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DEPARTMENT OF DEFENSE

INTERFACE STANDARD FOR LIFTING AND TIEDOWN PROVISIONS

AMSC N/A **FSC 2540**

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FOREWORD

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

2. This standard covers the design and testing of slinging, tiedown, and cargo tiedown provisions. The requirements in this standard are military-unique interface requirements developed specifically for ensuring that the lifting and tiedown provisions on military equipment meet the physical, functional and operational environment attributes for transportation assets of the Defense Transportation System (DTS). These requirements are necessary to permit the interoperability between transported military equipment and the transportation systems available for military movements. Specifically, this revision of the standard clarifies the design criteria for lifting and tiedown provisions, disallows the use of shackles as provisions, adds a requirement for large cargo tiedown provisions, and standardizes sling lengths for design.

3. Beneficial comments (recommendations, additions, or deletions) and any pertinent data which may be of use in improving this document should be addressed to Director, Military Traffic Management Command Transportation Engineering Agency (MTMCTEA), ATTN: MTTE-DPE, 720 Thimble Shoals Blvd, Suite 130, Newport News, VA 23606-2574 by using the Standardization Document Improvement Proposal (DD Form 1426) appearing at the end of this document or by letter.

CONTENTS

CONTENTS

CONTENTS

1. SCOPE

1.1 Coverage. This standard establishes dimensional limits, design considerations, positioning requirements, and strength requirements for lifting (to include helicopter external air transport (EAT)) and tiedown provisions for lifting or tying down tanks and other tracked vehicles, tactical wheeled vehicles, helicopters, and other military equipment shipped assembled or disassembled in unboxed or uncrated condition, and for restraining cargo or accessories to such equipment. The lifting and tiedown requirements in this standard are necessary to permit compatibility between military equipment and the transportation systems used for deployments.

1.1.1 Excluded equipment. This standard excludes external provisions on International Organization for Standardization (ISO) cargo containers. It also excludes helicopter and aircraft cargo tiedown provisions.

1.1.2 Military equipment for helicopter external air transport (EAT). Although the design of lifting provisions is covered in this standard, items of equipment requiring helicopter EAT certification must also meet the static lift and helicopter flight-test requirements of MIL-STD-913.

1.1.3 Military equipment for airdrop. Even though airdrop design criteria for military equipment are specified in MIL-STD-814, equipment must also be transported by surface modes. Therefore, lifting and tiedown provisions for airdrop-designed equipment should meet both the requirements of this standard and MIL-STD-814.

1.2 Application. This standard applies to the following:

a. All new commercial, modified commercial, nondevelopmental, developmental, and reprocurements as noted above.

b. Modified equipment, when the modifications result in changes to lifting or tiedown requirements (for example, provision relocation or item weight increase).

1.3 Classification.

1.3.1 Provision nomenclature. The following provision names will be used throughout this standard (definitions for each provision are in paragraph 3):

Lifting provisions
Equipment tiedown provisions
Multipurpose provisions
Cargo bed tiedown provisions
Flatbed/flatrack cargo tiedown provisions
Largo cargo tiedown provisions

1.3.2 Equipment types. Equipment is classified as follows:

Type I. Developmental, non-developmental and modified commercial equipment (for example, combat, tactical and tactical support vehicles, armored carriers, self-propelled artillery, tanks, and recovery vehicles, semitrailers, trailers, trucks, materials handling equipment and construction equipment.)

Type II. Unmodified materials handling equipment and commercial construction equipment, helicopters and items that are shipped unboxed or uncrated, and lifted separately as individual units.

2. APPLICABLE DOCUMENTS

2.1 General. The documents listed in this section are specified in sections 3, 4, and 5 of this standard. This section does not include documents cited in other sections of this standard or recommended for additional information or as examples. While every effort has been made to ensure the completeness of this list, document users are cautioned that they must meet all specified requirements documents cited in sections 3, 4, and 5 of this standard, whether or not they are listed.

2.1.1 Specifications and standards. The following specifications and standards form a part of this document to the extent specified herein. Unless otherwise specified, the issues of these documents are those listed in the issue of the Department of Defense Index of Specifications and Standards (DODISS) and supplement thereto cited in the solicitation (see para 6.2).

SPECIFICATIONS

FEDERAL

A-A-50271 Plate, Identification

STANDARDS

DEPARTMENT OF DEFENSE

MIL-STD-913 Requirements and Procedures for the Certification of Externally Transported Military Equipment by Department of Defense Rotary Wing Aircraft.

(Unless otherwise indicated, copies of above specifications and standards are available from the Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, phone number (215) 697-2179, facsimile (215) 697-1462.)

2.1.2 Other Government documents, drawings, and publications. The following documents form a part of this document to the extent specified herein. Unless otherwise indicated, the issues are those cited in the solicitation.

Code of Federal Regulations Title 49 - Transportation

(CFR Title 49 can be obtained from the Superintendent of Documents, US Government Printing Office, Washington, DC 20402, (202) 512-1800.)

2.2 Order of precedence. In the event of a conflict between the text of this document and the references cited herein, the text with the most severe requirement will take precedence.

3. **DEFINITIONS**

3.1 Lifting provision. An integral part of the equipment, commonly called a padeye, lug, eye, or attachment. A lifting provision provides a means of attaching a sling to the equipment for safe lifting.

3.2 Equipment tiedown provision. An integral part of an item, commonly called a tiedown eye, fixture, or attachment. A tiedown provision provides a means of attaching a tiedown lashing to the equipment for tiedown purposes during shipment.

3.3 Multipurpose provision. A single provision that meets the requirements of this standard for both lifting and equipment tiedown.

3.4 Cargo bed tiedown provision. A padeye, fixture, or attachment integral to the cargo compartments of trucks or trailers for securing cargo or accessories.

3.5 Flatbed/flatrack cargo tiedown provision. A padeye, fixture, or attachment integral to a flatbed trailer or flatrack used as a demountable truck or trailer bed for securing cargo or accessories.

3.6 Large cargo tiedown provision. A padeye, fixture, or attachment integral to cargo trucks and trailers, flatbed trailers and flatracks used as a demountable truck or trailer bed for securing large, heavy items.

3.7 Gross weight (GW). The weight of the basic equipment plus the weight of any associated support items of equipment and cargo attached to, contained within, or projected as payload for the equipment (for example, shelters). The weight of ammunition, fuel, water, and lubricants necessary to render a system combat ready are also considered as payload.

3.8 Permanent deformation. Any visible permanent change in the original dimensions or shape of the provision or connecting structure resulting from an applied force.

3.9 Static load. The anticipated maximum resultant force imposed on the provision when an item, at GW, is suspended in a specified lifting configuration without movement.

3.10 Design limit load. The applied force (for lifting only, the static load times the load factor (LF)), or maximum probable force, that a provision, including its connecting structural members, will be subjected to in its most severe transport environment.

3.11 Yield load. The force at which a provision, including its connecting structural members, exhibits a visible permanent deformation or set. The yield load must be greater than the design load limit.

3.12 Ultimate load. The force (not less than the design limit load times 1.5) a provision, including its connecting structural members, can sustain without breaking or rupturing.

3.13 Helicopter external air transport (EAT). A mode of transportation by which an item(s) is suspended beneath a rotary wing aircraft for the purpose of transport.

3.14 Static lift test. A test consisting of rigging and statically lifting the item to verify the rigging configuration and identify clearance problems.

3.15 Helicopter flight testing. A test consisting of flying the item(s) in its EAT rigging configuration, using military rotary wing aircraft. This test is used to verify stability during flight as well as an indication that the item can withstand the dynamic forces induced by flight.

3.16 Equipment. The item that requires provisions.

3.17 Plane of the provisions. A geometric plane connecting the centers of all lifting provisions of an item of equipment.

3.18 Container spreader bar. Material handling equipment specifically designed for lifting standard ANSI/ISO containers.

3.19 External air transport weight (EATWT). The specified weight of the item to be transported externally by helicopters. EATWT is used to calculate the EATWT to Maximum Project Frontal Area ratio and the corresponding materiel lift point load factor.

4. GENERAL REQUIREMENTS

4.1 Lifting, equipment tiedown, and multipurpose provisions.

4.1.1 Number. All types of equipment within the scope of this standard shall have four lifting provisions and four tiedown provisions to ensure interoperability between transported military equipment and lifting and tiedown devices commonly used in the transportation environment. Container spreader bars or other lifting sling sets available at ports are typically equipped with four locations for lifting. Also, because of limited tiedown devices on ships and railcars, military equipment must be capable of being adequately restrained with only four tiedown provisions. If equipment is sectionalized for shipping, these requirements apply to each section and to the equipment when assembled. For type II equipment, if specified in the equipment specifications, the options in paragraph 4.1.3 may be provided.

4.1.2 Location.

4.1.2.1 All provisions. All provisions shall be located so that:

a. Not less than 1 inch of clearance should be maintained between the equipment and the sling cables or chains, tiedown cables or chains, or the rope portion of helicopter slings. When a sling leg or tiedown must contact a part of the equipment, testing or computer aided engineering structural analysis must demonstrate that the affected part(s) has sufficient strength to withstand the force exerted by the sling leg or tiedown lashing to prevent permanent deformation of any part of the equipment, and that contact will not adversely affect the material of the sling or tiedown device.

b. Provisions do not interfere with the functioning of the equipment.

c. Maximum accessibility to the provision is maintained.

d. Orientation of the provision shall be such that an attaching device (hook), of the proper capacity, does not contact any part of the item being lifted except the provision. This ensures interoperability between the equipment and the transportation systems.

e. Height of provisions is 6 feet or less, measured from the ground when the equipment is resting on a level surface, unless an integral means for reaching the provisions is provided.

4.1.2.2 Lifting provisions. In addition to the requirements of paragraph 4.1.2.1, the provisions shall be located so that:

a. All lifting provisions provide dynamic stability during crane lifting and helicopter EAT. Lifting provisions should be located above the vertical center of gravity (CG). If this is not possible, lifting provisions shall be located so that a line connecting adjacent lifting provisions is located outside a 120° cone having its apex at the CG and its axis of rotation about the vertical axis (fig 1).

b. The equipment is lifted with an equal length single apex sling assembly. The minimum length of sling leg used for lifting with an equal length single apex sling assembly is determined by setting each sling angle to 45° (referenced from the plane of the provisions). The point in space where the four equal length slings intersect determines the minimum length of the single apex sling assembly. If the length determined by this method is less than 12 feet, the sling length shall be set to 12 feet. In no case shall the length be less than 12 feet. The minimum sling length shall be used for testing (see 5.5). Appendix B gives an example of how to determine the minimum sling length and the required loads for testing.

c. The equipment lifts level or nearly level. A level lift is the preferred scenario.

d. The 1-inch clearance, as described in paragraph 4.1.2.1.a, exists when lifting with the minimum equal length sling legs (see 4.1.2.2.b), with sling angles ranging from a 45° single apex sling assembly to those same sling legs attached to an 8-foot by 20-foot container spreader bar (fig 2).

e. After the requirements of 4.1.2.2.a, 4.1.2.2.b, and 4.1.2.2.c are met, the overall height of the attached sling apex shall not exceed a height of 24 feet above the lowest extremity of the equipment when suspended (fig 3).

4.1.2.3 Equipment tiedown provisions. Tiedown provisions shall be located so that in the elevation view tiedown legs may be placed anywhere from vertically downward to horizontal and, in the plan view, 90° to either side of the principal direction of the tiedown provision (fig 4). The principal direction is parallel to the longitudinal axis. Tiedown provisions shall be located on structural members of the chassis of wheeled vehicles or the hull of tracked vehicles. Tiedown points on the equipment should be located symmetrically about the item of equipment, preferably mounted on the front and rear ends, and higher than the CG. Each tiedown provision shall be used for restraint in only one longitudinal direction, either fore or aft, and only one lateral direction, either left or right.

4.1.3 Option for type II equipment. If type II equipment is allowed by the equipment specification to not have lifting, equipment tiedown or multipurpose provisions, the contractor shall specify, to the materiel developer, points on the equipment to be used for lifting and tiedown. The selected points shall meet the requirements in sections 4 and 5 of this standard. If holes are used as tiedown provisions, they shall be formed in the main structural members and shall conform to figure 5.

4.2 Surface of provisions. The material edges shall be rounded (1/8” radius to round cross-section) or chamfered (1/16” x 1/16” to 3/8” x 3/8”), and smoothed to prevent cutting or damage to the sling or tiedown devices.

4.3 Shackles. Shackles shall not be used as lifting, equipment tiedown or multipurpose provisions.

4.4 Hub and axle attachments. Wheel hubs and axles shall not be used as lifting or tiedown points.

4.5 Removable provisions. Provisions that can be removed are prohibited. A tiedown or lifting provision that doubles as another device, such as a towing provision, shall not be used if the secondary function requires removal of the provision. Figure 6 shows an example of a tiedown/towing provision that does not require removal of the provision.

4.6 Cargo tiedown provisions.

4.6.1 Number.

4.6.1.1 Cargo bed and flatbed/flatrack cargo tiedown provisions. The number of cargo tiedown provisions shall be determined by the design and size of the cargo compartment or platform; however, no cargo compartment or platform shall have fewer than four provisions.

