properties. A complex modulus can be thought of as existing for any material exhibiting creep or relaxation behavior. Also, by using the complex modulus for materials, both amplitude and phase angle are considered in the mathematical treatment for vibration analysis. Therefore, we used it in our mathematical formulation. However, it is recognized that complete data on this parameter are not available for all materials to be considered. Therefore, it has been necessary to estimate it from other parameters, such as static elastic modulus, material damping, etc. that are available. Therefore, consistent with notation in Reference 1, the complex modulus is

$$E^* = E_r + i E_\ell = E_r (1 + i \tan \delta) \tag{1}$$

where E_r is the storage modulus, E_ℓ is the loss modulus, and $\tan \delta$ is the loss tangent.

In view of the above formulation of the problem, the natural frequency of the supported item in the cushioning material is

$$\omega_n^2 = A_c E_{rn} g / T_c W \tag{2}$$

where A_c is the <u>supported</u> area, T_c is the <u>cushioning</u> material thickness, W is the weight, E_{rn} is the storage modulus at frequency, ω_n, and g is standard gravity (note that in this formulation the compliance contribution from the cushioning material outside the isolated object is ignored). With this, the squared magnitude of the transfer function for the material is

$$\left|H(\omega)\right|^2 = \left\{\left[1 - \frac{\omega^2}{\omega_n^2} \frac{E_{rn}}{E_r}\right]^2 + \tan^2 \delta\right\}^{-1} \tag{3}$$

where ω is steady-state excitation frequency.

If $P(t)$ is a steady-state sinusoidal input, then the complex transmitted acceleration is

$$Y(\omega) = H(\omega)\ x(\omega)$$

where $x(\omega)$ is the complex excitation. If $P(t)$ is a combination excitation which may include random and multiple sine components (which is usually the case), then it will be characterized in terms of its stationary acceleration power spectrum $S_x(\omega)$. In this case, the power spectrum of the transmitted acceleration response $S_y(\omega)$ is

$$S_y(\omega) = \left|H(\omega)\right|^2 S_x(\omega) \tag{4}$$

Equation (4) is directly from Equation (3.137), page 99, Bendat and Piersol[10]. Chapter 3 of this reference, "Mathematical Theory for Analyzing Random Data" provides the basis and derivation for Equation (4).

In general Equation (4) [i.e., Equation (3.137)[10]] is obtained from the transformation of [i.e., Equation (3.134)[10]]

$$R_y(\tau) = \int\int_0^{\infty} h(\xi)\; h(\eta)\; R_x\,(\tau + \xi - \eta)\; d\xi\, d\eta \tag{5}$$

where $R_x(\tau)$ and $R_y(\tau)$ are autocorrelation functions of the time displacement, τ, to a complex-valued frequency domain by taking Fourier transforms.

The latter approach was used in most cases, since the power spectral density formulation can always be used even for sinusoidal input, providing that the measured excitation data has been analyzed with a finite bandwidth resolution (which will always be the practical case), and this bandwidth is specified with the data.

The design problem is now clear. Upon selection of a trial material having a given modulus E_r and E_{rn}, we must solve for the thickness T_c from Equations (2), (3), and (4), with all other information given. The effect of temperature on the problem is discussed later.

The CAD Program allows three options to the users regarding the vibration environment specification. These options are:

(1) MIL-STD-810B Excitation (i.e., sinusoidal)

(2) Multiple Sine Excitation

(3) Random Excitation

<u>Vibration Optimization for MIL-STD-810B Type Excitation</u>

This excitation assumes a single sine wave is applied at the natural frequency for amplitudes given in the MIL-STD. The excitation at each i-octave band is calculated from Equation (2) for

$$\omega_j = \omega_{ni} \tag{6}$$

and

$$x_{oi} = \left|T_{oij}\right| x_j \tag{7}$$

also

$$T_{ci} = \frac{A_c\ E_{rni}\ g}{\omega_j^2\ W} \qquad (8)$$

The smallest T_{ci} of all frequency bands that satisfies $\ddot{x}_{oi} \leq \ddot{x}_{allow}$ is the optimum thickness value we seek.

The 1-octave band center frequencies, ω_j, are stored in a DATA statement in the subroutine VIBRTN as array OB(I). The stored frequencies are:

1., 2., 4., 8., 16., 31.5, 63., 125., 250., 500., and 1000. Hz. These frequencies, Hz, are subsequently changed by multiplying by 2π to obtain the frequencies in rad/sec. These frequencies were chosen based upon the International Standardization Organization (I.S.O.) Recommendation R.266, Preferred Frequencies for Acoustical Measurements.

Vibration Optimization for Multiple Sine Excitation

Single or multiple sine components each at a fixed amplitude and frequency are the excitation. Octave band transfer functions and thicknesses are again computed from Equations (2) and (3). For each octave band, the total response becomes (conservative)

$$\ddot{x}_{oi} = \sum_j \left| T_{oij} \right| \ddot{x}_j \qquad (9)$$

Again the smallest T_{ci} of all frequency bands that satisfies $\ddot{x}_{oi} \leq \ddot{x}_{allow}$ is the optimum thickness value that we seek.

Vibration Optimization from Random Excitation

Excitation power spectral density $S(\omega_i)$ must be specified in 1-octave frequency bands. Transfer functions and thicknesses are again calculated from Equations (2) and (3) for each i-th frequency band. For the material frequency in the i-th octave band, the total mean square response becomes

$$\sigma_i^2 = \sum_j S(\omega_j) \left| T_{oij}(\omega_j) \right|^2 \qquad (10)$$

and the RMS response is

$$\sigma_i = \sqrt{\sigma_i^2} \qquad (11)$$

Assume for a Gaussian process that

$$x_{oi} = 2.5\,\sigma_i \qquad (13)$$

Again, the smallest T_{ci} of all frequency bands that satisfies $x_{oi} \leq x_{allow}$ is the optimum thickness that we seek. Note that $2.5\,\sigma_i$ as maximum will be exceeded only 0.62% of the time.

These three options provide the user the ability to utilize whatever vibration environmental data he has available or to use typical vibration environments as provided in the sample problems.

The random excitation option provides for the utilization of the most comprehensive data that can be obtained and should be used wherever possible. The multiple sine excitation and single frequency MIL-STD-810B excitation provide for less comprehensive types of environmental vibrations.

3. Shock Isolation at Room Temperature

The rigorous mathematical design of cushioning for shock isolation is in a considerably less developed state than that for vibration. This results from more complexities involved with time, strain rate, and temperature dependence of the materials at large deflections normally considered part of the shock isolation problem. Therefore, we used the Direct Method. Again, temperature dependence will be discussed later.

The Direct Method is a relatively simple design approach which can be formulated for mathematical computations by use of the typical design data shown in Figure 2. Many such curves for various materials are given in Reference 1. The curves for a given material present the maximum transmitted acceleration as the function

$$G_m = \mathcal{F}(W/A)$$

for selected trial thicknesses T_c. One simply needs to verify that

$$G_m < G_F$$

for the given conditions. However, in order to incorporate this procedure into a digital computer program, it was necessary to store the data for these curves for the candidate materials. This was done by an appropriate interpolation scheme.* Here G_F is the fragility acceleration.

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*Discussed in Subsection F, Computer Software.

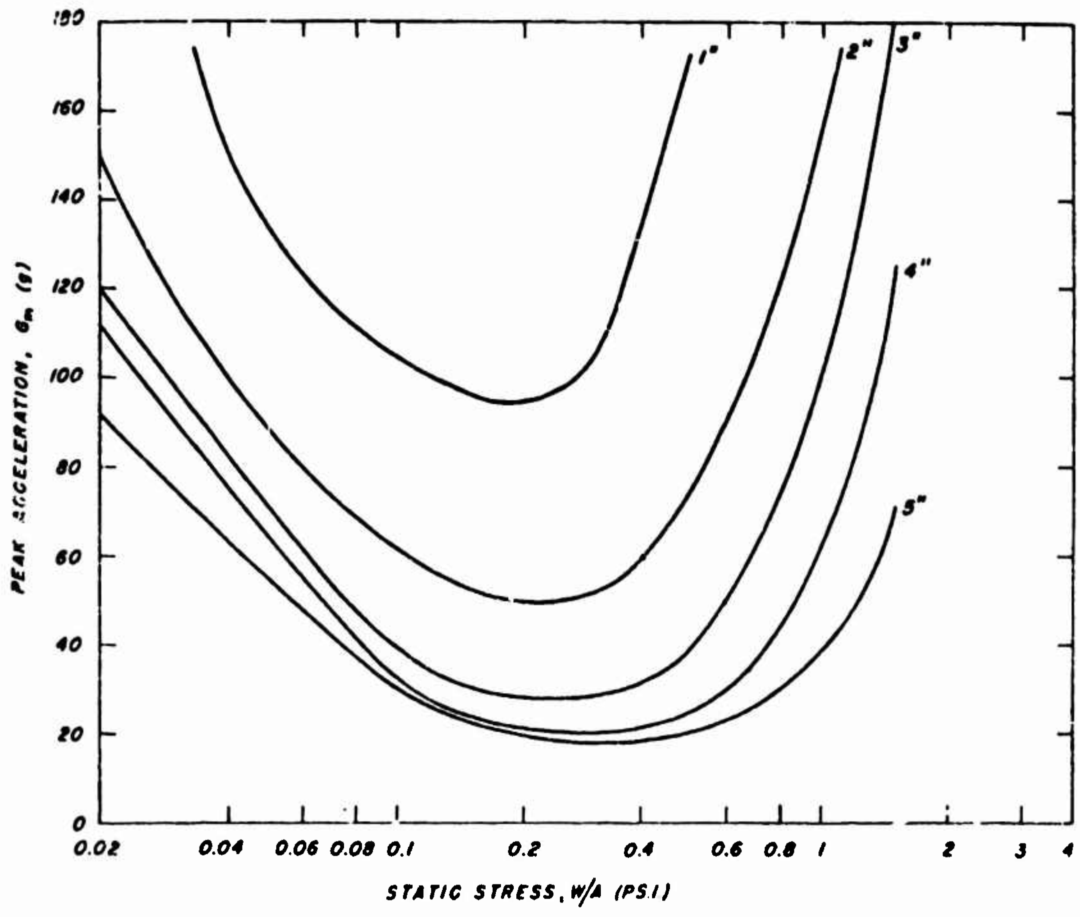


FIGURE 2. A TYPICAL SET OF PEAK ACCELERATION-STATIC STRESS (G_m-W/A) CURVES FOR FIXED DROP HEIGHT h.

Since different materials have different ranges of optimum static stress, the static stress, σ_s, that would be created by a particular shipped item (i.e., of weight, W, and area, A) has to be calculated by the equation

$$\sigma_s = W/A \tag{13}$$

and then checked to determine that the materials are within their static stress optimum range.

4. Temperature Influence on Material Properties

Ambient temperature variations over wide ranges have a significant influence on cushioning material properties. Unfortunately, data for such variations are extremely scanty for all of the materials of interest for this CAD Program.

Basically, the temperature effects on the complex modulus of a cushion material are typical of that shown in Figure 3. The effects are relatively insignificant until the so-called rubber-to-glass transition occurs. In any event, provisions were made for the storage and retrieval of vibration data (i.e., complex modulus, E^*) and shock data (i.e., maximum acceleration, G_m).

The complex modulus form is

$$E^* = E_r \mathcal{F}_1(T) \left(1 + i \tan \delta \, \mathcal{F}_2(T)\right) \tag{14}$$

where T is varying temperature and $\mathcal{F}_1(T)$ and $\mathcal{F}_2(T)$ are the functions which describe the temperature effects.

The maximum acceleration shock isolation form is

$$G_{mT} = G_m \mathcal{F}_3(T) \tag{15}$$

where $\mathcal{F}_3(T)$ is the function which describes the temperature effects. We generated the temperature effects on the complex modulus using the functional curves for $\mathcal{F}_1(T)$, $\mathcal{F}_2(T)$, and $\mathcal{F}_3(T)$ shown in Figures 4 and 5. These temperature effect curves (i.e., $\mathcal{F}_1(T)$, $\mathcal{F}_2(T)$, and $\mathcal{F}_3(T)$) are only estimates; therefore, any use of data from this CAD Program should be used with caution until actual temperature effect data have been cataloged.

Points on each of the Scale Factor Function Curves were used in the computer program TDATAF to generate the temperature effects on

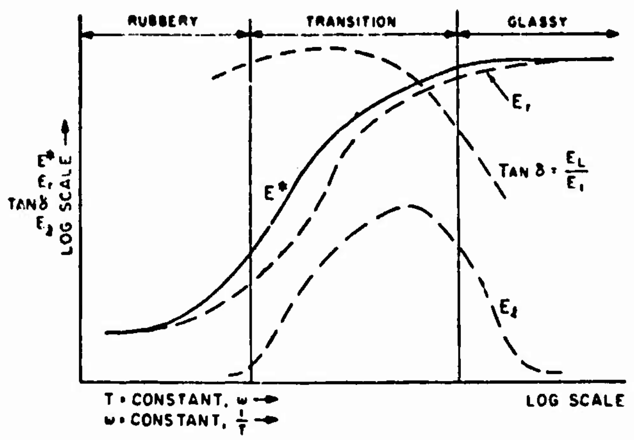


FIGURE 3a. FREQUENCY AND TEMPERATURE EFFECTS ON COMPLEX MODULI

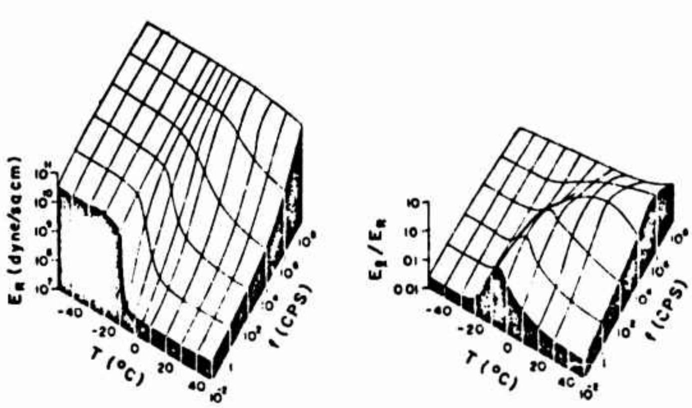


FIGURE 3b. APPROXIMATE BEHAVIOR OF E_r AND LOSS TANGENT OVER A WIDE RANGE OF FREQUENCY AND TEMPERATURE; SKETCHES ARE BASED ON EXPERIMENTAL DATA FOR A CARBON-FILLED BUNA-N. [Mustin, G. S.][(1)]

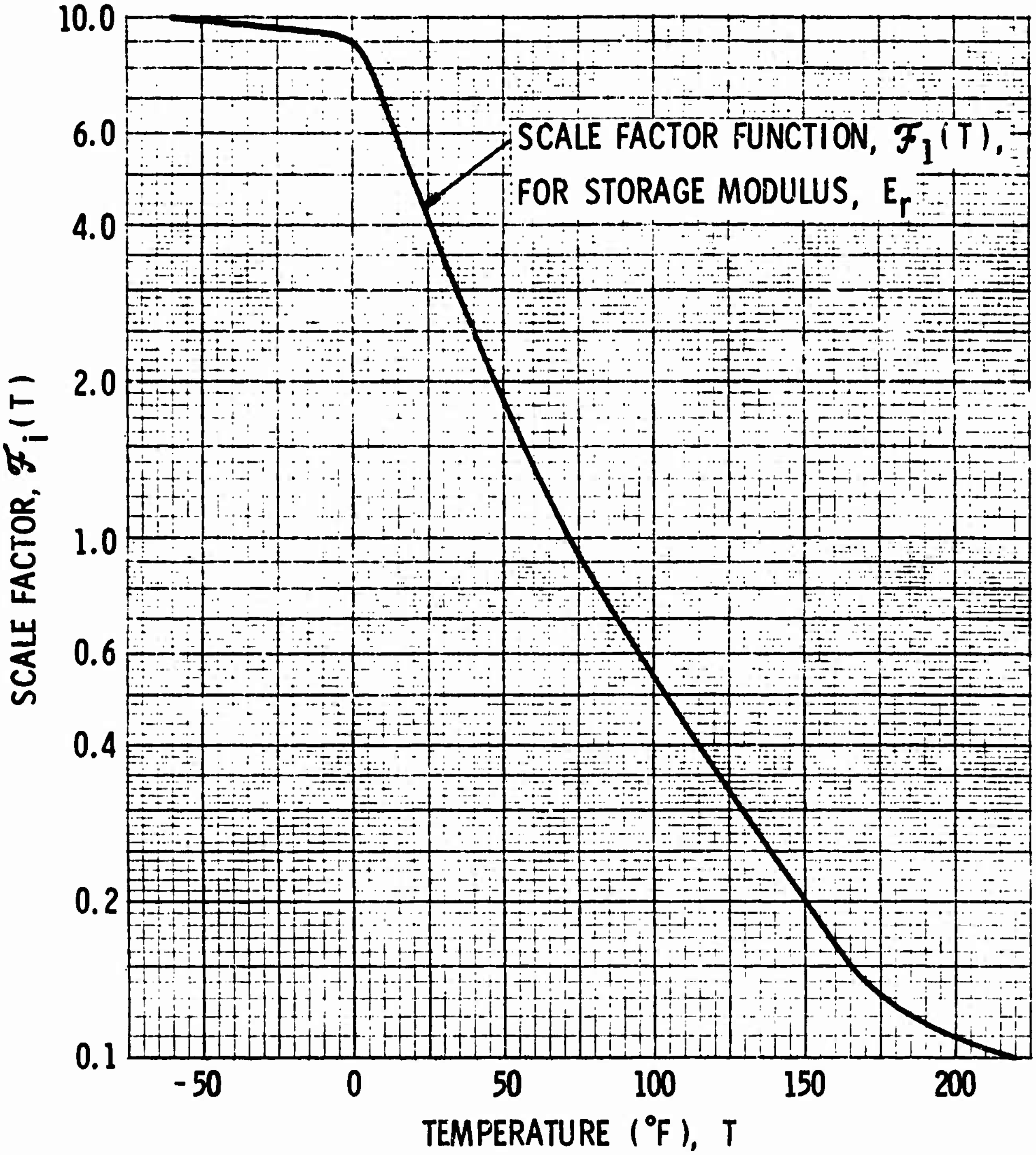


FIGURE 4. STORAGE MODULUS SCALE FACTOR AS A FUNCTION OF TEMPERATURE

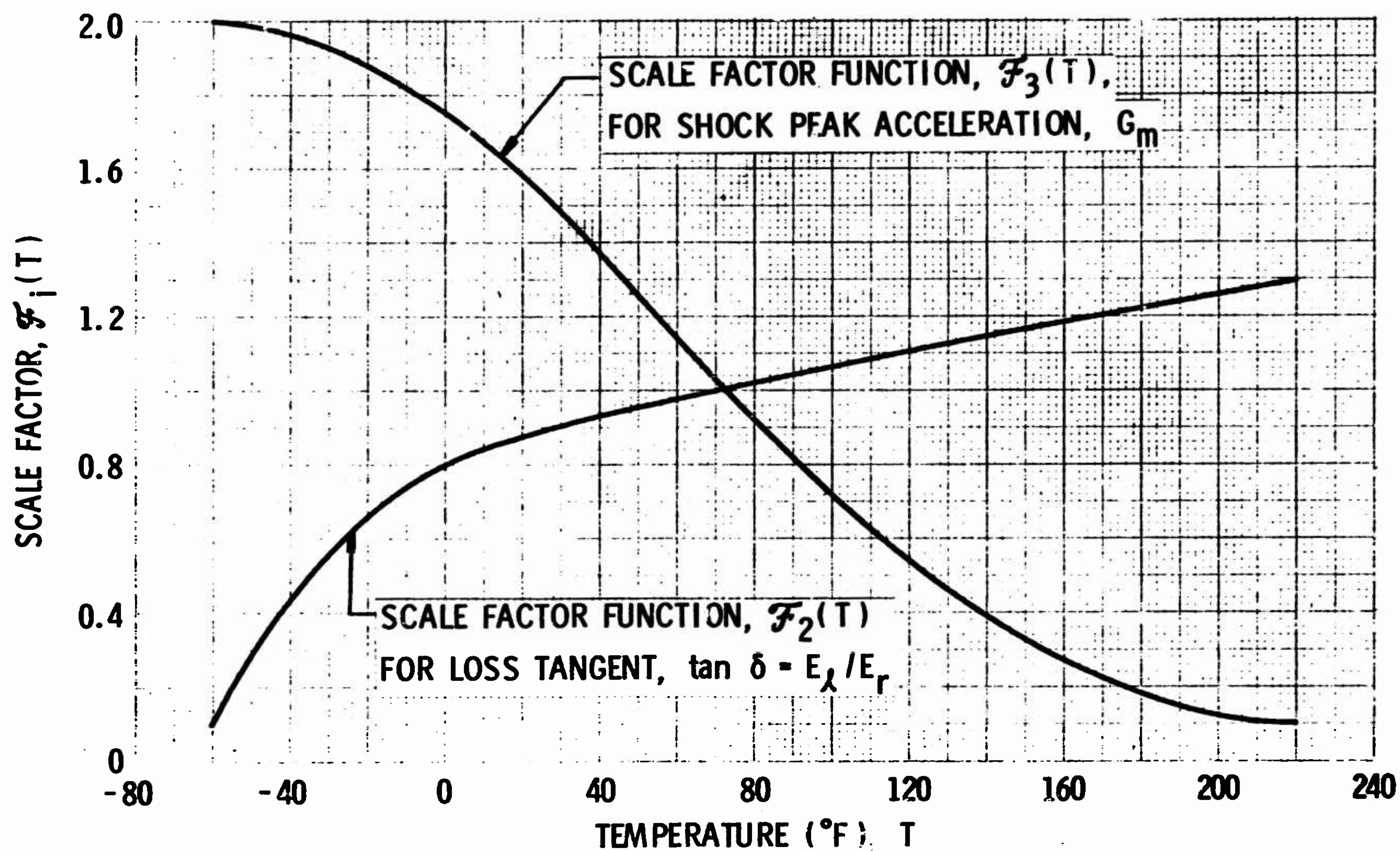


FIGURE 5. LOSS TANGENT AND SHOCK PEAK ACCELERATION SCALE FACTORS AS FUNCTIONS OF TEMPERATURE

the shock (i.e., peak acceleration, G_m) and the vibration (i.e., storage modulus, E_r, and loss tangent, tan δ) data. The shock and vibration data are then stored in the computer file.

C. Treatment of Fragility and Damage Susceptibility Criteria

The subject of fragility or damage criteria is complicated because of the way in which different items fail when they are subjected to different environments. Various individuals, depending upon their background and resources, advocate different concepts, equipment and testing procedures for obtaining fragility ratings for items.

The determination of fragility or damage susceptibility criteria for a specific item must be done by the program user prior to utilization of the computer program developed during this project.

Fragility rating, normally in terms of the peak acceleration of the pulse which causes damage or malfunction of the item, should represent the peak of the main pulse (as distinguished from peaks of superimposed high frequency components), expressed in multiples of gravitational acceleration, g. Fragility ratings for individual items of a group should be averaged to obtain a mean value for the group.

The fragility input data will have two forms:

(1) Those items that are not repairable and discarded when damaged

(2) Items that are made of components. These items can have a range of damage to the components.

For example, the fragility input data might be in the following form:

Fragility Rating, g	Probable Percent Damaged, %	Repair Cost per Damaged Item, $
55	0	0.00
60	5	5.00
65	20	25.00
70	80	475.00

D. Statistical Form of Environment

It is recognized that many possibilities of shock and vibration environments exist for transportation of packaged items. The modes of shipment include (1) Plane, (2) Truck, (3) Train, and (4) Ship. In each case, the length of exposure time can vary, depending on the details of the package and its destination. Therefore, herein we suggest a procedure for application of average and maximum environments for each case.

1. Shock Environment

Statistical information about the typical number of shocks which occur in a given transportation environment are available to varying degrees of detail from several sources. Figure 6 shows a profile of shock excitation measured during a typical airline flight[2]. Data of this type must be further reduced to an even more concise form as shown in Figure 6b. That is, by accumulation of such data from multiple flights of varying durations, in the future a probability density for shock levels must be developed by fitting a Gaussian distribution to the data. Then, the entire set of data is described mathematically by

$$p(g_x) = \frac{\sigma_s}{2\pi} e^{-[(g_x' - \mu_s)^2/2\sigma_s^2]} \tag{16}$$

where μ_s is the mean shock level, g_x' is the deviation from the mean level, and σ_s is the standard deviation. This form is particularly useful for computational purposes. The maximum shock expected in a given environment can be taken as

$$g_{max} = 3\sigma_s \tag{17}$$

Thus, the above formulation can be utilized for design to withstand repeated shocks (assuming superposition) or maximum as well.

Since all of the available shock isolation data for package cushioning materials are presented in the form shown in Figure 2, and since probability density shock levels for the different modes of transportation are not available, the shock conditions specified in MIL-STD-810B, Method 516.1, Shock, were coded into the computer program, OPPACK. The shock conditions from Method 516.1 are the drop heights based upon weight and dimensions. The weight and dimensions which determine specific drop heights are in Table II. The 48-inch drop height was omitted from the computer procedure because materials data for a 48-inch drop height were not available.

Thus, it is not necessary for the OPPACK Program user to specify any shock environment.

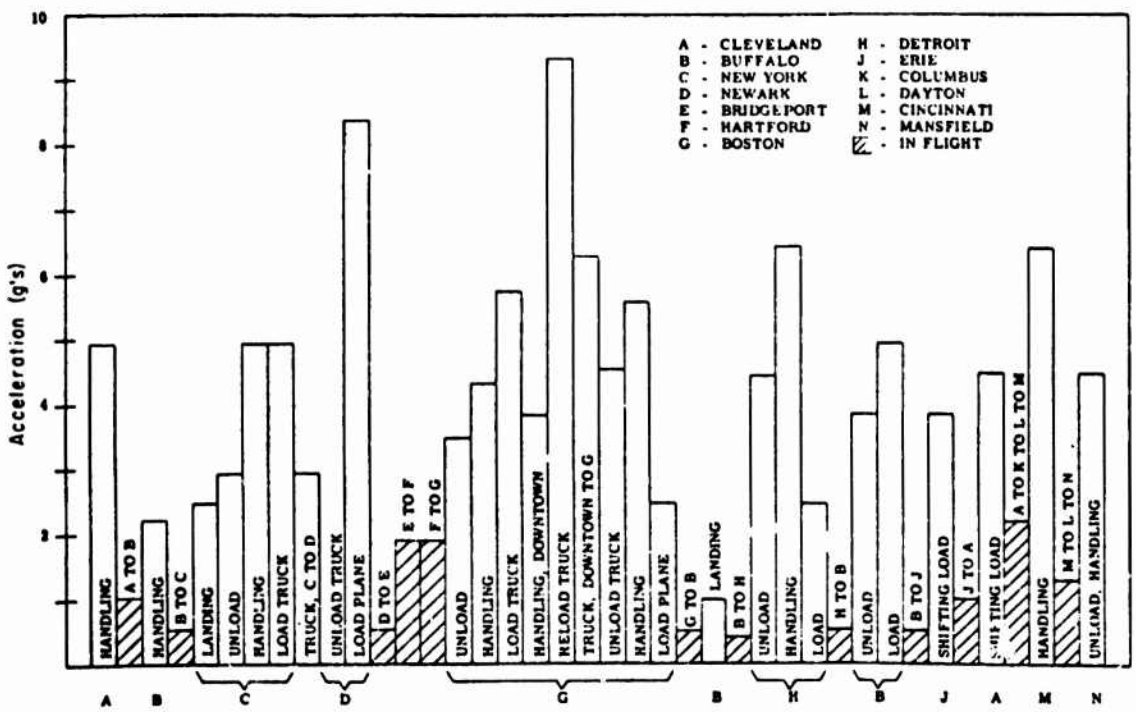


FIGURE 6a. MAXIMUM SHOCKS RECORDED DURING AIRLINE TEST SHIPMENT

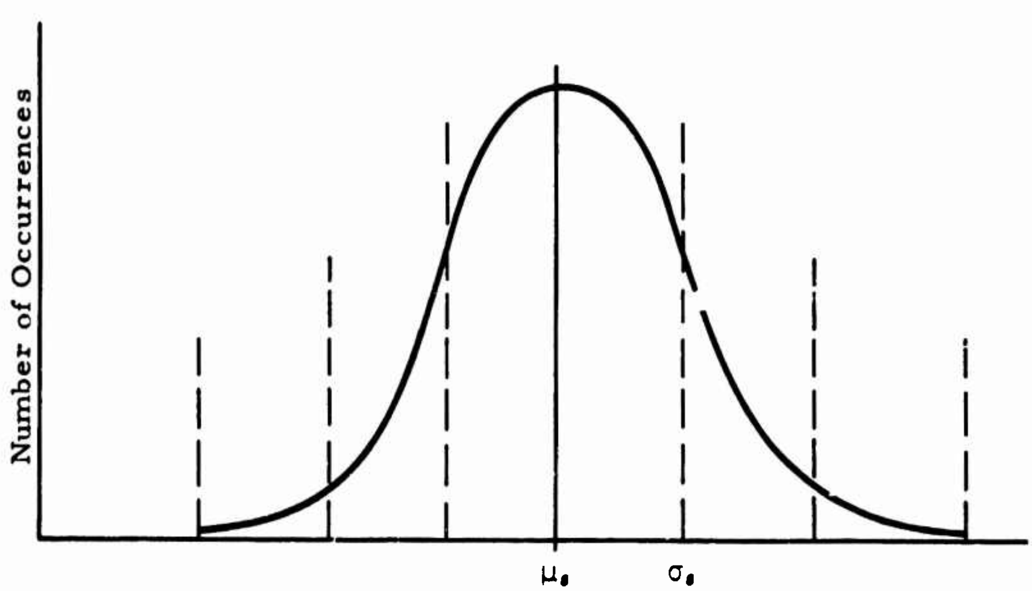


FIGURE 6b. SHOCK AMPLITUDE (g_x)

TABLE II

TRANSIT DROP TEST HEIGHTS FROM
MIL-STD-810E, METHOD 516.1

Weight of test item and case	Largest dimensions (inches)	Notes	Height of drop (inches)
Under 100 pounds man-packed and man-portable	Under 36	A	48*
	36 and over	A	30
100 to 200 pounds, inclusive	Under 36	A	30
	36 and over	A	24
Over 200 to 1,000 Pounds, inclusive	Under 36	A	24
	36 to 60	B	36
	Over 60	B	24
Over 1,000 pounds	No limit	C	18

*48-inch drop height was omitted from OPPACK Program because of the lack of materials data.

2. Vibration Environment

Vibration excitation can be expressed either as a discrete spectrum(2) as shown by the example for truck transportation in Figure 7, or by a power spectrum(3) as shown by Figure 8. In the latter case, the data have been accumulated for equipment mounted in air-launched missiles. In the past, the tendency has been to express transportation environments in terms of discrete spectra (Figure 7). However, in recent years, with the advent of more compact laboratory analysis and excitation equipment, presentations of data on such environments have been shifting more to the power spectral form (Figure 8).

For the present program, available data were reviewed, so that enveloping power spectra could be established for each type of environment. Considerable judgement was exercised in this process, to account for varying power spectra at different speeds in transportation environments. Again, the assumption of a Gaussian distribution about some mean levels allowed reduction of the data to two parameters,

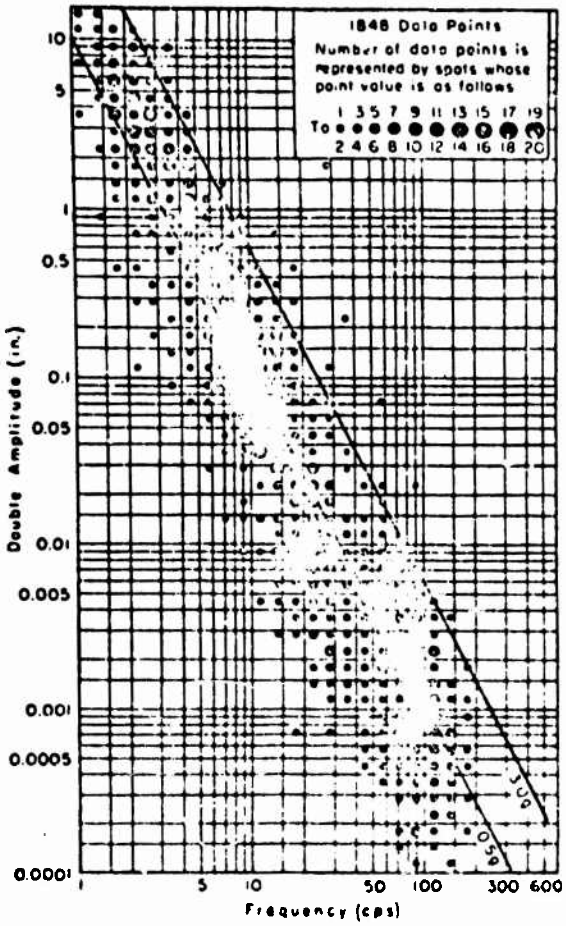
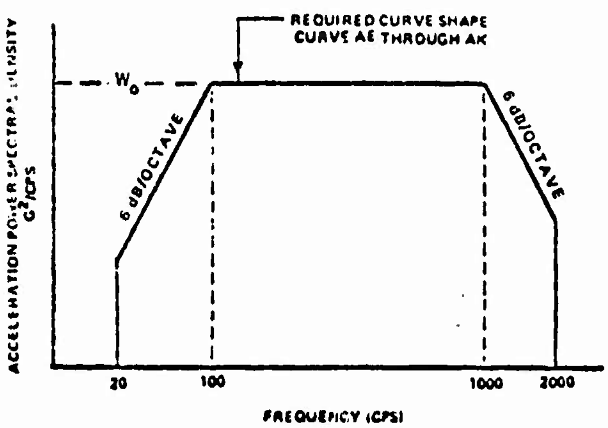


Figure 7. Truck Transportation Vibration Data (Ref. 2)

RANDOM VIBRATION CURVES

RANDOM VIBRATION ENVELOPE



RANDOM VIBRATION TEST LEVELS

TEST CURVE	ACCELERATION POWER SPECTRAL DENSITY W_o (G^2/CPS)	COMPOSITE G-RMS MINIMUM
AE	0.02	5.4
AF	0.04	7.6
AG	0.06	9.3
AH	0.10	12.0
AJ	0.20	16.9
AK	0.30	20.7

NOTE COMPOSITE G-rms $= \left[\int_{f_1}^{f_2} W(f)\,df \right]^{1/2}$

WHERE f_1 AND f_2 ARE THE LOWER AND UPPER TEST FREQUENCY LIMITS, RESPECTIVELY. W(f) IS THE ACCELERATION POWER SPECTRAL DENSITY IN G^2/CPS UNITS.

FIGURE 8. Vibration test curves for equipment installed in air launched missiles – equipment category (d)

mean and standard deviation. These power spectra of excitation then formed the inputs to the equations presented in the previous sections.

Since most of the package cushioning design procedures used in previous publications on the subject do not deal extensively with the protection of the packaged item from vibration, a widely accepted method of describing the materials data relative to vibration does not exist. Also, a widely accepted method of describing the environmental vibration does not exist. Therefore, because the vibration environment can be described in relatively simple conventional terms (i.e., single frequency sinusoidal excitation, such as MIL-STD-810B excitation) or in more complex terms (i.e., multiple sine excitation) or in the most complex terms (i.e., random excitation), the computer program OPPACK was written to allow three options for the optimization regarding the vibration environment. Those three options are:

- Single frequency sinusoidal excitation, i.e., MIL-STD-810B excitation (IC = 1)
- Multiple sine excitation (IC = 2)
- Random excitation (IC = 3)

The input environmental vibration data for the MIL-STD-810B excitation (IC = 1) are to be in the form of acceleration, g. at specific frequencies, rad/sec*. If the user of OPPACK has specific environmental vibration data and wishes to optimize the package design for single frequency excitation, he may input these data on Data Card Number Two (i.e., frequencies, rad/sec) and on Data Card Number Four (i.e., acceleration levels, g, for the specified frequencies).

If the user does not know what the environmental vibration data are, he may use the following frequencies, rad/sec:

6.283, 62.83, 125.66, 314.159, 628,300, 1884.96,

3141.59, 4398.23, 5654.87, 5969.03, 6283.19,

and the following accelerations, g, which correspond to the previously given frequencies:

0.5, 0.5, 1., 2., 3., 3., 3., 3., 3., 3., 3.

---

*Note that the input vibration frequencies are to be in radians per sec (rad/sec).

The input environmental vibration data for the multiple sine excitation (IC = 2) are also to be in the form of acceleration, g, at specific frequencies, rad/sec.

Also, if the user does not know what the environmental vibration data are, he may use the previously listed accelerations and frequencies.

The input environmental vibration data for random excitation (IC = 3) are to be in the form of Power Spectral Density (PSD), g^2/Hz at specific frequencies, rad/sec. If the user has PSD data they are to be put on Data Card Number Three (i.e., PSD, g^2/Hz, for the specified frequencies on Data Card Number Two). If the user does not know what the PSD, g^2/Hz data are, he may use the following PSD levels:

$3.66(10)^{-4}$, $5.17(10)^{-4}$, $1.91(10)^{-4}$, $1.19(10)^{-4}$,

$1.13(10)^{-4}$, $5.09(10)^{-7}$, $5.83(10)^{-6}$, $5.09(10)^{-7}$,

$5.09(10)^{-7}$, $5.09(10)^{-7}$, $5.09(10)^{-7}$.

which correspond to the previously given frequencies.

These vertical excitation data are from a truck transporting a LANCE missile at 19 to 45 MPH over a gravel road from the accelerometer mounted on the missile skid. The data are from Contract DA-31-124-ARO-D-226.

E. Cost Function Considerations

To formulate a function that expresses the total cost of cushioning, packaging and shipping of a given item while allowing for the possibility of some damage, to be covered by overshipment, requires a functional knowledge of all the cost variables in packaging design. Many of these cost variables are tangible, such as cushioning material costs and shipping costs; however, some are intangible such as costs of storage of the cushioning and packaging materials and some phases of loading and handling during shipment. Since we are mainly concerned with optimizing the cost function for a given variety of candidate materials and modes of shipment, many of the intangible variables play very minor roles in determining the optimum package, since these costs are shared nearly equally for all possible designs. The primary cost variables that were considered in the cost function are:

C_m ~ cost per unit volume of cushioning material,

C_c ~ cost of the exterior container,

C_f ~ cost of fabrication of the cushioning material to the specified dimensions,

C_p ~ cost of packaging of the item for shipment,

C_s ~ cost of shipment,

C_I ~ cost of the packaged item.

These cost variables can be grouped into four main categories; cost of materials, cost of labor, cost of shipping, and cost of allowable damage replacement.

1. Cost of Materials

The cost per unit volume of the cushioning material enters the cost function in a direct manner when the required volume of cushioning material is known. It is often the case that material prices are based on a given thickness and width of sheet; in these cases, the waste material must be accounted for in the overall cushion cost.

The exterior container for the purpose of cushion analysis was taken to be a rigid container. Cost and fabrication of the container were estimated for the sample problems from limited commercial data. Provisions were made in the program for the user to input container data (i.e.. Input Data Card Number Sixteen).

In the sample problems, the specific weight of the container is 0.0017 lb/in^3 and the container material cost is 0.00232 $\$/in.^3$.

CAUTION
The cost of container, $\$/in.^3$, is the cost of the container material volume, not the container volume.

2. Cost of Labor

The cost of fabrication of the cushioning material to the specified design dimensions, as available, is included in the cost analysis, as well as the cost of packaging of the item for shipment. These items are best initially expressed in units of time since the price of labor is generally changing, and therefore only a single dollar per hour rate is necessary to update existing data. At the present time, we are using an average rate of $3.00 per man-hour. This rate is based upon data from Area Wage Survey, U. S. Department of Labor.

3. Cost of Shipping

The cost of shipping is one of the more complex cost variables, in that, weight, cube, number of items to be shipped and mode of shipment can play equally important roles. When shipping by truck, train, plane, ship or any combination thereof, the package engineer must consider the limitations on weight and cargo volume of each of the possible modes of shipment. For a shipment that requires multiple modes, for example, by both train and plane, a least cost operation must consider the cost in each phase of shipment. Of course, the cushioning package will be designed to withstand the environmental conditions imposed by all required modes of shipment; however, the least cost package may not be the most cost efficient when cube and weight limitations arise in shipping.

4. Cost of Damage Replacement

The cost of the item being packaged enters the cost function when the cushion design accepts the possibility of some damage, by changing the item's fragility factor, and compares the excess cost of the items shipped to cover the damage against the reduced cost of the cushioning package.

Thus, the cost function is a linear sum of the above-mentioned cost variables. The general cost function then takes the form

$$CF = n\left[V_m C_m + C_c(W, V_c) + C_f(m, V_c) + C_p(W, V_c) + f_n C_I\right] + C_s(n, s, W, V_c) \qquad (18)$$

where the brackets denote a function of those variables and n is the number of items to be packaged, V_m the volume of cushioning material including waste, W the weight of the package, V_c the cube of the package, m denotes a particular cushioning material, f_n fraction of items allowed for possible damage, and s the particular mode of shipment. It should be pointed out that since a different cushioning material can be used on each of the three orthogonal surfaces, the expression $V_m C_m$ can be expanded to read

$$V_m C_m = \sum_{i=1}^{3} V_{m_i} C_{m_i} \qquad (19)$$

where the subscript denotes the three possible surfaces. Likewise, the possibility of multiple modes of shipping can be functionally expressed as

$$C_s(n, s, W, V_c) = \sum_{S=1}^{4} C_s(n, s, W, V_c). \qquad (20)$$

The value of cushioning material, V_m, in itself is a function of the cushioning material properties, fragility factor of the item, and the shipping environment.

F. Computer Software

The actual implementation of the FORTRAN computer software into the Natick Laboratories UNIVAC 1106 Executive 8 System was the culmination of all of the work on this project.

The Computer Aided Design (CAD) of package cushioning was accomplished through the FORTRAN language. FORTRAN permits the use of:

- Mathematical expression
- Data file input/output
- Procedural subroutines
- Batch and remote processing.

Thus, a main program is used to call and manipulate the subroutines. The subroutine programs were structured so that modifications can be done with a minimum amount of difficulty. The use of subroutines permitted the segmented development of the complete package cushioning design computer program.

1. Lagrange Interpolation of Data

Since we knew that a large number of data files were going to be required and that interpolation of the data contained in these files was necessary, we have developed and implemented a subroutine and function for interpolation and extrapolation[4]. They are the following:

- LAGINT (i.e., Lagrangian Interpolation Subroutine)
- FLAGR (i.e., Lagrangian Interpolating Function)

The interpolation programs are designed to save considerable computation time in generating data by interpolating a set for a more dense set so that a realistic data is realized. The mathematical interpolation scheme used is that of a three point Lagrange with a fairing over a four point set.

Program Theory for Lagrange Interpolation

Given a set of matrices $\gamma(k)$, we wish to interpolate this set to obtain a more dense set $\Gamma(k)$. The method of interpolation to be used is that of Lagrange by passing a parabola from the right and from the left and averaging. For those points in $\Gamma(k)$ which are not spanned by at least two points on either side by the set $\gamma(k)$, a single parabola will be used at these points. Higher order polynomials have been tried and have failed to yield any increase in accuracy and have often caused undesirable oscillations.

LaGrange's interpolation formula:

$$\Gamma(k) = \sum_{i=1}^{M} \gamma(k_i) \frac{(k-k_1)\cdots(k-k_{i-1})\,(k-k_{i+1})\cdots(k-k_m)}{(k_i-k_1)\cdots(k_i-k_{i-1})\,(k_i-k_{i+1})\cdots(k_i-k_m)} \tag{21}$$

Consider the five points shown below, where the 0 denotes values from the $\gamma(k)$ set and the X denotes the desired value for the $\Gamma(k)$ set.

γ_{i-1}	γ_i	Γ	γ_{i+1}	γ_{i+2}
0	0	X	0	0
k_{i-1}	k_i	k	k_{i+1}	k_{i+2}

Using Lagrange's interpolation formula for a parabola from the left (use points k_{i-1}, k_i, k_{i+1})

$$\begin{aligned}\Gamma(k)_L = {} & \gamma(k_{i-1}) \frac{(k-k_i)\quad(k-k_{i+1})}{(k_{i-1}-k_i)\,(k_{i-1}-k_i)} \\ & + \gamma(k_i) \frac{(k-k_{i-1})\,(k-k_{i+1})}{(k_i-k_{i-1})\,(k_i-k_{i+1})} \\ & + \gamma(k_{i+1}) \frac{(k-k_{i-1})\,(k-k_i)}{(k_{i+1}-k_{i-1})\,(k_{i+1}-k_i)}\end{aligned} \tag{22}$$

and a parabola from the right (use points k_i, k_{i+1}, k_{i+2})

$$\begin{aligned}\Gamma(k)_R = {} & \gamma(k_i) \frac{(k-k_{i+1})\,(k-k_{i+2})}{(k_i-k_{i+1})\,(k_i-k_{i+2})} + \gamma(k_{i+1}) \frac{(k-k_i)\,(k-k_{i+2})}{(k_{i+1}-k_i)\,(k_{i+1}-k_{i+2})} \\ & + \gamma(k_{i+2}) \frac{(k-k_i)\,(k-k_{i+1})}{(k_{i+2}-k_i)\,(k_{i+2}-k_{i+1})} \quad .\end{aligned} \tag{23}$$

Thus, if the desired point lies between two adjacent points, we average the parabolas as

$$\Gamma(k) = \tfrac{1}{2}[\Gamma(k)_L + \Gamma(k)_R] \quad . \tag{24}$$

The program is set up to interpolate a single set of input matrices or input two sets, scaling the second set by a scalar and adding it to the first set, then interpolating the combination.

