218

SCR-81

Sandia Corporation

MASTER

BIBLIOGRAPHY

**CUSHIONING MATERIALS
FOR PACKAGING**

by

Frances Strachwitz

May 1959

DISCLAIMER

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

DISCLAIMER

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

LEGAL NOTICE

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

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

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

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

Printed in USA. Price \$.75. Available from the Office of
Technical Services, Department of Commerce,
Washington 25, D.C.

SCR-81
AEC CATEGORY
PACKAGING
(TID-4500, 14th Ed.)

SANDIA CORPORATION BIBLIOGRAPHY

CUSHIONING MATERIALS FOR PACKAGING

Compiled by

Frances Strachwitz
Sandia Corporation Library

May 1959

Acknowledgment

We acknowledge with thanks the assistance given by Mr. A. B. Robertson of Sandia Corporation, who made his file on cushioning material available to the compiler.

CUSHIONING MATERIALS FOR PACKAGING

Introduction

In this brief bibliography the emphasis is on new cushioning materials for packaging and on environmental testing and performance of these materials. The survey is not intended to be exhaustive.

The following sources were consulted:

Technical Abstract Bulletin of the Armed Services Technical Information Agency	1958-59
Sandia Unclassified Documents Catalog	
U.S. Government Research Reports	1953-59
Technical Information Pilot of the Library of Congress	1949-51
Engineering Index	1952-59

ARTICLES AND SYMPOSIUM PAPERS

American Management Association
MILITARY PACKAGING REQUIREMENTS
AMA Packaging Series No. 37, 60 pp., 1951.

Outlook for materials and equipment. Papers presented at the
Packaging Conference of the American Management Association
at Atlantic City. April 17 to 20, 1951.

American Society for Testing Materials
TENTATIVE METHODS OF TESTING PACKAGE CUSHIONING MATERIALS
ASTM Standard D 1372-55T, ASTM Standards 1955, Part 7, pp. 1084-6.

Methods to test stress-strain, thickness loss, drift, and set of
cushioning materials.

Anon.
KNOW YOUR PACKAGING MATERIALS
American Management Association, Packaging Division, Report No. 5, 128 pp.,
1958.

Anon.
KNOW YOUR PACKAGING MATERIALS: FOILS - PAPERS - FILMS - BOX-
BOARD - FOAM PLASTICS
American Management Association, Packaging Series, 46, 123, 1955.

Includes urethane foams, expanded phenolics, polystyrene.

Anon.
PACKING FOR ALL CLIMATES
Engineering, 180, 869, December 23, 1955.

Anon.
PROTECTIVE PACKAGING FOR FRAGILE PARTS
Flow, 7, 102-4, 120, 122, October 1952.

Anon.
SCIENTIFIC PACKAGING
Aircraft Production, 16, 509-10, December 1954.

New export packing service in Kent, with research and development facilities for packaging problems.

Anon.
SOLVING OLD PACKAGING PROBLEMS WITH NEW PLASTIC MATERIALS
Modern Materials Handling, 10, 131-6, October 1955.

Anon.
TESTING PACKING METHODS FOR TRANSPORT ANYWHERE
Engineering, 186, 423-4, September 26, 1958.

Anon.
THEY'VE PACKED THE UNPACKABLE
Packaging Review, 74, 65-6, November 1954.

Packaging cathode-ray tubes with plywood, spring catches, lined with felt patches, sponge rubber.

Anon.
TWENTY-FIVE WAYS TO CUSHION YOUR PRODUCTS... SAFELY, QUICKLY AND ECONOMICALLY
Flow, 7, 92-4, 97-8, 101-2, 104-7, February 1952.

Birnbaum S M
AIR FORCE PACKAGING PROBLEMS
SAE Paper No. 364 for Meeting October 5-9, 1954, 6 pp.

Breslow S H
FOAM RUBBER DUNNAGE CUSHIONS JET ENGINE SPARES
Iron Age, 169, 150-2, February 7, 1952.

Cammarata J and Atalese V
DEVELOPMENT OF SHOCK AND VIBRATION TEST METHODS FOR PACKAGING
SAE Paper 495, for Meeting April 18-21, 1955, 7 pp.

Export Packing Service Ltd.
SCIENCE OF PACKAGING
Process Control and Automation, 4, 9-11, January 1957.

