

INCH-POUND

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DEPARTMENT OF DEFENSE

INTERFACE STANDARD FOR LIFTING AND TIEDOWN PROVISIONS



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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 lifting, 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 system available for military movements. Changes incorporated in this revision include the addition of a new type of provision to the standard, supplemental air transport tiedown provisions. This revision also redefines the definitions for the types of equipment that require provisions, and combines cargo bed tiedowns and flatbed/flatrack tiedowns into one type of provision that is simply called "cargo tiedown" provisions. Additionally, this revision of the standard has been reformatted so that it is easier to find the specific requirements for each type of provision covered under this standard.

3. The following service points of contact can provide assistance with questions concerning this military standard:

U.S. Army - SDDCTEA (for questions concerning interpreting this standard, and on highway, rail, and marine transport), dpemail@tea.army.mil, (757) 599-1109.

U.S. Air Force - ASC/ENFC (ATTLA) (for questions concerning transport on Air Force fixed wing aircraft), ATTLA@wpafb.af.mil, (937) 255-2330.

U.S. Navy/Marine Corps (for questions concerning transport on Navy/Marine Corps aircraft), (301) 342-9392 (internal transport), (732) 323-2578 (external transport).

U.S. Army - Natick (for questions concerning Helicopter Sling Load (HSL) and internal transport on U.S. Army helicopters), (508) 233-5289.

4. Comments, suggestions, or questions on this document should be addressed to Director, Surface Deployment and Distribution Command Transportation Engineering Agency (SDDCTEA), ATTN: SDTE-DPE, 720 Thimble Shoals Blvd, Suite 130, Newport News, VA 23606-4537 or emailed to DPEmail@tea.army.mil. Since contact information can change, you may want to verify the currency of this address information using the ASSIST Online database at <http://assist.daps.dla.mil>.

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1. SCOPE

1.1 Coverage.

This standard establishes dimensional limits, design considerations, positioning requirements, and strength requirements for lifting (to include helicopter sling load (HSL)) 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 internal cargo tiedown provisions on helicopters and fixed-wing aircraft, and cargo equipment and containers/flatracks built to International Organization for Standardization (ISO) standards and meeting the requirements for Conventions for Safe Containers (CSC) certification. However, ISO corner castings are not acceptable as a substitute for lifting and tiedown provisions on equipment not having CSC certification.

1.1.2 Military equipment for helicopter sling loading.

Although the design of lifting provisions is covered in this standard, items of equipment requiring helicopter sling loading 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 re-procurements weighing more than 500 pounds, and any removed components from such equipment weighing more than 500 pounds, as noted above in paragraph 1.1.

b. Modified equipment, when the modifications result in changes to lifting or tiedown requirements (for example, provision relocation, item weight increase, shift in center of gravity, or the addition of something to the equipment that interferes with lifting or tiedown), or when the modified equipment was not previously equipped with lifting and tiedown provisions that meet the requirements of this standard.

1.3 Equipment types.

Equipment is classified as follows:

Type I. All equipment issued to Table of Organization and Equipment (TOE) units (for example, combat, tactical and tactical support vehicles, armored carriers, self-propelled artillery, tanks, recovery vehicles, semi-trailers, trailers, trucks, construction equipment, and helicopters).

Type II. Equipment can be classified as Type II equipment only if the specification explicitly states that the equipment qualifies as Type II equipment for the purpose of meeting this standard. If a statement to this effect is not contained in the specification, then the equipment is Type I equipment. In general, Type II equipment will be equipment that is not TOE equipment (for example, unmodified materials handling equipment and commercial construction equipment, and items that are shipped unboxed or uncrated and lifted separately as individual units).

2. APPLICABLE DOCUMENTS

2.1 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 paragraph 6.2).

SPECIFICATIONS

FEDERAL

A-A-50271 Plate, Identification

RR-C-271 Chains and Attachments, Welded and Weldless

STANDARDS

DEPARTMENT OF DEFENSE

MIL-STD-913 Requirements for the Certification of Sling Loaded Military Equipment for External Transportation by Department of Defense Helicopters.

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

MIL-STD-1366 Interface Standard for Transportability Criteria

(Unless otherwise indicated, copies of above specifications and standards are available from the Documentation Automation and Production Service, Building 4/D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, phone number (215) 697-6257, or <http://assist.daps.dla.mil/online/start.>)

2.2 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 of these documents are those current on the date of 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, or <http://bookstore.gpo.gov.>)

2.3 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 restrictive requirement will take precedence. Additionally, illustrations do not supercede requirements that are otherwise specified in this standard or in the equipment specification.

3. DEFINITIONS

3.1 Cargo tiedown provision.

A padeye, fixture, or attachment integral to the cargo areas of trucks and trailers, flatbed trailers, or flatracks (used as a demountable truck or trailer bed) for securing cargo or accessories (see Figure 1).

3.2 Container spreader bar.

Material handling equipment specifically designed for lifting standard American National Standards Institute/International Organization for Standardization (ANSI/ISO) containers.

3.3 Design limit load.

The applied force, or maximum probable force, that a provision, including its connecting structural members, will be subjected to in its most severe transport environment. For lifting, the design limit load is the static load times the load factor (LF). For equipment tiedown, the design limit load is 4.0 times the gross weight in the longitudinal direction, 2.0 times the gross weight in the vertical direction, and 1.5 times the gross weight in the lateral direction.

3.4 Equipment.

The item that requires provisions.

3.5 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 restraint purposes during shipment (see Figure 1).

3.6 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 considered as payload and included in the gross weight. The GW equals the Gross Vehicle Weight Rating (GVWR) or the maximum projected weight of the equipment, whichever is greater.

3.7 Gross Vehicle Weight Rating (GVWR).

The unloaded vehicle weight, including all fluids, and its maximum payload (to include the weight of the crew), where the payload weight is based upon the manufacturer's rating of the vehicle's structural capability.

3.8 Helicopter flight testing.

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

3.9 Helicopter sling loading (HSL).

A mode of transportation by which an item(s) is suspended beneath a rotary wing aircraft (including tilt-rotor aircraft) for the purpose of transporting the item(s).

3.10 Helicopter sling load weight (HSLWT).

The specified weight of the item to be transported by helicopter sling loading. HSLWT is used to calculate the HSLWT to Maximum Projected Frontal Area (MPFA) ratio and the corresponding materiel lift point load factor (see Appendix A).

3.11 Largo cargo tiedown provision.

A padeye, fixture, or attachment integral to a cargo area on a vehicle used for securing large, heavy items (see Figure 1).

3.12 Lifting provision.

An integral part of the equipment, commonly called a padeye, lug, eye, ring, or attachment. A lifting provision provides a means of attaching a sling to the equipment for safe lifting (see Figure 1).

3.13 Multipurpose provision.

A single provision that meets the requirements of this standard for both lifting and equipment tiedown (see Figure 1).

3.14 Permanent deformation.

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

3.15 Plane of the provisions.

A geometric plane connecting the centers of all lifting provisions of an item of equipment. The “plane of the provisions” will only be a horizontal plane if the height of the front and rear provisions is the same (see appendix B for a pictorial of the “plane of the provisions”).

3.16 Static lift test.

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

3.17 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.

3.18 Supplemental air transport tiedown provision.

A padeye, fixture, or attachment used in addition to the equipment tiedown provisions for securing equipment on fixed-wing aircraft (see Figure 1).

3.19 Ultimate load.

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

3.20 Yield load.

The force at which a provision, including its connecting structural members, exhibits permanent deformation after the force is removed. The yield load must be greater than the design limit load.

4. GENERAL REQUIREMENTS

4.1 Restraint of Item.

The tiedown provisions shall provide the entire restraint of the item without any other restraint such as blocking, vehicle brakes, or other added material.

4.2 Surface of provisions.

The material edges shall be rounded (minimum of 1/8" radius to round cross-section) or chamfered (minimum of 1/16" x 1/16"), and smoothed to prevent cutting or damage to the lifting or tiedown chains.

4.3 Shackles.

Shackles shall not be used as lifting, equipment tiedown or multipurpose provisions unless they meet the requirements of an alloy, safety (bolt-pin) anchor shackle in RR-C-271D, and the nut is secured by tack welding. If the Working Load Limit (WLL) of the shackle is higher than what is required by RR-C-271D, then the shackle may be labeled with the higher WLL. The resulting provision shall meet all requirements of this standard.

4.4 Hub and axle attachments.

Wheel hubs and axles shall not be used as lifting or equipment tiedown provisions.

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 2 shows an example of an acceptable dual purpose provision that does not require removal of the provision. For cargo tiedown provisions that have bolts and nuts as their primary components, the nuts must be welded onto the bolts to prevent them from being disassembled by hand, with simple tools, or from vibrating loose during their life cycle.

4.6 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. If drain holes are used in the provisions, they shall meet the requirements of CFR Title 49 for ammunition shipments.

4.7 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 in this standard. 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. If a provision loses some of its strength capacity in its stowed position, it shall be made inaccessible so that it cannot be misused. If tools or locking pins are used to employ the stowed provisions, a suitable means must be provided to prevent the loss of these tools or pins.

4.8 Spreader bars.

The use of spreader bars to meet the requirements of this standard is not allowed unless approved by SDDCTEA or the appropriate service transportability agent. Stowage location(s) shall be provided to ensure the spreader bars stay with the item and they shall be basic issue item (BII) equipment. Designers should consider using cable guides or reinforcement of sling contact points on equipment as an alternative to requiring spreader bars. Cable guide openings for accepting slings shall meet the appropriate "Dmin" dimension in Figure 3. If required, spreader bars or cable guides shall be used during provision testing.

4.9 Deviations.

Request for modifications/special considerations from any requirements in this standard shall be identified and submitted to SDDCTEA or 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 selection and evaluation. Approval by SDDCTEA or the service transportability agent for a deviation from the requirements in this standard is required prior to contract award.

4.10 Strength of Provisions.

The load factors (LFs) in section 5 have been established to account for the dynamic loads encountered during highway, rail, marine, and USAF fixed wing air transport. Provisions meeting these strength requirements will be compatible with current transportation systems and techniques 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 LFs are a minimum requirement for meeting this standard and do not preclude the designer from making the provisions with a higher strength than required. The designer should make allowances 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.

4.11 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 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. For the required dimensions, see Figure 3.

4.12 Supplemental air transport tiedown provisions.

Efficient use of airlift dictates that equipment be designed for tiedown in the least

floor space possible and that tiedown provisions are compatible with aircraft restraint systems. To accomplish this, equipment weighing over 10,000 pounds that requires transport on USAF cargo aircraft shall be equipped with supplemental air transport tiedown provisions. The requirement for supplemental air transport provisions is in addition to meeting the requirements for equipment tiedown provisions used for other modes of transport. See paragraph 5.6 for the detailed requirements of supplemental air transport tiedown provisions.

4.13 Testing.

A baseline Non-Destructive Test (NDT) of the welds on the provisions and the connecting structure around the provisions shall be performed prior to applying paint to the equipment, and prior to any provision testing. All 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, a shackle, or a chain attached to the provision shall be used. The loads applied during testing shall not be less than the design limit load requirement. When field experience shows that the provisions are being deformed during transport, analysis and retesting of the provisions shall be performed to determine the weakness of the provisions. If the equipment can be transported in two orientations, then the provisions must meet the requirements of this standard and tested in both orientations.

4.14 Transport on Navy/Marine Corps aircraft.

Internal transport on Navy/Marine Corps aircraft require restraint above that required for other modes of transport. See appendix D for further guidance in designing for restraint aboard these transportation assets.

4.15 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 and shall require the approval of SDDCTEA or the appropriate service transportability agent. If holes are used as tiedown provisions, they shall be formed in the main structural members and shall meet all of the requirements of Figure 3. The location of points used for lifting and tiedown shall be shown on the data plate as required in paragraphs 5.7.1 and 5.7.2.

4.16. Large cargo tiedown provisions.

Equipment with a payload capability greater than 5,000 pounds shall be equipped with large cargo tiedown provisions. A "large cargo tiedown provision" can be used as a substitute for a "cargo tiedown provision" if the large cargo tiedown provision can meet the requirements of both types of provisions (see paragraphs 5.4 and 5.5).

5. DETAILED REQUIREMENTS

5.1 Lifting provisions.

5.1.1 Number.

Equipment shall have four lifting provisions to ensure interoperability between transported military equipment and lifting devices commonly used in the transportation environment. Lifting sling sets and ISO container spreader bars available at ports are typically equipped with four locations for lifting. If equipment is sectionalized for shipping, this requirement applies to each section and to the equipment when assembled. For type II equipment, the equipment shall have four selected points that can be used for lifting by attaching hooks or shackles.

5.1.2 Location.

Lifting provisions shall be located such that:

a. The equipment can be lifted using an equal length single apex sling assembly, as defined in this paragraph, without incurring damage to the equipment or the slings. 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. This is done because the sling sets typically available for lifting are 12 feet long, or longer. The minimum sling length shall be used for testing (see 5.1.5). Appendix B gives an example of how to determine the minimum sling length and the required loads for testing.

b. Not less than 1 inch of clearance should be maintained between the equipment and the sling cables, chains, or the rope portion of helicopter slings. The 1-inch clearance requirement applies when the equipment is lifted with the minimum equal length sling legs (see 5.1.2.a), with sling angles ranging from a 45° single apex sling assembly (this angle will be more than 45° if the spacing of the provisions dictates the use of 12 foot slings (see 5.1.2.a), and if the weight of the equipment is 67,200 pounds or less, to those same sling legs attached to a 20-foot ISO container spreader bar (Figure 4)). When a sling leg 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 to prevent permanent deformation of any part of the equipment, and that contact will not adversely affect the material of the sling device.

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

d. Maximum accessibility to the provision is maintained.

e. Orientation of the provision shall be such that an attaching device (hook or shackle), 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.

f. Height of provisions shall be between 2 and 6 feet, measured from the ground when the equipment is resting on a level surface, unless an integral means for reaching the provisions is provided.

g. Dynamic stability is required during crane lifting and helicopter sling loading. When possible, 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 (Figure 5).

h. When lifting with equal length slings, it is preferable that the resulting angle of lift be as close to level as possible. In most lifting situations, altering sling length to achieve a level lift is NOT an option, so the equipment shall be capable of being lifted at the resulting angle when using equal length slings.

i. When suspended, the overall height of the equipment and attached minimum length single apex sling assembly shall not exceed a height of 24 feet above the lowest extremity of the equipment (Figure 6).

