NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

January 30, 2015

Group Chairman's Factual Report

STRUCTURES

DCA13MA081

Attachment 4

National Airlines Cargo Operations Manual Revision 8 Issued September 17, 2012

These are only selected pages needed for the purposes of conducting the accident investigation. This is not a complete manual and not approved for commercial use.

Manual Issuance

National Airlines

Cargo Operations Manual

Copy Number: _____

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It shall be the responsibility of each employee to whom a National Airlines manual is issued, to maintain these manuals in good condition and to keep them current and up to date by inserting all revisions promptly when received.

These manuals shall be returned to the Company in good condition when recalled or upon termination of employment. In the event an employee fails to surrender said copies of manuals, the charge will be $150.00 per manual.

Sign one copy of this page and return to National Airlines Manager of Publications.

National Airlines manual control, distribution, availability and regulatory compliance requirements are defined in the Administrative Manual (ADM) Chapters 1 and 3.

List of Effective Pages

FAA Accepted/Appro
FAA Signature [redacted] Principal Operations Inspector Date 09-25-2012

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FAA Signature [redacted] Principal Operations Inspector Date 09-25-2012

Chapter 10: Instructions and Forms

FAA Accepted/Approv
FAA Signature [redacted] Principal Operations Inspector Date 09-25-2012

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Table of Contents

Chapter 1: Introduction

1. GENERAL

SRR: 121.135(b)(1)

1.1 PURPOSE

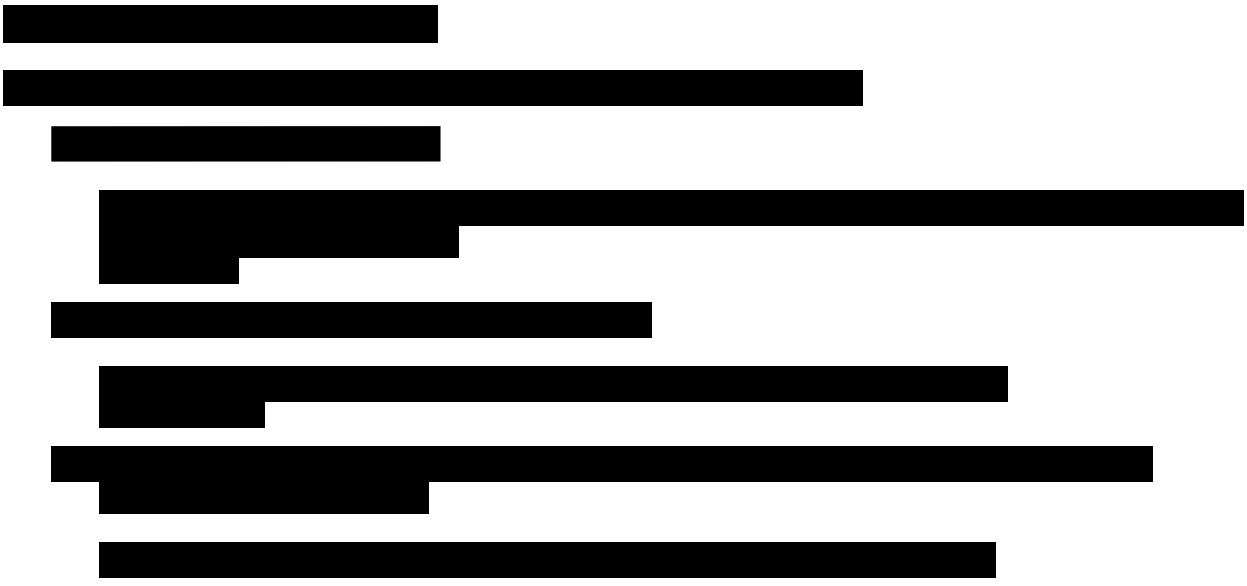
This manual contains the Cargo Operations Program. The procedures and processes contained within this manual are used to ensure that no aircraft is allowed to take off improperly loaded.

1.2 GUIDING AUTHORITIES

National Airlines will be utilizing the applicable Aircraft Cargo Loading Manuals for general aircraft loading data, Company policies and procedures regarding Cargo Operations are incorporated in this manual. Other guiding authorities for the information in this manual include:

These procedures, along with others within other Company developed manuals such as the Company's General Operations Manual (GOM) and Data Manual (DAT), have been established to maintain control of weight and balance of the Company's aircraft under the terms authorized by Operations Specification E096 Weight and Balance Control Procedures.

This Manual presents the Company Operations and System Control policies and procedures for Carriage of Cargo Operations. These policies and procedures supplement the General Operations Manual and General Maintenance Manual and were developed in accordance with Advisory Circular AC 120-85, IATA Dangerous Goods Regulations, National Airlines Hazardous Materials Manual, Flight Standards Information Management System 8900.1, ATOS Data Collection Tool SAI 1.3.25 Cargo Handling Equipment, Systems and Appliances (AW), ATOS Data Collection Tool SAI 3.1.8 Carriage of Cargo (OP) and all applicable Federal Aviation Regulations (14 CFRs). The procedures and processes contained within this chapter are used to ensure that no aircraft is allowed to take off unless all components of the Cargo Operations program have been executed.



1.3 PROCEDURES

The procedures contained in this chapter describe the method of accomplishing a process or task. Procedures in this chapter are procedures, not just a policy. The procedures contain sufficient detail to achieve desired results and identify who, what, when, where, and how. They assure compliance with the associated 14 CFR's on a continuous basis and meet the intent of written FAA guidance. They identify resources to support the procedures, including any required training. The procedures are also consistent between manuals where applicable

SRR: 121.135(a)(1),
SRR: 121.135(b)(3)

This chapter also contains instructions and information for those who manage the work required for the carriage of cargo. This Cargo Operations Manual sets forth the procedures for all ground personnel involved with the physical loading of Company aircraft.

SRR: 121.133(a)

[redacted]

Chapter 2: Palletized and Bulk Cargo

1. UNIT LOAD DEVICES (ULDS)

A unit load device, or ULD, is a pallet or container used to load luggage, freight, and mail on wide-body aircraft and specific narrow-body aircraft. It allows a large quantity of cargo to be bundled into a single unit. Since this leads to fewer units to load, it saves ground crews time and effort and helps prevent delayed flights. Each ULD normally has its own packing list (or manifest) so that its contents can be tracked.

There are some variations, but ULDs fit into two broad categories:

1. An enclosed container (known by names such as igloo, hut, A2, M1, LD-3) with either doors or a net / tarp assembly covering one end.
2. An open, flat base (a.k.a., pallet, cookie sheet, flat) used in conjunction with certified nets and/or straps.

ULD pallets are rugged sheets of aluminum with rims designed to lock onto cargo net lugs. ULD containers, also known as cans and pods, are closed containers made of aluminum or combination of aluminum (frame) and Lexan (walls), which, depending on the nature of the goods to be transported, may have built-in refrigeration units. Examples of common ULDs and their specifics are listed below.

- [redacted]

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5.2 AREA LOAD:

The load on any given area of significant size (typically more than 10 to 20% of the pallet's surface) should meet the maximum area load limitation specified for the lower, main or upper deck position it is intended to be loaded on in the aircraft.

Note:

What shall be taken into account to verify area load limitation is the total bearing area, i.e. that of the outer perimeter defined by all contact points of the load onto the pallet.

The maximum allowable weight per square foot for all ULDs is 300 pounds per square foot, or 2.08 lbs per square inch (psi) on the DC8.