Copies of the main program (i.e., TEST), the subroutine LAGINT, and the function, FLAGR, are shown in the Appendix.

2. Computer Aided Design (CAD) with Program OPPACK

The following pages identify the main driver program and subroutines. The usage of each subroutine, other subroutines called, and a glossary of variables are specified.

Table III, Glossary of Variables for OPPACK, contains the alphabetical listing and description of the FORTRAN variables in the Computer Program OPPACK.

TABLE III

GLOSSARY OF VARIABLES FOR OPPACK

A - - - - - - - - - - -	Support area of item (sq in.).
A (NPTSG, NPTSB, NPTSA) -	Input table.
AL(I) - - - - - - - - - -	Array of longest dimensions for each face of package. (CDPRO subroutine).
AL(I) - - - - - - - - - -	Area of the perpendicular face of the package. (COSTMT subroutine).
ALF (NPTSA) - - - - - - -	Vector of independent variables.
ALI (I) - - - - - - - - -	Actual dimensions of package.
ALL - - - - - - - - - -	Item length + container and cushion thickness.
AT - - - - - - - - - - -	Environmental temperature.
BETA (NPTSB) - - - - - - -	Vector of independent variables.
C1 - - - - - - - - - - -	Cost of material on face one.
C2 - - - - - - - - - - -	Cost of material on face two.
C3 - - - - - - - - - - -	Cost of material on face three.
C12 - - - - - - - - - -	Contains the minimum cost between the materials on face one and face two.
C13 - - - - - - - - - -	Contains the minimum cost between the materials on face one and face three.
C23 - - - - - - - - - -	Contains the minimum cost between the materials on face two and face three.
C123 - - - - - - - - - -	Contains the lowest cost of the three materials.
CA (I, J) - - - - - - - - -	Material cost and property matrix. Contains cost of material, cost of fabrication, cost of packaging, safe low temperature, low and high static stresses, and specific weight.

TABLE III (Contd.)

GLOSSARY OF VARIABLES FOR OPPACK

CAXIS(I, 1) - - - - - - - -	Cost of the packaging material for face one.
CAXIS(I, 2) - - - - - - - -	Cost of the packaging material for face two.
CAXIS(I, 3) - - - - - - - -	Cost of the packaging material for face three.
CAXIS(I, J̄) - - - - - - - -	Cost of packaging material for all three faces.
CD(I, J) - - - - - - - - -	Container cost and property matrix. Contains specific weight of container and cost of container.
CF(I) - - - - - - - - - -	Array containing cost of fabrication to specific dimensions.
CFF - - - - - - - - - -	Cost of fabrication.
CI - - - - - - - - - - -	Cost of item.
CM(I) - - - - - - - - - -	Array containing material cost.
COST - - - - - - - - - -	Total cost.
CP(I) - - - - - - - - - -	Array containing the cost of packaging.
CPP - - - - - - - - - -	Cost of packaging.
CS - - - - - - - - - - -	Cost of shipment.
CSS - - - - - - - - - -	Cost of shipping the package.
CVC - - - - - - - - - -	Cost of material for corner.
DH - - - - - - - - - - -	Calculated drop height.
DHH(I) - - - - - - - - -	Drop height.
DHL(I) - - - - - - - - -	Drop height longest length.

TABLE III (Contd.)

GLOSSARY OF VARIABLES FOR OPPACK

DHW (I) - - - - - - - -	Drop height upper weight limit.
DII - - - - - - - - - -	Array of drop heights.
DLH - - - - - - - - -	Dummy parameter.
DL (I) - - - - - - - - -	Change in package dimensions along each face.
DRPH - - - - - - - -	Actual drop height - stored on file.
DWB - - - - - - - - -	Weight added by the addition of a bearing board.
ERI - - - - - - - - -	Modulus at center frequency.
ERJ - - - - - - - - -	Modulus at environmental frequency.
F (I) - - - - - - - - -	Table of dependent variables.
F2 (I) - - - - - - - - -	1-D array of interpolated accelerations.
FE (I) - - - - - - - - -	Work - vector.
G - - - - - - - - - -	Interpolated acceleration.
GAM (NPTSG) - - - - - -	Vector of independent variables.
GM - - - - - - - - -	Maximum G-allowable (ft/sec/sec) (CDPRO subroutine)
GM - - - - - - - - -	Fragility limit (acceleration). (SHOCKE subroutine)
GMF (I) - - - - - - - -	G-levels for each percent damage allowable.
I1 - - - - - - - - - -	Array subscript for material used on face one.
I2 - - - - - - - - - -	Array subscript for material used on face two.

TABLE III (Contd.)

GLOSSARY OF VARIABLES FOR OPPACK

I3 - - - - - - - - - - -	Array subscript for material used on face three.
IC - - - - - - - - - - -	Procedure code.
IC = 1 - - - - - - - - -	MIL-STD-810B excitation.
IC = 2 - - - - - - - - -	Multiple sine excitation.
IC = 3 - - - - - - - - -	Random excitation.
IGO - - - - - - - - - -	Code to determine type of interpolation.
II (I) - - - - - - - - - -	Contains array positions of optimum thickness for each of the three faces.
IITM - - - - - - - - - -	Item number.
IJE - - - - - - - - - -	Deletion code.
ITEM - - - - - - - - - -	Item number.
ITEMP - - - - - - - - -	Number of temperatures considered.
MATOP (I, K) - - - - - - -	Optimum material for each face. MATOP (I, K) = F (G-level, axis).
MATSC (I) - - - - - - - -	Material code.
MC (I) - - - - - - - - - -	Contains material code for each of the three faces.
MIC - - - - - - - - - -	Maximum iterations for drop height weight convergence.
MITEM - - - - - - - - -	Item number.
MOMJ - - - - - - - - -	Number of input environment frequencies.
MOMS - - - - - - - - -	Number of frequencies stored on the vibration file. (CDPRO subroutine)

TABLE III (Cont'd.)

GLOSSARY OF VARIABLES FOR OPPACK

MOMS - - - - - - - - -	Number of frequencies stored on data files (VIBRTN Subroutine).
MTC - - - - - - - - - -	Material code.
MTS - - - - - - - - - -	Number of temperatures stored on the vibration file. (CDPRO subroutine)
MTS - - - - - - - - - -	Number of temperatures stored on data file. (VIBRTN subroutine)
MXI (I, J, K) - - - - - - - -	Array containing the number of thicknesses included in the dynamic thickness array.
MXIT (I, J, K) - - - - - - -	Number of thicknesses stored for each axis and temperature.
NMATS - - - - - - - - -	Number of materials to be considered.
NPCNT - - - - - - - - -	Number of different percent damage allowed.
NPTS - - - - - - - - - -	Number of points in table.
NPTSA - - - - - - - - -	Number of X-Y planes in input table.
NPTSB - - - - - - - - -	Number of columns in input table.
NS - - - - - - - - - - -	Number of static stresses. (CDPRO subroutine)
NS - - - - - - - - - - -	Number of static stresses stored on file (SHOCKE subroutine)
NT - - - - - - - - - - -	Number of temperatures. (CDPRO subroutine)
NT - - - - - - - - - - -	Number of temperatures stored on file. (SHOCKE subroutine)
NTH - - - - - - - - - -	Number of thicknesses.

TABLE III (Contd.)

GLOSSARY OF VARIABLES FOR OPPACK

OB (I) - - - - - - - - - -	Array of 1-Octave band center frequencies, Hz.
OCOST (I, K) - - - - - - -	Matrix of optimum cost for each allowed G-level. OCOST (I, K) = F (G-level, axis).
OM - - - - - - - - - - -	Environmental frequency.
OMJ (I) - - - - - - - - -	Environmental Frequencies (rad/sec)
OMS (I) - - - - - - - - -	Array of frequencies stored in ascending order. (CDPRO subroutine)
OMS (I) - - - - - - - - -	Frequency scale. (VIBRTN subroutine)
OPSS (I) - - - - - - - - -	The optimum number of packages to be shipped in order to have one reach the destination undamaged.
OTHK (I, K) - - - - - - - -	Optimum thickness for each face. OTHK (I, K) = F (G-level, axis).
PCTD (I) - - - - - - - - -	Percent of damage allowable.
REPCI (I) - - - - - - - -	Replacement cost.
RHOC - - - - - - - - - -	Specific weight of container material under consideration.
RHOM - - - - - - - - -	Specific weight of material under consideration.
S (I) - - - - - - - - - -	PSD (Power Spectral Density) input for random excitation. (DAMALW subroutine)
S (I) - - - - - - - - - -	Array of 1-octave band power spectral densities. (VIBRTN subroutine)
SI - - - - - - - - - - -	Static stress (W/A). (CDPRO subroutine)

TABLE III (Contd.)

GLOSSARY OF VARIABLES FOR OPPACK

SI - - - - - - - - - - -	Interpolating stress. (SHOCKE subroutine)
SIG (I) - - - - - - - -	Array of static stresses in ascending order. (CDPRO subroutine)
SIG (I) - - - - - - - -	1-D table of static stresses (W/A). (SHOCKE subroutine)
SIT (I) - - - - - - - -	Work array used for sorting.
SJ - - - - - - - - - -	Sum of output excitations for one center frequency.
SLT (I) - - - - - - - -	Safe low temperature.
T (I) - - - - - - - - -	Array of temperatures in ascending order. (CDPRO subroutine)
T (I) - - - - - - - - -	1-D table of temperatures. (SHOCKE subroutine)
T1 - - - - - - - - - -	Material thickness for face one.
T2 - - - - - - - - - -	Material thickness for face two.
T3 - - - - - - - - - -	Material thickness for face three.
TAB1 (I, J, K) - - - - - -	Work array - during shock calculations it contains G = F (thickness, static stress, temperature). During vibration calculations it contains ER = modulus = F (frequency, temperature). (CDPRO subroutine)
TAB1 (I, J, K) - - - - - -	3-D table of peak accelerations G = F (TH, SIG, T). (SHOCKE subroutine)
TAB1 (I, J, K) - - - - - -	Table containing behavior of storage modulus (ER) ER = F (frequency, temperature). (VIBRTN subroutine)

TABLE III (Contd.)

GLOSSARY OF VARIABLES FOR OPPACK

TAB2(I, J, K) - - - - - - -	Array which contains loss tangent = F (frequency, temperature). CDPRO subroutine)
TAB2(I, J, K) - - - - - - -	Table containing behavior of loss tangent EL/ER = F (Frequency, Temperature). (VIBRTN subroutine)
TCC - - - - - - - - - - -	Total cost of container by volume.
TCC(I) - - - - - - - - - -	Calculated thicknesses.
TCMV - - - - - - - - - -	Total cost of material by volume.
TCON - - - - - - - - - -	Thickness of container (in.).
TF(I) - - - - - - - - - - -	1-D array of guess thicknesses.
TF(WI, WJ, ERI, ERJ, DJ) - -	Statement function to calculate transfer function.
THCK(A, ERI, WI, W) - - -	Statement function to calculate thickness.
TH(I) - - - - - - - - - - -	Array of thicknesses in ascending order. (CDPRO subroutine)
TH(I) - - - - - - - - - - -	1-D table of thickness values. (SHOCKE subroutine)
THI - - - - - - - - - - -	A trial thickness. (CDPRO subroutine)
THI - - - - - - - - - - -	Guess thickness. (SHOCKE subroutine)
THIK(I, J) - - - - - - - -	Matrix of thicknesses generated during shock calculations.
THIKV(I, J) - - - - - - - -	Matrix of thicknesses generated during vibration calculations.
TI - - - - - - - - - - - - -	An environmental tamperature. (CDPRO subroutine)
TI - - - - - - - - - - - - -	Interpolating temperature. (SHOCKE subroutine)

TABLE III (Contd.)

GLOSSARY OF VARIABLES FOR OPPACK

TIII - - - - - - - - - -	Environmental temperature.
TMX - - - - - - - - - -	Maximum allowed shock thickness.
TOP - - - - - - - - - -	Optimum thickness.
TOPP(I) - - - - - - - - -	Array of acceptable thicknesses.
TS(I) - - - - - - - - - -	Array of temperatures stored in ascending order. (CDPRO subroutine)
TS(I) - - - - - - - - - -	Temperature scale. (VIBRTN subroutine).
TSK - - - - - - - - - -	Thickness predicted by shock environment.
TT(I) - - - - - - - - - -	A thickness work array.
TTHIK(I, J, K) - - - - - - -	Dynamic array which contains the union of the thicknesses of all three temperature environments.
TTHIK(I, J, L) - - - - - - -	Dynamic thickness array contains all acceptable vibration thicknesses for each material, axis, and temperature.
V1 - - - - - - - - - - -	Volume of packaging material needed for face one.
V2 - - - - - - - - - - -	Volume of packaging material needed for face two.
V3 - - - - - - - - - - -	Volume of packaging material needed for face three.
VAL - - - - - - - - - -	Interpolated value.
W - - - - - - - - - - -	Weight of item.
WI - - - - - - - - - -	Weight of item (lb) (CDPRO subroutine)
WI - - - - - - - - - -	1-octave band center frequency. (VIBRTN subroutine)
WII - - - - - - - - - -	Weight of item.

TABLE III (Contd.)

GLOSSARY OF VARIABLES FOR OPPACK

W(K) - - - - - - - - - -	Work array containing function weights.
WW - - - - - - - - - -	Item weight + container and cushion weight.
XB - - - - - - - - - - -	Horizontal argument (interpolating value).
XDD(I) - - - - - - - -	Calculated output excitation.
XDDA - - - - - - - -	Maximum allowable G-level.
XDJ(I) - - - - - - - -	Environmental G-levels.
XIK(I) - - - - - - - -	Table of independent variables to be interpolated.
XK - - - - - - - - - - -	Interpolating value.
XL - - - - - - - - - - -	Width (in.)
YG - - - - - - - - - - -	Vertical argument (interpolating value).
YL - - - - - - - - - - -	Height (in.) - shortest dimension.
ZA - - - - - - - - - - -	Depth (interpolating value).
ZL - - - - - - - - - - -	Length (in.) - longest dimension.

MAIN DRIVER AND SUBPROGRAMS

OPPACK -- Main Driver

Usage:

(1) Read first four input cards from problem card deck.

(2) Initialize appropriate variables.

(3) Print and define input data.

Subroutines called:

TEMPEV

```
              PROGRAM OPPACK(INPUT,OUTPUT,TAPE1,TAPE2,TAPE3,TAPE4,TAPE5,
             1   TAPE6,TAPE7,TAPE8,TAPE9,TAPE10)
          C   OPTIMIZATION  PACKAGE  MAIN  PROGRAM
          C   ROUTINE  READS  CARD  INPUT  DATA
000003        COMMON /COSTM/ CA(10,7),CD(10,2),CS,CI,WII
000003        COMMON /VPASS/ NIC,IC,IITM,MIC,MXI,MOMJ,TCON,TEML,TEMH
000003        DIMENSION OMJ(11),S(11),XDJ(11)
000003        READ 1000,NIC,IC,IITM,MIC,MXI,MOMJ,CS,CI,TCON,TEML,TEMH
000035        READ 1020,(OMJ(I),I=1,MOMJ)
000050        READ 1020,(S(I),I=1,MOMJ)
000063        READ 1020,(XDJ(I),I=1,MOMJ)
000076        PRINT 1070
000102        PRINT  1030, NIC,IC,IITM,MIC,MXI,MOMJ,CS,CI,TCON,TEML,TEMH
000124        PRINT  1040, (OMJ(I), I=1, MOMJ )
000147        PRINT 1050, (S(I), I=1, MOMJ )
000162        PRINT 1060, (XDJ(I), I=1, MOMJ )
000175        CALL  TEMPEV(OMJ,S,XDJ)
000200   1000 FORMAT(6I2,5E10.0)
000200   1010 FORMAT(40I2)
000200   1020 FORMAT(11E7.0)
000200   1030 FORMAT ( 1H0, I8  , 52H = NIC --- CODE NO. OF CONTAINER MATERIAL T
             1O BE USED /1X,I8,25H = IC---OPTIMIZATION CODE     /
             1/I8 , 23H = IITM --- ITEM NUMBER
             2/I8 , 56H = MIC --- MAXIMUM NO. OF ITERATIONS FOR DROP HT. CALC.
             3/I8 , 55H = MXI --- MAXIMUM NO. OF ITERATIONS FOR G-CONVERGENCE
             4/I8 , 47H = MOMJ --- NUMBER OF ENVIRONMENTAL FREQUENCIES
             5/E11.4,  33H ($/LB) = CS --- COST OF SHIPMENT
             6/F8.2 ,  29H ( $ )  = CI --- COST OF ITEM
             7/F8.6,   42H (IN.)  = TCON --- THICKNESS OF CONTAINER
             9/F8.2,   50H ( F )  = TEML ---  LOWEST ENVIRONMENT TEMPERATURE
             1/F8.2,   51H ( F )  = TEMH ---  HIGHEST ENVIRONMENT TEMPERATURE )
000200   1040 FORMAT ( 1H0,50H (RAD/SEC) = OMJ(I) ALL OF THE ENVIRONMENTAL FREQ.
             1/ 11E11.5 )
000200   1050 FORMAT ( 1H0,34H  PSD  INPUT FOR RANDOM EXCITATION
             1/ 11E11.5 )
000200   1060 FORMAT ( 1H0,92H (G'S) = XDJ(I) - ENVIRONMENTAL EXCITATIONS EACH
             1 CORRESPONDING TO ONE OF THE ABOVE OMJ(I)S/ 11E11.5)
000200   1070 FORMAT ( 1H1,// 30X, 65H***  OPTIMIZATION PROCEDURE FOR DESIGN OF
             1PACKAGE CUSHIONING  *** // )
000200        STOP
000202        END
```

```
OPPACK

PROGRAM LENGTH INCLUDING I/O BUFFERS
031022

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS
1000   -  000226    1010   -  000231    1020   -  000233    1030   -  000235
1040   -  000346    1050   -  000357    1060   -  000370    1070   -  000405

BLOCK NAMES AND LENGTHS
COSTM  -  000135    VPASS  -  000011

VARIABLE ASSIGNMENTS
CA     -  000000C01 CD     -  000106C01 CI     -  000133C01 CS     -  000132C01
I      -  000471    IC     -  000001C02 IITM   -  000002C02 MIC    -  000003C02
MOMJ   -  000005C02 MXI    -  000004C02 NIC    -  000000C02 OMJ    -  000430
S      -  000443    TCON   -  000006C02 TEMH   -  000010C02 TEML   -  000007C02
XDJ    -  000456

START OF CONSTANTS
000204

START OF TEMPORARIES
000420

START OF INDIRECTS
000430

UNUSED COMPILER SPACE
042400
```

TEMPEV - Subroutine

Usage:

This subroutine is used to initialize the three temperatures to be considered.

Subroutines called:

DAMALW

```
               SUBROUTINE  TEMPEV(OMJ,S,XDJ)
  000006       COMMON /VPASS/ NIC,IC,IITM,MIC,MXI,MOMJ,TCON,TEML,TEMH
  000006       COMMON /COSTM/ CA(10,7),CD(10,2),CS,CI,WII
  000006       COMMON /TEMPT/ TTHIK(10,3,11),IM,IAXS,ITEMP,IJE,TMX
  000006       DIMENSION TI(3)
  000006       DIMENSION OMJ(11),S(10),XDJ(11)
  000006       TMX=12.
  000007       ITEMP=3
  000010       TI(1)= TEML
  000012       TI(2)= 0.5*(TEMH+TEML)
  000015       TI(3)= TEMH
  000016       IF((TEMH-TEML).LT.20.)ITEMP=1
  000022       CALL DAMALW(NIC,IC,       IITM,TCON,TI,MIC,MXI,OMJ,MOMJ,S,XDJ)
  000035       RETURN
  000036       END
```

```
TEMPEV

SUBPROGRAM LENGTH
000055

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS

BLOCK NAMES AND LENGTHS
VPASS  -  000011     COSTM  -  000135     TEMPT  -  000517

[illegible]RIABLE ASSIGNMENTS
[illegible]     -  000000C02 CD     -  000106C02 IC     -  000001C01 IITM   -  000002C01
ITEMP  -  000514C03 MIC    -  000003C01 MU[illegible]J  -  000005C01 MXI    -  000004C01
NIC    -  000000C01 TCON   -  000006C01 TEMH   -  000010C01 TEML   -  000007C01
[illegible]     -  000052    TMX    -  000516C03 TTHIK  -  000000C03

START OF CONSTANTS
000040

START OF TEMPORARIES
000044

START OF INDIRECTS
0000[illegible]2

UNUSED COMPILER SPACE
043700
```

DAMALW - Subroutine

Usage:

(1) Reads remainder of problem data deck.

(2) Prints input and explanation of input.

(3) Determines materials to be considered.

(4) Determines best shipping policy.

(5) Prints appropriate information concerning the best shipping policy.

Subroutines called:

CDPRO

Glossary of Variables for DAMALW

CA (I, J) - - -	Material cost and property matrix. Contains cost of material, cost of fabrication, cost of packaging, safe low temperature, low and high static stresses, and specific weight.
CD (I, J) - - -	Container cost and property matrix. Contains specific weight of container and cost of container.
CI - - - - -	Cost of item.
CS - - - - -	Cost of shipment.
GMF (I) - - -	G-levels for each percent damage allowable.
I1 - - - - -	Array subscript for material used on face one.
I2 - - - - -	Array subscript for material used on face two.
I3 - - - - -	Array subscript for material used on face three.
MATOP (I, K) - -	Optimum material for each face. MATOP (I, K) = F (G-level, axis).
MATSC (I) - - -	Material code.
NMATS - - -	Number of materials to be considered.
NPCNT - - -	Number of different percent damage allowed.
OCOST (I, K) - -	Matrix of optimum cost for each allowed G-level. OCOST (I, K) = F (G-level, axis)
OMJ (I) - - - -	Environmental frequencies (rad/sec)
OPSS (I) - - -	The optimum number of packages to be shipped in order to have one reach the destination undamaged.
OTHK (I, K) - -	Optimum thickness for each face. OTHK (I, K) = F (G-level, axis)
PCTD (I) - - -	Percent of damage allowable.
REPCI (I) - - -	Replacement cost.

Glossary of Variables for DAMALW (Contd.)

S(I) - - - - - - PSD (Power Spectral Density) input for random excitation.

T1 - - - - - - Material thickness for face one.

T2 - - - - - - Material thickness for face two.

T3 - - - - - - Material thickness for face three.

WII - - - - - - Weight of item.

XDJ(I) - - - - The environmental G-levels.

```
                 SUBROUTINE  DAMALW(NIC,IC,      TIIM,TCON,TI,MIC,MXI,OMJ,MOMJ,S,
                1  XDJ)
          C      BASED UPON THE ALLOWED OAMAGE.
          C      CA(I,J) = COST ANO PROPERTY MATRIX - CONTAINS COST OF MATERIAL,
          C                COST OF FABRICATION,COST OF PACKAGING,SAFE LOW TEMP,
          C                LOW ANO HIGH STATIC STRESSES, SPECIFIC WEIGHT.
          C      CD(I,J) = COST ANO PROPERTY MATRIX - CONTAINS  SPECIFIC WT OF
          C                CONTAINER AND COST OF CONTAINER.
          C      CI = COST OF ITEM
          C      CS = COST OF SHIPPING
          C      DAMALW
          C      GMF(I) = ALLOWED G-LEVELS FOR EACH PER-CENT DAMAGE ALLOWABLE
          C      I1 = ARRAY SUBSCRIP-FOR MATERIAL USEO ON FACE ONE    (1)
          C      I2 = ARRAY  SUBSCRIP FOR MATERIAL USED ON FACE TWO  (2)
          C      I3 = ARRAY SUBSCRIP FOR MATERIAL USEO ON FACE THREE (3)
          C      MATOP(I,K) = OPTIMUM MATERIAL FOR EACH FACE
          C      MATSC(I)= MATERIAL CODE
          C      OCOST(I,J) = MATRIX OF OPTIMUM COST FOR EACH ALLOWED G-LEVEL
          C      OMJ(I) = ENVIRONMENTAL FREQUENCIES (RAO/SEC)
          C      OTHK(I,K) = OPTIMUM THICKNESS FOR EACH FACE
          C      PCTD(I)= PER-CENT OF OAMAGE ALLOWABLE
          C      REPCI(I)= REPLACEMENT COST
          C      S(I) = PSD INPUT - FOR RANDOM EXCITATION
          C      SUBROUTINE REAOS FRAGILITY DATA FOR DAMAGE ALLOWABLE
          C      SUBROUTINE REAOS MATERIAL COST AND PROPERTY FILE
          C      THEN ITERATES ON COPRO FOR DIFFERENT FRAGILITY DATA
          C      THEN IT DETERMINES THE OPTIMUM SHIPPING STRATEGY
          C      THE REMAINING INPUT VARIABLES ARE OEFINE IN THE OUTPUT FORMATS
          C      T1 = MATERIAL THICKNESS FOR FACE ONE
          C      T2 = MATERIAL THICKNESS FOR FACE TWO
          C      T3 = MATERIAL THCIKNESS FOR FACE THREE
          C      WII=WEIGHT OF ITEM
          C      XDJ(I) = THE ENVIRONMENTAL G-LEVELS
000016           DIMENSION TI(3)
000016           DIMENSION OPSS(10),OCOST(10,2),OTHK(10,3),MATOP(10,3)
000016           DIMENSION GMF(10),PCTD(10),REPCI(10),MATSC(10),OMJ(10),S(10),
                1   XDJ(10)
000016           COMMON /OPT/ I1,I2,I3,T1,T2,T3
000016           COMMON /COSTM/ CA(10,7),CO(10,2),CS,CI,WII
          C      READ COST FILE
000016           READ     500,NC,MITEM,MNMATS
000027           PRINT 4010, NC, MITEM, MNMATS
000041           READ     10, ((CA(I,J),J=1,7), I=1 ,MNMATS)
000060           READ     10, ((CO(I,J),J=1,2), I=1,NC)
000077           PRINT 4020, ((CA(I,J),J=1,7),I=1, MNMATS )
000116           PRINT 4030, ((CO(I,J),J=1,2), I=1, NC )
000135           RHOC=CO(NIC,1)
          C      READ FRAGILITY DATA FOR DAMAGE ALLOWABLE
000143        20 CONTINUE
000143           READ     5, ITEM,WI,XL,YL,ZL,NPCNT
000163           PRINT 4040, ITEM, WI, XL, YL, ZL, NPCNT
          C      USING THE RANGE OF OPTIMUM STRESSES OETERMINE THE MATERIALS TO BE
          C      CONSIDERED
000203           X=XL
000205           Y=YL
000206           Z=ZL
000210           W=WI
```

```
C      CHANGE PCF TO PCI
C      CHANGE COST/CF  TO  COST/CI
       DO  25  I=1,MNMATS
       CA(I,7)=CA(I,7)/1728.
    25 CA(I,1)=CA(I,1)/1728.
    26 CONTINUE
       S1 = W/(X * Y)
       S2 = W/(X * Z)
       S3 = W/(Z * Y)
       S11= AMIN1(S1,S2,S3)
       S22= AMAX1(S1,S2,S3)
       NMATS=0
       DO  28  I=1,MNMATS
C      SELECT  MATERIAL  TO  BE  CONSIDERED
       IF(S11.GT.CA(I,6).OR.S11.LT.CA(I,5))GO TO 28
       IF(S22.GT.CA(I,6).OR.S22.LT.CA(I,5))GO TO 28
       IF(CA(I,4).GT.TI(1)) GO TO 28
       NMATS=NMATS + 1
       MATSC(NMATS)=I
    28 CONTINUE
       IF(NMATS.EQ.0)PRINT 4000
       IF(NMATS.EQ.0)STOP
       PRINT 4060,(MATSC(I),I=1,NMATS)
       WII=WI
       IF(ITEM.NE.IITM)PRINT 3000
       READ    7, (GMF(I),PCTD(I),REPCI(I),I=1,NPCNT)
       PRINT 4050, (GMF(I), PCTD(I), REPCI(I),I=1, NPCNT)
       DO 40 IT=1,NPCNT
       GM=GMF(IT)
       CALL CDPRO(XL,YL,ZL,TCON,TI,WI,NMATS,RHOC,MIC,MXI,
      1   COST,MATSC,GM,OMJ,MOMJ,S,XDJ,IC,NIC)
       IF(TI(1).EQ.1500.)GO TO 45
       OTHK(IT,1)=T1
       OTHK(IT,2)=T2
       OTHK(IT,3)=T3
       MATOP(IT,1)=MATSC(I1)
       MATOP(IT,2)=MATSC(I2)
       MATOP(IT,3)=MATSC(I3)
       OPSS(IT)=1./(1.0-0.01*PCTD(IT))
C      COST OF OVERSHIPPING
       OCOST(IT,1)=COST*OPSS(IT)
C      COST OF ALLOWING DAMAGE
       OCOST(IT,2)=COST+REPCI(IT)
       PRINT 1000, PCTD(IT),GM,COST,OPSS(IT),OCOST(IT,1),OCOST(IT,2)
    40 CONTINUE
    45 CONTINUE
       IF(TI(1).EQ.1500.)NPCNT=IT-1
       IF(NPCNT.EQ.0)PRINT 4070
       IF(NPCNT.EQ.0)RETURN
       II=1
       OSB=OCOST(1,1)
       DO 50 I=1,NPCNT
       IF(OSB.LE.OCOST(I,1)) GO TO 50
       OSB=OCOST(I,1)
       II=I
    50 CONTINUE
       PRINT 1100
       PRINT 1500, OSB,GMF(II),PCTD(II),OPSS(II)
```

```
000576          PRINT 2000,OTHK(II,1),MATOP(II,1),OTHK(II,2),MATOP(II,2),
               1   OTHK(II,3),MATOP(II,3)
000616          II=1
000617          OVERS=OSB
000621          OSB=OCOST(1,2)
000622          DO 60 I=1,NPCNT
000627          IF(OSB.LE.OCOST(I,2)) GO TO 60
000632          OSB=OCOST(I,2)
000634          II=I
000635       60 CONTINUE
000640          PRINT 1600, OSB,GMF(II),PCTD(II),REPCI(II)
000653          PRINT 2000,OTHK(II,1),MATOP(II,1),OTHK(II,2),MATOP(II,2),
               1   OTHK(II,3),MATOP(II,3)
000673          IF(OVERS.GT.OSB)GO TO 70
000702          PRINT 1800
000705          PRINT 12000
000711          RETURN
000712       70 CONTINUE
000712          PRINT 1900
000716          PRINT 12000
000722          RETURN
000723        5 FORMAT(I4,2X,4E10.0,2X,I2)
000723        7 FORMAT(3E10.0)
000723       10 FORMAT(E5.0,E6.0,E6.0,E6.0,3E15.5)
000723      500 FORMAT(40I2)
000723     1000 FORMAT(2X,3HFOR1X,F6.2,1X,22HPER-CENT DAMAGE AND A
               1   17HFRAGILITY RATE OF F4.1,1X,3HG'S/
               2   2X,11HTHE COST IS1X,F9.2,1X,15HDOLLARS WITH A
               3   25HMULTIPLICATION FACTOR OF 1X,F6.2,1X,9HTIMES ONE /
               4   2X,20HWITH A FINAL COST OF1X,F9.2,1X,7HDOLLARS
               5   17HFOR OVER SHIPPING /
               6   2X,31HFOR ALLOWING DAMAGE THE COST IS 1X,F9.2,1X,
               7   12HDOLLARS/ITEM  /)
000723     1500 FORMAT(2X,18HOVER SHIPPING DATA /
               1   2X,19HTHE OPTIMUN COST IS1X,F9.2,1X,7HDOLLARS /
               2   2X,21HTHE FRAGILITY RATE IS1X,F4.1,1X,3HG'S /
               3   2X,22HTHE PER-CENT DAMAGE IS1X,F6.1 /
               4   2X,28HTHE MULTIPLICATION FACTOR IS1X,F5.1/)
000723     1600 FORMAT(2X,21HDAMAGE ALLOWABLE DATA /
               1   2X,19HTHE OPTIMUM COST IS1X,F9.2,1X,7HDOLLARS /
               2   2X,21HTHE FRAGILITY RATE IS1X,F4.1,1X,3HG'S /
               3   2X,22HTHE PER-CENT DAMAGE IS1X,F6.1, /
               4   2X,22HTHE REPAIR COST/ITEM =1X,F9.2,1X,7HDOLLARS/)
000723     1800 FORMAT(32HDOVERSHIPPING IS THE BEST POLICY/)
000723     1900 FORMAT(48HOTHE ABOVE PER-CENTAGE DAMAGE IS THE BEST POLICY/)
000723     2000 FORMAT(2X,37HTHE OPTIMUM THICKNESS FOR FACE ONE IS1X,F7.3,1X,
               1   6HINCHES1X,11HIF MATERIAL1X,I2,1X,7HIS USED/
               2       2X,37HTHE OPTIMUM THICKNESS FOR FACE TWO IS1X,F7.3,1X,
               3   6HINCHES1X,11HIF MATERIAL1X,I2,1X,7HIS USED/
               4       2X,39HTHE OPTIMUM THICKNESS FOR FACE THREE IS1X,F7.3,1X,
               5   6HINCHES1X,11HIF MATERIAL1X,I2,1X,7HIS USED//)
000723     3000 FORMAT(2X,45H*THE ITEM IDENTICATION NUMBER DOES NOT AGREE*
               133H*WITH THAT OF THE FRAGILITY DATA*)
000723     4000 FORMAT(2X,52HNO MATERIAL IS IN THE RANGE OF OPTIMUM STRESS---STOP)
000723     4010 FORMAT (1HO,I8,30H = NC --- NUMBER OF CONTAINERS/
               11X,I8,24H = MITEM --- ITEM NUMBER/
               21X, I8,40H = MNMATS--- NUMBER OF MATERIALS ON FILE )
000723     4020 FORMAT (1HO,2X, 85H CST-MAT      CST-FAB      CST-PAK      SL-TEMP
```

```
              1      LW-STRS       HI-STRS       GAMMA    / (E11.4,6E13.4))
000723     4030 FORMAT (1H0,2X,27H GAMMA        CST-CONTAINER  / (E11.4,6E13.4))
000723     4040 FORMAT (1H0,2X,I8,12H=ITEM NUMBER  /3X,E11.4,29H=WEIGHT OF ITEM WI
              1( POUNDS ) /3X,E11.4,65H= DIMENSION PARALLEL TO X-AXIS 2ND LONGEST
              2 DIMENSION XL (INCHES) /3X,E11.4,65H= DIMENSION PARALLEL TO Y-AXIS
              3 3RD LONGEST DIMENSION YL (INCHES) /3X,E11.4,61H= DIMENSION PARALL
              4EL TO Z-AXIS LONGEST DIMENSION ZL (INCHES) /,3X, 9HNUMBER = I8)
000723     4050 FORMAT ( 1H0,8X, 35H MAX-G       PCNT-DAM     REPLACE-CST  /
              1(3X,3E12.4) // 2(120(1H*)/ ) )
000723     4060 FORMAT(1H02X,30HMATERIAL CODES CONSIDERED ARE  10(1X,I2,2H,  ))
000723     4070 FORMAT(50H0  NONE OF THE DATA IS ACCEPTABLE FOR THIS PROBLEM      )
000723    11000 FORMAT (/    120(1H*)/    )
000723    12000 FORMAT ( //     (120(1H* )/ ) / 1H1 )
000723          END
```

DAMALW

SUBPROGRAM LENGTH
001706

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS

5	-	000735	7	-	000741	10	-	000743	20	-	000143
26	-	000224	28	-	000301	45	-	000523	50	-	000554
60	-	000635	70	-	000712	500	-	000747	1000	-	000751
1500	-	001032	1600	-	001072	1800	-	001133	1900	-	001140
2000	-	001147	3000	-	001216	4000	-	001231	4010	-	001241
[illegible]	-	001264	4030	-	001301	4040	-	001310	4050	-	001352
4060	-	001365	4070	-	001374	11000	-	001404	12000	-	001407

[illegible] NAMES AND LENGTHS

[illegible]	-	000006	COSTM	-	000135

VARIABLE ASSIGNMENTS

CA	-	000000C02	CD	-	000106C02	COST	-	001702	GM	-	001701
GMF	-	001602	I	-	001655	II	-	001703	IT	-	001700
ITEM	-	001660	I1	-	000000C01	I2	-	000001C01	I3	-	000C02C01
J	-	001656	MATOP	-	001544	MATSC	-	001640	MITEM	-	001653
MNMATS	-	001654	MOMJ	-	000002	MXI	-	000000	NC	-	001653
NMATS	-	001677	NPCNT	-	001665	OCOST	-	001462	OMJ	-	000001
OPSS	-	001450	OSB	-	001704	OTHK	-	001506	OVERS	-	001705
PCTD	-	001614	REPCI	-	001626	RHOC	-	001657	S	-	000003
S1	-	001672	S11	-	001675	S2	-	001673	S22	-	001676
S3	-	001674	T1	-	000003C01	T2	-	000004C01	T3	-	000005C01
W	-	001671	WI	-	001661	WII	-	000134C02	X	-	001666
XDJ	-	000004	XL	-	001662	Y	-	001667	YL	-	001663
Z	-	001670	ZL	-	001664						

START OF CONSTANTS
000725

START OF TEMPORARIES
001414

START OF INDIRECTS
001430

UNUSED COMPILER SPACE
037500

CDPRO - Subroutine

Usage:

(1) Reads material files.

(2) Stores material thicknesses by material and axis for the shock and vibration environments.

(3) Deletes materials that do not protect in all temperature regions.

Subprograms called:

(1) DHGHT

(2) SHOCKE

(3) VIBRTN

(4) COSTMT

Glossary of Variables for CDPRO

AL(I) - - - - - Array of longest dimensions for each face of package.

ALI(I) - - - - - Actual dimensions of package.

DH - - - - - - Calculated drop height.

DII - - - - - - Array of drop heights.

DLH - - - - - Dummy parameter.

DL(I) - - - - - Change in package dimensions along each face.

DRPH - - - - - Actual drop height - stored on file.

DWB - - - - - Weight added by the addition of a bearing board.

GM - - - - - - Maximum G-allowable (ft/sec/sec).

IJE - - - - - - Deletion code.

ITEMP - - - Number of temperatures considered.

MIC - - - - - Maximum iterations for drop height weight convergence.

MOMS - - - - Number of frequencies stored on the vibration file.

MTS - - - - - Number of temperatures stored on the vibration file.

MXIT (I, J, K) - - Number of thicknesses stored for each axis and temperature.

NMATS - - - Number of materials to be considered.

NS - - - - - - Number of static stresses.

NT - - - - - - Number of temperatures.

OMS(I) - - - Array of frequencies stored in ascending order.

RHOC - - - - Specific weight of container material under consideration.

RHOM - - - - Specific weight of material under consideration.

SI - - - - - - Static stress (W/A).

SIG(I) - - - - - Array of static stresses in ascending order.

Glossary of Variables for CDPRC (Contd.)

