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DEPARTMENT OF DEFENSE
HANDBOOK

LOADING ENVIRONMENT AND RELATED REQUIREMENTS FOR PLATFORM RIGGED AIRDROP MATERIEL

AMSC N/A

FSC 1670

FOREWARD

1. This Military Handbook is approved for use by all Departments and Agencies of the Department of Defense.

2. Several general guidance documents are in effect covering technical information and operational airdrop requirements for military equipment. Until recently, such information to design engineers for use during the development cycle of an end item has been quite limited.

3 In the past, airdrop requirements for an item usually were given consideration after the design of the item had been completed and test prototypes fabricated. This was particularly true of standard commercial items that were procured for military use with little or no modification. Then, by utilizing the available provisions and structural members of the item, supplemented by field modifications which added special hardware components and local reinforcements, the item was adapted to airdrop environment. Occasionally, the basic design of the item was such that suitable field modifications could not be accomplished and the item was determined incapable of being airdropped.

4. With the increased emphasis on mobility of military personnel and equipment, the requirement for airdrop capability of materiel must be given greater consideration and positive steps undertaken during the design phases to insure this capability.

5. To meet the need for a reference publication covering detailed technical airdrop design criteria, the U.S. Army Natick Research, Development and Engineering Center has prepared this handbook for use by the Department of Defense during the development of military equipment having an airdrop requirement.

6. Beneficial comments (recommendations, additions, deletions) and any pertinent data which may be used in improving this document should be addressed to: Commander, U.S. Army Natick Research, Development and Engineering Center, Natick, MA 01760-5017 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

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1. SCOPE

1.1 Scope. This handbook defines the loading environments for which items of military materiel experience when airdropped as platform loads, specifies essential design considerations, and establishes a method to obtain a preliminary determination of the capability of items of military materiel to withstand ground impact forces resulting from airdrop. This handbook is for guidance only. This handbook cannot be cited as a requirement. If it is, the contractor does not have to comply.

2. APPLICABLE DOCUMENTS

2.1 General. The following documents are not necessarily all the documents referenced herein, but are the ones that are needed in order to fully understand the information provided by this handbook.

2.2 Government documents.

2.2.1 Specifications, standards, and handbooks. The following specifications,standards, and handbooks form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the latest issue of the Department of Defense Index of Specifications and Standards (DoDISS) and supplement thereto, cited in the solicitation.

SPECIFICATIONS

MILITARY

MIL-H-9884 - Honeycomb Material, Cushioning Paper

STANDARDS

MILITARY

MIL-STD-814 - Requirements for Tiedown, Suspension and Extraction Provisions on Military Materiel for Airdrop

(Unless otherwise specified, copies of the above specifications, standards, and handbooks are available from the Standardization Order Desk, 700 Robbins Avenue, Building 4D, Philadelphia, PA 19111-5094)

2.3 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text of the reference document takes precedence. Nothing in this document supersedes applicable laws and regulations unless a specific exemption has been obtained.

3. DEFINITIONS

The following definitions apply to the terms stated:

3.1 Airdrop. A movement by aircraft, wherein personnel, supplies and equipment are unloaded in flight.

3.2 Airdrop Weight. The weight of the item, including external or internal loads such as fuel, ammunition, field gear or rations.

3.3 Developing agency. The agency of the Department of Defense which is responsible for research and development of the item of military materiel.

3.4 Drive-on, drive-off capability. Capability to drive a vehicle on or off the energy dissipater stacks without using an external power source.

3.5 Energy dissipater. As used in this standard, a crushable material (paper honeycomb) used to dissipate kinetic energy during impact.

3.6 Extraction provision. An integral fitting on the item used for attaching the extraction system.

3.7 Load spreader. A device for increasing the bearing area of a concentrated load. As applied in this standard, it may be used between either a wheel, frame, or other member and the energy dissipater to assure crushing of the desired dissipater area.

3.8 Retardation system. A system used to retard and stabilize the descent of an airdropped item.

3.9 Suspension provision. An integral fitting on the item for attaching the retardation system.

3.10 Tie-down provision. An integral fitting or part of an item for restraining the item to an airdrop platform or to the aircraft floor using tie-down assemblies.