5.1.3 Strength.

Equipment with a HSL requirement shall meet the strength requirements of paragraph 5.1.3.1. All other equipment shall meet the strength requirements of paragraph 5.1.3.2.

5.1.3.1 For equipment with a helicopter/tiltrotor sling load requirement and a crane lift requirement.

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

a. A crane lift 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, using the item's GW and the minimum sling length for an equal length single apex sling assembly (as defined by paragraph 5.1.2.a). A sample problem showing how to determine the required strength of the lifting provisions and sling lengths is in appendix B. The provision and connecting structural members must withstand the design limit load when the equipment is lifted by slings ranging from the minimum length for an equal length single apex sling assembly, and if the equipment weighs 67,200 pounds or less, to

these same slings attached to a 20-foot ISO container spreader bar. If there is sling interference with the equipment, the contact points on the equipment must have sufficient strength to withstand the compressive loads caused by sling contact at the design limit load.

b. An HSL 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) or by mathematical analysis, based on the item's GW and a specified rigging configuration provided by the U.S. Army Soldier Systems Center . 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 used to determine the static load and design limit load will be based on the helicopter's maximum lift capability. If there is sling interference with the equipment, the contact points on the equipment must have sufficient strength to withstand the compressive loads caused by sling contact at the design limit load.

c. An ultimate load of not less than 1.5 times the crane lift and HSL design limit loads.

d. The lifting provisions shall be tested for validation in accordance with paragraph 5.1.5 of this standard.

e. Equipment with a HSL requirement shall also meet the requirements of MIL-STD-913.

f. Items requiring sling load at speeds exceeding 130 knots require higher strength lifting provisions. The V-22 is the first aircraft capable of these higher speeds. Testing is ongoing, but preliminary analysis has indicated that the provision strength required may be four times the static load. Lifting provisions on equipment that is being designed for HSL by the V-22 must be designed with these higher strength requirements in mind. Contact the Navy/Marine Corps point of contact listed in the forward of this standard for additional information.

5.1.3.2 For equipment with only a crane lift requirement.

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, using the item's GW and the minimum sling length for an equal length single apex sling assembly (as defined by paragraph 5.1.2.a) A sample problem showing how to determine the required strength of the lifting 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, and if the equipment weighs 67,200 pounds or less, to these same slings

attached to a 20-foot ISO container spreader bar. If there is sling interference with the equipment, the contact points on the equipment must have sufficient strength to withstand the compressive loads caused by sling contact at the design limit load.

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 5.1.5 of this standard.

5.1.4 Provision Dimensions.

Lifting provisions shall conform to the dimensions specified in Figure 3.

5.1.5 Testing.

Testing shall meet the following requirements:

a. 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.

b. The angles and loads for the static pull shall be those loads and angles as determined by the methods specified in paragraphs 5.1.3.1.a, 5.1.3.1.b and 5.1.3.2.a. If evaluations show that the provisions may fail when lifted by a 20-foot ISO container spreader bar, an additional test using the container spreader bar, or equivalent, will be performed.

c. Since testing of the provisions includes testing of the connecting structure around the provisions, the points used to restrain the equipment during testing shall be located such that they do not interfere with or reduce the loading on the connecting structure around the provisions.

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

e. 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.)

f. Failure is defined as any visible permanent deformation, yielding, or bending of 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.

g. 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.

5.2 Equipment tiedown provisions.

This section applies to equipment with a requirement to be transported by highway, rail, marine, USAF fixed-wing aircraft, and CH-47 helicopters. For equipment with a requirement to be transported on Navy/Marine Corps aircraft, see Appendix D.

5.2.1 Number.

Equipment shall have four equipment tiedown provisions to ensure interoperability between transported military equipment and tiedown devices commonly used in the transportation environment. 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, the equipment shall have four selected points that can be used for tiedown.

5.2.2 Location.

Equipment tiedown provisions shall be located such that:

a. Not less than 1 inch of clearance should be maintained between the equipment and the restraint devices (tiedown cables or chains). When a restraint device must contact a part of the equipment, testing must demonstrate that the affected part(s) has sufficient strength to withstand the force exerted to prevent permanent deformation of any part of the equipment, and that contact will not adversely affect the material of the 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 or chain), of the proper capacity, does not contact any part of the item being tied down except the provision. This ensures interoperability between the equipment and the transportation systems.

e. Height of provisions shall be between 2 and 6 feet, measured from the ground when the equipment is resting on a level surface, unless an integral means for reaching the provisions is provided.

f. In the elevation view, chains or straps may be placed anywhere from vertically downward to horizontal and, in the plan view, 90° to either side of the principal direction of the equipment tiedown provision (Figure 7). The principal direction is parallel to the longitudinal axis. Equipment tiedown provisions shall be located on structural members of the chassis of wheeled vehicles or the hull of tracked vehicles. They should also be located symmetrically about the item of equipment, preferably mounted on the front and

rear ends of the equipment.

g. Each equipment 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.

h. Equipment that is normally attached to other equipment during transport (i.e. prime movers and trailers) shall have provisions that are located such that they are usable and meet the requirements of Figure 7 when coupled to another vehicle.

5.2.3 Strength.

Each equipment tiedown provision, including the connection to the structural frame, shall withstand its proportionate share of the loadings shown in Table I (see *MIL-STD-1366, Interface Standard for Transportability Criteria* for load requirements applicable for internal transport on helicopters smaller than the CH-47). Since the design limit load in the fore and aft direction is the largest, the principal direction of restraint for equipment 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 equipment tiedown provisions that would effectively resist motion along that axis. Distribution of the load among the equipment tiedown provisions shall

Table I - Load Requirements for Equipment Tiedown Provisions (transport by highway, rail, marine, USAF fixed-wing aircraft, and internally by CH-47 helicopter) and Large Cargo Tiedown Provisions.

Design Limit Load	Direction of Load
4.0 times Gross Weight ^{1, 2, 3, 4}	Fore and Aft (Longitudinal axis of equipment)
2.0 times Gross Weight ²	Downward (Vertical axis of equipment)
1.5 times Gross Weight	Left and Right (Lateral axis of equipment)
<p>1. The design limit load in the fore and aft direction for equipment tiedown provisions on helicopters is 3.0 times the gross weight of the helicopter. Helicopters are not transported by rail and the 4g requirement in the longitudinal direction is primarily seen in the rail transport mode.</p> <p>2. If the equipment can be oriented on a railcar or a USAF fixed-wing aircraft in two directions, then the equipment tiedown provisions must meet the design limit loads for both orientations.</p> <p>3. For transport on KC-10 aircraft in front of the barrier net, or with no barrier net, the design limit load in the forward direction is 9 times the gross weight.</p> <p>4. For transport on KC-135 aircraft with passengers forward or alongside of the cargo, the design limit load in the forward direction is 8 times the gross weight.</p>	

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. Although some vehicles are normally transported together (i.e. truck/trailer combinations), each vehicle's equipment tiedown provisions shall individually meet the strength requirements of this standard. A sample problem that shows how to determine the required strength of the equipment 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 equipment tiedowns. The ultimate load that each equipment tiedown provision can withstand shall not be less than 1.5 times the design limit load.

5.2.3.1 Option for equipment weighing 50,000 pounds or more.

To aid in meeting the strength requirements of 5.2.3, equipment weighing 50,000 pounds or more can have two openings on each equipment tiedown provision that are at least 3.5 inches in diameter each (dimension D_{min} in Figure 3). This is in lieu of having one large opening for the provision. The resulting provision with two openings must meet all the other dimensions in Figure 3 for its weight category. Figure 8 is an example of a provision with two openings. Both openings of the provision will be tested simultaneously.

5.2.3.2 Strength of helicopter equipment tiedown provisions.

Helicopters must be designed to be restrained to 3gs in the forward and aft longitudinal directions, 1.5gs in the lateral direction, and 2gs in the vertical direction. When designing equipment tiedown provisions on helicopters, the location options can be limited by the structure of helicopters. Additionally, because of the desire to load as many helicopters as possible into C-5 and C-17 aircraft, helicopters may be oriented at various angles to the longitudinal axis of the fixed wing aircraft. When determining the required strength of helicopter equipment tiedown provisions, an analysis of the loads encountered during orientations other than parallel to the longitudinal axis must be considered. This will ensure that the equipment tiedown provisions on helicopters can provide adequate restraint during fixed wing air transport.

5.2.4 Provision Dimensions.

Equipment tiedown provisions shall conform to the dimensions specified in Figure 3. See paragraph 5.2.3.1 for the dimensional requirements if two openings are used in lieu of one for equipment weighing 50,000 pounds or more. For equipment tiedown provisions, the maximum dimensions of the resulting cross section shall be capable of being inscribed in a 2-inch diameter circle (see Figure 9). This cross section shall be on the parts of the provisions that would be contacted by hooks pulling in the directions described in 5.2.2.f.

5.2.5 Testing.

Testing shall meet the following requirements:

a. 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.

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

c. Since testing of the provisions includes testing of the connecting structure around the provisions, the points used to restrain the equipment during testing shall be located such that they do not interfere with or reduce the loading on the connecting structure around the provisions.

d. 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.

e. Failure is defined as any visible permanent deformation, yielding, or bending of 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.

f. 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.

5.3 Multipurpose provisions.

Provisions meeting the requirements of both paragraph 5.1 and 5.2 can serve as multipurpose provisions.

5.4 Cargo tiedown provisions.

5.4.1 Number.

The total number of cargo tiedown provisions is determined by the size of the cargo area. Cargo tiedown provisions are located along the front, rear, and sides of the cargo area.

5.4.2 Location.

Cargo tiedown provisions may be located along the perimeter of the cargo area so as not to increase the dimensions of the equipment, or recessed inside the walls or floor of cargo areas. Recessed cargo provisions shall fold to provide a flush surface when not in use. The spacing for the provisions shall be approximately 18 inches on center

along the perimeter of the cargo area. The spacing between provisions may be adjusted as necessary to avoid interference with vehicle structural members. Provisions on the side and end walls of the cargo area shall be as close to the floor of the cargo area as practical. The center of the cargo tiedowns that are nearest to the corners of the cargo area shall not be more than 6 inches from the corner of the cargo area. If the cargo area is equipped with ISO corner fittings in addition to cargo tiedown provisions, the corner cargo tiedowns shall be located as close as possible to these fittings.

5.4.3 Strength.

All cargo tiedown provisions shall meet the strength requirements of Table II.

5.4.3.1 Ultimate design load.

The ultimate load each cargo tiedown provision can withstand shall not be less than 1.5 times the design limit load determined in paragraph 5.4.3.

5.4.3.1 Transport on Navy/Marine Corps aircraft.

Internal transport on Navy/Marine Corps aircraft require restraint above that required for other modes of transport. See appendix D for further guidance in designing for restraint aboard these transportation assets.

5.4.4 Provision Dimensions.

For cargo areas with a payload capacity less than or equal to 15,000 pounds, the provisions shall have an opening such that a 1-inch radius semi-circle can be inscribed in it and the thickness of the provision shall not be greater than three-fourths of an inch. For cargo areas with a payload capacity greater than 15,000 pounds, the cargo tiedown provisions shall have an opening not less than 2 inches in diameter and the thickness of the provision shall not be greater than 1 inch. Additionally, the cargo tiedown provisions shall be capable of accepting 2" x .065" steel banding without causing tearing of the banding. Examples of acceptable cargo tiedown provisions is shown in Figure 10.

5.4.5 Testing.

Testing shall meet the following requirements:

- a. A static pull to the required design limit load shall be conducted on a selected sample of cargo tiedown provisions. Selection of provisions for testing will be based on differences in provision design and mounting location.
- b. Loads applied to each provision shall be measured with a measuring device, such as a load cell or dynamometer.
- c. 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.

Table II - Load Requirements for Cargo Tiedown Provisions.

	LB	LB	LB	LB
Load-carrying range of equipment	0 - 3,000	> 3,000 to <10,000	> 10,000 to < 52,900	> 52,900
Load-carrying capacity (design load) of each tiedown provision	2,500	5,000	10,000	15,000
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.				

d. 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.

e. Failure is defined as any visible or measurable 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.

f. 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.

g. In addition to the other requirements of this paragraph, another load using banding shall be applied to the provisions for not less than 6.0 seconds. Selection of provisions for testing will be based on differences in provision design. The banding load shall be the design limit load of the cargo tiedown provision. The banding load shall be applied with 2" x .065" banding in a complete loop. A complete loop is that in which the the banding is looped through the cargo tiedown provision on the vehicle, through the cargo being restrained, and then looped back such that the the ends of the banding are joined together. Tearing of the banding, as a result of the banding load being applied, will constitute failure.

5.4.6 Directional capabilities.

Cargo tiedown provisions will be designed to optimize the interface between the cargo area and the cargo tiedown apparatus. Floor or wall mounted cargo tiedown provisions shall permit the cargo tiedown provision 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 (Figure 11). Side and end mounted cargo tiedown provisions shall translate a

minimum of 90° from the vertical towards the center of the cargo area and 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 (Figure 11).

5.4.7. Unique cargo tiedown provisions.

Special cargo tiedown provisions used to meet unique applications may be included in the system specification. The suitability of these provisions must be established and verified by testing that demonstrates the ability of the provision to provide adequate restraint for the unique application. At a minimum, this testing will verify the strength and directional capabilities of these unique provisions. Rail impact testing in accordance with MIL-STD-810 may be required to ensure that these unique cargo tiedown provisions provide adequate restraint during the dynamic loads encountered in various modes of transport.

5.5 Large Cargo Tiedown Provisions.

Large Cargo tiedown provisions are required on all equipment with cargo areas that have a maximum payload capability greater than 5,000 pounds.

5.5.1 Number.

The front and rear edges of the cargo area shall be equipped with large cargo tiedown provisions, either two or four provisions along each edge. For cargo areas 40 feet or longer, additional cargo tiedown provisions are required across the cargo area at the longitudinal midpoint of the cargo area (see Figure 12). These additional provisions may be grouped in two rows laterally across the cargo area on either side of the longitudinal midpoint as long as the center of the provisions are not more than 12 inches from the longitudinal midpoint (see Figure 12). Each row can consist of either two or four provisions each.

5.5.2 Location.

Large cargo tiedown provisions shall be located on the front, rear, and center (if the cargo area is 40 feet or longer) of the cargo area. If two provisions are used in each row, then the provisions shall be equidistant from the centerline of the cargo area. If four provisions are used in each row, the provisions shall be evenly spaced along the front, rear, or center of the cargo area.

