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Bibliography of Technical Reports and Articles Covering Complete AERIAL DELIVERY RESEARCH ACTIVITIES Conducted at the ARMY QUARTERMASTER RESEARCH AND ENGINEERING CENTER

by
Edward H. Schember

LIBRARY BULLETIN 9 Technical Report 239

ARMED FORCES FOOD AND CONTAINER INSTITUTE U.S. ARMY QUARTERMASTER RESEARCH AND ENGINEERING CENTER CHICAGO 9, ILLINOIS

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WALTER L. NECKER
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ABSTRACT

This bibliography presents a complete compilation of technical reports and articles concerning studies conducted in the field of aerial delivery by the Armed Forces Food and Container Institute during the period from 1954 through 1962.

The Institute's primary mission in aerial delivery was to assist the Quartermaster Research and Engineering Center in the design and development of systems and procedures for the aerial delivery of supplies and equipment. The reports and articles in this bibliography represent the accomplishments of both the in-house and contract phases of the program. In general, the reports deal with the following activities:

a. Investigation of the static and dynamic properties of energy absorbers.

b. Design and development of shock recording devices.

c. Development of drop test facilities and instrumentation.

d. Design and development of high velocity aerial delivery systems.

This survey presents the status of research on aerial delivery in military services and other agencies.


A proposed research program in aerial delivery.


Proposed approach for design and development of a shock recording device.


Lists the export packaging information on certain Army supply and equipment items known to have been airdropped during the Korean conflict.


Results of drop tests to establish operational parameters for design and development of a self-recording accelerometer.


Specifications for a shock measuring and recording device and design sketches of a proposed magnetic recording accelerometer.


Supplement to Technical Report No. 57 containing additional packaging information for supply items and equipment.

Discussion of the design and fabrication of sensing and recording unit and design of record transport and storage unit.


Evaluation of the dynamic energy absorbing characteristics of paper honeycomb by using the material in an aerial delivery system.


Evaluation of the dynamic energy absorbing characteristics of paper honeycomb by using the material in an aerial delivery system and airdropping. Retarded and free-fall drops were performed.


Discussion of the fabrication the sensing and recording unit.


Development and explanation of the drop test facility and instrumentation. Presents basic information on cushioning materials and a cost comparison between retarder and cushioning.


Initial report of the literature survey to investigate devices that are classified as a retarded falling store.

Report of the fabrication and assembly of nearly all the components for the sensing and recording unit, and of preliminary tests to prove the feasibility of the recording system with visible presentations of magnetic boundary displacement recording.


Determination of the force-compression characteristics of foamglass.


Initial report of the project organization and progress of the literature search.


Determination of the effectiveness of paper, honeycomb material for protecting C- and 5-in-1 rations against impact forces by guided free-fall drop tests.


Determination of the effectiveness of paper honeycomb material for protecting 5-gallon gasoline cans and 55-gallon drums by guided free-fall drop tests.


Three ideas for attitude control systems are presented.


Evaluation of the dynamic energy absorbing characteristics of paper honeycomb material by incorporating the material in an aerial delivery system.

Evaluation of the dynamic energy absorbing characteristics of paper honeycomb material by incorporating the material in displaced center of gravity aerial delivery systems.


Explanation of the design of the tape transport unit and the start-stop actuating unit.


Presentation of the performance analysis of four parachutes, the G-I-A. G-13, and the 15-foot and 24-foot extraction parachutes.


Summary of the literature search and details of various trips in regard to the contract.


Presents a theoretical analysis of an ideal attitude control device.


Determination of the dynamic energy absorbing characteristics of paper honeycomb material by incorporating the material in free-fall aerial delivery systems.
19 Dec. 1955, University of Texas, Container Research Laboratory,  
Austin, Texas (Contract No. DA 19-129-qm-150) 37 p. ill.  
Development and interpretation of the fundamental equations for the  
cost of airdrops involving the use of retarders alone, and the  
use of a combination of retarders and cushioning as a means of  
absorbing the kinetic energy of falling bodies. Optimum drop  
velocities are established.