T(I)	- - - - -	Array of temperatures in ascending order.
TAB1 (I, J, K)	- -	Work array—during shock calculations it contains G = F (thickness, static stress, temperature). During vibration calculations it contains ER = modulus = F (frequency, temperature).
TAB2 (I, J, K)	- -	Array which contains loss tangent = F (frequency, temperature).
TCON	- - - -	Thickness of container (in.).
TH(I)	- - - -	Array of thicknesses in ascending order.
THI	- - - -	A trial thickness.
THIK (I, J)	- - -	Matrix of thicknesses generated during shock calculations.
THIKV (I, J)	- -	Matrix of thicknesses generated during vibration calculations.
TI	- - - - -	An environmental temperature.
TIII	- - - -	Environmental temperature.
TMX	- - - -	Maximum allowed shock thickness.
TS(I)	- - - -	Array of temperatures stored in ascending order.
TSK	- - - -	Thickness predicted by shock environment.
TTHIK (I, J, K)	-	Dynamic array which contains the union of the thicknesses of all three temperature environments.
WI	- - - - -	Weight of item (lbs).
XL	- - - - -	Width (in.).
YL	- - - - -	Height (in.) - shortest dimension.
ZL	- - - - -	Length (in.) - longest dimension.

```
             SUBROUTINE CDPRO(XL,YL,ZL,TCON,TI,WI,NMATS,RHOC,MIC,MXI,COST,
            1   MATSC ,GM,OMJ,MOMJ,S,XDJ,IC,NIC)
         C   CUSHION  DESIGN  PROCEEDURE
         C   GM     ----- MAX G-ALLOWABLE     (FT./SEC/SEC)
         C   MATSC----- VECTOR  OF  MATERIAL  CODES
         C   MIC    ----- MAX  ITERATIONS  FOR  WEIGHT  CONVERGENCE
         C   MXI    ----- MAX  ITERATIONS  FOR  GM  CONVERGENCE
         C   NMATS----- NUMBER  OF  MATERIALS  TO  BE  CONSIDERED
         C   NS     ----- NUMBER  OF STRESSES
         C   NT     ----- NUMBER  OF TEMPERATURES
         C   NTH    ----- NUMBER  OF THICKNESSES
         C   RHOC ----- SPEC. W  OF CONTAINER UNDER  CONSIDERATION  (PCI)
         C   RHOM ----- SPEC. W  OF MATERIAL  UNDER  CONSIDERATION  (PCI)
         C   SI     ----- STATIC  STRESS -CALCULATED
         C   TCON ----- THICKNESS  OF  CONTAINER   (INCHES)
         C   THI    ----- GUESS  THICKNESS -CALCULATED
         C   THIK ----- ARRAY  OF  THICKNESSES  WORK  ARRAY
         C   THIKV----- ARRAY  OF  THICKNESSES  WORK  ARRAY
         C   TI     ----- INTERPOLATING  TEMPERATURE
         C   WI     ----- WEIGHT  OF  ITEM
         C   XL     ----- WIDTH           (INCHES)
         C   YL     ----- HEIGHT          (INCHES)
         C   ZL     ----- LENGTH          (INCHES)
000026       COMMON /MMM/ MXIT(10,3,3)
000026       COMMON /THK/ TSK,ITEM
000026       COMMON /TEMPT/ TTHIK(10,3,11),IM,IAXS,ITEMP,IJE,TMX
000026       COMMON /N/ NT,NS,NTH,SI,THI,TIII
000026       DIMENSION TI(3)
000026       DIMENSION TH(10),SIG(10),T(10),TAB1(10,10,10),MATSC(10),TS(10)
000026       DIMENSION OMS(10),THIK(10,3),DII(5),THIKV(10,3),TAB2(10,10,10)
000026       DIMENSION OMJ(11),XDJ(11),FE(10),S(10),AL(3),ALI(3),DL(3)
000026       EQUIVALENCE(TH,TS),(SIG,OMS),(T,FE)
000026       INTEGER DRPH
000026       INTEGER DH,DLH,DII
000026       DATA  DII/ 18,24,30,36,48/
         C   STATEMENT FUNCTION TO CALCULATE WEIGHT CHANGES
000026       WF(T1,T2,T3,RC,RM)=2.*((RC*TCON+RM*T1)*(Z +2.*(TCON+T1))*
            1   (Y +2.*(TCON+T1)) + (RC*TCON+RM*T2)*(X +2.*(TCON+T2))*
            2   (Z +2.*(TCON+T2)) + (RC*TCON+RM*T3)*(Y +2.*(TCON+T3))*
            3   (X +2.*(TCON+T3)))
         C
000106       ITIME = 0
000107       DWB=0.0
000110       DO  130  ITEM=1,ITEMP
000111       TIII = TI(ITEM)
000113       XDDA=GM
000115       AL(1)=ZL
000116       AL(2)=ZL
000117       AL(3)=XL
000120       X=XL
000121       Y=YL
000122       Z=ZL
000123       PRINT 11000
000126       DO  50  IM=1,NMATS
000133       MS = MATSC(IM)
000136       REWIND MS
000140       DO  4  IAXS=1,3
```

```
000142        4 THIKV(IM,IAXS)=0.0
000150        5 CONTINUE
000150          THI=3.5
000152          THIK(IM,1)=THI
000154          THIK(IM,2)=THI
000155          THIK(IM,3)=THI
000156          DLH=0
000156          T1= THI
000157          T2= THI
000160          T3= THI
000161          TT1= T1
000162          TT2= T2
000164          TT3= T3
000165          DL(1)= 2.*(THI + TCON)
000170          DL(2)= 2.*(THI + TCON)
000173          DL(3)= 2.*(THI + TCON)
000176          READ(MS,12)RHOM,DRPH,ICODE
000207          RHOM=RHOM/12.**3
000211          DO  16  ICOUNT=1,MIC
000216          DO  15  IAXS=1,3
000217          THI=THIK(IM,IAXS)
000223          ALI(IAXS)=AL(IAXS)+DL(IAXS)
000226          IF(IAXS.EQ.1)A=Y*Z
000232          IF(IAXS.EQ.2)A=X*Z
000236          IF(IAXS.EQ.3)A=Y*X
000242          WW = WI + WF(TT1,TT2,TT3,RHOC,RHOM) + DWB
000255          DH= DHGHT(WW,ALI(IAXS))
000263          IJ=0
000264       11 CONTINUE
000264          IJ=IJ+1
000266          IF(IJ.GT.4)PRINT 10000
000303          READ(MS,20)NT,NTH,NS
000315          READ(MS,10)(T(I),I=1,NT)
000330          READ(MS,10)(TH(I),I=1,NTH)
000343          READ(MS,10)(SIG(I),I=1,NS)
000356          DO  1000  K=1,NT
000363          DO  1000  I=1,NTH
000364     1000 READ(MS,10)(TAB1(I,J,K),J=1,NS)
000412          IF(DH.NE.DII(IJ))READ(MS,12)RHOM,DRPH,ICODE
000432          IF(DH.NE.DII(IJ))
               1RHOM=RHOM/12.**3
000437          IF(DH.NE.DII(IJ))GO TO 11
000442       13 CONTINUE
000442          REWIND  MS
000444          READ(MS,12)RHOM,DRPH,ICODE
000456          RHOM=RHOM/12.**3
000460          SI=WI/A
000466          THIK(IM,IAXS)= SHOCKE(TAB1,TH,SIG,T,GM,MXI)
000476          TT1 = THIK(IM,1)
000500          TT2 = THIK(IM,2)
000501          TT3 = THIK(IM,3)
000503          DL(1)=2.*(TT3+TCON)
000511          DL(2)=2.*(TT3+TCON)
000514          DL(3)=2.*(TT1+TCON)
          C     CALCULATE DELTA LENGTH FOR LONGEST DIMENSION
000517       15 CONTINUE
000521          IF(ABS(T1-TT1).LE.1.E-1.AND.ABS(T2-TT2).LE.1.E-1.AND.ABS(T3-TT3).
               1  LE.1.E-1) GO TO 45
```

```
000545          PRINT 7001,T1,T2,T3,TT1,TT2,TT3
000564          T1 = TT1
000566          T2 = TT2
000567          T3 = TT3
000571       16 CONTINUE
          C     PRINT  APPROPRIATE  MESSAGE  FOR  NON-CONVERGENCE
000577          PRINT 7000,MATSC(IM)
000605          MATSC(IM)=0
000610          GO TO 50
000614       45 CONTINUE
000614          IF(TT3.LE.TMX)GO TO 50
000617          ITIME = ITIME+1
000620          IF(ITIME.NE.1)GO TO 50
000621          REWIND MS
000623          Y=YL+2.*T2
000626          PRINT 8000,XL,Y,ZL,Y,IM
          C     CALCULATE WEIGHT OF (1./4) INCH PLYWOOD FOR EACH AXIS
000644          DW8=0.0098*(Y*Z + Y*X)
000650          GO TO 5
000654       50 CONTINUE
          C
000657          DO  56  IM=1,NMATS
000660          IF(MATSC(IM).EQ.0)GO TO 56
000662          MS=MATSC(IM)
          C     READ TO BEGINNING OF VIBRATION FILES
000664          REWIND MS
000666          DO  55  IR=1,4
000670          READ(MS,12)RHOM,DRPH,ICODE
000701          READ(MS,20)NT,NTH,NS
000713          READ(MS,10)(T(I),I=1,NT)
000726          READ(MS,10)(TH(I),I=1,NTH)
000741          READ(MS,10)(SIG(I),I=1,NS)
000754          DO  55  K=1,NT
000761          DO  55  I=1,NTH
000762       55 READ(MS,10)(TAB1(I,J,K),J=1,NS)
001012       56 CONTINUE
          C     CALCULATE THICKNESS FROM VIBRATION ENVIRONMENT
          C
001015          DO  100  IM=1,NMATS
001016          MS=MATSC(IM)
001021          IF(MS.EQ.0)GO TO 100
001022          READ(MS,12)RHOM,MTS,MOMS
001033          READ(MS,14)(TS(I),I=1,MTS)
001046          READ(MS,14)(OMS(I),I=1,MOMS)
001061          DO  60  I=1,MOMS
001066          READ(MS,14)(TAB1(1,J,1),J=1,MTS)
001101       60 CONTINUE
001107          DO  65  I=1,MOMS
001111          READ(MS,14)(TAB2(I,J,1),J=1,MTS)
001124       65 CONTINUE
001132          DO  70  IAXS=1,3
001134          THIKV(IM,IAXS)=THIK(IM,IAXS)
001141          IF(IAXS.EQ.1)A=Y*Z
001145          IF(IAXS.EQ.2)A=X*Z
001151          IF(IAXS.EQ.3)A=Y*X
001155          WW=WI
001156       69 CONTINUE
001156          TSK=THIKV(IM,IAXS)
```

```
001162         CALL  VIBRTN(TAB1,TAB2,TS,OMS,TOP,OMJ,FE,MOMJ,XDDA,A,WW,S,IC,XDJ)
001202         IF(IJE.EQ.0)GO TO 75
001207         THIKV(IM,IAXS)=TSK
001213      70 CONTINUE
001214      75 CONTINUE
          C
001214         IF(IJE.EQ.0)MATSC(IM)=0
001220     100 CONTINUE
          C      PRINT  THICKESSES
001223         PRINT 5000,((THIKV(I,J),J=1,3),I=1,NMATS)
          C      ELIMINATE  MATERIALS  THAT  DO  NOT  OVERLAP  ALL  TEMP  REGIONS
001242         IK=0
          C      UP-DATE  THICKNESS  ARRAY
001243         DO  120  IM=1,NMATS
001250         IF(MATSC(IM).EQ.0) GO TO 120
001252         IK=IK+1
001254         DO  110  IA=1,3
001255         MXX=MXIT(IM,IA,ITEM)
001262         DO  110  IU=1,MXX
001264         TTHIK(IK,IA,IU)=TTHIK(IM,IA,IU)
001275         MXIT(IK,IA,ITEM)=MXX
001301         IF(ITEMP.EQ.1)GO TO 110
001303         MXIT(IK,IA,ITEM-1)=MXIT(IM,IA,ITEM-1)
001312     110 CONTINUE
001317     120 CONTINUE
          C      SORT OUT DELETIONS
001322         DO 125 I=1,NMATS
001323         DO 125 J=I,NMATS
001324         IF(MATSC(J).LT.MATSC(I))GO TO 125
001330         SAVE = MATSC(J)
001332         MATSC(J)=MATSC(I)
001335         MATSC(I)=SAVE
001340     125 CONTINUE
001345         NMATS = IK
001346         IF(NMATS.NE.0)GO TO 126
001347         PRINT 6000
001352         TI(1)=1500.
001357         RETURN
001360     126 CONTINUE
          C      SORT MATSC(I) BACK INTO ASCENDING ORDER
001360         DO  127  I=1,NMATS
001362         DO  127  J=I,NMATS
001363         IF(MATSC(J).GT.MATSC(I))GO TO 127
001370         SAVE=MATSC(J)
001372         MATSC(J)=MATSC(I)
001375         MATSC(I)=SAVE
001377     127 CONTINUE
001404     130 CONTINUE
001406         DO  135  I=1,NMATS
001410         DO  135  IA=1,3
001411         MXII=MXIT(I,IA,ITEMP)
001416         IF(ITEMP.EQ.1)MXII=1
001421         THIKV(I,IA)=TTHIK(I,IA,MXII)
001431     135 CONTINUE
001436         CALL COSTMT(THIKV,X ,Y ,Z ,TCON,THIK ,MATSC,NMATS,COST,NIC)
001451         RETURN
001452      10 FORMAT(11E7.0)
001452      12 FORMAT(E7.0,5I2)
```

```
001452        14 FORMAT(11E11.4)
001452        20 FORMAT(5I2)
001452      5000 FORMAT(2X,39HMINIMUM THICKNESS FOR MATERIAL BY AXIS /
               1    10(2X,3E15.4/))
001452      6000 FORMAT(1X,58H ALL MATERIALS DELETED --- NO OVERLAP BETWEEN TEMPERA
               1TURES  29H-OPTIMIZE ON DATA ACCUMULATED  )
001452      7000 FORMAT(55H CAN NOT DETERMINE THICKNESS FOR DROP HGT. CALCULATIONS
               1  2X,15HMATERIAL CODE =I3,2X,21HTHIS MATERIAL DELETED)
001452      7001 FORMAT(2X,3HT1=E11.4,2X,3HT2=E11.4,2X,3HT3=E11.4,
               1    2X,4HTT1=E11.4,2X,4HTT2=E11.4,2X,4HTT3=E11.4)
001452      8000 FORMAT(2X,30HPLYWOOD BEARING BOARD 1/4 INCH/
               13X,10HDIMENSIONS F5.2,3H X F5.2,2X,6HSIDE 3
               23X,10HDIMENSIONS F5.2,3H X F5.2,2X,6HSIDE 1 3X,15HMATERIAL NUMBER
               3 I3)
001452     10000 FORMAT(1H0 25HCAN NOT FIND DROP HEIGHT      )
001452     11000 FORMAT (/   120(1H*)/   )
001452           END
```

```
CDPRO

SUBPROGRAM LENGTH
006032

FUNCTION ASSIGNMENTS
WF      -  U00034

STATEMENT ASSIGNMENTS
4       -  000142    5       -  000150    10      -  001466    11      -  000264
12      -  001470    13      -  000442    14      -  001473    20      -  001476
45      -  000614    50      -  000654    56      -  001012    69      -  001156
75      -  001214    100     -  001220    110     -  001312    120     -  001317
125     -  001340    126     -  001360    127     -  001377    5000    -  001500
6000    -  001511    7000    -  001525    7001    .  001542    8000    -  001556
10000   -  001603    11000   -  001610

BLOCK NAMES AND LENGTHS
MMM     -  000132    THK     -  000002    TEMPT   -  000517    N       -  000006

VARIABLE ASSIGNMENTS
A       -  006012    AL      -  005756    ALI     -  005761    COST    -  000004
DH      -  005770    DII     -  003743    DL      -  005764    DLH     -  005771
DRPH    -  005767    DWB     -  005776    FE      -  001723    GM      -  000006
I       -  006015    IA      -  006025    IAXS    -  000513C03 IC      -  000013
ICODE   -  006010    ICOUNT  -  006011    IJ      -  006014    IJE     -  000515C03
IK      -  006024    IM      -  000512C03 IR      -  006020    ITEM    -  000001C02
ITEMP   -  000514C03 ITIME   -  005775    IU      -  006027    J       -  006017
K       -  006016    MATSC   -  000005    MIC     -  000002    MOMJ    -  000010
MOMS    -  006022    MS      -  006000    MTS     -  006021    MXI     -  000003
MXII    -  006031    MXIT    -  000000C01 MXX     -  006026    NIC     -  000014
NMATS   -  000000    NS      -  000001C04 NT      -  000000C04 NTH     -  000002C04
OMJ     -  000007    OMS     -  001711    RHOC    -  000001    RHOM    -  006007
S       -  000011    SAVE    -  006030    SI      -  000003C04 SIG     -  001711
T       -  001723    TAB1    -  001735    TAB2    -  004006    TH      -  001677
THI     -  000004C04 THIK    -  003705    THIKV   -  003750    TIII    -  000005C04
TMX     -  000516C03 TOP     -  006023    TS      -  001677    TSK     -  000000C02
TTHIK   -  000000C03 TT1     -  006004    TT2     -  006005    TT3     -  006006
T1      -  006001    T2      -  006002    T3      -  006003    WW      -  006013
X       -  005774    XODA    -  005777    XDJ     -  000012    Y       -  005773
Z       -  005772

START OF CONSTANTS
U01454

START OF TEMPORARIES
001613

START OF INDIRECTS
001671

UNUSED COMPILER SPACE
036300
```

DHGHT - Function Subprogram

Usage:

Picks drop height using criterion set forth in the MIL-Standard.

Subroutines called:

None

Glossary of Variables for DHGHT

ALL - - - - Item length + container and cushion thickness.

DH - - - - - Calculated drop height.

DHH (I) - - - Drop height.

DHL (I) - - - Drop height longest length.

DHW (I) - - - Drop height upper weight limit.

WW - - - - - Item weight + container and cushion weight.

```
                      FUNCTION DHGHT(WW,ALL)
000005                DIMENSION DHW(7),DHL(7),DHH(7)
              C       ALL------ ITEM LENGTH + CONTAINER AND CUSHION THICKNESS
              C       DHH------ DROP HEIGHT
              C       DHL------ DROP HEIGHT MAXIMUM LENGTH
              C       DHW------ DROP HEIGHT UPPER WEIGHT LIMIT
              C       WW ------ ITEM WEIGHT + CONTAINER AND CUSHION WEIGHT
000005                DATA DHW/100.,100.,200.,200.,1000.,1000.,1000./
000005                DATA DHL/36.,500.,36.,500.,36.,60.,600./
              C       DATA DHH/48.,30.,30.,24.,24.,36.,24./
000005                DATA DHH/36.,30.,30.,24.,24.,36.,24./
              C       THIS  FUNCTION  PICKS  THE  APPROPRIATE  DROP  HEIGHT
000005                DH= 18.
000006                IF(WW.GT.1000.)GO TO 20
000011                DO  10  I=1,7
000012                II=I
000013              7 CONTINUE
000013                IF(WW.GT.DHW(II))GO TO 10
000017                IF(ALL.LT.DHL(II))GO TO 18
000021                IF(DHW(II).LT.DHW(II+1))GO TO 18
000023                II=II+1
000025                GO TO 7
000025             10 CONTINUE
000027             18 DH=DHH(II)
000031             20 DHGHT=DH+0.1
000033                RETURN
000034                END
```

DHGHT

SUBPROGRAM LENGTH
000101

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS

7	-	000013	10	-	000025	18	-	000027	20	-	000031

BLOCK NAMES AND LENGTHS

VARIABLE ASSIGNMENTS

DH	-	000076	DHGHT	-	000050	DHH	-	000067	DHL	-	000060
DHW	-	000071	I	-	000077	II	-	000100			

START OF CONSTANTS
000036

START OF TEMPORARIES
000042

START OF INDIRECTS
000044

UNUSED COMPILER SPACE
043300

COSTMT - Subroutine

Usage:

(1) Calculates cost of packing materials by axis.

(2) Calculates cost of container.

(3) Calculates cost of fabrication of package material.

(4) Calculates total cost.

(5) Prints total cost and cost by material and axis.

Subroutines called:

MINCOS

Glossary of Variables for COSTMT

AL(I) - - - - - - Area of the perpendicular face of the package.

C1 - - - - - - - Cost of material on face one.

C2 - - - - - - - Cost of material on face two.

C3 - - - - - - - Cost of material on face three.

C12 - - - - - - Contains the minimum cost between the materials on face one and face two.

C13 - - - - - - Contains the minimum cost between the materials on face one and face three.

C23 - - - - - - Contains the minimum cost between the materials on face two and face three.

C123 - - - - - - Contains the lowest cost of the three materials.

CAXIS(I, 1) - - - Cost of the packaging material for face one.

CAXIS(I, 2) - - - Cost of the packaging material for face two.

CAXIS(I, 3) - - - Cost of the packaging material for face three.

CF(I) - - - - - - Array containing cost of fabrication to specific dimensions.

CFF - - - - - - Cost of fabrication.

CM(I) - - - - - - Array containing material cost.

COST - - - - - - Total cost.

CP(I) - - - - - - Array containing the cost of packaging.

CPP - - - - - - Cost of packaging.

CSS - - - - - - Cost of shipping the package.

CVC - - - - - - Cost of material for corners.

II(I) - - - - - - Contains array positions of optimum thickness for each of the three faces.

Glossary of Variables for COSTMT (Contd.)

MC (I) - - - - - - Contains material code for each of the three faces.

MTC - - - - - - Material code.

SLT (I) - - - - - - Safe low temperature.

T1 - - - - - - - Optimum thickness for face one.

T2 - - - - - - - Optimum thickness for face two.

T3 - - - - - - - Optimum thickness for face three.

TCC - - - - - - Total cost of container by volume.

TCMV - - - - Total cost of material by volume.

V1 - - - - - - - Volume of packaging material needed for face one.

V2 - - - - - - - Volume of packaging material needed for face two.

V3 - - - - - - - Volume of packaging material needed for face three.

```
          SUBROUTINE COST MT(THIKV,XL,YL,ZL,TCON,CAXIS,MATSC,NMATS,COST,IC)
        C      CC ---- 1-D ARRAY COST/UNIT VOLUME OF CONTAINER MATERIAL
        C      CF ------ 1-D ARRAY CONTAINING COST OF FABRICATION TO
        C                 SPECIFIC DIMENSION (0.05-MIN)
        C      CI ---- COST OF ITEM
        C      CM ------ 1-D ARRAY CONTAINING MATERIAL COST/UNIT VOLUME
        C      COSTMT
        C      CP ---- 1-D ARRAY COST OF PACKING ITEM FOR SHIPMENT
        C      CS ---- COST OF SHIPMENT
        C      GAMAC ---- 1-D ARRAY CONTAINING SPECIFIC WEIGHT OF CONTAINER
        C                 MATERIAL
        C      ROS1 ---- 1-D ARRAY LOW END OF THE RANGE OF OPTIMUM
        C                 STRESS OF EACH MATERIAL
        C      ROS2 ---- 1-D ARRAY HIGH END OF THE RANGE OF OPTIMUM
        C                 STRESS OF EACH MATERIAL
        C      SLT ---- 1-D ARRAY OF SAFE LOW TEMPERATURE FOR EACH MATERIAL
000015         COMMON /COSTM/ CA(10,7),CD(10,2),CS,CI,WII
000015         COMMON /OPT/ I1,I2,I3,T1,T2,T3
000015         DIMENSION MATSC(10)
000015         DIMENSION CM(10),CF(10),CP(10),SLT(10),ROS1(10),ROS2(10),MC(3)
000015         DIMENSION GAMAC(10),CC(10),THIKV(10,3),CAXIS(10,3),AL(3),II(3)
000015         EQUIVALENCE (CA(1,1),CM),(CA(1,2),CF),(CA(1,3),CP),(CA(1,4),SLT),
              1  (CA(1,5),ROS1),(CA(1,6),ROS2)
000015         EQUIVALENCE (CD(1,1),GAMAC),(CD(1,2),CC),(MC,AL)
000015         AL(1) =ZL*YL
000016         AL(2)=ZL*XL
000017         AL(3)=XL*YL
000021         DO 20 I=1,NMATS
000022         MTC=MATSC(I)
000025         V1=AL(1)*THIKV(I,1)
000027         V2=AL(2)*THIKV(I,2)
000032         V3=AL(3)*THIKV(I,3)
000034         CAXIS(I,1)=V1*CM(MTC)
000040         CAXIS(I,2)=V2*CM(MTC)
000042         CAXIS(I,3)=V3*CM(MTC)
000045      20 CONTINUE
000050         CALL MINCOS(II,[illegible]IS,NMATS)
        C      DETERMINE COST OF PACKING MATERIAL
000052         DO 30 I=1,3
        C      II(I) CONTAINS ARRAY POSITIONS
000057         IL=II(I)
        C      MC(I) CONTAINS MAT. CODE
000061         MC(I)=MATSC(IL)
000064      30 CONTINUE
        C      I,J,K CONTAINS MAT. CODE
000066         I=MC(1)
000067         J=MC(2)
000070         K=MC(3)
        C      CALCULATE MIN. COST FOR CORNER AND EDGE CUSHIONING
000072         C123=AMIN1(CM(I),CM(J),CM(K))
000102         C12=AMIN1(CM(I),CM(J))
000110         C13=AMIN1(CM(I),CM(K))
000115         C23=AMIN1(CM(J),CM(K))
000123         I1=II(1)
000125         I2=II(2)
000126         I3=II(3)
000130         T1=THIKV(I1,1)
```

```
000132          T2=THIKV(I2,2)
000135          T3=THIKV(I3,3)
000137          CSS=(ZL*YL*T1*CA(I1,7)+ZL*XL*T2*CA(I2,7)+XL*YL*T3*CA(I3,7))*CS
              1    + CS*WII
000154          PRINT 2000,MC(1),THIKV(I1,1),MC(2),THIKV(I2,2),MC(3),THIKV(I3,3)
000221          C1=ZL*THIKV(I1,1)*THIKV(I2,2)*C12
000232          C2 =XL*THIKV(I2,2)*THIKV(I3,3)*C23
000237          C3=YL*THIKV(I3,3)*THIKV(I1,1)*C13
000244          CVC=THIKV(I1,1)*THIKV(I2,2)*THIKV(I3,3)*C123
          C     TOTAL COST OF MATERIAL BY VOLUME
000252          TCMV=2.*(CAXIS(I1,1)+CAXIS(I2,2)+CAXIS(I3,3))
              1  +8.*CVC+4.*(C1+C2+C3)
          C     TOTAL COST OF CONTAINER BY VOLUME
[illegible]     TCC=CC(IC)*TCUN*(2.*(ZL+2.*THIKV(I3,3))*(YL+2.*THIKV(I2,2))+
              1    2.*(ZL+2.*THIKV(I3,3))*(XL+2.*THIKV(I1,1))+
              2    2.*(XL+2.*THIKV(I1,1))*(YL+2.*THIKV(I2,2)))
          C     COST OF FABRICATION BASED ON A RATE OF 3 INCHES/MIN AND THE ASSUMPTION
          C     THAT IT TAKES 1/2 AS MUCH TIME TO CUT THE EDGE FILLER AS TO CUT
          C     THE SURFACE.
000315          CFF=2.*(CF(I)*(ZL+YL)+CF(J)*(XL+ZL)+CF(K)*(XL+YL))
          C     TOTAL COST
000332          CPP=6.*(CP(I)*(ZL+YL)+CP(J)*(XL+ZL)+CP(K)*(XL+YL))
000346          COST=TCMV+TCC+CFF+CSS+CI+CPP
          C     TO BE CONTINUED LATER      *********
000354          PRINT 1000, COST,(MATSC(IA),(CAXIS(IA,JA),JA=1,3),IA=1,NMATS)
000411          RETURN
000412     1000 FORMAT(2X,16HTOTAL COST/ITEM=F8.2,/,2X,12HMINCOS-INPUT /
              1  2X,46HCOST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL /
              2  10(2X,I2,2X,F8.2,2X,F8.2,2X,F8.2/))
000412     2000 FORMAT(2X,15HMATERIAL CODE = I4,2X,24HTHICKNESS FOR FACE ONE =F8.3
              1    ,1X,6HINCHES/
              2         2X,15HMATERIAL CODE = I4,2X,24HTHICKNESS FOR FACE TWO =F8.3
              3    ,1X,6HINCHES/
              4         2X,15HMATERIAL CODE = I4,2X,25HTHICKNESS FOR FACE THREE=
              5    F8.3,1X,6HINCHES/)
000412          END
```

```
COSTMT

SUBPROGRAM LENGTH
000701

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS
1000     -  000422     2000     -  000444

BLOCK NAMES AND LENGTHS
COSTM    -  000135     OPT      -  000006

VARIABLE ASSIGNMENTS
AL       -  000644     CA       -  000000C01 CC    -  000120C01 CD     -  000106C01
CF       -  000012C01  CFF      -  000675    CI    -  000133C01 CM     -  000000C01
COST     -  000002     CP       -  000024C01 CPP   -  000676    CS     -  000132C01
CSS      -  000666     CVC      -  000672    C1    -  000667    C12    -  000663
C123     -  000662     C13      -  000664    C2    -  000670    C23    -  000665
C3       -  000671     GAMAC    -  000106C01 I     -  000652    IA     -  000677
IC       -  000003     II       -  000647    IL    -  000657    I1     -  000000C02
I2       -  000001C02  I3       -  000002C02 J     -  000660    JA     -  000700
K        -  000661     MATSC    -  000000    MC    -  000644    MTC    -  000653
NMATS    -  000001     ROS1     -  000050C01 ROS2  -  000062C01 SLT    -  000036C01
TCC      -  000674     TCMV     -  000673    T1    -  000003C02 T2     -  000004C02
T3       -  000005C02  V1       -  000654    V2    -  000655    V3     -  000656
WII      -  000134C01

START OF CONSTANTS
000414

START OF TEMPORARIES
000510

START OF INDIRECTS
000574

UNUSED COMPILER SPACE
041500
```

MINCOS - Subroutine

Usage:

Picks the material that has the minimum cost for each axis.

Subroutines called:

None

Glossary of Variables for MINCOS

CAXIS (1, J) - - Cost of packaging material for all three faces.

II (I) - - - - - Contains array positions of optimum thicknesses for each face.

SIT (I) - - - - Work array used for sorting.

```
                 SUBROUTINE MINCOS(II,CAXIS,NMATS)
           C     MIN COST
           C     SUBROUTINE PICKS THE MATE' IAL FOR EACH AXIS-WHICH
           C                 HAS THE MINIMUM COST
000006           DIMENSION II(1),CAXIS(10,3),SIT(10)
000006           DO 50 IAXIS=1,3
000007           DO 30 I=1,NMATS
000010        30 SIT(I)=CAXIS(I,IAXIS)
000020           II(IAXIS)=1
000022           DO 40 IM=1,NMATS
000024           IF(SIT(1).LT.SIT(IM)) GO TO 40
000027           II(IAXIS)=IM
000031           SAVE=SIT(1)
000032           SIT(1)=SIT(IM)
000033           SIT(IM)=SAVE
000034        40 CONTINUE
000037        50 CONTINUE
000041           RETURN
000041           END
```

```
MINCOS

SUBPROGRAM LENGTH
000070

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS
30      - 000010    40      - 000034

BLOCK NAMES AND LENGTHS

VARIABLE ASSIGNMENTS
I       - 000065    IAXIS - 000064    IM      - 000066    SAVE    - 000057
SIT     - 000052

START OF CONSTANTS
000043

START OF TEMPORARIES
000044

START OF INDIRECTS
000046

UNUSED COMPILER SPACE
043400
```

SHOCKE - Function Subprogram

Usage:

Calculates the material thickness required to protect the packaged item in the given shock environment.

Procedure:

(1) Given: a table G = F (thickness, static stress),

(2) build a one-dimensional table thickness = F (G).

(3) Interpolate or extrapolate to find desired thickness.

Subprograms called:

LAGINT

FLAGR

Glossary of Variables for SHOCKE

F2 (I) - - - - - - 1-D array of interpolated accelerations.

G - - - - - - - Interpolated acceleration.

GM - - - - - - - Fragility limit (acceleration).

NS - - - - - - - Number of static stresses stored on file.

NT - - - - - - - Number of temperatures stored on file.

NTH - - - - - - Number of thicknesses.

SI - - - - - - - Interpolating stress.

SIG (I) - - - - - - 1-D table of static stresses (W/A).

T (I) - - - - - - 1-D table of temperatures.

TAB1 (I, J, K) - - 3-D table of peak accelerations
G = F (TH, SIG, T).

TF (I) - - - - - - 1-D array of guess thicknesses.

TH (I) - - - - - - 1-D table of thickness values.

THI - - - - - - - Guess thickness.

TI - - - - - - - Interpolating temperature.

```
              FUNCTION SHOCKE(TAB1,TH,SIG,T,GM,MXI)
000011        COMMON /N/ NT,NS,NTH,SI,THI,TI
000011        DIMENSION TAB1(10,10,10),TH(10),SIG(10),T(10),F(10)
000011        DIMENSION TF(5),F2(5)
         C    GM  -- FRAGILITY  LIMIT  (ACCELERATION)
         C    NS  -- NUMBER OF STRESSES  MUST BE AT LEAST 3 UNLESS EXTRAPOLATING
         C           THEN 2 ARE NEEDED
         C    NT  -- NUMBER  OF  TEMPERATURES  MUST  BE  AT  LEAST  1
         C    NTH -- NUMBER  OF  THICKNESS  VALUES  MUST BE AT LEAST 3
         C    T   -- 1-D TABLE OF TEMPERATURES (FAHRENHEIT)
         C    TAB1--3-D TABLE OF PEAK ACCELERATIONS  G=F(TH,SIG,T)
         C    TH  -- 1-D TABLE OF THICKNESS  VALUES  (PTS. AT WHICH DATA WAS TAKEN)
         C    THI -- (INITIAL THICKNESS)  (GUESS)
         C    TI -- (TEMPERATURE) INTERPOLATING VALUE
         C    SI  -- (STRESS) INTERPOLATING VALUE
         C    SIG -- 1-D TABLE OF STATIC STRESS W/A (PTS. AT WHICH DATA WAS TAKEN)
         C    UNLESS EXTRAPOLATING--THEN 2 ARE NEEDED
000011    110 CONTINUE
000011        DO  120  I=1,5
000013        THI=FLOAT(I)
000014        TF(I)=FLOAT(I)
000016        CALL LAGINT(TAB1,T,SIG,TH,G,F)
000021        F2(I)=G
000023        IF(ABS(G-GM).LT.0.1)GO TO 15
000033    120 CONTINUE
000035        SHOCKE=FLAGR(5,F2,TF,GM)
000044        RETURN
000045     15 CONTINUE
000045        SHOCKE=THI
000047        RETURN
000047        END
```

```
SHOCKE

SUBPROGRAM LENGTH
000112

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS
15      - 000045    110     - 000011

BLOCK NAMES AND LENGTHS
N       - 000006

VARIABLE ASSIGNMENTS
F       - 000064    F2      - 000103    G       - 000111    I       - 000110
SHOCKE  - 000063    TF      - 000076    THI     - 000004C01

START OF CONSTANTS
000051

START OF TEMPORARIES
000054

START OF INDIRECTS
000062

UNUSED COMPILER SPACE
043300
```

VIBRTN - Subroutine

Usage:

(1) Determines thickness needed to protect in the vibration environment.

(2) Determines the union of the temperature dependent thicknesses.

Options:

(1) Physical optimization based on MIL-STD-810B excitation.

(2) Physical optimization based on multiple sine excitation.

(3) Physical optimization based on random excitation.

Subroutines called:

LAGINT

Glossary of Variables for VIBRTN

A	- - - - - - - -	Support area of item (sq in.).
AT	- - - - - - - -	Environmental temperature.
ERI	- - - - - - -	Modulus at center frequency.
ERJ	- - - - - - -	Modulus at environmental frequency.
FE(I)	- - - - - - -	Work - vector.
IC	- - - - - - - -	Procedure code.
IC = 1	- - - - - - -	MIL-STD-810B excitation.
IC = 2	- - - - - - -	Multiple sine excitation.
IC = 3	- - - - - - -	Random excitation.
MOMJ	- - - - - - -	Number of input environment frequencies.
MOMS	- - - - - - -	Number of frequencies stored on data files.
MTS	- - - - - - -	Number of temperatures stored on data file.
MXI(I, J, K)	- - - -	Array containing the number of thicknesses included in the dynamic thickness array.
OB(I)	- - - - - - -	Array of 1-octave band center frequencies, Hz.
OM	- - - - - - - -	Environmental frequency.
OMJ(I)	- - - - - -	Environmental frequencies.
OMS(I)	- - - - - -	Frequency scale.
S(I)	- - - - - - - -	Array of 1-octave band power spectral densities.
SJ	- - - - - - - -	Sum of output excitations for one center frequency.
TAB1 (I, J, K)	- - -	Table containing behavior of storage modulus (ER) ER = F (frequency, temperature).
TAB2 (I, J, K)	- - -	Table containing behavior of loss tangent EL/ER = F (frequency, temperature).

Glossary of Variables for VIBRTN (Contd.)

TCC(I) - - - - - - - Calculated thicknesses.

TF(WI, WJ, ERI, ERJ, DJ) - Statement function to calculate transfer function.

THCK(A, ERI, WI, W) - Statement function to calculate thickness.

TOP - - - - - - - Optimum thickness.

TOPP(I) - - - - - - Array of acceptable thicknesses.

TS(I) - - - - - - - Temperature scale.

TSK - - - - - - - Thickness predicted by shock environment.

TT(I) - - - - - - - A thickness work array.

TTHIK(I, J, L) - - - Dynamic thickness array contains all acceptable vibration thicknesses for each material, axis, and temperature.

W - - - - - - - - Weight of item.

WI - - - - - - - - 1-octave band center frequency.

XDD(I) - - - - - - Calculated output excitation.

XDDA - - - - - - - Maximum allowable G-level.

XDJ(I) - - - - - - - Environmental G-levels.

```
              SUBROUTINE  VIBRTN(TAB1,TAB2,TS,OMS,TOP,OMJ,FE,MOMJ,XDDA,A,W,S,
             1IC,XDJ)
        C     SUBROUTINE  CALCULATES THE  OPTIMUN  THICKNESS FOR THE VIBRATION
        C     ENVIRONMENT
000021        DIMENSION  TAB1(10,10,10),TAB2(10,10,10),OB(11),TS(1),OMS(1),
             1OMJ(1),S(1),FE(1),XDD(11),TCC(11),XOJ(1),TOPP(11) ,TT(22)
000021        COMMON /MMM/ MXI (10,3,3)
000021        COMMON /TEMPT/ TTHIK(10,3,11),IM,IAX,ITEMP,IJ,TMX
000021        COMMON /THK/ TSK,ITEM
000021        COMMON /N/  M,MTS,MOMS,AT,OM,ZA
000021        DATA OB/1.,2.,4.,8.,16.,31.5,63.,125.,250.,500.,1000./
        C     *******
        C     FE   -----  WORK - VECTOR
        C     MOMJ -----  NUMBER  OF  INPUT  ENVIRONMENT  FREQ.
        C     OMJ  -----  ENVIRONMENTAL  FREQUENCIES - VECTOR
        C     OMS  -----  FREQUENCY SCALE (PTS. AT WHICH INFO. IS RECOROEO)   - VECTOR
        C     TAB1 -----  TWO - O  TABLE (CURVES)  CONTAINING  BEHAVIOR OF  STORAGE
        C                 MODULUS(ER)    ER = F(TEMP,FREQ)
        C     TAB2 -----  TWO - D  TABLE (CURVES)  CONTAINING  BEHAVIOR OF  LOSS
        C                 TANGENT (DJ)   DJ=EL/ER =F(TEMP,FREQ)
        C     TOP  -----  OPTIMUN THICKNESS
        C     TS   -----  TEMPERATURE SCALE (PTS. AT WHICH INFO. IS RECORDEO) - VECTOR
        C     XDDA -----  MAXIMUM  ALLOWABLE  G - LEVEL       *
        C     A    -----  SUPPORTED  AREA  OF  ITEM          ***     (SQ. INCHES)
        C     W    -----  WEIGHT  OF  ITEM                  *****
        C     S    -----  P S O - IN  1-OCTAVE BANDS *** INPUT IF IC = 3 *** - VECTOR
        C     XDJ  -----  ENVIRONMENTAL G-LEVELS - VECTOR   *****
        C     IC   -----  PROCEEOURE  COOE  VALUE=1,2,OR 3   ***
        C                                                     *
        C     AT   ----- ENVIROMENTAL TEMPERATURE
        C     IC=1 ----- PHYSICAL OPTIMIZATION FOR  MIL - STD 810B  EXCITATION
        C     IC=2 ----- PHYSICAL OPTIMIZATION FOR  MULTIPLE  SINE  EXCITATION
        C     IC=3 ----- PHYSICAL OPTIMIZATION FOR  RANOOM EXCITATION
        C     OM   ----- ENVIRONMENTAL  FREQ  OMJ(J)
        C     MOMS ----- NUMBER  OF  VALUES  ALONG  FREQ. SCALE (OMS)
        C     MTS------NUMBER OF TEMPERATURES STORED ON FILE
        C     **
        C     TAB1 AND TAB2 ARE ASSUMED TO USE THE SAME TS AND OMS VECTORS
        C     *******
000021        TF(WI,WJ,ERI,ERJ,OJ)= SQRT((1.+DJ**2)/((1.-(WJ/WI)**2*ERI/ERJ)**2
             1 +  DJ**2))
000047        THCK(A,ERI,WI,W) = 386.40*A*ERI/(W*WI**2)
000061        M=1
000062        ZA=0.0
000063        DO  50  I=1,11
000065        SJ = 0.0
000066        WI=6.2831853*OB(I)
000070        OM = WI
000071        XDD(I)=1.E10
000073        IF(OM.LT.OMS(1))GO TO 50
000076        CALL LAGINT(TAB1,DUMY,TS,OMS,ERI,FE)
000101        TCC(I) = THCK(A,ERI,WI,W)
000115        GO  TO  (10,20,30) , IC
000124     10 CONTINUE
        C     MIL  STD  810 - B  EXCITATION
000124        CALL  LAGINT(TAB2,DUMY,TS,OMS,DJ,FE)
000130        SJ = TF(WI,OM,ERI,ERI,DJ)*XDJ (I)
```

```
000147          GO TO 45
000147       20 CONTINUE
          C     MULTIPLE  SINE  EXCITATION
000147          DO  25  J=1,MOMJ
000151          OM = OMJ(J)
000153          IF(OM.LT.OMS(1).OR.OM.GT.OMS(MOMS))GO TO 25
000164          CALL  LAGINT(TAB1,DUMY,TS,OMS,ERJ,FE)
000167          CALL  LAGINT(TAB2,DUMY,TS,OMS,OJ, FE)
000176          SJ = SJ + TF(WI,OM,ERI,ERJ,OJ )* XDJ(J)
000217       25 CONTINUE
000222          GO TO 45
000222       30 CONTINUE
          C     RANDOM  EXCITATION  (PSD  INPUT )
000222          DO  35  J=1,MOMJ
000224          OM = OMJ(J)
000226          CALL  LAGINT(TAB1,DUMY,TS,OMS,ERJ,FE)
000231          CALL  LAGINT(TAB2,DUMY,TS,OMS,OJ ,FE)
000240          SJ =  SJ + S(J)*TF(WI,OM,ERI,ERJ,OJ )**2
000261       35 CONTINUE
000264          SJ =  2.5* SQRT(SJ)
000267       45 CONTINUE
000267          XDD(I) = SJ
000271       50 CONTINUE
000277          II=0
000300          CT=1.
000301          DO  60  I =1,11
000303          IF(XDD(I).EQ.1.E10)GO TO 60
000306          IF(XDD(I).GT.XDDA)GO TO 60
000312          II=II+1
000313          IF(CT.EQ.1.)TOP=TCC(I)
000317          TOP = AMIN1(TOP,TCC(I))
000323          TOPP(II)=TCC(I)
000325          CT = 0.0
000326       60 CONTINUE
          C     SORT THICKNESSES INTO ASCENDING ORDER
000330          DO  65  I=1,II
000332          DO  65  J=I,II
000333          IF(TOPP(J).GT.TOPP(I))GO TO 65
000340          SAVE=TOPP(J)
000341          TOPP(J)=TOPP(I)
000344          TOPP(I)=SAVE
000345       65 CONTINUE
          C     COMPARE SHOCK THICKNESS TO VIBRATION THICKNESS
000352          IF(TOP.LT.TSK)GO TO 62
000354          TSK=TOP
000355          III=1
000356          GO TO 80
000356       62 CONTINUE
000356          DO  70  I=1,II
000360          III=I
000361          IF(TSK.LE.TOPP(III))GO TO 75
000365       70 CONTINUE
          C     PRINT  APPROPRIATE  ERROR  MESSAGE
000367          PRINT 1000
000372          PRINT 2000,TSK,TOP
000405          PRINT 3000,IM
000413          IJ=0
000414          RETURN
```

```
000415        75 TSK=TOPP(III)
000417        80 CONTINUE
          C      CHECK OPTIMUM THICKNESS AGAINST MAX ALLOWABLE OPTIMUM
000417           IF(TSK.GT.TMX)IJ=0
000426           IF(TSK.GT.TMX)PRINT 3000,IM
000442           IF(TSK.GT.TMX)PRINT 5000,TSK,TMX
000460           IF(TSK.GT.TMX)RETURN
          C      DETERMINE THE UNION OF THE TEMPERATURE DEPENDENT THICKNESSES
000463           IF(ITEM.EQ.1)GO TO 105
000465           MXII=MXI(IM,IAX,ITEM-1)
000472           IJ=0
000473           DO  85  I=III,II
000475           I4=III+(I-III)
000477           IF(TTHIK(IM,IAX,1).GE.TOPP(I4))GO TO 85
000505           IJ=IJ+1
000507           TT(IJ)=TOPP(I4)
000512        85 CONTINUE
000515           IF(IJ.EQ.0)
                1PRINT 3000,IM
000527           IF(IJ.EQ.0)
                1PRINT 4000
000540           IF(IJ.EQ.0)RETURN
000542           IK=0
000543           DO  90  I=1,MXII
000545           IF(TTHIK(IM,IAX,I).GE.TT(IJ))GO TO 90
000551           IK = IK + 1
000556           TT(IJ+IK)=TTHIK(IM,IAX,I)
000564        90 CONTINUE
000567           IJK = IJ + IK
000571           DO  95  I=1,IJK
000572           DO  95  J=I,IJK
000573           IF(TT(J).GT.TT(I))GO TO 95
000600           SAVE = TT(J)
000601           TT(J)= TT(I)
000604           TT(I)= SAVE
000605        95 CONTINUE
000612           IF(IJK.GT.11)IJK=11
000615           DO  100  I=1,IJK
000617           TTHIK(IM,IAX,I) = TT(I)
000627       100 CONTINUE
000631           MXI(IM,IAX,ITEM)=IJK
000636           RETURN
000636       105 CONTINUE
000636           IT = II-III  +1
000641           DO  110  I=1,IT
000642           II=III+I-1
000645           TTHIK(IM,IAX,I) = TOPP(II)
000653       110 CONTINUE
000655           MXI(IM,IAX,1)=IT
000660           IJ=1
000661           RETURN
000661       500 FORMAT(2X,6E15.6)
000661      1000 FORMAT(51H SHOCK THICKNESS IS LARGER THAN VIBRATION THICKNESS)
000661      2000 FORMAT(2X,16HSHOCK THICKNESS=  E15.4,2X,28HOPTIMUM VIBRATION THICK
                1NESS=  E15.4)
000661      3000 FORMAT(9HUMATERIAL I3,17H IS BEING DELETED )
000661      4000 FORMAT(23H NO TEMPERATURE OVERLAP )
000661      5000 FORMAT(20H OPTIMUM THICKNESS = E15.5,2X,
```

```
              1    33HMAX ALLOWABLE OPTIMUM THICKNESS = E15.5,/)
000661         END
```

```
VIBRTN

SUBPROGRAM LENGTH
001133

FUNCTION ASSIGNMENTS
TF      -  000027   THCK   -  000053

STATEMENT ASSIGNMENTS
10      -  000124   20     -  000147   25     -  000217   30     -  000222
45      -  000267   50     -  000271   60     -  000326   62     -  000356
65      -  000345   75     -  000415   80     -  000417   85     -  000512
90      -  000564   95     -  000605   105    -  000636   500    -  000672
1000    -  000675   2000   -  000704   3000   -  000715   4000   -  000722
5000    -  000727

BLOCK NAMES AND LENGTHS
MMM     -  000132   TEMPT  -  000517   THK    -  000002   N      -  000006

VARIABLE ASSIGNMENTS
A       -  000003   CT     -  001123   OJ     -  001117   DUMY   -  001115
ERI     -  001116   ERJ    -  001121   FE     -  000000   I      -  001112
IAX     -  000513C02 IC    -  000006   II     -  001122   III    -  001125
IJ      -  000515C02 IJK   -  001131   IK     -  001130   IM     -  000512C02
IT      -  001132   ITEM   -  000001C03 I4    -  001127   J      -  001120
M       -  000000C04 MOMJ  -  000001   MOMS   -  000002C04 MXI   -  000000C01
MXII    -  001126   OB     -  001010   OM     -  000004C04 S     -  000005
SAVE    -  001124   SJ     -  001113   TCC    -  001036   TMX    -  000516C02
TOPP    -  001051   TSK    -  000000C03 TT    -  001064   TTHIK  -  000000C02
W       -  000004   WI     -  001114   XDD    -  001023   XODA   -  000002
XOJ     -  000007   ZA     -  000005C04

START OF CONSTANTS
000663

START OF TEMPORARIES
000743

START OF INDIRECTS
001001

UNUSED COMPILER SPACE
040600
```

LAGINT - Subroutine

Usage:

(1) Determine the number of dimensions of the input array.

(2) Builds the appropriate interpolated table.

(3) Returns the final interpolated value.

Subprograms called:

FLAGR

Glossary of variables for LAGINT

A(NPTSG, NPTSB, NPTSA) - - Input table.

ALF(NPTSA) - - - - - - - Vector of independent variables.

BETA(NPTSB) - - - - - - - Vector of independent variables.

GAM(NPTSG) - - - - - - - Vector of independent variables.

NPTSA - - - - - - - - - Number of X-Y planes in input table.

NPTSB - - - - - - - - - Number of columns in input table.

VAL - - - - - - - - - - Interpolated value.

XB - - - - - - - - - - - Horizontal argument (interpolating value).

YG - - - - - - - - - - - Vertical argument (interpolating value).