5.5.3 Strength.

Each large cargo tiedown provision and its supporting structure shall withstand its proportionate share of the strength requirements shown in Table I. In this case, use the maximum payload of the cargo area as the "Gross weight" in Table I. For cargo areas that are 40 feet or longer, it is assumed that the largest single item (other than a container) carried would only be half of the maximum payload capability of the vehicle. In this case, use half the maximum payload of the cargo area as the "Gross weight" in Table I.

5.5.3.1 Ultimate design load.

The ultimate load each large cargo tiedown provision can withstand shall not be less than 1.5 times the design limit load determined in paragraph 5.5.3.

5.5.3.2 Transport on Navy/Marine Corps aircraft.

Internal transport on Navy/Marine Corps aircraft require restraint above that required for other modes of transport. See appendix D for further guidance in designing for restraint aboard these transportation assets.

5.5.4 Provision dimensions.

Largo cargo tiedown provisions shall meet the dimensional requirements of Figure 3. If two large cargo tiedown provisions are in each row (front, rear, and center (if required), then use the maximum payload capability of the cargo area as the "Gross Weight of the Equipment." If four large cargo tiedown provisions are in each row, then use half the maximum payload capability of the cargo area as the "Gross Weight of the Equipment."

5.5.5 Testing.

Testing shall meet the following requirements:

a. 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.

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

c. Since testing of the provisions includes testing of the connecting structure around the provisions, the points used to restrain the equipment during testing shall be located such that they do not interfere with or reduce the loading on the connecting structure around the provisions.

d. 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.

e. Failure is defined as any visible permanent deformation, yielding, or bending of 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.

f. 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.

5.6 Supplemental air transport tiedown provisions.

Supplemental air transport tiedown provisions will be provided on all equipment weighing over 10,000 pounds or more with an internal air transport requirement. These provisions allow flexibility in air transport restraint and reduce floor space between equipment items to maximize aircraft utilization.

5.6.1 Number.

The number of supplemental air transport tiedown provisions is dependent upon the weight of the item, the strength of the provisions (see 5.6.3), and the directional capabilities of the provisions (see 5.6.6). The minimum number of air transport tiedown provisions is given in Table III.

5.6.2 Location.

The provisions shall be located symmetrically about the equipment longitudinal centerline. Provisions shall be located to provide restraint in both the fore and aft direction of the equipment. The area of action for each provision is illustrated in Figure 13. Longitudinal spacing between provisions shall be no less than 20 inches for 10,000 pound provisions, and 40 inches for 20,000, 25,000 pound, and 50,000 pound provisions. If a provision's location is suitable for use in only one direction, an additional provision must be provided for use in the opposite direction. Restraint devices should not contact any other part of the equipment. When a restraint device must contact a part of the equipment, testing must demonstrate that the affected part(s) has sufficient strength to withstand the force exerted to prevent permanent deformation of any part of the equipment, and that contact will not adversely affect the material of the tiedown device. Provisions shall be located on the chassis of wheeled vehicles or the hull of tracked vehicles. Provisions may be no higher than 6 feet on the equipment and no less than 2 feet.

5.6.3 Strength.

Supplemental air transport tiedown provisions are rated according to their strength throughout the required area of action. The design load limit for supplemental air transport tiedown provisions shall be 10,000 or 20,000 pounds for vehicles suitable for transport by C-130 and larger aircraft. For vehicles transportable only by C-5 and C17 aircraft, the provisions should have a design limit load of 25,000 or 50,000 pounds. All supplemental air transport tiedown provisions on equipment must have the same design limit load. Provision strength includes all load bearing structures associated with each provision. The ultimate load that each equipment tiedown provision can withstand shall not be less than 1.5 times the design limit load.

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Table III. Number of Supplemental Air Transport Tiedown Provisions
Required Per Side

Item Weight (lb)	Number of Supplemental Air Transport Tiedown Provisions per Side			
	10,000 lb provisions	20,000 lb provisions	25,000 lb provisions	50,000 lb provisions
10,001 - 15,000	1 or	1 or	1 or	1
15,001 - 25,000	2 or	1 or	1 or	1
25,001 - 30,000	3 or	2 or	1 or	1
30,001 - 35,000	3 or	2 or	2 or	1
35,001 - 45,000	4 or	2 or	2 or	1
45,000 - 62,500	N/A	N/A	2 or	2
62,501 - 87,500	N/A	N/A	3 or	2
87,501 - 112,500	N/A	N/A	4 or	2
112,501 - 125,000	N/A	N/A	5 or	2
125,001 - 137,500	N/A	N/A	5 or	3

Note: The number of provisions required must be increased by 50% (rounded up to the next whole number) if provisions that can swivel or pivot are used.

5.6.4 Provision Dimensions.

The minimum diameter of the opening size shall be as follows:

- 10,000 pound provisions - 1-5/8 inches
- 20,000 pound provisions - 2 inches
- 25,000 pound provisions - 2-1/2 inches
- 50,000 pound provisions - 3 inches

5.6.5 Qualification.

The supplemental air transport tiedown provisions shall be qualified through analysis or testing as follows:

- a. A static independent pull to the required design limit load shall be conducted on selected supplemental air transport tiedown provisions. Selection will be based on difference in provision design and mounting location.
- b. Loads applied to each provision shall be measured with an appropriate measuring device, such as a load cell or dynamometer.
- c. 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 supplemental air transport tiedown provisions.
- d. The load shall be applied from the provisions in the resultant directions as permitted by the range of restraint capabilities (see Figure 13). As a minimum, at least one pull 30° downward from the horizontal axis (in the vertical direction) and 30° outward from this same axis (in the lateral direction) is required (see Figure 14). As determined by the physical geometry of the provision, one additional pull 90° vertically downward and one pull 90° directly outward may be required. If the provisions can provide restraint in both the fore and aft directions and cannot be qualified by symmetry, the load described above shall be applied in both directions. The loads shall be applied for not less than 6.0 seconds and shall be not less than the required design limit load as defined in paragraph 5.6.3.
- e. 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.
- f. 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.

5.6.6 Directional capabilities.

Each provision shall provide restraint in the area of action as illustrated in Figure 13. Provisions can be fixed, swiveling, or pivoting on the equipment. Fixed provisions may be hardpoints that are cutouts, holes or structural features that tiedown devices may be wrapped around, without damage to the device or the equipment. Only fixed provisions may be used for longitudinal restraint in the fore and aft directions simultaneously. Swiveling or pivoting provisions may be used to provide restraint in one direction only, either fore or aft. When swiveling or pivoting provisions are used, the number of provisions required in Table III must be increased by 50%, rounded up to the next whole number.

5.7 Marking.

5.7.1 Shipping data plate.

A shipping data plate shall be furnished and shall conform to A-A-50271. The silhouette of the equipment in its transport configuration, which indicates the CG (of an empty vehicle, if the item can carry a payload) along each axis, the transport dimensions and weights (length, width, height, wheelbase, curb weight, gross vehicle weight, axle loads at curb weight, and axle ratings), the location of all types of provisions covered under this standard, the location of hard points that can be used for lifting and tying down of Type II equipment, and the design limit load of each provision shall be included on the data plate (see Figure 15). For cargo carrying vehicles, the acceptable longitudinal, lateral, and vertical CG limits of a loaded vehicle, referenced from the CG for an empty vehicle, shall be provided on the dataplate. A visual outline of the resulting "loaded CG envelope" shall be pictured on the dataplate. Procedures for lifting and tying down equipment shall be shown on the data plate only if special length slings, special equipment, or special procedures are required. If the procedures are lengthy, cite the reference document in which the required information can be found. These special procedures must be approved by SDDCTEA or the appropriate Service transportability agent. Nomenclature characters shall not be less than 0.187 inch (3/16-inch), and other characters shall not be less than 0.093 inch (3/32-inch) in height. The data plate shall be attached to the equipment by screws, bolts, or rivets in a conspicuous location.

5.7.2 Identification.

The identification of lifting, equipment tiedown, multipurpose, large cargo tiedown, and supplemental air transport tiedown provisions shall be stenciled or marked with decals in appropriate locations on the exterior of the equipment in characters not less than 1 inch in height, and visible to a person standing on the ground. 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 lifting, equipment tiedown, multipurpose, cargo tiedown, large cargo tiedown, and supplemental air transport 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 (paragraphs 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
5.1.5, 5.2.5, 5.4.5, 5.5.5, 5.6.5	DI-PACK-80880	Transportability Report

Prior to citing DIDs on DD Form 1423, the current issue of the AMSDL must be researched to ensure that the most current and approved DID is cited.

6.4 Tiedown system.

If a proposed rail tiedown procedure differs from that represented in TEA Pamphlet 55-19, *Tiedown Handbook for Rail Movements*, or if the procedure is marked “do not use for new equipment” (or has a similar statement) the materiel developer should obtain SDDCTEA concurrence prior to testing. Items that require more than four chains for rail tiedown will be tested with more than one chain at each tiedown provision, but all chains to each provision will act in the same general direction, usually out, away from the item. Nylon straps are not allowed to be used for rail tiedown.

6.5 Subject term (keyword) listing:

Cables and chains, sling	Lashing
Cables and chains, tiedown	Provision, cargo tiedown
Crane lifting	Provision, multipurpose
Eyes, lifting	Provision, lifting
Eyes, tiedown	Pull test
Helicopter Sling Load	Spreader bars
Lash	Static lift ltest

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 extent 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 paragraph 1.3.
- b. Specify whether or not the option for two openings for each equipment tiedown provision (for equipment weighing 50,000 or more) will be utilized (see paragraph 5.2.3.1).
- c. Specify if HSL is required (see 5.1.3.1).

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

6.9 Computer aided engineering (CAE) structural analysis.

Prior to all testing, the contractor may provide dimensional and material design data on the provisions and their surrounding structure to SDDCTEA 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 should be provided to SDDCTEA 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.

6.10 Checklist for Program Managers and Contractors.

Program Managers (PMs) and contractors should use the following checklist as a reference to help them ensure that their lifting and tiedown provisions meet this standard. This checklist identifies specific areas of consideration essential to understanding and meeting the requirements in this standard:

a) There are six different types of provisions covered in this standard; **lifting**, **equipment tiedown**, **multipurpose**, **cargo tiedown**, **large cargo tiedown**, and **supplemental air transport tiedown** provisions.

b) Determine if the equipment is **Type I** or **Type II** equipment (see paragraph 1.3 for definitions of each type).

c) Read all of section 4 of the standard. This section contains general requirements applicable to all types of provisions.

d) All equipment is required to have four, and only four, **lifting** provisions AND four, and only four, **equipment tiedown** provisions (see paragraphs 5.1.1 and 5.2.1, except for equipment transported on Navy/Marine Corps aircraft, see Appendix D). An alternative to this requirement is to have four provisions meeting the requirements for both **lifting** and **equipment tiedown** provisions. These provisions are called **multipurpose** provisions (see paragraph 5.3).

e) Determine the location of the **lifting** and **equipment tiedown** provisions (see paragraphs 5.1.2 and 5.2.2 for requirements)

f) Determine if helicopter sling load (HSL) is a required mode of transport. Use paragraph 5.1.3.1 for determining the required strength of the **lifting** provisions if HSL is a required mode of transport. Use paragraph 5.1.3.2 for determining the required strength of the **lifting** provisions if HSL is not required.

g) If the gross weight of the equipment is 50,000 pounds or more, determine if two openings will be used to meet the strength requirements for each **equipment tiedown** provision (see paragraph 5.2.3.1 for requirements if this option is pursued).

h) Use Table I and Table II to determine the required strength of the **equipment tiedown** provisions.

i) Using the gross weight of the item, use Figure 3 to determine the dimensional requirements for the **lifting**, **equipment tiedown**, and **multipurpose** provisions.

j) If the equipment has a cargo area, determine the required number, location, strength, dimensions, and directional capabilities of the **cargo tiedown** provisions (see paragraphs 5.4.1, 5.4.2, 5.4.3, 5.4.4, and 5.4.6).

k) If the equipment has a cargo area with a payload capability greater than 5,000 pounds, determine the required number, location, strength, and dimensions of the **large cargo tiedown** provisions (see paragraphs 5.5.1, 5.5.2, 5.5.3, and 5.5.4).

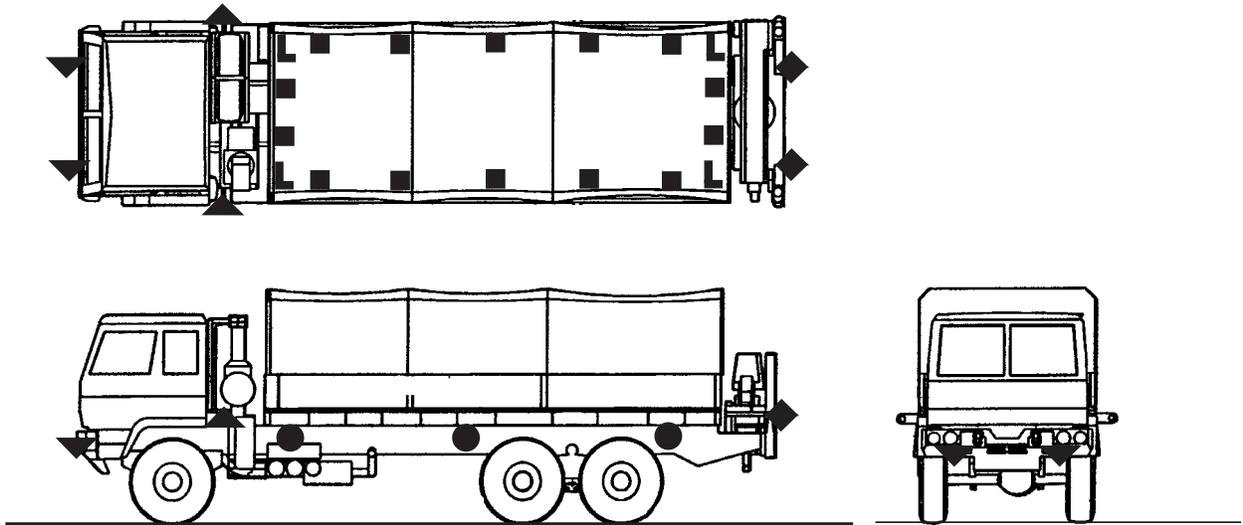
l) If the gross weight of the equipment is 10,000 pounds or more and internal air transport is a required mode of transport, determine the required number, location, strength, dimensions, and directional capabilities of the **supplemental air transport tiedown** provisions (see paragraphs 5.6.1, 5.6.2, 5.6.3, 5.6.4, and 5.6.6 for requirements).

m) Test the provisions in accordance with paragraph 5.1.5 for **lifting** provisions, paragraph 5.2.5 for **equipment tiedown** provisions, paragraph 5.4.5 for **cargo tiedown** provisions, paragraph 5.5.5 for **large cargo tiedown** provisions, and paragraph 5.6.5 for **supplemental air transport tiedown** provisions. **Multipurpose** provisions are tested to in accordance with both paragraphs 5.1.5 and 5.2.5.