T.R. 110. Dynamic Energy Absorbing Characteristics of Paperboard  
Honeycomb Material as Determined by Laboratory Tests, 21 Dec. 1955,  
W. D. Bowers, 24 p. ill.  
Dynamic characteristics of grades 1, 3, 5, and 6 paper honeycomb  
material are determined by drop tests.

T.R. 111. Investigation of Packaging Materials and Techniques in  
Aerial Delivery of Supplies, Bi-Monthly report, 22 Dec. 1955,  
University of Texas, Container Research Laboratory, Austin,  
Texas (Contract No. DA 19-129-qm-150) 2 p.  
Status of research is reported.

T.R. 112. Equilibrium Moisture Content of Paper Honeycomb and its  
Effect on Energy Absorption, Phase Report No. 1, 31 Dec. 1955,  
Forest Products Laboratory, Madison, Wis. 30 p. ill.  
The effect of moisture on the crushing strength and energy  
absorption of paper honeycomb pads designed for use as cushioning  
in aerial delivery of supplies and equipment is determined.

Packaging, Report No. 3, 31 Dec. 1955, Penn State University,  
Engineering Research Dept., University Park, Pa. (Contract No.  
DA 19-129-qm-386) 84 p. ill.  
Progress on the literature search and experimental work on  
instrumentation is discussed. Also included is a group of trip  
reports.

T.R. 114. A Design Analysis of Attitude Control Systems Applicable  
to Airdropped Packaging, Phase 1 Report, Literature Survey, Vol.  
1, 1 Feb. 1956, Midwest Research Institute, Kansas City, Mo.  
(Contract No. DA 19-129-qm-415) 83 p. ill.  
A literature survey comprising the more important articles and  
patents published on subjects pertaining to attitude control  
deVICES for aerial delivery systems, either free-fall or retarded- 
fall, is presented.

Experimental data for the design of a high velocity aerial delivery system for four 55-gallon drums utilizing paper honeycomb as the energy absorber and a 24-foot diameter horizontal ribbon extraction parachute as the stabilizer.


Experimental data for the design of a high velocity aerial delivery system for 48 cases of combat rations utilizing paper honeycomb as the energy absorber and a 24-foot diameter horizontal ribbon extraction parachute as the stabilizer.


Stress analysis of cellular paper cushioning materials.


A theoretical investigation of the dynamics of a rectangular box striking a flat plate at an angle, intended to verify Mindlin's theory. Requirements for evaluating the Convair accelerator and of an impact machine.


Results of airdrop tests of experimental high velocity aerial delivery systems of 55-gallon drums and combat and 5-in-1 rations.


Results of airdrop tests of experimental high velocity aerial delivery systems and standard aerial delivery systems for 55-gallon drums, and combat and 5-in-1 rations.


Results of tests of two cellular paper structures that were statically loaded in compression at various angles to the cell axes.

Theoretical work on the study of the dynamic characteristics of a rectangular box, on the application of MacGregor's two-load method of impact testing and on the dynamic loading of columns. Also discussed are some experimental work on the evaluation of the accuracy of instrumentation for Riehle machine; the development of instrumentation for dynamic force measurement for Riehle machine; and instrumentation of HYGE accelerator.


Results of airdrop tests of experimental high velocity aerial delivery systems for combat rations and 55-gallon drums.


Several minor modifications to be performed on the shock recorder are described.


Evaluation of initial calibration and field tests on the shock recorder.


Evaluation of a second series of field tests on the shock recorder.


Results of airdrop tests of experimental high velocity aerial delivery systems for 55-gallon drums and combat rations.


A study of existing mathematical methods for study of structures subject to impulsive loading and a discussion of experimental work on instrumentation.

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Results of airdrop tests of experimental high velocity and standard aerial delivery systems for 55-gallon drums and combat rations.


Results of airdrop tests of experimental high velocity aerial delivery systems for 55-gallon drums and combat rations.


Results of airdrop tests of experimental high velocity aerial delivery systems for 5-gallon gasoline cans and combat rations.


Results of airdrop tests of experimental high velocity aerial delivery systems for 5-gallon gasoline cans and dummy caliber 0.30 ammunition and displaced center of gravity systems for combat rations.