3.11 Tow-on, tow-off capability. Capability to tow a vehicle on and off the energy dissipater stacks using an external power source.

4. GENERAL REQUIREMENTS

4.1 General. Combat and support materiel which is airdropped to combat forces by parachute and/or assault landings should be capable of immediate effective employment. An airdropped item, from the time it is loaded in the aircraft until it is recovered on the ground, will have been subjected

to a force loading environment due to the following considerations:

(a) Restraint in the aircraft for flight safety.
(b) Deployment of the extraction system.
(c) Deployment of the retardation system.
(d) Deceleration at ground impact.

The item should be designed to withstand the forces due to the four conditions stated herein.

5. DETAIL REQUIREMENTS

5.1 Tie-down provisions. Tie-down provisions used to restrain the materiel and prevent displacement in flight should conform to MIL-STD-814.

5.2 Extraction provisions. Extraction provisions used for attachment of the extraction system should conform to MIL-STD-814.

5.3 Suspension provisions. Suspension provisions used for attachment of the retardation system should conform to MIL-STD-814.

5.4 Energy dissipater system. Each item to be airdropped should be designed to accommodate the current energy dissipater system in order to provide maximum protection against damage on ground impact. The item should withstand a deceleration force ration of G+1 or 19.5 plus or minus 10 percent, times its airdrop weight when decelerated from a velocity of 28.5 feet per second to zero feet per second on ground impact, and should comply with the performance requirements of the applicable end item specification when airdropped with the current energy dissipater system. (See also 7.5).

5.4.1 Energy dissipater. The energy dissipater should conform to MIL-H-9884, double-faced, 3-inch thick panel. This material crushes at an essentially constant dynamic crushing stress of 6300, plus or minus 900, pounds per square foot to 70 percent strain. Crushing stress rises rapidly beyond the 70 percent strain.

5.4.2 Application of energy dissipater. A minimum number of stacks of the energy dissipater, based upon the total area of the dissipater material required, the bottom configuration of the item, and the local and overall structural strength of the item should be applied. The deceleration force of G+1 or 19.5 times the item airdrop weight will be met by using 3.1 square feet of energy dissipator crushing area for each 1,000 pounds of item airdrop weight and a total thickness of 12 inches of energy dissipater composed of four layers of 3-inch thick panels. Arrangement of stacks should facilitate the item to be placed on the stacks with a minimum of mechanical handling equipment. Wherever possible, it is required that the dissipater configuration for wheeled or tracked items permit drive-on, drive-off, tow-on, or tow-off capability.

5.4.3 Preparing energy dissipater stacks. Glue the layers of energy dissipater to each other and to the skid or platform. Where the underside of the item in contact with the energy dissipater stack

does not present a flat contact surface, a wood load spreader should be used. The load spreader should be glued to the top of the energy dissipater stack and should be of sufficient thickness and size to insure crushing the entire area.

5.4.4 Distribution of energy dissipater area. Consideration should be given to the distribution of the dissipater area on the under surface of the item as well as the total area of the energy dissipater material used. The bearing area of the dissipater material necessary to produce 18.5 G net deceleration with built-up items such as vehicles, is less than the under surface of the item. The item in these instances, should withstand the dynamic compressive stresses at impact and the stresses due to the relative motion of the parts of the item.

6. TESTS

6.1 Static airdrop tests. Simulated airdrop impact tests are detailed to establish the capability of the item to meet the deceleration force and performance requirements of 5.4.

6.1.1 Initial tests. Initial tests are to be made with deceleration force levels less than G+1 level specified in 5.4. The total thickness of the energy dissipater stack should be 12 inches to permit a crushing stroke of approximately 9 inches. Use the equations in the appendix in determining the impact velocities and the total deceleration force levels selected. The developer should select the lower deceleration force levels for the initial tests to preclude extensive damage resulting to the test item.