ZA - - - - - - - - - - - Depth (interpolating value).

```
              SUBROUTINE  LAGINT(A,ALF,BETA,GAM,VAL,F)
        C     A(NPTSG,NPTSB,NPTSA) ---- INPUT TABLE
        C     ALF(NPTSA) --- VECTOR OF INDEPENDENT VARIABLES
        C     BETA(NPTSB)--- VECTOR OF INDEPENDENT VARIABLES
        C     GAM(NPTSG) --- VECTOR OF INDEPENDENT VARIABLES
        C     IF  NPTSA NOT EQ  TO 1 INPUT TABLE IS  3 - D
        C     IF  NPTSB EQ 1 AND NPTSA EQ 1 TABLE IS 1 - D
        C     IF  NPTSB NE 1 AND NPTSA EQ 1 TABLE IS 2 - D
        C     NPTSA ---- NUMBER OF X-Y PLANES IN INPUT TABLE DEPTH
        C     NPTSB ---- NUMBER OF COLUMNS IN INPUT TABLE    HORIZONTAL
        C     NPTSG ---- NUMBER OF ROWS IN INPUT TABLE        VERTICAL
        C     VAL------- INTERPOLATED VALUE
        C     XB ------- HORIZONTAL ARGUMENT
        C     YG ------- VERTICAL ARGUMENT
        C     ZA ------- DEPTH
000011        DIMENSION A(10,10,10),B(10,10),F(1),ALF(1),
             1  BETA(1),GAM(1)
000011        COMMON /N/ NPTSA, NPTSB,NPTSG,XB,YG,ZA
        C     CHECK  FOR  THREE  DIMENSIONS
000011        IF(NPTSA.EQ.1)GO TO 100
        C     SOLVE  THREE DIMENSIONAL  CASE
000013        DO  10  I=1,NPTSG
000014        DO  10  J=1,NPTSB
000015        DO  5   K=1,NPTSA
000016      5 F(K) = A(I,J,K)
000031        B(I,J) = FLAGR(NPTSA,ALF,F,ZA)
000043     10 CONTINUE
000047        GO  TO  120
        C     CHECK  FOR  TWO  DIMENSIONS
000050    100 CONTINUE
000050        IF(NPTSB.EQ.1)GO TO 200
000052        DO  110  I=1,NPTSG
000054        DO  110  J=1,NPTSB
000055    110 B(I,J)=A(I,J,1)
        C     SOLVE  TWO  DIMENSIONAL  CASE
000071    120 CONTINUE
000071        DO  150  I=1,NPTSG
000073        DO  140  J=1,NPTSB
000074    140 F(J) = B(I,J)
000105        B(I,1)=FLAGR(NPTSB,BETA,F,XB)
000115    150 CONTINUE
000117        GO  TO  220
        C     SOLVE  ONE  DIMENSIONAL  CASE
000120    200 CONTINUE
000120        DO  210  I=1,NPTSG
000122    210 B(I,1) = A(I,1,1)
000131    220 CONTINUE
000131        VAL = FLAGR(NPTSG,GAM,B,YG)
000140        RETURN
000141        END
```

```
LAGINT

SUBPROGRAM LENGTH
000322

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNM...
S      -  000016      100    -  000050      110    -  000055      120    -  000071
140    -  000074      200    -  000120      210    -  000122      220    -  000131

BLOCK NAMES AND LENGTHS
N      -  000006

VARIABLE ASSIGNMENTS
B      -  000153      I      -  000317      J      -  000320      K      -  000321
NPTSA  -  000000C01   NPTSB  -  000001C01   NPTSG  -  000002C01   XB     -  000003C01
YG     -  000004C01   ZA     -  000005C01

START OF CONSTANTS
000143

START OF TEMPORARIES
000144

START OF INDIRECTS
000150

UNUSED COMPILER SPACE
043000
```

FLAGR - Function Subprogram

Usage:

LAGRANGE interpolating function interpolates through a one-dimensional table and returns an interpolated value.

Options:

(1) Two point linear extrapolation to the left.

(2) Three point interpolation from left.

(3) Three point interpolation from left and right.

(4) Three point interpolation from right.

(5) Two point linear extrapolation to right.

Procedure:

For option one, a constant slope is assumed.

For option two a parabola is passed through the three nearest points (two at the left and one on the right of the interpolating value).

For option three a parabola is passed from the left and from the right with the final value being the average of the two.

For option four a parabola is passed from the right (two points on the right and one on the left of the interpolating value).

Subprograms called:

None.

Glossary of variables for FLAGR

F (I) - - - - - - - Table of dependent variables.

IGO - - - - - - - Code to determine type of interpolation.

NPTS - - - - - - Number of points in table.

W (K) - - - - - - Work array containing function weights.

XIK (I) - - - - - - Table of independent variables to be interpolated.

XK - - - - - - - Interpolating value.

```
                    FUNCTION    FLAGR(NPTS,XIK,F,XK)
000007              DIMENSION XIK(1),F(1),W(3)
              C     LAGRANGE  INTERPOLATING  FUNCTION
000007              DO  200  I=1,NPTS
000010              IT=I
000011              IF(XK.LE.XIK(I))GO TO 210
000014          200 CONTINUE
000016              FLAGR=F(NPTS)+(XK-XIK(NPTS))*(F(NPTS)-F(NPTS-1))
                  1   /(XIK(NPTS)-XIK(NPTS-1))
000030              RETURN
000030          205 CONTINUE
000030              FLAGR=F(1)+(XK-XIK(1))*(F(1)-F(2))
                  1   /(XIK(1)-XIK(2))
000040              RETURN
000040          210 IF(XK.EQ.XIK(I))GO TO 500
000043              IGO = 3
000043              IF(IT.LE.2)IGO=1
000047              IF(IT.EQ.NPTS) IGO = 2
000052              B=0.0
000053              IF(IGO.EQ.2) GO TO 350
              C     PARABOLA  FROM  THE  RIGHT
000055              IF(IT.EQ.1)GO TO 205
000057              DO  300  I=1,3
000060              IARG = IT-2+I
000062              WEIGHT = 1.
000064              DO  290  J=1,3
000065              IF(J.EQ.I)GO TO 290
000067              JARG = IT - 2 + J
000070              WEIGHT = WEIGHT*((XK-XIK(JARG))/(XIK(IARG)-XIK(JARG)))
000077          290 CONTINUE
000101              W(I) = WEIGHT
000103          300 CONTINUE
000105              DO  310  K=1,3
000107              IARG = IT - 2 + K
000111              B = B + W(K)*F(IARG)
000115          310 CONTINUE
000117              IF(IGO.EQ.1)GO TO 600
              C     PARABOLA  FROM  THE  LEFT
000121          350 CONTINUE
000121              DO  400  I=1,3
000123              IARG = IT - 3 + I
000125              WEIGHT = 1.0
000127              DO  390  J=1,3
000130              IF(J.EQ.I)GO TO 390
000132              JARG = IT - 3 + J
000133              WEIGHT = WEIGHT*((XK-XIK(JARG))/(XIK(IARG)-XIK(JARG)))
000142          390 CONTINUE
000144              W(I)= WEIGHT
000146          400 CONTINUE
000150              DO  410  K=1,3
000152              IARG = IT - 3 + K
000154              B = B + W(K)*F(IARG)
000160          410 CONTINUE
000162              IF(IGO.EQ.2)GO TO 600
000164              B = B * 0.5
000165              GO TO 600
000166          500 CONTINUE
```

```
000166          B = F(IT)
000170      600 CONTINUE
000170          FLAGR = 3
000172          RETURN
000172          END
```

FLAGR

SUBPROGRAM LENGTH
000231

FUNCTION ASSIGNMENTS

STATEMENT ASSIGNMENTS

205	-	000030	210	-	000040	290	-	000077	350	-	000121
390	-	000142	500	-	000166	600	-	000170			

BLOCK NAMES AND LENGTHS

VARIABLE ASSIGNMENTS

B	-	000223	FLAGR	-	000214	I	-	000220	IARG	-	000224
I[illegible]	-	000222	IT	-	000221	J	-	000226	JARG	-	000227
K	-	000230	W	-	000215	WEIGHT	-	000225			

START OF CONSTANTS
000174

START OF TEMPORARIES
000177

START OF INDIRECTS
000207

UNUSED COMPILER SPACE
043000

SCOPE 3.4 - CONTROL-CARD-INITIATED LOAD LOADER L340 12/19/73 07.49.45. PAG-

FWA OF THE LOAD 101
LWA+1 OF THE LOAD 53077

62531B WORDS WERE REQUIRED FOR LOADING

TRANSFER ADDRESS -- OPPACK 250

NO. TABLE MOVES 38

PROGRAM AND BLOCK ASSIGNMENTS.

BLOCK	ADDRESS	LENGTH	FILE	PREFIX TABLE CONTENTS
/COSTM/	101	135		
/VPASS/	236	11		
OPPACK	247	31022	BINPAK	
/TEMPT/	31271	517		
TEMPEV	32010	55	BINPAK	
/OPT/	32065	6		
DAMALW	32073	1706	BINPAK	
/MMM/	34001	132		
/TMK/	34133	2		
/N/	34135	6		
COPRO	34143	6032	BINPAK	
DHGHT	42175	101	BINPAK	
COSTMT	42276	701	BINPAK	
MINCOS	43177	70	BINPAK	
SHOCKE	43267	112	BINPAK	
VIHRTN	43401	1133	BINPAK	
LAGINT	44534	322	BINPAK	
FLAGR	45056	231	BINPAK	
SYSTEM	45307	1125	SL-NUCLEUS	05/24/73
ACGOER	46434	12	SL-LIB33	OP
GETBA	46446	17	SL-LIB33	OP
CHEKIT	46465	32	SL-LIB33	OP
SORT	46517	45	SL-LIB33	OP
INPUTC	46564	104	SL-LIB33	OP
OUTPTC	46670	104	SL-LIB33	OP
REWINM	46774	115	SL-LIB33	OP
KRAKER	47111	1041	SL-LIB33	OP
KODER	50152	1254	SL-LIB33	05/17/73
SIOS	51426	1451	SL-SYSIO	10/30/73 14.49.36. SCOPE 3.4 COMPASS 3.73297

1.149 CP SECONDS LOAD TIME

3. Input Data to OPPACK Program

Input consists of problem card data deck(s) and material files stored on disk. The form of the data stored on the material disk files will be discussed later. Data contained in the problem card data deck(s) consist of integers and real numbers. All integers must be right adjusted in the proper card field. Real numbers must contain a decimal point in the proper position.

The content of each card in a problem deck is as follows:

Input Data - Card Deck

Card Number One is read according to statement 10?0 FORMAT (612, 5E 10.0)

Columns

1- 2	NIC - Code number of container material to be used.
3- 4	IC - Code denoting type of optimization to be used;
	IC = 1, MIL-STD-810B excitation
	IC = 2, Multiple sine excitation
	IC = 3, Random excitation.
5- 6	IITM - Item number which is an arbitrary number assigned to the item being shipped. IITM must not be greater than two digits (i.e., 99). The condition IITM = MITEM = ITEM must exist.
7- 8	MIC - Maximum number of iterations needed for convergence of drop height calculations.
9-10	MXI* - Maximum number of iterations needed for convergence in shock environment.
11-12	MOMJ - Maximum number [illegible] ironmental frequencies (Max. = 11).
13-22	CS - Cost of shipping ($/lb).
23-32	CI - Cost of item ($).

* Not needed. Set equal to 0.

Columns

33-42 TCON - Thickness of container (in.).

43-52 TEML* - Low environmental temperature (°F).

53-62 TEMH* - High environmental temperature (°F).

Card Number Two is read according to statement 1020 FORMAT (11 E 7.0)

Columns

1-77 (OMJ(I), I = 1, MOMJ) - Environmental frequencies (rad/sec) - in ascending order.

Card Number Three is read according to statement 1020 FORMAT (11 E 7.0)

Columns

1-77 (S(I), I = 1, MOMJ) - Environmental Power Spectral Density, (PSD). g^2/Hz each corresponding to one of the above environmental frequencies.

This card is blank unless "IC = 3."

Card Number Four is read according to statement 1020 FORMAT (11 E 7.0)

Columns

1-77 (XDJ(I), I = 1, MOMJ) - Environmental acceleration levels, g, each corresponding to one of the above environmental frequencies.

Card Number Five is read according to statement 500 FORMAT (40I 2)

Columns

1- 2 NC - Number of containers (Max. = 10).

3- 4 MITEM - Item number (see IITM on Card Number One).

---

* If (TEMH-TEML) is less than 20°F, make TEMH = TEML.

Columns

5- 6 MNMATS - Number of materials on file (Max. = 10).

Cards Number Six through Fifteen* are read according to statement 10 FORMAT (E5.0, 3E6.0, 3E15 5).

Columns

1-68 ((CA(I, J), J = 1, 7), I = 1, MNMATS) - Cost and property matrix.

1- 5 Cost of material ($/ft^3).

6-11 Cost of fabrication ($/min).

12-17 Cost of packaging ($/min).

18-23 Safe low temperature ($^\circ$F).

24-38 Low stress(1) (lb/in.^{2}).

39-53 High stress(1) (lb/in.^{2}).

54-68 Gamma (lb/ft^3).

Card Number Sixteen** is read according to statement 10 FORMAT (E5.0, 3E6.0, 3E15.5). Only input data type specifications E5.0 and the first of 3E6.0 are used to read the data from this card type. Statement 10 FORMAT is also used for other data card input.

Columns

1-11 ((CD(I, J), J = 1, 2), I = 1, NC) - Cost and property matrix - container material.

1- 5 Gamma (i.e., specific weight) of container (lb/in.^{3}).

---

* Must have one card for each material.
** May have one to ten container material cards.
(1) From range of optimum stress of a particular material.

Columns

6-11 Cost of container ($\$/in.^3$). CAUTION: This is cost of container material volume, not container volume.

Card Number Seventeen is read according to statement 5 FORMAT (I4, 2X, 4E10.0, 2X, 12).

Columns

1- 4 ITEM - Item number (see IITM on Card Number One).

7-16 WI - Weight of item.

17-26 XL* - X-length (2nd longest length) in inches.

27-36 YL* - Y-length (shortest length) in inches.

37-46 ZL* - Z-length (longest length) in inches.

49-50 NPCNT - Number different percent damage allowable cases (Max. = 10).

Card Number Eighteen through... are read according to statement 7 FORMAT (3E10.0).

Columns

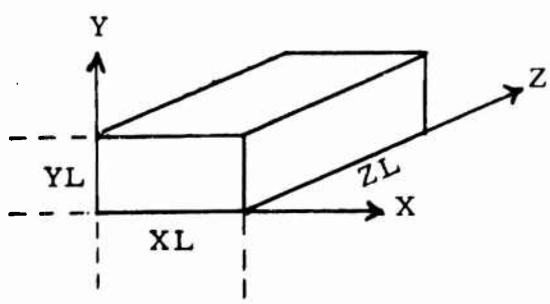
1-30 (GMF(I), PCTD(I), REPCI(I), I = 1, NPCNT).

1-10 (GMF(I) - Fragility in units of acceleration, g.

11-20 PCTD(I) - Percent damage at above acceleration level.

21-30 REPCI(I) - Replacement cost for above percent damage ($/item).

*



Input Data - Disk Files

The program is set up to handle one to ten cataloged disk files. Each file contains the shock and vibration information needed for a meaningful scrutinization of that candidate material.

Each material file is assigned a two-digit numerical material code which is linked to the logical device on which that material file is cataloged through the ASG control card and the USE control card. Once execution starts, the material is referenced through the use of the numerical material code.

The file structure is the same for all material files. The front portion contains the shock environment information, and the rear portion contains the vibration environment information. The content and read sequence of each section is as follows:

Input Data - Disk File

Shock Environment - 18-Inch Drop Height

Format	
(E7.0, 5I2)	RHOM, DRPH, ICODE
E7.0	RHOM - Specific weight of the material (PCF)
I2	DRPH - Drop height
I2	ICODE - Code used in updating files
(5I2)	NT, NTH, NS
I2	NT - Number of temperatures (Max. = 5)
I2	NTH - Number of thicknesses (Max. = 10)
I2	NS - Number of stresses (Max. = 10)
(11E7.0)	(T(I), I = 1, NT)
E7.0	T(I) - One of the temperatures at which data is recorded (degrees fahrenheit)
(11E7.0)	(TH(I), I = 1, NTH)
E7.0	TH(I) One of the material thicknesses considered during data gathering.

(11E7.0)	(SIG(I), I = 1, NS)
E7.0	SIG(I) - Static stress at a point
	DO XX K = 1, NT
	DO XX I = 1, NTH
(11E7.0)	XX READ (MS, F) (TAB1 (I, J, K), J = 1, NS)
	TAB1 (I, J, K) = G = F (Thickness, Stress, Temperature)

The preceding type of information is also stored for the 24-inch, 30-inch, and 36-inch drop heights, respectively.

Next is the vibration environment which consists of the following:

Input Data - Disk Files

Vibration Environment

Format	
(E7.0, 5I2)	RHOM, MTS, MOMS
E7.0	RHOM - Specific weight of the material (PCF)
I2	MTS - Number of temperatures (Max. = 10)
I2	MOMS - Number of frequencies (Max. = 10)
(11E11.4)	(TS(I), I = 1, MTS)
E11.4	TS(I) - A temperature at which data is recorded (degrees fahrenheit)
(11E11.4)	(QMS(I), I = 1, MOMS)
E11.4	QMS(I) - A frequency at which data is recorded (rad/sec)
	DO X I = 1, MOMS
(11E11.4)	X READ (MS, F1) (TAB1 (I, J, 1), J = 1, MTS)
	TAB1 (I, J, 1) = ER = F (Temp., Freq.)
	DO XX I = 1, MOMS
(11E11.4)	XX READ (MS, F2) (TAB2 (I, J, 1), J = 1, MTS)
	TAB2 (I, J, 1) = EL/ER = F (Temp., Freq.)

4. Description of Output

Output Item #1

This output item consists of a listing and definition of all the card data input. The first four output tables of this item are printed in the main program of OPPACK. The last five tables are printed in the subroutine DAMALW.

Output Items #2.1 - 2.5

These output items consist of the results of some of the intermediate calculations done in the subroutines CDPRO, COSTMT, and DAMALW. The first two output tables are printed in the subroutine CDPRO. They are Item #2.1 and Item #2.2.

Item #2.1 - consists of the thicknesses calculated by the function subprogram SHOCKE. At the end of each drop height iteration, the thicknesses T1, T2, and T3 are compared to the corresponding newly calculated thicknesses TT1, TT2, and TT3, respectively. If the change in the corresponding thicknesses is greater than the allotted tolerance, the thicknesses are printed and another iteration is initiated. The amount of output in this item is purely a function of the number of iterations required for the drop height convergence and the number of materials being considered.

Item #2.2 - is a N x 3 table of minimum thicknesses where the rows correspond to materials and the columns correspond to different axis. Items #2.1 and #2.2 are repeated for each of the three possible temperatures.

Items #2.3 and #2.4 - are output from the subroutine COSTMT.

Item #2.3 - shows the optimum thicknesses and the materials to be used with these thicknesses.

Item #2.4 - shows the total cost of shipping one item. This cost includes everything except the cost for allowing damage. Item #2.4 also contains the material cost matrix where each row corresponds to a different material and each column to a different perpendicular face of the package.

Item #2.5 - is output in the subroutine DAMALW. This output is self-explaratory.

Output Items #2.1 - 2.5 are repeated for each percent damage allowed.

Output Items #3.1 - 3.5

Output Items #3.1 - 3.5 are all printed in the subroutine DAMALW and are considered to be self-explanatory. Item #3.5 may appear in two different ways. If Item #3.5 reads "overshipping is the best policy," the information in Items #3.1 - #3.2 is considered to be the optimum information. If Item #3.5 reads "the above percent damage is the best policy," then the information contained in Items #3.3 - #3.4 is the optimum information.

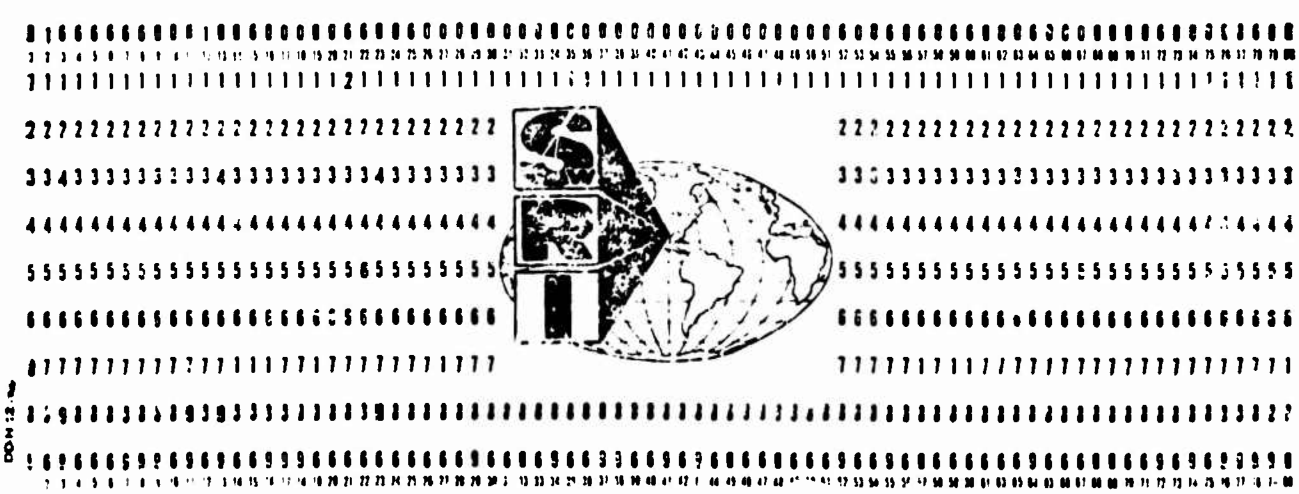
These output item numbers correspond with the circled item numbers on the following nine sample problems. Tables IV through XII contain the input data cards for the sample problems. Each table appears prior to the OPPACK Program output for each of the nine sample problems.

TABLE IV

SAMPLE PROBLEM NUMBER ONE

INPUT DATA CARDS

Card No.	
1	[illegible]
2	[illegible]
3	[illegible]
4	[illegible]
5	[illegible]
6	[illegible]
7	[illegible]
8	[illegible]
9	[illegible]
10	[illegible]
11	[illegible]
12	[illegible]
13	[illegible]
14	[illegible]
15	[illegible]
16	[illegible]
17	[illegible]
18	[illegible]
19	[illegible]
20	[illegible]
21	[illegible]



SAMPLE PROBLEM #1 (MULTIPLE SINE EXCITATION) CONSTANT TEMPERATURE

(1.0)

```
  1 = NIC --- CODE NO. OF CONTAINER MATERIAL TO BE USED
  2 = IC---OPTIMIZATION CODE

      1 = IITM --- ITEM NUMBER
     20 = MIC --- MAXIMUM NO. OF ITERATIONS FOR DROP HT. CALC.
     75 = MXI --- MAXIMUM NO. OF ITERATIONS FOR G-CONVERGENCE
     11 = MOMJ --- NUMBER OF ENVIRONMENTAL FREQUENCIES
3.3590E-01 ($/LB) = CS --- COST OF SHIPMENT
  25.00 ( $ )  = CI --- COST OF ITEM
.125000 (IN.)  = TCON --- THICKNESS OF CONTAINER
 -40.00 ( F )  = TEML ---  LOWEST ENVIRONMENT TEMPERATURE
 120.00 ( F )  = TEMH ---  HIGHEST ENVIRONMENT TEMPERATURE

 (RAD/SEC) = OMJ(I) ALL OF THE ENVIRONMENTAL FREQ.
.28300E+006.28300E+011.25660E+023.' '59E+026.28300E+021.88496E+033.14159E+034.398… +035.65487E+035.96903E+036.28319E+03

  PSD  INPUT FOR RANDOM EXCITATION
.      0.      0.      0.      0.      0.      0.      0.      0.      0.      0.

 (G'S) = XOJ(I) - ENVIRONMENTAL EXCITATIONS EACH   CORRESPONDING TO ONE OF THE ABOVE OMJ,I'S
.00000E-015.00000E-011.00000E+002.00000E+003.00000E+003.00000E+003.00000E+003.00000E+003.0 000E+003.00000E+003.00000E+00

      1 = NC --- NUMBER OF CONTAINERS
      1 = MITEM --- ITEM NUMBER
     10 = MNMATS--- NUMBER OF MATERIALS ON FILE
```

CST-MAT	CST-FAB	CST-PAK	SL-TEMP	LW-STRS	HI-STRS	GAMMA
1.9200E+00	5.0000E-02	1.0000E-02	-2.2000E+01	1.0000E-01	1.0000E+00	1.5000E+00
5.4000E+00	5.0000E-02	1.0000E-02	-6.0000E+01	1.0000E-01	1.5000E+00	2.0000E+00
2.1600E+00	5.0000E-02	1.0000E-02	-3.4000E+01	3.0000E-02	3.0000E-01	2.4000E+00
1.4400E+00	5.0000E-02	1.0000E-02	-6.0000E+01	2.0000E-01	1.5000E+00	8.0000E-01
1.5800E+00	5.0000E-02	1.0000E-02	-4.0000E+01	3.0000E-02	3.0000E-01	1.5000E+00
1.3600E+00	5.0000E-02	1.0000E-02	-2.0000E+01	3.0000E-02	5.0000E-01	3.0000E+00
1.0000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	2.0000E-02	2.0000E-01	7.9000E+00
1.0000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	3.0000E-02	2.3000E-01	1.1000E+00
4.2000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	1.0000E-02	1.5000E-01	1.1900E+01
2.1100E+00	5.0000E-02	1.0000E-02	-2.0000E+01	2.0000E-02	8.0000E-01	1.1100E+01

```
  GAMMA        CST-CONTAINER
1.7700E-03   2.3200E-03

        1=ITEM NUMBER
   1.0000E+02=WEIGHT OF ITEM WI( POUNDS )
   1.2000E+01= DIMENSION PARALLEL TO X-AXIS 2ND LONGEST DIMENSION XL (INCHES)
   1.2000E+01= DIMENSION PARALLEL TO Y-AXIS 3RD LONGEST DIMENSION YL (INCHES)
   2.4000E+01= DIMENSION PARALLEL TO Z-AXIS LONGEST DIMENSION ZL (INCHES)
  NUMBER =        4

  MATERIAL CODES CONSIDERED ARE    2,    4,
```

MAX-G	PCNT-DAM	REPLACE-CST
5.5000E+01	0.	0.
6.0000E+01	5.0000E+00	5.0000E+00
6.5000E+01	2.0000E+01	1.0000E+01
7.0000E+01	8.0000E+01	1.5000E+01

```
*********************************************************************************************

    T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.5505E+00  TT2= 2.5505E+00  TT3= 3.0306E+00
    T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.2311E+00  TT2= 2.2311E+00  TT3= 2.2050E+00
(2.1) T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1569E+00  TT2= 2.1569E+00  TT3= 2.0991E+00
    T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1511E+00  TT2= 2.1511E+00  TT3= 2.6241E+00
   SHOCK THICKNESS IS LARGER THAN VIBRATION THICKNESS
    SHOCK THICKNESS=      2.6241E+00  OPTIMUM VIBRATION THICKNESS=      3.2187E-02

   MATERIAL  4 IS BEING DELETED
(2.2) MINIMUM THICKNESS FOR MATERIAL BY AXIS
         3.1085E+00      3.1085E+00      3.6565E+00
         3.5987E+00      3.5987E+00      3.4550E+00
         3.0097E+00      3.0098E+00      2.9943E+00
         2.9322E+00      2.9322E+00      2.6241E+00

    MATERIAL CODE =   4  THICKNESS FOR FACE ONE =    3.010 INCHES
    MATERIAL CODE =   4  THICKNESS FOR FACE TWO =    3.010 INCHES
    MATERIAL CODE =   4  THICKNESS FOR FACE THREE=   2.994 INCHES

    TOTAL COST/ITEM=    81.01
    MINCOS-INPUT
    COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
     1        .99        .99        .59
     2       3.24       3.24       1.55
     4        .72        .72        .36

    FOR   0.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF55.0 G'S
(2.5) THE COST IS      81.01 DOLLARS WITH A MULYIPLICATION FACTOR OF     1.00 TIMES ONE
    WITH A FINAL COST OF      81.01 DOLLARSFOR OVER SHIPPING
    FOR ALLOWING DAMAGE THE COST IS      81.01 DOLLARS/ITEM


*********************************************************************************************

    T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.4078E+00  TT2= 2.4078E+00  TT3= 2.9497E+50
    T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 1.9053E+00  TT2= 1.9053E+00  TT3= 2.000_E+00
    T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.0818E+00  TT2= 2.0818E+00  TT3= 2.0506E+00

   MATERIAL  3 IS BEING DELETED
   OPTIMUM THICKNESS =     1.32901E+02  MAX ALLOWABLE OPTIMUM THICKNESS =     1.20000E+01

    MINIMUM THICKNESS FOR MATERIAL BY AXIS
         4.7316E+00      4.7316E+00      3.4839E+00
         7.4540E+00      7.4540E+00      3.7270E+00
         2.0818E+00      0.              0.

    MATERIAL CODE =   1  THICKNESS FOR FACE ONE =    4.732 INCHES
    MATERIAL CODE =   1  THICKNESS FOR FACE TWO =    4.732 INCHES
    MATERIAL CODE =   1  THICKNESS FOR FACE THREE=   3.984 INCHES

    TOTAL COST/ITEM=    88.50
    MINCOS-INPUT
    COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
     1       1.51       1.51        .64
     2       6.71       6.71       1.68

    FOR   5.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF60.0 G'S
    THE COST IS      88.50 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.05 TIMES ONE
    WITH A FINAL COST OF      93.15 DOLLARSFOR OVER SHIPPING
    FOR ALLOWING DAMAGE THE COST IS      93.50 DOLLARS/ITEM
```

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****************************************************************************************************

T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.2650E+00  TT2= 2.2650E+00  TT3= 2.8687E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 1.5796E+00  TT2= 1.5796E+00  TT3= 1.7876E+00
MINIMUM THICKNESS FOR MATERIAL BY AXIS
     4.5755E+00      4.5755E+00      3.9839E+00
     1.9587E+00      1.9587E+00      1.9272E+00

MATERIAL CODE =   1  THICKNESS FOR FACE ONE =    4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE TWO =    4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE THREE=    3.984 INCHES

TOTAL COST/ITEM=   87.98
MINCOS-INPUT
COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
 1       1.46       1.46       .64
 2       1.76       1.76       .87

FOR  20.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF65.0 G'S
THE COST IS      87.98 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.25 TIMES ONE
WITH A FINAL COST OF     109.97 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS      97.98 DOLLARS/ITEM

****************************************************************************************************

T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1222E+00  TT2= 2.1222E+00  TT3= 2.7877E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 1.2538E+00  TT2= 1.2538E+00  TT3= 1.5790E+00
MINIMUM THICKNESS FOR MATERIAL BY AXIS
     4.5755E+00      4.5755E+00      3.9839E+00
     1.9587E+00      1.9587E+00      1.9272E+00

MATERIAL CODE =   1  THICKNESS FOR FACE ONE =    4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE TWO =    4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE THREE=    3.984 INCHES

TOTAL COST/ITEM=   87.98
MINCOS-INPUT
COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
 1       1.46       1.46       .64
 2       1.76       1.76       .87

FOR  80.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF70.0 G'S
THE COST IS      87.98 DOLLARS WITH A MULTIPLICATION FACTOR OF     5.00 TIMES ONE
WITH A FINAL COST OF     439.90 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS     102.98 DOLLARS/ITEM

****************************************************************************************************

      OVER SHIPPING DATA
(3.1) THE OPTIMUM COST IS      81.01 DOLLARS
      THE FRAGILITY RATE IS 55.0 G'S
      THE PER-CENT DAMAGE IS     0.0
      THE MULTIPLICATION FACTOR IS    1.0

      THE OPTIMUM THICKNESS FOR FACE ONE IS    3.010 INCHES IF MATERIAL   4 IS USED
(3.2) THE OPTIMUM THICKNESS FOR FACE TWO IS    3.010 INCHES IF MATERIAL   4 IS USED
      THE OPTIMUM THICKNESS FOR FACE THREE IS    2.994 INCHES IF MATERIAL   4 IS USED
```

```
(3.3) DAMAGE ALLOWABLE DATA
      THE OPTIMUM COST IS      81.01 DOLLARS
      THE FRAGILITY RATE IS 55.0 G'S
      THE PER-CENT DAMAGE IS     0.0
      THE REPAIR COST/ITEM =       0.00 DOLLARS

(3.4) THE OPTIMUM THICKNESS FOR FACE ONE IS    3.010 INCHES IF MATERIAL  4 IS USED
      THE OPTIMUM THICKNESS FOR FACE TWO IS    3.010 INCHES IF MATERIAL  4 IS USED
      THE OPTIMUM THICKNESS FOR FACE THREE IS   2.994 INCHES IF MATERIAL  4 IS USED

(3.5) OVERSHIPPING IS THE BEST POLICY

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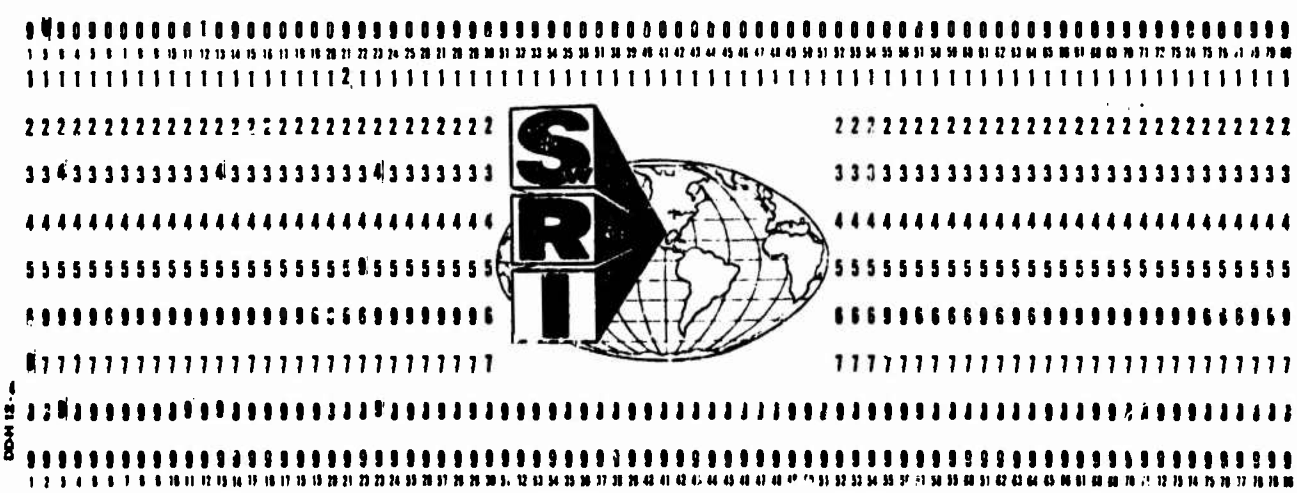
TABLE V

SAMPLE PROBLEM NUMBER TWO
INPUT DATA CARDS

Card No.											
1	0102012075110.3359000025.000000 0.12500 [illegible] 40.00 0 0 12. 0.0										
2	6.283	62.83	125.65	314.159628.3	1884.763141.594398.2356[illegible]4.87596[illegible].036283.19						
3											
4	0.5	0.5	1.	2.	3.	3.	3.	3.	3.	3.	3.
5	010110										
6	1.92	0.05	0.01	-22.	0.10	1.00	1.5	1			
7	5.40	0.05	0.01	-60.	0.14	1.50	2.0	2			
8	2.16	0.05	0.01	-34.	0.03	0.30	2.4	3			
9	1.44	0.05	0.01	-60.	0.20	1.50	0.8	4			
10	1.58	0.05	0.01	-4[illegible].	0.03	0.30	1.5	5			
11	1.36	0.05	0.01	-20.	0.03	0.50	3.0	6			
12	1.00	0.05	0.01	-20.	0.02	0.20	7.9	7			
13	1.00	0.05	0.01	-20.	0.03	0.20	[illegible]	8			
14	4.20	0.05	0.01	-20.	0.01	0.15	11.9	9			
15	2.11	0.05	0.01	-20.	0.02	0.80	11.1	10			
16	.0017.0023										
17	1	100.	12.	12.	24.	4					
18	55.	0.0	0.0								
19	60.	5.	5.								
20	65.	20.	10.								
21	70.	80.	15.								



*** OPTIMIZATION PROCEDURE FOR DESIGN OF PACKAGE CUSHIONING ***

(1.0)

SAMPLE PROBLEM #2 (MULTIPLE SINE EXCITATION) VARYING TEMPERATURE

```
1 = NIC --- CODE NO. OF CONTAINER MATERIAL TO BE USED
2 = IC---OPTIMIZATION CODE

     1 = IITM --- ITEM NUMBER
    20 = MIC --- MAXIMUM NO. OF ITERATIONS FOR DROP HT. CALC.
    75 = MXI --- MAXIMUM NO. OF ITERATIONS FOR G-CONVENGENCE
    11 = MOMJ --- NUMBER OF ENVIRONMENTAL FREQUENCIES
3.3590E-01 ($/LB) = CS --- COST OF SHIPMENT
  25.00 ( $ )  = CI --- COST OF ITEM
.125000 (IN.)  = ICON --- THICKNESS OF CONTAINER
  72.00 ( F )  = TEML ---  LOWEST ENVIRONMENT TEMPERATURE
  72.00 ( F )  = TEMH ---  HIGHEST ENVIRONMENT TEMPERATURE

(RAD/SEC) = OMJ(I) ALL OF THE ENVIRONMENTAL FREQ.
[illegible]E+006.28300E+011.25660E+023.14159E+026.28300E+021.88496E+033.14159E+034.39823E+035.65487E+035.96903E+036.28319E+03

 [illegible]  INPUT FOR RANDOM EXCITATION
.      4.      4.      4.      4.      4.      4.      4.      4.      4.      4.

(G'S) = XOJ(I) - ENVIRONMENTAL EXCITATIONS EACH   CORRESPONDING TO ONE OF THE ABOVE OMJ(I)S
[illegible]5.00000E-011.00000E+002.00000E+003.00000E+003.00000E+003.00000E+003.00000E+003.00000E+003.00000E+003.00000E+00

     1 = NC --- NUMBER OF CONTAINERS
     1 = MITEM --- ITEM NUMBER
    10 = MNMATS--- NUMBER OF MATERIALS ON FILE
```

CST-MAT	CST-FAB	CST-PAK	SL-TEMP	LW-STRS	HI-STRS	GAMMA
1.4200E+00	5.0000E-02	1.0000E-02	-2.2000E+01	1.0000E-01	1.0000E+00	1.5000E+00
5.4000E+00	5.0000E-02	1.0000E-02	-4.0000E+01	1.4000E-01	1.5000E+00	2.0000E+00
2.1600E+00	5.0000E-02	1.0000E-02	-3.4000E+01	3.0000E-02	3.0000E-01	2.4000E+00
1.4400E-03	5.0000E-02	1.0000E-02	-6.0000E+01	2.0000E-01	1.5000E+00	8.0000E-01
1.5800E+00	5.0000E-02	1.0000E-02	-4.0000E+01	3.0000E-02	3.0000E-01	1.5000E+00
1.3600E+00	5.0000E-02	1.0000E-02	-2.0000E+01	3.0000E-02	5.0000E-01	3.0000E+00
1.0000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	2.0000E-02	2.0000E-01	7.4000E+00
1.0000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	3.0000E-02	2.0000E-01	1.1000E+00
4.2000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	1.0000E-02	1.5000E-01	1.1900E+01
2.1100E+00	5.0000E-02	1.0000E-02	-2.0000E+01	2.0000E-02	8.0000E-01	1.1100E+01

GAMMA	CST-CONTAINER
1.7000E-03	2.3200E-03

```
        1=ITEM NUMBER
  1.0000E+02=WEIGHT OF ITEM WI( POUNDS )
  1.2000E+01= DIMENSION PARALLEL TO X-AXIS 2ND LONGEST DIMENSION XL (INCHES)
  1.2000E+01= DIMENSION PARALLEL TO Y-AXIS 3RD LONGEST DIMENSION YL (INCHES)
  2.4000E+01= DIMENSION PARALLEL TO Z-AXIS LONGEST DIMENSION ZL (INCHES)
 NUMBER =        4

 MATERIAL CODES CONSIDERED ARE   1,   2,   4,  10,
```

MAX-G	PCNT-DAM	REPLACE-CST
5.5000E+01	0.	0.
6.0000E+01	5.0000E+00	5.0000E+00
6.5000E+01	2.0000E+01	1.0000E+01
7.0000E+01	8.0000E+01	1.5000E+01

```
*********************************************************************************************************

(2.1) T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 3.9766E+00  TT2= 3.9766E+00  TT3= 3.3233E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.5589E+00  TT2= 2.5589E+00  TT3= 2.3593E+00

MATERIAL  2 IS BEING DELETED
OPTIMUM THICKNESS =     1.32901E+02  MAX ALLOWABLE OPTIMUM THICKNESS =     1.20000E+01

(2.2) MINIMUM THICKNESS FOR MATERIAL BY AXIS
     7.4540E+00     7.4540E+00     3.7270E+00
     2.5589E+00     0.             0.

*********************************************************************************************************

 T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 3.1217E+00  TT2= 3.1217E+00  TT3= 2.7756E+00
 MINIMUM THICKNESS FOR MATERIAL BY AXIS
      3.8544E+00     3.8544E+00     3.7283E+00

*********************************************************************************************************

 T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1=-8.8229E+00  TT2=-8.8229E+00  TT3=-9.6140E+00
 MINIMUM THICKNESS FOR MATERIAL BY AXIS
      1.9587E+00     1.9587E+00     9.7936E-01

      MATERIAL CODE =   2  THICKNESS FOR FACE ONE =  20.592 INCHES
(2.3) MATERIAL CODE =   2  THICKNESS FOR FACE TWO =  20.592 INCHES
      MATERIAL CODE =   2  THICKNESS FOR FACE THREE=  10.296 INCHES

      TOTAL COST/ITEM=  465.60
(2.4) MINCUS-INPUT
      COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
       2     18.53     18.53      4.63

      FOR    0.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF55.0 G'S
(2.5) THE COST IS     465.60 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.00 TIMES ONE
      WITH A FINAL COST OF     465.60 DOLLARSFOR OVER SHIPPING
      FOR ALLOWING DAMAGE THE COST IS     465.60 DOLLARS/ITEM

*********************************************************************************************************

 T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 3.8096E+00  TT2= 3.8096E+00  TT3= 3.2163E+00
 MINIMUM THICKNESS FOR MATERIAL BY AXIS
      3.8544E+00     3.8544E+00     3.7283E+00

*********************************************************************************************************

 T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.8769E+00  TT2= 2.8769E+00  TT3= 2.6188E+00
 MINIMUM THICKNESS FOR MATERIAL BY AXIS
      3.8544E+00     3.8544E+00     3.7283E+00

*********************************************************************************************************

 T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1=-1.0693E+01  TT2=-1.0693E+01  TT3=-1.1334E+01
 T1=-1.0693E+01  T2=-1.0693E+01  T3=-1.1334E+01  TT1=-6.7993E+00  TT2=-6.7993E+00  TT3= 1.0726E+00
 T1=-6.7993E+00  T2=-6.7993E+00  T3= 1.0726E+00  TT1=-1.0693E+01  TT2=-1.0693E+01  TT3=-1.1334E+01
 T1=-1.0693E+01  T2=-1.0693E+01  T3=-1.1334E+01  TT1=-6.7993E+00  TT2=-6.7993E+00  TT3= 1.0726E+00
 T1=-6.7993E+00  T2=-6.7993E+00  T3= 1.0726E+00  TT1=-1.0693E+01  TT2=-1.0693E+01  TT3=-1.1334E+01
```

```
T1=-1.0693E+01  T2=-1.0693E+01  T3=-1.1334E+01  TT1=-6.7993E+00  TT2=-6.7993E+00  TT3= 1.0726E+00
T1=-6.7993E+00  T2=-6.7993E+00  T3= 1.0726E+00  TT1=-1.0693E+01  TT2=-1.0693E+01  TT3=-1.1334E+01
T1=-1.0693E+01  T2=-1.0693E+01  T3=-1.1334E+01  TT1=-6.7993E+00  TT2=-6.7993E+00  TT3= 1.0726E+00
T1=-6.7993E+00  T2=-6.7993E+00  T3= 1.0726E+00  TT1=-1.0693E+01  TT2=-1.0693E+01  TT3=-1.1334E+01
T1=-1.0693E+01  T2=-1.0693E+01  T3=-1.1334E+01  TT1=-6.7993E+00  TT2=-6.7993E+00  TT3= 1.0726E+00
T1=-6.7993E+00  T2=-6.7993E+00  T3= 1.0726E+00  TT1=-1.0693E+01  TT2=-1.0693E+01  TT3=-1.1334E+01
T1=-1.0693E+01  T2=-1.0693E+01  T3=-1.1334E+01  TT1=-6.7993E+00  TT2=-6.7993E+00  TT3= 1.0726E+00
T1=-6.7993E+00  T2=-6.7993E+00  T3= 1.0726E+00  TT1=-1.0693E+01  TT2=-1.0693E+01  TT3=-1.1334E+01
T1=-1.0693E+01  T2=-1.0693E+01  T3=-1.1334E+01  TT1=-6.7993E+00  TT2=-6.7993E+00  TT3= 1.0726E+00
T1=-6.7993E+00  T2=-6.7993E+00  T3= 1.0726E+00  TT1=-1.0693E+01  TT2=-1.0693E+01  TT3=-1.1334E+01
T1=-1.0693E+01  T2=-1.0693E+01  T3=-1.1334E+01  TT1=-6.7993E+00  TT2=-6.7993E+00  TT3= 1.0726E+00
T1=-6.7993E+00  T2=-6.7993E+00  T3= 1.0726E+00  TT1=-1.0693E+0   TT2=-1.0693E+01  TT3=-1.1334E+01
T1=-1.0693E+01  T2=-1.0693E+01  T3=-1.1334E+01  TT1=-6.7993E+00  TT2=-6.7993E+00  TT3= 1.0726E+00
T1=-6.7993E+00  T2=-6.7993E+00  T3= 1.0726E+00  TT1=-1.0693E+01  TT2=-1.0693E+01  TT3=-1.1334E+01
T1=-1.0693E+01  T2=-1.0693E+01  T3=-1.1334E+01  TT1=-6.7993E+00  TT2=-6.7993E+00  TT3= 1.0726E+00
CAN NOT DETERMINE THICKNESS FOR DROP HGT. CALCULATIONS  MATERIAL CODE =  2  THIS MATERIAL DELETED
MINIMUM THICKNESS FOR MATERIAL BY AXIS
     0.              0.              0.

ALL MATERIALS DELETED --- NO OVERLAP BETWEEN TEMPERATURES-OPTIMIZE ON DATA ACCUMULATED

**************************************************************************************************

      OVER SHIPPING DATA
      THE OPTIMUN COST IS     465.60 DOLLARS
(3.1) THE FRAGILITY RATE IS 55.0 G'S
      THE PER-CENT DAMAGE IS     0.0
      THE MULTIPLICATION FACTOR IS    1.0

      THE OPTIMUM THICKNESS FOR FACE ONE IS  20.592 INCHES IF MATERIAL  2 IS USED
(3.2) THE OPTIMUM THICKNESS FOR FACE TWO IS  20.592 INCHES IF MATERIAL  2 IS USED
      THE OPTIMUM THICKNESS FOR FACE THREE IS  10.296 INCHES IF MATERIAL  2 IS USED


      DAMAGE ALLOWABLE DATA
      THE OPTIMUM COST IS     465.60 DOLLARS
(3.3) THE FRAGILITY RATE IS 55.0 G'S
      THE PER-CENT DAMAGE IS     0.0
      THE REPAIR COST/ITEM =       0.00 DOLLARS

      THE OPTIMUM THICKNESS FOR FACE ONE IS  20.592 INCHES IF MATERIAL  2 IS USED
(3.4) THE OPTIMUM THICKNESS FOR FACE TWO IS  20.592 INCHES IF MATERIAL  2 IS USED
      THE OPTIMUM THICKNESS FOR FACE THREE IS  10.296 INCHES IF MATERIAL  2 IS USED


(3.5) OVERSHIPPING IS THE BEST POLICY


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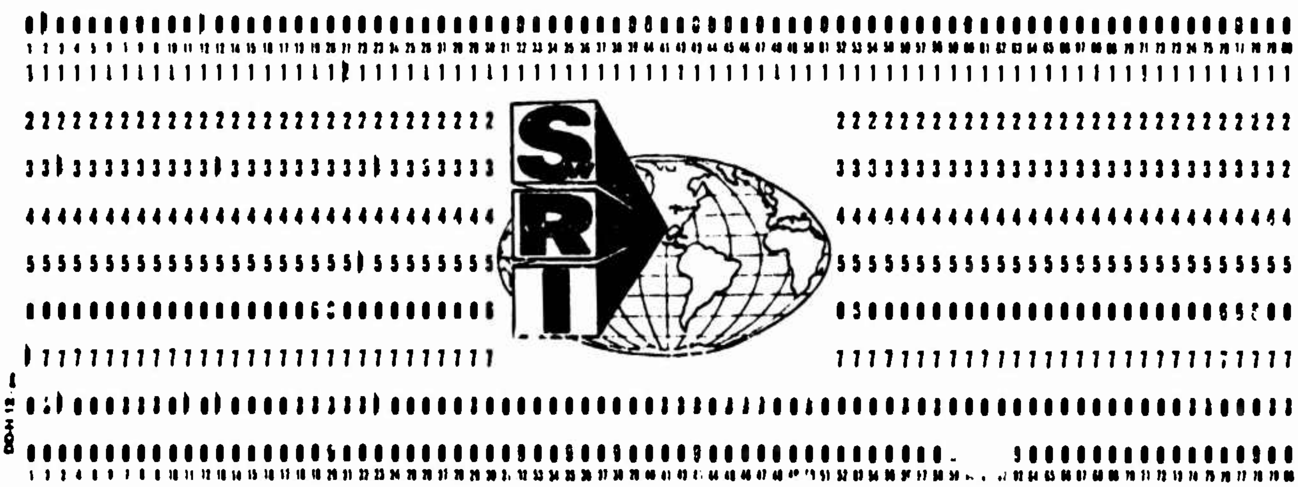
TABLE VI

SAMPLE PROBLEM NUMBER THREE

INPUT DATA CARDS

Card No.											
1	0101012075110.335900025.00 0 0.125.0 0 72.0000 75.000.										
2	6.283	62.83	125.66	314.159628.3	1884.963141.594398.2355.4.87596	.036283.14					
3											
4	0.5	0.5	1.	2.	3.	3.	3.	3.	3.	3.	3.
5	010110										
6	1.92	0.05	0.01	-22.	0.10	1.00	1.5.	1			
7	5.40	0.05	0.01	-60.	0.14	1.50	2.0	2			
8	2.16	0.05	0.01	-34.	0.03	0.30	2.4	3			
9	1.44	0.05	0.01	-60.	0.20	1.50	0.8	4			
10	1.58	0.05	0.01	-40.	0.03	0.30	1.5	5			
11	1.36	0.05	0.01	-20.	0.03	0.50	3.0	6			
12	1.00	0.05	0.01	-20.	0.02	0.20	7.9	7			
13	1.00	0.05	0.01	-20.	0.03	0.20	1.1	8			
14	4.20	0.05	0.01	-20.	0.01	0.15	11.9	9			
15	2.11	0.05	0.01	-2[illegible].	0.02	0.80	11.1	10			
16	.0017.0023.										
17	1	100.	12.	12.	24.	4					
18	10.	0.0	0.0								
19	60.	5.	1.								
20	65.	20.	4.								
21	70.	80.	15.								



*** OPTIMIZATION PROCEDURE FOR DESIGN OF PACKAGE CUSHIONING ***

SAMPLE PROBLEM #3 (MIL-STD 810B EXCITATION) CONSTANT TEMPERATURE

(1.0)

```
1 = NIC --- CODE NO. OF CONTAINER MATERIAL TO BE USED
1 = IC---OPTIMIZATION CODE

1 = IITM --- ITEM NUMBER
20 = MIL --- MAXIMUM NO. OF ITERATIONS FOR DROP HT. CALC.
[illegible] = MXI --- MAXIMUM NO. OF ITERATIONS FOR G-CONVERGENCE
11 = NOMJ --- NUMBER OF ENVIRONMENTAL FREQUENCIES
3.359.[illegible] ($/CWT) = CS --- COST OF SHIPMENT
25.00 ( $ ) = CI --- COST OF ITEM
.125000 (IN.) = T[illegible] --- THICKNESS OF CONTAINER
72.00 ( F ) = TEML --- LOWEST ENVIRONMENT TEMPERATURE
[illegible] ( F ) = TEMH --- HIGHEST ENVIRONMENT TEMPERATURE

[illegible] = OMJ(I) ALL OF THE ENVIRONMENTAL FREQ.
[illegible]E+006,28300E+011,25660E+023,14159E+026,28300E+021,88496E+033,14159E+034,39823E+035,65487E+035,96903E+036,28319E+03

INPUT FOR RANDOM EXCITATION
   .      .      .      .      .      .      .      .      .      .