4.6.1.2 Large cargo tiedown provisions. Equipment with a payload capability greater than 5,000 pounds shall be equipped with four large cargo tiedown provisions. Additional large cargo tiedown provisions may be added if required by the equipment specification. A large cargo tiedown provision can be used as a substitute for a cargo bed or flatbed/flatrack cargo tiedown provision if the large cargo tiedown provision can accept 2-inch steel banding and meet the dimensional requirements of a cargo bed or flatbed/flatrack cargo tiedown provision, whichever one is being substituted.

4.6.2 Location.

a. Cargo bed tiedown provisions are recessed inside the walls of cargo compartments. They fold to provide a flush surface when not in use. Spacing of provisions shall be approximately 18 inches on center along each side and end of the cargo body of the vehicle, with spacing between provisions adjusted as necessary to avoid interference with vehicle structural members. Provisions on the side and end walls of cargo bodies shall be as close to the floor of the cargo body as practical. The center of each side and end tiedown provision shall be not more than 6 inches nor less than 4 inches from each of the four corners of the cargo bed/wall.

b. Flatbed/flatrack cargo tiedown provisions are located on the perimeter of the cargo bed so as not to increase the dimensions of the equipment. Spacing of provisions shall be approximately 18 inches on center along each side of the vehicle and at both ends of cargo bed, with spacing between provisions adjusted as necessary to avoid interference with vehicle structural members. The center of each side and end tiedown provision shall be located not more than 6 inches nor less than 4 inches from each of the four corners of the cargo bed/bulkhead.

c. Large cargo tiedown provisions shall be located at each end of the cargo bed/platform, two at the front and two at the rear. Each provision in a pair of provisions (front or rear) shall be equidistant from the centerline of the cargo bed/platform.

4.7 Freezing and jamming. All lifting, tiedown, and cargo tiedown provisions shall be designed to prevent the movable parts from freezing in place during cold weather or from jamming because of accumulations of mud, paint, rust and/or infrequent use. (Drain holes shall meet the requirements of CFR Title 49 for ammunition shipments.)

4.8 Stowable lifting provisions. "Hideaway" provisions, which are nonremovable parts of the equipment and can be stowed out of the way, are acceptable where other types of lifting eyes would interfere with loading and unloading of cargo, or to prevent sling interference during lifting. Stowed provisions shall meet all provision design requirements. If stowed provisions are covered, the cover shall be removed and provision unstowed without tools. Allowances must be made to stow the cover when the provisions are in use. The contractor shall provide instructions for the servicing of the retracting mechanism for stowable provisions.

4.9 Spreader bars. The use of spreader bars to meet the requirements of this standard is discouraged. To ensure maximum compatibility between military equipment and transportation systems, spreader bars, if required, should be integral to the design of the equipment and used during provision testing. Stowage location(s) shall be provided to ensure the spreader bars stay with the item. Spreader bars shall be basic issue item (BII) equipment. Openings for integral spreader bars shall meet the appropriate "D" dimension in figure 5. Spreader bars not integral to the system shall not be used unless allowed by the new equipment specification.

4.10 Computer aided engineering (CAE) structural analysis. Prior to all testing, the contractor must provide dimensional and material design data on the provisions and their surrounding structure to MTMCTEA or the appropriate service transportability agent. This data will be used to perform a structural analysis of the provisions. In lieu of providing the required design information, the contractor can perform a structural analysis and provide the results of the analysis for review and concurrence. Either the required data or the contractor's structural analysis results shall be provided to MTMCTEA or the appropriate service transportability agent at least 90 days prior to scheduled provision testing. The purpose of the structural analysis is to assess the risk of testing, thereby reducing the number of failures or possibly eliminating the test in acceptable cases. This will result in lower overall acquisition costs to materiel developers.

4.11 Deviations. Request for modifications/special considerations from the above requirements shall be identified and submitted to the appropriate service transportability agent. Requests shall be submitted as soon as the need is identified, to support early resolution. If not previously approved, a request shall be included in the data package submitted to materiel developers for source evaluation. Service agent approval for deviation is required prior to contract award.

5. **DETAILED REQUIREMENTS**

5.1 Strength of eyes and provisions. The load factors (LFs) in this section have been established to account for the dynamic loads likely to be encountered during highway, rail, marine, and air transport. Provisions meeting these strength requirements will be compatible with current transportation systems used for military deployments. LFs have been adopted for reasons of simplicity, convenience, economy in testing, and repeatability of test procedures and results. However, since statically applying the LFs cannot precisely reproduce the effects of many of the actual dynamic loads found in operations, factors such as characteristics of load application, load repetition, load reversal, and equipment life shall be considered in the design process. The designer shall also determine the amount, if any, by which the provision should exceed the design requirements of this section. Allowances shall be made for the physical and chemical properties of the material (for example, fatigue, corrosion and galvanic action because of dissimilar metals, and harsh environments) and for normal wear and tear during the expected life of the equipment.

5.1.1 Lifting provisions. Equipment with a helicopter EAT requirement shall meet the requirements of paragraphs 5.1.1.1 and 5.1.1.2. All other equipment shall meet the requirements of paragraph 5.1.1.2. Lifting provisions shall meet the requirements of paragraphs 5.1.1.1 and 5.1.1.2 at the item's GW. If the GW of the item of equipment exceeds the helicopter's lift capability, but can be reduced in weight to fall within the helicopter's lift capability, the GW (for para 5.1.1.1 only) will be based on the helicopter's maximum lift capability. The provisions shall meet the strength requirements when the equipment is being lifted by slings ranging from the minimum length for an equal length single apex sling assembly to those same slings attached to an 8-foot by 20-foot container spreader bar (fig 2). If there is sling interference with the equipment, the contact points on the equipment must have sufficient strength to withstand sling contact for both crane lifting and EAT. For crane lift, the minimum equal length single apex sling assembly as determined by Appendix B and a 2.3 load factor are used to determine compressive loads. For EAT, the sling lengths can vary and the load factors are determined by appendix A. Contact the Natick Research, Development and Engineering Center to determine appropriate sling lengths for determining EAT sling contact compressive loads.

5.1.1.1 For equipment with a helicopter EAT requirement. Each lifting provision, including the connecting structure, shall meet the following requirements:

a. A design limit load of not less than the lift point LF, calculated from appendix A procedures, times the static load. The static load is determined by a static lift test(s), based on Natick Research, Development and Engineering Center (NRDEC) provided rigging configuration, or by mathematical analysis. A sample problem that shows how to determine the required strength of the lifting provisions is in appendix B.

b. An ultimate load of not less than 1.5 times the design limit load.

c. The lifting provisions shall be tested for validation in accordance with paragraph 5.5 of this standard.

d. Equipment with a helicopter EAT requirement shall also meet MIL-STD-913.

5.1.1.2 Crane lifting requirements. Each lifting provision, including the connecting structure, shall meet the following requirements:

a. A design limit load of not less than 2.3 times the static load. The static load is determined by static lift test or by mathematical analysis, based on the minimum sling length for an equal length single apex sling assembly as defined by paragraph 4.1.2.2.c. A sample problem showing how to determine the required strength of the slinging provisions and sling lengths is in appendix B. The provision and connecting structural members must withstand the design limit load when the item of equipment is lifted by slings ranging from the minimum length for an equal length single apex sling assembly to these same slings attached to an 8-foot by 20-foot container spreader bar.

b. An ultimate load of not less than 1.5 times the design limit load.

c. The lifting provisions shall be tested for validation in accordance with paragraph 5.5 of this standard.

5.1.2 Equipment tiedown provisions. Each equipment tiedown provision, including the connection and the structural frame, shall withstand its proportionate share of the loadings shown in Table I.

TABLE I. **Load Requirements for equipment tiedown provisions.**

Design Limit Load	Direction of Load
4.0 times GW	Fore and Aft (Longitudinal axis of equipment)
2.0 times GW	Downward (Vertical axis of equipment)
1.5 times GW	Left and Right (Lateral axis of equipment)

Since the design limit load in the fore and aft direction is the largest, the principal direction of restraint for tiedown provisions shall be in this direction. These loads shall be applied statically and independently. The directional load (design limit load in each direction) shall be distributed among the tiedown eyes or provisions that would effectively resist motion along that axis. Distribution of the load among the tiedown provisions shall be based on using two provisions for restraint in both longitudinal directions (fore and aft), two provisions for restraint in both lateral directions (left and right), and four provisions for restraint in the vertical direction. A sample problem that shows how to determine the required strength of the tiedown provisions is in appendix C. No permanent deformation of the provision or other equipment structural components shall occur as a result of application of the loads to the tiedowns. The ultimate load that each tiedown provision can withstand shall not be less than 1.5 times the design limit load.

5.1.2.1 Option for equipment weighing more than 100,800 pounds. To meet the strength requirements of 5.1.2, equipment weighing more than 100,800 pounds can have two openings per provision that meet the dimensional and strength requirements for the next lower weight category (> 49,280 pounds to 100,800 pounds) in lieu of having one provision opening. Figure 7 is an example of a provision with two openings. Both openings of the provision will be tested simultaneously.

5.1.3 Multipurpose provisions. Each multipurpose provision shall meet the requirements of both lifting and equipment tiedown provisions in paragraphs 5.1.1 and 5.1.2.

5.1.4 Cargo tiedown provisions.

a. Each cargo bed tiedown provision and its supporting structure shall withstand the forces specified in table II in the vertical, longitudinal, and lateral directions. These loads are applied statically and independently.

TABLE II. **Load requirements for cargo bed tiedown provisions**.

	Lb	Lb	Lb
Load-carrying range of equipment	0 - 3,000	3,001 - 10,000	more than 10,000
Load-carrying capacity (design load) of **each** tiedown provison	2,500	5,000	10,000
Note: The load-carrying capacity of the cargo tiedown provisions do not have to match the load-carrying range of the equipment since there will be several provisions to restrain the load.			

The ultimate load each cargo tiedown provision can withstand shall not be less than 1.5 times the design limit load listed in table II.

b. Each flatbed/flatrack cargo tiedown provision and its supporting structure shall withstand a force in the vertical, longitudinal, and lateral directions, applied statically and independently, of 15,000 pounds. If the flatbed trailer or flatrack is issued with BII tiedown assemblies (chains, load binders, shackles, and so forth) with a safe working load greater than 15,000 pounds, the design limit load of the flatbed/flatrack cargo tiedown provision shall meet or exceed the safe working load of the number of anticipated tiedown assemblies to each provision (Title 49 CFR 393.102). The ultimate load that each cargo tiedown provision can withstand shall not be less than 1.5 times the design limit load.

c. To verify that cargo bed and flatbed/flatrack cargo tiedown provisions can accept 2-inch steel banding without causing tearing of the banding, a force equal to the corresponding load in table II shall be applied to the provision. Two-inch banding shall be used to apply the load.

d. Each large cargo tiedown provision and its supporting structure shall withstand its proportionate share of the loadings shown in table I. In this case, the GW is the maximum payload of the cargo bed, platform or flatrack.

5.2 Provision dimensions. To ensure compatibility and interoperability between lifting and tiedown provisions on military equipment and the transportation systems used for deployments, provision openings must be meet certain dimensional requirements. The provision openings must be within a range of dimensions to allow for commonly available hooks and tiedown devices to interface with the provisions.

5.2.1 Lifting, equipment tiedown, multipurpose and large cargo tiedown provisions. Lifting, equipment tiedown, multipurpose and large cargo tiedown provisions shall conform to the dimensions specified in figure 5.

5.2.2 Cargo bed tiedown provisions. Cargo bed tiedown provisions shall have openings of not less than 2 inches in diameter and shall have a thickness of not greater than three-fourths of an inch. The provisions shall have the capability to accept 2-inch steel banding without causing tearing of the banding. An example of an acceptable cargo bed tiedown provision is shown in figure 8.

5.2.3 Flatbed/flatrack cargo tiedown provisions. Flatbed/flatrack cargo tiedown provisions shall have openings of not less than 2 inches in diameter and shall have a thickness of not greater than 1 inch. The provisions shall have the capability to accept 2-inch steel banding without causing tearing of the banding. An example of an acceptable flatbed/flatrack cargo tiedown provision is shown in figure 8.

5.3 Directional capabilities of cargo tiedown provisions. Cargo tiedown provisions will be designed to optimize the interface between the cargo bed and the cargo tiedown apparatus.

5.3.1 Cargo bed tiedown provisions. Cargo bed tiedown provisions shall permit the cargo ring to rotate a minimum of 180° about its base and be functional at least 75° to either side of the true vertical in any rotational position (fig 9).

5.3.2 Flatbed/flatrack and large cargo tiedown provisions. Flatbed/flatrack and large cargo tiedown provisions shall translate a minimum of 90° from the vertical towards the center of the cargo bed/platform. Also, the provisions shall be functional at least 45° to either side of the vertical. For side-mounted provisions, the required movement will be in the fore and aft directions, and for end-mounted provisions, the required movement will be towards the left or right side of the equipment (fig 9).

5.4 Figures. Illustrations are not intended to preclude requirements that are otherwise specified in this standard or in the equipment specification.

