NATIONAL TRANSPORTATION SAFETY BOARD

Office of Aviation Safety
Washington, D.C. 20594

January 30, 2015

Group Chairman's Factual Report

STRUCTURES

DCA13MA081

Attachment 5

National Airlines Weight and Balance Manual Revision 6 Issued October 2, 2011

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

Weight and Balance 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/Approv
FAA Signature [redacted] Principal Operations Inspector Date 10-10-12

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FAA Signature [redacted] Principal Operations Inspector Date 10-10-12

Table of Contents

Chapter 1: Weight and Balance Program

1. PURPOSE

SRR: 119.43(b)(2
SRR: 121.135(b)(9)
SRR: 121.135(b)(21)
SRR: 121.153(b)
SRR: AC 120-27E

National Airlines has developed a Weight and Balance Program, consisting of Weight and Balance Control and Loading Systems to ensure compliance with applicable Federal Regulations and that every flight is operated within weight and center of balance limitations for which the aircraft was certified. Operation Specifications A099 approves the use of the Weight and Balance Programs in this manual. Compliance with applicable Federal Regulations and the provisions of the Operations Specifications is mandatory for all employees.

2. PROCEDURES

The procedures contained in this manual describe the method of accomplishing a process or task.Procedures in this manual are procedures, not just a policy. The procedures contain sufficient detail to achieve the desired results and identify who, what, when, where, and how. They assure compliance with the associated 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 were applicable.

[redacted]

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6. LOADING LIMITATIONS

Practical loading challenges encountered with aircraft might come in the form of package restrictions and/ or load limitations. Having checked that a package can physically be placed upon a pallet or within an

aircraft compartment, it is necessary to consider whether or not the piece will exceed additional load restrictions. Observing these predetermined limits (not to exceed them) will protect the structural integrity of the aircraft. These limitations, for all practical purposes, apply equally to loads on pallets, as well as bulk.

6.1 LOAD LIMIT APPLICATION

The five basic structural limitations to be considered prior to positioning a concentrated load on a ULD or positioning the loaded ULD in the aircraft are:

1. Aircraft Compartment Limit.
2. Linear Load Limit.
3. Area Load Limit.
4. Aircraft Pallet Limit (lbs. per square foot).
5. Cumulative Load Limit (Function of Weight and Balance).

6.1.1 Aircraft Compartment Limit

Comparison must be made to assure the Aircraft Compartment Limit is not exceeded even when the area load limit and linear load limit is determined to be within limits. In all cases, the most restrictive of these limits must be used. Aircraft compartment limits are based on fuselage shell (Monocoque) structural capacities which are often more restrictive than floor bearing capacities by themselves. In comparison, consider the following:

- 88” x 125" pallet has: 84 x 121 ÷ 144 = 70 sq. ft.
- 96” x 125" pallet has: 92 x 121 ÷ 144 = 77 sq. ft.
- Allow 2 inches each side for pallet edge rail (which includes ring tracks).
- The maximum area load limit, then, would be:
- 70 sq. ft. x 136 kg/sq. ft. = 9,526 kg (20,957 lbs)
- 77 sq. ft. x 136 kg/sq.ft. = 10,478 kg (23,051 lbs)

Check all limits pertaining to a single pallet position BEFORE making final assessment of a given unit for onloading and calculation of weight and balance. Floor loading limits vary between aircraft utilized at National Airlines.

6.1.2 Linear Load Limit

Linear Load Limit is the maximum weight allowed per each running inch along an aircraft fuselage.

The limit applies to the whole cross-section of the floor.

Load ÷ 125” = Linear load (kg per linear inch)

- **Example:** Given a load item of 4,082 kg (8,980 lbs) which is 130” long (built up on a pallet of 125”) with a 5” overhang. Therefore, only that part which makes contact with the pallet will be considered for linear load calculation. To find the kg per linear inch of this load item:

4,082 kg (8,980 lbs) ÷ 125” = 32 kg per linear inch

The load item (4,082 kg (8,980 lbs)) could be positioned in any compartment where the load limit is not exceeded.

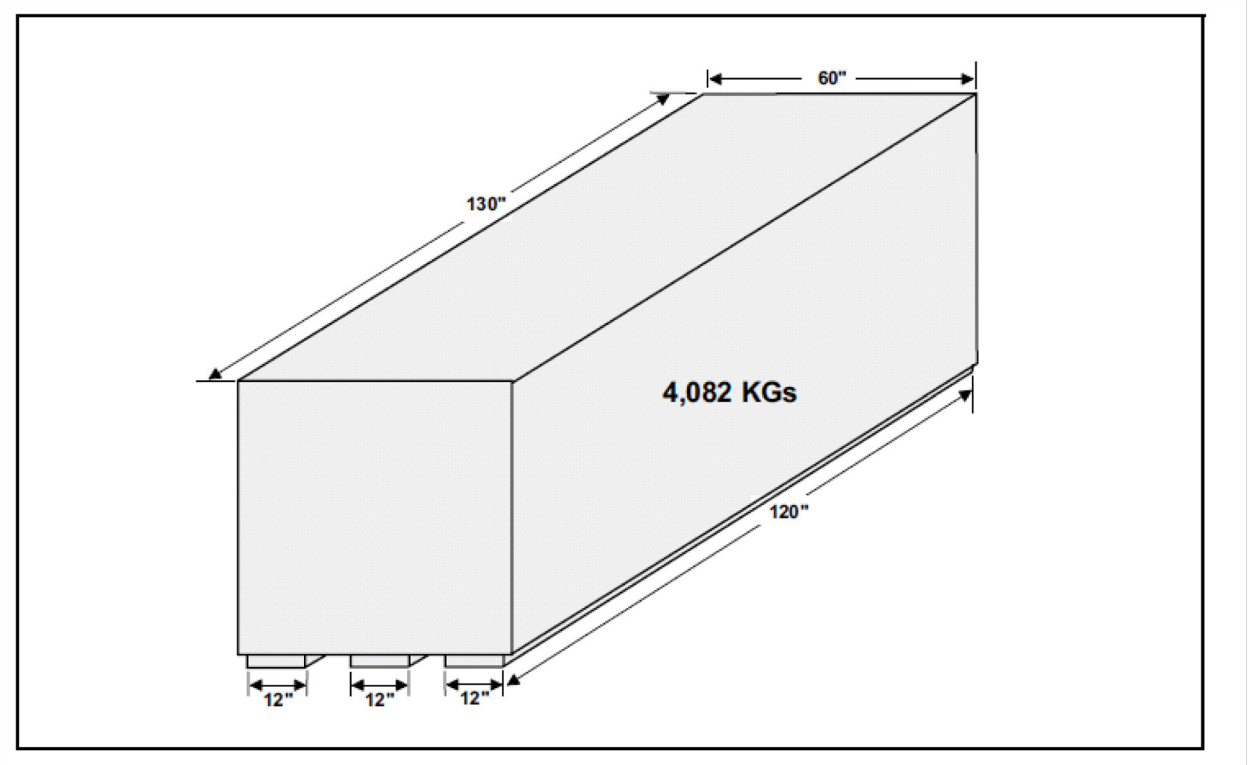
The maximum pallet gross weight of 4,989 kg (10,975 lbs) on B747 lower hold/compartment for a 96” x 125" pallet is restricted by the linear limit of 52 kg (114 lbs) per inch (96” x 116” = 11,136 kg (24,499 lbs) rounded down).

