CHAPTER 4

GENERAL LOADING PROCEDURES

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CHAPTER 4

GENERAL LOADING PROCEDURES

4.1 GENERAL

This chapter contains general instructions and data for the study and preplanning of loading operations, as well as procedures for each of the loading categories (bulk, palletized, wheeled, winching, etc.). Data and information contained in this chapter serve also to determine if a particular cargo unit is suitable for airlift on the C-295, and if it requires special loading procedures, tiedown, use of shoring, or placement in a particular area on the aircraft. In this chapter, general concepts relative to loading/offloading operations are also explained. At the end of the chapter, a loadmaster's amplified checklist is included, covering each phase of the specific procedure and summarizing information presented along the chapter body.

4.2 FACTORS TO BE CONSIDERED

During the load-planning phase for transport missions, it is necessary to take many factors into consideration before actually accomplishing the loading operation. Some of these factors are a previous knowledge of the materials to be transported, their weight, dimensions, etc., to determine whether a load can be airlifted or not on the aircraft, and to select the most suitable method for the loading and offloading operations. A good load planning enables the loadmaster to know exactly where each item of cargo should be placed, how it should be tied down, how to achieve the best aircraft balance condition, and if any special material handling equipment (forklifts, cargo loaders, etc.) is required. Good load planning will reduce ground time to a minimum.

This part of the manual contains instructions for computing the center of gravity (CG) of single items of cargo, computing the combined center of gravity for the total load to be airlifted, weight and balance factors, cargo size limitations, use of shoring for weight distribution or solving problems due to the inclined aircraft ramp, restraint criteria and calculations, winch loading, general vehicle loading procedures, and procedures and limitations with palletized cargo.

4.3 CARGO SIZE AND WEIGHT LIMITATIONS

When loading large items of cargo from the ground, and especially with vehicles, it is necessary to consider not only the internal dimensions of the cargo cabin, but also the possibility that the bottom or top parts of the vehicle contact the aircraft during the transition from the inclined ramp to the cargo cabin floor. Due to the angle formed by the inclined aircraft ramp with the parking ground, the overall length and height of the item are critical factors that must be taken into account during loading operations. If the vehicle front or rear overhang is large, care must be taken to prevent the vehicle from coming in contact with the ground or cargo cabin overhead. Vehicle ground clearance is another of the factors to be considered because, if the wheelbase is large in relation to the ground clearance beneath the vehicle, it may contact the ramp crest. The use of planking under the ramp and auxiliary loading ramps (approach shoring) to reduce the ramp slope, may be a solution to some of the problems encountered due to vehicle dimensions.

As a general rule to observing all limitations, vehicles should be backed to reduce as much as possible any overhead projection problems, and loaded on the loading floor strengthened zones. All general cargo (crates, boxes, etc.) should be placed on HCU-6/E pallets to take advantage of the features of the CHADS. If cargo must be loaded directly on the cargo floor (bulk cargo), spread the cargo as evenly as possible over as much of the floor as possible, and distribute its weight symmetrically in respect of the longitudinal axis of the aircraft.

4.4 LOADING AREA DIMENSIONS

(See Figure 2-4)

With the cargo door open and the ramp fully horizontal, the aircraft presents a clear opening 171 cm high by 230 cm wide (67.3 x 90.5 in.). Cargoes on HCU-6/E pallets, or 224-cm wide (88-in.) platforms, compatible with the 463L standard, may be loaded on the aircraft. Available height from the top plane of the roller conveyors at the aft end of the ramp is 166 cm (65.4 in.).

WARNING: DESPITE OF AIRCRAFT DIMENSIONS, LIMITATIONS ESTABLISHED ON APPLICABLE REGULATIONS, REGARDING SAFETY AISLES, UNOBSTRUCTED EMERGENCY EXITS, AND SAFETY MARGINS MUST BE OBSERVED. THE AIRCREW MUST HAVE ACCESS TO THE AFT OF THE AIRCRAFT IN ALL CASES.

When the ramp is open to ground level and the auxiliary loading ramps are installed, the loading area dimensions will be the same, but some precautions must be observed because of the crest formed by the ramp and the cargo cabin floor, especially when loading very long cargo items. The following paragraphs describe the restrictions imposed on loading with the inclined ramp.

4.5 CRATED CARGO OVERHEAD PROJECTION

(See Figure 4-1)

Loading of large crates, or containers directly on the cargo floor with the ramp open to ground level, creates the problem of projection to the cargo cabin overhead, due to the angle formed by the cargo floor with the ramp. The load will not tend to adopt a horizontal position, parallel to the cargo floor, until its center of gravity (hinge point) reaches the ramp hinge.

Figure 4-1 permits to determine the maximum allowable projection of a load from the ramp hinge, according to its height and CG position from its front end in loading direction, with a 16º ramp slope.