5.5 Analysis and test considerations.

5.5.1 General.

a. For type I equipment, all lifting, tiedown, and cargo tiedown provisions shall be analyzed using CAE structural analysis tools prior to any testing. Either the contractor or MTMCTEA will perform this analysis. In cases where the structural analysis indicates that the provisions will clearly pass the test, actual physical testing will not be necessary. In cases where the structural analysis indicates that the provisions will clearly fail the test, a redesign of the provisions will be recommended to the contractor. If the structural analysis indicates that the provisions will marginally pass or fail the test, redesign or testing will be recommended to the contractor. MTMCTEA or the appropriate service transportability agent shall make the decision on using analysis results in lieu of actual physical testing. Whenever possible, such decisions will seek to reduce the overall cost impact based on sound risk/benefit analyses.

b. If testing is required, all lifting, tiedown, and cargo tiedown provisions shall be tested attached to the equipment. Testing may be accomplished using a frame assembly, provided all load-bearing structures (structural components in tension and compression) are included in the frame assembly. For test purposes, only wire rope, wire rope with a thimble loop, or a chain attached to the provision shall be used. Textile straps, such as nylon and polyester (Dacron) and synthetic ropes, shall not be used. The loads applied during testing shall not be less than the design limit load requirement and not more than 10 percent in excess.

5.5.2 Lifting provisions.

a. Prior to testing, the contractor shall provide the materiel developer, for submission to the appropriate Service transportability agent, design limit and ultimate loads for the provisions. The contractor shall also provide detailed drawings of the equipment, and any three dimensional computer-aided design/computer-aided engineering (3D CAD/CAE) models of the equipment, provisions, and their supporting structure. This information will be used to perform a CAE structural analysis to help identify and correct potential design deficiencies in the provisions and surrounding structure. In lieu of providing this information, the contractor can provide the results of their own CAE structural analysis.

b. The CAE structural analysis shall meet the following requirements:

(1) A simulated static pull to the required design limit load shall be performed on all provisions.

(2) The angles and loads of the simulated static pull shall be those loads and angles as determined by the methods specified in paragraphs 5.1.1.1.a and 5.1.1.2.a.

(3) A simulated static pull using the angles and loads that the provisions would experience when lifted with an 8-foot by 20-foot container spreader bar shall also be performed on the provisions.

(4) The load applied to each provision shall not be less than the required design limit load. (Note: For helicopter transport, the required design limit load will be based on the highest LF required in appendix A.)

(5) Failure is defined as any stress level determined by the analysis exceeding the yield strength of the provision material.

(6) If the structural analysis indicates that the provisions have the strength to withstand the loads applied to it, actual physical test will not be required. MTMCTEA or the appropriate service transportability agent will make this determination.

c. Physical testing, if required, shall meet the following requirements:

(1) A static pull to the required design limit load shall be conducted on all provisions; however, all provisions do not have to be tested at the same time.

(2) The angles and loads for the static pull shall be those loads and angles as determined by the methods specified in paragraphs 5.1.1.1.a and 5.1.1.2.a. If evaluations show that the provisions may fail when lifted by an 8-foot by 20-foot container spreader bar, an additional test using the container spreader bar, or equivalent, will be performed.

(3) The points used to restrain the equipment during testing shall be located so they do not interfere with or reduce the loading on the structural member next to the provisions.

(4) Loads in the sling legs shall be measured with an appropriate measuring device, such as a load cell or dynamometer.

(5) The load applied to each provision shall not be less than the required design limit load and shall be applied for not less than 90 seconds. (Note: For helicopter transport, the required design limit load will be based on the highest LF required in appendix A.)

(6) Failure is defined as any visible permanent deformation, yielding, or bending to the provision or other structural component. A possible failure indication during the initial material analysis shall be justification to use more detailed analysis and

testing methods (for example, calibrated measurements, finite element analysis, magnetic particle inspection, X-ray, fatigue testing, ultimate testing, and so forth). Cracks in welds will constitute test failure.

(7) The contractor shall provide a material analysis showing the ultimate load is not less than 1.5 times the required design limit load for the provisions.

5.5.3 Equipment and large cargo tiedown provisions.

a. Prior to testing, the contractor shall provide the materiel developer, for submission to the appropriate Service transportability agent, design limit and ultimate loads for the provisions. The contractor shall also provide detailed drawings of the equipment, and any 3D CAD/CAE models of the equipment, provisions, and their supporting structure. This information will be used to perform a CAE structural analysis to help identify and correct potential design deficiencies in the provisions and surrounding structure. In lieu of providing this information, the contractor can provide the results of their own CAE structural analysis.

b. The CAE structural analysis shall meet the following requirements:

(1) A simulated static pull to the required design limit load shall be performed on all provisions.

(2) The directional loads of the simulated static pull shall be those loads as determined by the methods specified in paragraph 5.1.2.

(3) The load applied in the longitudinal, vertical and lateral directions shall be applied statically and independently, and shall be not less than the required design limit load in each direction.

(4) Failure is defined as any stress level determined by the analysis exceeding the yield strength of the provision material.

(5) If the structural analysis indicates that the provisions have the strength to withstand the loads applied to it, actual physical testing will not be required. MTMCTEA or the appropriate Service transportability agent will make this determination.

c. Actual physical testing, if required, shall meet the following requirements:

(1) A static independent pull to the required design limit load shall be conducted on all tiedown provisions; however, all provisions do not have to be tested at the same time.

(2) Loads applied to each provision shall be measured with an appropriate measuring device, such as a load cell or dynamometer.

(3) The points used to apply the load to the equipment shall be located so they do not interfere with or reduce the loading on the structural member next to the tiedown provisions.

(4) Loads applied in the longitudinal, vertical, and lateral directions shall be applied statically and independently for not less than 6.0 seconds and shall be not less than the required design limit load in each direction.

(5) Failure is defined as any visible permanent deformation, yielding, or bending to the provision or other structural component. A possible failure indication during the initial material analysis shall be justification to use more detailed analysis and testing methods (for example, calibrated measurements, finite element analysis, magnetic particle inspection, X-ray, fatigue testing, ultimate testing, and so forth). Cracks in welds will constitute test failure.

(6) The contractor shall provide a material analysis showing the ultimate load is not less than 1.5 times the required design limit load for the provisions.

5.5.4 Multipurpose provisions. These provisions shall meet the analysis and test requirements of paragraphs 5.5.2 and 5.5.3.

5.5.5 Cargo bed and flatbed/flatrack cargo tiedown provisions.

a. Prior to testing, the contractor shall provide the materiel developer, for submission to the appropriate Service transportability agent, design limit and ultimate loads for the provisions. The contractor shall also provide detailed drawings of the equipment, and any 3D CAD/CAE models of the equipment, provisions, and their supporting structure. This information will be used to perform a CAE structural analysis to help identify and correct potential design deficiencies in the provisions and surrounding structure. In lieu of providing this information, the contractor can provide the results of their own CAE structural analysis.

b. The CAE structural analysis shall meet the following requirements:

(1) A simulated static pull to the required design limit load shall be performed on all provisions.

(2) The directional loads of the simulated static pull shall be those loads as determined by the methods specified in paragraph 5.1.2.

(3) The load applied in the longitudinal, vertical and lateral directions shall be applied statically and independently, and shall be not less than the required design limit load in each direction.

(4) Failure is defined as any stress level determined by the analysis exceeding the yield strength of the provision material.

(5) If the structural analysis indicates that the provisions have the strength to withstand the loads applied to it, actual physical test will not be required. MTMCTEA or the appropriate service transportability agent will make this determination.

c. Actual physical testing, if required, shall meet the following requirements:

(1) A static pull to the required design limit load shall be conducted on a selected sample of cargo tiedown provisions. Selection will be based on difference in provision design and mounting location.

(2) Loads applied to each provision shall be measured with a measuring device, such as a load cell or dynamometer.

(3) The points used to apply the load to the equipment shall be located so they do not interfere with or reduce the loading on the structural member next to the cargo tiedown provision.

(4) Loads applied in the vertical, longitudinal, and lateral directions shall be applied statically and independently for not less than 6.0 seconds and shall be not less than the required design limit load in each direction.

(5) Failure is defined as any visible permanent deformation, yielding, or bending to the provision or other structural component. A possible failure indication during the initial material analysis shall be justification to use more detailed analysis and testing methods (for example, calibrated measurements, finite element analysis, magnetic particle inspection, X-ray, fatigue testing, ultimate testing, and so forth). Cracks in welds will constitute test failure.

(6) The contractor shall provide a material analysis showing the ultimate load is not less than 1.5 times the required design limit load for the provisions.

(7) Banding loads shall be applied to the provision for not less than 6.0 seconds. The banding load shall not be less than the strength of the provisions as shown in table II. Tearing of the banding, as a result of the banding load being applied, will constitute failure.

5.6 Marking.

5.6.1 Shipping data plate. A shipping data plate shall be furnished and shall conform to A-A-50271. The silhouette of the equipment in transport configuration, which indicates the CG (of an empty vehicle if the item can carry a payload) along each axis and the location of the lifting and tiedown provisions shall be included on the data plate. Lifting and tiedown procedures shown on the data plate shall be approved by the appropriate Service transportability agent. Nomenclature characters shall not be less than

0.187 inch, and other characters shall not be less than 0.093 inch in height. The data plate shall be attached by screws, bolts, or rivets in a conspicuous location.

5.6.2 Identification. The identification of lifting, tiedown, or multipurpose provisions used for transport shall be stenciled or marked with decals in appropriate locations on the exterior of the equipment in letters not less than 1 inch in height. Interior cargo tiedown provisions do not have to be marked. Accessories resembling provisions for lifting or tiedown shall be located or designed to avoid mistaken use and marked as unacceptable for lifting or tiedown.

6. NOTES

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

6.1 Intended use. This standard covers the design and testing of slinging, tiedown, and cargo tiedown provisions.

6.2 Issue of DODISS. When this standard is used in acquisition, the issue of the DODISS applicable to the solicitation should be cited (para 2.1.1 and 2.1.2).

6.3 Associated Data Item Descriptions (DIDs). This standard is cited in DOD 5010.12-L, Acquisition Management Systems and Data Requirements Control List (AMSDL), as a source document for the following DID. When it is necessary to obtain the applicable data, this DID must be listed on the Contract Data Requirements List (DD Form 1423), except where DOD FAR Supplement exempts the requirement for a DD Form 1423.

Reference Paragraphs	DID Number	DID Title
5.5.2, 5.5.3, 5.5.5	DI-Pack-80880A	Transportability Report

The above DID was current as of the date of this standard. The current issue of the AMSDL must be researched to ensure that only current and approved DIDs are cited on the DD Form 1423.

6.4 Tiedown system. If a proposed rail tiedown procedure differs from that represented in MTMCTEA Pamphlet 55-19, Tiedown Handbook for Rail Movements, the materiel developer should obtain MTMCTEA concurrence prior to testing.

6.5 Subject term (keyword) listing:

Cables and chains, sling
Cables and chains, tiedown
Crane lifting
Eyes, lifting
Eyes, tiedown
Helicopter EAT
Provision, cargo tiedown
Provision, multipurpose
Provision, lifting
Pull test
Spreader bars
Static lift test

6.6 International interest. Certain provisions of this standard are the subject of international standardization agreements (QSTAG-328, ASCC Air Standard 44/21, STANAG-4062, and STANAG-3548). When an amendment, a revision, or a cancellation of this standard is proposed that 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.

6.7 Changes from previous issue. Marginal notations are not used in this revision to identify changes with respect to the previous issue because of the extensiveness of the changes.

6.8 Tailoring. This standard requires very little tailoring, but a few items should be decided and stated in the paragraph referring to MIL-STD-209 in the solicitation. These items are as follows:

a. Determine and state the equipment type defined in 1.3.2.

b. Specify whether or not the option in 4.1.3 is to be used.

c. Specify if helicopter EAT is required (see 5.1.1.1).

If it is known that an item cannot meet a requirement of MIL-STD-209J, contact MTMCTEA for assistance with tailoring your solicitation.