Elementary shoring procedures such as using wooden pallets to enlarge cargo's footprint on the pallet should be considered first and are in many circumstances sufficient to ensure compliance with the maximum area load restriction. In very heavy or concentrated load cases, study and implementation of a proper shoring arrangement may be necessary: see Shoring: (Chapter 2 paragraph 5.10).

5.3 RUNNING LOAD:

The aircraft floor's maximum running load, in lb/in (kg/m) measured parallel to the aircraft's centerline, is usually met by complying with the pallet position's maximum allowable gross weight.

For heavy and concentrated loads shorter than the pallet, a running load check may be necessary when the load's dimension measured parallel to the aircraft's centerline exceeds two fuselage frames spacings, i.e. 40 to 50 in (1.0 to 1.2 m). In such a case, a shoring calculation taking into account the pallet's stiffness/ load distribution effectiveness is required, and may result in the necessity of longitudinal shoring: Shoring: (Chapter 2 paragraph 5.10)

5.4 C.G. LOCATION (PLAN VIEW):

The pallet load's overall Center of Gravity (C.G.) shall be within the maximum plan view limits specified at maximum gross weight by the pallet's certification NAS 3610 configuration.

Note:

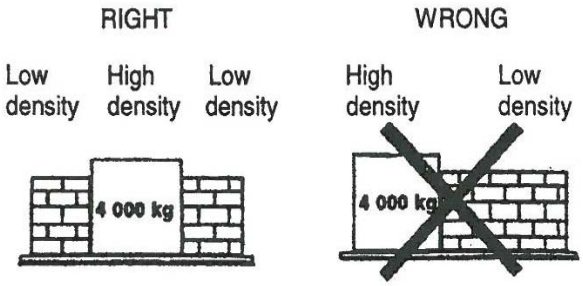
The pallet's certification NAS 3610 configuration is engraved or permanently marked on the pallet edge rail (e.g. "NAS 3610 - 2A6P" for configuration 2A6), at a location selected to remain readable after the pallet was loaded with cargo.

If there is uncertainty about the CG limits to be used for the pallet on hand, a ± 10% of pallet length and width maximum CG deviation from pallet geometric center may generally be used.

The methods to be used to control the load's overall CG location vary depending on its nature:

- For a heavy single piece of cargo, the piece's CG location should be marked by the shipper or, if not, physically measured balancing the piece with a forklift or equivalent lifting means,
- For homogeneous nature and density package cargo, CG location can be assessed and controlled by ensuring an even level of stacking throughout the pallet's surface,
- In the event of significantly different densities of cargo being loaded on the same pallet, care should be taken when stacking to ensure symmetrical loading (See Figure 2-1. on page 2-20).

Figure 2-1. Example of High and Low Density Mix



5.5 C.G. LOCATION (HEIGHT):

The pallet load's overall Center of Gravity (C.G.) shall be within the maximum height limit specified at maximum gross weight by the pallet's certification NAS 3610 configuration.

Note:

The pallet's certification NAS 3610 configuration is engraved or permanently marked on the pallet edge (e.g. "NAS 3610 - 2A6P" for configuration 2A6), at a location selected to remain readable after the pallet was loaded with cargo.

If there is uncertainty about the maximum CG height to be used for the pallet on hand, a maximum of half the pallet contour's maximum height may in most cases be used, when the contour height does not exceed 8 ft (2.44 m).

For a load lower than the pallet position's maximum gross weight, higher CG heights may be considered subject to the stated rules and requirements in the aircraft's Weight and Balance Manual: linear extrapolation of maximum allowable CG height vs pallet position maximum gross weight may generally be applied, if required.

Whenever possible, which is in most circumstances, it is recommended never to simultaneously use maximum allowable CG deviation in both the height and plan view directions.

The methods to be used to control the load's overall CG height vary depending on its nature:

- For a heavy single piece of cargo, the piece's CG height should be marked by the shipper or, if not, calculated or physically measured,
- For stacked smaller cargo, overall CG height can be assessed and controlled by ensuring any higher density cargo is loaded first at the bottom of the pallet stack: see Cargo Stacking: (Chapter 2 paragraph 5.7).

[redacted]

6. PALLET TIEDOWN

All fasteners, rings, and hooks of the pallet nets should be positioned at least three inches from corners of the load after the net is tightened to lessen the possibility of damage from metallic objects. Lay the top net over the load using care not to snag the cargo with the attaching hardware. There should be five track attach fittings open each long pallet side and four on each 88 inch side. Engage the attach fittings in the pallet tiedown track. Tighten the net over the load by pulling on the hooks or buckles fitted to the net in the direction best suited for restraint and remove the slack from the net. Engage the hook with the most strategic rope member of the net. In some cases, due to the shape of the load, it may be necessary to supplement the net with additional restraint devices.

Cargo Straps must be checked prior to their use for excessive wear or cuts, working hardware may be deformed but must operable, if an expiration date is shown it must not exceed that date or if only month and year are shown it may not exceed the last day of month shown. Straps should be traceable to standard such as a TSO-C172, ISO 16049-1, SAE AS 5385A, IATA UTM60/2 and may be of the ratchet or over center buckle type. Any cargo strap which has exceeded its expiration date can not be used and must be returned to KYIP cargo for a check for its usefulness and re-validation, in accordance with Company procedures.

7. RESTRAINT

[redacted]

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7.3 STRAPS TIE-DOWN

The net may also have to be totally replaced by a straps tie-down arrangement, when it is by nature inappropriate for the load or inadequate to effectively restrain it under ultimate accelerations. Examples:

- Vehicles, helicopters, aircraft engines, etc.
    - Cargo overhanging from the pallet, that cannot be restrained by the net, etc.
- Oversize or odd size cargo.

Preference should always be given to the use of the net whenever it can ensure proper restraint.

Such tie-down shall be performed using approved straps meeting all the design, testing and quality control requirements of TSO-C172, AS5385 and ISO 16949-1 (See Appendix X). In view of the load weights usually associated with air cargo pallets, it is recommended to use only 5000 lb (22250 N) guaranteed ultimate load straps, together with double stud tie-down fittings of the same capability. No mixing of straps of different ultimate strength, material or make (e.g., different tensioning mechanisms) is allowable.

The total tie-down arrangement shall be symmetrical in relation to the pallet's centerline and should meet the general, specific and ultimate strength calculation requirements of ARP5595, Cargo Restrain Straps - Utilization Guidelines (in preparation, Also see ISO 16049-2). The tie-down fittings location on the pallet's track should be as close as possible from those defined in the applicable NAS 3610 configuration, and shall at least ensure a 20 in (0.5 m) minimum spacing. See Figure 2-4. on page 2-27, See Figure 2-5. on page 2-27 and See Figure 2-6. on page 2-28.

The tie-down arrangement with straps shall be systematically checked by the Loading Supervisor prior to pallet release for loading aboard an aircraft.