To determine maximum allowable projection for a cargo item, enter the graphic from the horizontal scale at load height and move up until intersecting the curve. From this point, continue moving horizontally to the left until the projection scale. If the reading is equal or greater than the distance from the cargo hinge point (center of gravity) to the front end, the item can be safely loaded. If not, it will be necessary to force the load down to the horizontal position before its center of gravity reaches the ramp hinge, in the event appropriate means to do so are available.

To determine a load maximum allowable projection in relation to its CG position, use the graphic conversely.

NOTE: Graphic in Figure 4-1 is computed from the cargo floor. When loading over rolling shoring, roller trays, pallets, or any other base support, subtract proper height from graphic readings.

4.6 VEHICLE OVERHANG AND PROJECTION LIMITS

Front and rear vehicle overhangs (FOH and ROH, respectively), ground clearance from the bottom of the vehicle to the ground, and vehicle distance between axles or wheelbase (WB) (see Figure 4-12), along with cargo floor height from the ramp hinge to the parking ground, are factors which must be considered to determine if a vehicle can be safely loaded without contact or projection problems. Among these, cargo floor height to the parking ground is the factor that affects the most when loading vehicles on the aircraft. With main landing gear wheels and struts at normal conditions, and assuming a smooth and level loading field, the cargo floor height at the ramp hinge may be between 115 and 140 cm (45.2 and 55.1 in.). The most convenient point to measure ramp crest height is the bottom aft corner of paratroop doors, as depicted in Figure 4-2.

NOTE: Since vehicles are normally backed into the cargo cabin to facilitate offloading, in the following paragraphs and graphics this case has been assumed when referring to front and rear overhangs. If vehicle front-end loading is required, adapt vehicle data as necessary.

This chapter includes four graphics for determining allowable dimensions:

A. Ramp crest contact (Figure 4-3): used to determine if the vehicle bottom may contact the vertex of the angle formed by the inclined ramp and the cargo cabin floor (ramp crest).

B. Overhang limits over the ramp closed (Figure 4-4): used to determine the available distance between the front of the vehicle on board and the closed ramp.

C. Overhang ramp and ground contact limitation (Figure 4-5): used to determine if the front or rear end of the vehicle may contact the parking ground or ramp.

D. Vehicle overhead projection (Figure 4-6): used to determine if a vehicle may cause overhead projection problems.

CAUTION: WHEN DIMENSIONS OF VEHICLES (GROUND CLEARANCE, OVERHANG, PROJECTION) ARE PERMISSIBLE, BUT THEY ARE VERY CLOSE TO THE MEASURED RAMP CREST HEIGHT, THE VEHICLE MAY CONTACT THE CORRESPONDING CRITICAL POINT DUE TO ROCKING ON THE VEHICLE SUSPENSION SYSTEM. IN THESE CASES, GROUND SLOPE SHOULD BE REDUCED BY MEANS OF APPROACH SHORING PLACED UNDER THE RAMP SCUFF PLATE AND AUXILIARY LOADING RAMPS (SEE PARAGRAPH 4.11.1.6)

CAUTION: DO NOT DEFLATE VEHICLE TIRES IN ANY CASE. MANUFACTURER TIRE INTERNAL PRESSURE IS SET TO WITHSTAND THE VEHICLE WEIGHT. REDUCTION AT RANDOM OF NOMINAL PRESSURE DECREASES TIRE INTERNAL CONSISTENCY. DURING FLIGHT THROUGH TURBULENCE, TIRE DEFLATION MAY CAUSE THE TIRE SEAL TO BREAK, ALLOWING THE RIM TO CONTACT THE CARGO FLOOR. DURING LOADING/OFFLOADING, VEHICLES WITH DEFLATED TIRES MAY NOT TRACK STRAIGHT, THUS PERMITTING THE VEHICLE TO STRIKE THE AIRCRAFT, ESPECIALLY IF DIMENSIONS ARE VERY TIGHT.

NOTE: Internal pressure in pneumatic tires may be set to lower if a specific internal pressure for air transport has been established and properly certified, according to vehicle characteristics. Internal tire pressure for airlift must guarantee that contact and steering control problems mentioned above are not encountered.

NOTE: Figures in graphics are expressed in centimeters. If available data are in English units, convert them into centimeters before entering graphic.

4.6.1 Ramp crest contact

(See Figure 4-3)

To determine if the bottom of the vehicle may contact the ramp hinge during loading, this graphic relates wheelbase (horizontal scale), minimum ground clearance from bottom (vertical scale), and ramp crest height (intersection lines).

Once these distances have been obtained, enter graphic from the horizontal scale at wheelbase length and proceed vertically to the line corresponding floor height at ramp crest. From this point move left horizontally until intersecting vertical scale “minimum vehicle ground clearance”. If reading is equal or less than actual ground clearance from the bottom, the vehicle will not contact the ramp crest.

This graphic also serves to determine the maximum permissible cargo floor height to load a particular vehicle. Known wheelbase and minimum ground clearance from the bottom, enter the graphic simultaneously from “wheelbase” and “minimum vehicle ground clearance” and move vertically and horizontally until the point at which both lines intersect. Maximum cargo floor height at ramp crest will be the corresponding to the line immediately below intersection point. In this case, if actual measured height is greater than resulting maximum height, approach shoring should be used under the ramp scuff plate and auxiliary ramps. Shoring thickness must be equal or higher than the difference between actual and maximum height (see Figure 4-23).