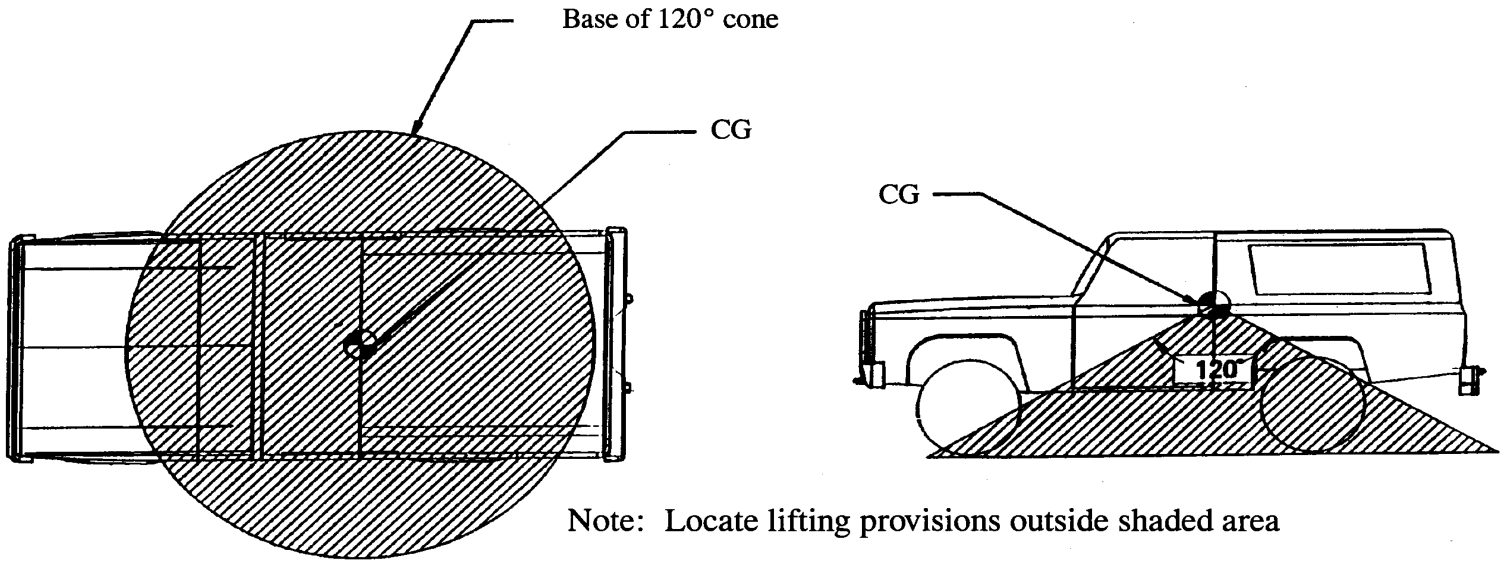


FIGURE 1. **Location of lifting provisions.**

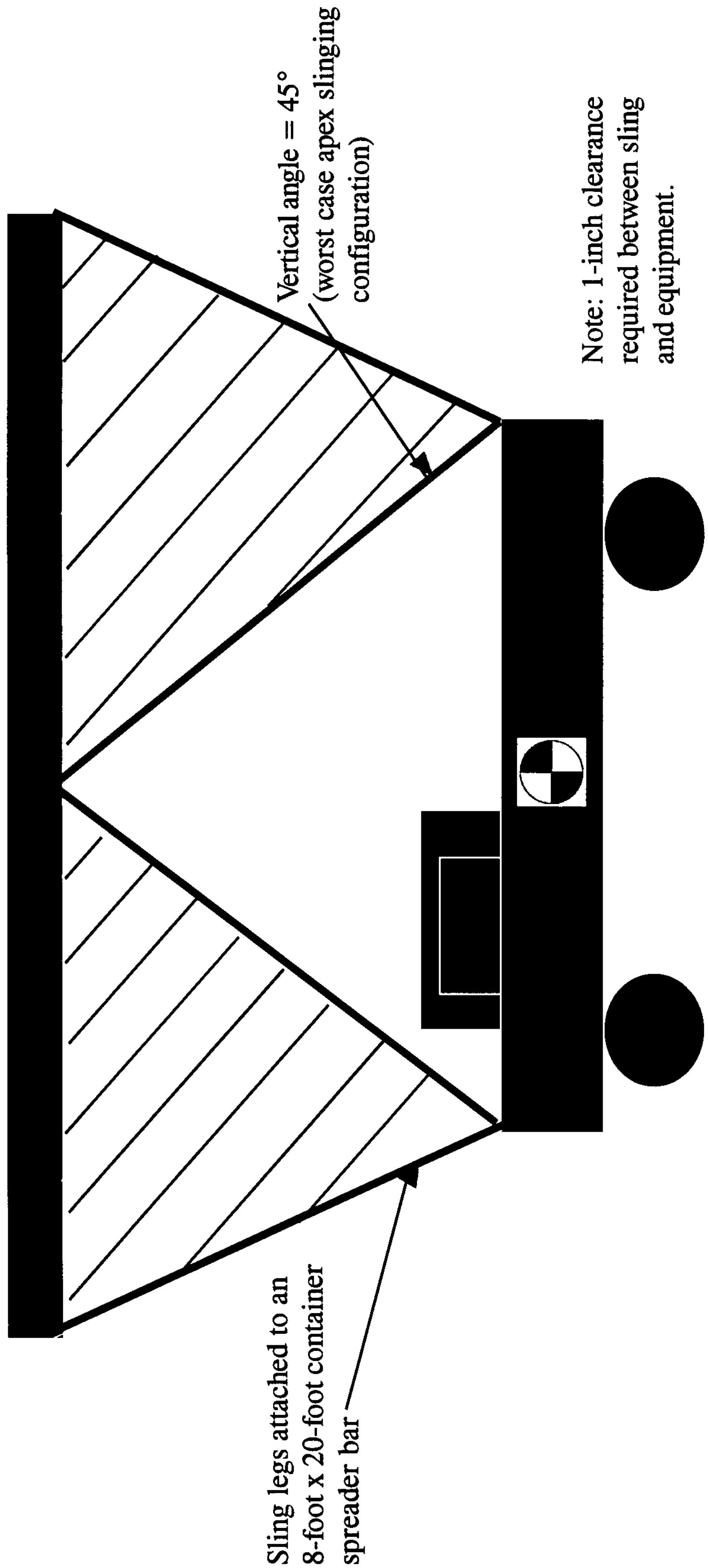


FIGURE 2. **Sling leg clearance requirements.**

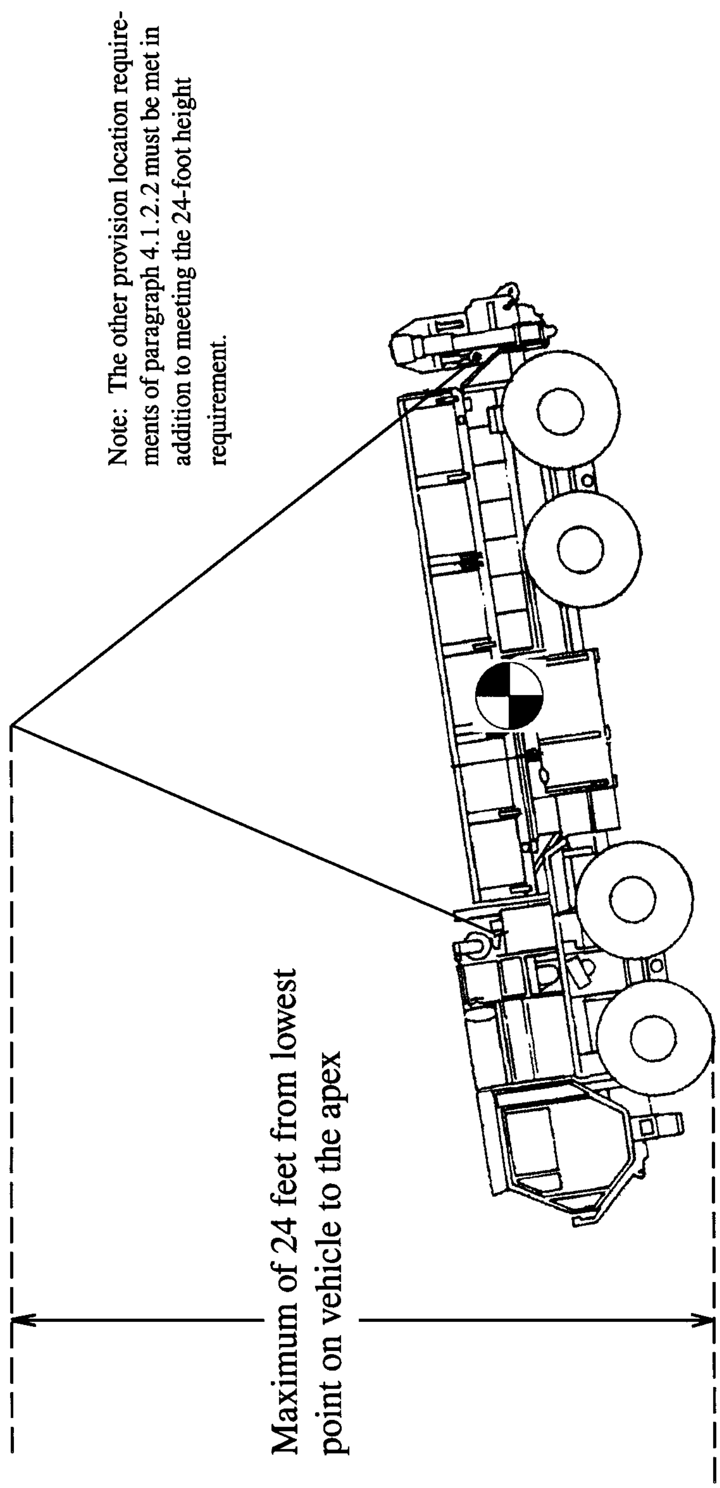


FIGURE 3. **Apex height.**

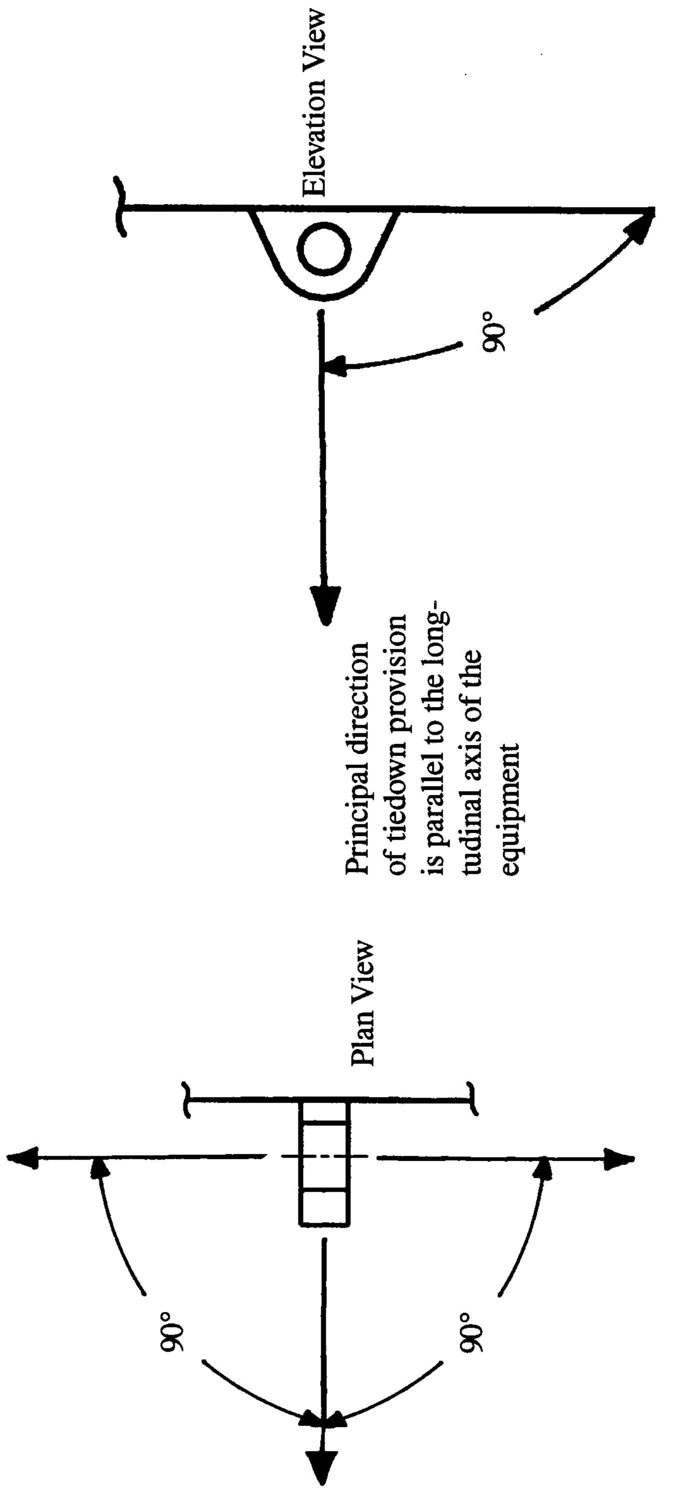


FIGURE 4. **Working angles for equipment tiedown provisions.**

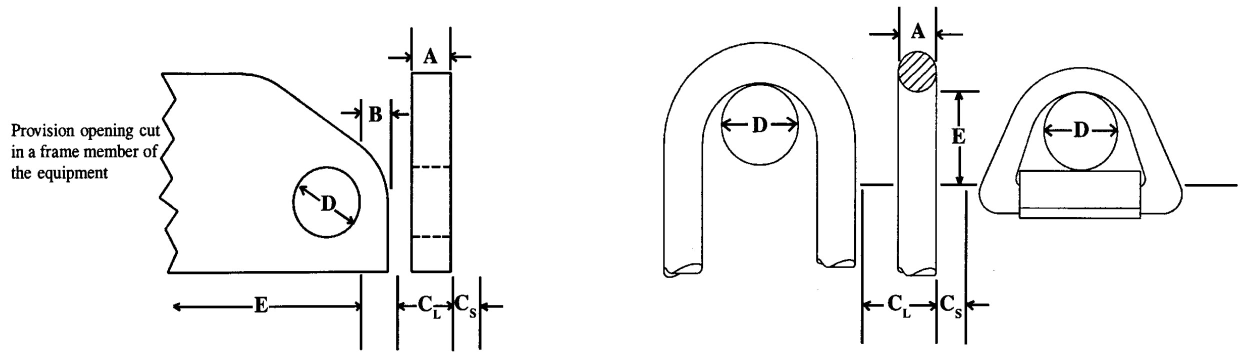


Table 1 - Design Criteria for Lifting, equipment tiedown, multipurpose and large cargo tiedown provisions.