6.1.3 Area Load Limit

Area Load Limit is the maximum weight allowed per each square foot of floor contact area of either an aircraft or aircraft compartment. The area load distribution in an aircraft can differ from the area load limit certified on a pallet by the manufacturer. Both 88” and 96” pallets are rated for 136 kg (299 lbs) per square foot load distribution. Also, the area load limits differ not only between aircraft types, but also between compartments. Prior to loading a ULD with a concentrated load item, the load distribution should be checked to assure the compartment limit is not exceeded.

- **Example:** Given a 4,082 kg (8,980 lbs) load at 130” x 60” mounted on 3 beams (each beam measuring 120” x 12”), what is the area load distribution derived from the 3 beams, and is it adequate to support the load?

Figure 2-1. Load Limit Example



First convert the dimensions of the beams from inches to feet (120”L ÷ 12” = 10’L, 12”W ÷ 12” = 1’W). Convert further to square feet (10’L X 1’ W = 10 sq. ft.)

Total contact area, 10 sq. ft. x 3 beams = 30 sq. ft.

The area load distribution, 4,082 kg (8,980 lbs) ÷ 30 sq. ft = 136 kg/sq. ft.

6.1.4 Aircraft ULD Limits

As demonstrated earlier, actual ULD (pallet) structural limits are excessive (much higher) than their TSO C90c approved pallet/net certification.

Structural capacity:

- 88” x 125" @ 70 sq. ft. x 136 kg/sq. ft. = 9,525 kg (20,955 lbs)
- 96” x 125" @ 77 sq. ft. x 136 kg/sq. ft. = 10,478 kg (23,110 lbs)
- TSO C90c pallet/net certification:
- 88” x 125" = 6,804 kg (14,968 lbs)
- 96” x 125" = 6,804 kg (14,968 lbs)

7. SPECIAL CARGO LOADING

The basic reason for limitations is the safety of the aircraft.

Anything placed on an aircraft is restricted in some form to ensure the integrity of the aircraft, and its safe operation. From a small box to a very large piece of machinery, each has their own limits on where and how it will be loaded on an aircraft. 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. Everything secured to a seat track receives its strength from the structure below it. The strongest part of the airframe is the center wing section where the ribs are closer and the beams are heavier and stronger. This area is the “high gross weight section” of the Main Deck. All of these connection points result in limitations to be imposed by the aircraft manufacturer and must be adhered to in order to maintain the integrity of the structure and the safety of the aircraft.

8. SPECIAL HANDLING PRECAUTIONS HEAVY, LARGE BULK-LOADED ITEMS

Heavy, large, bulk-loaded items require special handling techniques to avoid damaging or puncturing the aircraft floor, or hold during the positioning of, or movement through the aircraft of the specific piece in question. During handling, never lay a heavy package - one that weighs more than 110 pounds (or 50 kg) - on one corner. Also, never drop a heavy object weighing 110 pounds or more on an edge or comer, because the impact might puncture the flooring panels. Additionally, care shall be taken when loading and unloading heavy objects to avoid injury to persons and / or damage to the item, the aircraft or loading equipment.

9. LOADING OVERSIZE BIG AND/OR OHG ITEMS

Prior to loading Oversize BIG and/or OHG items, ensure that there is sufficient and suitable tic-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.

10. FLOATING PALLETS

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. 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.

11. SOLID LOADED CARGO

Solid loaded cargo is cargo that is loaded flush against the floor, ceiling, and bulkheads, using them as restraints. Therefore, solid loaded cargo needs no tiedown.