EXAMPLE:

Vehicle wheelbase is 600 cm and ground clearance is 45 cm. Cargo floor is 130 cm high over the parking ground.

Case 1:

Enter the graphic from the horizontal scale at 600 cm and proceed vertically along the 600-cm line until intersecting the line representing a cargo floor 130-cm high. Move left horizontally until the vertical scale. Resulting reading is 50 cm, thus the bottom of the vehicle will contact the ramp crest.

Case 2:

To determine the required height to load the vehicle, enter the graphic simultaneously from vertical scale, at the 45 cm-line, and from horizontal scale, at the 600-cm line and follow both lines horizontally and vertically until they intersect. Intersection point is between lines representing a 120-cm and 130-cm cargo floor height. Since actual cargo floor height is 130 cm, and maximum safe height is 120 cm, it will be necessary to place shoring under the ramp and auxiliary loading ramps, at least 10-cm thick.

4.6.2 Overhang limits over the ramp closed

(See Figure 4-4)

To take maximum advantage of space available in the cargo cabin, sometimes it is necessary to place one axle of the vehicle close to the end of the cargo cabin (STA 17190). In these cases, a part of the vehicle overhang will be over the ramp floor. This projection over the ramp will be possible only when overhang does not reach so far aft that it contacts the ramp, or makes it impossible to close the ramp. Graphic in Figure 4-4 shows the maximum overhang projection over the ramp if vehicle axle is positioned at STA 17190.

Known overhang length and ground clearance from the bottom at the appropriate end of the vehicle, enter the graphic from “minimum height from bottom of vehicle overhang to cargo floor” and read across to the intersection line. Move down vertically to “maximum overhang past the ramp hinge”. The reading on the horizontal scale indicates maximum allowable overhang over the ramp closed.

In practical terms, it is not permissible to place the axle of a vehicle just over the ramp hinge because, besides of structural considerations, it will somehow or other interfere with ramp closure. Main utility of the graphic will be determining the aft-most STA at which the vehicle axle may be placed without contact with the ramp closed.

EXAMPLE:

The vehicle intended to be loaded on the aft end of the cargo cabin has a front overhang 75 cm long, and the bottom of vehicle height at the front end is 35 cm.

Enter the graphic from the vertical scale at height from the bottom of the vehicle, 35 cm, and move along the 35-cm line to the intersection line. Move down vertically to maximum overhang with the ramp closed. The reading is 62 cm. Difference from maximum allowable to actual vehicle overhang is 75 - 62 = 13 cm, this means that the front of the vehicle must be placed, at least, 13 cm forward of the ramp hinge, that is, 17190 - 130 = STA 17060.

4.6.3 Overhang ramp and ground contact limitation

(See Figure 4-5)

Vehicles having a long overhang in relation to their ground clearance from the bottom on the corresponding end, may contact the auxiliary loading ramps before the wheels start to climb them. On the other hand, vehicles having a long overhang in relation to their ground clearance on the corresponding end may drag the parking ground, when the axle starts to rise as it goes up the inclined auxiliary loading ramps.

To determine if there will be contact it is necessary to calculate the "overhang ratio", which is the quotient resulting from dividing the overhang length by the ground clearance on the related end. If the overhang ratio is less than 2.75, the vehicle will not contact the ramp before the wheels start to climb the auxiliary loading ramps. For the second part of the loading operation, this ratio is required on the opposite end of the vehicle, along with its wheelbase (WB), and the actual cargo floor height. Enter the graphic from "wheelbase", and move vertically until crossing the intersection line corresponding the actual cargo floor height. From this point, proceed horizontally to the left reaching the vertical scale "overhang ratio". If the reading is equal or less than the vehicle overhang ratio, there will not be contact with the parking ground.

NOTE: When checking both contact possibilities described above for the same vehicle, calculate front and rear overhang ratios separately. Determine contact possibility corresponding to each case according to vehicle loading direction.

To determine the maximum cargo floor height for a safe loading of the vehicle, enter the graphic simultaneously from both scales and move vertically and horizontally along values corresponding to wheelbase and overhang ratio, to the point at which both lines intersect. Maximum cargo floor height will be the value of the line immediately above intersection point.

EXAMPLE:

A vehicle is intended to be backed into the cargo cabin. Rear overhang is 75 cm, and ground clearance on rear end is 30 cm. Wheelbase is 500 cm. Front overhang is 70 cm, and ground clearance on front end is 15 cm. Cargo floor is, in this case, 125 cm high.

Case 1:

Since the vehicle is intended to be backed into the cargo cabin, for the first phase of the loading operation, overhang ratio on rear end must be calculated:

$$\text{Overhang ratio} = \frac{\text{Overhang length}}{\text{Ground clearance}} = \frac{75}{30} = 2.5$$

Overhang ratio on the vehicle rear end is less than 2.75. Its rear end will not contact the ramp before the rear axle starts to climb the auxiliary loading ramps.