Weight Range of equipment		Amax		Bmax		C_L min		C_S min		Dmax		Dmin		Emax		Emin	
LB	KG	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm	in.	mm
0 to 11,200	0 to 5,080	1	25	1	25	7	178	3	76	3.2	81	3	76	5	127	3	76
>11,200 to 22,400	>5,080 to 10,160	1.5	38	1.125	29	9	229	4	102	3.5	89	3	76	5	127	3	76
>22,400 to 49,280	>10,160 to 22,353	1.75	44	1.5	38	12	305	5	127	3.5	89	3	76	5	127	3.5	89
>49,280 to 100,800	>22,353 to 45,722	1.75	44	1.5	38	16	406	7	179	5.3	135	4.9	124	6	152	5	127
>100,800	>66,043	1.75	44	1.75	44	20	508	8	203	5.3	135	4.9	124	6	152	5.5	139

Note 1 - There shall be no interference or obstruction within the dimensions C_L and C_s that could interfere with engaging a shackle and pin in the provision. Either side of the provision may be used as the datum from which to measure C_L and C_s.

Note 2 - Provisions may be designed to swivel or rotate. When provisions are designed to swivel or rotate, dimension Dmin shall be met throughout the full range of motion.

FIGURE 5. **Lifting, equipment tiedown, multipurpose and large cargo tiedown provision openings and clearance dimensions.**

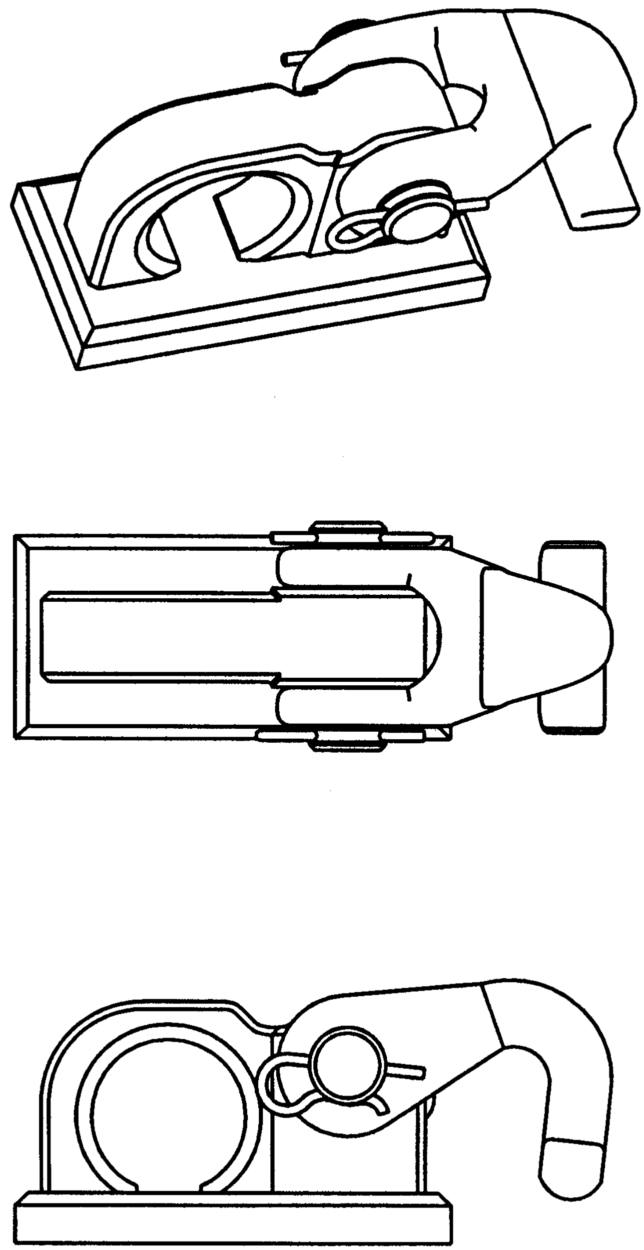
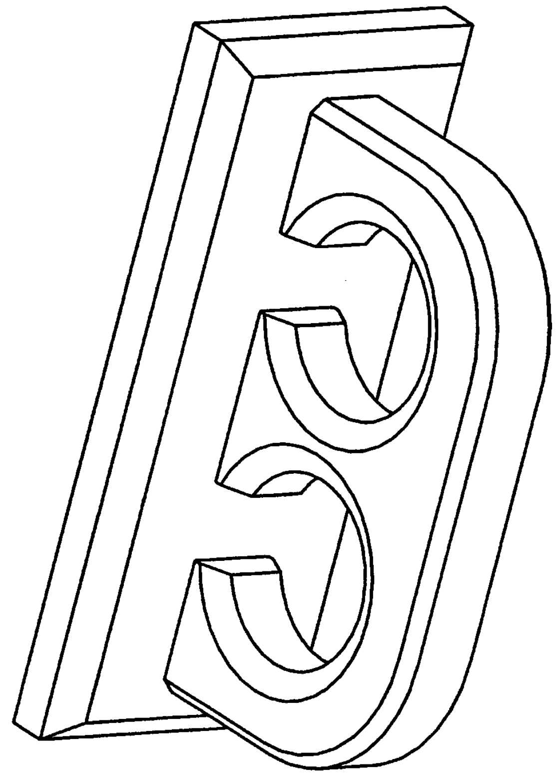
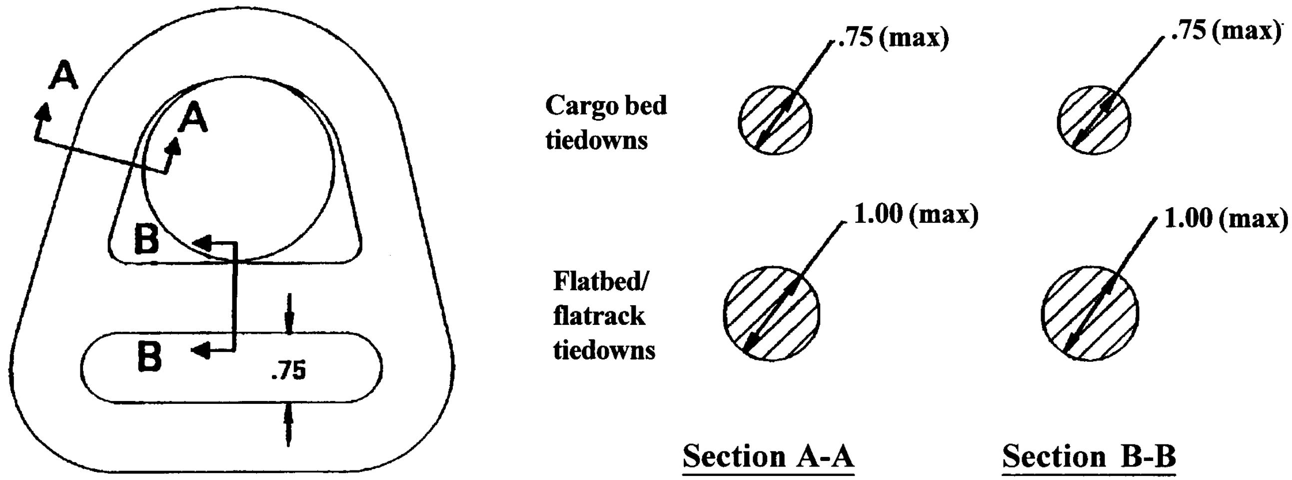


FIGURE 6. **Example of a nonremovable, dual-purpose provision.**



Note: Acceptable for equipment with a gross weight over 100,800 pounds only

FIGURE 7. **Example of a provision with two openings.**



Notes:
1. All dimensions are in inches.
2. Drawing not to scale.

FIGURE 8. **Required dimensions of cargo bed and flatbed/flatrack cargo tiedowns.**

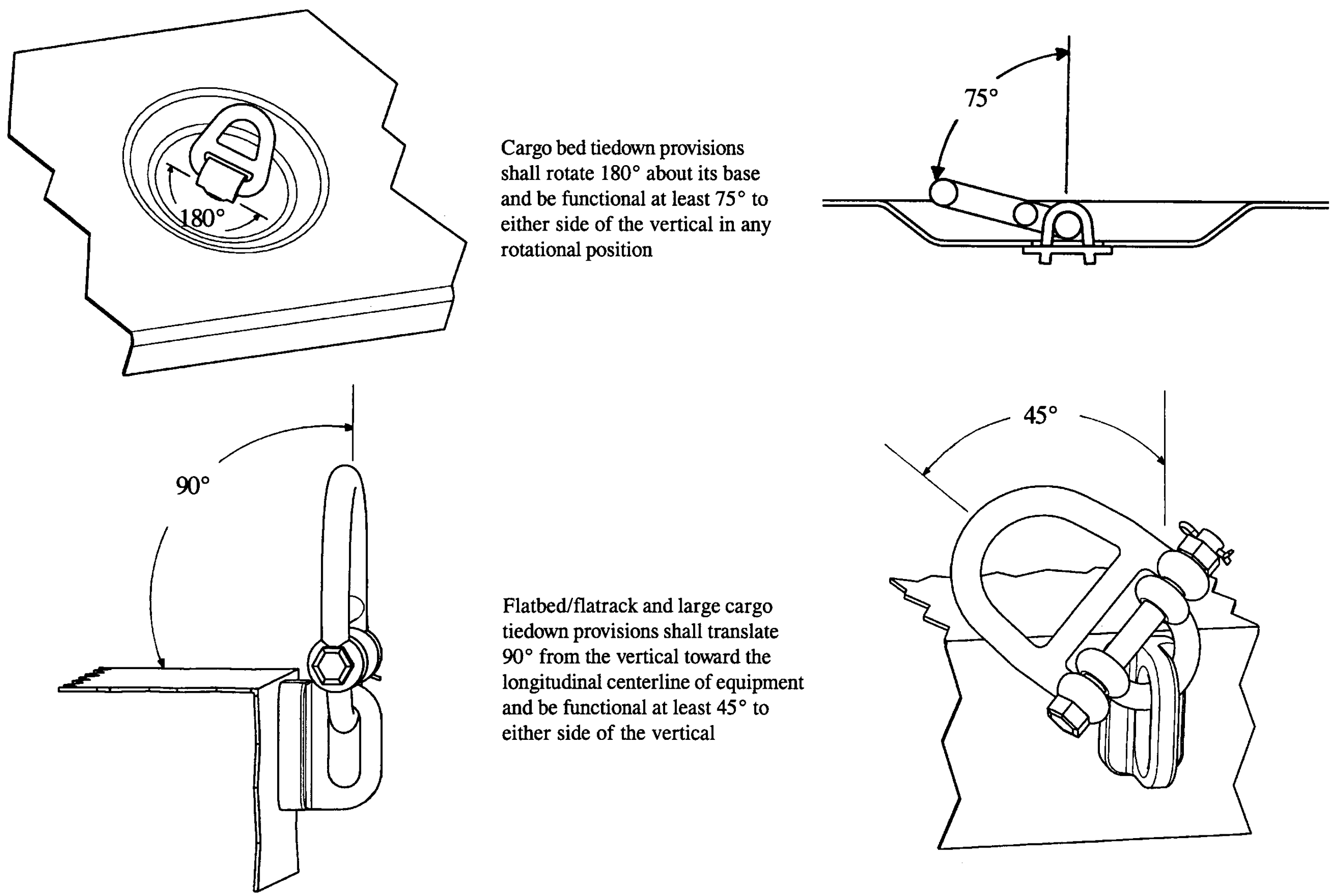


FIGURE 9. **Directional capabilities of cargo tiedown provisions.**

APPENDIX A

HELICOPTER EAT MATERIEL LIFT POINT LOAD FACTOR

A.1 GENERAL

A.1.1 Scope. This appendix provides the procedures for calculating the helicopter EAT materiel lift point load factor (LF).

A.2 APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

A.3 REQUIREMENTS

A.3.1 Determine the helicopter EAT materiel lift point LF. The helicopter EAT materiel lift point LF is used to calculate the design limit load for all materiel with a helicopter EAT requirement. The LF is calculated using the table below. The LF is a function of the helicopter EAT weight (EATWT) and the helicopter EATWT/maximum projected frontal area (MPFA) ratio, in accordance with the table below. The MPFA for a single-point load is the maximum area projected on a vertical plane as the item is rotated about a vertical axis through the aircraft hook; for dual-point or tandem loads, the maximum projected area on a vertical plane is in the direction of flight.