[illegible] = X(I) = ENVIRONMENTAL EXCITATIONS EACH CORRESPONDING TO ONE OF THE ABOVE OMJ(I)S
[illegible]E+015,[illegible]E+011,[illegible]E+002,00000E+003,00000E+003,00000E+003,00000E+003,00000E+003,00000E+003,00000E+003,00000E+00

[illegible] = NC --- NUMBER OF CONTAINERS
1 = NITEM --- ITEM NUMBER
10 = NNMATS--- NUMBER OF MATERIALS ON FILE
```

ST-MAT	CST-FAH	CST-MAH	SL-TEMP	LW-STRS	HI-STRS	GAMMA
[illegible]	5.[illegible]E-02	1.[illegible]E-02	-2.2000E+01	1.0000E-01	1.0000E+00	1.5000E+00
5.[illegible]E+00	5.[illegible]E-02	1.0000E-02	-6.0000E+01	1.4000E-01	1.5000E+00	2.0000E+00
2.[illegible]E+0[illegible]	5.[illegible]E-02	1.0000E-02	-3.4000E+01	3.0000E-02	3.0000E-01	2.4000E+00
1.4[illegible]E+00	5.0000E-02	1.0000E-02	-6.0000E+01	2.0000E-01	1.5000E+00	8.0000E-01
[illegible]	5.[illegible]E-02	1.0000E-02	-4.0000E+01	3.0000E-02	[illegible].0000E-01	1.5000E+00
1.[illegible]E+00	5.0000E-02	1.0000E-02	-2.0000E+01	3.0000E-02	5.0000E-01	3.0000E+00
1.[illegible]E+0[illegible]	5.0000E-02	1.[illegible]E-02	-2.0000E+01	2.0000E-02	2.0000E-01	2.9000E+00
1.[illegible]E+00	5.000[illegible]E-02	1.0000E-02	-2.0000E+01	3.0000E-02	2.0000E-01	1.1000E+00
4.2[illegible]E+00	5.0000E-02	1.0000E-02	-2.0000E+01	1.0000E-02	1.5000E-01	1.1900E+01
2.1100E+00	5.0000E-02	1.0000E-02	-2.0000E+01	2.0000E-02	8.0000E-01	1.1100E+01

GAMMA	CST-CONTAINER
1.[illegible]E-0[illegible]	2.3[illegible]E-03

```
1=ITEM NUMBER
1.0000E+02=WEIGHT OF ITEM WI( POUNDS )
1.2000E+01= DIMENSION PARALLEL TO X-AXIS 2ND LONGEST DIMENSION XL (INCHES)
1.2000E+01= DIMENSION PARALLEL TO Y-AXIS 3RD LONGEST DIMENSION YL (INCHES)
2.4000E+01= DIMENSION PARALLEL TO Z-AXIS LONGEST DIMENSION ZL (INCHES)
NUMBER =      .

MATERIAL CODES CONSIDERED ARE   1,   2,   4,  10,
```

MAX-G	PCNT-DAM	REPLACE-CST
1.0000E+01	.	0.
6.[illegible]E+01	5.0000E+00	1.0000E+00
5.[illegible]E+01	2.0000E+01	4.0000E+00
7.[illegible]E+01	4.0000E+01	1.5000E+01

```
****************************************************************************************************

(2.1) T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 3.8356E+00  TT2= 3.8356E+00  TT3= 3.7594E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 5.1629E+00  TT2= 5.1629E+00  TT3= 4.0832E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.8322E+00  TT2= 2.8322E+00  TT3= 2.5361E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.4109E+00  TT2= 2.4109E+00  TT3= 2.9096E+00

MATERIAL  2 IS BEING DELETED
OPTIMUM THICKNESS =    1.86532E+01  MAX ALLOWABLE OPTIMUM THICKNESS =    1.20000E+01

MATERIAL  3 IS BEING DELETED
OPTIMUM THICKNESS =    1.86532E+01  MAX ALLOWABLE OPTIMUM THICKNESS =    1.20000E+01

SHOCK THICKNESS IS LARGER THAN VIBRATION THICKNESS
 SHOCK THICKNESS=     2.9096E+00  OPTIMUM VIBRATION THICKNESS=     3.2187E-02

(2.2) MATERIAL  4 IS BEING DELETED
 MINIMUM THICKNESS FOR MATERIAL BY AXIS
      5.6061E+00     5.6061E+00     4.3535E+00
      5.1629E+00     0.             0.
      2.8322E+00     0.             0.
      2.9322E+00     2.9322E+00     2.9096E+00

(2.3) MATERIAL CODE =  1  THICKNESS FOR FACE ONE =   5.606 INCHES
      MATERIAL CODE =  1  THICKNESS FOR FACE TWO =   5.606 INCHES
      MATERIAL CODE =  1  THICKNESS FOR FACE THREE=   4.354 INCHES

(2.4) TOTAL COST/ITEM=   92.01
      MINCOS=INPUT
      COST MATRIX=MATERIAL VERTICAL,AXIS HORIZONTAL
       1      1.29      1.29       .20

(2.5) FOR   0.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF10.0 G'S
      THE COST IS     92.01 DOLLARS WITH A MULTIPLICATION FACTOR OF    1.00 TIMES ONE
      WITH A FINAL COST OF      92.01 DOLLARSFOR OVER SHIPPING
      FOR ALLOWING DAMAGE THE COST IS     92.01 DOLLARS/ITEM

****************************************************************************************************

 T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.4078E+00  TT2= 2.4078E+00  TT3= 2.9497E+00
 MINIMUM THICKNESS FOR MATERIAL BY AXIS
      4.5755E+00     4.5755E+00     3.9839E+00

 MATERIAL CODE =  1  THICKNESS FOR FACE ONE =   4.575 INCHES
 MATERIAL CODE =  1  THICKNESS FOR FACE TWO =   4.575 INCHES
 MATERIAL CODE =  1  THICKNESS FOR FACE THREE=   3.984 INCHES

 TOTAL COST/ITEM=   67.98
 MINCOS=INPUT
 COST MATRIX=MATERIAL VERTICAL,AXIS HORIZONTAL
  1      1.46      1.46       .64

 FOR   5.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF60.0 G'S
 THE COST IS     87.98 DOLLARS WITH A MULTIPLICATION FACTOR OF    1.05 TIMES ONE
 WITH A FINAL COST OF      92.61 DOLLARSFOR OVER SHIPPING
 FOR ALLOWING DAMAGE THE COST IS     88.98 DOLLARS/ITEM

****************************************************************************************************
```

```
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.2650E+00  TT2= 2.2650E+00  TT3= 2.8687E+00
MINIMUM THICKNESS FOR MATERIAL BY AXIS
     4.5755E+00     4.5755E+00     3.9839E+00

MATERIAL CODE =   1  THICKNESS FOR FACE ONE =    4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE TWO =    4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE THREE=    3.984 INCHES

TOTAL COST/ITEM=    87.98
MINCOS-INPUT
COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
 1       1.46       1.46         .64

FOR  20.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF65.0 G'S
THE COST IS      87.98 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.25 TIMES ONE
WITH A FINAL COST OF     109.97 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS      91.98 DOLLARS/ITEM

***************************************************************************************************

T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1222E+00  TT2= 2.1222E+00  TT3= 2.7877E+00
MINIMUM THICKNESS FOR MATERIAL BY AXIS
     4.5755E+00     4.5755E+00     3.9839E+00

MATERIAL CODE =   1  THICKNESS FOR FACE ONE =    4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE TWO =    4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE THREE=    3.984 INCHES

TOTAL COST/ITEM=    87.98
MINCOS-INPUT
COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
 1       1.46       1.46         .64

FOR  80.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF70.0 G'S
THE COST IS      87.98 DOLLARS WITH A MULTIPLICATION FACTOR OF     5.00 TIMES ONE
WITH A FINAL COST OF     439.90 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS     102.98 DOLLARS/ITEM

***************************************************************************************************

      OVER SHIPPING DATA
(3.1) THE OPTIMUM COST IS       92.01 DOLLARS
      THE FRAGILITY RATE IS 10.0 G'S
      THE PER-CENT DAMAGE IS      0.0
      THE MULTIPLICATION FACTOR IS    1.0

      THE OPTIMUM THICKNESS FOR FACE ONE IS     5.606 INCHES IF MATERIAL   1 IS USED
(3.2) THE OPTIMUM THICKNESS FOR FACE TWO IS     5.606 INCHES IF MATERIAL   1 IS USED
      THE OPTIMUM THICKNESS FOR FACE THREE IS    4.354 INCHES IF MATERIAL   1 IS USED

      DAMAGE ALLOWABLE DATA
(3.3) THE OPTIMUM COST IS       88.98 DOLLARS
      THE FRAGILITY RATE IS 60.0 G'S
      THE PER-CENT DAMAGE IS      5.0
      THE REPAIR COST/ITEM =       1.00 DOLLARS

      THE OPTIMUM THICKNESS FOR FACE ONE IS     4.575 INCHES IF MATERIAL   1 IS USED
(3.4) THE OPTIMUM THICKNESS FOR FACE TWO IS     4.575 INCHES IF MATERIAL   1 IS USED
      THE OPTIMUM THICKNESS FOR FACE THREE IS    3.984 INCHES IF MATERIAL   1 IS USED
```

3.5 THE ABOVE PER-CENTAGE DAMAGE IS THE BEST POLICY

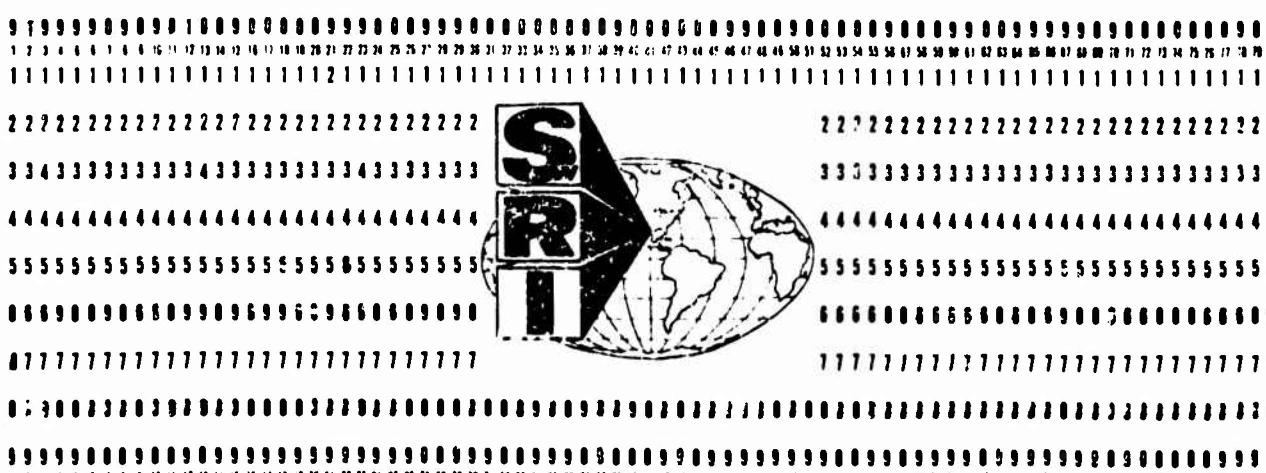
****

TABLE VII

SAMPLE PROBLEM NUMBER FOUR

INPUT DATA CARDS

```
Card
 No.
  1    0103 120751 0.2359000 25. 0    0  .125 0 0   72. 0 0   75.000
  2    9.42 781 . 49037.5791 75.3962150.706301.593603.180120 .372412.744825.49
  3    3.06E-45.17E-41.91E-4 . .9E-41. 3E-45.09E-75.83E-65.09E-75.09E-75.09E-7
  4
  5    01  10
  6     .92   0. 5    . 1   -22.     0.10          1.00          1.5         1
  7    5.40   0. 5    . 1   -6 .     0.14          1.50          2.0         2
  8    2.16   0. 5    . 1   -34.     0.13          0.30          2.4         3
  9    1.44   0. 5    . 1   -6 .     0.20          1.50          0.8         4
 10    1.58   0. 5    . 1   -40.     0.03          0.30          1.5         5
 11    1.36   0. 5    . 1   -2 .     0. 3          0.50          3.0         6
 12    1.00   0. 5    . 1   -28.     0.02          0.20          7.9         7
 13    1.00    . 5    . 1   -2 .     0. 3          0.20          1.           8
 14    4.20   0. 5    . 1   -2 .     0.01          0.15         11.9         9
 15    2.11   0. 5    . 1   -2 .     0.02          0.80         11.1        10
 16    .0017,0 23
 17       1   100.       12.       12.       24.       4
 18    15.       0.        0.
 19    60.       5.        5.
 20    65.       20.       10.
 21    70.       80.       15.
```



*** OPTIMIZATION PROCEDURE FOR DESIGN OF PACKAGE / SHIPPING ***

SAMPLE PROBLEM #4 (RANDOM EXCITATION) CONSTANT TEMPERATURE

(1.0)

```
  1 = NIC --- CODE NO. OF CONTAINER MATERIAL TO BE USED
  3 = IC---OPTIMIZATION CODE

    1 = IITM --- ITEM NUMBER
   2  = MIC --- MAXIMUM NO. OF ITERATIONS FOR DROP HT. CALC.
  [illegible] = MXI --- MAXIMUM NO. OF ITERATIONS FOR G-CONVERGENCE
   1  = NUMJ --- NUMBER OF ENVIRONMENTAL FREQUENCIES
3.366E-01 ($/LB) = CS --- COST OF SHIPMENT
 25.00 ( $ )  = CI --- COST OF ITEM
.125  (IN.)  = TCON --- THICKNESS OF CONTAINER
 72.00 ( F )  = TEML ---  LOWEST ENVIRONMENT TEMPERATURE
 72.00 ( F )  = TEMH ---  HIGHEST ENVIRONMENT TEMPERATURE

 (RAD/SEC) = OMJ(I) ALL OF THE ENVIRONMENTAL FREQ.
.92478E+001.88496E+013.76991E+017.53982E+011.50796E+023.01593E+026.03186E+021.20637E+032.41274E+034.82549E+03

  PSD  INPUT FOR RANDOM EXCITATION
.66[illegible]E-[illegible]5.17[illegible]E-[illegible]1.81000E-[illegible]1.19000E-[illegible]1.13000E-[illegible]5.09000E-075.83000E-065.09000E-075.09000E-075.09000E-07

 (G'S) = AOJ(I) = ENVIRONMENTAL EXCITATIONS EACH   CORRESPONDING TO ONE OF THE ABOVE OMJ(I)S
.         0.         0.         0.         0.         0.         0.         0.         0.         0.

      1 = NC --- NUMBER OF CONTAINERS
      1 = MITEM --- ITEM NUMBER
     10 = NNMATS--- NUMBER OF MATERIALS ON FILE
```

CST-MAT	CST-FAB	CST-PAK	SL-TEMP	LW-STRS	HI-STRS	GAMMA
1.42[illegible]E+01	5.[illegible]E-02	1.0000E-02	-2.2000E+01	1.0000E-01	1.0000E+00	1.5000E+00
5.40[illegible]E+00	5.0000E-02	1.0000E-02	-6.0000E+01	1.4000E-01	1.5000E+00	2.0000E+00
2.16[illegible]E+0[illegible]	5.[illegible]E-02	1.0000E-02	-1.4000E+01	3.0000E-02	4.0000E-01	2.4000E+00
1.44[illegible]E+00	5.0000E-02	1.0000E-02	-6.0000E+01	2.0000E-01	1.5000E+00	8.0000E-01
1.58[illegible]E+0[illegible]	5.0000E-02	1.0000E-02	-4.0000E+01	4.0000E-02	3.0000E-01	1.5000E+00
1.3600E+00	5.0000E-02	1.0000E-02	-[illegible].0000E+01	3.0000E-02	5.0000E-01	3.0000E+00
1.00[illegible]E+00	5.0000E-02	1.0000E-02	-2.0000E+01	2.0000E-02	2.0000E-01	7.9000E+00
1.0000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	3.0000E-02	2.0000E-01	1.1000E+00
4.2000E+00	5.[illegible]E-02	1.0000E-02	-2.0000E+01	1.0000E-02	1.5000E-01	1.1900E+01
2.1100E+00	5.0000E-02	1.0000E-02	-2.0000E+01	2.0000E-02	8.0000E-01	1.1100E+01

GAMMA	CST-CONTAINER
1.2000E-03	2.32[illegible]E-01

```
        1=ITEM NUMBER
  1.0000E+02=WEIGHT OF ITEM WI( POUNDS )
  1.2000E+01= DIMENSION PARALLEL TO X-AXIS 2ND LONGEST DIMENSION XL (INCHES)
  1.2000E+01= DIMENSION PARALLEL TO Y-AXIS 3RD LONGEST DIMENSION YL (INCHES)
  2.4000E+01= DIMENSION PARALLEL TO Z-AXIS LONGEST DIMENSION ZL (INCHES)
 NUMBER =        [illegible]

 MATERIAL CODES CONSIDERED ARE   1,   2,   4,  10,
```

MAX-G	PCNT-DAM	REPLACE-CST
1.5000E+01	0.	0.
6.0000E+01	5.0000E+00	5.0000E+00
6.5000E+01	2.0000E+01	1.0000E+01
7.0000E+01	8.0000E+01	1.5000E+01

```
*******************************************************************************************

    T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 3.6928E+00  TT2= 3.6928E+00  TT3= 3.6784E+00
(2.1) T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 4.8371E+00  TT2= 4.8371E+00  TT3= 3.8745E+00
    T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.7572E+00  TT2= 2.7572E+00  TT3= 2.4875E+00
    T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.3820E+00  TT2= 2.3820E+00  TT3= 2.9779E+00
   SHOCK THICKNESS IS LARGER THAN VIBRATION THICKNESS
    SHOCK THICKNESS=      2.8779E+00  OPTIMUM VIBRATION THICKNESS=      3.2187E-02

   MATERIAL   4 IS BEING DELETED
(2.2) MINIMUM THICKNESS FOR MATERIAL BY AXIS
         5.6061E+00      5.6061E+00      4.3535E+00
         6.9101E+00      6.9101E+00      6.2941E+00
         3.0098E+00      3.0098E+00      2.9943E+00
         2.9322E+00      2.9322E+00      2.8779E+00

    MATERIAL CODE =    4   THICKNESS FOR FACE ONE =    3.010 INCHES
    MATERIAL CODE =    4   THICKNESS FOR FACE TWO =    3.010 INCHES
    MATERIAL CODE =    4   THICKNESS FOR FACE THREE=   2.994 INCHES

    TOTAL COST/ITEM=   81.01
    COS-INPUT
    COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
     1        1.29        1.29        .29
     2        6.22        6.22       2.83
     4         .72         .72        .36

    FOR    0.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF15.0 G'S
(2.5) THE COST IS      81.01 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.00 TIMES ONE
    WITH A FINAL COST OF      81.01 DOLLARSFOR OVER SHIPPING
    FOR ALLOWING DAMAGE THE COST IS      81.01 DOLLARS/ITEM


*******************************************************************************************

    T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.4078E+00  TT2= 2.4078E+00  TT3= 2.9497E+00
    T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 1.9053E+00  TT2= 1.9053E+00  TT3= 2.0000E+00
    T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.0818E+00  TT2= 2.0818E+00  TT3= 2.0506E+00

   MATERIAL   3 IS BEING DELETED
   OPTIMUM THICKNESS =    1.32901E+02  MAX ALLOWABLE OPTIMUM THICKNESS =    1.20000E+01

    MINIMUM THICKNESS FOR MATERIAL BY AXIS
         4.7316E+00      4.7316E+00      3.9839E+00
         2.4540E+00      2.4540E+00      3.7270E+00
         2.0618E+00      0.              0.

    MATERIAL CODE =    1   THICKNESS FOR FACE ONE =    4.732 INCHES
    MATERIAL CODE =    1   THICKNESS FOR FACE TWO =    4.732 INCHES
    MATERIAL CODE =    1   THICKNESS FOR FACE THREE=   3.984 INCHES

    TOTAL COST/ITEM=   88.50
    MINC S-INPUT
    COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
     1        1.51        1.51        .64
     2        6.71        6.71       1.68

    FOR    5.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF60.0 G'S
    THE COST IS      88.50 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.05 TIMES ONE
    WITH A FINAL COST OF      93.16 DOLLARSFOR OVER SHIPPING
    FOR ALLOWING DAMAGE THE COST IS      93.50 DOLLARS/ITEM
```

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*******************************************************************************************************

T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.2650E+00  TT2= 2.2650E+00  TT3= 2.8687E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 1.5796E+00  TT2= 1.5796E+00  TT3= 1.7876E+00
MINIMUM THICKNESS FOR MATERIAL BY AXIS
     4.5755E+00     4.5755E+00     3.9839E+00
     1.9587E+00     1.3587E+00     1.9272E+00

MATERIAL CODE =   1  THICKNESS FOR FACE ONE =    4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE TWO =    4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE THREE=   3.984 INCHES

TOTAL COST/ITEM=    87.98
MINCOS=INPUT
COST MATRIX=MATERIAL VERTICAL,AXIS HORIZONTAL
 1       1.46       1.46       .64
 2       1.76       1.76       .87

FOR  20.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF65.0 G'S
THE COST IS      87.98 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.25 TIMES ONE
WITH A FINAL COST OF     109.97 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS      97.98 DOLLARS/ITEM

************ ******************************************************************************************

TI= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1222E+00  TT2= 2.1222E+00  TT3= 2.7877E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 1.2538E+00  TT2= 1.2538E+00  TT3= 1.5790E+00
MINIMUM THICKNESS FOR MATERIAL BY AXIS
     4.5755E+00     4.5755E+00     3.9839E+00
     1.9587E+00     1.3587E+00     1.9272E+00

MATERIAL CODE =   1  THICKNESS FOR FACE ONE =    4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE TWO =    4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE THREE=   3.984 INCHES

TOTAL COST/ITEM=    87.98
MINCOS=INPUT
COST MATRIX=MATERIA  VERTICAL,AXIS HORIZONTAL
 1       1.46       1.46       .64
 2       1.76       1.76       .87

FOR  80.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF70.0 G'S
THE COST IS      87.98 DOLLARS WITH A MULTIPLICATION FACTOR OF     5.00 TIMES ONE
WITH A FINAL COST OF     439.90 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS    102.98 DOLLARS/ITEM

******************************************************************************************************
```

(3.1)
```
OVER SHIPPING DATA
THE OPTIMUM COST IS      81.01 DOLLARS
THE FRAGILITY RATE IS 15.0 G'S
THE PER-CENT DAMAGE IS     0.0
THE MULTIPLICATION FACTOR IS    1.0
```

(3.2)
```
THE OPTIMUM THICKNESS FOR FACE ONE IS    3.010 INCHES IF MATERIAL  4 IS USED
THE OPTIMUM THICKNESS FOR FACE TWO IS    3.010 INCHES IF MATERIAL  4 IS USED
THE OPTIMUM THICKNESS FOR FACE THREE IS   2.994 INCHES IF MATERIAL  4 IS USED
```

```
(3.3) DAMAGE ALLOWABLE DATA
      THE OPTIMUM COST IS        81.01 DOLLARS
      THE FRAGILITY RATE IS 15.0 G'S
      THE PER-CENT DAMAGE IS     0.0
      THE REPAIR COST/ITEM =       0.00 DOLLARS

(3.4) THE OPTIMUM THICKNESS FOR FACE ONE IS    3.010 INCHES IF MATERIAL  4 IS USED
      THE OPTIMUM THICKNESS FOR FACE TWO IS    3.010 INCHES IF MATERIAL  4 IS USED
      THE OPTIMUM THICKNESS FOR FACE THREE IS    2.994 INCHES IF MATERIAL  4 IS USED

(3.5) OVERSHIPPING IS THE BEST POLICY

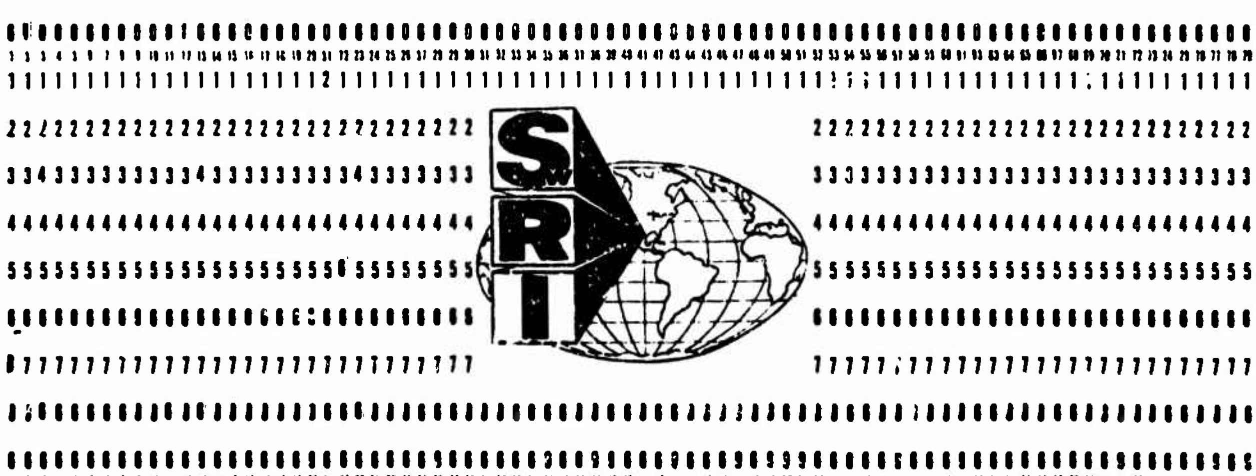
***********************************************************************************
```

TABLE VIII

SAMPLE PROBLEM NUMBER FIVE

INPUT DATA CARDS

Card No.											
1	0152 120/5110.5359000 25.00 0.0 0.12500.. 72.00 0 72.000.0										
2	6.283 64.83 125.6 214.159028.5 1084.763141.594598.235654.87576 2.036283.19										
3											
4	0.5	0.5	. .	2.	3.	3.	3.	3.	3.	3.	3.
5	010110										
6	1.92	0.05	0.1	-22.	0.10	1.00	1.5	1			
7	5.40	0.05	0.1	-60.	0.14	1.50	2.0	2			
8	2.16	0.05	0.1	-34.	0.03	0.30	2.4	3			
9	1.44	0.05	0.1	-60.	0.20	1.50	0.8	4			
10	1.53	0.05	0.1	-40.	0.03	0.30	1.5	5			
11	1.36	0.05	0.1	-20.	0.03	0.50	3.0	6			
12	1.00	0.05	0.1	-20.	0.02	0.20	7.9	7			
13	1.00	0.05	0.1	-20.	0.03	0.20	1.1	8			
14	4.20	0.05	0.01	-20.	0.01	0.15	11.9	9			
15	2.11	0.05	0.01	-20.	0.02	0.80	11.1	10			
16	.0017.00234										
17	1	055.	12.	12.	12.	4					
18	20.	0.0	0.0								
19	60.	5.	5.								
20	65.	20.	10.								
21	70.	80.	15.								



*** OPTIMIZATION PROCEDURE FOR DESIGN OF PACKAGE CUSHIONING ***

SAMPLE PROBLEM #5 (MULTIPLE SINE EXCITATION) CONSTANT TEMPERATURE

```
(1.0)   1 = MIC --- CODE NO. OF CONTAINER MATERIAL TO BE USED
        2 = IC---OPTIMIZATION CODE

      1 = IITM --- ITEM NUMBER
     20 = MIC --- MAXIMUM NO. OF ITERATIONS FOR DROP HT. CALC.
     75 = MXI --- MAXIMUM NO. OF ITERATIONS FOR G-CONVERGENCE
     11 = NOMJ --- NUMBER OF ENVIRONMENTAL FREQUENCIES
3.3590E-01 ($/LB) = CS --- COST OF SHIPMENT
  25.00 ( $ )  = CI --- COST OF ITEM
.125000 (IN.)  = TCON --- THICKNESS OF CONTAINER
  72.00 ( F )  = TEML ---  LOWEST ENVIRONMENT TEMPERATURE
  72.00 ( F )  = TEMH ---  HIGHEST ENVIRONMENT TEMPERATURE

 (RAD/SEC) = OMJ(I) ALL OF THE ENVIRONMENTAL FREQ.
.28300E+016.28300E+011.25660E+023.14159E+026.28300E+021.88496E+033.14159E+034.39823E+035.65487E+035.96903E+036.28319E+03

      INPUT FOR RANDOM EXCITATION
         *.         *.         *.         *.         *.         *.         *.         *.         *.         *.

 (G'S) = ADJ(I) - ENVIRONMENTAL EXCITATIONS EACH   CORRESPONDING TO ONE OF THE ABOVE OMJ(I)S
.50000E-015.00000E-011.00000E+002.00000E+003.00000E+003.00000E+003.00000E+003.00000E+003.00000E+003.00000E+003.00000E+00

      1 = NC --- NUMBER OF CONTAINERS
      1 = MITEM --- ITEM NUMBER
     10 = MNMATS--- NUMBER OF MATERIALS ON FILE
```

[illegible]	CST-FAM	CST-PAK	SL-TEMP	LW-STRS	HI-STRS	GAMMA
[illegible]	5.0000E-02	1.0000E-02	-2.2000E+01	1.0000E-01	1.0000E+00	1.5000E+00
5.4000E+00	5.0000E-02	1.0000E-02	-6.0000E+01	1.4000E-01	1.5000E+00	2.0000E+00
2.1600E+00	5.0000E-02	1.0000E-02	-3.4000E+01	3.0000E-02	3.0000E-01	2.4000E+00
1.4400E+00	5.0000E-02	1.0000E-02	-6.0000E+01	2.0000E-01	1.5000E+00	8.0000E-01
1.5400E+00	5.0000E-02	1.0000E-02	-4.0000E+01	3.0000E-02	3.0000E-01	1.5000E+00
1.3600E+00	5.0000E-02	1.0000E-02	-2.0000E+01	3.0000E-02	5.0000E-01	3.0000E+00
1.0000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	2.0000E-02	2.0000E-01	7.9000E+00
[illegible]	5.0000E-02	1.0000E-02	-2.0000E+01	3.0000E-02	2.0000E-01	1.1000E+00
4.2000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	1.0000E-02	1.5000E-01	1.1900E+01
2.1100E+00	5.0000E-02	1.0000E-02	-2.0000E+01	2.0000E-02	8.0000E-01	1.1100E+01

GAMMA	CST-CONTAINER
1.7000E-03	2.3200E-03

```
          1=ITEM NUMBER
   5.0000E+01=WEIGHT OF ITEM WI( POUNDS )
   1.2000E+01= DIMENSION PARALLEL TO X-AXIS 2ND LONGEST DIMENSION XL (INCHES)
   1.2000E+01= DIMENSION PARALLEL TO Y-AXIS 3RD LONGEST DIMENSION YL (INCHES)
   1.2000E+01= DIMENSION PARALLEL TO Z-AXIS LONGEST DIMENSION ZL (INCHES)
  NUMBER =         4

  MATERIAL CODES CONSIDERED ARE   1,   2,   4,   6,  10,
```

MAX-G	PCNT-DAM	REPLACE-CST
2.0000E+01	0.	0.
6.0000E+01	5.0000E+00	5.0000E+00
6.5000E+01	2.0000E+01	1.0000E+01
7.0000E+01	8.0000E+01	1.5000E+01

```
****************************************************************************************************

(2.1) T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 3.6079E+00  TT2= 3.6079E+00  TT3= 3.6079E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 4.5007E+00  TT2= 4.5007E+00  TT3= 4.5007E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 3.1777E+00  TT2= 3.1777E+00  TT3= 3.1777E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 4.2808E+00  TT2= 4.2808E+00  TT3= 4.2808E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.7021E+00  TT2= 2.7021E+00  TT3= 2.7021E+00
(2.2) MINIMUM THICKNESS FOR MATERIAL BY AXIS
           5.6276E+00      5.6276E+00      5.6276E+00
           6.9366E+00      6.9366E+00      6.9366E+00
           6.0115E+00      6.0115E+00      6.0115E+00
           6.1683E+00      6.1683E+00      6.1683E+00
           2.9435E+00      2.9435E+00      2.9435E+00

(2.3) MATERIAL CODE =  10  THICKNESS FOR FACE ONE =    2.943 INCHES
      MATERIAL CODE =  10  THICKNESS FOR FACE TWO =    2.943 INCHES
      MATERIAL CODE =  10  THICKNESS FOR FACE THREE=    2.943 INCHES

      TOTAL COST/ITEM=    59.12
(2.4) MINCOS-INPUT
      COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
       1         .90         .90         .90
       2        3.12        3.12        3.12
       4         .72         .72         .72
       6         .70         .70         .70
      10         .52         .52         .52

      FOR    0.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF20.0 G'S
(2.5) THE COST IS      59.12 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.00 TIMES ONE
      WITH A FINAL COST OF      59.12 DOLLARSFOR OVER SHIPPING
      FOR ALLOWING DAMAGE THE COST IS      59.12 DOLLARS/ITEM


****************************************************************************************************

      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.6616E+00  TT2= 2.6616E+00  TT3= 2.6616E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.4155E+00  TT2= 2.4155E+00  TT3= 2.4155E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.3442E+00  TT2= 2.3442E+00  TT3= 2.3442E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 3.8600E+00  TT2= 3.8600E+00  TT3= 3.8600E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.3853E+00  TT2= 2.3853E+00  TT3= 2.3853E+00
      MINIMUM THICKNESS FOR MATERIAL BY AXIS
           3.1204E+00      3.1204E+00      3.1204E+00
           3.6125E+00      3.6125E+00      3.6125E+00
           3.0213E+00      3.0213E+00      3.0213E+00
           6.1683E+00      6.1683E+00      6.1683E+00
           2.9435E+00      2.9435E+00      2.9435E+00

      MATERIAL CODE =   4  THICKNESS FOR FACE ONE =    3.021 INCHES
      MATERIAL CODE =   4  THICKNESS FOR FACE TWO =    3.021 INCHES
      MATERIAL CODE =   4  THICKNESS FOR FACE THREE=    3.021 INCHES

      TOTAL COST/ITEM=    57.94
      MINCOS-INPUT
      COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
       1         .50         .50         .50
       2        1.63        1.63        1.63
       4         .36         .36         .36
       6         .70         .70         .70
      10         .52         .52         .52

      FOR    5.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF60.0 G'S
      THE COST IS      57.94 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.05 TIMES ONE
```

```
WITH A FINAL COST OF      60.44 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS      62.94 DOLLARS/ITEM


*****************************************************************************************************

T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.5433E+00  TT2= 2.5433E+00  TT3= 2.5433E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1548E+00  TT2= 2.1548E+00  TT3= 2.1548E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.2400E+00  TT2= 2.2400E+00  TT3= 2.2400E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 3.8074E+00  TT2= 3.8074E+00  TT3= 3.8074E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.3457E+00  TT2= 2.3457E+00  TT3= 2.3457E+00
MINIMUM THICKNESS FOR MATERIAL BY AXIS
     3.1204E+00     3.1204E+00     3.1204E+00
     3.6125E+00     3.6125E+00     3.6125E+00
     3.0213E+00     3.0213E+00     3.0213E+00
     6.1683E+00     6.1683E+00     6.1683E+00
     2.9435E+00     2.9435E+00     2.9435E+00

MATERIAL CODE =   4  THICKNESS FOR FACE ONE =   3.021 INCHES
MATERIAL CODE =   4  THICKNESS FOR FACE TWO =   3.021 INCHES
MATERIAL CODE =   4  THICKNESS FOR FACE THREE=   3.021 INCHES

TOTAL COST/ITEM=   57.94
MINCOS-INPUT
COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
 1        .50        .50        .50
 2       1.63       1.63       1.63
 4        .36        .36        .36
 6        .70        .70        .70
10        .52        .52        .52

FOR  20.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF65.0 G'S
THE COST IS      57.94 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.25 TIMES ONE
WITH A FINAL COST OF      72.43 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS      62.94 DOLLARS/ITEM


*****************************************************************************************************

T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.4250E+00  TT2= 2.4250E+00  TT3= 2.4250E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 1.8942E+00  TT2= 1.8942E+00  TT3= 1.8942E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1358E+00  TT2= 2.1358E+00  TT3= 2.1358E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 3.7547E+00  TT2= 3.7547E+00  TT3= 3.7547E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.3061E+00  TT2= 2.3061E+00  TT3= 2.3061E+00
MINIMUM THICKNESS FOR MATERIAL BY AXIS
     3.1204E+00     3.1204E+00     3.1204E+00
     3.6125E+00     3.6125E+00     3.6125E+00
     3.0213E+00     3.0213E+00     3.0213E+00
     6.1683E+00     6.1683E+00     6.1683E+00
     2.9435E+00     2.9435E+00     2.9435E+00

MATERIAL CODE =   4  THICKNESS FOR FACE ONE =   3.021 INCHES
MATERIAL CODE =   4  THICKNESS FOR FACE TWO =   3.021 INCHES
MATERIAL CODE =   4  THICKNESS FOR FACE THREE=   3.021 INCHES

TOTAL COST/ITEM=   57.94
MINCOS-INPUT
COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
 1        .50        .50        .50
 2       1.63       1.63       1.63
 4        .36        .36        .36
 6        .70        .70        .70
```

```
10        .52        .52        .52

FOR  80.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF70.0 G'S
THE COST IS      57.94 DOLLARS WITH A MULTIPLICATION FACTOR OF     5.00 TIMES ONE
WITH A FINAL COST OF     289.72 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS      72.94 DOLLARS/ITEM

*********************************************************************************
```

(3.1)

```
OVER SHIPPING DATA
THE OPTIMUN COST IS      59.12 DOLLARS
THE FRAGILITY RATE IS 20.0 G'S
THE PER-CENT DAMAGE IS     0.0
THE MULTIPLICATION FACTOR IS    1.0
```

(3.2)

```
THE OPTIMUM THICKNESS FOR FACE ONE IS    2.943 INCHES IF MATERIAL 10 IS USED
THE OPTIMUM THICKNESS FOR FACE TWO IS    2.943 INCHES IF MATERIAL 10 IS USED
THE OPTIMUM THICKNESS FOR FACE THREE IS    2.443 INCHES IF MATERIAL 10 IS USED
```

(3.3)

```
DAMAGE ALLOWABLE DATA
THE OPTIMUM COST IS      59.12 DOLLARS
THE FRAGILITY RATE IS 20.0 G'S
THE PER-CENT DAMAGE IS     0.0
THE REPAIR COST/ITEM =       0.00 DOLLARS
```

(3.4)

```
THE OPTIMUM THICKNESS FOR FACE ONE IS    2.943 INCHES IF MATERIAL 10 IS USED
THE OPTIMUM THICKNESS FOR FACE TWO IS    2.943 INCHES IF MATERIAL 10 IS USED
THE OPTIMUM THICKNESS FOR FACE THREE IS    2.943 INCHES IF MATERIAL 10 IS USED
```

(3.5)

```
OVERSHIPPING IS THE BEST POLICY

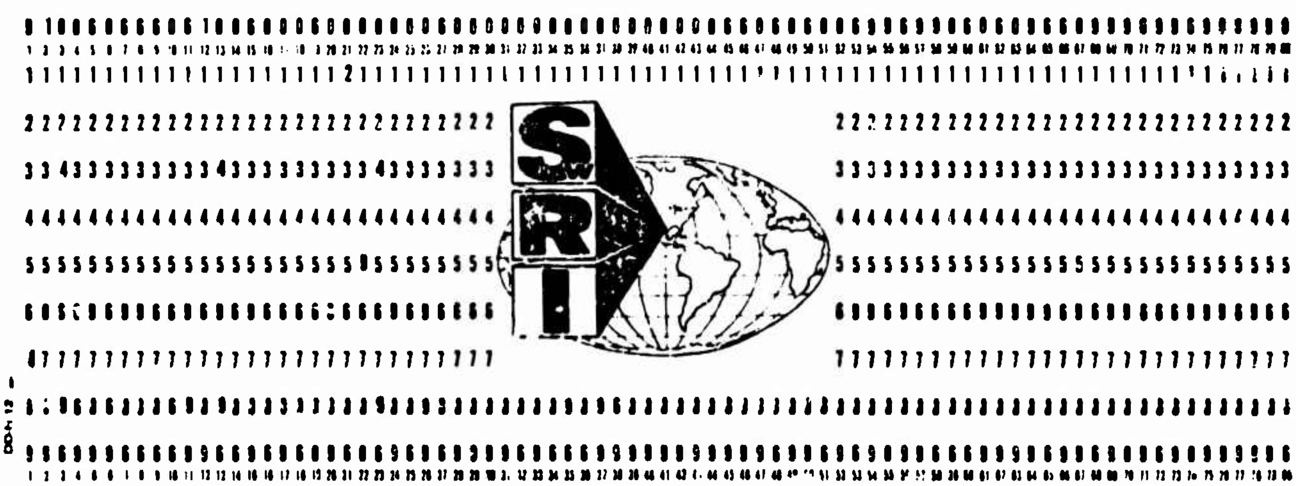
*********************************************************************************
```

TABLE IX

SAMPLE PROBLEM NUMBER SIX

INPUT DATA CARDS

Card No.											
1	[illegible].[illegible].[illegible].125[illegible] 75.00000 100.00000										
2	5.283 62.83 125.66 314.159628.3 1884.96514.15742 98.2356 4.87596 .036283.17										
3											
4	0.3	0.5	1.	2.	3.	3.	3.	3.	3.	3.	3.
5	010110										
6	1.92	0.05	.1	-22.	0.10	1.00	1.5	1			
7	5.40	0.05	.1	-60.	0.14	1.50	2.0	2			
8	2.16	0.05	.1	-34.	0.03	0.30	2.4	3			
9	1.44	0.05	.1	-6 .	0.20	1.50	0.8	4			
10	1.58	0.05	0.1	-40.	0.03	0.30	1.5	5			
11	1.36	0.05	.1	-2 .	0.03	0.50	3.0	6			
12	1.00	0.05	0.1	-2 .	0.02	0.20	7.9	7			
13	1.00	0.05	.1	-20.	0.03	0.20	1.1	8			
14	4.20	0.05	.1	-20.	0.01	0.15	11.9	9			
15	2.11	0.05	.1	-20.	0.02	0.80	11.1	10			
16	.0017.0 23.										
17	1 100.	12.	12.	24.	4						
18	55.	0.0	0.0								
19	60.	5.	5.								
20	65.	20.	10								
21	70.	60.	15.								