Please contact SDDCTEA or your service transportability agent (email and street address listed in the forward of this standard) as soon as possible when designing lifting and tiedown provisions to ensure they meet all the requirements of this standard.

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This figure depicts the approximate location of the six different types of provisions covered in this standard



- ▲ - Lifting Provision
- ▼ - Equipment Tiedown Provision
- ◆ - Multipurpose Provision
- - Cargo Tiedown Provision
- ⌒ - Large Cargo Tiedown Provision
- - Supplemental Air Transport Tiedown Provision

Figure 1. Approximate Location of the Six Different Types of Provisions.

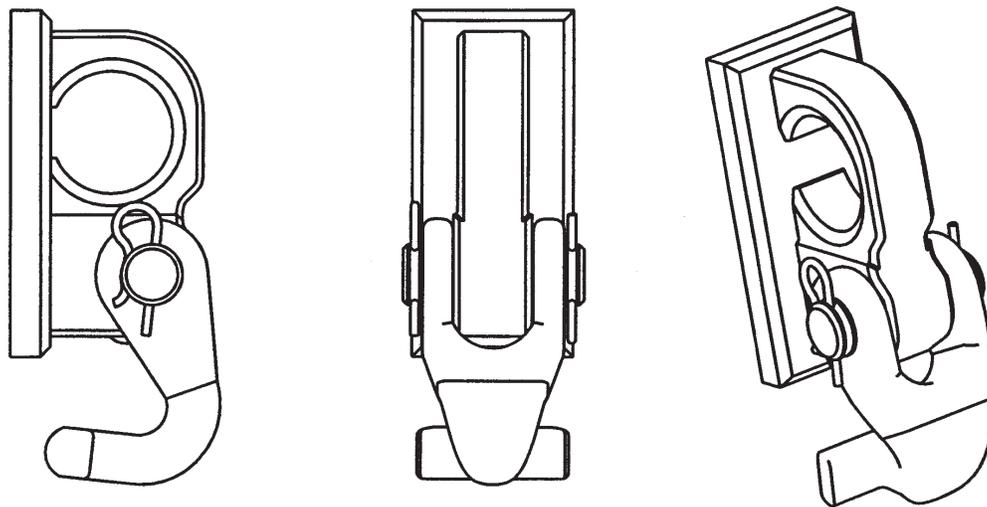
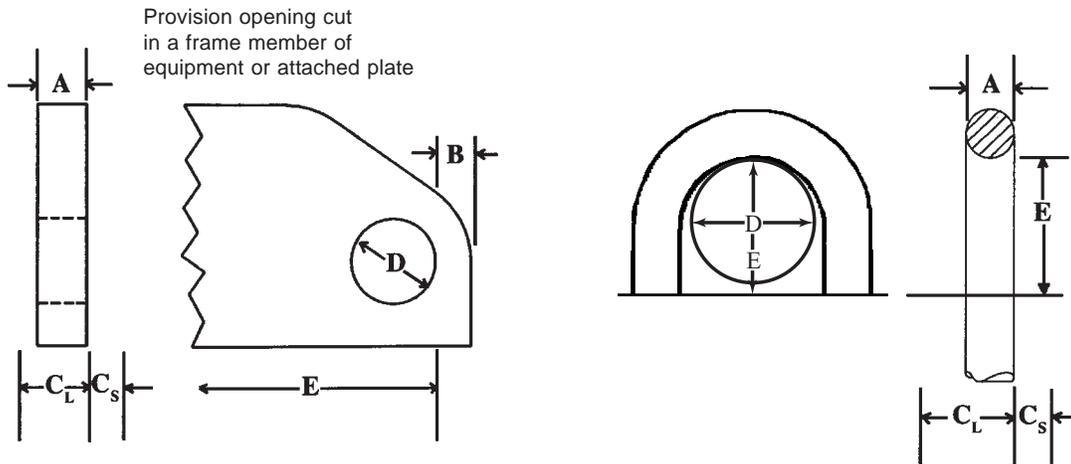


Figure 2. Example of a Nonremovable, Dual-Purpose Provision.

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Gross Weight of Equipment ¹		A _{max} and B _{max} ²		C _L min ³		C _S min ³		D min ⁴		E min	
LB	KG	in	mm	in	mm	in	mm	in	mm	in	mm
0 to <10,000	0 to <4,536	1	25	7	178	3	76	3	76	3.2	81
10,000 to <25,000	4,536 to <11,340	1.5	38	9	229	4	102	3	76	3.4	86
25,000 to <50,000	11,340 to <22,680	1.75	44	12	305	5	127	3.5	89	3.9	99
50,000 to <82,000 ⁵	22,680 to <37,195	1.75 ⁶ 2 ⁷	44 ⁶ 51 ⁷	12	305	7	179	4.5 ⁶ 3.5 ⁷	114 ⁶ 89 ⁷	5.3	135
>82,000 ⁵	>37,195	1.75 ⁶ 2.25 ⁷	44 ⁶ 57 ⁷	12	305	7	179	4.9 ⁶ 3.5 ⁷	124 ⁶ 89 ⁷	5.3	135

Note 1: Helicopters do not have to meet the dimensions of this table. The dimensions of lifting and equipment tiedowns on helicopters shall be designed such that they are compatible with the appropriate number of 10k or 15k polyester straps, or MB-1 or MB-2 chains required for adequate restraint for air, marine and highway transport.

Note 2: For tiedown provisions, the maximum dimensions of the resulting cross section must be capable of being inscribed in a 2 inch diameter circle (see Figure 8).

Note 3: There shall be no interference or obstruction within the dimensions C_L and C_S that could interfere with engaging a shackle and pin (of the appropriate size for the equipment) in the provision. Either side of the provision may be used as the datum from which to measure C_L and C_S.

Note 4: Provisions may be designed to swivel or rotate, however dimension D min shall be met throughout the full range of motion.

Note 5: For equipment weighing 50,000 pounds or more, two holes may be used in lieu of one large opening for the equipment tiedown provisions (see paragraph 5.2.3.1). Each of the two holes must have a D min of 3.5 inches.

Note 6: Equipment tiedown provisions and multipurpose provisions.

Note 7: Lifting provisions.

Figure 3. Lifting, Equipment Tiedown, Multipurpose, and Large Cargo Tiedown Provision Openings and Clearance Dimensions.

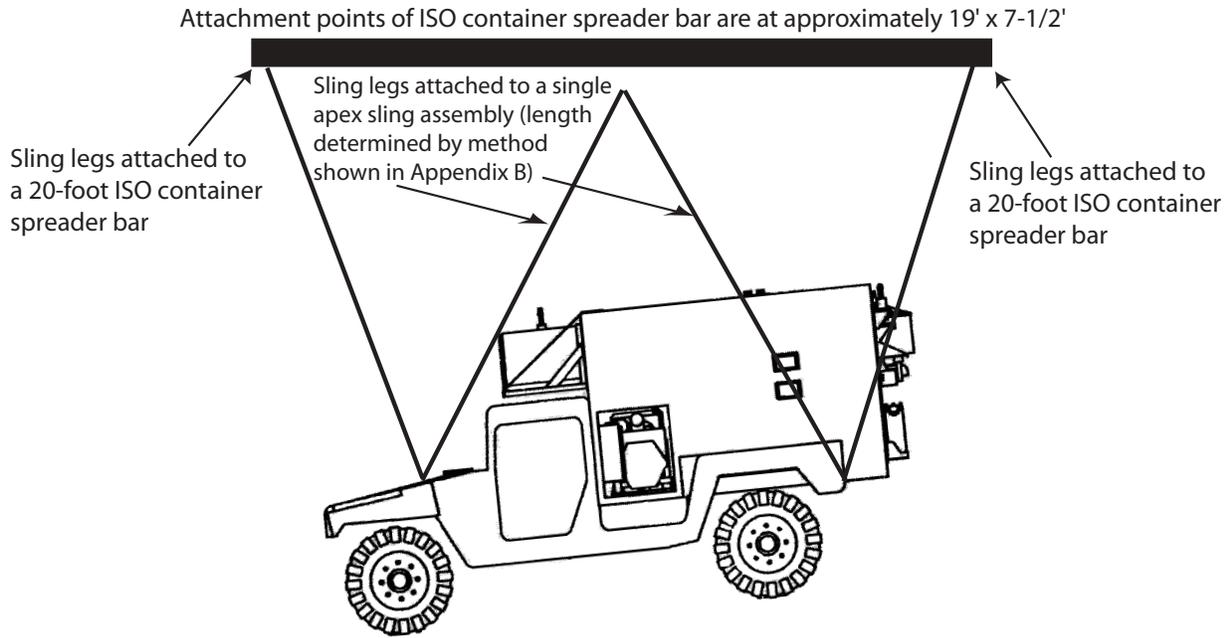


Figure 4. Range of Sling Leg Orientations.

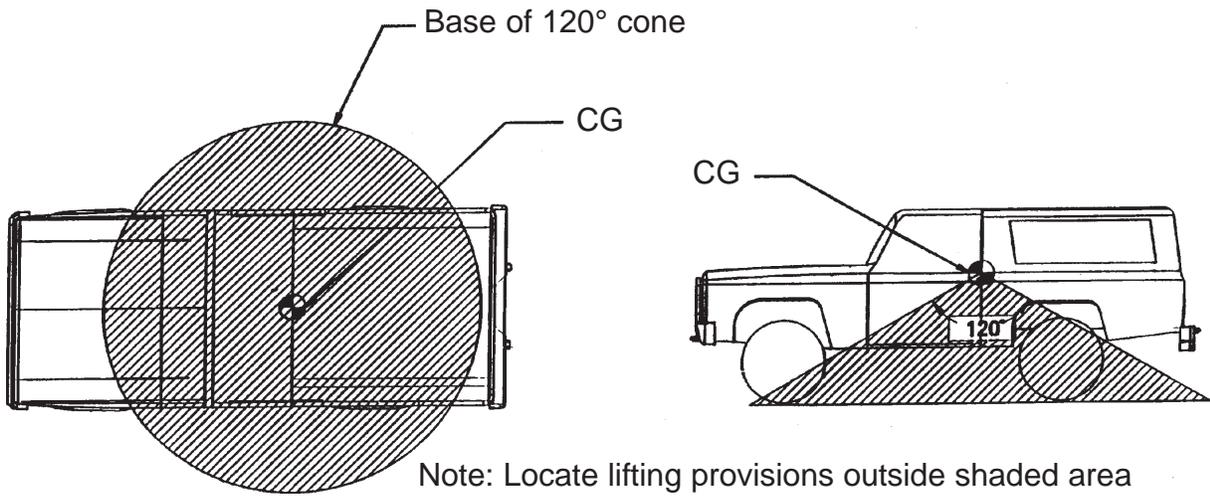


Figure 5. Location of Lifting Provisions.