TABLE A-1. **Calculation of Materiel Lift Point LF**

EAT/MPFA (lb/sq ft)	EAT Weight (lb)	Load Factor
≤45	< 5,000	5.9
≤45	5,000 - 15,000	5.6
≤45	15,001 - 36,000	3.2 - [0.000038 x (EATWT - 15,000)] + 2.4
>45 but <60	< 5,000	3.5 + [0.16 x (60 - (EATWT/MPFA))]
>45 but <60	5,000 - 15,000	3.2 + [0.16 x (60 - (EATWT/MPFA))]
>45 but <60	15,001 - 36,000	3.2 - [0.000038 x (EATWT - 15,000)] + [0.16 x (60 - (EATWT/MPFA))]
≥60	< 5,000	3.5
≥60	5,000 - 15,000	3.2
≥60	15,001 - 36,000	3.2 - [0.000038 x (EATWT - 15,000)]

A.3.2 Cargo equipment. For items of equipment with cargo-carrying capability, the materiel lift point LF shall be calculated for the minimum and maximum possible helicopter EATWTs. Depending upon the weights, the lesser weight could have higher design limit load requirements. Thus, the design limit load shall be the greater value of the EATWT multiplied by the lift point LF.

APPENDIX B

SAMPLE PROBLEM FOR DETERMINING THE
REQUIRED STRENGTH OF THE LIFTING PROVISIONS

B.1 SCOPE

B.1.1 Scope. This appendix establishes a method for determining the required strength of the lifting provisions.

B.2 APPLICABLE DOCUMENTS

This section is not applicable to this appendix.

B.3 NOTATION

B.3.1 Symbols. The following letter symbols are used throughout this appendix:

D_a - lateral distance from CG to provision **a**, on a horizontal plane, in inches

D_b - lateral distance from CG to provision **b**, on a horizontal plane, in inches

D_c - lateral distance from CG to provision **c**, on a horizontal plane, in inches

D_d - lateral distance from CG to provision **d**, on a horizontal plane, in inches

D_{ab} - lateral distance from provision **a** to provision **b**, on a horizontal plane, in inches

D_{cd} - lateral distance from provision **c** to provision **d**, on a horizontal plane, in inches

GW - gross weight, in pounds

h_a - distance from provision **a** to the CG, on a horizontal plane, in inches

h_b - distance from provision **b** to the CG, on a horizontal plane, in inches

h_c - distance from provision **c** to the CG, on a horizontal plane, in inches

h_d - distance from provision **d** to the CG, on a horizontal plane, in inches

h_L - distance from the provisions to the CG, on the plane of the provisions, when the equipment is resting on a level surface, in inches

h_{at} - distance from provision **a** to the CG, on the plane of the provisions, when the equipment is lifted with equal length slings, in inches

h_{bt} - distance from provision **b** to the CG, on the plane of the provisions, when the equipment is lifted with equal length slings, in inches

h_{ct} - distance from provision **c** to the CG, on the plane of the provisions, when the equipment is lifted with equal length slings, in inches

h_{dt} - distance from provision **d** to the CG, on the plane of the provisions, when the equipment is lifted with equal length slings, in inches

H_a - apex height, from the ground to the top of the equal length single apex sling assembly, in inches

H_f - height from the ground to the front provisions, **a** and **b**, in inches

H_r - height from the ground to the rear provisions, **c** and **d**, in inches

H_t - vertical distance between the horizontal plane and the plane of the provisions, on the CG axis, in inches

K - vertical distance between the CG and the sling apex when the equipment is lifted with equal length slings, in inches

L - longitudinal distance between front and rear provisions, measured on a horizontal plane, in inches

L_f - longitudinal distance from front provisions, **a** and **b**, to the CG, on a horizontal plane, in inches

L_r - longitudinal distance from front provisions, **c** and **d**, to the CG, on a horizontal plane, in inches

L_x - longitudinal distance from the rear provisions to the intersection of K_L with the plane of the provisions, when the item is resting on a level surface, in inches

L_y - longitudinal distance from the rear provisions to the intersection of K_L with the plane of the provisions, when the item is resting on a level surface, in inches

L_{xy} - longitudinal distance between the front provisions and the rear provisions on the plane of the provisions, in inches

R_a - static load on sling **a**, in pounds

R_b - static load on sling **b**, in pounds

R_c - static load on sling **c**, in pounds

R_d - static load on sling **d**, in pounds

S - sling leg length, in inches

SA - angle of the slings, with respect to the plane of the provisions, in degrees

T_a - design limit load of provision **a**, in pounds

T_b - design limit load of provision **b**, in pounds

T_c - design limit load of provision **c**, in pounds

T_d - design limit load of provision **d**, in pounds

U_a - ultimate load requirement of provision **a**, in pounds

U_b - ultimate load requirement of provision **b**, in pounds

U_c - ultimate load requirement of provision **c**, in pounds

U_d - ultimate load requirement of provision **d**, in pounds

V_a - vertical load at provision **a**, in pounds

V_b - vertical load at provision **b**, in pounds

V_c - vertical load at provision **c**, in pounds

V_d - vertical load at provision **d**, in pounds

VA_a - angle between the sling leg attached to provision **a** and the vertical when the equipment is lifted with equal length slings, in degrees

VA_b - angle between the sling leg attached to provision **b** and the vertical when the equipment is lifted with equal length slings, in degrees

VA_c - angle between the sling leg attached to provision **c** and the vertical when the equipment is lifted with equal length slings, in degrees

VA_d - angle between the sling leg attached to provision **d** and the vertical when the equipment is lifted with equal length slings, in degrees β - angle of the plane of the provisions with respect to the horizontal, in degrees

Δ - difference in height between the front and rear provisions, when the equipment is resting on a level surface, in inches

B.4 GENERAL REQUIREMENTS

None

B.5 DETAILED REQUIREMENTS

B.5.1 Example. See figure B-1. The equations in this example have been established such that the free-body diagram is valid when the front and rear provisions are at the same height or if they are at different heights. This example demonstrates the case when the rear provisions are higher than the front provisions.

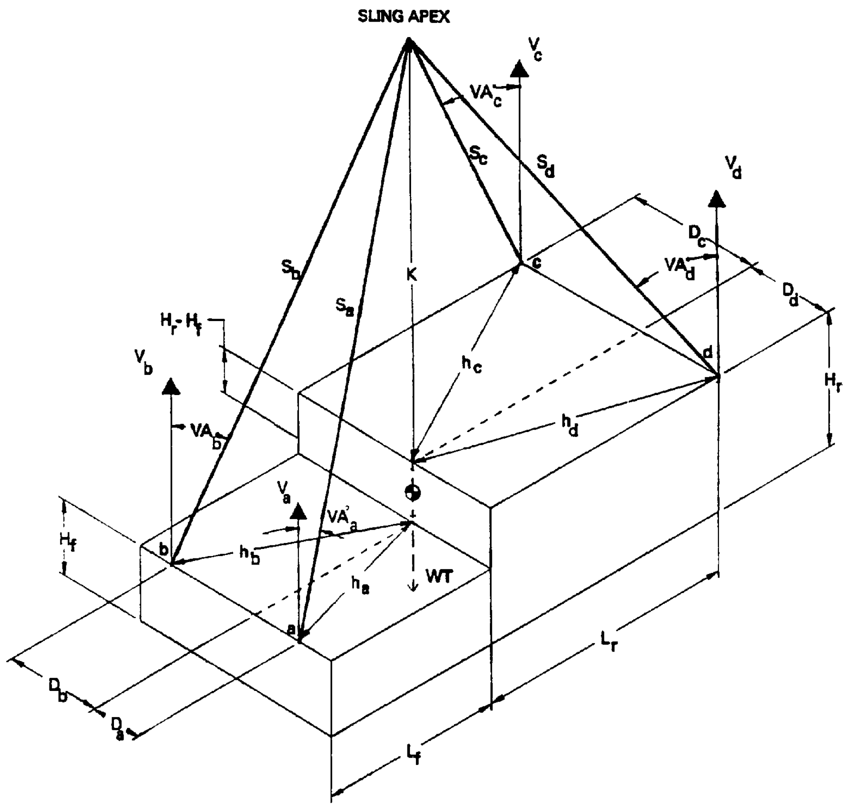


FIGURE B-1. MIL-STD-209J Free Body Diagram

GW = 10,000 lb

L_f = 56 in., L_r = 79 in. H_f = 24 in., H_r = 33 in.

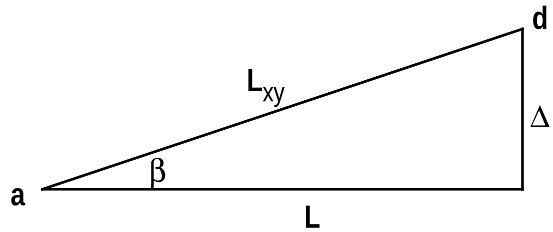
D_a = 16 in., D_b = 17 in., D_c = 34 in., D_d = 33 in.

Basic assumptions: 1) The front and rear provision pairs are symmetrical about the longitudinal centerline of the equipment, and 2) The vertical CG is on a plane containing all provisions, referred to as the "plane of the provisions." These assumptions are made merely to simplify the load calculations. The second assumption in no way negates the location requirements of paragraph 4.1.2.2. For stability reasons, the lift provisions should be located above the vertical CG.

B.5.1.1 Determine β, the angle of the plane of the provisions with respect to the horizontal, and L_{xy}.

$$\mathbf{H_r - H_f = \Delta = 33 - 24 = 9 \text{ inches}}$$

$$\mathbf{L = L_f + L_r = 56 + 79 = 135 \text{ inches}}$$



$$\mathbf{TAN(\beta) = \frac{\Delta}{L} \Rightarrow \beta = TAN^{-1}\left(\frac{\Delta}{L}\right)}$$

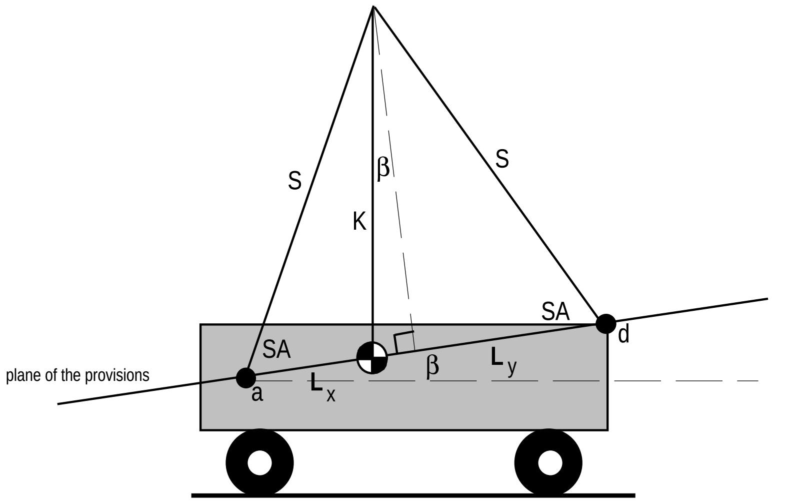
$$\mathbf{\beta = TAN^{-1}\left(\frac{9}{135}\right) = 3.8^\circ}$$

$$\mathbf{COS(\beta) = \frac{L}{L_{xy}} \Rightarrow L_{xy} = \frac{L}{COS(\beta)}}$$

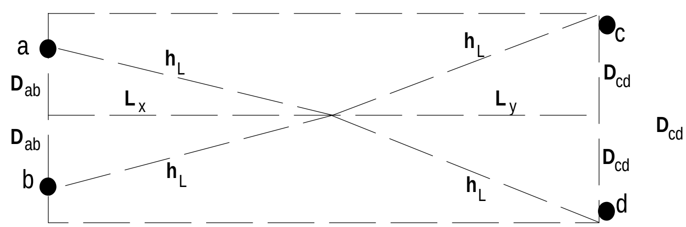
$$\mathbf{L_{xy} = \frac{135}{COS(3.8^\circ)} = 135.3 \text{ inches}}$$

B.5.1.2 Determine h_L and S (these are constant for all slings).

Elevation view of equipment when resting on a level surface



Plan view of the plane of the provisions



$$\mathbf{D_{ab}} = \frac{\mathbf{D_a + D_b}}{\mathbf{2}} = \frac{\mathbf{16 + 17}}{\mathbf{2}} = \mathbf{16.5\ inches}$$

$$\mathbf{D_{cd}} = \frac{\mathbf{D_c + D_d}}{\mathbf{2}} = \frac{\mathbf{34 + 33}}{\mathbf{2}} = \mathbf{33.5\ inches}$$

To solve for h_L, we have three equations and three unknowns.

$$\mathbf{h_L} = \sqrt{\mathbf{D_{ab}^2 + L_x^2}}$$

$$\mathbf{h_L} = \sqrt{\mathbf{D_{cd}^2 + L_y^2}}$$

$$\mathbf{L_x = L_{xy} - L_y}$$

By substituting the third equation into the first equation, we can solve for L_y.

$$\mathbf{h_L = \sqrt{D_{ab}^2 + (L_{xy} - L_y)^2} = \sqrt{D_{cd}^2 + L_y^2}}$$

$$\mathbf{L_y = \frac{D_{ab}^2 - D_{cd}^2 + L_{xy}^{\ 2}}{2L_{xy}} = \frac{16.5^2 - 33.5^2 + 135.3^2}{2(135.3)} = 64.5 \text{ inches}}$$

And then solve for L_x and h_L.

$$\mathbf{L_x = L_{xy} - L_y = 135.3 - 64.5 = 70.8 \text{ inches}}$$

$$\mathbf{h_L = \sqrt{D_{ab}^2 + L_x^2} = \sqrt{16.5^2 + 70.8^2} = 72.7}$$

SA is set to 45° to determine the sling length for a single apex sling assembly.