Figure 2-4. Forbidden (50cm/20 in Spacing Minimum for Two Straps in the Same Direction)

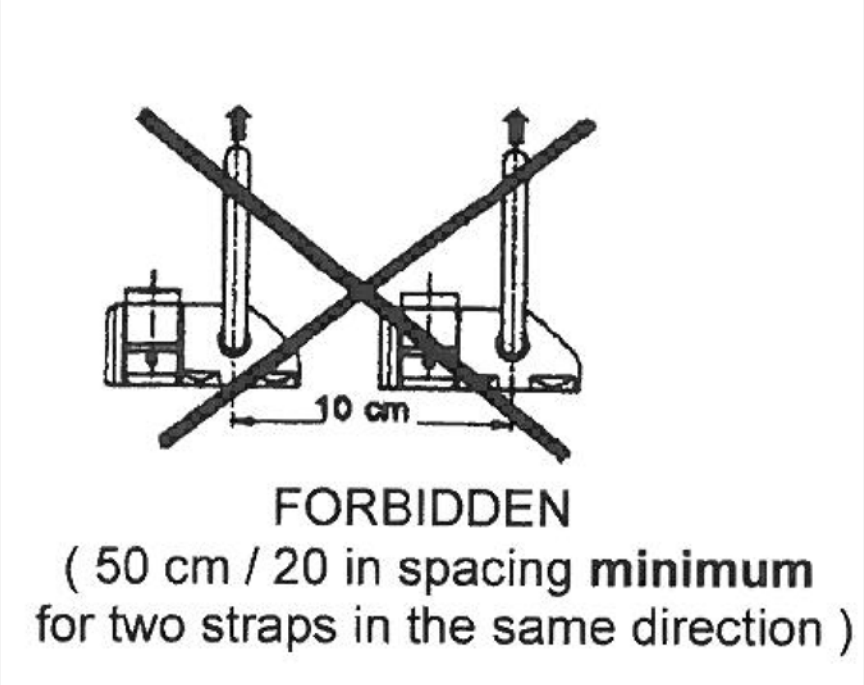


Figure 2-5. Allowable 4 Inch Separation with Strap at 30 Degree maximum angle

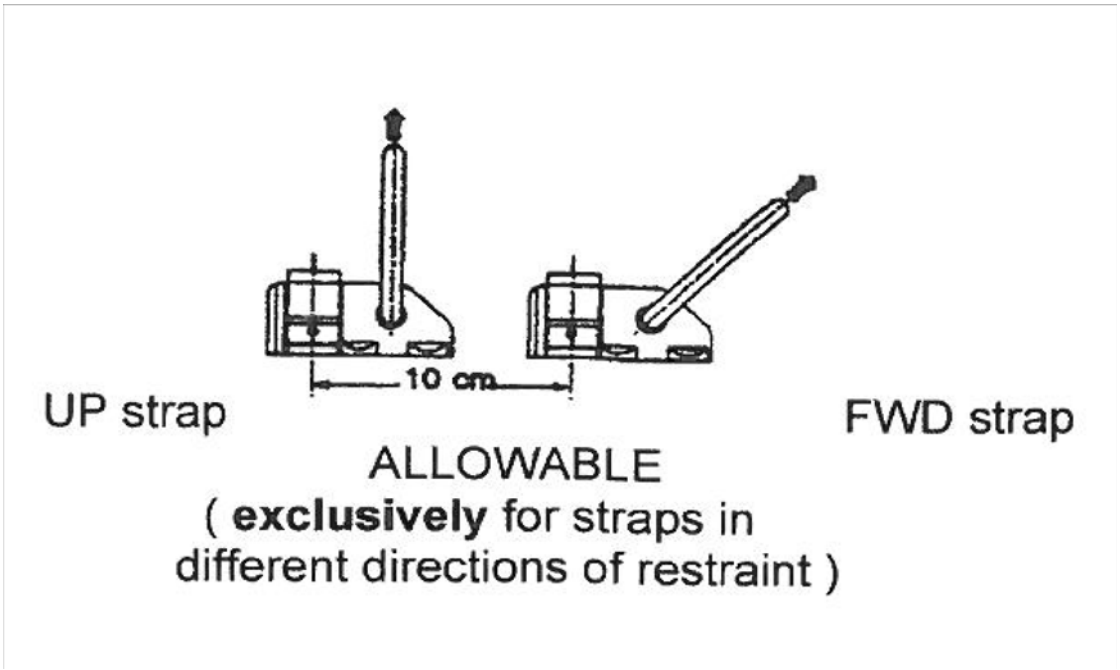
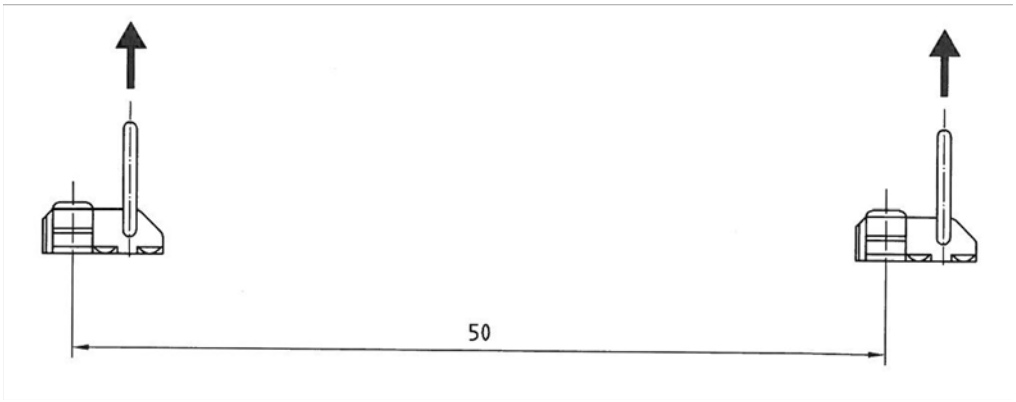


Figure 2-6. Example of Permissible 20 inch separation



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11. BULK CARGO RESTRAINT

Local Tiedowns

Bulk cargo is defined as cargo place on the aircraft floor, or on pallets or shoring resting on the aircraft floor, with restraints accomplished by local tiedown. Bulk cargo is not to be loaded on top of the loading system rollers, as this may damage them. On aircraft converted from passenger aircraft, floor loading is permitted only when placed on adequate shoring or pallets used as shoring with the load secured to the floor track.

Cargo restraint involves the prevention of movement in five principal direction; forward, aft, upward (vertical), left (side), and right (side). These movement are the result of forces exerted upon the cargo due to acceleration or deceleration of the aircraft in takeoffs and landings as well as forces due to air turbulence in-flight. Such forces are commonly expressed in terms of gravitational units (Gs). Correct restraint provides the proper relationship between the weight of the cargo and the restraint required in Gs.

DC8 cargo restraint requirements are:

- Forward, Side, and Aft (all positions) - 1.5 Gs

- Vertical (positions 1-17) - 2.6 Gs
- Vertical (position 18) - 3.4 Gs

Cargo restrained by local tiedown shall be tied down with nylon straps, (rated strength - 5,000 pounds) or 3/8 inch poly (MIL R24049A rated at 2440 pounds). It shall be tied to approved tiedown fittings installed in tiedown tracks in the aircraft floor. Allowable tiedown track load must not be exceeded. Allowable tiedown track loads are 5,000 pounds in any direction at all points on the track. Loads shall not exceed 5,000 pounds in any 20 inch section of track. When tiedown rings are included on side rails as a component of the assemblies, they have a maximum allowable pull of 2,000 pounds each in any direction. After all retraining devices are in place, each tiedown device should be adjusted to remove all slack. This is desirable to insure that as force is brought to bear, it does so uniformly on all units of tieddown applied. If for instance, 2 lengths of rope were used to secure a piece of freight, one of which was applied with no slack, effective restraint would be limited to the length of rope with no slack. It is entirely possible that one unit would be unable to restrain the force and break. This creates as dangerous situation, as it allows the piece to move and gather momentum, which in turn increases forces at a very rapid rate. It is a scientific fact that a rope tied at one point, extended around an object and back to the same point will have a pulling strength double to what it is rated. A rope of 2,000 pounds strength running from one ring, around a piece of freight and back to the same ring will provide 4,000 pounds of restraint. One rope tied to a ring and extended around the freight, then back to another ring will also provide 4,000 pounds of restraint. This application is specially useful when securing heavy pieces.