6.1.2 Final tests. The requirement of 28.5 feet per second ground impact velocity specified in 5.4 will be attained when the item is free-dropped from a height of 12.7 feet. Measure this height from the lowest point on the bottom of the skid or platform upon which this item is positioned and the impact surface. Rig the item for test using a skid or standard platform with predetermined number and sizes of energy dissipater stacks, and load spreaders, if required. Figure 1 illustrates a typical vehicle rigged for test. The test is to be conducted using a concrete impact surface. The dissipater configuration should be designed to minimize rebound by placing the energy dissipater material under rigid frame members of the item. The platform or skid must strike the impact surface at an angle of not greater than 2.5 degrees in any direction for airdrop results to be valid. The platform or skid should be approximately parallel to the impact surface prior to drop. The item, after impact, should meet the performance requirements of the applicable end item specification.

6.1.3 Instrumentation. The developing agency should determine the instrumentation to be used with the simulated airdrop impact tests. This instrumentation may include, but is not restricted to, high frame rate motion pictures, high speed video accelerometers and permanent deformation data.

7. NOTES

(This section contains information of a general or explanatory nature that may be helpful, but is not mandatory.)

7.1 Engineering assistance. The U.S. Army Natick Research, Development and Engineering Center will provide engineering assistance on the use of this standard.

7.2 Simulated airdrop impact test. The developing agency will specify whether the impact test will be performed at a contractor or government facility.

7.3 Approval of airdrop provisions. The developing agency will approve the location and number of the airdrop provisions specified in 5.1, 5.2 and 5.3.

7.4 Item design and energy dissipater configuration. The final energy dissipater configuration for items to be airdropped is presently established during the service test phase of the item development cycle. Design changes, at this point, are expensive and time consuming. Consideration should be given to the airdrop requirement early in the development cycle to insure the final end item design will meet the airdrop requirements.

7.5 International standardization agreements. Certain provisions of this standard (identified by paragraph number or similiar manner, if appropriate) are the subject of international standardization agreement (STANAG No.3778). When change notice, revision, or cancellation of this standard is proposed which will modify the international agreement concerned, the preparing activity will take appropriate action through international standardization channels, including departmental standardization offices, to change the agreement or make other appropriate accommodations.

7.6 Supersession data. This document replaces MIL-STD-669 Loading Environmental and Related Requirements for Platform Rigid Airdrop Material.

7.7 Subject term (key word) listing.

Energy dissipater
Extraction
Restraint
Suspension
Tiedown

APPENDIX

10. ENERGY DISSIPATER CONFIGURATION DESIGN EQUATIONS.

10.1 Purpose. This appendix is a mandatory part of this handbook. This appendix lists the equations to calculate the values required to design energy dissipater configurations and to obtain data for static airdrop impact tests.

10.2 Equation to determine total energy dissipater area necessary to sustain a specified decelerating force level.

$$A = \frac{W\,(G+1)}{Sa}$$

A = energy dissipater area (sq. ft.)
W = test item weight (lbs.)
Sa = average dynamic crushing stress of dissipater materials (lbs./sq./ft.)
G = number of g's deceleration

The deceleration force level is the product of the item weight (W) and the number of g's deceleration plus 1 (G+1).

10.3 Equation to determine impact velocity for specific decelerating force level.

$$V = \sqrt{2g\,GEt}$$

V = impact velocity (ft/sec)
g = acceleration due to gravity (32.2 ft./sec.^{2})
G = number of g's deceleration
E = material thickness efficiency (0.7)
t = thickness of energy dissipater stack (ft.)

10.4 Equation to determine free-drop height necessary to develop specific velocity on ground impact.

$$h = \frac{V^2}{2g}$$

h = free-drop height (ft.)
V = desired impact velocity (ft./sec.)
g = acceleration due to gravity (32.2 ft./sec^2)

10.5 Final deceleration value. The final design value for G value shall be 18.5. This value is based upon the desired maximum dissipater stack height of 12 inches and the results of an investigation of standard military vehicles undergoing tests specified herein. It was observed that military vehicles which met the requirements of the tests specified herein were successfully airdropped.

10.6 Sample calculations.

10.6.1 Case I. Assume that the desired deceleration force level during an initial simulated airdrop test shall not exceed 10 g's. The calculations to determine the area of this energy dissipater, the impact velocity, and the drop height to attain results with the specified deceleration force level are specified in 10.6.1.1, 10.6.1.2, 10.6.1.3 and 10.6.1.4.