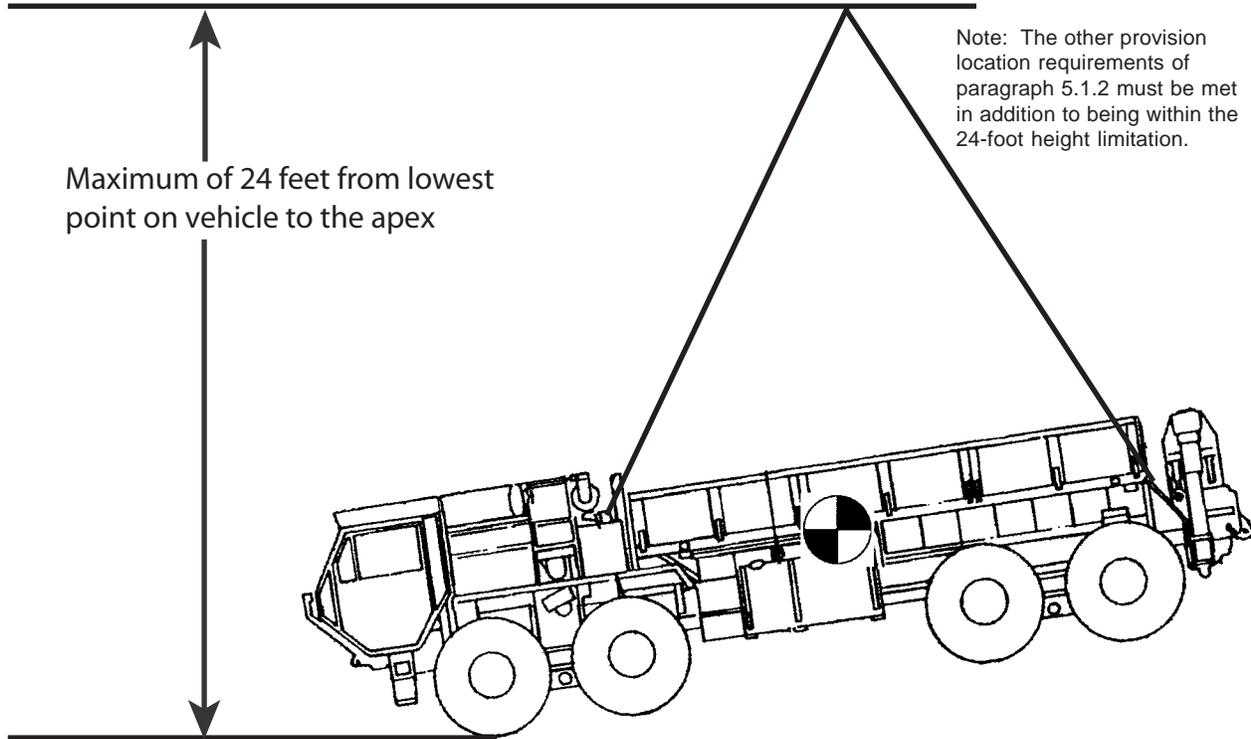


Figure 6. Apex Height

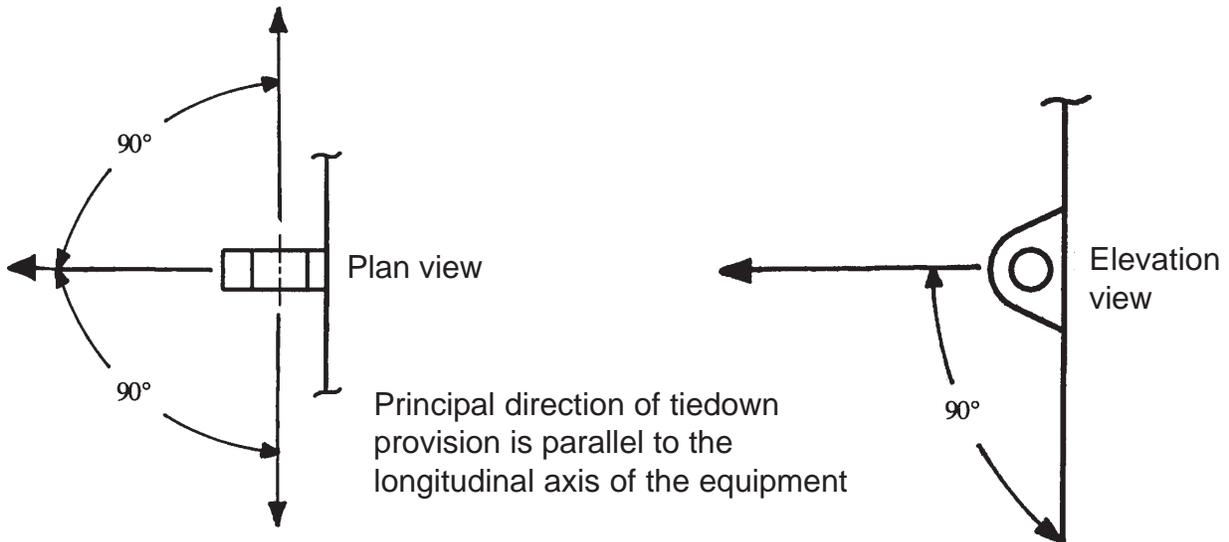
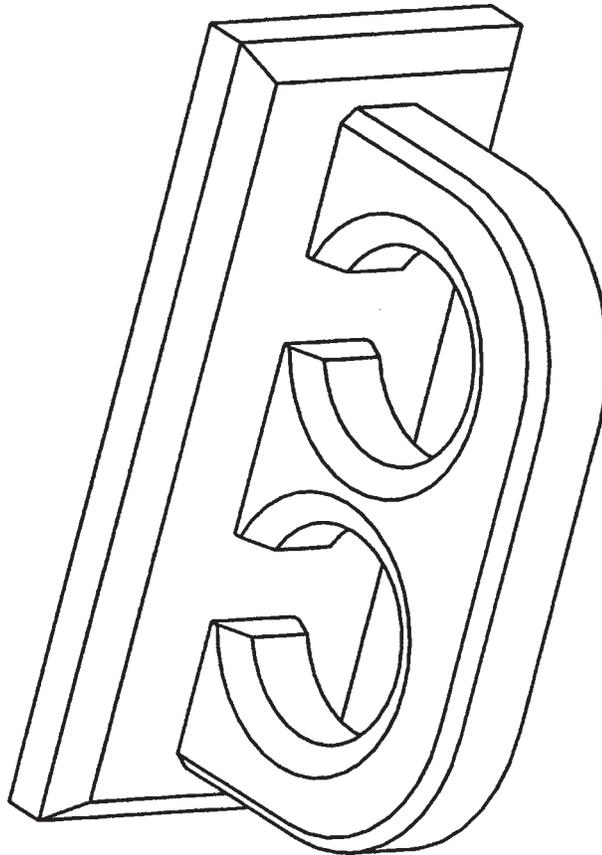


Figure 7. Working Angles for Equipment Tiedown Provisions



Note: This option applies for equipment with a GW of 50,000 pounds or more

Figure 8. Example of an Equipment Tiedown Provision with Two Openings.

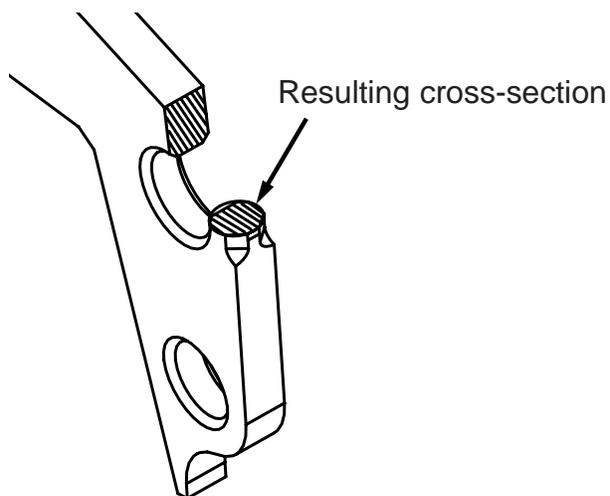
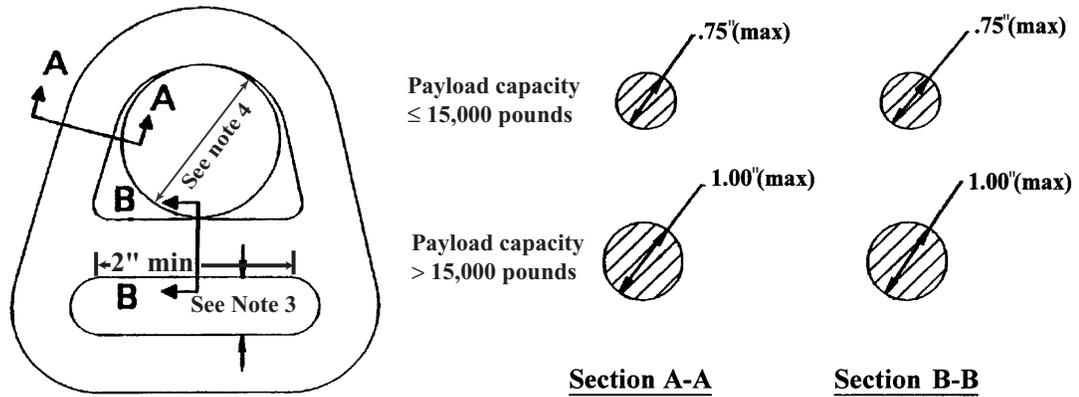


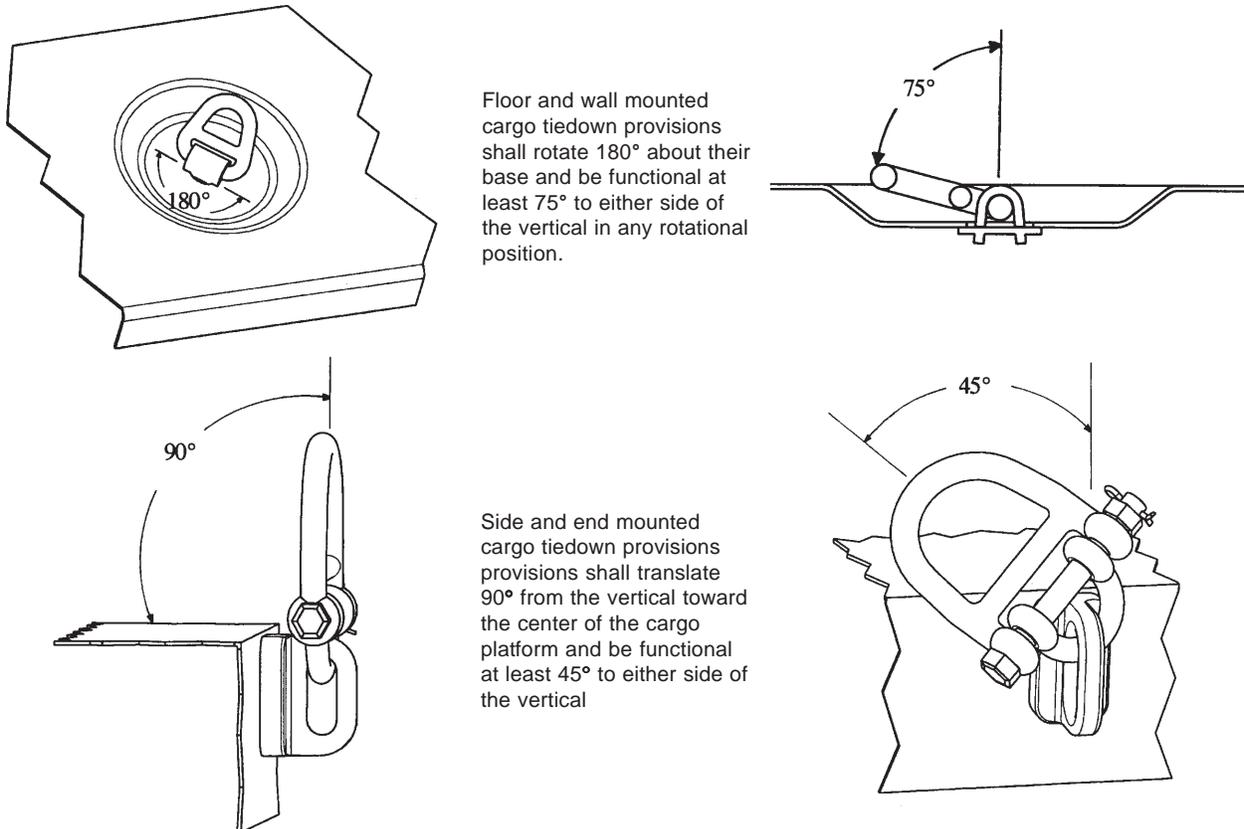
Figure 9. Example of resulting cross-section that must be inscribed in a 2 inch diameter circle



Notes:

1. All dimensions are in inches.
2. Drawing not to scale.
3. This space must be capable of accepting 2" x .065" banding.
4. Payload capacity \leq 15,000 lbs, the opening must be such that a 1-inch radius semi-circle can be inscribed in it.
Payload capacity $>$ 15,000 lbs, the opening must be 2 inches or more in diameter.

Figure 10. Required Dimensions of Cargo Tiedown Provisions.



Floor and wall mounted cargo tiedown provisions shall rotate 180° about their base and be functional at least 75° to either side of the vertical in any rotational position.

Side and end mounted cargo tiedown provisions shall translate 90° from the vertical toward the center of the cargo platform and be functional at least 45° to either side of the vertical

Figure 11. Directional Capabilities of Cargo Tiedown Provisions.

Cargo area that is 40 feet or longer

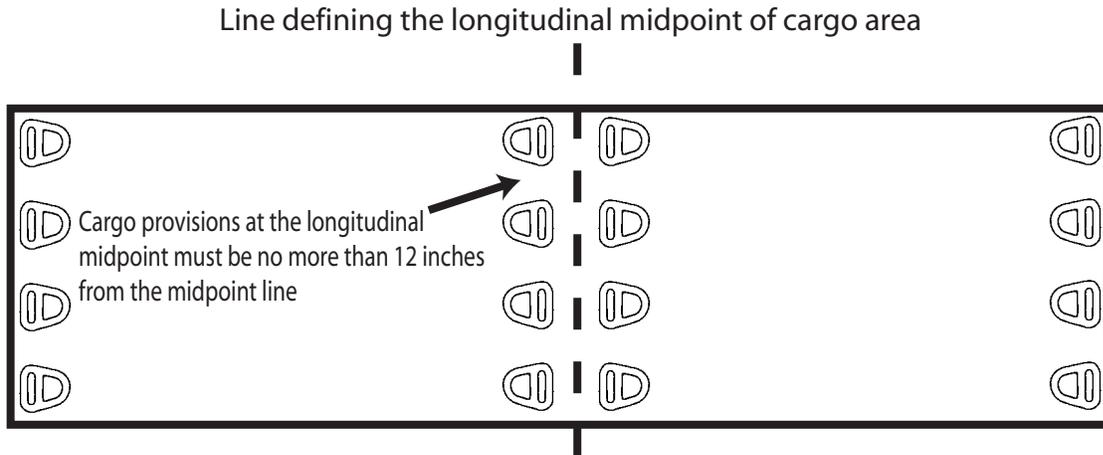
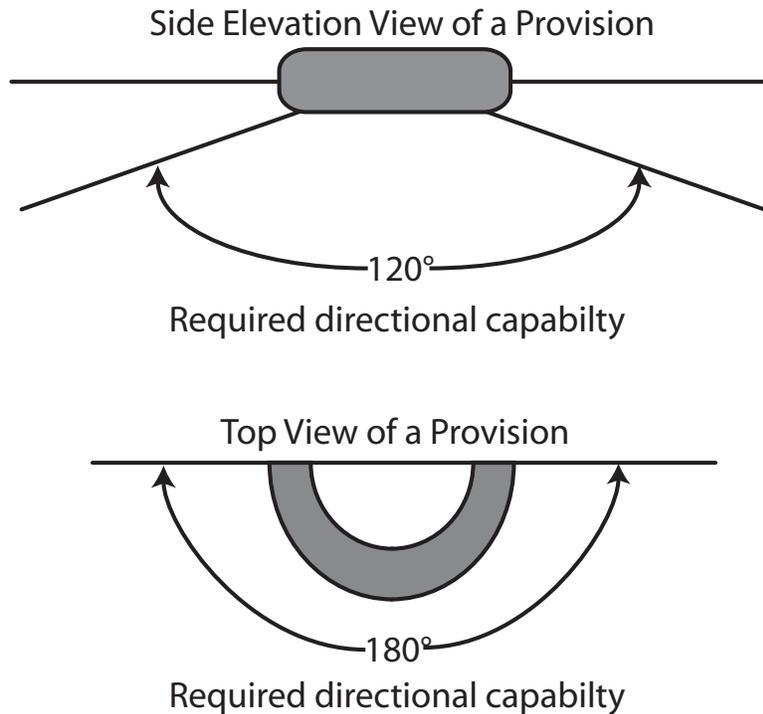


Figure 12. Center cargo tiedown provisions for cargo areas 40 feet or longer.