12. LOADING EQUIPMENT

12.1 UNIT LOAD DEVICES (ULDS)

All cargo loaded onto an aircraft must be placed on or in a Unit Load Device (ULD). With very few exceptions the only area where cargo can be placed on the floor of the aircraft is in the Bulk compartment. The ULD protects the structure, spreads the load over a larger area and provides a means of restraining the cargo to the pallet as well as providing a means of easy movement of the cargo to, in and from the aircraft. A pallet forms the base to place the cargo on. A net assembly is placed over the cargo and attached to the pallet base by means of rings and studs placed in a seat track along the edge of the pallet. An igloo arrangement may also be used to contain the cargo, with or without a net assembly depending on the manufacturing limits. Each ULD has a specified limit, conditional of all equipment being functional, and specifies the maximum weight limit and any reduction of this limit if parts are inoperable or missing. All cargo nets must have a manufacturers' TSO label attached and all pallets must be airworthy as defined by the manufacturer of that pallet. All cargo must be restrained to the pallet, or the aircraft, so it will not shift or become a hazard to the aircraft. The restraint of the ULD is provided by side rails, pallet locks and vertical restraints lips and other hardware. The roller trays under the pallet move the pallet throughout the aircraft and spread the cargo weight over the floor to the floor beams. The pallet must be free of defects in order to avoid damage to the loading system and maintain its integrity. The pallet bottom must be checked for cracks and deformation. The loading of a ULD on an aircraft is determined by the ULD's weight, contour, size, and type. Size "A" or "M" ULDs that are built within the dimensions of the pallet, including contour, are only restricted by their weight in terms of where they can be located on the aircraft.

[redacted]

Note:

Adjacent positions are those [redacted]

13. TIE-DOWN RULES

It is not allowed to tie-down a load with different equipment (fittings, ropes, straps). Tie-down must be performed exclusively either with straps or with ropes, without any mixing.

Except in absolute necessity (no other equipment available), single stud fittings and ropes may be used only for tie-down in bulk compartments or inside containers.

Minimum distance between two adjacent tie-down points should be specified for each type of aircraft, e.g.:

- 12 inches between two single stud fittings
- 20 inches between two double stud fittings

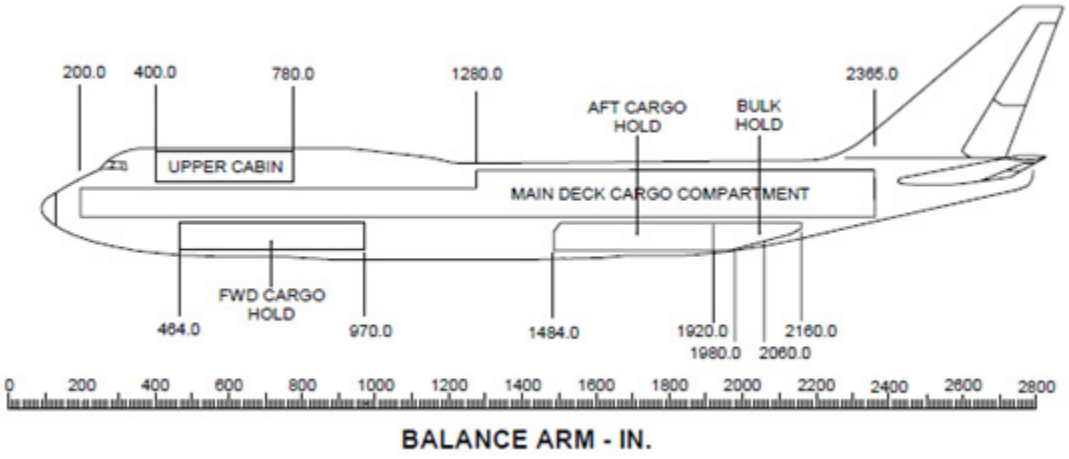
Tie-down shall ensure restraint in at least three directions – forward, aft and upwards in relation to the aircraft. Lateral tie-down may be considered as covered if tie-down in the three above directions is adequately performed - it constitutes in fact a net, sufficient to restrain the load against sideward movement. Each strap or rope shall make a maximum angle of 30° with the direction of restraint.

[redacted]

2.9 GENERAL LOCATION

The following airplane profile illustrates cargo compartment locations:

Figure 5-5. Cargo Compartment Locations



The following table provides the main deck cargo compartment location, usable volume and the corresponding volumetric centroid arm.

Table 5-1: Main Deck Cargo Compartment Location

CARGO COMPARTMENT	LOCATION - B.A.		USABLE VOLUME - CU FT	B. A. IN.
	FROM	TO		
Main Deck	228.0	2365.0	26000	1250.0

The following tables provides cargo compartment locations, usable volumes and the corresponding volumetric centroid arms with the net installed at B.A. 1920.0.

CARGO COMPARTMENT	LOCATION - B.A.		USABLE VOLUME - CU FT	B. A. IN.
	FROM	TO		
Forward	464.0	970.0	3415	717.0
Aft	1484.0	1920.0[a]	2970	1702.0
Bulk	1920.0	2160.0	852	2003.3
Total			7237	1272.7

[a] Location of net.

The following tables provides cargo compartment locations, usable volumes and the corresponding volumetric centroid arms with the net installed at B.A. 1980.0.

CARGO COMPARTMENT	LOCATION - B.A.		USABLE VOLUME - CU FT	B. A. IN.
	FROM	TO		
Forward	464.0	970.0	3415	717.0
Aft	1484.0	1980.0[a]	3370	1732.0
Bulk	1980.0	2160.0	452	2051.7
Total			7237	1273.0

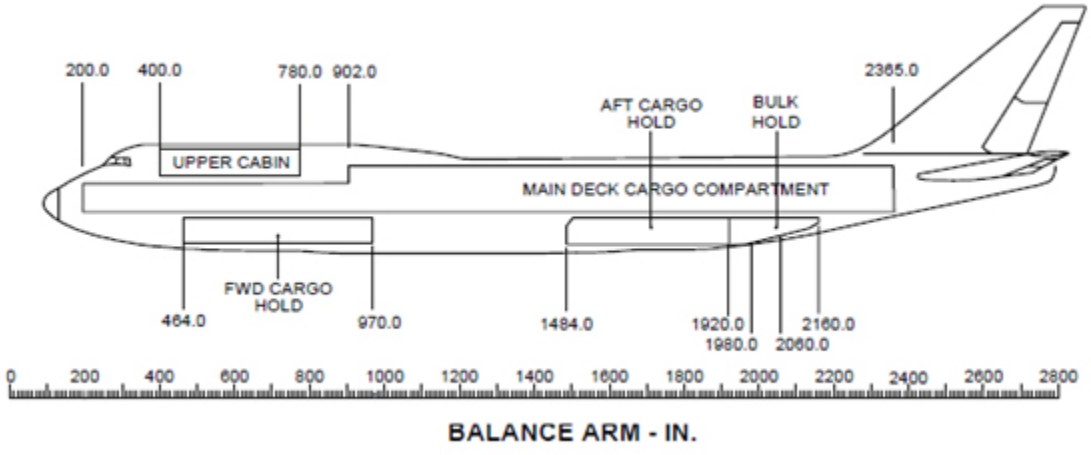
[a] Location of net.