Practices of Research and Development Establishment of Export Packing Service Ltd., Kent, in design and test of packs; tropical climatic chamber; physics and chemistry laboratories.

Foster J H
RESEARCH ON PACKAGES
Petroleum, 20, 171-2, 186, May 1957.

Study of journey hazards and packaging protection; testing of packaging performance, atmospheric dangers, and insect attack.

Gallacher L
URETHANE FOAMS FOR ELECTRONIC PACKAGING
Military Electronics, 7, 14-16, April 1959.

Gretz J L
HOW TO ENGINEER PACKAGE CUSHIONING
Flow, 7, 100-2, 112, 114, 116-8, April 1952. Also in Modern Packaging, 25, 125-33, 1952.

Definition of G factor, discussion of load-compression characteristics of cushioning materials, and classification of various cushioning materials by load-deflection curve are discussed.

Gretz J L
PRINCIPLES OF CUSHIONING
Presented at SIPMHE Short Course, Boston, October 1953.

Semitechnical presentation of the functional design of package cushioning followed by a discussion of the various types of available instrumentation and their limitations for measuring cushioning performance.

Hardigg J S
CUSHIONING THEORY: ARE WE KIDDING OURSELVES?
Modern Materials Handling, 14, 97-104, April 1959.

Hardigg J S
NOMOGRAM FOR SOLVING CUSHIONING PROBLEMS
Flow, 9, 110, 112-14, 134, 136-42, August 1954.

Hess R
"UNTERSUCHUNGEN ÜBER DIE HALTBARKEIT VERPACKTER
FEUCHTIGKEITSEMPFINDLICHER GÜTER
Chemie-Ingenieur Technik, 28, 763-8, December 1956.

Investigation of durability of packaged, moisture-sensitive products; calculations based on vapor permeability of plastic, aluminum foil, and paper-type packaging materials and sorption isotherms of packed products.

Jacobson R H
CUSHIONS FOR COMPONENTS
Machine Design, 31, 28, 30, April 16, 1959.

A multilayer grid of Teflon rods embedded in a matrix of Silastic silicone rubber was developed by Armour Research Foundation for Wright Air Development Center. Environmental and other evaluations are given.

Janssen R R
CALCULATING MAXIMUM CUSHIONING PROTECTION WITH MINIMUM THICKNESS
Packaging Review, 73, 38-43, March 1953.

Janssen R R
SELECTING PACKAGE CUSHIONING MATERIALS TO PROVIDE MINIMUM CONTAINER CUBAGE
North American Aviation, Inc., Los Angeles, 1952.

A talk delivered at the Packaging and Materials Short Course at the College of Mechanical Engineering, University of Illinois, October 13 through 16, 1952.

Joint Industry Conference on Cushioning in Packaging, Detroit, Michigan, December 7 and 8, 1953.
PROCEEDINGS
Sponsored by the Materials Management Center, Wayne University; and General Motors Preservation-Packing Committee. 1 vol., 1953.

Short papers discuss many new, commercially available cushioning materials and some instrumentation. A longer article by J S Hardigg, of the Container Laboratories, discusses progress in developing a cushioning nomogram; while R E Jones, of the Forest Products Laboratory, provides a 25-page discussion of the basic principles of package cushioning.

Jones R E and James W L
CALCULATING CUSHION REQUISITES
Modern Packaging, February 1956.

Three different methods of selecting and designing package cushioning materials; estimating cushion thickness, exact cushion design, and approximate cushion design. (Thirteen references.)

Klingelhoeffer, H
EIN NEUER RÜCKPRALL UND DURCHSCHLAGSCHREIBER FÜR
VERPACKUNGSFOLIEN UND POLSTERSTOFFE
Kunststoffe, 43, 181-4, May 1953.

New resilience and penetration recorder for packaging sheets and cushioning materials.

Lieberg E O

WOOD FIBER FELTS FOR PROTECTIVE PACKAGING

Paper presented at the National Meeting of the Forest Research Society, Memphis, Tennessee, June 1953.

Outline of the basic requirements of protective cushioning material; presentation of suggested method of design.

Malmstrom H E and Gresham J T

DYNAMIC MEASUREMENT OF CUSHIONING

Kimberly-Clark Company, Neenah, Wisconsin, 1946.

Determination of the dynamic stress-strain curve using an Eastman high-speed motion picture camera.

Martin L P

ANALYSIS OF CUSHIONED IMPACT BY WAVE PROPAGATION TECHNIQUES

MS Thesis, University of New Mexico, Albuquerque, New Mexico, 1958.