SAMPLE PROBLEM #6 (MULTIPLE SINE EXCITATION) VARYING TEMPERATURE

*** OPTIMIZATION PROCEDURE FOR DESIGN OF PACKAGE CUSHIONING ***

(1.0)

```
        1 = NIC --- CODE NO. OF CONTAINER MATERIAL TO BE USED
        2 = IC---OPTIMIZATION CODE

        1 = ITTM --- ITEM NUMBER
       20 = MIC --- MAXIMUM NO. OF ITERATIONS FOR DROP HT. CALC.
       25 = MXI --- MAXIMUM NO. OF ITERATIONS FOR G-CONVERGENCE
       11 = MOMJ --- NUMBER OF ENVIRONMENTAL FREQUENCIES
3.3590E-01 ($/LB) = CS --- COST OF SHIPMENT
   25.00 ( $ )  = CI --- COST OF ITEM
 .125000 (IN.)  = TCCN --- THICKNESS OF CONTAINER
   72.00 ( F )  = TEML ---  LOWEST ENVIRONMENT TEMPERATURE
  100.00 ( F )  = TEMH ---  HIGHEST ENVIRONMENT TEMPERATURE

 (RAD/SEC) = OMJ(I) ALL OF THE ENVIRONMENTAL FREQ.
.28300E+006.28300E+011.25660E+023.14159E+026.28300E+021.88496E+033.14159E+034.39823E+035.65487E+035.96903E+036.28319E+03

  PSD  INPUT FOR RANDOM EXCITATION
.        0.         0.         0.         0.         0.         0.         0.         0.         0.         0.

 (G'S) = XOJ(I) - ENVIRONMENTAL EXCITATIONS EACH   CORRESPONDING TO ONE OF THE ABOVE OMJ(I)S
.00000E-015.00000E-011.00000E+002.00000E+003.00000E+003.00000E+003.00000E+003.00000E+003.00000E+003.00000E+003.00000E+00

        1 = NC --- NUMBER OF CONTAINERS
        1 = MITEM --- ITEM NUMBER
       10 = MNMATS--- NUMBER OF MATERIALS ON FILE
```

CST-MAT	CST-FAB	CST-PAK	SL-TEMP	LW-STRS	HI-STRS	GAMMA
1.9200E+00	5.0000E-02	1.0000E-02	-2.2000E+01	1.0000E-01	1.0000E+00	1.5000E+00
5.4000E+00	5.0000E-02	1.0000E-02	-6.0000E+01	1.4000E-01	1.5000E+00	2.0000E+00
2.1600E+00	5.0000E-02	1.0000E-02	-3.4000E+01	3.0000E-02	3.0000E-01	2.4000E+00
1.4400E+00	5.0000E-02	1.0000E-02	-6.0000E+01	2.0000E-01	1.5000E+00	8.0000E-01
1.5800E+00	5.0000E-02	1.0000E-02	-4.0000E+01	3.0000E-02	3.0000E-01	1.5000E+00
1.3600E+00	5.0000E-02	1.0000E-02	-2.0000E+01	3.0000E-02	5.0000E-01	3.0000E+00
1.0000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	2.0000E-02	2.0000E-01	7.9000E+00
1.0000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	3.0000E-02	2.0000E-01	1.1000E+00
4.2000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	1.0000E-02	1.5000E-01	1.1900E+01
2.1100E+00	5.0000E-02	1.0000E-02	-2.0000E+01	2.0000E-02	8.0000E-01	1.1100E+01

GAMMA	CST-CONTAINER
1.[illegible]000E-03	2.3200E-03

```
        1=ITEM NUMBER
   1.0000E+02=WEIGHT OF ITEM WI( POUNDS )
   1.2000E+01= DIMENSION PARALLEL TO X-AXIS 2ND LONGEST DIMENSION XL (INCHES)
   1.2000E+01= DIMENSION PARALLEL TO Y-AXIS 3RD LONGEST DIMENSION YL (INCHES)
   2.4000E+01= DIMENSION PARALLEL TO Z-AXIS LONGEST DIMENSION ZL (INCHES)
  NUMBER =        4

  MATERIAL CODES CONSIDERED ARE    1,   2,   4,  10,
```

MAX-G	PCNT-DAM	REPLACE-CST
5.5000E+01	0.	0.
6.0000E+01	5.0000E+00	5.0000E+00
6.5000E+01	2.0000E+01	1.0000E+01
7.0000E+01	8.0000E+01	1.5000E+01

```
****************************************************************************************************

 T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.5505E+00  TT2= 2.5505E+00  TT3= 3.0306E+00
(2.1) T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.2311E+00  TT2= 2.2311E+00  TT3= 2.2050E+00
 T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1569E+00  TT2= 2.1569E+00  TT3= 2.0991E+00
 T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1511E+00  TT2= 2.1511E+00  TT3= 2.6241E+00
SHOCK THICKNESS IS LARGER THAN VIBRATION THICKNESS
 SHOCK THICKNESS=     2.6241E+00  OPTIMUM VIBRATION THICKNESS=     3.2187E-02

MATERIAL  4 IS BEING DELETED
(2.2) MINIMUM THICKNESS FOR MATERIAL BY AXIS
       3.1085E+00      3.1085E+00      3.6565E+00
       3.5987E+00      3.5987E+00      3.4550E+00
       3.0098E+00      3.0098E+00      2.9943E+00
       2.9322E+00      2.9322E+00      2.6241E+00


 ***************************************************************************************************

 T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.3060E+00  TT2= 2.3060E+00  TT3= 2.8920E+00
 T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 1.6730E+00  TT2= 1.6730E+00  TT3= 1.8477E+00
 T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.0284E+00  TT2= 2.0284E+00  TT3= 2.0160E+00

MATERIAL  3 IS BEING DELETED
OPTIMUM THICKNESS =    1.32901E+02  MAX ALLOWABLE OPTIMUM THICKNESS =    1.20000E+01

 MINIMUM THICKNESS FOR MATERIAL BY AXIS
       4.7316E+00      4.7316E+00      3.9839E+00
       7.4540E+00      7.4540E+00      1.7270E+00
       2.0284E+00      0.              0.


****************************************************************************************************

 T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 1.9914E+00  TT2= 1.9914E+00  TT3= 2.7136E+00
 T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1=-4.0578E+00  TT2=-4.0578E+00  TT3= 1.3880E+00
 T1=-4.0578E+00  T2=-4.0578E+00  T3= 1.3880E+00  TT1= 1.6556E+00  TT2=-4.0578E+00  TT3= 1.3880E+00
 T1= 1.6556E+00  T2=-4.0578E+00  T3= 1.3880E+00  TT1=-4.0578E+00  TT2= 1.6556E+00  TT3= 1.3880E+00
 T1=-4.0578E+00  T2= 1.6556E+00  T3= 1.3880E+00  TT1=-4.0578E+00  TT2=-4.0578E+00  TT3= 2.0497E+00
 T1=-4.0578E+00  T2=-4.0578E+00  T3= 2.0497E+00  TT1=-4.0578E+00  TT2=-4.0578E+00  TT3= 1.3880E+00
 T1=-4.0578E+00  T2=-4.0578E+00  T3= 1.3880E+00  TT1= 1.6556E+00  TT2=-4.0578E+00  TT3= 1.3880E+00
 T1= 1.6556E+00  T2=-4.0578E+00  T3= 1.3880E+00  TT1=-4.0578E+00  TT2= 1.6556E+00  TT3= 1.3880E+00
 T1=-4.0578E+00  T2= 1.6556E+00  T3= 1.3880E+00  TT1=-4.0578E+00  TT2=-4.0578E+00  TT3= 2.0497E+00
 T1=-4.0578E+00  T2=-4.0578E+00  T3= 2.0497E+00  TT1=-4.0578E+00  TT2=-4.0578E+00  TT3= 1.3880E+00
 T1=-4.0578E+00  T2=-4.0578E+00  T3= 1.3880E+00  TT1= 1.6556E+00  TT2=-4.0578E+00  TT3= 1.3880E+00
 T1= 1.6556E+00  T2=-4.0578E+00  T3= 1.3880E+00  TT1=-4.0578E+00  TT2= 1.6556E+00  TT3= 1.3880E+00
 T1=-4.0578E+00  T2= 1.6556E+00  T3= 1.3880E+00  TT1=-4.0578E+00  TT2=-4.0578E+00  TT3= 2.0497E+00
 T1=-4.0578E+00  T2=-4.0578E+00  T3= 2.0497E+00  TT1=-4.0578E+00  TT2=-4.0578E+00  TT3= 1.3880E+00
 T1=-4.0578E+00  T2=-4.0578E+00  T3= 1.3880E+00  TT1= 1.6556E+00  TT2=-4.0578E+00  TT3= 1.3880E+00
 T1= 1.6556E+00  T2=-4.0578E+00  T3= 1.3880E+00  TT1=-4.0578E+00  TT2= 1.6556E+00  TT3= 1.3880E+00
 T1=-4.0578E+00  T2= 1.6556E+00  T3= 1.3880E+00  TT1=-4.0578E+00  TT2=-4.0578E+00  TT3= 2.0497E+00
 T1=-4.0578E+00  T2=-4.0578E+00  T3= 2.0497E+00  TT1=-4.0578E+00  TT2=-4.0578E+00  TT3= 1.3880E+00
 T1=-4.0578E+00  T2=-4.0578E+00  T3= 1.3880E+00  TT1= 1.6556E+00  TT2=-4.0578E+00  TT3= 1.3880E+00
 T1= 1.6556E+00  T2=-4.0578E+00  T3= 1.3880E+00  TT1=-4.0578E+00  TT2= 1.6556E+00  TT3= 1.3880E+00
 T1=-4.0578E+00  T2= 1.6556E+00  T3= 1.3880E+00  TT1=-4.0578E+00  TT2=-4.0578E+00  TT3= 2.0497E+00
CAN NOT DETERMINE THICKNESS FOR DROP HGT. CALCULATIONS  MATERIAL CODE =  2  THIS MATERIAL DELETED
 MINIMUM THICKNESS FOR MATERIAL BY AXIS
       4.5755E+00      4.5755E+00      3.9839E+00
       0.              0.              0.

(2.3) MATERIAL CODE =   1  THICKNESS FOR FACE ONE =    2.968 INCHES
 MATERIAL CODE =   1  THICKNESS FOR FACE TWO =    2.968 INCHES
```

```
MATERIAL CODE =   1  THICKNESS FOR FACE 3 REF=    3.984 INCHES

(2.4) TOTAL COST/ITEM=  100.82
MINCOS-INPUT
COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
 1       2.55       2.55        .64

FOR    0.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF55.0 G'S
(2.5) THE COST IS     100.82 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.00 TIMES ONE
WITH A FINAL COST OF     100.82 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS    100.82 DOLLARS/ITEM

*****************************************************************************************************

T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.4078E+00  TT2= 2.4078E+00  TT3= 2.9497E+00
MINIMUM THICKNESS FOR MATERIAL BY AXIS
     4.5755E+00     4.5755E+00     3.9839E+00

*****************************************************************************************************

T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1410E+00  TT2= 2.1410E+00  TT3= 2.7984E+00

MATERIAL  1 IS BEING DELETED
NO TEMPERATURE OVERLAP
 MINIMUM THICKNESS FOR MATERIAL BY AXIS
     4.5755E+00     4.5755E+00     2.7984E+00

ALL MATERIALS DELETED --- NO OVERLAP BETWEEN TEMPERATURES-OPTIMIZE ON DATA ACCUMULATED

*****************************************************************************************************

OVER SHIPPING DATA
(3.1) THE OPTIMUN COST IS     100.82 DOLLARS
THE FRAGILITY RATE IS 55.0 G'S
THE PER-CENT DAMAGE IS     0.0
THE MULTIPLICATION FACTOR IS    1.0

THE OPTIMUM THICKNESS FOR FACE ONE IS    7.968 INCHES IF MATERIAL  1 IS USED
(3.2) THE OPTIMUM THICKNESS FOR FACE TWO IS    7.968 INCHES IF MATERIAL  1 IS USED
THE OPTIMUM THICKNESS FOR FACE THREE IS    3.984 INCHES IF MATERIAL  1 IS USED

DAMAGE ALLOWABLE DATA
(3.3) THE OPTIMUM COST IS     100.82 DOLLARS
THE FRAGILITY RATE IS 55.0 G'S
THE PER-CENT DAMAGE IS     0.0
THE REPAIR COST/ITEM =       0.00 DOLLARS

THE OPTIMUM THICKNESS FOR FACE ONE IS    7.968 INCHES IF MATERIAL  1 IS USED
(3.4) THE OPTIMUM THICKNESS FOR FACE TWO IS    7.968 INCHES IF MATERIAL  1 IS USED
THE OPTIMUM THICKNESS FOR FACE THREE IS    3.984 INCHES IF MATERIAL  1 IS USED

(3.5)
OVERSHIPPING IS THE BEST POLICY

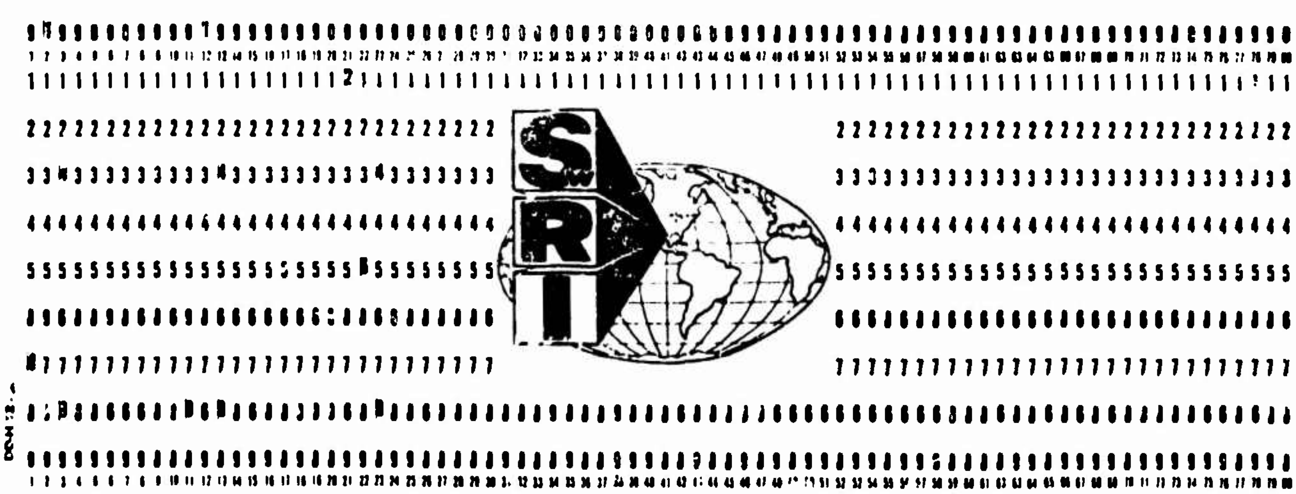
*****************************************************************************************************
```

TABLE X

SAMPLE PROBLEM NUMBER SEVEN

INPUT DATA CARDS

Card No.											
1	01 0.20751110.335900 25. 0	.125 0 0	72. 0 0	73.0 .0							
2	6.283	62.83	125.66	314.159628.3	1084.96314	.574398.2356	4.87556	.03028..17			
3											
4	.5	0.5	1.	2.	3.	3.	3.	3.	3.	3.	3.
5	010...										
6	1.92	0.5	0.1	-22.	0.10	1.00	1.5	1			
7	5.40	0.5	.1	-60.	0.14	1.50	2.0	2			
8	2.16	0.5	.1	-34.	0.3	0.30	2.4	3			
9	.44	0.5	.1	-60.	0.20	1.50	0.8	4			
10	1.58	0.5	.1	-40.	0.3	0.30	1.5	5			
11	1.36	0.5	.1	-2.	0.03	0.50	3.0	6			
12	1.00	.5	.1	-20.	0.02	0.20	7.9	7			
13	1.00	.5	.1	-2.	0.03	0.20	1.1	8			
14	4.20	0.5	.1	-2.	0.01	0.15	11.9	9			
15	2.11	0.5	.1	-2.	0.02	0.80	11.1	10			
16	.0017.00237										
17	1	100.	12.	12.	24.	4					
18	55.	0.0	0.								
19	60.	5.	5.								
20	65.	20.	10.								
21	70.	60.	15.								



*** OPTIMIZATION PROCEDURE FOR DESIGN OF PACKAGE CUSHIONING ***

SAMPLE PROBLEM #7 (MIL-STD 810B EXCITATION) CONSTANT TEMPERATURE

(1.0)

```
1 = NIC --- CODE NO. OF CONTAINER MATERIAL TO BE USED
1 = IC---OPTIMIZATION CODE

 1 = IITM --- ITEM NUMBER
20 = MII --- MAXIMUM NO. OF ITERATIONS FOR DROP HT. CALC.
25 = MI  --- MAXIMUM NO. OF ITERATIONS FOR G-CONVERGENCE
11 = MCJ --- NUMBER OF ENVIRONMENTAL FREQUENCIES
3.3590E-01 ($/LB) = CS --- COST OF SHIPMENT
  25.00 ( $ )  = CI --- COST OF ITEM
.125000 (IN.)  = TCON --- THICKNESS OF CONTAINER
  72.00 ( F )  = TEML ---  LOWEST ENVIRONMENT TEMPERATURE
  73.00 ( F )  = TEMH ---  HIGHEST ENVIRONMENT TEMPERATURE

(RAD/SEC) = OMJ(I) ALL OF THE ENVIRONMENTAL FREQ.
.28300E+000.28300E+011.25660E+023.14159E+026.28300E+021.88496E+033.14159E+034.39823E+035.65487E+035.96903E+036.28319E+03

 PSD  INPUT FOR RANDOM EXCITATION
.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.

(G'S) = XUJ(I) - ENVIRONMENTAL EXCITATIONS EACH   CORRESPONDING TO ONE OF THE ABOVE OMJ(I)S
.00000E-015.00000E-011.00000E+002.00000E+003.00000E+003.00000E+003.00000E+003.00000E+003.00000E+003.00000E+003.00000E+00

    1 = NC --- NUMBER OF CONTAINERS
    1 = MITEM --- ITEM NUMBER
   10 = MNMATS--- NUMBER OF MATERIALS ON FILE
```

CST-MAT	CST-FAB	CST-MAK	SL-TEMP	LW-STRS	HI-STRS	GAMMA
1.9200E+00	5.0000E-02	1.0000E-02	-2.2000E+01	1.0000E-01	1.0000E+00	1.5000E+00
5.4000E+00	5.0000E-02	1.0000E-02	-6.0000E+01	1.4000E-01	1.5000E+00	2.0000E+00
2.1600E+00	5.0000E-02	1.0000E-02	-3.4000E+01	3.0000E-02	3.0000E-01	2.4000E+00
1.4400E+00	5.0000E-02	1.0000E-02	-6.0000E+01	2.0000E-01	1.5000E+00	8.0000E-01
1.5800E+00	5.0000E-02	1.0000E-02	-4.0000E+01	3.0000E-02	3.0000E-01	1.5000E+00
1.3600E+00	5.0000E-02	1.0000E-02	-2.0000E+01	3.0000E-02	5.0000E-01	3.0000E+00
1.0000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	2.0000E-02	2.0000E-01	7.9000E+00
1.0000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	3.0000E-02	2.0000E-01	1.1000E+00
4.2000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	1.0000E-02	1.5000E-01	1.1400E+01
2.1100E+00	5.0000E-02	1.0000E-02	-2.0000E+01	2.0000E-02	8.0000E-01	1.1100E+01

GAMMA	CST-CONTAINER
1.7000E-03	2.3200E-03

```
        1=ITEM NUMBER
  1.0000E+02=WEIGHT OF ITEM WI( POUNDS )
  1.2000E+01= DIMENSION PARALLEL TO X-AXIS 2ND LONGEST DIMENSION XL (INCHES)
  1.2000E+01= DIMENSION PARALLEL TO Y-AXIS 3RD LONGEST DIMENSION YL (INCHES)
  2.4000E+01= DIMENSION PARALLEL TO Z-AXIS LONGEST DIMENSION ZL (INCHES)
 NUMUFR =         4

 MATERIAL CODES CONSIDERED ARE    1,    2,    4,   10,
```

MAX-G	PCNT-DAM	REPLACE-CST
5.5000E+01	0.	0.
6.0000E+01	5.0000E+00	5.0000E+00
6.5000E+01	2.0000E+01	1.0000E+01
7.0000E+01	8.0000E+01	1.5000E+01

```
 *********************************************************************************************

(2.1) T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.5505E+00  TT2= 2.5505E+00  TT3= 3.0306E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.2311E+00  TT2= 2.2311E+00  TT3= 2.2050E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1569E+00  TT2= 2.1569E+00  TT3= 2.0991E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1511E+00  TT2= 2.1511E+00  TT3= 2.6241E+00
 SHOCK THICKNESS IS LARGER THAN VIBRATION THICKNESS
  SHOCK THICKNESS=      2.6241E+00  OPTIMUM VIBRATION THICKNESS=     3.2187E-02

(2.2) MATERIAL  4 IS BEING DELETED
      MINIMUM THICKNESS FOR MATERIAL BY AXIS
          3.1085E+00      3.1085E+00      3.6565E+00
          3.5987E+00      3.5987E+00      3.4550E+00
          3.0098E+00      3.0098E+00      2.9943E+00
          2.4322E+00      2.4322E+00      2.6241E+00

      MATERIAL CODE =    4   THICKNESS FOR FACE ONE =    3.010 INCHES
      MATERIAL CODE =    4   THICKNESS FOR FACE TWO =    3.010 INCHES
      MATERIAL CODE =    4   THICKNESS FOR FACE THREE=   2.994 INCHES

      TOTAL COST/ITEM=    81.01
      MINCOS=INPUT
       COST MATRIX=MATERIAL VERTICAL,AXIS HORIZONTAL
       1        .99        .99        .59
       2       3.24       3.24       1.55
       4        .72        .72        .36

      FOR   3.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF55.0 G'S
(2.5) THE COST IS      81.01 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.00 TIMES ONE
      WITH A FINAL COST OF      81.01 DOLLARSFOR OVER SHIPPING
      FOR ALLOWING DAMAGE THE COST IS      81.01 DOLLARS/ITEM


 *********************************************************************************************

      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.4078E+00  TT2= 2.4078E+00  TT3= 2.9497E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 1.9053E+00  TT2= 1.9053E+00  TT3= 2.0000E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.0816E+00  TT2= 2.0816E+00  TT3= 2.0506E+00

 MATERIAL  3 IS BEING DELETED
 OPTIMUM THICKNESS =     1.32901E+02  MAX ALLOWABLE OPTIMUM THICKNESS =     1.20000E+01

      MINIMUM THICKNESS FOR MATERIAL BY AXIS
          4.7316E+00      4.7316E+00      3.9839E+00
          2.4540E+00      2.4540E+00      3.7220E+00
          2.0818E+00      0.              0.

      MATERIAL CODE =    1   THICKNESS FOR FACE ONE =    4.732 INCHES
      MATERIAL CODE =    1   THICKNESS FOR FACE TWO =    4.732 INCHES
      MATERIAL CODE =    1   THICKNESS FOR FACE THREE=   3.984 INCHES

      TOTAL COST/ITEM=    88.50
      MINCOS=INPUT
      COST MATRIX=MATERIAL VERTICAL,AXIS HORIZONTAL
       1       1.51       1.51        .64
       2       5.71       5.71       1.68

      FOR   5.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF60.0 G'S
      THE COST IS      88.50 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.05 TIMES ONE
      WITH A FINAL COST OF      93.16 DOLLARSFOR OVER SHIPPING
      FOR ALLOWING DAMAGE THE COST IS      94.51 DOLLARS/ITEM
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*************************************************************************************************

T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.2650E+00  TT2= 2.2650E+00  TT3= 2.8637E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 1.5796E+00  TT2= 1.5796E+00  TT3= 1.7876E+00
MINIMUM THICKNESS FOR MATERIAL BY AXIS
     4.5755E+00     4.5755E+00     3.9839E+00
     1.9587E+00     1.9587E+00     1.9272E+00

MATERIAL CODE =   1  THICKNESS FOR FACE ONE =    4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE TWO =    4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE THREE=   3.984 INCHES

TOTAL COST/ITEM=   87.98
MINCOS-INPUT
COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
 1      1.46      1.46      .64
 2      1.76      1.76      .87

FOR  20.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF65.0 G'S
THE COST IS      87.98 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.25 TIMES ONE
WITH A FINAL COST OF     109.97 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS      97.98 DOLLARS/ITEM

*************************************************************************************************

T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1222E+00  TT2= 2.1222E+00  TT3= 2.7877E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 1.2538E+00  TT2= 1.2538E+00  TT3= 1.5790E+00
MINIMUM THICKNESS FOR MATERIAL BY AXIS
     4.5755E+00     4.5755E+00     3.9839E+00
     1.9587E+00     1.9587E+00     1.9272E+00

MATERIAL CODE =   1  THICKNESS FOR FACE ONE =    4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE TWO =    4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE THREE=   3.984 INCHES

TOTAL COST/ITEM=   87.98
MINCOS-INPUT
COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
 1      1.46      1.46      .64
 2      1.76      1.76      .87

FOR  80.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF70.0 G'S
THE COST IS      87.98 DOLLARS WITH A MULTIPLICATION FACTOR OF     5.00 TIMES ONE
WITH A FINAL COST OF     439.90 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS     102.98 DOLLARS/ITEM

*************************************************************************************************

(3.1) OVER SHIPPING DATA
THE OPTIMUN COST IS        81.01 DOLLARS
THE FRAGILITY RATE IS 55.0 G'S
THE PER-CENT DAMAGE IS     0.0
THE MULTIPLICATION FACTOR IS    1.0

THE OPTIMUM THICKNESS FOR FACE ONE IS    3.010 INCHES IF MATERIAL  4 IS USED
(3.2) THE OPTIMUM THICKNESS FOR FACE TWO IS    3.010 INCHES IF MATERIAL  4 IS USED
THE OPTIMUM THICKNESS FOR FACE THREE IS    2.994 INCHES IF MATERIAL  4 IS USED
```

```
(3.3) DAMAGE ALLOWABLE DATA
      THE OPTIMUM COST IS      81.01 DOLLARS
      THE FRAGILITY RATE IS 55.0 G'S
      THE PER-CENT DAMAGE IS    0.0
      THE REPAIR COST/ITEM =      0.00 DOLLARS

(3.4) THE OPTIMUM THICKNESS FOR FACE ONE IS   3.010 INCHES IF MATERIAL  4 IS USED
      THE OPTIMUM THICKNESS FOR FACE TWO IS   3.010 INCHES IF MATERIAL  4 IS USED
      THE OPTIMUM THICKNESS FOR FACE THREE IS   2.994 INCHES IF MATERIAL  4 IS USED

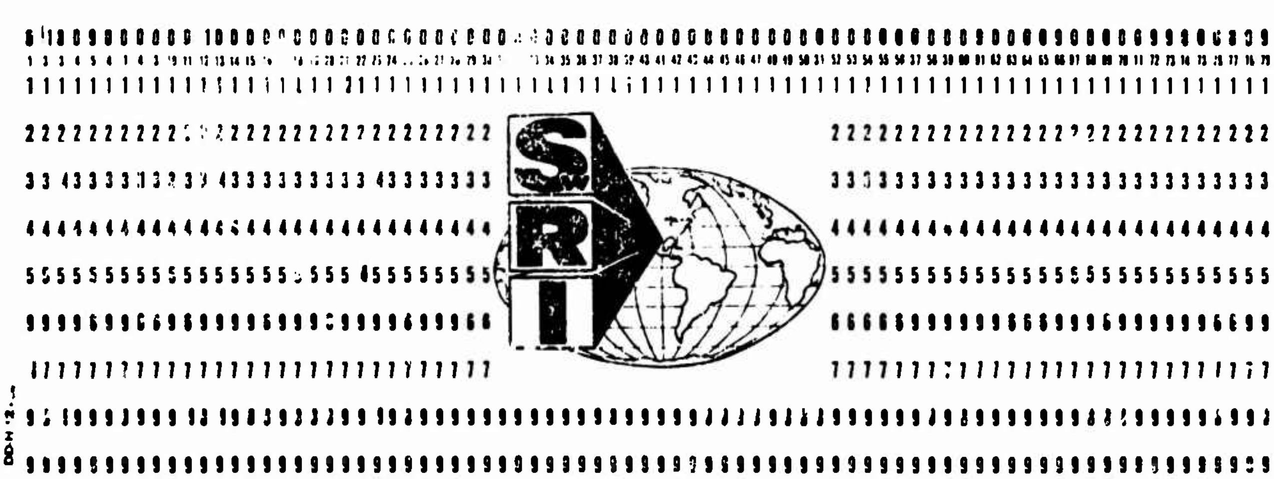

(3.5) OVERSHIPPING IS THE BEST POLICY


      ******************************************************************************
```

SAMPLE PROBLEM NUMBER EIGHT

INPUT DATA CARDS

Card No.								
1	0103012075100.3359000 25.0000.0 0.12500 0 72.000 0 73.000.0							
2	9.42-781. .49637.699175.3982150.796301.593603.180120.372412.744825.49							
3	3.66E-45.17E-41.91E-41.17E-41. 3E-45.04E-75.83E-65.04E-75.09E-75.04E-7							
4								
5	010110							
6	1.92	0.05	0.01	-22.	0.10	1.00	1.5	1
7	5.40	0.05	0.01	-60.	0.14	1.50	2.0	2
8	2.16	0.05	0.01	-34.	0.03	0.30	2.4	3
9	1.44	0.05	0.01	-60.	0.20	1.50	0.8	4
10	1.58	0.05	0.01	-40.	0.03	0.30	1.5	5
11	1.36	0.05	0.01	-20.	0.03	0.50	3.0	6
12	1.00	0.05	0.01	-20.	0.02	0.70	7.9	7
13	1.00	0.05	0.01	-21.	0.03	0.20	1.1	8
14	4.20	0.05	0.01	-20.	0.01	0.15	11.9	9
15	2.11	0.05	0.01	-20.	0.02	0.80	11.1	10
16	.0017.0023							
17	1	100.	12.	12.	24.	4		
18	55.	0.0	0.0					
19	60.	5.	5.					
20	65.	20.	10.					
21	70.	80.	15.					



SAMPLE PROBLEM #8 (RANDOM EXCITATION) CONSTANT TEMPERATURE

(1.0)

1 = NIC --- CODE NO. OF CONTAINER MATERIAL TO BE USED
3 = IC---OPTIMIZATION CODE

1 = IITM --- ITEM NUMBER
20 = MIC --- MAXIMUM NO. OF ITERATIONS FOR DROP HT. CALC.
75 = MXI --- MAXIMUM NO. OF ITERATIONS FOR G-CONVERGENCE
10 = MOMJ --- NUMBER OF ENVIRONMENTAL FREQUENCIES
3.3590E-01 ($/LB) = CS --- COST OF SHIPMENT
25.00 ($) = CI --- COST OF ITEM
.125000 (IN.) = TCON --- THICKNESS OF CONTAINER
72.00 (F) = TEML --- LOWEST ENVIRONMENT TEMPERATURE
73.00 (F) = TEMH --- HIGHEST ENVIRONMENT TEMPERATURE

(RAD/SEC) = OMJ(I) ALL OF THE ENVIRONMENTAL FREQ.
.942478E+001.88496E+013.76991E+017.53982E+011.50796E+023.01593E+026.03186E+021.20637E+032.41274E+034.82549E+03

PSD INPUT FOR RANDOM EXCITATION
[illegible]E-04 .17000E-041.91000E-041.14000E-041.13000E-045.09000E-075.83000E-065.09000E-075.09000E-075.09000E-07

(G'S) = XDJ(I) - ENVIRONMENTAL EXCITATIONS EACH CORRESPONDING TO ONE OF THE ABOVE OMJ(I)S
. *. *. *. *. *. *. *. *. *.

1 = NC --- NUMBER OF CONTAINERS
1 = MITEM --- ITEM NUMBER
10 = MNMATS--- NUMBER OF MATERIALS ON FILE

CST-MAT	CST-FAB	CST-PAK	SL-TEMP	LW-STRS	HI-STRS	GAMMA
1.9200E+00	5.0000E-02	1.0000E-02	-2.2000E+01	1.0000E-01	1.0000E+00	1.5000E+00
5.4000E+00	5.0000E-02	1.0000E-02	-6.0000E+01	1.4000E-01	1.5000E+00	2.0000E+00
2.1600E+00	5.0000E-02	1.0000E-02	-3.4000E+01	3.0000E-02	3.0000E-01	2.4000E+00
1.4400E+00	5.0000E-02	1.0000E-02	-6.0000E+01	2.0000E-01	1.5000E+00	8.0000E-01
1.5800E+00	5.0000E-02	1.0000E-02	-4.0000E+01	3.0000E-02	3.0000E-01	1.5000E+00
1.3600E+00	5.2000E-02	1.0000E-02	-2.0000E+01	3.0000E-02	5.0000E-01	3.0000E+00
1.0000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	2.0000E-02	2.0000E-01	7.9000E+00
1.0[illegible]E+00	5.0000E-02	1.0000E-02	-2.0000E+01	3.0000E-02	2.0000E-01	1.1000E+00
4.2000E+00	5.0000E-02	1.0000E-02	-2.0000E+01	1.0000E-02	1.5000E-01	1.1900E+01
2.1100E+00	5.0000E-02	1.0000E-02	-2.0000E+01	2.0000E-02	8.0000E-01	1.1100E+01

GAMMA	CST-CONTAINER
1.2000E-03	2.3200E-03

1=ITEM NUMBER
1.0000E+02=WEIGHT OF ITEM WI(POUNDS)
1.2000E+01= DIMENSION PARALLEL TO X-AXIS 2ND LONGEST DIMENSION XL (INCHES)
1.2000E+01= DIMENSION PARALLEL TO Y-AXIS 3RD LONGEST DIMENSION YL (INCHES)
2.4000E+01= DIMENSION PARALLEL TO Z-AXIS LONGEST DIMENSION ZL (INCHES)
NUMBER = *

MATERIAL CODES CONSIDERED ARE 1, 2, 4, 10,

MAX-G	PCNT-DAM	REPLAC'-CST
5.5000E+01	0.	0.
6.0000E+01	5.0000E+00	5.0000E+00
6.5000E+01	2.0000E+01	1.0000E+01
7.0000E+01	8.0000E+01	1.5000E+01

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 ****************************************************************************************************

  T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.5505E+00  TT2= 2.5505E+00  TT3= 3.0306E+00
(2.1)  T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.2311E+00  TT2= 2.2311E+00  TT3= 2.2050E+00
  T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1569E+00  TT2= 2.1569E+00  TT3= 2.0991E+00
  T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1511E+00  TT2= 2.1511E+00  TT3= 2.6241E+00
 SHOCK THICKNESS IS LARGER THAN VIBRATION THICKNESS
  SHOCK THICKNESS=     2.6241E+00  OPTIMUM VIBRATION THICKNESS=     3.2187E-02

 MATERIAL  4 IS BEING DELETED
(2.2)  MINIMUM THICKNESS FOR MATERIAL BY AXIS
       3.1085E+00     3.1085E+00     3.6565E+00
       3.5987E+00     3.5987E+00     3.4550E+00
       3.0098E+00     3.0098E+00     2.9943E+00
       2.9322E+00     2.9322E+00     2.6241E+00

  MATERIAL CODE =   4   THICKNESS FOR FACE ONE =    3.010 INCHES
(2.3)  MATERIAL CODE =   4   THICKNESS FOR FACE TWO =    3.010 INCHES
  MATERIAL CODE =   4   THICKNESS FOR FACE THREE=    2.994 INCHES

  TOTAL COST/ITEM=    81.01
(2.4)  MINCOS-INPUT
  COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
   1        .99        .99        .59
   2       3.24       3.24       1.55
   4        .72        .72        .36

  FOR   0.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF55.0 G'S
(2.5)  THE COST IS       81.01 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.00 TIMES ONE
  WITH A FINAL COST OF      81.01 DOLLARSFOR OVER SHIPPING
  FOR ALLOWING DAMAGE THE COST IS      81.01 DOLLARS/ITEM


 ****************************************************************************************************

  T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.4078E+00  TT2= 2.4078E+00  TT3= 2.9497E+00
  T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 1.9053E+00  TT2= 1.9053E+00  TT3= 2.0000E+00
  T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.0818E+00  TT2= 2.0818E+00  TT3= 2.0506E+00

 MATERIAL  3 IS BEING DELETED
 OPTIMUM THICKNESS =    1.32901E+02  MAX ALLOWABLE OPTIMUM THICKNESS =    1.20000E+0'

  MINIMUM THICKNESS FOR MATERIAL BY AXIS
       4.7316E+00     4.7316E+00     3.9839E+00
       7.4540E+00     7.4540E+00     3.7270E+00
       2.0818E+00     0.             0.

  MATERIAL CODE =   1   THICKNESS FOR FACE ONE =    4.732 INCHES
  MATERIAL CODE =   1   THICKNESS FOR FACE TWO =    4.732 INCHES
  MATERIAL CODE =   1   THICKNESS FOR FACE THREE=    3.984 INCHES

  TOTAL COST/ITEM=    88.50
  MINCOS-INPUT
  COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
   1       1.51       1.51        .64
   2       6.71       6.71       1.68

  FOR   5.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF60.0 G'S
  THE COST IS       88.50 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.05 TIMES ONE
  WITH A FINAL COST OF      93.16 DOLLARSFOR OVER SHIPPING
  FOR ALLOWING DAMAGE THE COST IS      93.50 DOLLARS/ITEM
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****************************************************************************************************

T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.2650E+00  TT2= 2.2650E+00  TT3= 2.8687E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 1.5796E+00  TT2= 1.5796E+00  TT3= 1.7876E+00
MINIMUM THICKNESS FOR MATERIAL BY AXIS
     4.5755E+00      4.5755E+00      3.9839E+00
     1.9587E+00      1.9587E+00      1.9272E+00

MATERIAL CODE =   1  THICKNESS FOR FACE ONE =   4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE TWO =   4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE THREE=   3.984 INCHES

TOTAL LOST/ITEM=   87.98
MINCOS-INPUT
COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
 1       1.46       1.46       .64
 2       1.76       1.76       .87

FOR   0.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF65.0 G'S
THE COST IS      87.98 DOLLARS WITH A MULTIPLICATION FACTOR OF    1.25 TIMES ONE
WITH A FINAL COST OF     104.97 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS      97.98 DOLLARS/ITEM

****************************************************************************************************

T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1222E+00  TT2= 2.1222E+00  TT3= 2.7877E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 1.2538E+00  TT2= 1.2538E+00  TT3= 1.5790E+00
MINIMUM THICKNESS FOR MATERIAL BY AXIS
     4.5755E+00      4.5755E+00      3.9839E+00
     1.9587E+00      1.9587E+00      1.9272E+00

MATERIAL CODE =   1  THICKNESS FOR FACE ONE =   4.575 INCHES
MATERIAL CODE =   1  THICKNESS FUR FACE TWO =   4.575 INCHES
MATERIAL CODE =   1  THICKNESS FOR FACE THREE=   3.984 INCHES

TOTAL COST/ITEM=   87.98
MINCOS-INPUT
COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
 1       1.46       1.46       .64
 2       1.76       1.76       .87

FOR  80.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF70.0 G'S
THE COST IS      87.98 DOLLARS WITH A MULTIPLICATION FACTOR OF    5.00 TIMES ONE
WITH A FINAL COST OF     439.90 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS    102.98 DOLLARS/ITEM

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(3.1)

```
OVER SHIPPING DATA
THE OPTIMUN COST IS      81.01 DOLLARS
THE FRAGILITY RATE IS 55.0 G'S
THE PER-CENT DAMAGE IS    0.0
THE MULTIPLICATION FACTOR IS    1.0
```

(3.2)

```
THE OPTIMUM THICKNESS FOR FACE ONE IS    3.010 INCHES IF MATERIAL  4 IS USED
THE OPTIMUM THICKNESS FOR FACE TWO IS    3.010 INCHES IF MATERIAL  4 IS USED
THE OPTIMUM THICKNESS FOR FACE THREE IS   2.994 INCHES IF MATERIAL  4 IS USED
```

(3.3) DAMAGE ALLOWABLE DATA
THE OPTIMUM COST IS 81.01 DOLLARS
THE FRAGILITY RATE IS 55.0 G'S
THE PER-CENT DAMAGE IS 0.0
THE REPAIR COST/ITEM = 0.00 DOLLARS

(3.4) THE OPTIMUM THICKNESS FOR FACE ONE IS 3.010 INCHES IF MATERIAL 4 IS USED
THE OPTIMUM THICKNESS FOR FACE TWO IS 3.010 INCHES IF MATERIAL 4 IS USED
THE OPTIMUM THICKNESS FOR FACE THREE IS 2.994 INCHES IF MATERIAL 4 IS USED

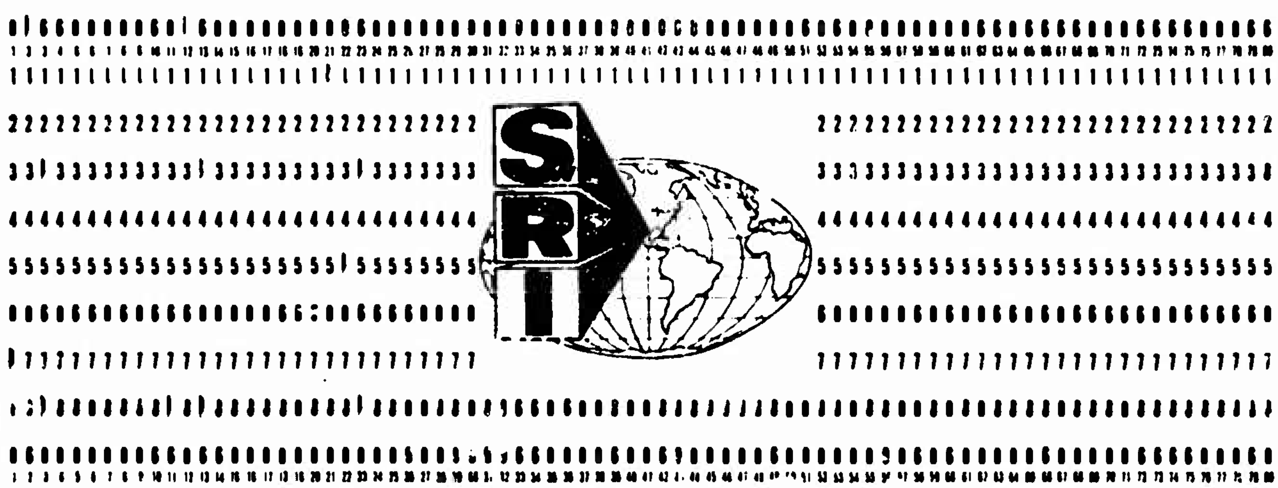
(3.5) OVERSHIPPING IS THE BEST POLICY

****

SAMPLE PROBLEM NUMBER NINE

INPUT DATA CARDS

Card No.	
1	0102012075110.0359000.25 0.0. 0.1250.0 72.00 0 72.000.0
2	6.283 62.83 125.66 314.159628.3 1884.963141.594398.2356 4.8/596 .036283.19
3	
4	0.5 0.5 1. 2. 3. 3. 3. 3. 3. 3. 3.
5	[illegible]
6	1.92 0.05 0.1 -22. 0.10 1.00 1.5 1
7	5.40 0.05 0.1 -60. 0.14 1.50 2.0 2
8	2.16 0.05 0.1 -34. 0.03 0.30 2.4 3
9	1.44 0.05 0.1 -60. 0.20 1.50 0.8 4
10	1.50 0.05 0.1 -40. 0.03 0.30 1.5 5
11	1.36 0.05 0.1 -20. 0.03 0.50 3.0 6
12	1.00 0.05 0.1 -20. 0.02 0.20 7.9 7
13	1.00 0.05 0.1 -20. 0.03 0.20 1. 8
14	4.20 0.05 0.1 -20. 0.01 0.15 11.9 9
15	2.11 0.05 0.1 -20. 0.02 0.80 11. 10
16	.0017.0023.
17	1 055. 12. 12. 12. 4
18	55. 0.0 0.0
19	60. 5. 1.
20	65. 20. 4.
21	70. 60. 15.