2.10 MAXIMUM ALLOWABLE WEIGHTS

This section provides main deck and lower deck cargo compartment loading. These values are the maximum allowable weights that can be sustained by the basic monocoque structure.

The following illustration shows the configuration of the cargo compartments.

Figure 5-6. Configuration of the Cargo Compartments



Five basic structural limitations that must be observed when loading payload are compartment, linear loading, floor loading, net loading and cumulative load limitations. Cumulative load limitations are discussed in this chapter.

Maximum allowable weights, and maximum allowable linear and floor loading are provided in the following table:

Table 5-2: Maximum Allowable Weight

MAXIMUM ALLOWABLE WEIGHT							
COMPARTMENT		TOTAL WEIGHT		FLOOR LOADING			
		LB	KG	LB/IN.	KG/IN.	LB/SQ FT	KG/SQ FT
	Upper Cabin B.A. 400.0 to B.A. 780.0			31.8[a]	14.4[a]	100.0	45.3
	Main Deck Cargo[b] B.A. 200.0 to B.A. 525.0	19500	8845	60.0	27.2	100.0	45.3
	B.A. 525.0 to B.A. 1000.0	71250	32318	150.0	68.0	200.0	90.7
	B.A. 1000.0 to B.A. 1480.0	139200	63140	290.0	131.5	400.0	181.4
	B.A. 1480.0 to B.A. 2218.0	125460	56907	170.0	77.1	400.0	181.4
	B.A. 2218.0 to B.A. 2365.0	4500	2041	36.0	16.3	100.0	45.3
	Forward Cargo Hold[c] B.A. 464.0 to B.A. 970.0	58400	26489	116.0	52.6	200.0	90.7
Net at B.A. 1980.0	Aft Cargo Hold[c] B.A. 1484.0 to B.A. 1980.0	57500	26081	116.0	52.6	200.0	90.7
Net at B.A. 1980.0	Bulk Hold B.A. 1980.0 to B.A. 2160.0	9720[d]	4408[d]	Varies[e]		150.0	68.0
Net at B.A. 1980.0	Maximum Load Distribution Between Net Locations B.A. 1980.0 to 2060.0	5386	2443				
Net at B.A. 1980.0	B.A. 2060.0 to 2160.0	4334	1965				
Net at B.A. 1920.0	Aft Cargo Hold[c] B.A. 1484.0 to B.A. 1920.0	50570	22938	116.0	52.6	200.0	90.7
Net at B.A. 1920.0	Bulk Hold B.A. 1920.0 to B.A. 2160.0	14880[f]	6749[f]	Varies[g]		150.0	68.0
Net at B.A. 1920.0	Maximum Load Distribution Between Net Locations B.A. 1920.0 to 1980.0	5160	2340				
Net at B.A. 1920.0	B.A. 1980.0 to 2060.0	5386	2443				
Net at B.A. 1920.0	B.A. 2060.0 to 2160.0	4334	1965				

[a] The upper cabin allowable load includes the weight of supernumeraries, supernumeraries seats, and supernumeraries carry-on baggage stowed under the seats.
[b] The main deck limitations include the weight of cargo and the unit load devices (ULDs).
[c] The lower hold limitations include the weight of cargo and the unit load devices (ULDs).
[d] The bulk cargo net at B.A. 1980.0 must be installed or the maximum allowable weight is 0 LB (0 KG). The net at 1920.0 is not required.
[e] 78.0 LB/IN. (35.3 KG/IN.) at B.A. 1980.0 decreasing linearly to 30.0 LB/IN. (13.6 KG/IN.) at B.A. 2160.0
[f] The bulk cargo net at B.A. 1920.0 must be installed or the maximum allowable weight is 0 LB (0 KG). The net at B.A. 1980.0 is not required.
[g] 116.0 LB/IN. (52.6 KG/IN.) from B.A. 1920.0 to B.A. 1980.0. 78.0 LB/IN. (35.3 KG/IN.) at B.A. 1980.0 decreasing linearly to 30.0 LB/IN. (13.6 KG/IN.) at B.A. 2160.0.