The specific problem of two rods, connected end to end, impacting longitudinally on a rigid surface, is considered, using a short foam plastic cushion as the leading rod and a long plexiglass bar as the trailing rod.

Meyer J A and Shapiro H

SELECTION OF URETHANE PLASTIC FOAMS FOR PACKAGING ELECTRONIC EQUIPMENT

Machine Design, 30, 47-50, March 20, 1958

Mindlin R D

DYNAMICS OF PACKAGE CUSHIONING

Bell System Technical Journal, 24, 353-461, July - October 1945.

A Bell Telephone Laboratories study for packaging large vacuum tubes. Part I is concerned with methods for predicting maximum acceleration of the packaged article, with emphasis on nonlinear cushioning. Part II deals with predicting the form of the acceleration-time relation. Part III deals with acceleration effects on packaged articles and gives methods for determining whether or not strength of material would be exceeded. Part IV considers the influence of distributed mass and elasticity.

Morgner J

TROPENFESTE ANSTRICHMITTEL UND VERPACKUNG

Technik, 12, 831-5, December 1957.

Paints and packaging materials resistant to tropical conditions; protection of electrical products.

Muller J T
OPTIMUM PROPERTIES OF PACKAGING MATERIAL
SAE Paper No. 365 for Meeting October 5-9, 1954, 6 pp.

Mustin G S
USE OF THE ENERGY METHOD IN THE DESIGN OF PACKAGE CUSHIONS
Shock and Vibration Bulletin No. 20, Naval Research Laboratory, Washington,
D. C., pp. 171-6.

Development of energy method for computing the amount of
cushion required by using a load-energy curve.

Nictoch H E
CUSHION DESIGN FROM FRAGILITY RATING
SAE Paper 493, for Meeting April 18-21, 1955, 8 pp.

Nopco Chemical Company, North Arlington, New Jersey
MOLDED AND FABRICATED FOAM PLASTIC PACKAGING MATERIALS
R E Jones, 10 pp., August 29, 1958.

A talk prepared for the Fourth Annual Joint Military Packaging
and Handling Symposium in Washington, D. C., on October 1, 1958.
A brief summary is given of the physical characteristics of cellular
plastics. Attention is given to flexible foams for use as a
cushioning material. Illustrations of packaging applications are
given for styrene, urethane, and phenolic foams.

Paine F A
SOME ASPECTS OF PACKAGING
Chemistry and Industry, 52, 1656-63, December 28, 1957.

Methods of evaluating transport hazards, including field tests
and correlation with laboratory data; cushioning materials and
design of packages; drop-hammer apparatus for package testing;
factors in use of folding cartons.

Peterson M S
LOOKING AT PHYSICAL PRINCIPLES THAT EXPLAIN PACKAGING TESTS
Package Engineer, 3, 41-2, 45, 47-51, April 1958.

Principles for shock testing.

Pye E R and Smith M D
IMPACT PROTECTION WITH FOAM PLASTICS
Mechanical Engineering, 80, 65-7, December 1958.

A procedure used to select a low-density cellular plastic of
the right dimensions and mechanical properties to protect
the head in impact in vehicular accidents.

Roberts H C
ANALYSIS AND INTERPRETATION OF DYNAMIC RECORDS
ASTM, Special Technical Publication No. 104, 1950.

Presentation of generalized summary of the problem of analysis and interpretation of dynamic test data and a discussion of effects of economic considerations on interpretation and analysis.

Sandia Corporation, Albuquerque, New Mexico
PACKAGING SYMPOSIUM
October 21 through 23, 1957, 1 vol.

Articles by L T Wilson on resilient cushioning materials; by G W Dyckes on elastomers for shock and vibration isolation; by R A Harley on cushioning materials for packaging; and by R T Othmer on shock and vibration environments of special packaging.

Schuler S C
SHOCK PROTECTION AND CUSHIONING FOR AIRBORNE ELECTRONIC EQUIPMENT
Packaging Review, 73, 38-40, July 1953.

Moisture protection during storage, shock protection during transit.

Skidmore W H
FRAGILITY RATING FOR AIRCRAFT EQUIPMENT
SAE Paper No. 364 for Meeting October 5-9, 1954, 6 pp.