Note: Provision may be mounted in a different orientation than shown

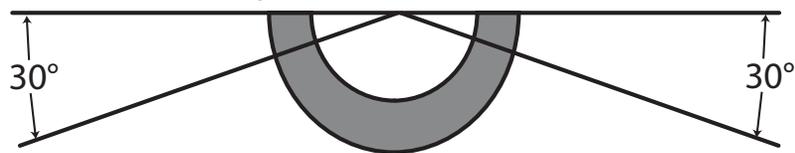
Figure 13. Range of restraint capabilities of supplemental air transport tiedown provisions.

Side Elevation View of a Provision

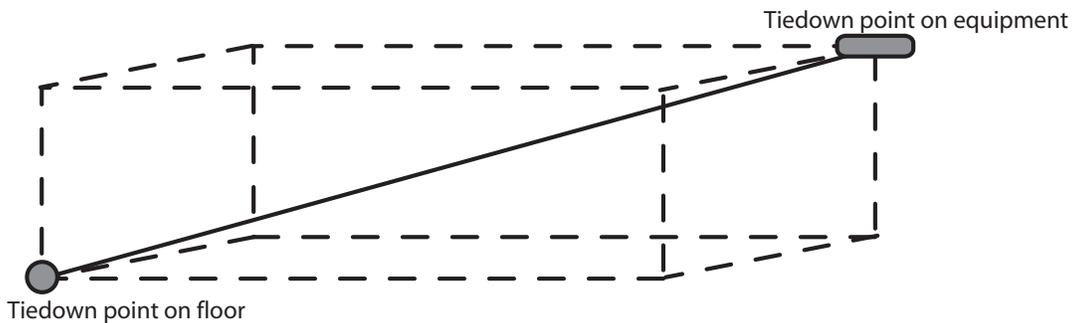


Required angle of pull for test - 30° from horizontal in the vertical direction

Top View of a Provision



Required angle of pull for test - 30° from horizontal in the lateral direction



Resultant pull required for test

Note: Provision may be mounted in a different orientation than shown

Figure 14. Resultant direction of pull for testing supplemental air transport tiedown provisions.

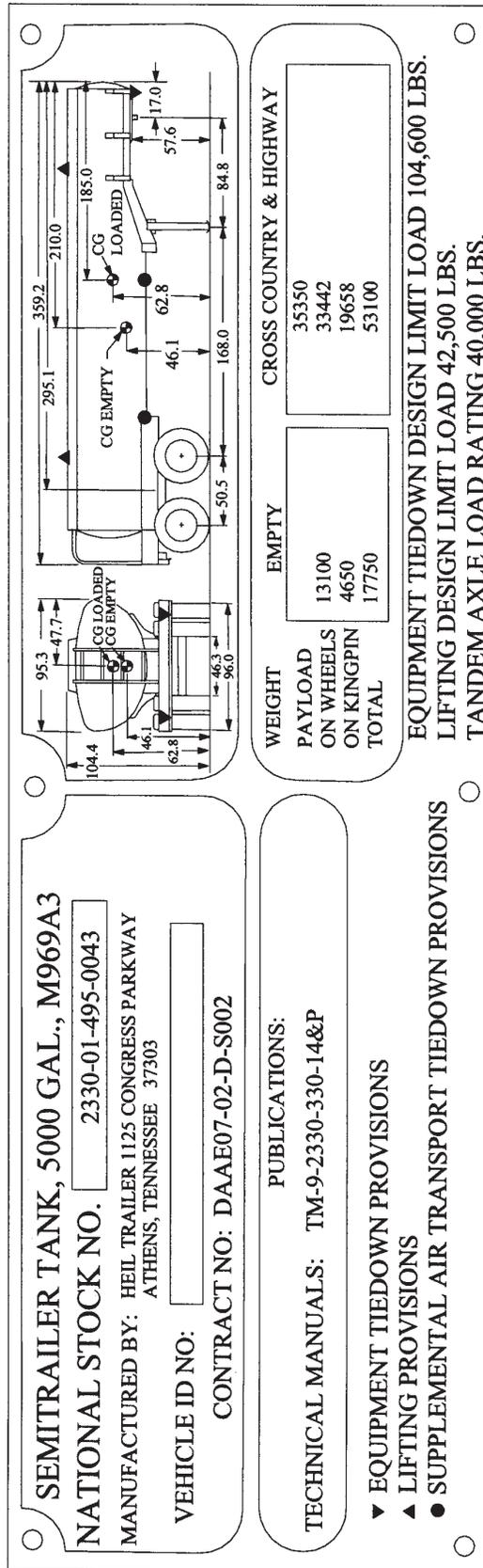


Figure 15. Sample Dataplate with Required Information.

MIL-STD-209K APPENDIX A

APPENDIX A

HELICOPTER SLING LOAD MATERIEL LIFT POINT LOAD FACTOR

A.1 GENERAL

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

A.2 APPLICABLE DOCUMENTS.

Department of Defense
Standards

MIL-STD-913

Requirements for the Certification of Sling Loaded Military Equipment for External Transportation by Department of Defense Helicopters.

A.3 REQUIREMENTS

A.3.1 Determine the helicopter sling load (HSL) materiel lift point LF. The HSL materiel lift point LF is used to calculate the design limit load for all materiel with a HSL requirement. The LF is calculated using the Table A-1 (page A-2). The LF is a function of the HSL weight (HSLWT) and the helicopter HSLWT/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 (see figure A-1).

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 HSLWTs. 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 HSLWT multiplied by the lift point LF. Consult MIL-STD-913 for detailed information on determining design limit load for HSL.

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

TABLE A-1. Calculation of Materiel Lift Point LF

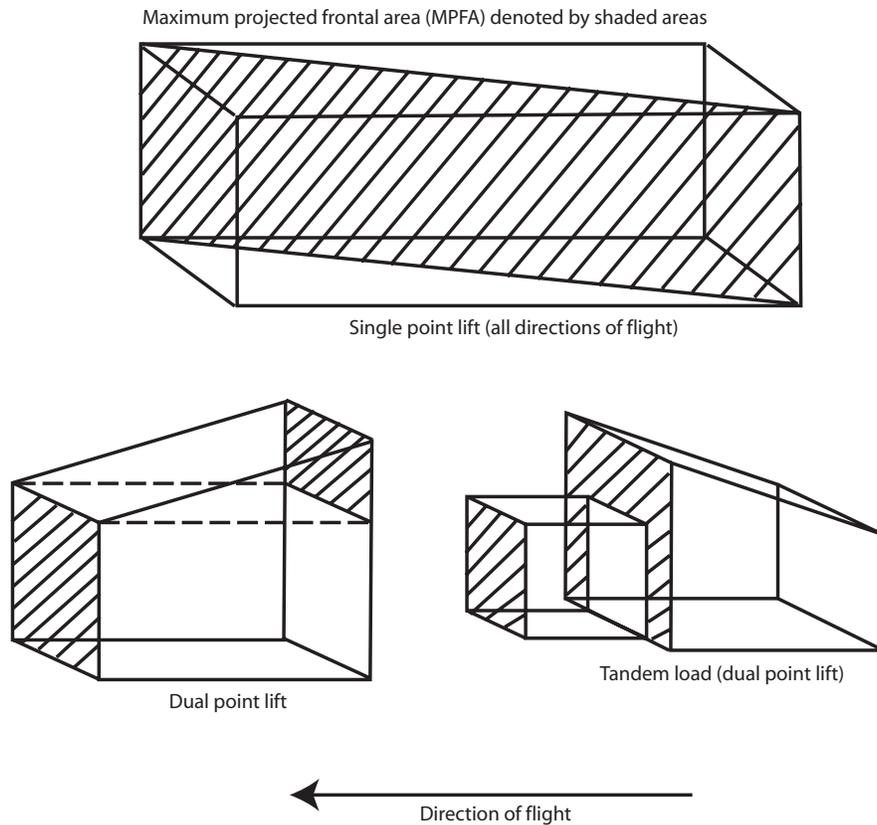


Figure A-1. Maximum projected frontal area

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APPENDIX B

SAMPLE PROBLEM FOR DETERMINING THE REQUIRED TEST SLING LENGTHS AND 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, and length of slings to use for testing. If the resulting length of slings using this method causes interference between the equipment and the slings when the equipment is lifted, then see paragraph B.5.1.11 for the required test sling length.

B.2 APPLICABLE DOCUMENTS. None

B.3 NOTATION

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

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

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

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

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

Dab - lateral distance from provision a to provision b, on a horizontal plane,
in inches

Dcd - lateral distance from provision c to provision d, on a horizontal plane,
in inches

GW - gross weight, in pounds

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

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

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

hd - 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

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hat - distance from provision a to the CG, on the plane of the provisions, when the equipment is lifted with equal length slings, in inches

hbt - distance from provision b to the CG, on the plane of the provisions, when the equipment is lifted with equal length slings, in inches

hct - distance from provision c to the CG, on the plane of the provisions, when the equipment is lifted with equal length slings, in inches

hdt - distance from provision d to the CG, on the plane of the provisions, when the equipment is lifted with equal length slings, in inches

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

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

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

Ht - 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

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

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

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

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

Lxy - longitudinal distance between the front provisions and the rear provisions on the plane of the provisions, in inches

Ra - static load on sling a, in pounds

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Rb - static load on sling b, in pounds

Rc - static load on sling c, in pounds

Rd - 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

Ta - design limit load of provision a, in pounds

Tb - design limit load of provision b, in pounds

Tc - design limit load of provision c, in pounds

Td - design limit load of provision d, in pounds

Ua - ultimate load requirement of provision a, in pounds

Ub - ultimate load requirement of provision b, in pounds

Uc - ultimate load requirement of provision c, in pounds

Ud - ultimate load requirement of provision d, in pounds

Va - vertical load at provision a, in pounds

Vb - vertical load at provision b, in pounds

Vc - vertical load at provision c, in pounds

Vd - vertical load at provision d, in pounds

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

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

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

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

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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.

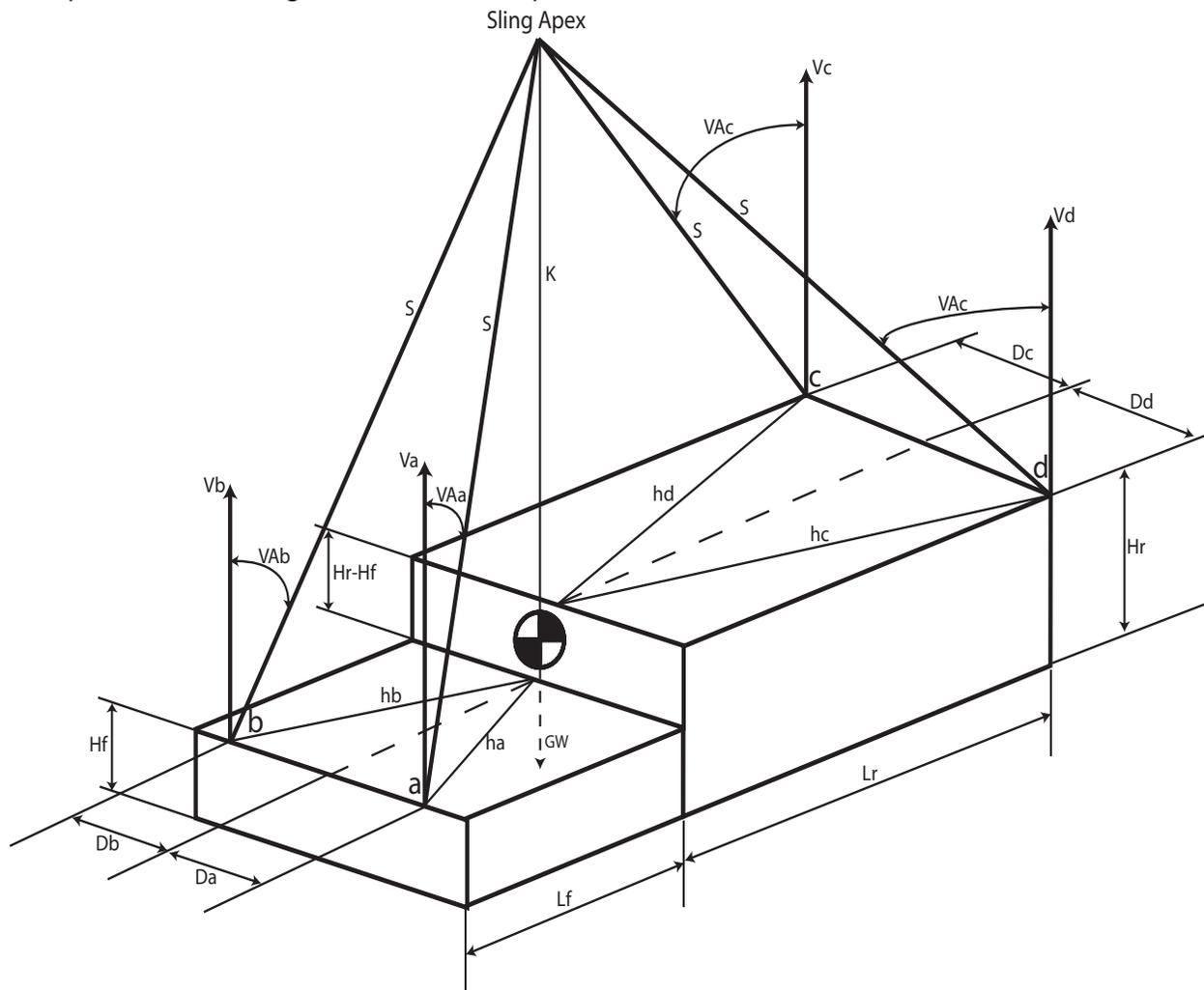


Figure B-1. MIL-STD-209K Free Body Diagram

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$$GW = 10,000 \text{ lb}$$

$$L_f = 56 \text{ in.}, \quad L_r = 79 \text{ in.}, \quad H_f = 24 \text{ in.}, \quad H_r = 33 \text{ in.}$$

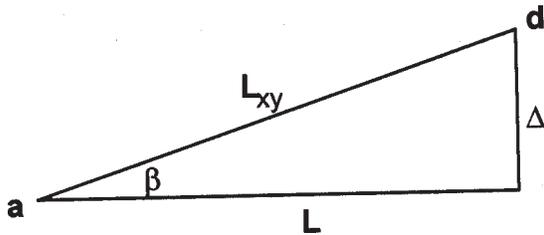
$$D_a = 16 \text{ in.}, \quad D_b = 17 \text{ in.}, \quad D_c = 34 \text{ in.}, \quad D_d = 33 \text{ in.}$$

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, per paragraph 5.1.2.g.