Caution

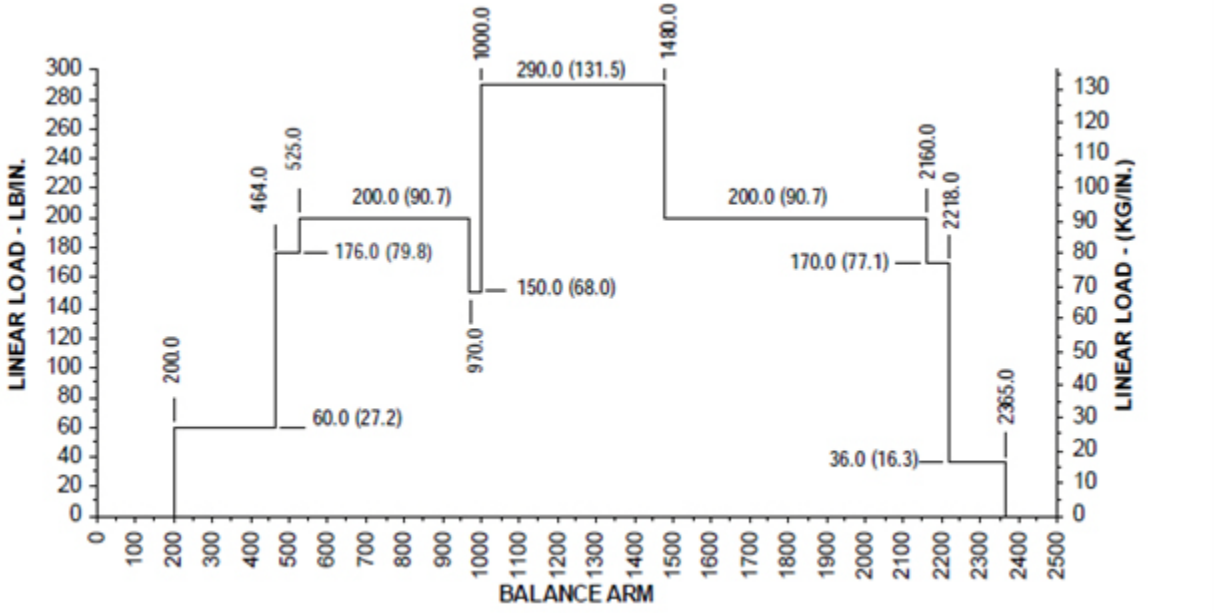
These loads may be further limited by cumulative load limitations

2.11 MAXIMUM COMBINED LINEAR LOAD LIMITS

Total loading for the main deck and lower deck cargo must not exceed the combined linear loading limits shown in the following diagram:

Figure 5-7. Maximum Combined Linear Load Limits

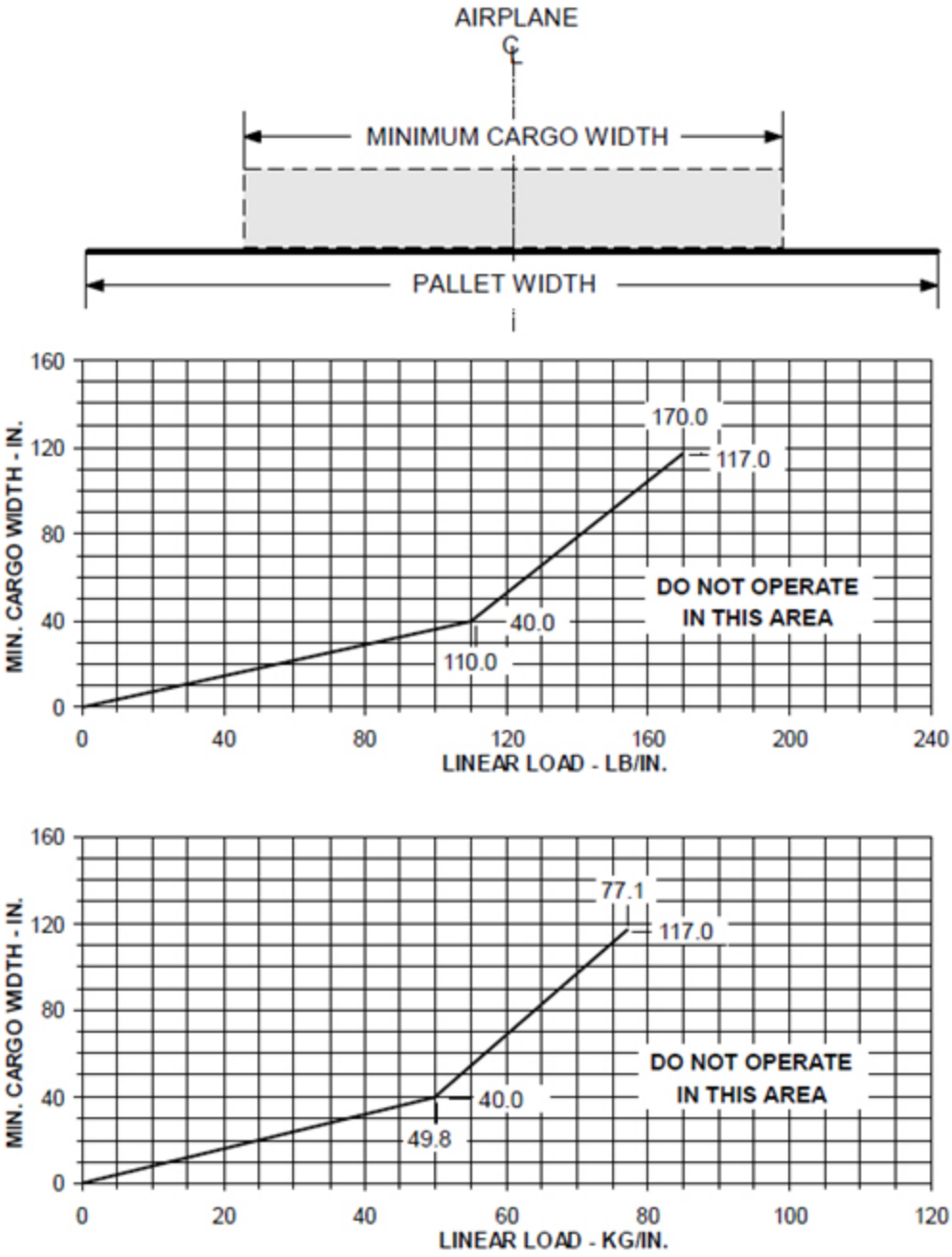
Weights in Lbs/Kg



Note:

Cumulative loads are typically more restrictive than combined linear loads.

Figure 5-9. Main Deck Centerline Load Limits



3. CUMULATIVE LOADS

3.1 FORWARD BODY CUMULATIVE LOADS CUMULATIVE LOAD CHECK

The cumulative total load profile is computed forward to aft in the forward body and must not exceed the load distribution limitations shown in the table below.