SAMPLE PROBLEM #9 (MULTIPLE SINE EXCITATION) CONSTANT TEMPERATURE

(1.0)

```
1 = NIC --- CODE NO. OF CONTAINER MATERIAL TO BE USED
2 = IC---OPTIMIZATION CODE

1 = IITM --- ITEM NUMBER
20 = MIC --- MAXIMUM NO. OF ITERATIONS FOR DROP HT. CALC.
[illegible] = MIG --- MAXIMUM NO. OF ITERATIONS FOR G-CONVERGENCE
11 = NUMJ --- NUMBER OF ENVIRONMENTAL FREQUENCIES
3.[illegible]E-03 ($/LB) = CS --- COST OF SHIPMENT
25.00 ( $ ) = CI --- COST OF ITEM
.12500 (IN.) = TCON --- THICKNESS OF CONTAINER
72.00 ( F ) = TEML --- LOWEST ENVIRONMENT TEMPERATURE
72.00 ( F ) = TEMH --- HIGHEST ENVIRONMENT TEMPERATURE

(RAD/SEC) = OMJ(I) ALL OF THE ENVIRONMENTAL FREQ.
.28100E+006,.28300E+011.25660E+023,1.4159E+026.28300E+021.88496E+033,14159E+034,39823E+035,65487E+035.96903E+036,28319E+03

PSD INPUT FOR RANDOM EXCITATION
.        0.        0.        0.        0.        0.        0.        0.        0.        0.        0.

(G'S) = ACJ(I) = ENVIRONMENTAL EXCITATIONS EACH CORRESPONDING TO ONE OF THE ABOVE OMJ(I)S
.[illegible]E-0[illegible].5.[illegible]E-0[illegible]1.00000E+002,00000E+003,00000E+003,00000E+003,00000E+003.00000E+003,00000E+003,00000E+003,00000E+003.00000E+00

1 = NC --- NUMBER OF CONTAINERS
1 = NITEM --- ITEM NUMBER
10 = NMATS--- NUMBER OF MATERIALS ON FILE
```

CST-MAT	CST-FAB	CST-PAK	SL-TEMP	LW-STRS	HI-STRS	GAMMA
1.420[illegible]E+[illegible]	5.[illegible]E-02	1.0000E-02	-2.2000E+01	1.0000E-01	1.0000E+00	1.5000E+00
5.400[illegible]E+[illegible]	5.[illegible]E-02	1.0000E-02	-6.0000E+01	1.4000E-01	1.5000E+00	2.0000E+00
2.1[illegible]E+[illegible]	5.[illegible]E-02	1.0000E-02	-3.4000E+01	3.0000E-02	3.0000E-01	2.4000E+00
1.440[illegible]E+0[illegible]	5.0000E-02	1.0000E-02	-6.0000E+01	2.0000E-01	1.5000E+00	8.0000E-01
1.5[illegible]E+[illegible]	5.[illegible]E-02	1.0000E-02	-4.0000E+01	5.0000E-02	3.0000E-01	1.5000E+00
1.3600E+00	5.0000E-02	1.0000E-02	-2.0000E+01	3.0000E-02	5.0000E-01	3.0000E+00
1.[illegible]E+00	5.[illegible]E-02	1.0000E-02	-2.0000E+01	2.0000E-02	2.0000E-01	7.9000E+00
1.[illegible]00E+00	5.0000E-02	1.0000E-02	-2.0000E+01	3.0000E-02	2.0000E-01	1.1000E+00
4.2[illegible]E+0[illegible]	5.[illegible]E-02	1.0000E-02	-2.0000E+01	1.0000E-02	1.5000E-01	1.1900E+01
2.[illegible]00E+00	5.[illegible]00E-02	1.0000E-02	-2.0000E+01	2.0000E-02	8.0000E-01	1.1100E+01

GAMMA	CST-CONTAINER
1.[illegible]E-03	2.[illegible]E-03

```
1=ITEM NUMBER
5.0000E+01=WEIGHT OF ITEM W( POUNDS )
1.2000E+01= DIMENSION PARALLEL TO X-AXIS AND LONGEST DIMENSION XL (INCHES)
1.2000E+01= DIMENSION PARALLEL TO Y-AXIS 3RD LONGEST DIMENSION YL (INCHES)
1.2000E+01= DIMENSION PARALLEL TO Z-AXIS LONGEST DIMENSION ZL (INCHES)
NUMBER =        4

MATERIAL CODES CONSIDERED ARE    1,   2,   4,   6,  10,
```

MAX-G	PCNT-DAM	REPLACE-CST
[illegible]E+01	0.	0.
[illegible]E+01	5.[illegible]E+00	1.[illegible]E+00
[illegible]E+0[illegible]	2.[illegible]E+01	4.[illegible]E+00
7.[illegible]E+01	8.[illegible]E+01	1.500[illegible]E+01

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*********************************************************************************************

(2.1) T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.7799E+00  TT2= 2.7799E+00  TT3= 2.7799E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.6761E+00  TT2= 2.6761E+00  TT3= 2.6761E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.4483E+00  TT2= 2.4483E+00  TT3= 2.4483E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 3.9126E+00  TT2= 3.9126E+00  TT3= 3.9126E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.4249E+00  TT2= 2.4249E+00  TT3= 2.4249E+00
(2.2) MINIMUM THICKNESS FOR MATERIAL BY AXIS
          3.1204E+00      3.1204E+00      3.1204E+00
          3.6125E+00      3.6125E+00      3.6125E+00
          3.0213E+00      3.0213E+00      3.0213E+00
          6.1683E+00      6.1683E+00      6.1683E+00
          2.9435E+00      2.9435E+00      2.9435E+00

(2.3) MATERIAL CODE =   4   THICKNESS FOR FACE ONE =    3.021 INCHES
      MATERIAL CODE =   4   THICKNESS FOR FACE TWO =    3.021 INCHES
      MATERIAL CODE =   4   THICKNESS FOR FACE THREE=    3.021 INCHES

      TOTAL COST/ITEM=    57.94
(2.4) MINCOS-INPUT
      COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
       1        .50        .50        .50
       2       1.63       1.63       1.63
       4        .36        .36        .36
       6        .70        .70        .70
      10        .52        .52        .52

      FOR   0.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF55.0 G'S
(2.5) THE COST IS       57.94 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.00 TIMES ONE
      WITH A FINAL COST OF      57.94 DOLLARSFOR OVER SHIPPING
      FOR ALLOWING DAMAGE THE COST IS      57.94 DOLLARS/ITEM


*********************************************************************************************

      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.6616E+00  TT2= 2.6616E+00  TT3= 2.6616E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.4155E+00  TT2= 2.4155E+00  TT3= 2.4155E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.3442E+00  TT2= 2.3442E+00  TT3= 2.3442E+00
      T1  3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 3.8600E+00  TT2= 3.8600E+00  TT3= 3.8600E+00
      T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.3853E+00  TT2= 2.3853E+00  TT3= 2.3853E+00
      MINIMUM THICKNESS FOR MATERIAL BY AXIS
          3.1204E+00      3.1204E+00      3.1204E+00
          3.6125E+00      3.6125E+00      3.6125E+00
          3.0213E+00      3.0213E+00      3.0213E+00
          6.1683E+00      6.1683E+00      6.1683E+00
          2.9435E+00      2.9435E+00      2.9435E+00

      MATERIAL CODE =   4   THICKNESS FOR FACE ONE =    3.021 INCHES
      MATERIAL CODE =   4   THICKNESS FOR FACE TWO =    3.021 INCHES
      MATERIAL CODE =   4   THICKNESS FOR FACE THREE=    3.021 INCHES

      TOTAL COST/ITEM=    57.94
      MINCOS-INPUT
      COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
       1        .50        .50        .50
       2       1.63       1.63       1.63
       4        .36        .36        .36
       6        .70        .70        .70
      10        .52        .52        .52

      FOR   5.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF60.0 G'S
      THE COST IS       57.94 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.05 TIMES ONE
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WITH A FINAL COST OF      60.99 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS      58.94 DOLLARS/ITEM

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T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.5433E+00  TT2= 2.5433E+00  TT3= 2.5433E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1548E+00  TT2= 2.1548E+00  TT3= 2.1548E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.2400E+00  TT2= 2.2400E+00  TT3= 2.2400E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 3.8074E+00  TT2= 3.8074E+00  TT3= 3.8074E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.3457E+00  TT2= 2.3457E+00  TT3= 2.3457E+00
MINIMUM THICKNESS FOR MATERIAL BY AXIS
      3.1204E+00      3.1204E+00      3.1204E+00
      3.6125E+00      3.6125E+00      3.6125E+00
      3.0213E+00      3.0213E+00      3.0213E+00
      6.1683E+00      6.1683E+00      6.1683E+00
      2.9435E+00      2.9435E+00      2.9435E+00

MATERIAL CODE =    4   THICKNESS FOR FACE ONE =     3.021 INCHES
MATERIAL CODE =    4   THICKNESS FOR FACE TWO =     3.021 INCHES
MATERIAL CODE =    4   THICKNESS FOR FACE THREE=     3.021 INCHES

TOTAL COST/ITEM=    57.94
MINCOS-INPUT
COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
 1        .50        .50        .50
 2       1.63       1.63       1.63
 4        .36        .36        .36
 6        .70        .70        .70
10        .52        .52        .52

FOR  20.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF65.0 G'S
THE COST IS      57.94 DOLLARS WITH A MULTIPLICATION FACTOR OF     1.25 TIMES ONE
WITH A FINAL COST OF      72.43 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS      61.94 DOLLARS/ITEM

*******************************************************************************************

T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.4250E+00  TT2= 2.4250E+00  TT3= 2.4250E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 1.8942E+00  TT2= 1.8942E+00  TT3= 1.8942E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.1358E+00  TT2= 2.1358E+00  TT3= 2.1358E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 3.7547E+00  TT2= 3.7547E+00  TT3= 3.7547E+00
T1= 3.5000E+00  T2= 3.5000E+00  T3= 3.5000E+00  TT1= 2.3061E+00  TT2= 2.3061E+00  TT3= 2.3061E+00
MINIMUM THICKNESS FOR MATERIAL BY AXIS
      3.1204E+00      3.1204E+00      3.1204E+00
      3.6125E+00      3.6125E+00      3.6125E+00
      3.0213E+00      3.0213E+00      3.0213E+00
      6.1683E+00      6.1683E+00      6.1683E+00
      2.9435E+00      2.9435E+00      2.9435E+00

MATERIAL CODE =    4   THICKNESS FOR FACE ONE =     3.021 INCHES
MATERIAL CODE =    4   THICKNESS FOR FACE TWO =     3.021 INCHES
MATERIAL CODE =    4   THICKNESS FOR FACE THREE=     3.021 INCHES

TOTAL COST/ITEM=    57.94
MINCOS-INPUT
COST MATRIX-MATERIAL VERTICAL,AXIS HORIZONTAL
 1        .50        .50        .50
 2       1.63       1.63       1.63
 4        .36        .36        .36
 6        .70        .70        .70
```

```
10        .52        .52        .52

FOR  80.00 PER-CENT DAMAGE AND A FRAGILITY RATE OF70.0 G'S
THE COST IS      57.94 DOLLARS WITH A MULTIPLICATION FACTOR OF     5.00 TIMES ONE
WITH A FINAL COST OF     289.72 DOLLARSFOR OVER SHIPPING
FOR ALLOWING DAMAGE THE COST IS      72.94 DOLLARS/ITEM

*******************************************************************************

     OVER SHIPPING DATA
(3.1) THE OPTIMUN COST IS      57.94 DOLLARS
     THE FRAGILITY RATE IS 55.0 G'S
     THE PER-CENT DAMAGE IS     0.0
     THE MULTIPLICATION FACTOR IS    1.0

     THE OPTIMUM THICKNESS FOR FACE ONE IS    3.021 INCHES IF MATERIAL  4 IS USED
     THE OPTIMUM THICKNESS FOR FACE TWO IS    3.021 INCHES IF MATERIAL  4 IS USED
     THE OPTIMUM THICKNESS FOR FACE THREE IS    3.021 INCHES IF MATERIAL  4 IS USED

     DAMAGE ALLOWABLE DATA
(3.3) THE OPTIMUM COST IS      57.94 DOLLARS
     THE FRAGILITY RATE IS 55.0 G'S
     THE PER-CENT DAMAGE IS     0.0
     THE REPAIR COST/ITEM =       0.00 DOLLARS

     THE OPTIMUM THICKNESS FOR FACE ONE IS    3.021 INCHES IF MATERIAL  4 IS USED
(3.4) THE OPTIMUM THICKNESS FOR FACE TWO IS    3.021 INCHES IF MATERIAL  4 IS USED
     THE OPTIMUM THICKNESS FOR FACE THREE IS    3.021 INCHES IF MATERIAL  4 IS USED