Streeter V L and Volpe V F
CRUSHABLE MATERIALS AS SHOCK CUSHIONING
Notes made available to the Structural Mechanics Research Laboratory of the University of Texas in 1953. (Unpublished.)

Discussion of cushioning design and air-dropping supplies indicating that air resistance is efficient for absorbing energy at high velocity, and crushable packing is better for low-velocity energy absorption.

Underhill A M
BASIC PRINCIPLES OF PACKAGE CUSHIONING
Packaging Series No. 33 of American Management Association, New York, 1950.

Description of testing procedures, together with a method for selecting materials for package cushion.

Underhill A M
WHAT MAKES CUSHIONING WORK?
Modern Materials Handling, 8, 97-103, November 1953.

Verlot J B

LE ROLE DU FROID DANS UNE ETUDE SCIENTIFIQUE DE L'EMBALLAGE
Revue Pratique du Froid, 12, 42-8, January 1957.

Role of refrigeration in scientific study on packaging; design, equipment, and air conditioning of general laboratory for packaging, in Paris, for study of properties of packaging materials subjected to different refrigerating conditions.

Wiltse R L

PRACTICAL DEVELOPMENT OF SUSPENSION CUSHIONING FOR GUIDED
MISSILE

SAE Paper 498, for Meeting April 18-21, 1955, 11 pp.

Protection against transit handling and environmental conditions in transit and storage.

REPORTS

Army Chemical Center, Chemical and Radiological Laboratories, Edgewood, Maryland
HUMIDITY-INDICATING CARD FOR PACKAGING
December 1953, 25 pp. PB-113 548; CRL-IR-257.

Container Laboratories, Inc., Washington, D.C.
THE DEVELOPMENT OF A CUSHIONING NOMOGRAM
J E Hardigg, Contract NOrd 13882, 51 pp. February 9, 1954.

Describes the development of a single alignment chart for package cushioning. This chart, it is claimed, will show the thickness of cushioning for many cushioning materials that will enable a fragile article to withstand any prescribed straight drop test.

Forest Products Laboratory, Madison, Wisconsin
APPLICATION OF THE PROPERTIES OF CUSHIONING MATERIALS IN THE DESIGN OF CUSHIONS
Keith Q Kellicutt, Report R 1627, 61 pp. Reissued July 1952.

Curves were prepared for wadding, rubberized fiber, sponge rubber, rubberized hair, cotton, kraft pulp, wood fiber, jute, felt, corrugated fiberboard. Design curves for some families of material were prepared for use in determining the approximate thickness of cushioning of any one member of the group.

Forest Products Laboratory, Madison, Wisconsin
CALCULATING CUSHION THICKNESS BY ANALYSIS OF STRESS-STRAIN CURVES
R E Jones and D L Hunzicker, January 1954, 156 pp. PB-111 520; WADC-TR-53-334.

A method for designing and selecting package cushioning to protect an article against shock is developed from physical and mathematical concepts. Design curves for calculating cushion thickness are included for many currently available cushioning materials--curled cattle hair, glass fibers, sponge rubber, creped wadding, cotton wadding, synthetic rubber, felt, and wool. On page 35 there is an annotated bibliography which includes eight items.

Forest Products Laboratory, Madison, Wisconsin
DEVELOPMENT OF A PROCEDURE FOR THE DETERMINATION OF THE
PROPERTIES OF CUSHIONING MATERIALS AND THEIR APPLICATION IN THE
DESIGN OF CUSHIONS

L Lassen, K Q Kellicutt, W J Sanderson, Report No. R 1489, 48 pp., June 1945.

Important qualities of cushioning materials are discussed and a technique for the design of cushions is introduced. The most important qualities of a cushioning material can be evaluated by an energy concept. Tables and curves of various materials, and examples for the evaluation of cushioning materials, are given.

Forest Products Laboratory, Madison, Wisconsin
EVALUATION OF POPCORN AS A CUSHIONING MATERIAL
R K Storn, May 1957, 34 pp. PB-131 162; WADC-TR-56-660.

Comparison with bound hair and cellulosic wadding--humidity effect.

Forest Products Laboratory, Madison, Wisconsin
AN INVESTIGATION OF CUSHIONING MATERIALS FOR PACKAGING OF SIGNAL
CORPS EQUIPMENT

C A Jordan and R H Witting, Final Report, February 20, 1949, to February 20, 1950, 48 pp. PB-101164.