Chapter 6: Special Loads

1. OVERSIZED OR HEAVY CARGO LOADS

1.1 GENERAL

Heavy and Outsized Cargo (BIG) is anything loaded onto an aircraft that is larger or heavier than normal position restrictions would allow. The core reasoning behind limitations is in order to protect the structural integrity and the safe operation of the aircraft. The terms HEAVY and BIG indicate those shipments of abnormal size, shape or weight that require special handling.

The aircraft structure has full circumference ribs separated by stringers. The floor beams are attached to the ribs across the body of the aircraft laterally. On top of the lateral beams are longitudinal beams. The floor, which is not a heavy structural component, is placed on top of these beams and then the seat tracks and roller trays are secured to the longitudinal beams through the floor. Everything placed on the rollers/ roller trays transfers its weight through the floor to the beams and ultimately to the attach points at the ribs.

The strongest part of the airframe is normally the center wing section where the ribs are closer together and of heavier and stronger construction. This area is the “high gross weight section” of most airplanes. Aircraft manufacturers place certain restrictions and limitations that must adhered to in order to maintain the integrity of the structure and the safety of the aircraft.

[redacted]

[redacted]

1.5 LOADING OVERSIZE BIG AND/OR OHG ITEMS

Prior to loading Oversize BIG and/or OHG items, ensure that there is sufficient and suitable tie-down positions available, and if necessary, raise the load above the pallet surface to gain access to, or make more tie-downs available.

Check the loading sequence whenever possible to ensure that 'through' Oversize BIG and/or OHG item will not have to be moved to gain access to cargo, pallets, or ULD's scheduled to be off-loaded at intermediate stops.

2. FLOATING PALLETS

2.1 DEFINITION

Floating pallets are defined as pallets which are oriented in the aircraft in such a manner that the forward and aft pallet end restraint fittings and side rails will not all engage the pallet to restrain it, and it might not be possible to place all pallet end restraint fittings in proximity of the floating pallet in the locked position.

2.2 EXAMPLE

The example is the 88 X 125 inch pallet most commonly used by the Company.

Normally, the 88 X 125 inch pallet is installed in the aircraft (except for the most rearward pallet position) oriented with the 88 inch sides engaging the side rails and the 125 inch sides engaging the five forward and five rear pallet end restraint fittings.

On a typical floating pallet installation, the pallet is rotated so that the 88 inch sides face fore and aft, while the 125 inch sides face the side rails.

In this installation, the 88 inch side which faces the rear of the aircraft can only engage the three center pallet end restraint fittings of the position in which the pallet is to be installed. The 125 inch sides will not engage the side rail system, and the 88 inch side facing the front of the aircraft will not engage any pallet end restraint fittings at all, because the pallet will be sitting on top of the pallet end restraints which normally lock the pallet in place.

This type installation is used for large, BIG, or oversized cargo where the pallet is used for floor load weight distribution and protection, and not the restraining of the cargo on it.

With this arrangement, all cargo must be secured in such a manner that the cargo (and pallet) cannot move. This is done through the use of sufficient number of approved cargo straps, ropes, cables, etc., and double stud locking devices.

2.3 ADDITIONAL EXAMPLE

Another type floating pallet installation is used on occasion.

In this type installation, the pallet is oriented with the 125 inch sides (which normally face fore and aft) facing the side rail system and the 88 inch sides (which normally engage the side rail system) facing fore

and aft. The difference between this type floating pallet and the one previously mentioned is that in this type installation the floating pallet does not engage any pallet end restraint fittings at all. Instead, this floating pallet sits on spreader flooring which is sandwiched between the floating pallet and two pallets installed normally beneath spreader flooring.

Although this type installation sounds better than the floating pallet installation previously mentioned, this type installation has a marked disadvantage in that it is very difficult (and sometimes not possible) to install and place cargo on the floating pallet in any positions other than those closest the main deck cargo door.

Note:

In all floating pallet installations, the Loading Supervisors shall ensure and certify that all pallet end restraint fittings that are not beneath the floating pallet assembly or blocked by the floating pallet are in the locked position prior to closure of the main cargo door on departure.

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[redacted]

4. TIEDOWN AND RESTRAINT OF OVERSIZE LOADS

4.1 GENERAL

Air cargo is subjected to forces caused by maneuvering, rough air, rough landing, extreme flight attitudes and may be subjected to extreme forces due to emergency landings. These forces will shift cargo unless it is secured firmly in the aircraft. During normal operation, the aircraft and cargo are moving rapidly forward. If the aircraft is slowed suddenly, the cargo will tend to continue moving forward. This forward tendency is likely to be the strongest force encountered by the cargo. In addition, there are forces in other directions: vertical, lateral, and rearward (aft).

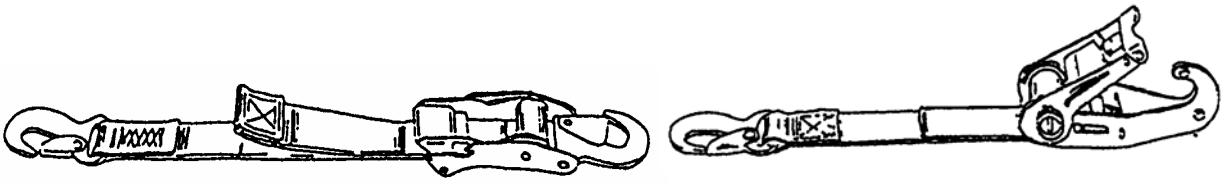
Restraint criteria for air cargo are based upon the weight of each cargo unit and the dynamic forces (loads) imposed upon each unit due to a change in motion (changing direction, slowing down, speeding up). The dynamic forces increase as the rate of change in motion increases. An object that is slowed down over a long distance has lower dynamic forces than the same object when stopped in a short distance. All cargo on an aircraft, except that placed in bulk compartments, shall be restrained so it will not shift during any flight conditions normally experienced by the aircraft. CARGO SHALL BE RESTRAINED FOR LOADS IN ALL DIRECTIONS.

See Chapter 9 For airplane specific Minimum Restraints.

4.2 TIEDOWN EQUIPMENT

For bulky oversize freight where nets would not provide effective restrain, the principle piece of equipment used for tiedown is the standard 24 ft. nylon aircraft cargo strap (Figure 6-3. on page 6-5). These can be used for heavy and bulky pieces, securing floating pallets, and supplementing net assemblies. Straps have attachment hardware at either end, usually double-stud fittings compatible with the seat-track found on ULDs and the cargo compartment floor. They may also have hooks which can be used in conjunction with D-rings (Figure 6-4. on page 6-5)

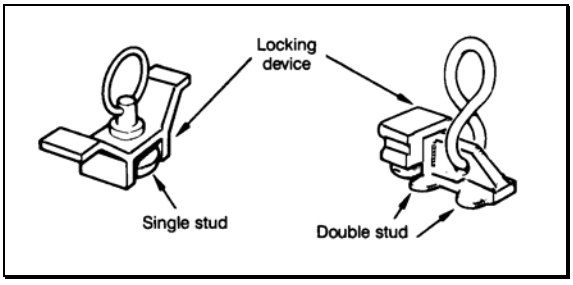
Figure 6-3. Cargo Straps.