10.6.1.1 Calculation of area of energy dissipater required.

$$A = \frac{W\,(G \pm 1)}{Sa}$$

Given:

$W = 30{,}000$ lbs.
$Sa = 6300$ lbs./sq. ft.
$G = 10$ g's

$$A = \frac{30{,}000\,(10 \pm 1)}{6300}$$

$A = 52.4$ sq. ft.

The total area of energy dissipater to be distributed under the item is 52.4 square feet.

10.6.1.2 Calculation of impact velocity necessary to preclude exceeding the 70 percent strain of 1 foot high dissipater stack.

$$V = \sqrt{2g\,GEt}$$

Given:

$g = 32.2$ ft./sec.^{2}
$G = 10$ g's
$E = .7$
$t = 1$ ft

$$V = \sqrt{2\,(32.2\,(10)\,(.7)\,(1)}$$

$$V = \sqrt{450.8}$$

$V = 21.45$ ft./sec.

The impact velocity necessary to preclude exceeding the 70 percent strain on the 1 foot high dissipater stack is 21.45 feet per second.

10.6.1.3 Calculation of drop height.

$$h = \frac{V^2}{2g}$$

Given:

$V = 21.45$ ft./sec.
$g = 32.2$ ft./sec.^{2}

$$h = \frac{(21.45)^2}{2\ (32.2)}$$

$h = 7.15$ ft.

The drop height for the item on the skid or platform shall be 7.15 feet.

10.6.1.4 Analysis. The item which weighs 30,000 pounds, if positioned on a skid or platform with energy dissipater in stacks of 1 foot in height and total surface area of 52.4 square feet, and dropped from a height of 7.15 feet will experience a deceleration force of 10 g's. The impact velocity at ground impact will be 21.45 feet per second.

10.6.2 Case II. Calculation of final energy dissipater configuration is specified herein.

10.6.2.1 Calculation of area of energy dissipater required with standard deceleration force level.

$$A = \frac{W\ (G \pm 1)}{Sa}$$

Given:

$W = 30{,}000$ lbs.
$G = 18.5$ g's
$Sa = 6{,}300$ lbs./sq. ft.

$$A = \frac{(30{,}000)\ \ (18.5 \pm 1)}{6300}$$

$A = 92.9$ sq. ft.

The total area of the energy dissipater to be distributed under the item is 92.9 square feet.

10.6.2.2 Calculation of height of energy dissipater stacks required with standard deceleration force level.

$$V = \sqrt{2g\ GEt}$$

Given:

$V = 28.5$ ft./sec.
$g = 32.2$ ft./sec.^{2}
$G = 18.5$ g's
$E = .7$

$$28.5 = \sqrt{2\ (32.2)\ (18.5)\ (.7)t}$$

$t = .98$ ft.

The height of the energy dissipater stacks should be 1 foot.

10.6.2.3 Calculation of drop height.

$$h = \frac{V^2}{2g}$$

Given:

$V = 28.5$ ft./sec.
$g = 32.2$ ft./sec.^{2}

$$h = \frac{(28.5)^2}{(2)\ 32.2}$$

$h = 12.6$ ft.

The drop height is 12.6 feet.

10.6.2.4 Analysis. An item which weighs 30,000 pounds, if positioned on a skid or platform with energy dissipaters in stacks of 1 foot in height and total surface area of 97.5 square feet, and dropped from a height of 12.6 feet will experience a deceleration force of 18.5 g's. The impact velocity at ground impact will be 28.5 feet per second.

10.6.2.5 Summary. The energy dissipater configuration based upon the calculations for Case II will sustain the item for the environments experienced in airdrop.