Cellulosic, bound hair, cotton wadding, and foamed sponge rubber cushioning materials were tested for impact and drift in order to develop design criteria by which their basic properties can be applied to the packaging of Signal Corps equipment.

Forest Products Laboratory, Madison, Wisconsin
AN INVESTIGATION OF CUSHIONING MATERIALS FOR PACKAGING OF SIGNAL
CORPS EQUIPMENT

C A Jordan, Quarterly Progress Reports: No. 1 (February 20-May 20, 1949); No. 2 (May 20-August 20, 1949); and No. 3 (August 20-November 20, 1949).

Forest Products Laboratory, Madison, Wisconsin
INVESTIGATION OF SHOCK WAVES DEVELOPED DURING DYNAMIC TESTS OF
CUSHIONING MATERIALS
Vern N Smiley, August 1957, 27 pp. AD-131 019; PB-131 429; WADC-TR-56-547.

This report discusses methods of obtaining agreement between theory and test results.

Forest Products Laboratory, Madison, Wisconsin
PROPERTIES OF VARIOUS CUSHIONING MATERIALS AT -70°F
C A Jordan and R H Witting, Report No. 207-21.

Impact tests using a spring-contact-type accelerometer were employed in evaluating various cushioning materials at low temperatures. While cellulose materials withstood low temperatures, rubber and rubber-bonded materials were affected.

Frankford Arsenal, Pittman-Dunn Laboratories, Philadelphia, Pennsylvania
DETERMINATION OF THE SHOCK AND VIBRATION ISOLATION OF A REACTOR
FILTER CHOKE PACKAGED IN POLYURETHANE CUSHIONING MATERIAL
Technical Report S-5654, Aleck Goldberg, December 27, 1957, 5 pp., AD-155 144.

Further study of the shock and vibration isolation effectiveness of
this material is advised.

Lowell Institute of Technology, Lowell, Massachusetts
PERFORMANCE CHARACTERISTICS OF PAPER HONEYCOMB CUSHIONING
MATERIALS IMPACTED UNDER A HEAVYWEIGHT, HIGH-IMPACT SHOCK
MACHINE
E N Sabbagh, January 1956, 59 pp. WADC-TR-55-343.

Lowell Institute of Technology, Lowell, Massachusetts
PERFORMANCE CHARACTERISTICS OF PAPER HONEYCOMB CUSHIONING
MATERIALS IMPACTED UNDER A HEAVYWEIGHT, HIGH-IMPACT SHOCK
MACHINE
E N Sabbagh, February 1956, 233 pp. WADC-TR-55-229.

The energy absorption characteristics of cushioning materials
impacted under heavyweight, high-impact shock machine and
analyzed by an analog computer system are reported. Dynamic
performance curves in the form of graphs of energy versus
maximum stress and maximum strain versus maximum stress
are given for polystyrene, wool pads, cotton wadding, tampico
fiber, polyvinyl chloride, resin-bonded felt wadding, rubber-
ized curled hair, corrugated paper wrapping, etc.

Lowell Institute of Technology, Research Foundation, Lowell, Massachusetts
THE EVALUATION OF SHOCK-ABSORBING TEXTILES
E N Sabbagh, Progress Reports Nos. 1 to 8, 1952-54.

Presentation of design, construction, and operation of an
impact tester for the purpose of evaluating shock-absorbing
textiles.

Naval Ordnance Laboratory, White Oak, Maryland
A SUPPLEMENTARY STUDY OF THE CUSHIONING NOMOGRAM
(No date.) 1 vol.

This supplementary study of the cushioning nomogram, which
was prepared by Container Laboratories, Inc., is based on an
expanded number of samples and groups of materials tested.
It was found that samples of the same type of material do not
necessarily exhibit the same cushioning characteristics, par-
ticularly with polyurethane and fiberglass.

Naval Ordnance Test Station, China Lake, California
BIBLIOGRAPHY ON SHOCK ABSORPTION STUDIES
Revision No. 4, March 1957, 73 pp. incl. ill. (Prepared for ASTM Committee
D-10, Shipping Containers Subcommittee VI, Interior Packing.) AD-154 650.

Naval Research Laboratory, Washington, D.C.
DYNAMICS OF PACKAGE CUSHIONING INVOLVING COMBINED ROTATIONS AND
TRANSLATIONS

D M Chase and I Vigness, PB-121015, NRL-4719, 13 pp., March 1956.