<u>Case 2:</u>

Since the vehicle has a very low ground clearance in relation to its overhang length, along with a relatively long wheelbase, it is necessary to determine if the front end will contact the parking ground. Calculate overhang ratio on the front end:

$$\text{Overhang ratio} = \frac{70}{15} = 4.7$$

Enter the graphic simultaneously from the vertical scale, on the overhang ratio line corresponding to 4.7, and from the horizontal scale, on the 500-cm wheelbase line. Intersection point is between lines representing a 120-cm and 130-cm cargo floor height. Since actual cargo floor height is 125 cm, it will be necessary to use approach shoring, at least 5 cm thick under the ramp and auxiliary loading ramps, or considering the possibility of loading the vehicle front end first.

4.6.4 Vehicle overhead projection

(See Figure 4-6)

Although a vehicle may be lower than the maximum height available in the cargo cabin, the loading operation with the inclined ramp may be difficult if its maximum height is near the end of the vehicle that is going into the aircraft first. The larger the distance from the maximum height point to the axle entering first, the higher the possibility to contact the cargo cabin overhead. If the point of maximum height is between both axles, that is, behind the first axle reaching the ramp crest, then the full height available in the cargo cabin (171 cm) may be used.

Figure 4-6 serves to determine the maximum permissible height for a vehicle according to its overhang length, or the distance from the axle to the point of maximum height, if that point is not just at the vehicle end.

Enter the vertical scale “vehicle overhang” with the distance from the critical point to the next axle and move horizontally to the right until intersecting the line representing actual cargo floor height. From this point, move down vertically to the horizontal scale. If reading is equal or higher than the height at the vehicle critical point, there will not be contact with the cargo cabin overhead due to projection.

To determine the maximum cargo floor height to prevent the vehicle from contacting the cargo cabin overhead, enter the graphic simultaneously from both scales, and move vertically and horizontally along line values corresponding overhang length, or distance to critical point, and critical point height, until both lines intersect. Maximum permissible cargo floor height will be the value of the intersection line located immediately above intersection point.

<u>EXAMPLE:</u>

The vehicle, which is intended to be loaded backwards, has a 90-cm rear overhang, is 152 cm high at its rear end, and is 160 cm width. Ramp crest is 130 cm high from the parking ground.

<u>Case 1:</u>

As vehicle width is less than 63 cm, usable height limitation is used. Enter the vertical scale with the vehicle rear overhang, at 90 cm, and follow the 90-cm line until intersecting the ramp crest height line representing 130 cm. Then move down vertically until the vehicle height scale. Reading is 150 cm, thus there will be contact with the cargo cabin overhead.

Case 2:

Enter the graphic simultaneously from the vertical scale, at 90 cm, and from horizontal scale, at 152 cm. Intersection point is between cargo floor lines representing 130 and 120 cm. Since actual cargo floor height is 130 cm, it will be necessary to use approach shoring under the ramp and auxiliary loading ramps, at least 10 cm thick, or considering the possibility of loading the vehicle front end first.

4.6.5 Final considerations about overhang and projection limitations

When vehicle dimensions create one or several of the problems described in preceding paragraphs and, nevertheless, they are smaller than those available in the aircraft, some of the following solutions may be attempted:

A. If vehicle is slightly higher than height available in the cargo cabin, tire deflation is not an acceptable solution. Internal pressure in pneumatic tires may be set to lower if a specific internal pressure for airlift has been established and properly certified, according to vehicle characteristics. With unit's or vehicle user's approval, detach removable components, such as cover bows, antennas, etc.

B. Use approach shoring under the ramp and auxiliary loading ramps to reduce slope.

C. For points on which there may be contact with the bottom of the vehicle (ramp crest, auxiliary loading ramps, parking ground), use rolling shoring properly positioned to raise the bottom of the vehicle to pass over the critical point and prevent contact.

D. If appropriate means are available, load the vehicle with the ramp in the horizontal position. For this, place the vehicle on a cargo loader or other suitable loading platform, and install the auxiliary loading ramps over the horizontal ramp. Then transfer the vehicle from the loading platform onto the aircraft ramp (see CHAPTER 3 - AIRCRAFT CONFIGURATION and paragraph 3.1 in this chapter). Use the cargo winch to load the vehicle into the aircraft.

E. Palletize the vehicle. In this case, married HCU-6/E pallets or airdrop platforms can be used if vehicle length requires.

   NOTE: When palletizing a vehicle, subtract roller height and pallet or airdrop platform thickness from height available in the cargo cabin.

4.7 CARGO CABIN DIAGRAMS

Figure 4-7 contains cargo cabin diagrams to be used as a reference for load planning, normal and specific airlift procedures, etc. Diagrams show frame (FR) and fuselage stations (STA) references to ease weight and balance calculations once the load has been distributed on the diagram. Longitudinal references (STA) allow a direct reading of all cargo items CG location on the aircraft, once they have been drawn on the diagram.