Table 5-3: Load Distribution Limitations

LOCATION & LOADING DIRECTION	BALANCE ARM (IN.)		MAXIMUM COMBINED FWD CUMULATIVE LOAD	
	FROM	TO	LB	KG
Forward Body - Loading Forward to Aft	200	525 1000 1240	19500 101500 159100	8845 46039 721676

When determining the allowable forward cumulative load, the weight of up to three upper deck occupants and four flight crew members (pilot, copilot, and two observers) may be excluded from the forward body cumulative load. The weight of any additional occupants must be either included in the cumulative load and/or the cumulative load limits must be reduced accordingly.

Note:

The load limits above include the weight of cargo, main deck crew baggage and the unit load devices.

3.2 AFT BODY CUMULATIVE LOADS CUMULATIVE LOAD CHECK

The cumulative total load profile is computed aft to forward in the aft body and must not exceed the load distribution limitations shown in the table below.

Table 5-4: Load Distribution Limitations

LOCATION & LOADING DIRECTION	BALANCE ARM (IN.)		MAXIMUM COMBINED FWD CUMULATIVE LOAD	
	FROM	TO	LB	KG
Aft Body - Loading Aft to Forward	2365	2218 1980 1740 1480 1240	4500 14870 53750 97950 155550	2041 6744 24380 44429 70556
Aft Body - Loading Aft to Forward Increased Aft Cumulative Loads [a]	2365	2218 1980 1740 1480 1240	4500 38966 77846 122046 179646	2041 17674 35310 55359 81486

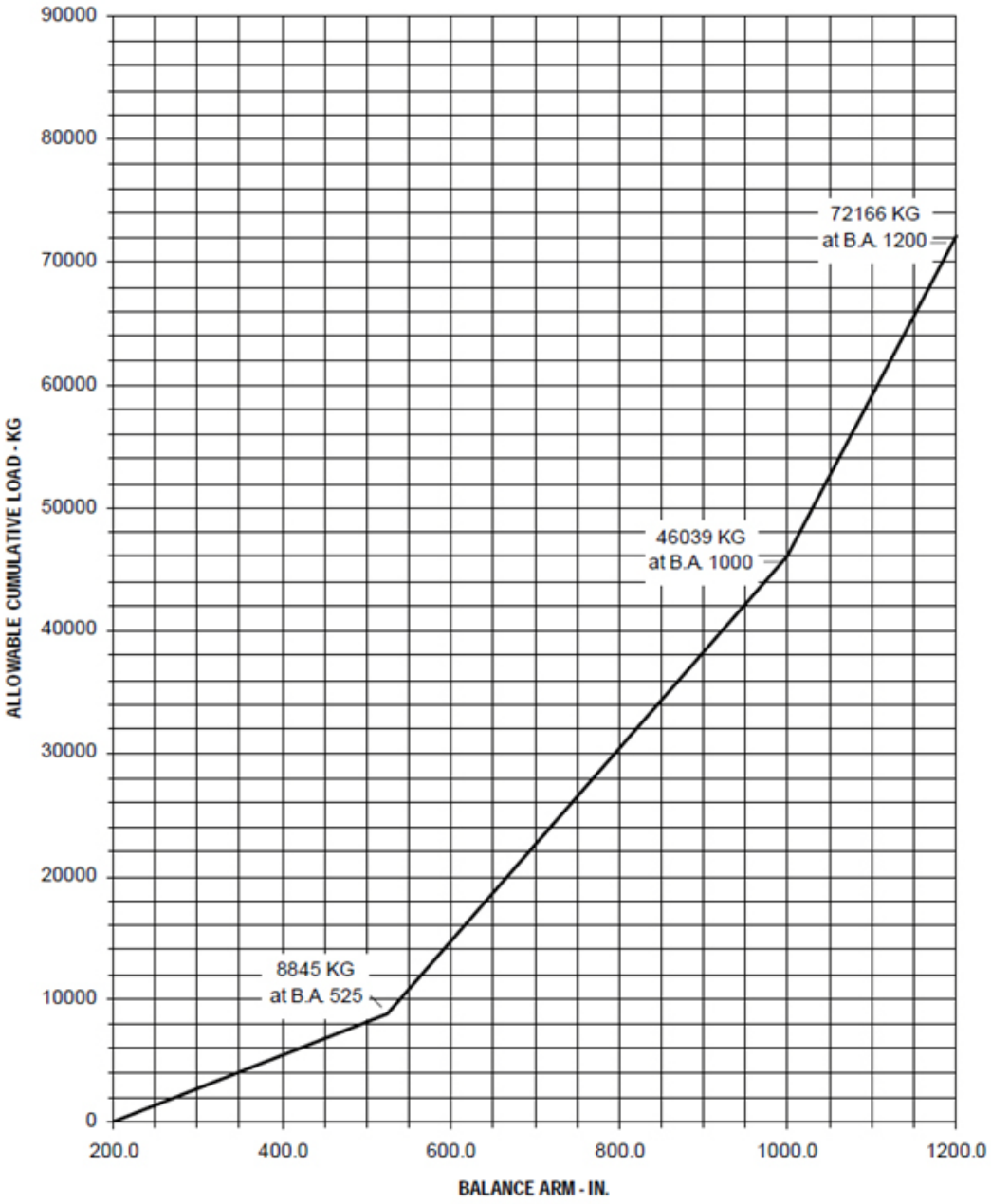
[a] Use of these limits requires observation of the limit labeled "Forward Taxi and Takeoff Limit with Increased Aft Cumulative Loads" in chapter.

Note:

The load limits above include the weight of cargo and the unit load devices.