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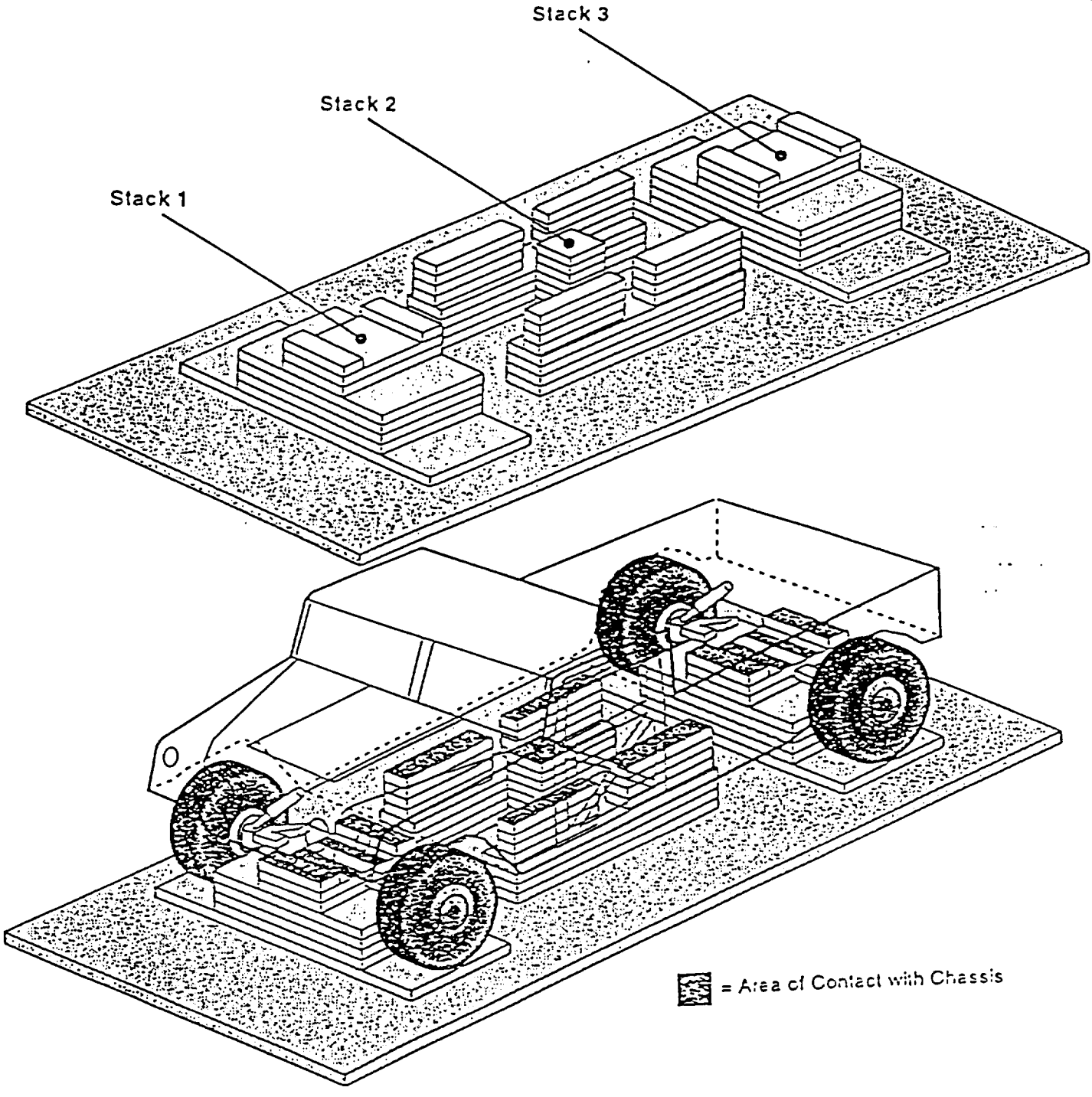

FIGURE 1. Cushioning Configuration For Vehicle

Custodians:

Army - GL
Air Force - 99

Review activities:

Army - AT, MT,
Air Force - 82

Preparing activity:

Army - GL

(Project No. 1670-0868)

STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER MIL-STD-669	2. DOCUMENT DATE (YYMMDD) 97 02 03

3. DOCUMENT TITLE Loading Environment and Related Requirements for Platform Rigged Airdrop Materiel

4. NATURE OF CHANGE (Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME (Last, First, Middle Initial)	b. ORGANIZATION	
c. ADDRESS (Include Zip Code)	b. TELEPHONE (Include Area Code) (1) Commercial (2) AUTOVON (If applicable)	7. DATE SUBMITTED (YYMMDD)

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