4.8 WEIGHT AND BALANCE

Total aircraft weight and correct balance (equilibrium) are among the most important factors for a safe operation of the aircraft. The aircraft is designed with a number of weight limitations, determined by performance, control and structural considerations. The amount of cargo that may be transported in a particular mission depends on the empty aircraft weight (basic weight), number of crewmembers, additional equipment and quantity of fuel, etc., whose sum must be equal or less than the maximum allowable weight at takeoff and landing.

Cargo on the aircraft must be distributed so that the center of gravity of the whole set lies within the permissible limits. Different distributions and quantities of cargo and fuel cause aircraft gross weight and CG position to change. The aircraft will only be cleared for takeoff when it is guaranteed that its gross weight and CG will be within the prescribed limits, established on the Aircraft Flight Manual and Aircraft Weight and Balance Control and Loading Data Manual, during all flight phases until landing.

Flight characteristics and performance of the aircraft are directly dependent upon its weight and balance conditions throughout its flight. An aircraft whose weight is greater than its allowable maximum gross weight and/or whose center of gravity is located outside its prescribed permissible limits, will experience performance degradation (instability, increase in takeoff distance and landing ground run, decrease in service ceiling, increase in stall speeds, etc.). Except in the event an in-flight emergency situation arises, flying the aircraft in an out-of-limits condition is absolutely forbidden.

4.8.1 Aircraft center of gravity

The aircraft center of gravity is that point at which the combined aircraft weight and all its contents may be assumed to be concentrated, and on which the resultant of all gravitatory forces acting on it is applied. The aircraft is considered to be balanced when the combined CG of the aircraft and all its contents lies within the permissible CG range. This range, which is located within a determined wing area, and has been established by the manufacturer using design calculations and performing flight tests, is delimited by its most forward and aft positions within which the aircraft center of gravity must be located to keep intact its flight qualities (see Figure 4-9).

Aircraft balance is the condition of stability that exists when all weights and forces act on it in such a way as to prevent rotation. To determine whether the aircraft is properly balanced, CG location must be calculated and checked to be within the permissible CG range, between forward and aft limits, for the gross weight and configuration existing at the time calculations are made. For computations to be reliable, it is mandatory to know the exact weight and CG location for each item to be airlifted. Although it is also worthwhile achieving a uniform lateral distribution of loads, the C-295 only requires longitudinal CG computations.

4.8.2 Concepts in weight and balance calculations

Aircraft CG computations are based, basically, on the equilibrium condition attained in a see-saw (see Figure 4-8): starting from the balance point, the see-saw is in a level position due to equal weights placed equal distance from the balance point on both sides, or because a greater weight placed nearer the balance point has the same effect than a lighter weight placed farther from the balance point. If this weight times distance condition on both sides is broken, the see-saw becomes unbalanced. Therefore, there are three parameters that take part in the see-saw balance: weight (W), distance to balance point or arm (A), and product of both or moment (M):

$$M = W \times A \qquad A = \frac{M}{W} \qquad W = \frac{M}{A}$$

Principles governing aircraft balance are, basically, those of balance in a see-saw. The aircraft lifts on the wing surface, and arm is the distance from a reference line to the CG of each item in the aircraft. The aim of calculations is achieving and checking that the center of gravity of the whole set (aircraft weight plus cargo, passengers, etc.) is located in an optimum point within this area, that is, between permissible CG range forward and aft limits.

Once similarity between aircraft and see-saw balance has been established, formulas and concepts to be used for aircraft weight and balance computations are as follows (see Figure 4-9):

A. Reference Datum Line (RDL). An imaginary plane, located 1587 mm ahead of the nose, from which all longitudinal distances are measured.

B. Station (STA). An imaginary vertical plane, perpendicular to the longitudinal axis of the aircraft, measured from the RDL and expressed in millimeters.

C. Arm of an item in the aircraft (A). Distance in meters from the RDL to the center of gravity of an item, expressed to the hundredths. It can be considered the STA on which the CG of an item is located, changed into meters and expressed to the hundredths. For computations, the arm of an item whose center of gravity is on STA 14352 will be 14.35 m.

D. Moments (M). Product resulting from multiplying the weight of an item, in kilograms, by its arm in the aircraft. Moments are rounded off to the nearest whole number.

E. Gross Weight (GW). Total aircraft weight, in kilograms, including crew, fuel, cargo, and all its contents.

F. Chord. Straight line from the leading edge to the trailing edge of an airfoil or wing (see Figure 4-10).

G. Mean Aerodynamic Chord (MAC). Is the chord of a section of an imaginary rectangular airfoil or wing, which would have a force vector throughout the flight range identical to that of the actual wing. MAC on the C-295 is 2.561 m.

H. Leading Edge of Mean Aerodynamic Chord (LEMAC). Distance from the RDL to the leading (forward) edge of MAC. On the C-295, LEMAC is 11.115 m.