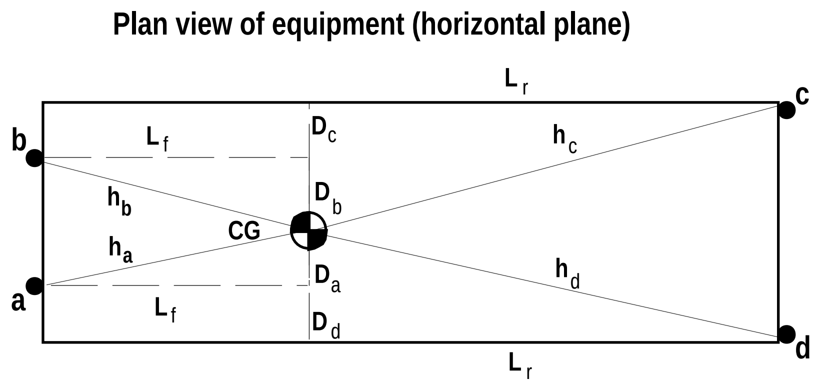
$$\mathbf{COS(45°) = \frac{h_L}{S} \ ; \quad S = \left[\frac{h_L}{COS(45°)}\right] = \left[\frac{72.7}{.707}\right] = 102.8 \text{ inches} = 8.6 \text{ feet}}$$

Since S is shorter than 12 feet, the sling leg length for an equal length single apex sling assembly is set to 12 feet. This is most likely the shortest size of slings that will be available in the field to lift an item.

$$\mathbf{\therefore S = 12 \text{ feet} = 144 \text{ inches for all slings}}$$

$$\mathbf{\text{and } COS(SA) = \frac{h_L}{S} \ ; \ SA = COS^{-1}\left[\frac{h_L}{S}\right] = COS^{-1}\left[\frac{72.7}{144}\right] = 59.7°}$$

B.5.1.3 Determine h_a, h_b, h_c, h_d, h_{at}, h_{bt}, h_{ct}, h_{dt}, and K.

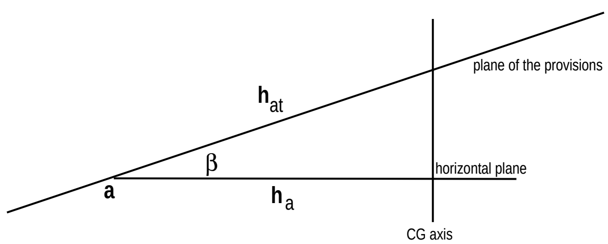


$$h_a = \sqrt{L_f^2 + D_a^2} = \sqrt{56^2 + 16^2} = 58.2 \text{ inches}$$

$$h_b = \sqrt{L_f^2 + D_b^2} = \sqrt{56^2 + 17^2} = 58.5 \text{ inches}$$

$$h_c = \sqrt{L_r^2 + D_c^2} = \sqrt{79^2 + 34^2} = 86.0 \text{ inches}$$

$$h_d = \sqrt{L_r^2 + D_d^2} = \sqrt{79^2 + 33^2} = 85.6 \text{ inches}$$



$$\text{COS}(\beta) = \frac{h_a}{h_{at}}$$

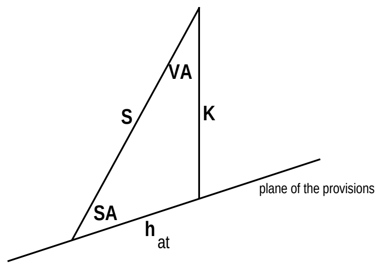
$$h_{at} = \frac{h_a}{\text{COS}(\beta)} = \frac{58.2}{\text{COS}(3.8^\circ)} = 58.3 \text{ inches}$$

The same equation can be applied to the other provisions.

$$COS(\beta) = \frac{h_b}{h_{bt}} \quad ; \quad h_{bt} = \frac{h_b}{COS(\beta)} = \frac{58.5}{COS(3.8^\circ)} = 58.6 \text{ inches}$$

$$COS(\beta) = \frac{h_c}{h_{ct}} \quad ; \quad h_{ct} = \frac{h_c}{COS(\beta)} = \frac{86.0}{COS(3.8^\circ)} = 86.2 \text{ inches}$$

$$COS(\beta) = \frac{h_d}{h_{dt}} \quad ; \quad h_{dt} = \frac{h_d}{COS(\beta)} = \frac{85.6}{COS(3.8^\circ)} = 85.8 \text{ inches}$$



$$K^2 = S^2 + h_{at}^2 - 2Sh_{at}COS(SA)$$

$$K = \sqrt{S^2 + h_{at}^2 - 2Sh_{at}COS(SA)}$$

$$K = \sqrt{144^2 + 58.3^2 - 2(144)(58.3)COS(59.7^\circ)} = 125.2 \text{ inches}$$

B.5.1.4 Determine VA, the angle of the slings with the vertical when the equipment is lifted.

$$h_{at}^2 = S^2 + K^2 - 2SKCOS(VA_a)$$

$$VA_a = COS^{-1}\left[\frac{S^2 + K^2 - h_{at}^2}{2SK}\right] = COS^{-1}\left[\frac{144^2 + 125.2^2 - 58.3^2}{2(144)(125.2)}\right] = 23.7^\circ$$

$$VA_b = COS^{-1}\left[\frac{S^2 + K^2 - h_{bt}^2}{2SK}\right] = COS^{-1}\left[\frac{144^2 + 125.2^2 - 58.6^2}{2(144)(125.2)}\right] = 23.9^\circ$$

$$VA_c = COS^{-1}\left[\frac{S^2 + K^2 - h_{ct}^2}{2SK}\right] = COS^{-1}\left[\frac{144^2 + 125.2^2 - 86.2^2}{2(144)(125.2)}\right] = 36.5^\circ$$

$$VA_d = COS^{-1}\left[\frac{S^2 + K^2 - h_{dt}^2}{2SK}\right] = COS^{-1}\left[\frac{144^2 + 125.2^2 - 85.8^2}{2(144)(125.2)}\right] = 36.3°$$

B.5.1.5 Determine the vertical force component, V, at each provision.

Based on the assumption that the CG lies on the plane of the provisions, the horizontal distance between the provisions and the vertical axis of the CG when the equipment is lifted with equal length slings is proportional to the distance between the provisions and the vertical axis of the CG when the equipment is resting on a level surface. Therefore, the following equations apply:

$$V_a = \frac{L_r}{L_r + L_f} \text{ x } \frac{D_b}{D_a + D_b} \text{ x GW}$$

$$= \frac{79}{56 + 79} \text{ x } \frac{17}{16 + 17} \text{ x } 10{,}000 = 3{,}015 \text{ lb}$$

$$V_b = \frac{L_r}{L_r + L_f} \text{ x } \frac{D_a}{D_a + D_b} \text{ x GW}$$

$$= \frac{79}{56 + 79} \text{ x } \frac{16}{16 + 17} \text{ x } 10{,}000 = 2{,}837 \text{ lb}$$

$$V_c = \frac{L_f}{L_r + L_f} \text{ x } \frac{D_d}{D_c + D_d} \text{ x GW}$$

$$= \frac{56}{56 + 79} \text{ x } \frac{33}{33 + 34} \text{ x } 10{,}000 = 2{,}043 \text{ lb}$$

$$V_d = \frac{L_f}{L_r + L_f} \text{ x } \frac{D_c}{D_c + D_d} \text{ x GW}$$

$$= \frac{56}{56 + 79} \text{ x } \frac{34}{33 + 34} \text{ x } 10{,}000 = 2{,}105 \text{ lb}$$

B.5.1.6 Determine the static load, R, for each sling leg.

$$R_a = \frac{V_a}{COS(VA_a)} = \frac{3{,}015}{COS(23.7^\circ)} = 3{,}293 \text{ lb}$$

$$R_b = \frac{V_b}{COS(VA_b)} = \frac{2{,}837}{COS(23.9^\circ)} = 3{,}103 \text{ lb}$$

$$R_c = \frac{V_c}{COS(VA_c)} = \frac{2{,}043}{COS(36.5^\circ)} = 2{,}541 \text{ lb}$$

$$R_d = \frac{V_d}{COS(VA_d)} = \frac{2{,}105}{COS(36.3^\circ)} = 2{,}612 \text{ lb}$$

B.5.1.7 Determine the required design limit load, T. For items of equipment without helicopter EAT requirements, the materiel lift point LF is 2.3. For items of equipment with helicopter EAT requirements, the materiel lift point LF is calculated using appendix A. The helicopter EAT materiel lift point LF is a function of helicopter EATWT and the helicopter EATWT/MPFA ratio. If the equipment has a cargo-carrying capability, the materiel lift point LF shall be calculated for the minimum and maximum helicopter EATWTs.

For demonstration purposes, assume that this item of equipment has a helicopter EAT and crane lift requirement and an MPFA of 105 square feet. Thus, the EATWT/MPFA ratio (10,000 ÷ 105) equals 95.24 pounds per square foot. Using appendix A, we find the materiel lift point LF for helicopter EAT is 3.2. Since this value is greater than the 2.3 materiel lift point LF required for crane lifting, 3.2 will be used.

$$T_a = R_a \times LF = 3{,}293 \times 3.2 = 10{,}538 \text{ lb}$$

$$T_b = R_b \times LF = 3{,}103 \times 3.2 = 9{,}930 \text{ lb}$$

$$T_c = R_c \times LF = 2{,}541 \times 3.2 = 8{,}131 \text{ lb}$$

$$T_d = R_d \times LF = 2{,}612 \times 3.2 = 8{,}358 \text{ lb}$$

B.5.1.8 Determine the required ultimate load, U.

$$U_a = T_a \times 1.5 = 10{,}538 \times 1.5 = 15{,}807 \text{ lb}$$

$$U_b = T_b \times 1.5 = 9{,}930 \times 1.5 = 14{,}895 \text{ lb}$$

$$U_c = T_c \times 1.5 = 8{,}131 \times 1.5 = 12{,}197 \text{lb}$$

$U_d = T_d$ x 1.5 = 8,358 x 1.5 = 12,537 lb

B.5.1.9 Testing Requirements.

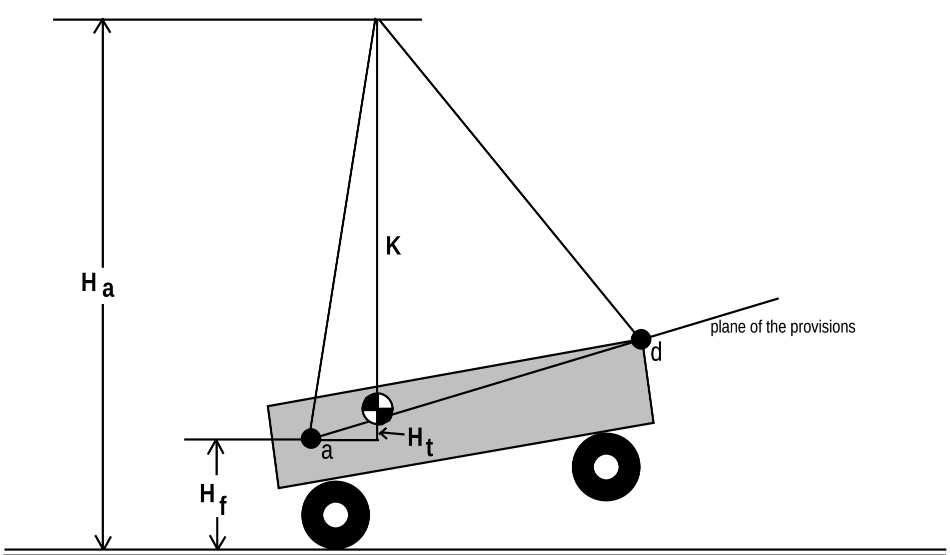
TABLE B-1. **Lift Test Requirements**.

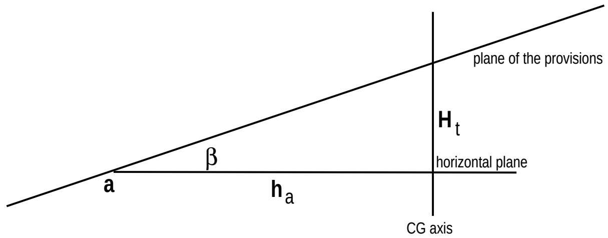
Location	Angle of Pull (from the vertical, in degrees)	Sling Leg Length (inches)	Design Limit Load (lb)	Ultimate Load (lb)
Front Right Provision a	**23.7°**	**144**	**10,538**	**15,807**
Front Left Provision b	**23.9°**	**144**	**9,930**	**14,895**
Rear Left Provision c	**36.5°**	**144**	**8,131**	**12,197**
Rear Right Provision d	**36.3°**	**144**	**8,358**	**12,537**

B.5.1.10 Determine the apex height, H_a.