Equations of motion, describing the behavior of a rigid article
flexibly mounted in a rigid container, have been formulated.

Naval Research Laboratory, Washington, D.C.
FUNDAMENTALS OF GUIDED MISSILE PACKAGING, SHOCK AND VIBRATION
DESIGN FACTORS

E Klein, Editor, July 1955, RD-219/3.

Chapter IX and Appendix IX deal with cushioning materials for
missile containers, giving formulas, equations and test pro-
cedures.

New Mexico University, Albuquerque, New Mexico
THE EFFECT OF LOADING RATE ON MECHANICAL PROPERTIES
University of New Mexico Engineering Experiment Station, UNM-QPR-EE-3,
January 1, 1958.

Compression versus time, and force versus time curves, for
various polyurethane materials.

New Mexico University, Albuquerque, New Mexico
THE EFFECT OF LOADING RATE ON MECHANICAL PROPERTIES
University of New Mexico Engineering Experiment Station, UNM-QPR-EE-4,
22 pp., April 1, 1958.

New Mexico University, Albuquerque, New Mexico
THE EFFECT OF LOADING RATE ON MECHANICAL PROPERTIES
University of New Mexico Engineering Experiment Station, Final Report on
Project 57-IME. June 30, 1958.

Evaluation of pertinent mechanical properties of various cushion-
ing materials and the use of these properties to determine the
suitability of a given type of material for specific cushioning ap-
plications. A variable rate-testing machine was modified and a
drop-test facility constructed. Various polyurethane materials
were tested. A literature search on impact is appended.

Nopco Chemical Company, North Arlington, New Jersey
NOPCOFOAM AS A PACKAGE-CUSHIONING MATERIAL
R E Jones, 16 pp. July 1957, NOPCO-LP-143.

Describes a new urethane foam, Nopcofoam, and its properties.

Picatinny Arsenal. Samuel Feltman Ammunition Laboratories, Dover, New Jersey
SORPTION OF WATER VAPOR BY CELLULOSIC CUSHIONING MATERIALS
H M Weiner, PB-111 661, PA-TR-2141, 11 pp., February 1955.

Seven cushioning materials were tested at 100°F and 95-percent relative humidity, with and without silica gel desiccant.

Quartermaster Food and Container Institute, Chicago, Illinois
INVESTIGATION OF A PAPERBOARD HONEYCOMB MATERIAL FOR USE AS CUSHIONING IN AERIAL DELIVERY OF SUPPLIES AND EQUIPMENT
R Witting, 1954.

Brief description of the testing of three specimens of honeycomb cushioning materials.

Quartermaster Research and Engineering Command, Natick, Massachusetts
BASIC CONCEPTS ON THE ENERGY DISSIPATION OF CUSHIONING MATERIALS
G E Murray, Technical Report No. CP-12, AD-159 583, 14 pp., April 1958.

It is shown that the energy dissipation of a foamed plastic is a function of the chemical composition of the plastic and varies directly with the square of the density of the foam. It is probably independent of the size of the foam bubbles. Material energy dissipation requirements are calculated from aerial drop conditions.

Rock Island Arsenal Laboratory, Illinois
SIX-YEAR STORAGE PROGRAM TESTS-PACKAGED ITEMS
G F Martin, March 28, 1951. 1 vol., RIAL-51-1145.

Rock Island Arsenal, Illinois
SIX-YEAR STORAGE PROGRAM TESTS-PACKAGED ITEMS
G F Martin, January 1955, 172 pp., PB-117 326, RIAL-54-4415.

Sandia Corporation, Albuquerque, New Mexico
RESILIENT CUSHIONING MATERIALS
L T Wilson, February 1959, 130 pp., SCTM-35-59 (12)

Tests were conducted on a variety of thicknesses and types of resilient cushioning materials. The test results are expressed in graphs, tables, and photographs.

The Stearns and Foster Company, Lackland, Ohio
THEORETICAL COMPARISON OF CUSHIONING MATERIALS
R E Slaughter, 1954, 14 pp. (Bibliography included.)

Texas University, Austin, Texas
CRITERIA FOR DESIGN OF CUSHIONING
J E Lacy, 1954. (Unpublished.)

Derivation of fundamental mathematical relations dealing with the cushioning of equipment and supplies to be air-dropped, including presentation of method of design.

Texas University, Austin, Texas

CUSHIONING FOR AIR DROP

Structural Mechanics Research Laboratory, University of Texas.