I. Permissible CG Range. Portion of MAC within which the aircraft CG must be located for flight.

J. Forward limit. Most forward position on which the aircraft CG may be located for safe flight operation.

K. Aft limit. Most rear position on which the CG may be located to guarantee full aircraft control.

L. Center of Gravity Arm (CGA). Distance from the RDL to the aircraft CG. CGA is expressed in meters and is rounded off to the thousandths.

M. Percent of MAC (% MAC). Aircraft CG location is normally expressed in percent of MAC, instead of using distance or arm from the RDL. 0% MAC identifies the leading edge of MAC, 11.115 m from the RDL. 100% MAC corresponds to the trailing edge of MAC, 11.115 plus 2.561 m (length of MAC), that is, 13.676 m from the RDL. Percent of MAC is expressed and rounded off to the nearest tenth.

4.8.3 Computing weight and balance

(See Table 4-1)

NOTE: All data, tables and graphics required to determine weight and position of crewmembers, lubricants, fuel, etc., together with permissible CG range limits, are contained in the Weight and Balance manual.

Computing the aircraft CG consists of combining weights and moments of all items in the aircraft, and is based on the seesaw balance formulas presented above. To do so, it is necessary to know the exact weight and CG position (STA) of every cargo item in the aircraft. Table 4-2 shows an example of aircraft weight and balance calculation with loads depicted in Figure 4-15. Table 4-1 depicts this computation process, which must include the following steps.

A. Obtain and fill in Basic Weight and Moment for the particular aircraft.

NOTE: Basic Weight and Moment for each particular aircraft is included in its Weight and Balance Handbook, and must be kept permanently updated, according to the weight and balance control requirements shown in the Weight and Balance manual.

B. Determine Operating Weight and Moment. For this, add consecutively weight and moments for crew, mission equipment, emergency equipment, extra equipment, and any other item on board which does not match cargo, passenger, or fuel categories.

C. Determine Zero Fuel Weight (ZFW) and Moment. For this, add consecutively weight and moments of passengers, troops and/or parachutists, and those of every cargo item in the aircraft, to Operating Weight and Moment. Check that resulting weight does not exceed Maximum Zero Fuel Weight (MZFW) limitation.

WARNING: AIRCRAFT OPERATION WITH A ZERO FUEL WEIGHT HIGHER THAN MZFW MAY CAUSE STRUCTURAL DAMAGE.

NOTE: Refer to Weight and Balance manual for distribution diagrams and weight criteria for passengers, troops, parachutists, and personnel carried on stretchers (MEDEVAC).

D. Determine Takeoff Weight and Moment. For this, obtain fuel distribution by tanks and corresponding weight and moments, and add to ZFW. Check that resulting weight does not exceed Maximum Takeoff Weight (MTOW).

E. Compute aircraft Center of Gravity Arm (CGA):

$$\text{CGA} = \frac{\text{Takeoff moments}}{\text{Takeoff weight}}$$

F. Change CGA into % MAC. Check that result is within permissible CG range for that Takeoff Weight:

$$\%\ \text{MAC} = \frac{(\text{CGA - LEMAC}) \times 100}{\text{MAC}}$$

With corresponding values included, this formula for the C-295 is as follows:

$$\%\ \text{MAC} = \frac{(\text{CGA} - 11.115) \times 100}{2.561}$$

G. For computing aircraft condition at landing, subtract from ZFW weight and moments of airdropped personnel and/or cargo, if it is a personnel or cargo airdrop mission.

H. Determine Estimated Landing Weight. For this, estimate remaining fuel quantity and distribution at landing, and add corresponding weights and moments to Zero Fuel Weight and Moment, or to the resultant after subtracting personnel and cargo airdropped.

I. Compute estimated CGA and % MAC at landing, in the same way as for takeoff. Check the result is within permissible CG range for Estimated Landing Weight.

NOTE: Data and form presented in the following example are for information only. Refer to aircraft weight handbook and Weight and Balance manual for an up-to-date basic weight and actual data. Use appropriate weight and balance form, as prescribed in applicable regulations.

	ITEM		WEIGHT (kg)		ARM (m)		MOMENT (kg x m)	CGA (m)	%MAC
	BASIC WEIGHT								
+	CREW	PILOT & COPILOT		x		=			
		FLIGHT ENGINEER		x		=			
		LOADMASTERS		x		=			
		EXTRA CREWMEMBERS		x		=			
+	CREW BAGGAGE			x		=			
+	MISSION EQUIPMENT (seats, stanchions, stretchers, specific airdrop equipment, etc.)			x		=			
+	EMERGENCY EQUIPMENT (life vests, parachutes, anti-exposure equipment, etc.)			x		=			
+	EXTRA EQUIPMENT (other non-aircraft equipment required for the mission)			x		=			
+	OTHER (spares, items not matching cargo, fuel or passengers)			x		=			
=	**OPERATING WEIGHT**								
+	PASSENGERS AND CARGO	PASSENGERS		x		=			
		CARGO		x		=			
=	**ZERO FUEL WEIGHT (weight limitation)**								
+	TAKEOFF FUEL	INBOARD TANKS		x		=			
		OUTBOARD TANKS		x		=			
=	**TAKEOFF WEIGHT (weight and CG limitation)**								
	ZERO FUEL WEIGHT								
-	AIRDROPPED PERSONNEL AND CARGO	PARATROOPS		x		=			
		CARGO		x		=			
+	ESTIMATED LANDING FUEL	INBOARD TANKS		x		=			
		OUTBOARD TANKS		x		=			
=	**LANDING WEIGHT (weight and CG limitation)**								