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

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

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



$$\text{If } \text{TAN}(\beta) = \Delta/L \text{ then } \beta = \text{TAN}^{-1}(\Delta/L)$$

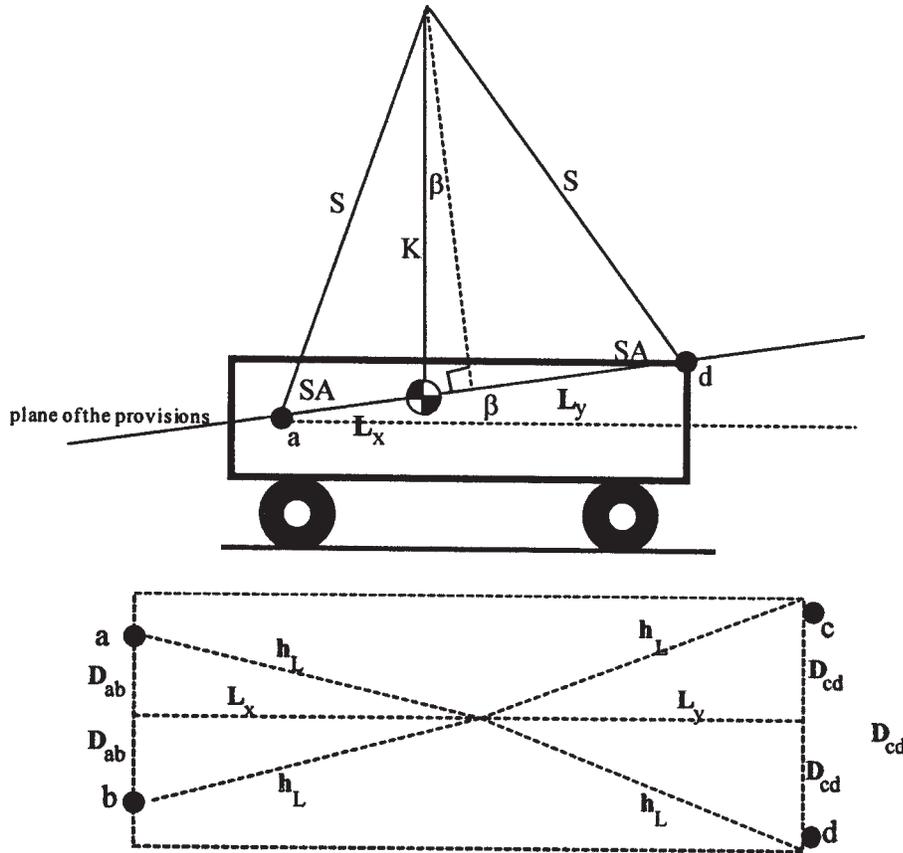
$$\beta = \text{TAN}^{-1}(\Delta/L) = 3.8^\circ$$

$$\text{COS}(\beta) = L/L_{xy} \Rightarrow L_{xy} = L/\text{COS}(\beta)$$

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

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

Elevation view of the plane of the provisions
Plan view of the plane of the provisions



$$D_{ab} = (D_a + D_b)/2 = (16+17)/2 = 16.5 \text{ inches}$$

$$D_{cd} = (D_c + D_d)/2 = (34+33)/2 = 33.5 \text{ inches}$$

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

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

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

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

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

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

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

And then solve for L_x and h_L .

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

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

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

$$\text{COS}(45^\circ) = h_L/S; \quad S = h_L/\text{COS}(45^\circ) = 72.7/0.707 = 102.8 \text{ inches} = 8.6 \text{ feet}$$

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. If S had been greater than 12 feet, then the calculated value of S would be used from this point forward to complete the calculations.

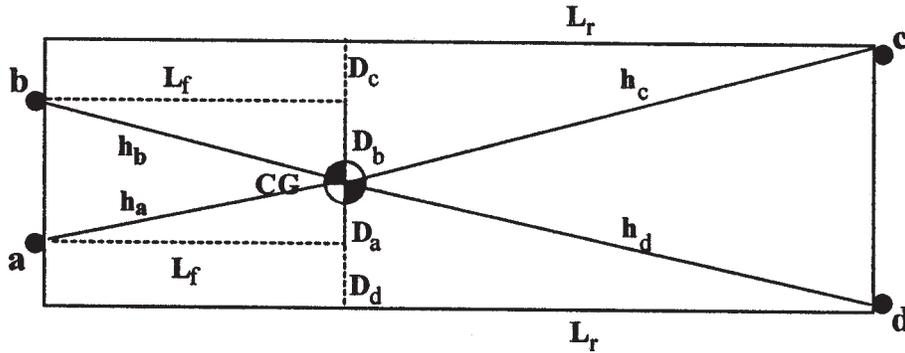
For your piece of equipment, if the calculated sling lengths result in interference between the vehicle and slings when the vehicle is lifted, the angle of the slings will be verified at the test site prior to testing. This verification will ensure that a 45° angle is achieved between the slings and the surface of the vehicle or equipment (see paragraph 5.1.2). Adjustment to the slings lengths may be required if the sling angles are smaller than 45° .

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

$$\text{and } \text{COS}(SA) = h_L/S; \quad SA = \text{COS}^{-1}(h_L/S) = \text{COS}^{-1}(72.7/144) = 59.7^\circ$$

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

Plan view of equipment (horizontal plane)



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

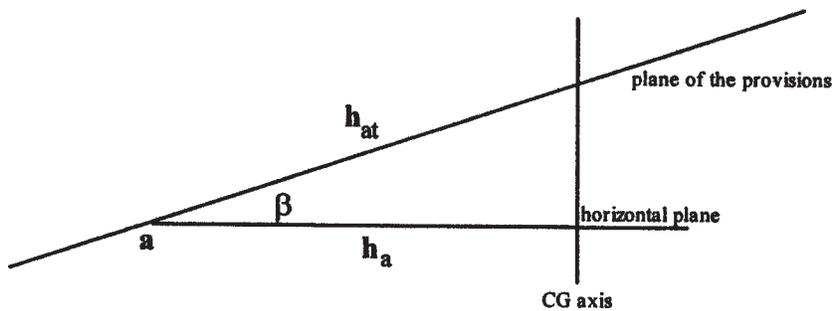
$$h_b = \sqrt{L_f^2 + D_b^2} = \sqrt{56^2 + 17^2} = 58.5 \text{ inches}$$

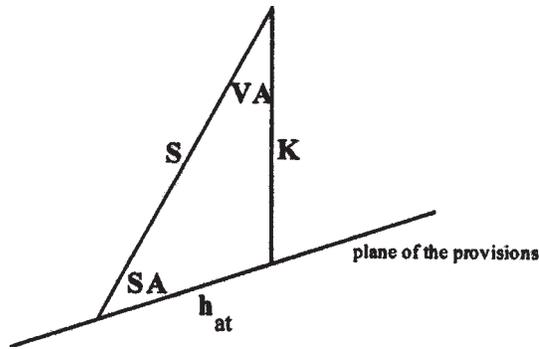
$$h_c = \sqrt{L_r^2 + D_c^2} = \sqrt{79^2 + 34^2} = 86.0 \text{ inches}$$

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

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

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





The same equation can be applied to the other provisions.

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

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

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

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

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

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

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

$$h_{at}^2 = S^2 + K^2 - 2SK\text{COS}(VA_a)$$

$$VA_a = \text{COS}^{-1}((S^2 + K^2 - h_{at}^2)/2SK)$$

$$VA_a = \text{COS}^{-1}((144^2 + 125.2^2 - 58.3^2)/2(144)(125.2)) = 23.7^\circ$$

$$VA_b = \text{COS}^{-1}((S^2 + K^2 - h_{bt}^2)/2SK)$$

$$VA_b = \text{COS}^{-1}((144^2 + 125.2^2 - 58.6^2)/2(144)(125.2)) = 23.9^\circ$$

$$VA_c = \text{COS}^{-1}((S^2 + K^2 - h_{ct}^2)/2SK)$$

$$VA_c = \text{COS}^{-1}((144^2 + 125.2^2 - 86.2^2)/2(144)(125.2)) = 36.5^\circ$$

$$VA_d = \text{COS}^{-1}((S^2 + K^2 - h_{dt}^2)/2SK)$$

$$VA_d = \text{COS}^{-1}((144^2 + 125.2^2 - 85.8^2)/2(144)(125.2)) = 36.3^\circ$$

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

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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:

$$V_a = L_r / (L_r + L_l) \times D_b / (D_a + D_b) \times GW$$

$$V_a = 79 / (56 + 79) \times 17 / (16 + 17) \times 10,000 = 3,015 \text{ lb}$$

$$V_b = L_r / (L_r + L_l) \times D_a / (D_a + D_b) \times GW$$

$$V_b = 79 / (56 + 79) \times 16 / (16 + 17) \times 10,000 = 2,837 \text{ lb}$$

$$V_c = L_r / (L_r + L_l) \times D_d / (D_c + D_d) \times GW$$

$$V_c = 56 / (56 + 79) \times 33 / (33 + 34) \times 10,000 = 2,043 \text{ lb}$$

$$V_d = L_r / (L_r + L_l) \times D_c / (D_c + D_d) \times GW$$

$$V_d = 56 / (56 + 79) \times 34 / (33 + 34) \times 10,000 = 2,105 \text{ lb}$$

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

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

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

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

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

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

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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.

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

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

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

$$U_d = T_d \times 1.5 = 8,358 \times 1.5 = 12,537 \text{ lb}$$

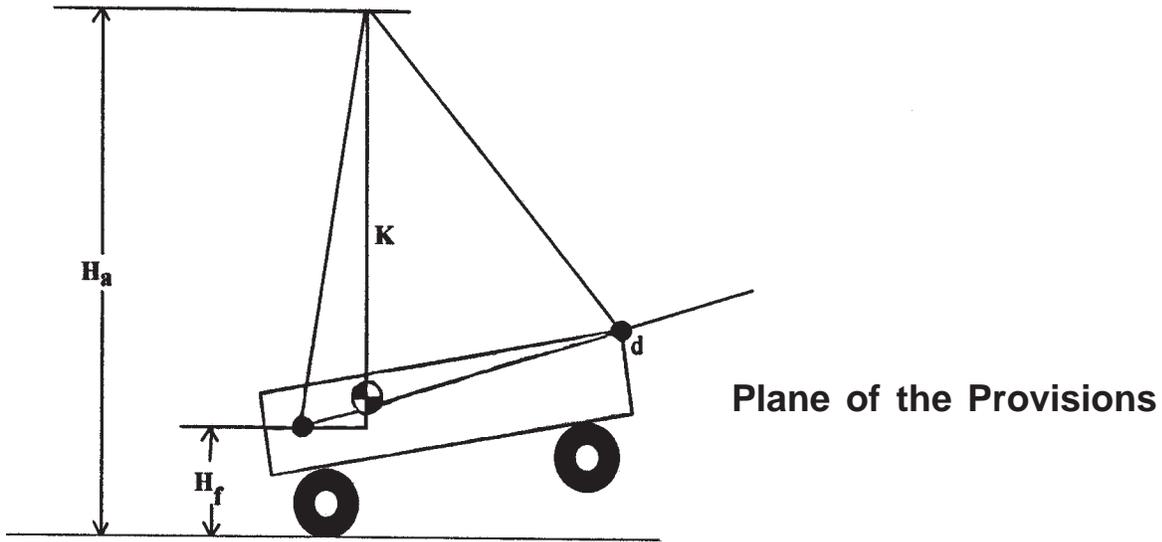
B.5.1.9 Testing Requirements.

Table B-1 Lift Test Requirements.

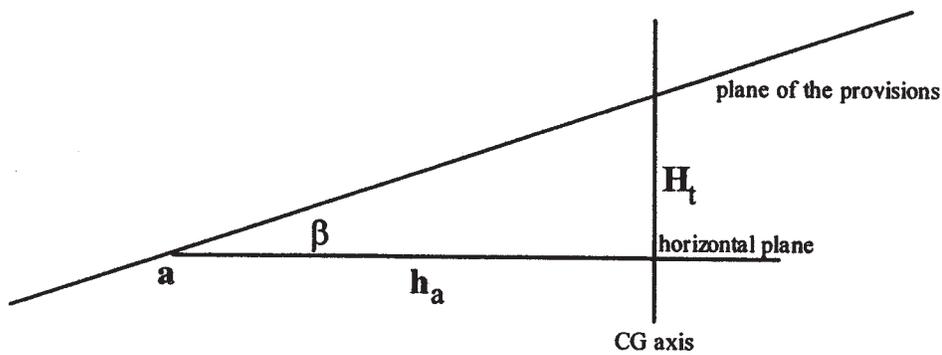
Location	Angle of Pull (from the vertical, in degrees)	Sling Leg Length (inches)	Design Limit Load (pounds)	Ultimate Load (pounds)
Front Right Provision a	23.7	144	10,538	15,807
Front Left Provision b	23.9	144	9,930	14,895
Rear Left Provision c	36.5	144	8,131	12,197
Rear Right Provision d	36.3	144	8,358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



$$H_a = H_f + H_t + K$$

$$\text{TAN}(\beta) = H_t/h_a$$

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

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

This is less 24 feet and therefore meets the apex height requirements of paragraph 5.1.2.i.

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B.5.1.11. When the resulting length of slings using the method described previously in this appendix causes interference between the equipment and the slings when the equipment is lifted, the sling lengths to use for the test can be determined as follows:

- 1) Determine the point of interference on the equipment.
- 2) Determine the length of sling between the provision and the point of interference.
- 3) Using a 45° degree sling angle (measured from the horizontal when the equipment is resting on a level surface), determine the length of sling from the point of interference to a vertical line running through the location of the longitudinal and lateral CG.
- 4) Add #2 and #3 together.
- 5) If #4 is less than 12 feet, then set the sling length at 12 feet for the test. If #4 is 12 feet or more, use this length as the test sling length.
- 6) If there is interference in more than one location, use the above method to determine the test sling lengths for each location and then use the longest resulting sling length as the test sling length. All slings will be the same length for the test.

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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.

