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MILITARY STANDARD

LOADING ENVIRONMENT AND RELATED REQUIREMENTS FOR PLATFORM RIGGED AIRDROP MATERIEL

FSC 1670

DEPARTMENT OF DEFENSE

WASHINGTON 25, D. C.

LOADING ENVIRONMENT AND RELATED REQUIREMENTS

FOR PLATFORM RIGGED AIRDROP MATERIEL

MIL-STD-669

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

2. Recommended corrections, additions or deletions should be addressed to the U. S. Army Natick Laboratories, Natick, Massachusetts 01762.

FOREWORD

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.

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.

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.

To meet the need for a reference publication covering detailed technical airdrop design criteria, the U. S. Army Natick Laboratories have prepared this standard for Department of Defense use during the development of military equipment having an airdrop requirement.

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1. SCOPE

1.1 This standard defines the loading environments 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.

2. REFERENCED DOCUMENTS

2.1 The following documents, of the issue in effect on the date of invitation for bids or request for proposal, form a part of this standard to the extent specified herein.

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

REGULATIONS

ARMY

AR 705 35 - Research and Development of Materiel - Criteria for Air Portability and Airdrop of Materiel

(Copies of specification, standard and regulation required by suppliers in connection with specific procurement actions should be obtained from the procuring activity or as directed by the contracting officer.)

3. DEFINITIONS

3.1 The following definitions shall apply to the terms stated:

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

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

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

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

Energy dissipater. As used in this standard, a crushable material used to dissipate kinetic energy during impact.

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

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.

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

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

Tiedown provision. An integral fitting or part of an item for restraining the item to an airdrop platform or to the aircraft floor using tiedown assemblies.

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 shall 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 shall be designed to withstand the forces due to the four conditions stated herein.

5. DETAIL REQUIREMENTS

5.1 Tiedown provisions. Tiedown provisions which are used to restrain the materiel and prevent displacement in flight shall conform to MIL-STD-814.

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

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

5.4 Energy dissipater system. Each item which will be airdropped shall be designed to accommodate the current energy dissipater system in order to provide maximum protection against damage on ground impact. The item shall withstand a deceleration force ratio 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 shall comply with the performance requirements of the applicable end item specification when airdropped with the current energy dissipater system.

5.4.1 Energy dissipater. The energy dissipater shall be paper honeycomb, class 3 of MIL-H-9884, expanded, 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 over-all structural strength of the item shall 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 paper honeycomb crushing area for each 1,000 pounds of item airdrop weight and a total thickness of 12 inches of paper honeycomb composed of 4 layers of 3 inch thick panels. The stacks shall be arranged to permit 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. The layers of paper honeycomb shall be glued 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 shall be used. The load spreader shall be of sufficient thickness and size to insure full crushing of the energy dissipater stack over its entire area. The load spreader shall be glued to the top of the stack.

5.4.4 Distribution of energy dissipater area. Consideration shall 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, shall 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 Simulated airdrop impact test. The simulated airdrop impact test detailed herein will establish the capability of the item to meet the deceleration force and performance requirements of 5.4.

6.1.1 Initial tests. Initial tests shall be made with deceleration force levels less than the G+1 level specified in 5.4 while retaining a total thickness of the honeycomb stack of 12 inches. The equations in the appendix shall be used in determining the impact velocities and the total areas of the energy dissipater stacks for the force levels selected. The developer shall 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. This height shall be measured from the lowest point on the bottom of the skid or platform upon which this item is positioned and the impact surface. The item shall be rigged 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 shall be conducted using a concrete impact surface. The dissipater configuration shall be designed to minimize rebound by placing the energy dissipater material under rigid frame members of the item. The platform or skid shall 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 must be approximately parallel to the impact surface prior to drop. The item, after impact, shall meet the performance requirements of the applicable end item specification.

6.1.3 Instrumentation. The developing agency shall determine the instrumentation to be used with the simulated airdrop impact test. This instrumentation may include, but is not restricted to, high frame rate motion pictures, strain gage engineering data, and permanent deformation data. The frame rate for high frame rate motion pictures may vary from 2,000 to 4,000 frames per second.

7. NOTES

7.1 Engineering assistance. The U. S. Army Natick Laboratories, Natick, Mass., 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 contractor or government facility.

7.3 Approval of airdrop provisions. The developing agency shall 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 which are to be airdropped is established, presently, during the service test phase of the item development cycle. Design changes, at this point, are expensive and time consuming. Consideration should be given on the use of energy dissipaters early in the development cycle. This will insure that the final end item design will meet the required impact forces.