(3.5)OVERSHIPPING IS THE BEST POLICY

*******************************************************************************
```

G. Material Selection and Cataloging

1. Literature

The literature on cushioning materials is very large and being expanded. Most of the cushioning material data is empirical; however, work has been done to improve the generation of material data through analytical methods. Cushioning materials can be divided into three broad groups:

(1) RESILIENT materials - These materials absorb relatively small amounts of energy and recover most of the cushion thickness in a short time. An example is a lightweight open-celled plastic foam.

(2) QUASI-RESILIENT materials - These materials remain resilient under small excursions; however, under large distortions do not recover completely.

(3) NON-RESILIENT materials - These materials are used for one-time absorption of very large amounts of energy and the material performs its function once. This type of material is not applicable to this project.

The data on materials was available primarily from researchers with very little data obtained from the manufacturer. The most common practice is to present the data in terms of peak acceleration (a_p in g's) versus static stress (σ_s in psi). These curves are normally illustrated parametrically in terms of cushion thickness, T_c in inches, and drop height, h in inches.

2. Selection

The selection of materials to be cataloged was based on information gathered throughout this effort. Table XIII lists the materials selected and cataloged. For each material (Table XIII) which was cataloged into the materials data computer file, there is a material code. For each material code there are a number of parameters which describe the cushioning material used. Tables XIV through XXIII provide the user with physical descriptions of particularly coded materials. For example, if the selected material code from the program was 1, the user would know that the material was a urethane foam (ether type) with a density of 2.0 lb/ft^3. The user would know that the SHOCK DATA in the computer program was cataloged from the indicated Data Reference Source, for a density of 2.0 lb/ft^3, for the four listed drop heights, for the listed thicknesses, and for a temperature of 72°F. Also, as a part of the cataloged file is the

TABLE XIII

CATALOGED MATERIALS

Material Code	Material
1	Urethane Foam
2	Foamed Polyethylene
3	Felt
4	Expanded Resilient Polystyrene
5	Rubberized Hair
6	Cellulosic
7	Vinyl Foam
8	Fiber Glass
9	Rubber Foam
10	Air Bubbles

range of Optimum Static Stress of 0.10 to 1.00 lb/in.^{2}, and the Safe Low Temperature of -22°F. Likewise, the user would know that for the cataloged VIBRATION DATA, data were obtained from the indicated Data Reference Source for the parameters of Density, Static Stress, Thickness, and Temperature listed.

Figure 9 illustrates the typical data form for peak acceleration versus static stress curves. This data form was converted into digital tabulation for computer compatibility. The previously described interpolation program will be used for the material data. This program uses a sophisticated and accurate Lagrangian parabolic interpolation technique(4). Thus, with a minimum amount of digitized data, these empirical curves can be represented for computer usage.

Figure 10 illustrates the availability of recorded optimum static stresses. The inclusion of this data reduces the iterative process within the physical optimization routine of the computer program because it readily eliminates some candidate materials.

TABLE XIV

URETHANE DATA

Material Description:	Urethane Foam (Ether Type)
Material Code:	1
Density in Data File: (lb/ft^3)	2.0

Data Reference Source	Parameters	
	Parameters for SHOCK DATA	
MIL-Hdbk. 304 (5)	Density: (lb/ft^3)	2.0
"	Drop Heights: (in.)	18, 24, 30, 36
"	Thicknesses: (in.)	2, 3, 4, 5
"	Temperature: (°F)	72
From Data Plots	Range of Optimum Static Stress: (lb/in.^{2})	0.10 to 1.00
Mustin, SVM-2 (1)	Safe Low Temperature: (°F)	-22
	Parameters for VIBRATION DATA	
PB 167 372, Zell (6)	Density: (lb/ft^3)	2.0
"	Static Stress: (lb/in.^{2})	0.16
"	Thickness: (in.)	2.9
"	Temperature: (°F)	72.0
	COST DATA	
Commercial Quote to SwRI	Material Cost: (\$/ft^3)	1.02
Estimated	Fabrication Cost: (\$/min)	0.05
Estimated	Packing Cost: (\$/min)	0.01

TABLE XV

POLYETHYLENE DATA

Material Description:	Polyethylene Foam
Material Code:	2
Density in Data File (lb/ft³)	2.0

Data Reference Source	Parameters for SHOCK DATA	
MIL-Hdbk. 304 (5)	Density: (lb/ft³)	2.0
"	Drop Heights: (in.)	18, 24, 30, 36
"	Thicknesses: (in.)	2, 3, 4, 5
"	Temperature: (°F)	72
From Data Plots	Range of Optimum Static Stress: (lb/in.²)	0.14 to 1.50
Estimated	Safe Low Temperature: (°F)	-60
	Parameters for VIBRATION DATA	
Estimated	Density: (lb/ft³)	2.1
Estimated	Static Stress: (lb/in.²)	1.0
Estimated	Thickness: (in.)	2.0
Estimated	Temperature: (°F)	72
	COST DATA	
Commercial Quote to SwRI	Material Cost: ($/ft³)	5.40
Estimated	Fabrication Cost: ($/min)	0.05
Estimated	Packing Cost: ($/min)	0.01

TABLE XVI

FELT DATA

Material Description:	Wood Fiber Felt
Material Code:	3
Density in Data File: (lb/ft^3)	2.4

Data Reference Source		
	Parameters for SHOCK DATA	
MIL-Hdbk 304 (5)	Density: (lb/ft^3)	2.4
"	Drop Heights: (in.)	18, 24, 30, 36
"	Thicknesses: (in.)	2, 3, 4, 5
"	Temperature: (°F)	72
From Data Plots	Range of Optimum Static Stress: (lb/in.^{2})	0.03 to 0.30
Mustin, SVM-2 (1)	Safe Low Temperature: (°F)	-34
	Parameters for VIBRATION DATA	
Estimated	Density: (lb/ft^3)	1.8
Estimated	Static Stress: (lb/in.^{2})	0.08
Estimated	Thickness: (in.)	4.0
Estimated	Temperature: (°F)	72
	COST DATA	
Commercial Quote to SwRI	Material Cost: (\$/ft^3)	2.16
Estimated	Fabrication Cost: (\$/min)	0.05
Estimated	Packing Cost: (\$/min)	0.01

TABLE XVII

POLYSTYRENE DATA

Material Description:	Polystyrene (Expanded Resilient)
Material Code:	4
Density in Data File: (lb/ft^3)	0.8

Data Reference Source	Parameters for SHOCK DATA	
MIL-Hdbk. 304 (5)	Density: (lb/ft^3)	0.4 to 1.5
"	Drop Heights: (in.)	18, 24, 30, 36
"	Thicknesses: (in.)	1*, 1.5, 2, 3, 4, 6
"	Temperature: (°F)	72
From Data Plots	Range of Optimum Static Stress: (lb/in.^{2})	0.20 to 1.50
Mustin, SVM-2 (1)	Safe Low Temperature: (°F)	-60
	Parameters for VIBRATION DATA	
PB 167 372, Zell (6)	Density: (lb/ft^3)	0.8
"	Static Stress: (lb/in.^{2})	1.46
"	Thickness: (in.)	5.0
"	Temperature: (°F)	72
	COST DATA	
Commercial Quote to SwRI	Material Cost: ($/ft^3)	1.44
Estimated	Fabrication Cost: ($/min)	0.05
Estimated	Packing Cost: ($/min)	0.01

*1 inch only for 18, 24, 36 inch drops.

TABLE XVIII

RUBBER HAIR DATA

Material Description:	Rubberized Hair
Material Code:	5
Density in Data File: (lb/ft^3)	1.5

Data Reference Source	Parameters for SHOCK DATA		
MIL-Hdbk. 304 (5)	Density: (lb/ft^3)		1.5
"	Drop Heights: (in.)	18, 24, 30, 36	
"	Thicknesses: (in.)	2, 3, 4, 5	
"	Temperature: (°F)		72
From Data Plots	Range of Optimum Static Stress: (lb/in.^{2})		0.03 to 0.30
Mustin, SVM-2 (1)	Safe Low Temperature: (°F)		-40
	Parameters for VIBRATION DATA		
Estimated	Density: (lb/ft^3)		1.48
Estimated	Static Stress: (lb/in.^{2})		.256
Estimated	Thickness: (in.)		3.0
Estimated	Temperature: (°F)		72
	COST DATA		
Commercial Quote to SwRI	Material Cost: ($/ft^3)		1.58
Estimated	Fabrication Cost: ($/min)		0.05
Estimated	Packing Cost: ($/min)		0.01

TABLE XIX

CELLULOSE DATA

Material Description:	Cellulose Wadding, Asphalt Treated
Material Code:	6
Density in Data File: (lb/ft^3)	3.0 (Estimated)

Data Reference Source	Parameters for SHOCK DATA	
MIL-Hdbk, 304 (5)	Density: (lb/ft^3)	2.91
"	Drop Heights: (in.)	18, 24, 30, 36*
"	Thicknesses: (in.)	2, 3, 4, 5
"	Temperature: (°F)	72
From Data Plots	Range of Optimum Static Stress: (lb/in.^{2})	0.03 to 0.50
Estimated	Safe Low Temperature: (°F)	-20
	Parameters for VIBRATION DATA	
Wilson, L. T. (7) Sandia Labs	Density: (lb/ft^3)**	2.91
"	Static Stress: (lb/in.^{2})	.268
"	Thickness: (in.)	3.0
"	Temperature: (°F)	72
	COST DATA	
Commercial Quote to SwRI	Material Cost: ($/ft^3)	1.36
Estimated	Fabrication Cost: ($/min)	0.05
Estimated	Packing Cost: ($/min)	0.01

*Drop Height 36" was estimated.

**Compression of 16.7%.

TABLE XX

VINYL FOAM DATA

Material Description:	Vinyl Foam
Material Code:	7
Density in Data File: (lb/ft^3)	7.9

Data Reference Source	Parameters for SHOCK DATA	
Estimated	Density: (lb/ft^3)	7.97
"	Drop Heights: (in.)	18, 24, 30, 36
"	Thicknesses: (in.)	2, 3, 4, 5
"	Temperature: (°F)	72
From .. Plots	Range of Optimum Static Stress: (lb/in.^{2})	0.02 to 0.20
Estimated	Safe Low Temperature: (°F)	-20
	Parameters for VIBRATION DATA	
Wilson, L. T. (7) Sandia Labs	Density: (lb/ft^3)*	7.93
"	Static Stress: (lb/in.^{2})	.266
"	Thickness: (in.)	3.0
"	Temperature: (°F)	72
	COST DATA	
Estimated	Material Cost: ($/ft^3)	1.00
Estimated	Fabrication Cost: ($/min)	0.05
Estimated	Packing Cost: ($/min)	0.01

*Compression of 16.1%.

TABLE XXI
FIBER GLASS DATA

Material Description:	Fiber Glass	
Material Code:	8	
Density in Data File: (lb/ft^3)	1.1	

Data Reference Source	Parameters for SHOCK DATA	
MIL-Hdbk. 304 (5)	Density: (lb/ft^3)	1.1
"	Drop Heights: (in.)	18*, 24*, 30, 36*
"	Thicknesses: (in.)	2, 3, 4
"	Temperature: (°F)	72
From Data Plots	Range of Optimum Static Stress: ($lb/in.^2$)	0.03 to 0.20
Estimated	Safe Low Temperature: (°F)	-20
	Parameters for VIBRATION DATA	
Wilson, L. T. (7) Sandia Labs	Density: (lb/ft^3)**	2.0
"	Static Stress: ($lb/in.^2$)	.256
"	Thickness: (in.)	3.0
"	Temperature: (°F)	72
	COST DATA	
Estimated	Material Cost: ($\$/ft^3$)	1.00
Estimated	Fabrication Cost: ($/min)	0.05
Estimated	Packing Cost: ($/min)	0.01

*18, 24, 36 inch drop heights were estimated.

**Compression of 15.8%.

TABLE XXII

RUBBER FOAM DATA

Material Description:	Rubber Foam
Material Code:	9
Density in Data File: (lb/ft^3)	11.9

Data Reference Source		
	Parameters for SHOCK DATA	
Estimated	Density: (lb/ft^3)	11.9
"	Drop Heights: (in.)	18, 24, 30, 36
"	Thicknesses: (in.)	2, 3, 4, 5
"	Temperature: (°F)	72
From Data Plots	Range of Optimum Static Stress: (lb/in.^{2})	0.01 to 0.15
Mustin, SVM-2 (1)	Safe Low Temperature: (°F)	-20
	Parameters for VIBRATION DATA	
Wilson, L. T. (7) Sandia Labs	Density: (lb/ft^3)*	11.9
"	Static Stress: (lb/in.^{2})	1.28
"	Thickness: (in.)	3.0
"	Temperature: (°F)	72
	COST DATA	
Commercial Quote to SwRI	Material Cost: ($/ft^3)	4.20
Estimated	Fabrication Cost: ($/min)	0.05
Estimated	Packing Cost: ($/min)	0.01

*Compression of 3.0%.

TABLE XXIII

AIR CAP DATA

Material Description:	Air Cap
Material Code:	10
Density in Data File: (lb/ft^3)	1.1

Data Reference Source	Parameter	Value
	Parameters for SHOCK DATA	
Kinetic Systems, Inc. (8)	Density: (lb/ft^3)	1.0
"	Drop Heights: (in.)	18, 24, 30, 36
"	Thicknesses: (in.)	1, 2, 3
"	Temperature: (°F)	72
From Data Plots	Range of Optimum Static Stress: (lb/in.^{2})	0.02 to 0.80
Estimated	Safe Low Temperature: (°F)	-20
	Parameters for VIBRATION DATA	
Estimated	Density: (lb/ft^3)	1.8
"	Static Stress: (lb/in.^{2})	0.08
"	Thickness: (in.)	4.0
"	Temperature: (°F)	72
	COST DATA	
Commercial Quote to SwRI	Material Cost: (\$/ft^3)	2.11
Estimated	Fabrication Cost: (\$/min)	0.05
Estimated	Packing Cost: (\$/min)	0.01

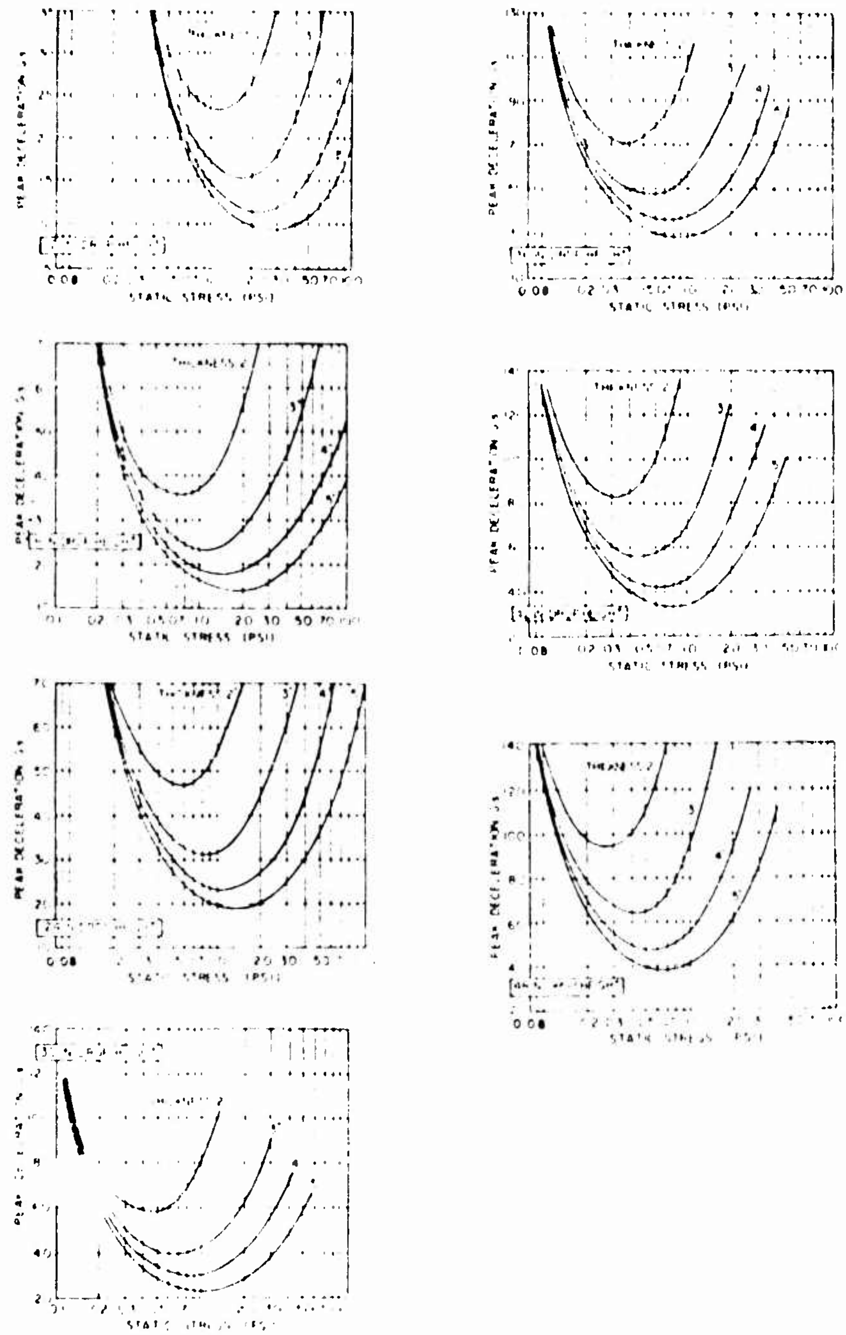


FIGURE 9. PEAK ACCELERATION VERSUS STATIC STRESS CURVES FOR POLYETHYLENE FOAM
[Mustin, G. S.][1]

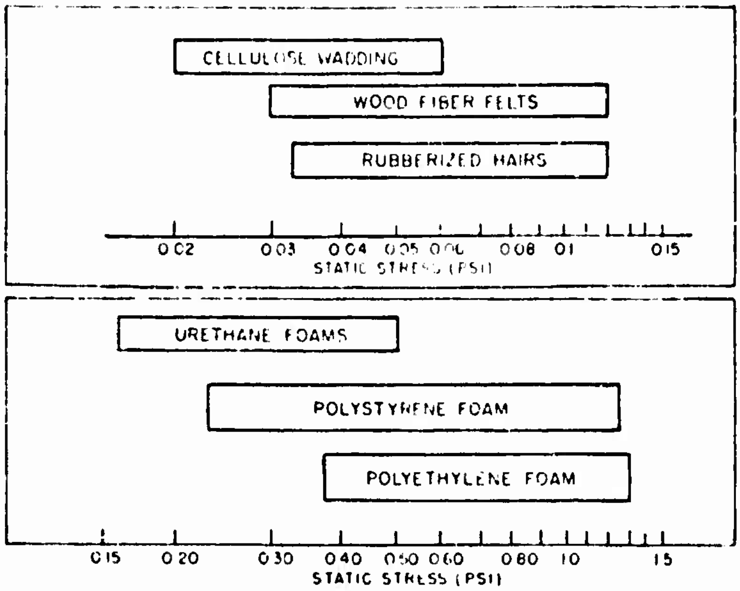


FIGURE 10. RANGE OF RECORDED OPTIMUM STATIC STRESSES

3. Materials Data

For each material listed in Table XIII, there is a coded file containing the following:

Data on Disk File for Each Package Cushioning Material

Shock Environment

Format	Record No.	
(E7.0, 5I2)	1	RHOM, DRPH, ICODE
E7.0		RHOM - Specific weight of the material (PCF)
I2		DRPH - Drop height
I2		ICODE - Code used in updating files
(5I2)	2	NT, NTH, NS
I2		NT - Number of temperatures (Max. = 5)
I2		NTH - Number of thicknesses (Max. = 10)
I2		NS - Number of stresses (Max. = 10)

Format	Record No.	
(11E7.0)	3	(T (I), I = 1, NT)
E7.0		T (I) - One of the temperatures at which data is recorded (degrees fahrenheit)
(11E7.0)	4	(TH(I), I = 1, NTH)
E7.0		TH(I) - One of the material thicknesses considered during data gathering
(11E7.0)	5	(SIG (I), I = 1, NS)
E7.0		SIG (I) - Static stress at a point
		DO XX K = 1, NT
		DO XX I = 1, NTH
(11E7.0)	6 thru (NT) * (NTH)	XX READ (MS, F) (TAB1 (I, J, K), J = 1, NS)
		TAB1 (I, J, K) = G = F(Thickness, Stress, Temperature)
		where (NT) * (NTH) = (5) * (4) = 20 for the 18-inch drop height,

The preceding type of information is also stored for the 24-inch drop height, 30-inch drop height, and 36-inch drop height, respectively.

Next is the vibration environment which consists of the following:

The first record number for the vibration data will be $\ell rs + 1$, since the last record of the shock data (ℓrs) will be

$$\ell rs = 4 * 5 + (NT_{18}) * (NTH_{18}) + (NT_{24}) * (NTH_{24}) + (NT_{30}) * (NTH_{30}) + (NT_{36}) * (NTH_{36})$$

where for NT_i and NTH_i the subscript i denotes the indicated drop height.

Input Data - Disk Files

Vibration Environment

Format	Record No.		
(E7.0, 5I2)	$\ell rs + 1$	RHOM, MTS, MOMS	
E7.0		RHOM - Specific weight of the material (PCF)	
I2		MTS - Number of temperatures (Max. = 10)	
I2		MOMS - Number of frequencies (Max. = 10)	
(11E11.4)	$\ell rs + 2$	(TS(I), I = 1, MTS)	
E11.4		TS(I) - A temperature at which data is recorded (degrees fahrenheit)	
(11E11.4)		(QMS(I), I = 1, MOMS)	
E11.4		QMS(I) - A frequency at which data is recorded (rad/sec)	
			DO X I = 1, MOMS
(11E11.4)	$\ell rs + 3$ thru $\ell rs + MOMS$	X	READ (MS, F1) (TAB1 (I, J, 1), J = 1, MTS) TAB1 (I, J, 1) = ER = F(Temp., Freq.) DO XX I = 1, MOMS
(11E11.4)	$\ell rs + MOMS + 1$ thru $\ell rs + MOMS + 1 + MOMS$	XX	READ (MS, F2) (TAB2 (I, J, 1), J = 1, MTS) TAB2 (I, J, 1) = EL/ER = F(Temp., Freq.)

The complete shock and vibration data file printout is available from the cognizant project engineer at U.S. Army Natick Laboratories.

II. Optimization Technique

The general concept of an optimization process involves the problem of minimizing a function of several variables, wherein the variables are subject to a set of constraints. The function to be minimized is generally referred to as a cost function and for the present problem it is exactly that, an expression of cost. The conditions of constraint for the package problem involve numerous variables most of which deal with either the protection of the packaged item and thus the cushioning designs that meet the required fragility limits for a given shipping environment, or are of concern in the total weight and cube of the package for purposes of determining the cost of shipping.

Unfortunately, the constraint equations for this problem cannot be explicitly written out in functional form, such as in the form of inequalities, since most of the cushion design variables are in the form of various graphs which are stored as discrete variables; likewise, packaging exterior container designs and shipping costs are also in discrete form. Therefore, an optimization solution technique such as linear programming[8] does not conveniently lend itself to the present problem.

Thus, the optimization technique used in this computer-aided design procedure is to take the specified problem input values and use the input data in conjunction with the data stored for each material in an iterative process. The iterative process will finally produce only those materials which will meet all aspects of the shipping problem. The optimum material is finally selected on the basis of least cost.

After the input data are read by the computer, the three temperatures are set by using the specified high and low temperatures and a third temperature halfway between the two extremes.

Those materials that cannot provide protection throughout the specified temperature range are eliminated. If the static stress of the shipped item is outside of the optimum static stress range of a material, that material is eliminated from further consideration.

I. Package Cushioning CAD Program User Guide

To use the CAD Program, OPPACK, for the design of package cushioning, the user must be able to adequately understand, define, and describe his package cushioning problem. A very simple step-by-step tabulation of the required input data to the CAD Program, OPPACK, is shown in Table XXIV

Sample Problem No. 1

The problem is to optimumly ship a 12 in. x 12 in. x 24 in., 100-lb item in a cardboard contained from Point A to Point B.

The package cushioning engineer completes the information in Table XXIV and codes the computer sheets for keypunching. The punched cards would appear as shown in Table XXV.

TABLE XXIV

STEP-BY-STEP CAD PROGRAM, OPPACK, INPUT DATA REQUIREMENTS FROM USER

Input Data on Card Number One

Step 1. What is the shipping container material?

- Wood - NIC = ______
- Paperboard - NIC = ______
- etc.

Step 2. Which type of vibration optimization is to be used?

- MIL-STD-810B - IC = 1
- Multiple sine - IC = 2
- Random - IC = 3

Step 3. What is the Item Number?

Set IITM = 1

Step 4. What are the maximum number of iterations needed for convergence of drop height calculations?

MIC = __________

If the number of iterations are unknown,

Set MIC = 20

Step 5. Set MXI = 0

Step 6. What is the number of environmental frequencies which are going to be provided as input? (Up to a maximum of 11)

MOMJ = __________

Step 7. What is the cost of shipping?

CS = __________ ($/lb)

Step 8. What is the cost of the item?

CI = __________ ($)

Step 9. What is the thickness of the shipping container?

TCON = __________ (in.)

Step 10. What is the lowest environmental temperature ($^{\circ}$F) to which the item will be exposed?

TEML = __________ ($^{\circ}$F)

TABLE XXIV (Contd.)

Step 11. What is the highest environmental temperature (°F) to which the item will be exposed?

TEMH = ________ (°F)

NOTE If (TEMH - TEML) ≤ 20°F, make TEMH = TEML

Input Data on Card Number Two

Step 12. What are the environmental frequencies (radians/second) in ascending order up to a maximum of 11 (i.e., MOMJ ≤ 11) from Step 6?

_____, _____, _____, _____, _____, _____,

_____, _____, _____, _____, _____.

If the environmental frequencies are UNKNOWN, use

6.283, 62.83, 125.66, 314.159, 628.300, 1884.96,

3114.59, 4398.23, 5654.87, 5969.03, 6283.19

(rad/sec).

Input Data on Card Number Three

Step 13. What is the Power Spectral Density (PSD), g^2/Hz value at each of the corresponding environmental frequencies in Step 12?

If the environmental frequencies of Step 12 are used and PSD values are UNKNOWN, use

0.000366, 0.000517, 0.000191, 0.000191, 0.000113,

$4.09(10)^{-7}$, $5.83(10)^{-6}$, $5.09(10)^{-7}$, $5.09(10)^{-7}$, $5.09(10)^{-7}$

(g^2/Hz).

Input Data on Card Number Four

Step 14. What are the environmental acceleration levels, g, which correspond to the environmental frequencies in Step 12?

If the environmental frequencies of Step 12 are used and acceleration levels are UNKNOWN, use

0.5, 0.5, 1., 2., 3., 3., 3., 3., 3., 3., 3. (g)

Input Data on Card Number Five

Step 15. How many different types of containers are there to be considered?

NC = __________

What is the Item Number?

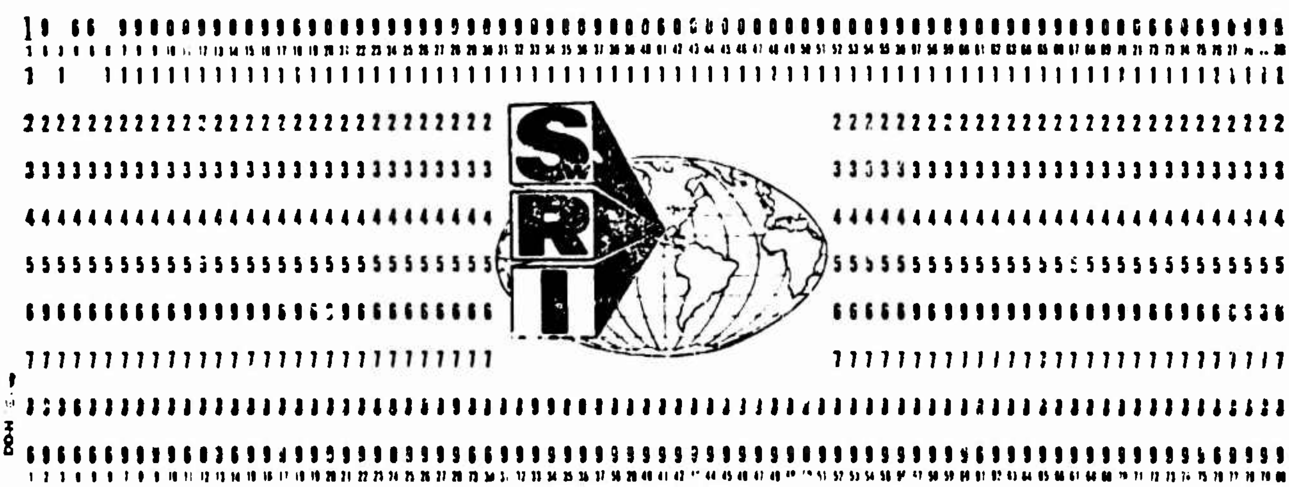
MITEM = __________

MITEM - is an arbitrary number assigned to the item being shipped. MITEM must not be greater than two digits (i.e., 99). The following must exist: MITEM = IITEM = ITEM.

What is the number of materials on disk file?

MNMATS = 10

MNMATS (Columns 5-6) on Card Number Five should be the following (i.e., 10) until modified by Natick Laboratories. Check with cognizant engineer.



where Number of Container types to be considered -------- NC = 1
(The input data for each type of container are as shown on Input Data Card Sixteen)

Item Number ---------- MITEM = 1

Number of Materials on File - MINMATS = 10

Input Data on Cards Numbers Six through Fifteen

Step 16. Cards Numbers Six through Fifteen should be the following, until modified by Natick Laboratories. Check with cognizant engineer.

[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.5	1
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.1	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	11.1	10

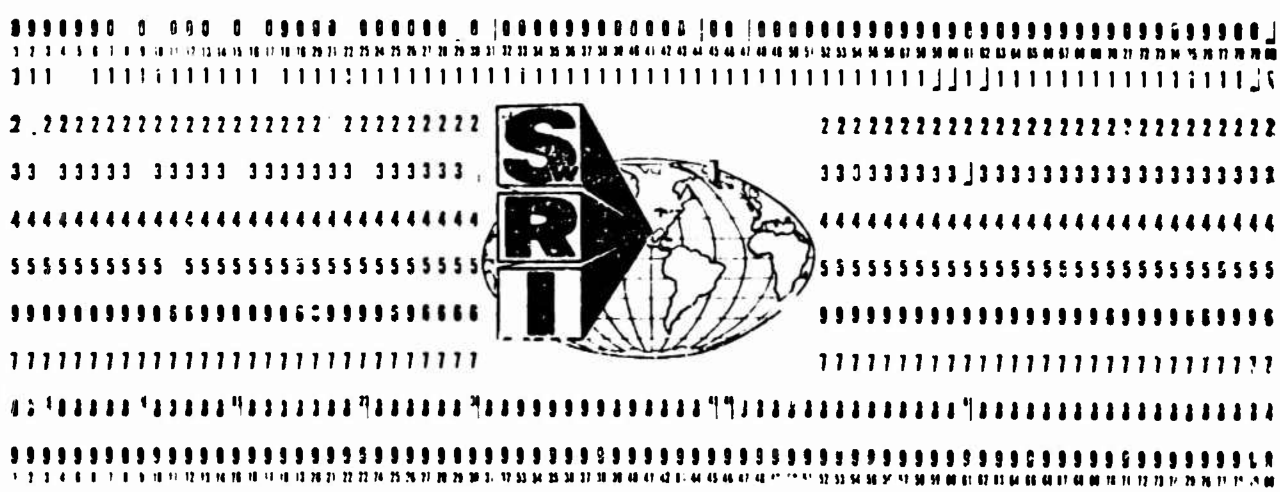
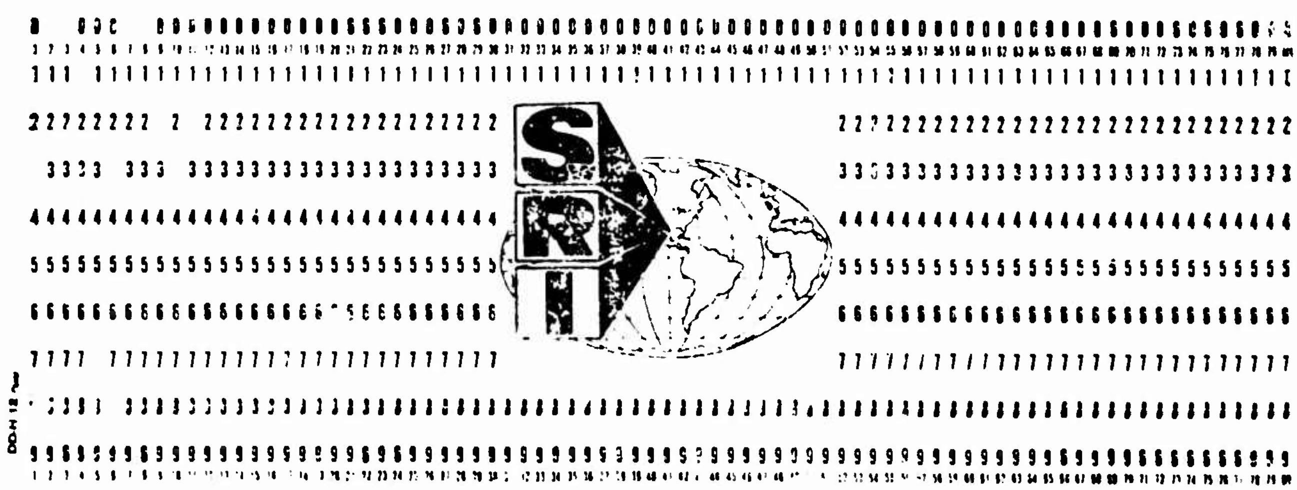


TABLE XXIV (Contd.)

Input Data on Card Number Sixteen through .....

Step 17. Card Number Sixteen contains the specific weight (lb/in.^{3}) and cost (\$/in.^{3}) of the container material. The cost of container material is material volume, NOT container volume.

There should be one Card Number Sixteen type card for each container material specified in Data Card Number Five (i.e., NC). The data cards would appear as follows:



Input Data on Card Number Fifteen + Number of Container Material Cards (i.e., Card Number Seventeen in Sample Problem)

Step 18. What is the number of items? ITEM = __________

Step 19. What is the weight of the item? WI = __________ (lb)

Step 20. What is the X-length (2nd longest length) of the item?

XL = __________ (in.)

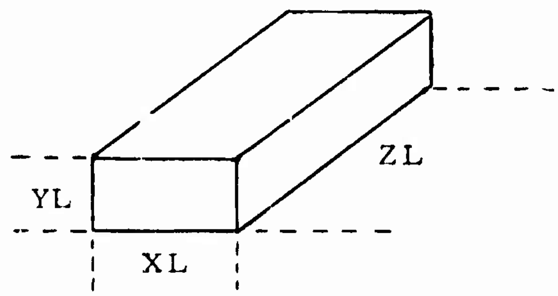
Step 21. What is the Y-length (shortest length) of the item?

YL = __________ (in.)

Step 22. What is the Z-length (longest length) of the item?

ZL = __________ (in.)

where the lengths are:



Step 23. How many different percent damage allowable cases are there? (Maximum = 10)

NPCNT = __________

Input Data on Cards Numbers Fifteen + Number of Container Material Cards + 1 (i.e., Card Number Eighteen in Sample Problem), through.... Last Card Containing Damage Allowable Data (i.e., Card Number Twenty-One in Sample Problem One).

Step 24. What is the fragility of the item in acceleration, g?

GMF(I) = __________ (g)

Step 25. What is the percent damage at the acceleration level in Step 24?

PCTD(I) = __________ (%)

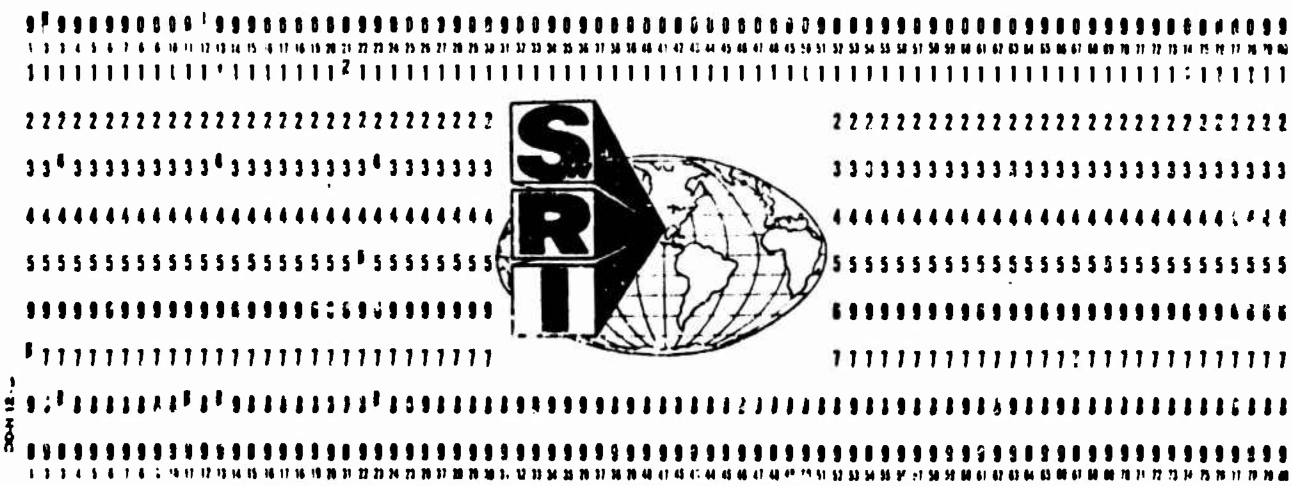
Step 26. What is the replacement cost for the percent damage in Step 25?

REPCI(I) = __________ ($/item)

Step 27. Repeat Steps 24, 25, 26 for each different percent damage allowable case indicated in Step 23 on a separate input data card.

TABLE XXV. SAMPLE PROBLEM NUMBER ONE INPUT DATA CARDS

Card No.	Data
1	0102 1207511 0.2359000 25. 0 .125 0 72.10 72.00
2	6.283 62.83 125.60 314.159628.3 1084.96314.1574398.2356 4.87596 .036283.19
3	
4	0.5 0.5 1. 2. 3. 3. 3. 3. 3. 3. 3.
5	.1 1
6	1.92 0.5 .1 -22. 0.10 1.00 1.5 1
7	5.40 0.75 .1 -6. 0.14 1.50 2.0 2
8	2.16 0.5 .1 -34. 0.3 0.30 2.4 3
9	1.44 0.75 .1 -6. 0.20 1.50 0.8 4
10	1.58 0.5 .1 -4. 0.3 0.30 1.5 5
11	1.35 0.5 .1 -2. 0.3 0.50 3.0 6
12	1.00 0.5 .1 -2. 0.2 0.20 7.9 7
13	1.00 0.5 .1 -2. 0.03 0.20 1. 8
14	4.20 0.5 .1 -2. 0.1 0.15 11.9 9
15	2.11 0.5 .1 -2. 0.02 0.80 11. 10
16	.0017.0023
17	1 100. 12. 12. 24. 4
18	55. 0. 0.
19	60. 5. 5.
20	65. 20. 10.
21	70. 80. 15.



Input Data on Card Number One

Step 1. The shipping container is cardboard.

NIC = 1

Step 2. The shipping environment is considered to have Multiple Sine Excitation.

IC = 2

Step 3. The item number is No. 1

IITM = 1

IITM is an arbitrary number assigned to the item being shipped. IITM must not be greater than two digits (i.e., 99). The following must exist: IITM = MITEM = ITEM.

Step 4. The maximum number of iterations are desired for the drop height calculations.

MIC = 20

Step 5. Set MXI = 0

Step 6. The eleven environmental frequencies are going to be provided.

Step 7. The shipping cost is \$0.3359 per pound.

CS = 0.3359 (\$/lb)

Step 8. The item cost is \$25.00.

CI = 25.00 (\$)

Step 9. The shipping container is 0.125-in. thick.

TCON = 0.125 (in.)

Step 10. 55°F is the lowest environmental temperature.

TEML = 55 (°F)

Step 11. 72°F is the highest environmental temperature.

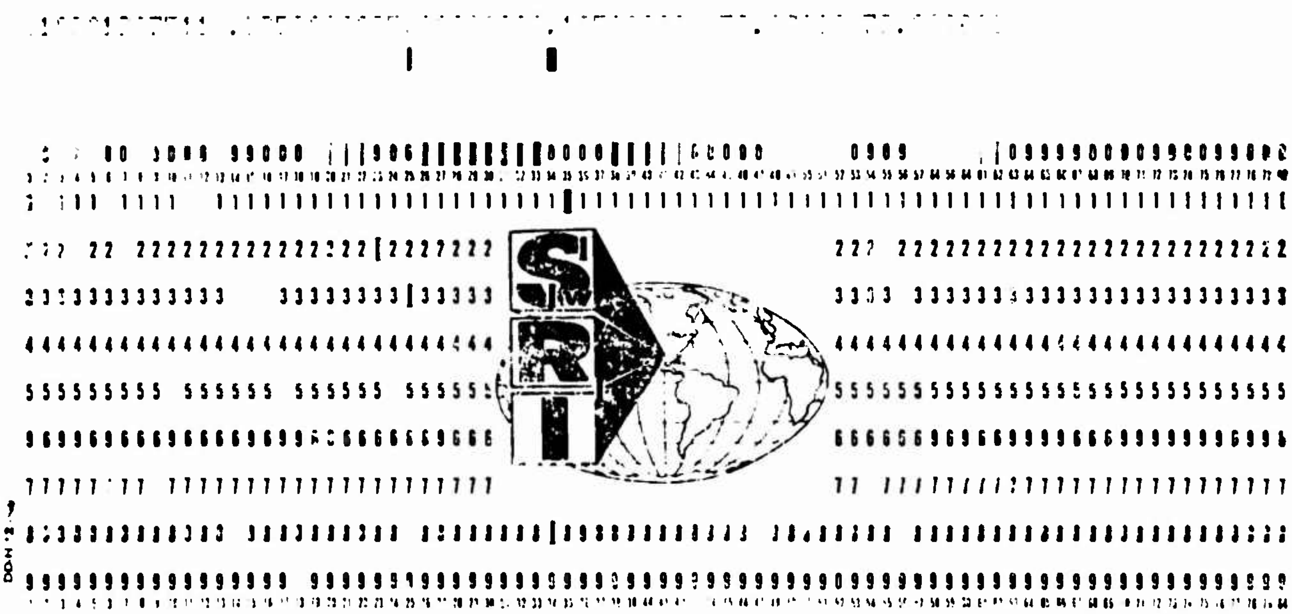
TEMH = 72 (°F)

Since (TEMH - TEML) $\leq$ 20°F, make

TEMH = TEML

Input Data Card Number One would look like the following:

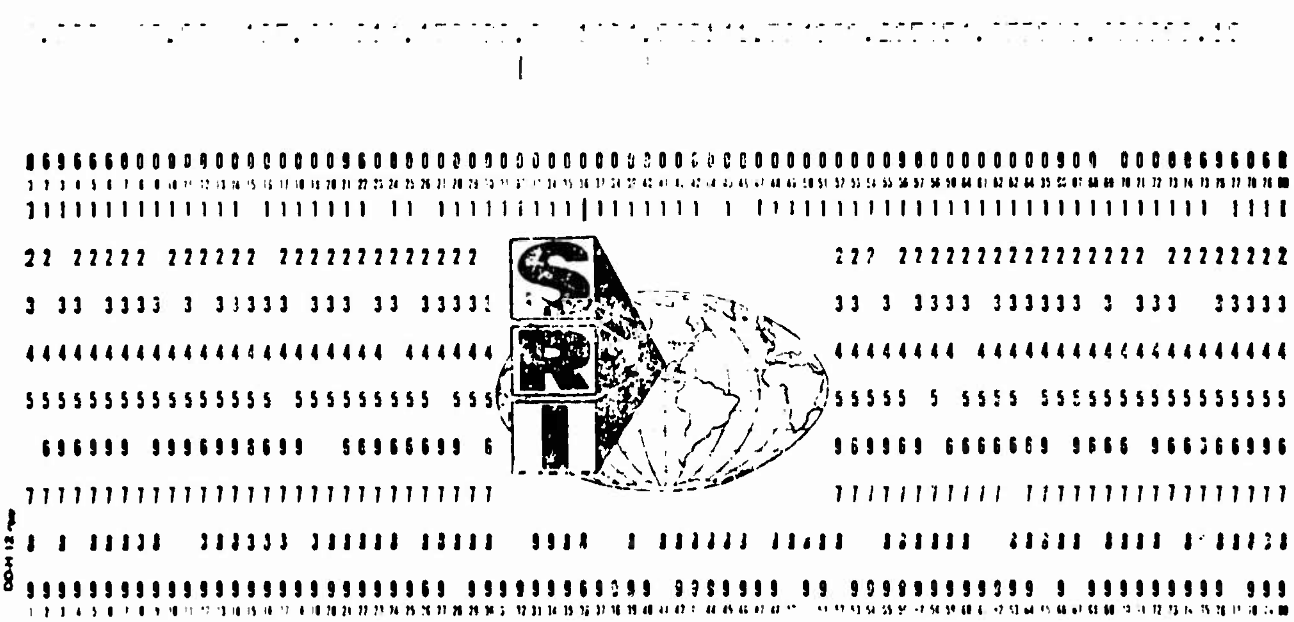
(Input Data Card Number One)



Input Data on Card Number Two

Step 12. The environmental frequencies (rad/sec) are UNKNOWN; therefore, the suggested frequencies are used.

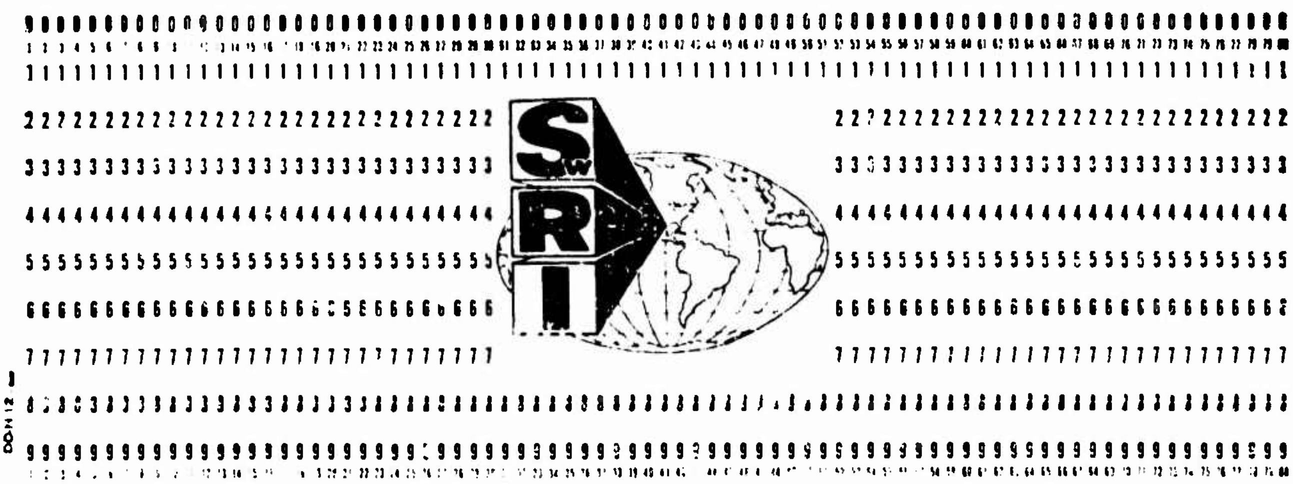
Input Data Card Number Two would look like the following:



Input Data on Card Number Three

Step 13. Since the Multiple Sine Excitation (IC = 2) is being used, this card is blank.

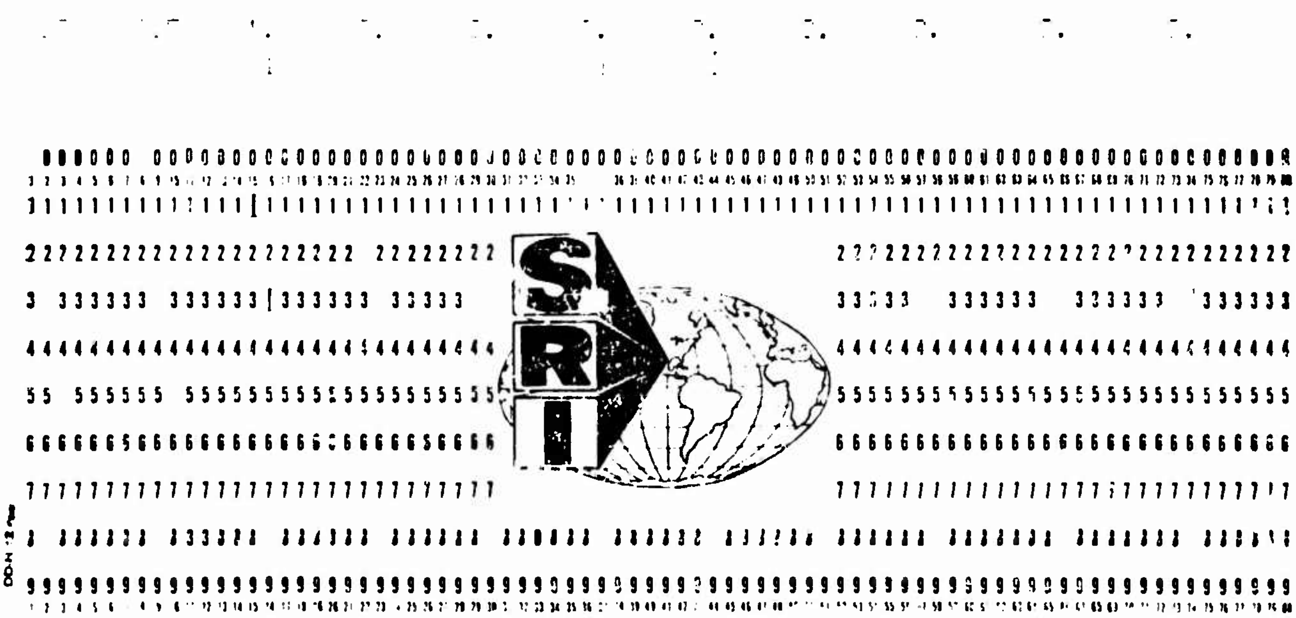
Input Data Card Number Three would look like the following:



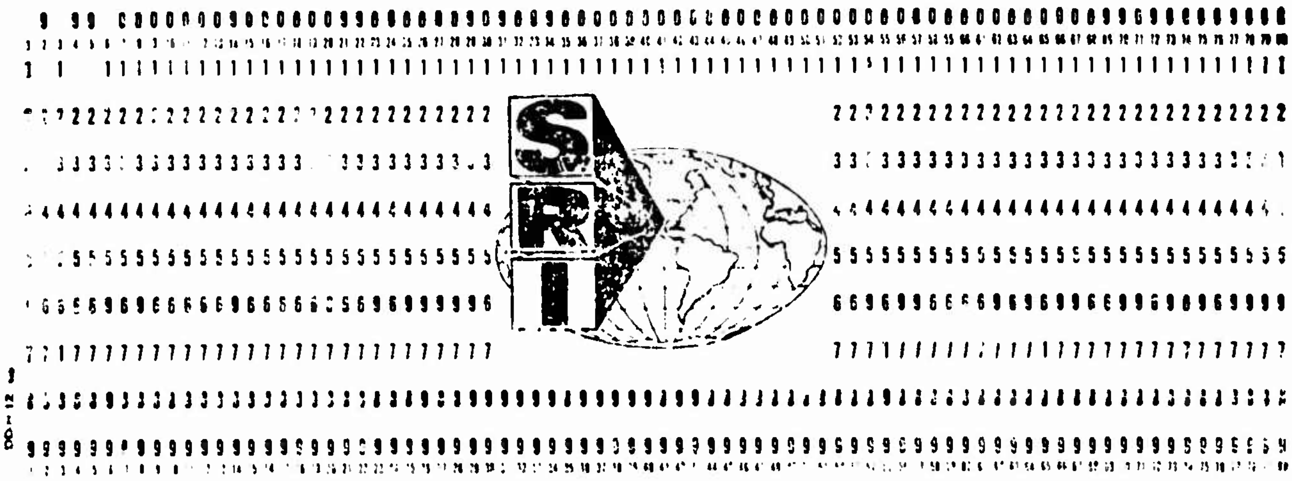
Input Data Card Number Four

Step 14. Since the suggested environmental frequencies are used (i.e., Step 12), the suggested acceleration levels are used.

Input Data Card Number Four would look like the following:

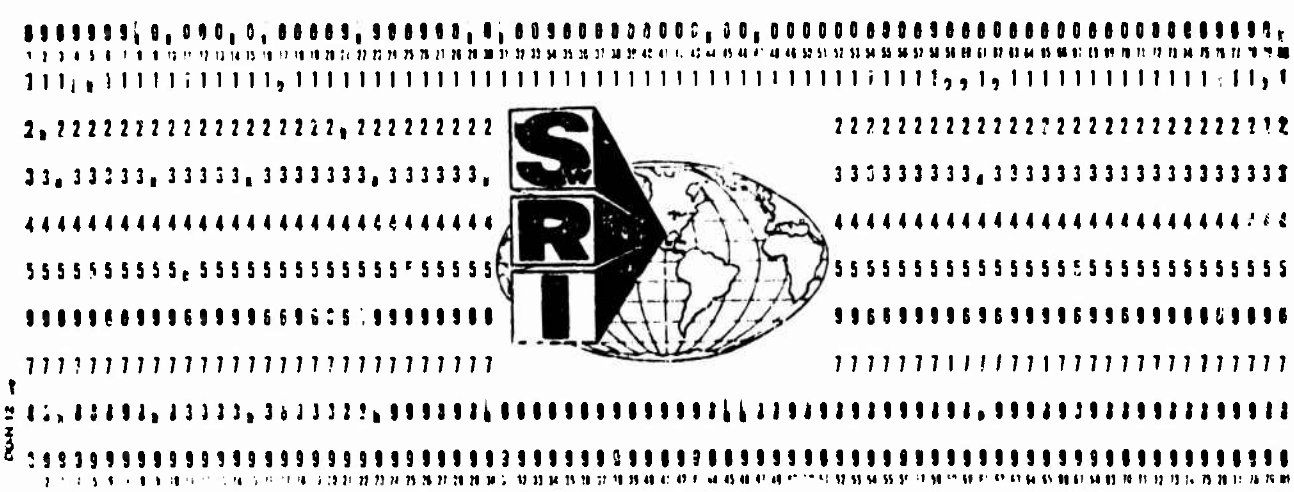


Step 15. Since there is only one type of container to be checked and the item number is "1", Input Data Card Number Five would look like the following:



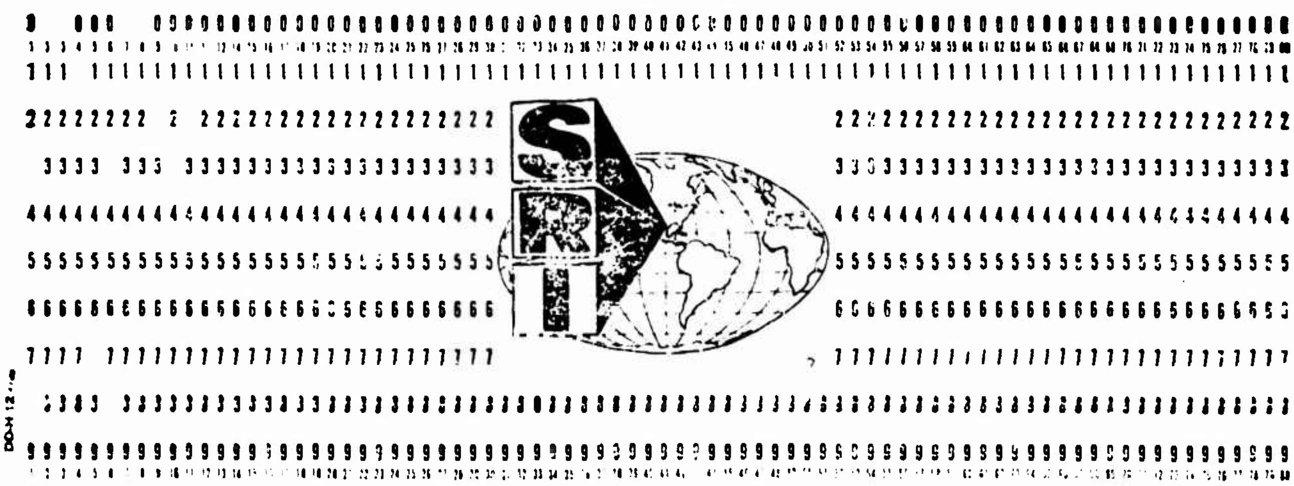
Input Data on Cards Numbers Six through Fifteen

Step 16. Input Data Cards Numbers Six through Fifteen would look like the following:



Input Data on Card Number Sixteen

Step 17. Since the specific weight of the container is 0.0017 lb/in.^{3} and the container material cost is 0.00232 \$/in.^{3}. Input Data Card Number Sixteen would look like the following:



Input Data on Card Number Seventeen

Step 18. There is 1 item.

ITEM = 1

Step 19. The item weighs 100 lb.

WI = 100 (lb)

Step 20. The second largest length is 12 inches.

XL = 12 (in.)

Step 21. The shortest length is 12 inches.

YL = 12 (in.)

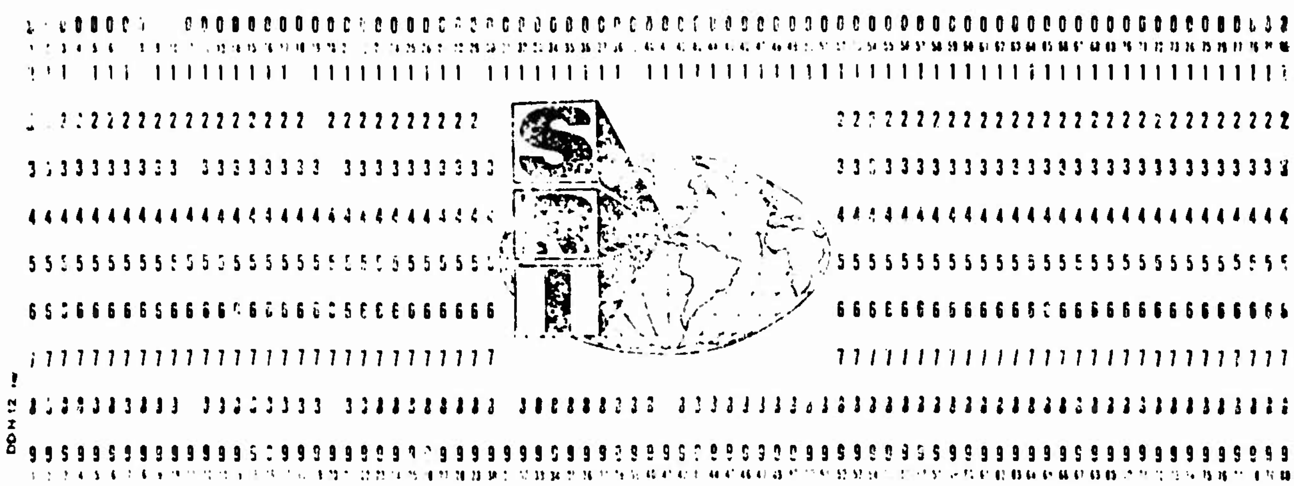
Step 22. The longest length is 24 inches.

ZL = 24 (in.)

Step 23. There are 4 different percent damage allowable cases.

NPCUT = 4

Input Data Card Number Seventeen would look like the following:

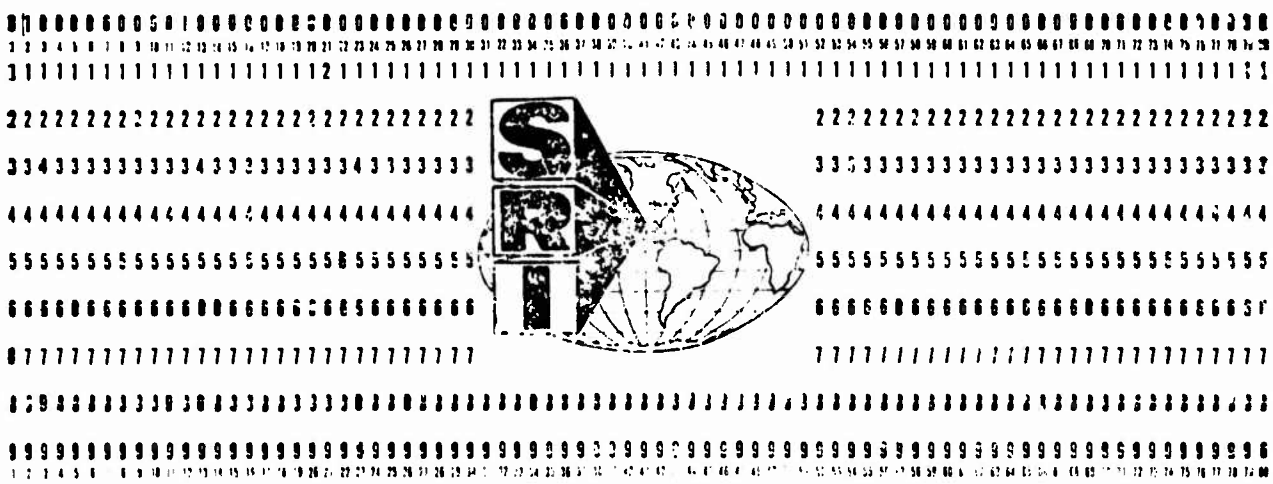


Input Data on Cards Numbers Eighteen through Twenty-One

Step 24
thru
Step 26 The four different percent damage allowable cases are:

Fragility (g)	Percent Damage (%)	Repair Cost ($)
50.	0.	0
60.	5.	5.00
65.	20.	10.00
70.	80.	15.00

Input Data Cards Numbers Eighteen through Twenty-One would look like the following:



J. Source Program and Data File Change Procedures

The documentation for the basic procedures to change the computer resident object program for OPPACK or to change the computer resident data files is in:

NLABS U-1106 COMPUTER FACILITY
USERS GUIDE

Any modifications to any or all of the OPPACK subroutines should be made not only to the Source Program disk file (i. e., OPPACK., which contains OPPACK. MAIN, OPPACK. TEMPEV, OPPACK. DAMALW, OPPACK. CDPRO, OPPACK. DHGHT, OPPACK. COSTMT, OPPACK. MINCOS, OPPACK. SHOCKE, OPPACK. VIBRTN, OPPACK. LAGINT, and OPPACK. FLAGR) but to the Source Program card file. After changes have been made to the Source Program disk file, the listing shown in Appendix J should be used to create the object program on the disk file.

Any modifications to the materials data file on disk can be made either by using SCALE and TDATAF programs or by using the disk file edit procedures in the NLABS U-1108 COMPUTER FACILITY USERS GUIDE. Since the programs SCALE and TDATAF were used to generate much of the estimated data information, it would be appropriate to use the file edit procedures in the USERS GUIDE to change the materials data as they become available.

III. SUMMARY

The initial development of a Computer Aided Design (CAD) program (designated as, OPPACK) for package cushioning has been done. The mathematical algorithms were computer-coded and the available materials data cataloged.

Since Natick Laboratories does not have fragility criteria data available, SwRI has set forth the assumptions and methods for describing the computer program fragility data input requirements. Also, SwRI constructed artificial shock, vibration, and temperature environments in statistical form. At some point, Natick Laboratories may be able to provide information about shock, vibration, and temperature environments.

The assumptions for the CAD program have been stated in this report. This report and the CAD program provide the basis and necessary starting point in a building-block approach to the refinement and enhancement of this CAD program for package cushioning.

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APPENDIX A

TEST, SUBROUTINE LAGINT, FUNCTION FLAGR

To debug and test the LAGINT subroutine and the FLAGR function, digital data were taken from the peak acceleration versus static stress curves shown in Figure A-1.

For a urethane foam, the tabulated input data are shown in Table A I. The actual computer printout is shown in Table A-II. The tabulated interpolated and extrapolated output data are shown in Table A-III. As would be expected, the interpolated output data are very good and the extrapolated output data are less accurate, dependent upon how the data changes beyond the tabulated input data; the basis for this statement is a comparison of Peak Acceleration (g) data (Table AIII) the the Peak Acceleration from Figure A-1. It is anticipated that the LAGINT subroutine will only be used for interpolation of tabulated data; however, it was desirable to design for the possibility of extrapolation, in case it is needed later.

Copies of the program (i.e., TEST), the subroutine LAGINT, and the function, FLAGR, are shown in Tables A-IV, A-V, and A-VI.

TABLE A-I. - URETHANE FOAM INPUT DATA

Static Stress	5 in. thick	4 in. thick	3 in. thick	2 in. thick
W/A (psi)	GM_5 (g)	GM_4 (g)	GM_3 (g)	GM_2 (g)
0.04	62	70	80	100
0.05	54	60	70	90
0.07	43	48	55	75
0.09	35	40	45	65
0.14	26	29	34	54
0.16	24	25	30	52
0.18	22	24	29	50
0.20	20	22	28	50
0.50	19	25	42	78
0.80	30	48	79	124

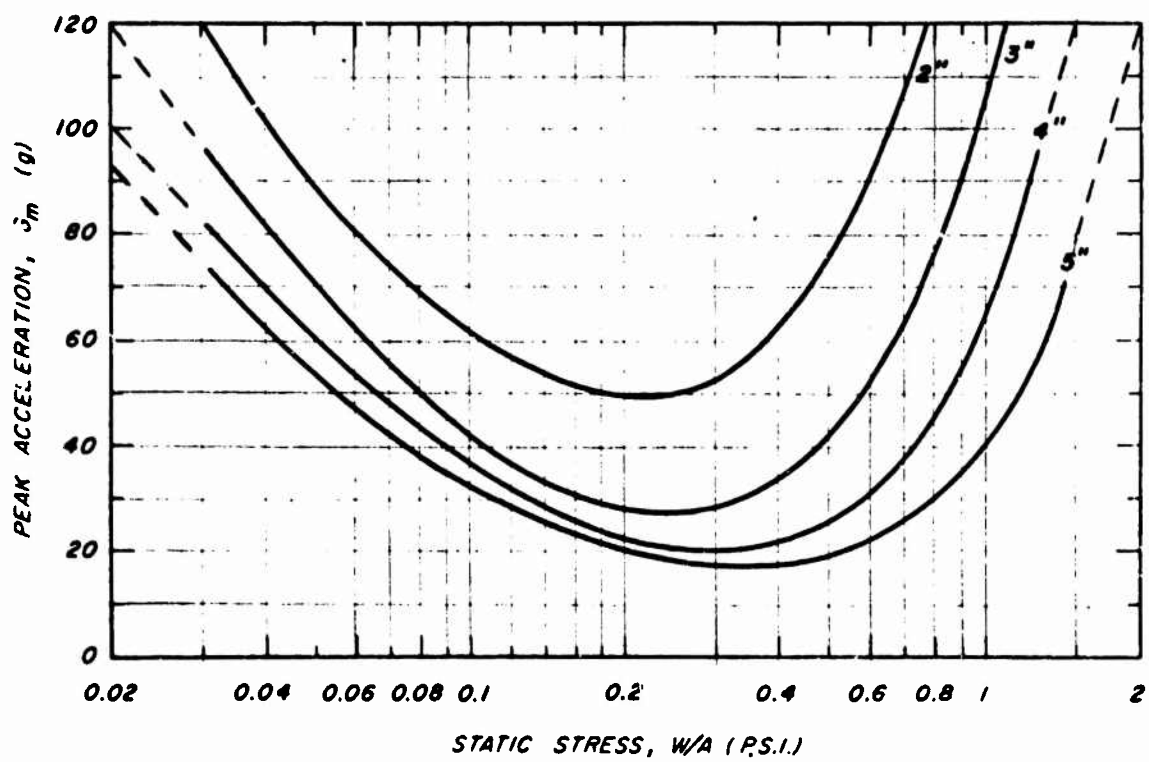

FIGURE A-1. G_m-W/A Curves for Urethane Foam (Polyester Type, Large Celled, 4.0 pcf) for a 30-inch Drop Height.

```
$NXYZ

NX        =  10,

NY        =  4,

NZ        =  1,

XV        =  0.11E+00,

YV        =  0.32E+01,

ZV        =  0.0,

$END
 FUNCTION VALUE=    3.7802E+01
 XV=  1.1000E-01   YV=  3.2000E+00   ZV=  0.
 FUNCTION VALUE=    6.1657E+01
 XV=  1.0000E-01   YV=  2.0000E+00   ZV=  0.
 FUNCTION VALUE=    4.1943E+01
 XV=  1.0000E-01   YV=  3.0000E+00   ZV=  0.
 FUNCTION VALUE=    3.7229E+01
 XV=  1.0000E-01   YV=  4.0000E+00   ZV=  0.
 FUNCTION VALUE=    3.2343E+01
 XV=  1.0000E-01   YV=  5.0000E+00   ZV=  0.
 FUNCTION VALUE=    2.9836E+01
 XV=  1.0000E-01   YV=  5.5000E+00   ZV=  0.
 FUNCTION VALUE=    2.8000E+01
 XV=  2.0000E-01   YV=  3.0000E+00   ZV=  0.
 FUNCTION VALUE=    4.2000E+01
 XV=  5.0000E-01   YV=  3.0000E+00   ZV=  0.
 FUNCTION VALUE=    1.050[illegible]E+02
 XV=  2.0000E-02   YV=  3.0000E+00   ZV=  0.
 FUNCTION VALUE=    9.8000E+01
 XV=  2.0000E-02   YV=  4.0000E+00   ZV=  0.
 FUNCTION VALUE=    8.8000E+01
 XV=  2.0000E-01   YV=  1.0000E+00   ZV=  0.
 FUNCTION VALUE=    9.6371E+01
 XV=  1.0000E-01   YV=  1.0000E+00   ZV=  0.
 FUNCTION VALUE=    9.6371E+01
 XV=  1.0000E-01   YV=  1.0000E+00   ZV=  0.
```

TABLE A-II. OUTPUT DATA

TABLE A-III. - URETHANE FOAM OUTPUT DATA

Static Stress W/A (psi)	Thickness (in.)	Peak Acceleration (g)	
0.11	3.2	37.8	interpolated
0.10	2.0	61.7	interpolated
0.10	3.0	41.9	interpolated
0.10	4.0	37.2	interpolated
0.10	5.0	32.3	interpolated
0.10	5.5	29.8	interpolated
0.20	3.0	28.0	interpolated
0.50	3.0	42.0	interpolated
0.02	3.0	105.0	extrapolated
0.02	4.0	98.0	extrapolated
0.20	1.0	88.0	extrapolated
0.10	1.0	96.4	extrapolated

```
                 PROGRAM TEST(INPUT,OUTPUT,TAPE1=INPUT,TAPE2=OUTPUT)
000003           DIMENSION X(20),Y(20),Z(20),TAB(20,20,20),F(20)
000003           COMMON /N/ NZ,NY,NX,YV,XV,ZV
000003           NAMELIST /NXYZ/ NX,NY,NZ,XV,YV,ZV
000003           READ(1,NXYZ)
000006           WRITE(2,NXYZ)
000011           READ 1000,(X(I),I=1,NX)
000024           IF(NY.GT.1)READ 1000,(Y(I),I=1,NY)
000041           IF(NZ.CT.1)READ 1000,(Z(I),I=1,NZ)
000056           READ 1000,(((TAB(I,J,K),I=1,NX),J=1,NY),K=1,NZ)
000104           GO TO 20
000105        10 CONTINUE
000105           IF(EOF,1)9999,15
000110        15 CONTINUE
000110           READ(1,NXYZ)
000113        20 CONTINUE
000113           CALL LAGINT(TAB,Z,Y,X,FV,F)
000117           PRINT 2000,FV,XV,YV,ZV
000133      1000 FORMAT(10F8.0)
000133      2000 FORMAT(1H 2X,*FUNCTION VALUE= *E12.4,/,
                1    3X,*XV=*E12.4,2X,*YV=*E12.4,2X,*ZV=*E12.4,)
000133           GO TO 10
000134      9999 CONTINUE
000134           STOP
000136           END
```

TABLE A-IV. MAIN PROGRAM, TEST

```
                 SUBROUTINE  LAGINT(A,ALF,BETA,GAM,VAL,F)
           C     NPTSG ---- NUMBER OF ROWS IN INPUT TABLE        VERTICAL
           C     NPTSB ---- NUMBER OF COLUMNS IN INPUT TABLE    HORIZONTAL
           C     NPTSA ---- NUMBER OF X-Y PLANES IN INPUT TABLE DEPTH
           C     XB ------- HORIZONTAL ARGUMENT
           C     YG ------- VERTICAL ARGUMENT
           C     ZA ------- DEPTH
           C     VAL------- INTERPOLATED VALUE
           C     ALF(NPTSA) --- VECTOR OF INDEPENDENT VARIABLES
           C     BETA(NPTSB)--- VECTOR OF INDEPENDENT VARIABLES
           C     GAM(NPTSG) --- VECTOR OF INDEPENDENT VARIABLES
           C     A(NPTSG,NPTSB,NPTSA) ---- INPUT TABLE
           C     IF  NPTSA NOT EQ  TO 1 INPUT TABLE IS  3 - D
           C     IF  NPTSB NE 1 AND NPTSA EQ 1 TABLE IS 2 - D
           C     IF  NPTSB EQ 1 AND NPTSA EQ 1 TABLE IS 1 - D
000011           DIMENSION A(20,20,20),B(20,20),F(1),ALF(1),
                1  BETA(1),GAM(1)
000011           COMMON /N/ NPTSA, NPTSB,NPTSG,XB,YG,ZA
           C     CHECK  FOR  THREE  DIMENSIONS
000011           IF(NPTSA.EQ.1)GO TO 100
           C     SOLVE  THREE DIMENSIONAL  CASE
000013           DO  10  I=1,NPTSG
000014           DO  10  J=1,NPTSB
000015           DO  5  K=1,NPTSA
000016         5 F(K) = A(I,J,K)
000032           B(I,J) = FLAGR(NPTSA,ALF,F,ZA)
000044        10 CONTINUE
000050           GO  TO  120
           C     CHECK  FOR  TWO  DIMENSIONS
000051       100 CONTINUE
000051           IF(NPTSB.EQ.1)GO TO 200
000053           DO  110  I=1,NPTSG
000055           DO  110  J=1,NPTSB
000056       110 B(I,J)=A(I,J,1)
           C     SOLVE  TWO  DIMENSIONAL  CASE
000073       120 CONTINUE
000073           DO  150  I=1,NPTSG
000075           DO  140  J=1,NPTSB
000076       140 F(J) = B(I,J)
000107           B(I,1)=FLAGR(NPTSB,BETA,F,XB)
000117       150 CONTINUE
000121           GO  TO  220
           C     SOLVE  ONE  DIMENSIONAL  CASE
000122       200 CONTINUE
000122           DO  210  I=1,NPTSG
000124       210 B(I,1) = A(I,1,1)
000133       220 CONTINUE
000133           VAL = FLAGR(NPTSG,GAM,B,YG)
000142           RETURN
000143           END
```

TABLE A-V. SUBROUTINE, LAGINT

```
                  FUNCTION    FLAGR(NPTS,XIK,F,XK)
000007            DIMENSION XIK(1),F(1),W(3)
             C    LAGRANGE  INTERPOLATING  FUNCTION
000007            DO  200  I=1,NPTS
000010            IT=I
000011            IF(XK.LE.XIK(I))GO TO 210
000014        200 CONTINUE
000016        210 IF(XK.EQ.XIK(I))GO TO 500
000021            IGO = 3
000021            IF(IT.LE.2)IGO=1
000025            IF(IT.EQ.NPTS) IGO = 2
000030            B=0.0
000031            IF(IGO.EQ.2) GO TO 350
             C    PARABOLA  FROM  THE  RIGHT
000033            IF(IT.EQ.1)IT=2
000036            DO  300  I=1,3
000040            IARG = IT-2+I
000042            WEIGHT = 1.
000044            DO  290  J=1,3
000045            IF(J.EQ.I)GO TO 290
000047            JARG = IT - 2 + J
000050            WEIGHT = WEIGHT*((XK-XIK(JARG))/(XIK(IARG)-XIK(JARG)))
000057        290 CONTINUE
000061            W(I) = WEIGHT
000063        300 CONTINUE
000065            DO  310  K=1,3
000067            IARG = IT - 2 + K
000071            B = B + W(K)*F(IARG)
000075        310 CONTINUE
000077            IF(IGO.EQ.1)GO TO 600
             C    PARABOLA  FROM  THE  LEFT
000101        350 CONTINUE
000101            DO  400  I=1,3
000103            IARG = IT - 3 + I
000105            WEIGHT = 1.0
000107            DO  390  J=1,3
000110            IF(J.EQ.I)GO TO 390
000112            JARG = IT - 3 + J
000113            WEIGHT = WEIGHT*((XK-XIK(JARG))/(XIK(IARG)-XIK(JARG)))
000122        390 CONTINUE
000124            W(I)= WEIGHT
000126        400 CONTINUE
000130            DO  410  K=1,3
000132            IARG = IT - 3 + K
000134            B = B + W(K)*F(IARG)
000140        410 CONTINUE
000142            IF(IGO.EQ.2)GO TO 600
000144            B = B * 0.5
000145            GO TO 600
000146        500 CONTINUE
000146            B = F(IT)
000150        600 CONTINUE
000150            FLAGR = B
000152            RETURN
000152            END
```

TABLE A-VI. FUNCTION, FLAGR