Table 4-1 Weight and balance computation process for the C-295

	ITEM		WEIGHT (kg)		ARM (m)		MOMENT (kg x m)	CGA (m)	%MAC
	BASIC WEIGHT		11908				142111		
+	CREW	PILOT & COPILOT	170	x	3.57	=	607		
		FLIGHT ENGINEER	85	x	4.35	=	370		
		LOADMASTERS, 2	170	x	6.15	=	1046		
+	CREW BAGGAGE		100	x	5.28	=	528		
+	EMERGENCY EQUIPMENT, life vests and rafts		100	x	6.85	=	685		
+	OTHER (spares, items not matching cargo, fuel or passengers)		150	x	6.15	=	923		
=	**OPERATING WEIGHT**		12683				146270		
+	CARGO	Vehicle 1	3500	x	8.95	=	31325		
		Vehicle 2	4200	x	14.76	=	61992		
=	**ZERO FUEL WEIGHT (20700)**		20383				239587		
+	TAKEOFF FUEL	INBOARD TANKS	900	x	11.94	=	10746		
		OUTBOARD TANKS	1800	x	12.05	=	21690		
=	**TAKEOFF WEIGHT (23200)**		23083				272023	11.785	26.2
	ZERO FUEL WEIGHT		20383				239570		
+	ESTIMATED LANDING FUEL	INBOARD TANKS	0	x	11.94	=			
		OUTBOARD TANKS	700	x	12.05	=	8435		
=	**LANDING WEIGHT (weight and CG limitation)**		21083				248005	11.763	25.3

Table 4-2 Weight and balance computation process for the C-295 (example)

4.8.4 Aircraft CG limits on the ground

In some instances when airlifting personnel and cargo, mission requirements and schedule may dictate accomplishing the load of cargo well in advance of the estimated takeoff time. In these cases, since personnel is usually loaded forward of cargo cabin, aircraft balance condition may be unstable. The aft CG limit on the ground for a partially loaded aircraft is 43% MAC. When aircraft CG is located aft of this percentage, keep the fuselage support legs installed until all passengers have boarded the aircraft.

4.9 CARGO CG COMPUTATIONS

Weight and CG location of each cargo unit must be exactly known for the calculated aircraft weight and balance to be reliable. The agency, unit or organization offering cargo for air shipment is responsible for providing the aircrew with the correct weight and CG position for each item of cargo. Reported weight for each piece of cargo, vehicle, or pallet shall never be estimated, but it shall be updated at the time of transport. If available data does not seem to be reliable, every cargo unit must be weighed before being offered for airlift.

WARNING: ALL PALLETS SHALL ALWAYS BE WEIGHED ONCE THE LOAD HAS BEEN PLACED AND RESTRAINED TO THE PALLET.

NOTE: To obtain reliable readings, cargo items and vehicles must be level during weighing.

4.9.1 Weighing and CG marking requirements

WARNING: AIRLIFT OF CARGO ITEMS OF UNKNOWN WEIGHT AND CG LOCATION SERIOUSLY JEOPARDIZES IN FLIGHT SAFETY. LOADS WHOSE REPORTED WEIGHT IS NOT RELIABLE OR NOT HAVING A MARKED CG ACCORDING TO PRECEDING REQUIREMENTS, WILL NOT BE ACCEPTED FOR AIR SHIPMENT.

Each item of cargo will be weighed before being offered for airlift. In addition, CG will be marked in the following cases:

A. Any cargo item longer than 3 m (10 ft), or heavier than 150 kg (330 lb).

B. Any cargo unit having a balance point other than its longitudinal geometric center.

C. Any vehicle or wheeled cargo item.

D. Wheeled cargo, vehicles or shelter-like crates having a cargo-carrying capability will be weighed with the actual load to carry in flight. Marking shall include an empty or loaded CG notation, as appropriate.

E. Single pallets shall be weighed after all cargo has been placed and restrained. Pallet CG will be located within the limits shown in Figure 4-45.

F. Palletized loads longer than a single pallet.

G. All married pallets.

4.9.2 Determining cargo unit weight and CG location

Figure 4-11 shows two different methods for obtaining weight and determining the CG location of a cargo item.