Part I, 80 pp., July 15, 1955, Contract DA-19-129-SM-150, UT-150, Pt. I.

A drop-test facility was developed and, during its development, specimens of some representative cushioning materials underwent a fairly extensive series of tests using perpendicularly applied impact loads. This is the preliminary data. A selected and annotated bibliography is given on pages 74-80.

Texas University, Austin, Texas

CUSHIONING FOR AIR DROP

Part VIII, A Ali, Structural Mechanics Research Laboratory, University of Texas, June 3, 1957.

Dynamic stress-strain characteristics of various materials.

U. S. Air Force, Washington, D. C., et al

PROCEEDINGS OF THE SECOND JOINT MILITARY-INDUSTRY PACKAGING AND MATERIALS HANDLING SYMPOSIUM

Departmental Auditorium, Washington, D. C., October 9, 1956, 307 pp., PB-128 964.

U. S. Navy, Washington, D. C.; U. S. Army, Washington, D. C.; U. S. Air Force, Washington, D. C.; and Department of Commerce, Washington, D. C.

PROCEEDINGS OF THE FIRST JOINT MILITARY-INDUSTRY PACKAGING AND MATERIALS HANDLING SYMPOSIUM

Department of Commerce Auditorium, Washington, D. C., October 10-12, 1955, 695 pp., PB-121 350.

Wright Air Development Center. Materials Laboratory, Wright-Patterson Air Force Base, Ohio

DESIGN OF RECLAIMED LATEX FOAM PACKAGE CUSHIONING

R B Orenstein, January 1954, 19 pp., PB-111 518, WADC-TR-53-132..

Design curves are provided for selecting density, thickness, and cushion area for economical cushion design. Procedures are recommended and discussed.

Wright Air Development Center. Materials Laboratory, Wright-Patterson Air Force Base, Ohio

DEVELOPMENT OF A NON-ADHERING CHEMICALLY FOAMED-IN-PLACE POLYURETHANE CUSHIONING MATERIAL FOR PACKAGING PURPOSES

S Childers and S Allinikov, January 1958, 23 pp., AD-142 282, PB-131665, WADC-TR-57-682.

Wright Air Development Center. Materials Laboratory, Wright-Patterson Air Force Base, Ohio
MEASURING FIELD HANDLING AND TRANSPORTATION CONDITIONS
D S Martin, November 1956, 32 pp., PB-121 866, WADC-TR-56-464.

Recording instruments for a packaging shipping program.

Wright Air Development Center. Materials Laboratory, Wright-Patterson Air Force Base, Ohio
SELECTION OF CUSHION AREA IN THE DESIGN OF PACKAGE CUSHIONING
R B Orensteen, March 1953, 14 pp., PB-111 227, WADC-TR-53-43.

Wright Air Development Center. Materials Laboratory, Wright-Patterson Air Force Base, Ohio
THE SELECTION OF CUSHION AREA IN THE DESIGN OF PACKAGE CUSHIONING
R B Orensteen, March 1953, 13 pp., WADC-TR-53-43.

Wright Air Development Center. Materials Laboratory, Wright-Patterson Air Force Base, Ohio
A TECHNIQUE FOR THE DESIGN OF GLASS FIBER PACKAGE CUSHIONING
R B Orensteen, March 1953, 14 pp., WADC-TR-53-68.

Design curves are provided for selecting density, thickness, and cushion area for economical cushion design. Advantages of glass-fiber cushioning of small area and high density are discussed.

Wright Air Development Center. Materials Laboratory, Wright-Patterson Air Force Base, Ohio
THE THEORY AND OPERATION OF A DYNAMIC TESTER FOR EVALUATING PACKAGE CUSHIONING MATERIAL
A D Klingenberg, September 1956, 35 pp., PB-121 692, WADC-TR-56-342.

Wright Air Development Center. Materials Laboratory, Wright-Patterson Air Force Base, Ohio
THE THEORY AND OPERATION OF A DYNAMIC TESTER FOR EVALUATING PACKAGE CUSHIONING MATERIAL
Report for June 1956 to January 1958 on Finishes and Materials.
S M Krakover, May 1958, 19 pp., AD-151195; WADC-TR-56-342, Suppl. 1.

The purpose of the ASTM dynamic cushion-testing program is described, and data are presented from the laboratories which participated in this program.