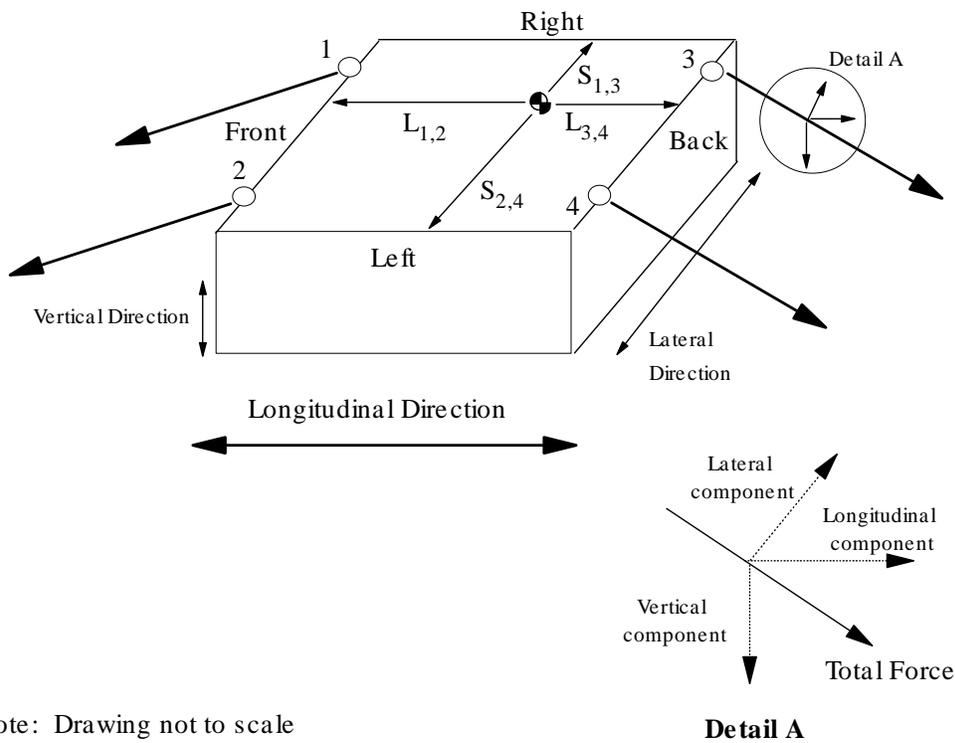
C.4 REQUIREMENTS

C.4.1 Example.

GW = 20,000 lb

S1 = 5 S2 = 10 S3 = 5 S4 = 10

L1 = 15 L2 = 15 L3 = 10 L4 = 10



Note: Drawing not to scale

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.

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

$$4 \times GW = 4 \times 20,000 \text{ lb} = 80,000 \text{ lb}$$

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:

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

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:

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

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

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

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

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:

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

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

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

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

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

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

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

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

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

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:

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

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

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

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

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

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

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$$T_{4v} = \frac{S_3}{(S_3 + S_4)} \times \frac{L_2}{(L_2 + L_4)} \times (T_{1v} + T_{2v} + T_{3v} + T_{4v})$$
$$T_{4v} = \frac{5}{(5 + 10)} \times \frac{15}{(15 + 10)} \times 40,000 = 8,000 \text{ lb}$$

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:

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

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

$$U_{3v} = 1.5 \times T_{3v} = 1.5 \times 16,000 = 24,000 \text{ lb}$$

$$U_{4v} = 1.5 \times T_{4v} = 1.5 \times 8,000 = 12,000 \text{ lb}$$

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

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

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:

$$T_{2s} + T_{4s} = 30,000 \text{ lb}$$

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:

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

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

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

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

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:

$$T_{1S} = \frac{L_3 \times (T_{1S} + T_{3S})}{(L_1 + L_3)} = \frac{10 \times 30,000}{(15 + 10)} = 12,000 \text{ lb}$$

$$T_{3S} = \frac{L_1 \times (T_{1S} + T_{3S})}{(L_1 + L_3)} = \frac{15 \times 30,000}{(15 + 10)} = 18,000 \text{ lb}$$

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

$$\text{Right } U_{2S} = T_{2S} \times 1.5 = 1.5 \times 12,000 \text{ lb} = 18,000 \text{ lb}$$

$$U_{4S} = T_{4S} \times 1.5 = 1.5 \times 18,000 \text{ lb} = 27,000 \text{ lb}$$

$$\text{Left } U_{1S} = T_{1S} \times 1.5 = 1.5 \times 12,000 \text{ lb} = 18,000 \text{ lb}$$

$$U_{3S} = T_{3S} \times 1.5 = 1.5 \times 18,000 \text{ lb} = 27,000 \text{ lb}$$

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APPENDIX D TRANSPORT BY NAVY/MARINE CORPS AIRCRAFT

D.1 Scope.

This appendix provides the restraint requirements for transport in subject helicopter, tilt-rotor, and fixed wing aircraft.

D.2 Applicable Documents.

- (a) A1-V22AB-CLG-000 - Cargo Loading Manual, MV-22B
- (b) A1-H53BE-CLG-000 - Cargo Loading Manual, Navy Models CH-53A, CH-53D, RH-53D, CH-53E, and MH-53E Helicopters
- (c) A1-H46AE-CLG-000 – Cargo Loading Manual, Navy Models HH-46D/UH-46D/CH-46E Helicopters
- (d) NAVAIR 01-75GAA-9 – Cargo Loading Manual, Navy Models C-130 Series
- (e) A1-H60SA-CLG-000 – Cargo Loading Manual, Navy Model MH-60S
- (f) Appropriate NATOPS Manuals for Specific T/M/S aircraft.

D.3 Requirements.

D.3.1 Application.

Cargo equipment to be transported internally by helicopter, tilt-rotor aircraft, or the USMC C-130 aircraft must be designed for restraint to the values in the following table:

Cargo equipment must be properly restrained and have the structural integrity to

Aircraft Type	Static Limit Load Restraint Criteria			
	<i>Forward G's</i>	<i>Aft G's</i>	<i>Lateral G's</i>	<i>Up G's</i>
USMC C-130	3	2	1.5	2
Helicopter/ Tilt-rotor	4	3	3	3
Fixed-wing	3	2	2	2
Carrier On-board Delivery (COD) transport	20 ¹	7	7	4

1. COD forward G is defined as an ultimate load factor.

maintain the noted G loads, defined as limit load factors, for the required aircraft. Item weight for calculating restraint requirements for the subject aircraft will be the items transportable weight and its weight distribution. The ultimate load factors are found by multiplying a factor of 1.5 to the limit load cases in paragraph D.3.1.

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D.3.3 Method of Analysis for Determination of Retention Loads.

The load factors defined in section D.3.1 shall be applied to the structure to determine cargo retention loads, and analyzed using two methodologies. The first method uses geometry of the chain from the aircraft tiedown ring and cargo item, stiffness of the chain/strap, and cargo item suspension system rates to determine retention loads. This method also takes into account the location of center of gravity of the cargo item. With this method, the chain/strap limit load and aircraft tie down ring limit load are fixed constraints. The sizing, location and geometry of the tiedown provision on the cargo item are varied along with the tiedown device geometry to ensure the limit loads are not exceeded. Examples of the second method is given in the cargo loading manuals cited in section D.2. Briefly, the second method computes total restraint required unidirectionally without regard to center of gravity location and stiffness of tie down member, with a geometric reduction or knockdown factor. Details of the second method can be found in the cargo loading manuals cited in section D.2. Both methods are required to be presented in a report to NAVAIR for approval when calculating chain/strap loads for vehicle restraint. Method one shall be labeled the "Engineering Method", and method two labeled the "Loadmaster Method". When determining retention loads using method one, since several worst case load solutions may result. The worst case conditions define the method one design loads for the provision and vehicle backup structure. However, many more solutions are possible during aircrew restraint operations of the cargo item for transport. To assist the loadmaster in his determination of where to place cargo, the reaction load at the tiedown provision from method one analysis should be rounded up to the nearest 5,000 lb whole number increment. The rounding up of the results from method one to the nearest 5,000lb determines method one design loads. For example, if method one results in a provision design load of 4,900lb., rounding to the nearest 5,000 lb increment results in a method one design load of 5,000lb. If method one results in a provision design load of 8,250lb, the method one design load is 10,000lb. This philosophy is to accommodate loadmaster techniques used in the Navy/Marine Corps. Final retention design loads are determined from the larger values from the two methodologies.

D.3.4.5 Structural Load Criteria.

Structural load factors for determining load requirements for transport of cargo equipment in Navy/Marine Corps aircraft are shown in paragraph D.3.1. Positive margins of safety for limit and ultimate load conditions are required for all structure, aircraft, vehicle and cargo. Limit load cases shall show no permanent set by analysis or test.

D.3.5 Supporting Structure.

The supporting structure is considered to be vehicle/cargo structure which supports and attaches the tiedown provision on the vehicle/cargo. The design and testing of individual provisions and vehicle back-up structure must be proven structurally adequate for all applied load conditions. The load conditions for the vehicle are in paragraph D.3.1. The back-up or provisions' structure can be structurally substantiated by hand analysis, finite element analysis or static test. Upon review of the analysis, NAVAIR will determine if the supporting analysis is adequate. Whenever possible, such decisions will seek to reduce

the overall cost impact based on sound risk/benefit analysis. Bypassing the submission of analysis, and performing a test to prove structural adequacy, may require additional local structural testing or analysis to adequately substantiate the back-up structure and determine locations of high stress. Positive margins of safety for limit and ultimate load conditions are required for all structure.

D.3.6 Structural Analysis.

Structural analysis consists of structural substantiation of the vehicle, tiedown provisions and backup structure for the load factors defined in paragraph D.3.1. As part of a preliminary structural analysis package, a matrix of all possible tiedown patterns, cone of action for each vehicle tiedown, and plans to structurally substantiate the individual tiedown patterns and cones of action shall be submitted to NAVAIR for approval. The analysis package shall show structural substantiation by structural testing, analysis or both, for securing the vehicle to the aircraft. The analysis shall include structural substantiation of the vehicle, vehicle backup structure, and provision. Methods of structural analysis and substantiation include hand analysis, finite element analysis and structural test. All high stress structural members and critical load cases shall be identified, margin of safety calculations shown, location of high stress in the model illustrated, assumption stated for boundary conditions and interpretation of results, and enough information in the vendor submitted structural report such that an analyst can reproduce the results from the information provided. Load paths shall be identified for each provision with structural analysis showing positive margin of safety or passage of structural testing. All analysis shall be performed to structurally substantiate the local tiedown provision and backup structure to the point where nominal uniform stress occurs. When multiple provisions use the same back up structure the worst loading case scenarios shall be assumed, identified and analyzed. Standard structural analysis techniques shall be applied, such as stress reduction factors for welds, detailed finite element analysis identifying local high stress areas, conservative assumptions for load application and load distribution, etc. Margins of safety shall be positive for all ultimate load cases as defined in paragraph D.3.1. Positive margins of safety for limit and ultimate load conditions are required for all structure. Limit load cases shall show no permanent set by analysis or test. A structural analysis report shall be submitted for approval to the transport approving agent.

D.3.6.5 Vehicle Structural Analysis and Test.

The entire vehicle shall be structurally substantiated for carriage in Navy/Marine Corps aircraft by test and/or structural analysis. The vehicle structure and all peripheral components shall remain undeformed and an integrated unit when subject to the limit load conditions specified in paragraph D.3.1. The vehicle subject to ultimate load conditions can deform, but must remain as an integral unit. Structural substantiation can be shown by test, structural analysis by hand or finite element, engineering inference or a combination of methods. The vehicle and all peripheral components, such as cargo, weapon systems, seats, mirrors, windshield, seats etc., shall be shown to be retained and undeformed for the appropriate condition in paragraph D.3.1. A test plan or structural analysis shall be submitted for approval to the approving air transport certifying authority. Testing may be static or dynamic in nature or a combination of both. For ex-

ample, a windshield can be tested using a dynamic/impact test with a Navy/Marine Corps specified pulse as part of peripheral vehicle equipment test whereas a machine gun installation can be structurally substantiated by hand analysis for a critical static load condition. Loose cargo items within the vehicle may have multiple configurations for carriage and are also required to be restrained to the appropriate conditions in paragraph D.3.1. All configurations must be structurally substantiated by analysis or test.

D.3.7 Provision Testing.

Provision testing consists of structurally substantiating each vehicle provision for the vehicle loads generated from the application of load conditions in paragraph D.3.1. A matrix of all possible tiedown patterns shall be submitted as part of the provision testing process, along with provision cone of action. Testing of the provisions and back-up structure shall be of a production representative configuration. The tiedown provisions and back-up structure shall be analyzed through the entire stated cone of action from loads calculated in procedures in paragraph D.3.3. Provision pull testing will be conducted to validate the results of the analysis. The number and direction of pull tests may be determined from a combination of structural analysis and engineering inference based on the actual structure and geometry being tested. In general, a minimum of 4 pull tests will be performed to simulate worst load case vehicle tiedown pattern geometry, for each provision, within the cone of action. If the vendor can show structural substantiation with less than the minimum tests, a complete data package shall be submitted to NAVAIR. A test plan with total number of pulls and directions with substantiating documentation will be submitted to NAVAIR or the appropriate service transportability agent for approval.

D.3.8 Aircraft Restraint Pattern Testing.

The aircraft restraint pattern testing shall structurally substantiate the vehicle tiedown patterns for a specific aircraft platform. The vehicle will be restrained to an aircraft mockup using the procedures submitted for paragraph D.3.6. The forward restraint criteria will be applied to the vehicle to simulate the tie down geometry in the aircraft. The same will be performed in the other test directions. At least one complete tiedown pattern pull test shall be performed in the forward, aft and side directions to simulate the worst case loading. This test will be performed for each aircraft platform. When performing pattern testing, five items must be considered when developing and executing the aircraft restraint pattern test plan: 1) Local provision strength and influence on strength capability from neighboring provisions, 2) provisions sharing the same backup structure, 3) Combinations of tiedown patterns which simulate worst case loading, 4) simultaneous testing of provisions that share the same backup structure, 5) influence of suspension system of the vehicle. A test plan shall be submitted to NAVAIR for approval. The plan shall show the range of tiedown patterns for the vehicle in the aircraft, justification for choosing the test patterns proposed for testing, loads predicted in tiedowns devices, and loads and stresses predicted in vehicle structure for each test condition. A post test report documenting results and how they compare to predicted values shall be submitted to NAVAIR.

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Custodian:

Army - MT
Air Force - 11
Navy - SA

Preparing Activity:

Army - MT

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Review activities:

Army - AR, AT, AV, CR, CR4, GL, MI, SM, TE
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DLA - CC

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