5000 Pound Rating
24 Ft. Standard Length

5000 Pound Rating
CGU/1B Type Strap

Figure 6-4. D- rings



Note:

IAW AD 2004-22-01 Discontinue the use of Supplemental Type Certificate (STC) ST01004NY to install Airline Container Manufacturing Company, Inc., cargo restraint straps, part number 1519-MCIDS, as the only means of securing cargo to Technical Standard Order (TSO) C90c/NAS3610 pallets. Such cargo restraint straps may continue to be used as supplemental restraints to secure cargo to (TSO) C90c/NAS3610 pallets, or to the cargo restraint fittings in the airplane floor, per the airplane manufacturer's weight and balance manuals, and within the strap rated load (5,000 lbs).

The rated strength for the various fittings and devices are:

Cargo strap, ratchet tensioner	5000 lbs
Cargo strap, fold-over tensioner	5000 lbs (or as listed on tag)
D-ring, single stud	2500 lbs
D-ring, double stud	5000 lbs
Seat track	2000 lbs per stud in all directions except 2500 lbs per stud vertical direction

Note:

The total load of supplemental tiedown attached to any 20-inch stretch of seat track must not exceed 5000 lbs.

A tiedown is only as strong as its weakest link. Therefore a 5000 lb. strap with a single stud D-ring attached to seat track has a maximum load of 2500 lbs vertical or 2000 lbs non-vertical. If a double stud attachment or D-ring is used, the tiedown is good for 5000 lbs vertical, but only 4000 lbs at any other angle.

Various diameters of nylon rope can be used for repairing or supplementing cargo nets. The following four standard types of rope are most commonly used for these purposes:

Material	Diameter	Rated Strength
Nylon	1/4 inch	1900 lbs
Nylon	3/8 inch	2440 lbs

4.3 PRINCIPLES OF RESTRAINT

Certain principles of restraint must be observed when tying down cargo. The details of tying each unit of cargo will vary with its bulk, weight, configuration and position in the aircraft. However, these principles of restraint always apply in achieving satisfactory restraint of cargo movement.

A basic principle of developing sufficient strength of tiedown is that the strap must lead off in the general direction of the load to be restrained (fwd, aft, etc.). A very light load applied at 90 degrees to the direction of the strap will deflect it. However, if the weight (load) is applied in the direction of the strap, the strap will support a weight equal to its strength (Figure 6-5. on page 6-7 & Figure 6-6. on page 6-7).

Figure 6-5. Incorrect Forward and Aft Restraint

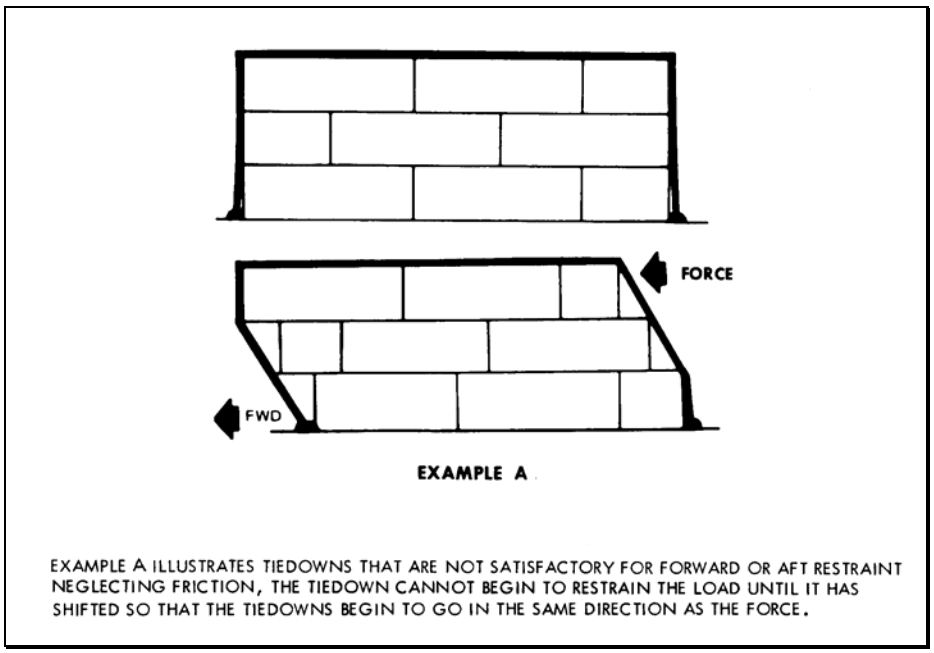
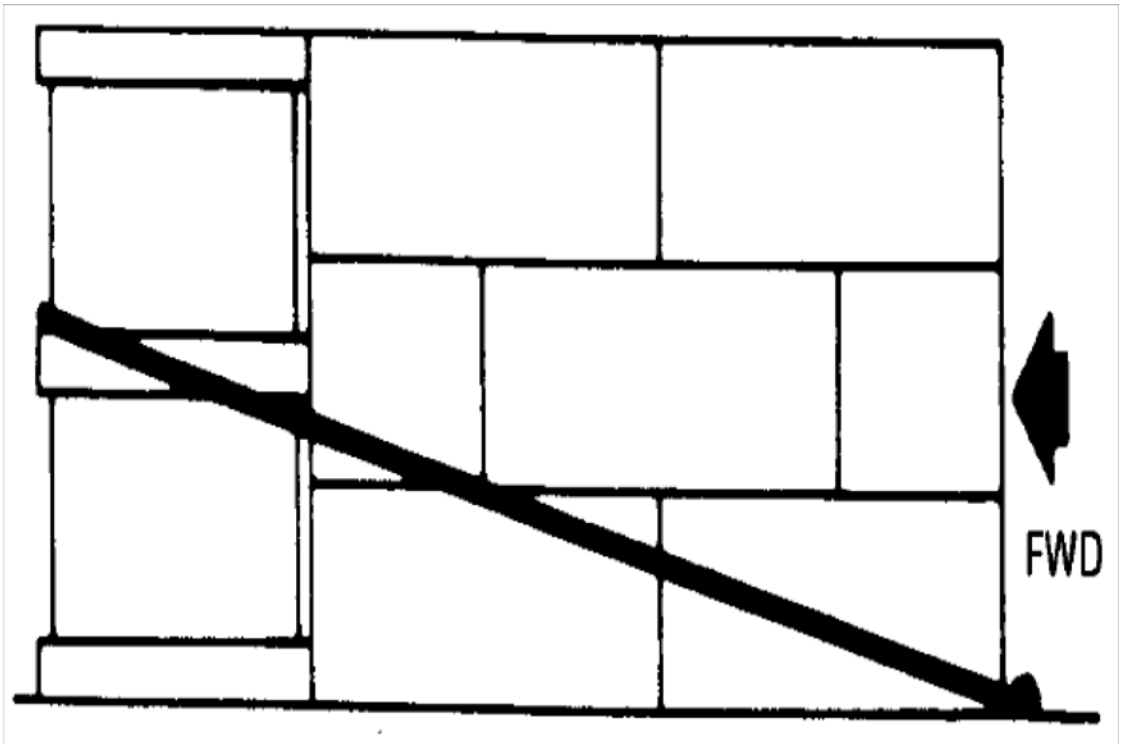
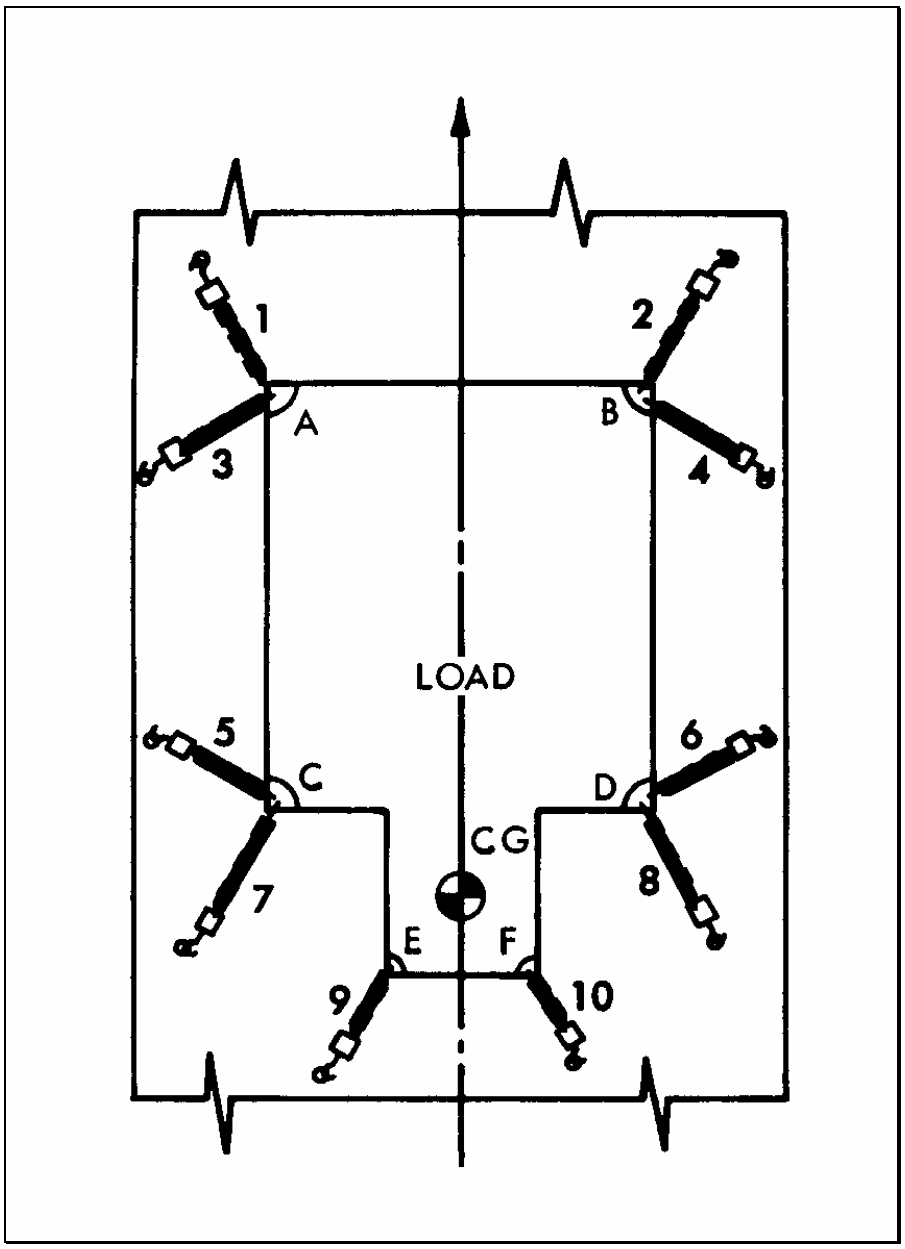