Results of airdrop tests of experimental high velocity aerial delivery systems for 55-gallon drums and combat and 5-in-1 rations.


Results of airdrop tests of experimental high velocity aerial delivery systems for 55-gallon drums, 5-gallon gasoline cans and combat rations.


Results of airdrop tests of experimental high velocity aerial delivery systems for 55-gallon drums and combat rations.


Results of airdrop tests of experimental high velocity aerial delivery systems for 55-gallon drums and combat and 5-in-1 rations, and of standard aerial delivery systems for combat rations.

Results of airdrop tests of experimental high velocity aerial delivery systems for 55-gallon drums, 5-gallon gasoline cans and combat rations.


Results of airdrop tests of experimental high velocity aerial delivery systems for 55-gallon drums and 5-gallon gasoline cans.


A discussion of the Institute test facilities and electronic instrumentation that were developed for the purpose of investigating the dynamic properties of materials to be used in aerial delivery.


Static compression test data for five grades of double-faced honeycomb whose cell axes were inclined at 20° and 40° with the vertical.


Results of drop tests of a jeep from heights of 10, 16, and 25 feet. The jeep was protected in all drops with a crushable energy absorber.


Results of airdrop tests of experimental high velocity aerial delivery systems for 5-in-1 rations and a design of a partial-area energy absorber.

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Results of airdrop tests of experimental high velocity aerial delivery systems for 55-gallon drums and 5-in-1 and combat rations and a design of a partial-area energy absorber.


Results of airdrop tests of experimental high velocity aerial delivery systems for 5-gallon gasoline cans and dummy small arms ammunition.


Results of airdrop tests of experimental high velocity aerial delivery systems for 5-in-1 rations and dummy small-arms ammunition and a design of a partial-area energy dissipator.


Results of airdrop tests of experimental high velocity aerial delivery systems for 5-in-1 rations and dummy small-arms ammunition.


Results of airdrop tests of experimental high velocity aerial delivery systems for inert ammunition (57 mm cartridges, 76 mm shells, 81 mm mortar shells, 90 mm cartridges and 105 mm shells) and 55-gallon drums.


Results of airdrop tests of experimental high velocity aerial delivery systems for combat rations.

Results of airdrop tests of experimental high velocity aerial delivery systems for 55-gallon drums, dummy caliber 0.30 cartridges and small detachment (5-in-1) rations.


Results of airdrop tests of experimental high velocity aerial delivery systems for 55-gallon drums, small detachment (5-in-1) rations and dummy caliber 0.30 cartridges.


Results of airdrop tests of experimental high velocity aerial delivery systems for inert ammunition (57 mm cartridges, 76 mm shells, 81 mm mortar shells, 90 mm cartridges and 105 mm shells).


Results of airdrop tests of experimental high velocity aerial delivery systems for small detachment (5-in-1) rations.


Results of airdrop tests of experimental high velocity aerial delivery systems for 55-gallon drums, small detachment (5-in-1) rations and inert ammunition (57 mm cartridges and 81 mm mortar shells).


Results of airdrop tests of experimental high velocity aerial delivery systems for inert ammunition (57 mm cartridges, 81 mm mortar shells, 90 mm cartridges and 105 mm shells).

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Results of airdrop tests of experimental high velocity aerial delivery systems for small detachment (5-in-1) rations.


Static stress-strain curves are given for Lockfoam, Lockfoam expanded over beer cans, and beer cans.


Results of airdrop tests of experimental high velocity aerial delivery systems for inert ammunition (57 mm cartridges, 76 mm shells, 81 mm mortar shells, 90 mm cartridges and 105 mm shells) and dummy caliber 0.30 cartridges.


Brief summary of contract status.


Static stress-strain curves are given for the following materials: paper honeycomb, corrugated fiberboard blocks, foamglass, polystyrene, beer cans, aluminum honeycomb, Styrofoam and Dylite.


Results of airdrop tests of experimental high velocity aerial delivery systems for 55-gallon drums and combat rations.


Results of airdrop tests of experimental high velocity aerial delivery systems for 55-gallon drums, small detachment (5-in-1) rations and water filled No. 2½ cans.