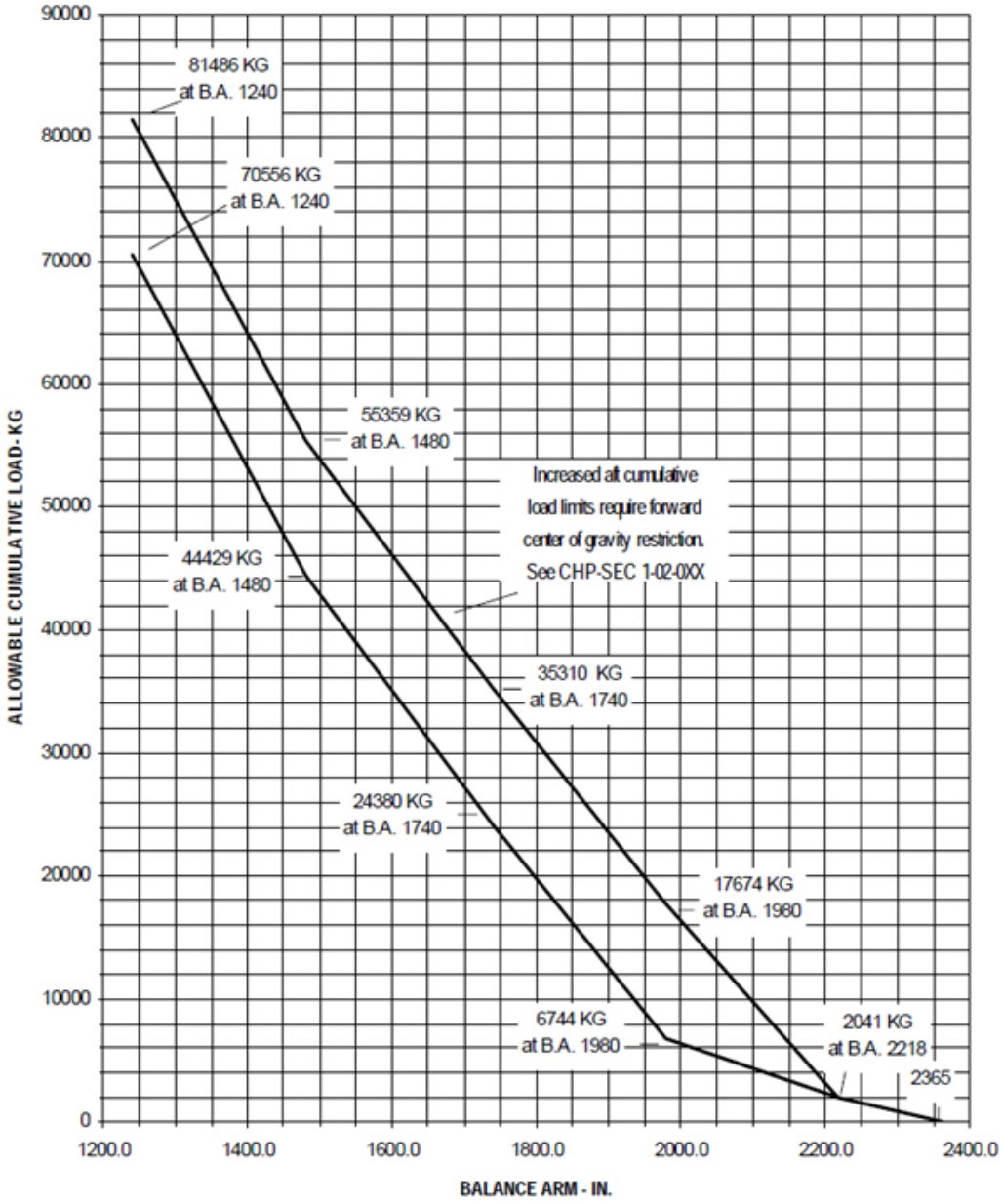
3.3 FORWARD BODY CUMULATIVE LOADS

The following chart shows the allowable cumulative load in kilograms.



3.4 AFT BODY CUMULATIVE LOADS

The following chart shows the allowable cumulative load in kilograms.



4. AIRPLANE LATERAL IMBALANCE LIMITS

4.1 LATERAL IMBALANCE

The airplane should be loaded symmetrically. When off center loading of payload and/or fuel does occur, the airplane can be operated if the following gross weight and lateral imbalance limits are not exceeded. The lateral balance arms of ULD's can be found in the Boeing Weight and Balance Manual CHP-SEC 1-69-00x.

Note:

The package size table above does not pertain to internal engine carriage. However, when loading an aircraft engine through the side cargo door, the full dimensions of the door shown above may be used when loading with care.

Note:

Refer to the Cargo Operations Manual for compatible ULDs for the Maindeck and the Belly Compartments of the B747-400

5. MAIN DECK UNIT LOAD DEVICE LOCATIONS

5.1 GENERAL

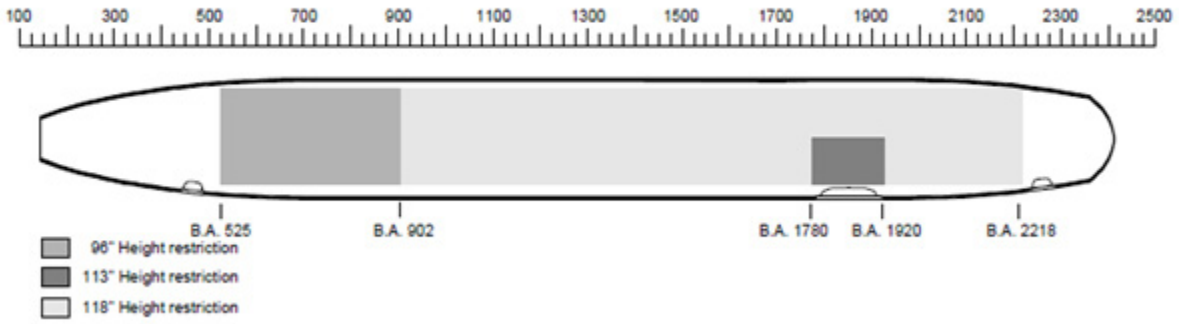
The following considerations should be observed when loading cargo on the main deck:

- Only Size Code A and M pallets can be loaded laterally forward of B.A. 525.
- Only Size Code A, B, and M pallets can be loaded longitudinally forward of B.A. 525.
- Only Size Code A, B, F, and M pallets can be loaded aft of B.A. 2218.
- Containers forward of B.A. 902 are limited to 96 inches in height to ensure at least a 2 inch clearance between the top of the ULD and the ceiling. This clearance is required to allow air flow around ULDs for decompression and smoke detection.
- Pallets forward of B.A. 902 are limited to 86 inches in height. A minimum of 10 inches of clearance must be maintained for netted pallets due to the upward deflection of the cargo in a negative "1G" load maneuver condition. The deflected pallet must not contact overhead structure to prevent damage to control cables and brackets. Crushable freight or freight restrained by chains may be loaded to a height of 96 inches forward of B.A. 902.
- Aft of B.A. 902, ULDs are limited to 118 inches tall.
- The most forward position for tall rigid cargo that is 118 inches tall is B.A. 1220. The most forward position for tall rigid cargo that is 110 inches tall is B.A. 902. All cargo in excess of 110 inches tall between B.A. 902 and B.A. 1220 must be frangible cargo. See Boeing Weight and Balance Manual CHP-SEC 1-69-12X for limitations and sample problems for the loading of tall rigid cargo on the airplane. Tall rigid cargo is defined as cargo that is in excess of 96 inches tall and will not break apart during an emergency landing event (a 777 engine is an example of tall rigid cargo).
- ULDs longer than 240 inches (no larger than a Size Code G) cannot be loaded through the side cargo door because they cannot be rotated through the side cargo door.
- When positioned in the side cargo door area, ULDs are limited to 113 inches in height to allow for actuator movement.
- Size Codes G and R ULDs greater than 96 inches in height have profile restrictions to allow rotation through the side cargo door (see Figure 5-14.).

5.2 MAIN DECK UNIT LOAD DEVICES

The illustration below shows the allowable region in the main deck compartment for main deck unit load devices. Location data for these or other ULD types is the responsibility of the STC holder of the cargo restraint system (Telair).

Figure 5-17.



Note:

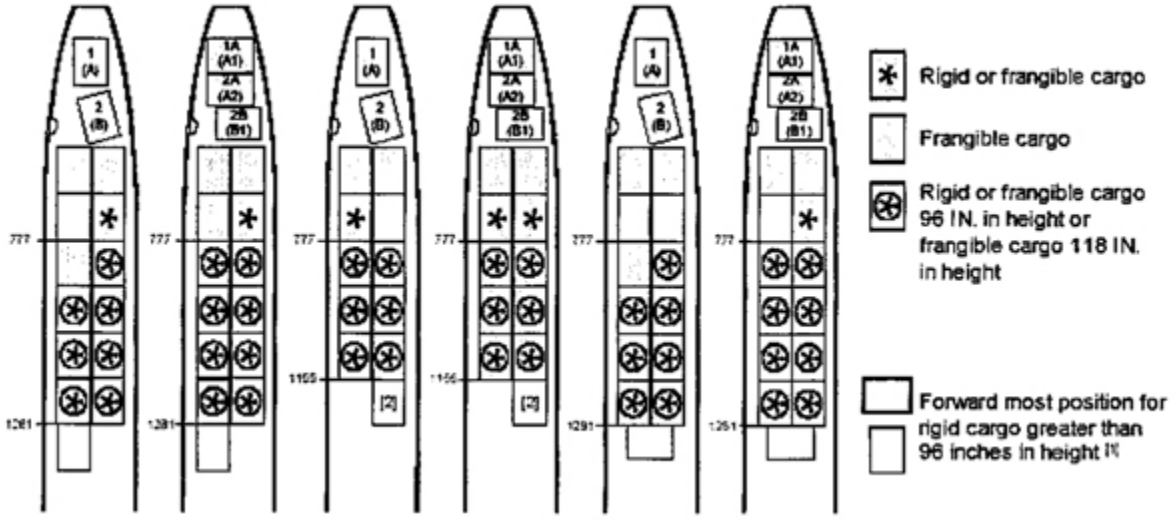
When rigid cargo is carried on the right side of the airplane, any one or all of the ULD positions 1, 1A, 2, 2A, and 2B count towards the frangible ULD positions discussed in the above restrictions (See illustration below).

Note:

When rigid cargo is carried on the left side of the airplane, any one or all of the ULD positions 1, 1A, and 2A only count towards the frangible ULD positions discussed in the above restrictions (See illustration below).

The following graphic illustrates the loading restrictions described above. Al pallets shown forward of the rigid cargo are assumed to be loaded on size code M pallets (96 IN. x 125 IN.)

Figure 5-18. Rigid or Frangible Cargo



When loading other than size code M pallets (96 IN. X 125 IN.), the forward most position for rigid cargo greter than 96 inches in height is still B.A. 1160 right side, or B.A. 1220 center loaded. Furthermore, the mass of the cargo forward of the rigid cargo must be a minimum of the equivalent of seven size code M pallets shown in the illustration above.

1. This restriction does not apply if the ULD with rigid cargo over 96 IN. in height, and all ULD positions aft of it, are restrained to a 9G forward load factor.

2. Rigid cargo must be aft of B.A. 1160 on this pallet.

5.2.1 Size Code A & E or Q

The illustration below shows the allowable positions in the main deck compartment for size code A unit load devices using the delivery restraint hardware configuration. Pallet locks may be relocated in one inch increments anywhere between B.A. 235 and B.A. 2360 allowing ULD locations outside the footprints shown below.