Figure 6-6. Correct Forward Restraint



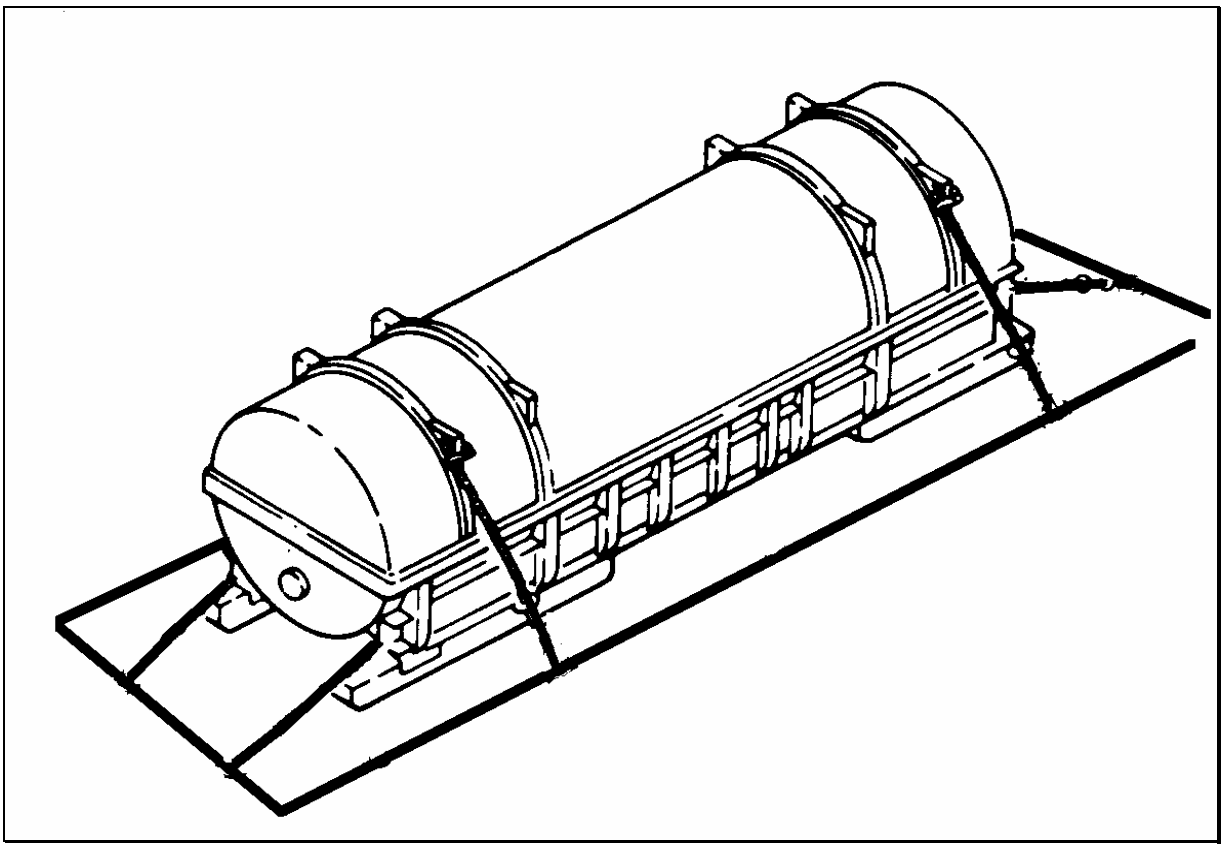
The arrangement of straps must be symmetrical around the cargo unit, i.e., the number of straps used for forward restraint must be equal on each side, must be the same approximate length, and must be applied at the same approximate angle. Asymmetrical, or uneven, tiedown results in an uneven distribution of load among the tiedown devices (*(See Page 6-8)* & *(See Page 6-9)*).