The height of the apex equals the height of the lowest provisions, plus the vertical difference between the horizontal plane and the plane of the provisions, plus the vertical distance between the CG and the apex, K.

Elevation view of equipment when lifted with equal length slings





$$\mathbf{H_a = H_f + H_t + K}$$

$$\mathbf{TAN(\beta) = \frac{H_t}{h_a}}$$

$$\mathbf{H_t = TAN(\beta)(h_a) = TAN(3.8^\circ)(58.2) = 3.9\ inches}$$

$$\mathbf{H_a = 24 + 3.9 + 125.2 = 153.1\ inches = 12.8\ feet}$$

This is less 24 feet and therefore meets the apex height requirements of paragraph 4.1.2.2.e.

APPENDIX C

SAMPLE PROBLEM FOR DETERMINING THE REQUIRED STRENGTH OF THE TIEDOWN PROVISIONS

C.1 SCOPE

C.1.1 Scope. This appendix establishes a method for determining the required strength of the tiedown provisions.

C.2 APPLICABLE DOCUMENTS. This section is not applicable to this appendix.

C.3 NOTATION

C.3.1 Symbols.

T_L - design limit load in longitudinal direction, in pounds

U_L - ultimate load in longitudinal direction, in pounds

T_V - design limit load in vertical direction, in pounds

U_V - ultimate load in vertical direction, in pounds

T_S - design limit load in lateral direction, in pounds

U_S - ultimate load in lateral direction, in pounds

S_1 - lateral distance from CG to provision 1, in inches

S_2 - lateral distance from CG to provision 2, in inches

S_3 - lateral distance from CG to provision 3, in inches

S_4 - lateral distance from CG to provision 4, in inches

L_1 - longitudinal distance from CG to provision 1, in inches

L_2 - longitudinal distance from CG to provision 2, in inches

L_3 - longitudinal distance from CG to provision 3, in inches

L_4 - longitudinal distance from CG to provision 4, in inches

GW - gross weight, in pounds.

C.4 REQUIREMENTS

C.4.1 Example.

GW = 20,000 lb

$S_1 = 5$	$S_2 = 10$	$S_3 = 5$	$S_4 = 10$
$L_1 = 15$	$L_2 = 15$	$L_3 = 10$	$L_4 = 10$

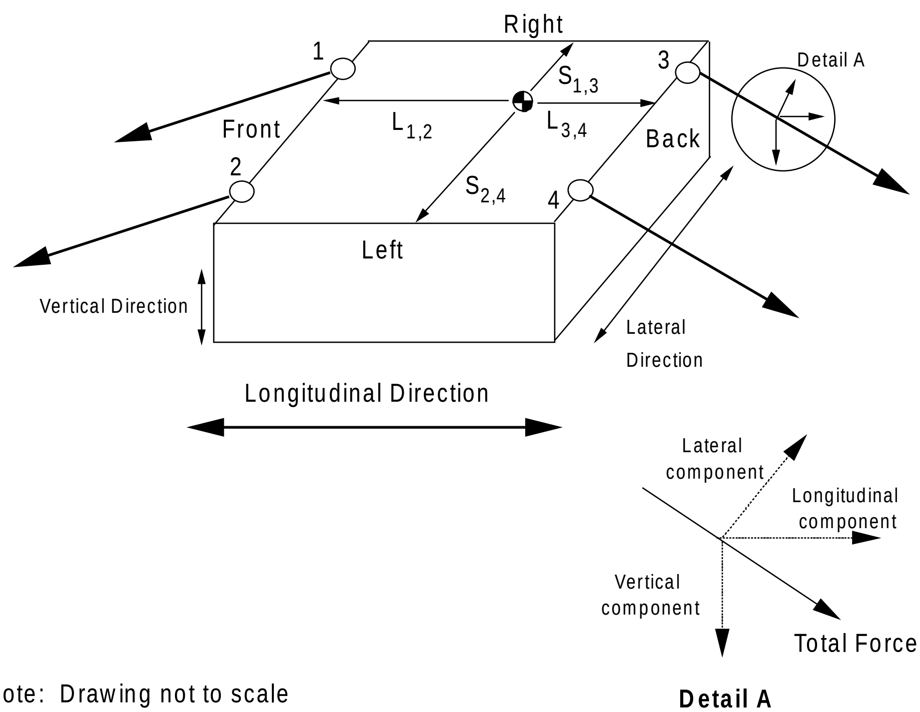


Figure C.1 Example of a tiedown procedure

This example does not represent a particular item, but rather the way tiedown provisions will be used based on their locations. All four provisions will be used to restrain items in the longitudinal, vertical, and lateral directions. Provisions will restrain forces in only one longitudinal or lateral direction.

C.4.1.1 Minimum required longitudinal design and ultimate loads. The longitudinal inertia force acting through the CG is:

4 x GW = 4 x 20,000 lb = 80,000 lb

Assume the inertia force will be balanced/restrained by the longitudinal components of the applicable tiedown provisions to restrict the movement of the item in the forward and aft directions.

a. To restrict movement in the forward direction, two provisions can be used:

$$\mathbf{T_{3L} + T_{4L} = 80{,}000\ lb}$$

For this example, the provisions are not located symmetrically about the CG so the proportionate share of the load that is applied to each provision is not equal and is as follows:

$$T_{3L} = \frac{S_4 \times (T_{3L} + T_{4L})}{(S_3 + S_4)} = \frac{10 \times 80{,}000}{(5 + 10)} = 53{,}333\ lb$$

$$T_{4L} = \frac{S_3 \times (T_{3L} + T_{4L})}{(S_3 + S_4)} = \frac{5 \times 80{,}000}{(5 + 10)} = 26{,}667\ lb$$

b. To restrict movement in the aft direction, two provisions can be used:

$$\mathbf{T_{1L} + T_{2L} = 80{,}000\ lb}$$

For this example, the provisions are not located symmetrically about the CG so the proportionate share of the load that is applied to each provision is not equal and is as follows:

$$T_{1L} = \frac{S_2 \times (T_{1L} + T_{2L})}{(S_1 + S_2)} = \frac{10 \times 80{,}000}{(5 + 10)} = 53{,}333\ lb$$

$$T_{2L} = \frac{S_1 \times (T_{1L} + T_{2L})}{(S_1 + S_2)} = \frac{5 \times 80{,}000}{(5 + 10)} = 26{,}667\ lb$$

Ultimate load requirements (1.5 x design limit load) are:

Forward $\mathbf{U_{3L} = 1.5 \times T_{3L} = 1.5 \times 53{,}333\ lb = 80{,}000\ lb}$

$\mathbf{U_{4L} = 1.5 \times T_{4L} = 1.5 \times 26{,}667\ lb = 40{,}000\ lb}$

Aft $\mathbf{U_{1L} = 1.5 \times T_{1L} = 1.5 \times 53{,}333\ lb = 80{,}000\ lb}$

$$U_{2L} = 1.5 \text{ x } T_{2L} = 1.5 \text{ x } 26{,}667 \text{ lb} = 40{,}000 \text{ lb}$$

C.4.1.2 Minimum required vertical design and ultimate loads. The vertical inertia force acting through the CG is:

$$2 \text{ x GW} = 2 \text{ x } 20{,}000 \text{ lb} = 40{,}000 \text{ lb}$$

It should be assumed that this force will be restrained by the vertical force components of all four tiedown provisions against upward movement of the item.

$$T_{1V} + T_{2V} + T_{3V} + T_{4V} = 40{,}000 \text{ lb}$$

For this example, the provisions are not located symmetrically about the CG so the proportionate share of the load that is applied to each provision is not equal and is as follows:

$$T_{1V} = \frac{S_2}{(S_1 + S_2)} \text{ x } \frac{L_3}{(L_1 + L_3)} \text{ x } (T_{1V} + T_{2V} + T_{3V} + T_{4V})$$

$$T_{1V} = \frac{10}{(5 + 10)} \text{ x } \frac{10}{(15 + 10)} \text{ x } 40{,}000 = 10{,}667 \text{ lb}$$

$$T_{2V} = \frac{S_1}{(S_1 + S_2)} \text{ x } \frac{L_4}{(L_2 + L_4)} \text{ x } (T_{1V} + T_{2V} + T_{3V} + T_{4V})$$

$$T_{2V} = \frac{5}{(5 + 10)} \text{ x } \frac{10}{(15 + 10)} \text{ x } 40{,}000 = 5{,}333 \text{ lb}$$

$$T_{3V} = \frac{S_4}{(S_3 + S_4)} \text{ x } \frac{L_1}{(L_1 + L_3)} \text{ x } (T_{1V} + T_{2V} + T_{3V} + T_{4V})$$

$$T_{3V} = \frac{10}{(5 + 10)} \text{ x } \frac{15}{(15 + 10)} \text{ x } 40{,}000 = 16{,}000 \text{ lb}$$

$$T_{4V} = \frac{S_3}{(S_3 + S_4)} \text{ x } \frac{L_2}{(L_2 + L_4)} \text{ x } (T_{1V} + T_{2V} + T_{3V} + T_{4V})$$

$$T_{4V} = \frac{5}{(5 + 10)} \text{ x } \frac{15}{(15 + 10)} \text{ x } 40{,}000 = 8{,}000 \text{ lb}$$

each provision must withstand a vertical force (required design limit load) of 10,000 pounds applied in the downward direction. Ultimate load requirements (1.5 x design limit load) are:

$$\mathbf{U_{1V} = 1.5 \times T_{1V} = 1.5 \times 10{,}667 = 16{,}000\ lb}$$

$$\mathbf{U_{2V} = 1.5 \times T_{2V} = 1.5 \times 5{,}333 = 8{,}000\ lb}$$

$$\mathbf{U_{3V} = 1.5 \times T_{3V} = 1.5 \times 16{,}000 = 24{,}000\ lb}$$

$$\mathbf{U_{4V} = 1.5 \times T_{4V} = 1.5 \times 8{,}000 = 12{,}000\ lb}$$

C.4.1.3 Minimum required lateral design limit and ultimate loads. The lateral inertia force acting through the CG is:

$$\mathbf{1.5 \times GW = 1.5 \times 20{,}000\ lb = 30{,}000\ lb}$$

It should be assumed that this force will be restrained by the lateral force components of the tiedown provisions toward the left and right.

a. To restrict movement toward the right, two provisions can be used:

$$\mathbf{T_{2S} + T_{4S} = 30{,}000\ lb}$$

For this example, the provisions are not located symmetrically about the CG so the proportionate share of the load that is applied to each provision is not equal and is as follows:

$$\mathbf{T_{2S} = \frac{L_4 \times (T_{2S} + T_{4S})}{(L_2 + L_4)} = \frac{10 \times 30{,}000}{(15 + 10)} = 12{,}000\ lb}$$

$$\mathbf{T_{4S} = \frac{L_2 \times (T_{2S} + T_{4S})}{(L_2 + L_4)} = \frac{15 \times 30{,}000}{(15 + 10)} = 18{,}000\ lb}$$

b. To restrict movement toward the left, two provisions can be used:

$$\mathbf{T_{1S} + T_{3S} = 30{,}000\ lb}$$

For this example, the provisions are not located symmetrically about the CG so the proportionate share of the load that is applied to each provision is not equal and is as follows:

$$\mathbf{T_{1S} = \frac{L_3 \; x \left(T_{1S} + T_{3S}\right)}{\left(L_1 + L_3\right)} = \frac{10 \; x \; 30{,}000}{(15 + 10)} = 12{,}000 \; lb}$$

$$\mathbf{T_{3S} = \frac{L_1 \; x \left(T_{1S} + T_{3S}\right)}{\left(L_1 + L_3\right)} = \frac{15 \; x \; 30{,}000}{(15 + 10)} = 18{,}000 \; lb}$$

Ultimate strength requirements (1.5 x design limit load) are:

<u>right</u> $\mathbf{U_{2S} = T_{2S} \; x \; 1.5 = 1.5 \; x \; 12{,}000 \; lb = 18{,}000 \; lb}$

$\mathbf{U_{4S} = T_{4S} \; x \; 1.5 = 1.5 \; x \; 18{,}000 \; lb = 27{,}000 \; lb}$

<u>left</u> $\mathbf{U_{1S} = T_{1S} \; x \; 1.5 = 1.5 \; x \; 12{,}000 \; lb = 18{,}000 \; lb}$

$\mathbf{U_{3S} = T_{3S} \; x \; 1.5 = 1.5 \; x \; 18{,}000 \; lb = 27{,}000 \; lb}$

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a. NAME Jennifer L. Napiecek	b. TELEPHONE *(Include Area Code)* (1) Commercial (757) 599-1647 (2) AUTOVON 927-4646
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