Static stress-strain and energy-strain curves are given for five grades of paper honeycomb that were subjected to a 73 degree F., 50 percent relative humidity atmosphere.


Details of several modifications and results of additional dynamic and static calibration tests are presented.


Dynamic stress-strain and energy-strain curves are given for three grades of paper honeycomb, beer cans, and styrofoam.


Static stress-strain and energy-strain curves for five grades of paper honeycomb after being subjected to a 24 hour water immersion of 100 degrees F.


Results of airdrop tests of experimental high velocity aerial delivery systems for small detachment (5-in-1) rations.


The main factors to be considered in the design of can packs for aerial delivery are presented. Various 5-in-1 ration pack re-designs are evaluated and their force levels given.


A 35-foot centrifuge was used to determine accelerations required to cause failure of army supplies. Results show good correlation with data obtained dynamically. Design values for maximum allowable force are suggested for rations and fuel cans.

Combinations of foamed plastic and metal cans were tested in static compression to determine their energy absorbing properties. The addition of foamed plastic reduced the initial high peak force normally associated with empty metal cans alone.


Combinations of foamed plastic and metal cans were tested in static compression to determine their energy absorbing properties. The addition of foamed plastic reduces the initial high peak force normally associated with empty metal cans alone.


The capacity of wood for absorbing impact energy and also the principles which should govern the design of wood blocking for effective energy absorption have been studied.

Average stress-strain curves are presented for impacts on small blocks of dense Southern Yellow Pine. The effects of variations in the weight of the impacting mass, the impact velocity, block dimensions, and moisture content of the wood are shown. The efficiency is essentially independent of the size of the impacting mass and the impact velocity, so long as the block is large enough to absorb all the impact energy without "bottoming." It is found that except at the two extremes of moisture content, very dry or very wet, moisture content does not greatly affect energy-absorbing efficiency.

A design criteria for the use of wood blocking as cushioning is presented.


Continuation of report 184 dated 5 November using up to 15 inches thickness of Lockfoam under beer cans in static compression tests.


Description of various pack redesigns which have substantially higher resistance to damage than the standard type "C" Ration pack. Force levels are given for the standard pack as well as for redesigned packs.

A new method of applying falling weight with mechanical advantage through pulley systems is described to produce accelerations above normal gravity. The method is particularly adapted for developing steady state accelerations above gravity, and for increasing impact velocity.


The use of a liquid column as the reacting mass in an accelerometer is discussed for application to measurement of impact and shock phenomena. Problem areas are outlined for further research and a self contained low cost package testing unit is proposed.


Load configurations of 5-in-l rations for the M-4A high speed aerial delivery container were designed and evaluated. The designs were based on item shock ratings and the dynamic characteristics of the M-4A nose cone.


Load configurations of "C" rations for the M-4A high speed aerial delivery container were designed and evaluated. The designs were based on item shock ratings and the dynamic characteristics of the M-4A nose cone.


This study was concerned with the design and evaluation of load configurations of "C" rations for airdrop in the M-4A high speed aerial delivery container. Two systems were developed which permitted safe delivery of "C" rations at impact velocities of 35 feet per second. By slightly modifying one of the systems, it was possible to drop at impact velocity up to 42 feet per second.


Discusses problems of unit load supply for tactical element support from the viewpoint of aircargo delivery by ground ejection. Evaluates problems of container dimensions and weights for compatibility with the 40 x 48 pallet, and the use of this load in various types of combat transport media.
This study deals with the design and evaluation of load configurations of the individual combat meal for airdrop in the M-4A high speed aerial delivery container.

Analysis was made of methods of loading inert caliber 30 M-1 rifle and carbine ammunition into the M-4A high speed aerial delivery container. Factors considered were resistance to damage, space utilization, ease of loading and distribution. A method of predicting the performance of a system to be airdropped is described. Load configurations developed performance satisfactorily at an impact velocity of 35 feet per second. By using paper honeycomb in the cargo compartment, drop velocities of 50 feet per second for the caliber 30 carbine ammunition loads and 57 feet per second for caliber 30 M-1 rifle ammunition loads were attained without damage to the loads.