Figure 6-7. Symmetrical Strap Arrangement



Any material subject to a tension load will stretch a given percentage of its length. Cargo straps made to IATA standards can stretch over 8% in length as the strap nears its load capacity, therefore, the greater the length the greater the potential amount of stretch. If two straps of the same type and capacity are used to restrain a load in a given direction and one is longer than the other, the longer strap, with its greater stretch potential, will make the shorter strap take on the majority of any load that may develop. If as a result the shorter strap should be overstressed and fail, the longer strap would then be subjected to the full load and it too would probably fail.

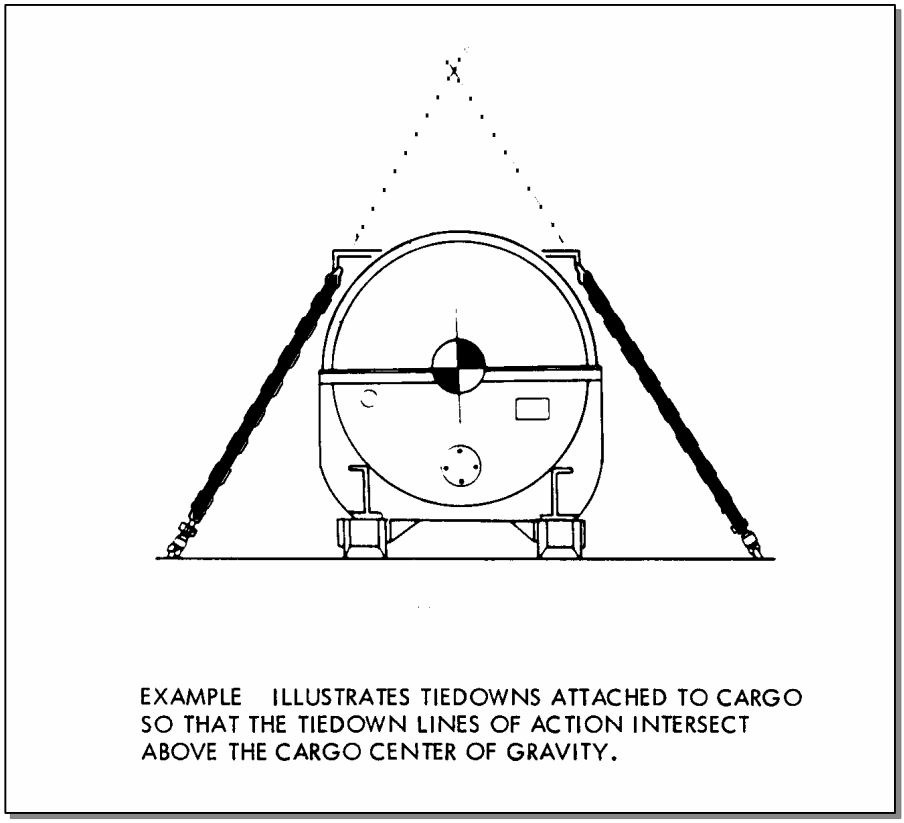
Figure 6-8. Symmetrical Strap Arrangement



Although all materials stretch in direct proportion to the applied load, different materials have different rates of stretch. Nylon devices stretch more readily than chain or cable and, under tension, almost immediately permit the steel device to assume the majority of the load. Therefore, when two or more tiedown devices are required to restrain a unit of cargo for a given load direction, the devices should be of the same type and the ties should be of approximately the same length.

When tiedown devices are attached to cargo, the lines of action of the tiedown device should, if possible, intersect above the cargo center of gravity (Figure 6-9. on page 6-10). Such a tiedown reduces the tendency of cargo to overturn when subjected to combined upward and side loads.

Figure 6-9. Tiedown Lines of Action

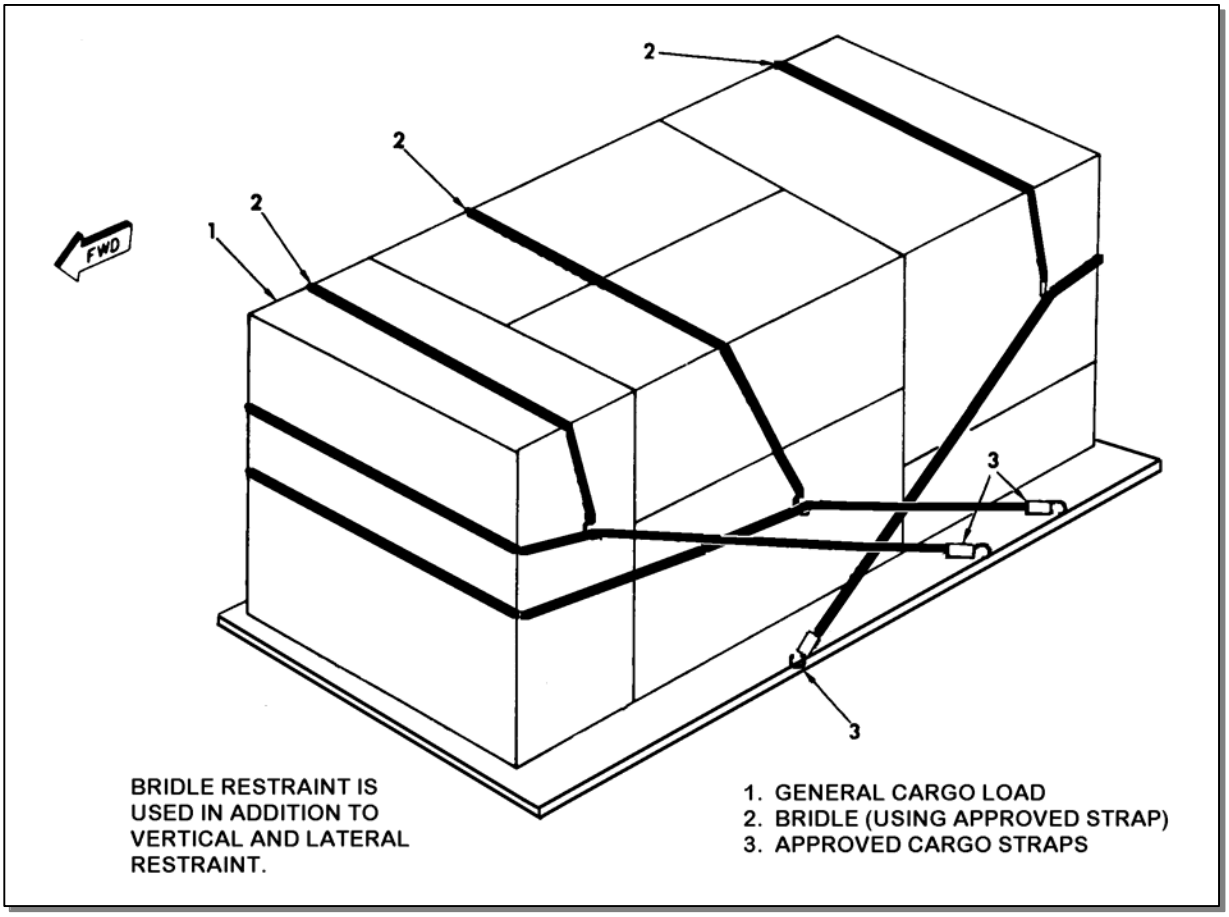


The amount of tension or tightening applied to a tiedown device or net does not increase its capacity or ability to bear its maximum rated load. Tiedown must be moderately tight - enough to prevent cargo from shifting - but no so much as to damage the cargo, the tiedown device itself, or the tiedown attachment points. It is much more important to have all tiedowns equally tensioned to a reasonable degree, than to have all as taut as guitar strings.