Custodians:

Army - GL
Air Force - 11

Review activities:

Army - AV
Air Force - 11, 82

User activities:

Army - AT, EL
Navy - AS

Preparing activity:

Army - GL

Project No. 1670-0223

APPENDIX

10. ENERGY DISSIPATER CONFIGURATION DESIGN EQUATIONS.

10.1 Purpose. This appendix lists the equations to calculate the values required to design energy dissipater configurations and to obtain data for ground 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 decelerating 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 G 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 the energy dissipater, the impact velocity, and the drop height to attain results with the specified deceleration force level shall be as specified herein.

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 55 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 55 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 shall be as 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

$E = .7$

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

$$t = .98 \text{ ft.}$$

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

10.6.2.3 Calculation of drop height.

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

Given:

$$V = 28.5 \text{ ft./sec.}$$

$$g = 32.2 \text{ ft./sec.}^2$$

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

$$h = 12.6 \text{ ft.}$$

The drop height shall be 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.

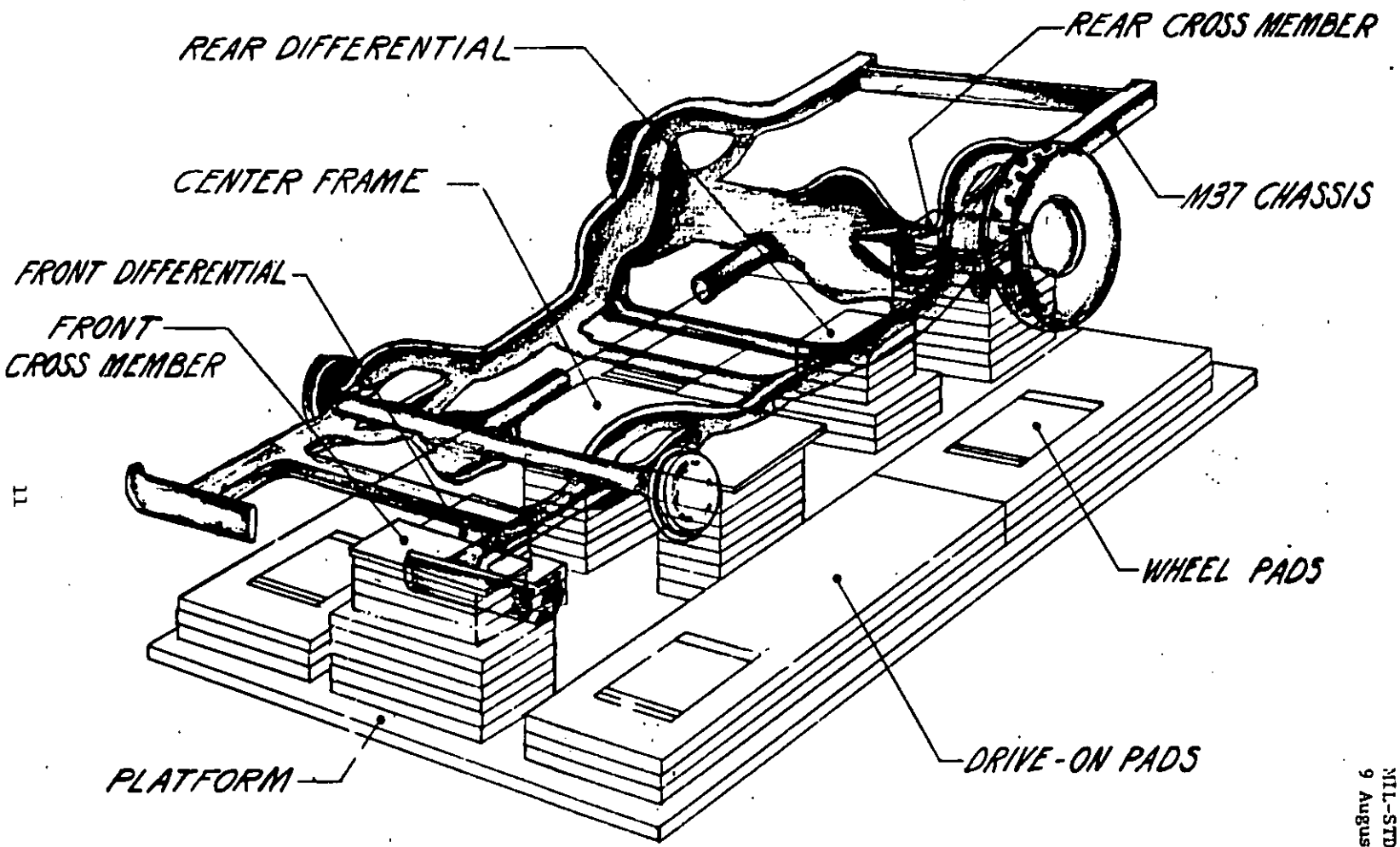

FIG. 1. CUSHIONING CONFIGURATION FOR $\frac{3}{4}$ TON TRUCK, M37