Analysis was made of load configurations for 6-in-l and 25-in-l dehydrated rations in M-4A high speed aerial delivery container. Resistance to damage, space utilization and ease of loading were deciding factors in determining types of load configurations to be used. Shock ratings were used to predetermine if damage would occur when loads were dropped in M-4A container. A system was developed whereby 16 of the 6-in-l rations could be dropped in container at design impact velocity and at higher velocities. Unless modifications were introduced to protect the high-vacuum-packed cans of bread and date pudding, three standard pack 25-in-l rations could not be dropped successfully at the design impact velocity.

A protective system was developed for the AN/GRC-3 Radio Set and battery power supply for air dropping in the M-4A container at an impact velocity of 35 feet per second. Component tests were run on most fragile parts of the set (electron tubes) in order to obtain initial information on impact resistance without exposing the entire set to severe damage. Final evaluation of the systems was accomplished by making simulated airdrops in the elevator drop-shaft.


Load configurations of medical supplies to be airdropped in the M-4A high speed aerial delivery container were designed, developed, and evaluated. Medical supplies consisted of Individual and Combat Surgical Instrument and Supply Sets, also a kit recommended by the Surgeon General's Office. The load configurations designed were successfully dropped in the elevator drop-shaft at impact velocities of 35 feet per second. By use of honeycomb energy absorbers, drops were made at velocities up to 58 feet per second.


Mixed supply load configurations were designed for airdrop in M-4A high speed aerial delivery container. Load configurations of rations, water, ammunition, and medical supplies were evaluated by simulated airdrops in elevator drop-shaft facility. Three load configurations performed satisfactorily when subjected to vertical impacting at velocities of 35 feet per second and topple tests simulating side impacting. By use of paper honeycomb energy absorbers in container cargo compartment, one load configuration was dropped at impact velocity of 46.8 feet per second without damage.

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Provides general information as well as detailed instructions regarding the loading of the M-4A high speed AD container and sealed canister. The load configurations covered include rations, small arms ammo, medical supplies, communications equipment, high explosive ammo, and mixed supply loads. Loading instructions covered not only loads dropped at the operational velocity (35 feet per second), but also loads dropped at velocities up to 58 feet per second.


Load configurations consisting of 81 mm mortar shells and 57 mm and 90 mm rifle cartridges were designed for the aerial delivery container. Shock ratings of ammunition were used in conjunction with graphs of the dynamic impact characteristics of the M-4A nose cone to predict resistance to impact forces developed at impact velocities of 35 feet per second and higher. Simulated airdrops were made in the elevator drop-shaft facility to verify predicted performance.


Load configurations were developed for the three different loads in this study capable of withstanding forces due to impact velocities of 35 feet per second without the need for additional energy absorbers. With the addition of cushioning material, the load configurations of the ration and carbines with ammunition were found to be capable of withstanding higher impact velocities.


Load configurations were developed for the two loads capable of withstanding forces due to impact velocities of 35 feet per second without the need for additional energy absorbers. With additional cushioning material, the loads were capable of withstanding higher impact velocities.
AERIAL DELIVERY ARTICLES


A general discussion of aerial delivery packaging for either free-fall or retarded-fall delivery and the objectives of Quartermaster research in aerial delivery.


A discussion of the Quartermaster Food and Container Institute's short- and long-range aerial delivery program.


A discussion of the shock and impact characteristics of supplies and equipment based on the relationships existing among force, time, and distance.


A discussion of the use of cushioning materials for aerial delivery packaging.


The present state of knowledge regarding preparation of materiel for airdrop, and what is being done to improve that knowledge.


A discussion of workable airdrop systems that require a minimum of time in preparation, specialized equipment and money.


A description of the test facilities and instrumentation at the Quartermaster Food and Container Institute applicable to aerial delivery research.

Research involved in the design of a high velocity aerial delivery system for C-rations.


The concept and reason for aerial delivery is discussed along with the test facilities used for conducting simulated field tests used at the QMFCIAF.


Evaluation of load configurations for different type loads and the various principles and techniques developed for loading items to withstand higher impact forces are discussed.


A description of the facilities and an evaluation of the progress of aerial delivery research being conducted at the QMFCIAF.
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