Sometimes large cargo does not have suitable attachment points for straps, and it is difficult to put cargo straps across the ends to provide longitudinal restraint. A technique called bridle restraint can be used to supplement or provide forward and aft restraint. *(See Page 6-11)* shows three straps positioned around the end of some cargo, each with another strap attached to it and going over the top of the cargo, much like a horse's bridle (hence the name). Due to the low, shallow angles of the straps, there is very little, if any, vertical or lateral restraint.

Additional tiedown (not shown here for the sake of clarity), must be used to adequately restrain the load.

Figure 6-10. Bridle Restraint



4.4 CALCULATION OF RESTRAINT

Cargo must be restrained so it will not shift because of loads resulting from dynamic forces encountered during takeoff, flight, and landing. The restraint must be adequate for the greatest load that may result. These loads are expressed in terms of cargo-weight times the applicable load factor. If a cargo unit is subjected to a load equal to 1.5 times its weight, it must be restrained for a load factor of 1.5 to prevent it from shifting.

If the calculation result in an odd number, use the next highest number of tiedowns. Use good sense with heavy and high density objects. Always use extra straps - it does no good when they are lying on the floor.

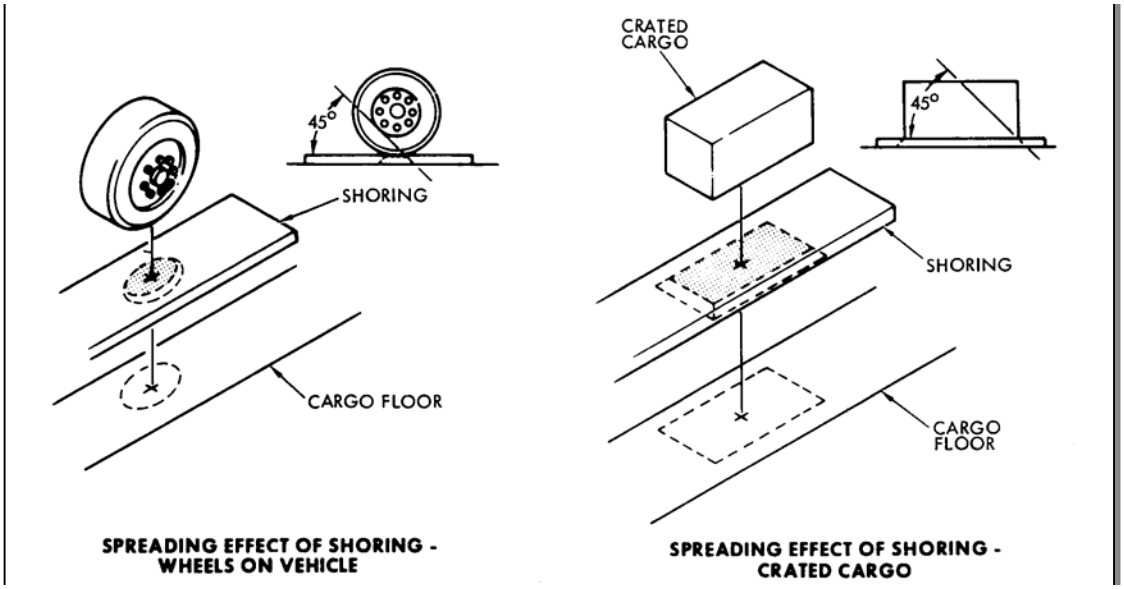
4.5 SHORING REQUIREMENTS

Shoring is used to spread highly concentrated loads over a greater base area than that occupied by the cargo alone. Use of shoring permits carrying a load with a higher concentration than would be normally allowed. It is also used to protect ULD surfaces from damage caused by vehicle cleats, steel wheel rims, and packing case studs or protrusions.

Cargo exceeding the rated floor bearing capacity of a ULD or aircraft will require shoring to distribute the load over a greater area. Shoring used for weight distribution may be ordinary planking laid beneath the cargo, or it may be composed of plywood sheets.

The weight of the load is not spread evenly over the entire area of contact between the shoring and the surface on which the shoring is resting. The cargo weight will spread at a 45-degree angle from the base of the load outward through the shoring to the ULD surface (Figure 6-11. on page 6-12). In general, the thickness of the shoring and the increase of load bearing area is linear in that every inch of shoring height extends the load bearing area out from the base of the item by one inch. Therefore, two-inch shoring under a 12 inch square box will increase the contact area to 16 X 16 inches (2 inches out from each side), increasing the total area from 144 sq. in to 256 sq. in.

Figure 6-11. Spreading Effect of Shoring



To calculate the thickness of shoring required:

1. Measure the cargo base (footprint) in square inches, then calculate the weight bearing on the ULD floor.

2. If the weight exceeds 2.08 PSI, then shoring will be required. The easiest way to determine the amount of shoring is to recalculate the footprint by trial and error, increasing the shoring until the psi falls below 2.08 lbs. Be sure to use the actual thickness of the shoring, not just its dimensional specifications. *(See Page 6-13)* shows actual dressed lumber dimensions as used by US lumber mills.

Figure 6-12. Lumber Dimensionsl

Nominal Dimension (in.)	Actual Dimension (in.)
1	3/4
2	1 1/2
3	2 1/2
4	3 1/2
5	4 1/2
6	5 1/2
8	7 1/4
10	9 1/4
12	11 1/4
14	13 1/4
16	15 1/4
18	17 1/2
20	19 1/2
Reference: American Softwood Lumber Standard, Voluntary Product Standard PS20-70.	

[redacted]

12. LOADMASTER CHECKLIST (CO-9)

Checklist Design

The Loadmaster Checklist (CO-9) is a paper product that is laminated and available on the aircraft for the Loadmaster. The Checklist is designed to be quickly and easily accomplished in a logical time sequence during various phases of the ground operations. Checklist groupings are selected so the items are consistent with established flow patterns and can be quickly accomplished. Following the checklist is a very critical procedure in completing all areas of your duties.

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- [redacted]

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12.4 AFTER LOADING AND BEFORE TAKEOFF

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[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]

[redacted]

5. CHECK CARGO RESTRAINT;

The LM will check the cargo before departure to ensure all the nets, straps and chains are tightened. Any items that are found to need additional restraint will be secured before departure. Special attention should be paid to items loaded on top of nets, pipes and small items.

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12.12 MATHEMATICAL CONVERSIONS;

The following are quick reference for math conversions.

Kg to lb Kg x 2.2046

Lb to kg Lb x 0.454

Meter to ft Meter x 3.281

Ft to meter Ft x 0.305

Centimeters to in Cm x 0.3994

Inches to cm Inches x 2.54

Cu. meter to Cu. Ft Cu. m x 35.31

Cu. ft to Cu. meter Cu. ft x 0.028

Liter to US Gallon Liter x 0.264

US Gallon to L US Gal x 3.785

Nautical to Statue Mile NM x 1.151

Statute to Nautical Mile SM x 0.869

Volume (cube) L x W x H

Area = L x W

PSI = Weight / Area

12.13 RESTRAINT CRITERIA FORMULAS;

The following is a quick reference for restraining cargo on the aircraft.

Required Restraint = $\frac{\text{Weight x Criteria}}{\text{75\% of the rated tie-down}}$

Minimum Restraint Requirements

Fwd, Aft, Lateral (All aircraft)	1.5g x Cargo Wt
Vertical (All aircraft)	2.6g x Cargo Wt
Vertical Position 18 (DC-8 only)	3.4g x Cargo Wt