4.9.2.1 GENERAL METHOD

A. Weight is determined by weighing each cargo item.

B. To determine CG location, position the cargo item on a skid or pipe until it balances.

C. Mark CG on the load over the balance point.

4.9.2.2 METHOD FOR LARGE OR BULKY LOADS

If weighing scales to accommodate the entire unit are not available, determine weight of each end using angled irons or skids as narrow as possible, as follows:

A. Mark a reference point on each end of the load (W_1 and W_2), and measure the distance between both of them (L).

B. Position the cargo item on a skid or wood block, so the reference point on one end rests on the weighing machine, and the reference point on the opposite end rests on a similar support. The cargo item must be level. Write down obtained weight as W_1.

   NOTE: For accuracy on determining CG, support points used should be as narrow as possible.

C. Repeat step B on the other end of the cargo item. Write down obtained weight as W_2.

D. Overall cargo unit weight is the sum of both weighing operations:

$$W_T = W_1 + W_2$$

   CG location is determined by applying again the relationship:

$$M = W \times A$$

   Taking one of the two marked points on the cargo item as origin (W_2 in the case in Figure 4-11), the aim of the operation is obtaining the distance X to the CG (arm) from W_2; solve out A:

$$A = \frac{M}{W}$$

   Next, replace weight and distance values to obtain the formula:

$$M = W \times A \qquad M = L \times W_1 \qquad \text{CG from } W_2\ (x) = \frac{L \times W_1}{W_T}$$

4.9.3 Weights and distances for vehicle CG computations

For the identification of weights and distances in a vehicle, there is a set of abbreviations, internationally used, that defines each weight and dimension (see Figure 4-12 and Figure 4-13).

4.9.3.1 CALCULATING VEHICLE CG LOCATION

(See Figure 4-13)

After all necessary weights and distances have been obtained, computations are made in the same way as for large cargo items:

$$M = W \times A \qquad M = RAW \times WB \qquad CGFA = \frac{RAW \times WB}{GW}$$

Figure 4-13 shows an example of vehicle CG computation. Taking the front axle as the reference line, the operation involves calculating moments by multiplying rear axle weight (RAW) by its arm (wheelbase, WB). Next, moments are divided by vehicle gross weight (GW). The result is the distance-arm to the center of gravity from the front axle (CGFA).

<u>CAUTION:</u> TANDEM AXLES LESS THAN 90 CM (35 IN.) APART WILL BE CONSIDERED AS A SINGLE AXLE FOR FLOOR LOADING CAPACITIES AND CG COMPUTATIONS, SO REFERENCE DISTANCE WILL BE MEASURED FROM THE TANDEM AXLE PIVOT POINT, AND WEIGHT WILL BE THE SUM OF BOTH AXLE WEIGHTS.

<u>CAUTION:</u> IF THE VEHICLE IS GOING TO BE AIRLIFTED WITH CARGO INSIDE, ACCOMPLISH THE WEIGHING OPERATION AFTER ALL CARGO HAS BEEN ARRANGED IN THE VEHICLE, SO ACTUAL WEIGHTS PER AXLE AND GROSS WEIGHT CAN BE OBTAINED

4.9.3.2 <u>CALCULATING COMBINED CG FOR A TRACTOR-TRAILER LOAD</u>

(See Figure 4-14)

When a vehicle is going to be airlifted connected to a trailer, the tractor vehicle will support some of the trailer weight through the towing pintle or lunette. Hence, weight and CG location available data for each of the vehicles separately will not be usable to compute the overall unit CG location. In these instances, it will be necessary to weigh both vehicles joined together, with all cargo to be transported inside, and to determine the combined CG position from the new data.

Starting from partial weights obtained, and after choosing a point on the set as the reference line (RL), the operation involves calculating different moments, by multiplying weights (W_2 and W_3) times their corresponding distances to the reference line (arms, A_1 and A_2), and then dividing the sum of the moments by the combined gross weight of both vehicles:

$$CGRL = \frac{(W_2 \times A_1) + (W_3 \times A_2)}{W_1 + W_2 + W_3}$$

Figure 4-14 shows an example of combined tractor-trailer CG computation. Calculation starts after vehicles have been weighed connected together, and all weights per axle have been obtained.

<u>NOTE:</u> The formula does not include weight on the first axle (W_1) in the numerator because, in the examples, distance from first axle is zero, and resulting product would also be zero. If a point forward of the first axle is chosen as the RL, it will be necessary to include the product of the weight by its corresponding distance in the formula numerator.

4.9.3.3 <u>CALCULATING COMBINED CG FOR SEVERAL CARGO ITEMS</u>

(See Figure 4-15)

Overall CG of all cargo items making up the load to be airlifted may be computed starting from individual weight and CG position of each unit in the aircraft. This procedure may be useful when trying to achieve a determined balance condition (% MAC) due to the mission profile. After cargo CG has been computed, it is combined with aircraft data to obtain aircraft CGA and % MAC.

4.10 LOAD SHIFTING EFFECT

Load shifting effect in the aircraft balance is quite simple. If a certain amount of load is shifted forward, the aircraft CG shifts forward. If the load is shifted aft, the aircraft CG shifts aft. Numerical computation of this effect is useful, because it allows to correct an out-of-limits aircraft balance condition, in other words, to achieve a CG within the permissible range, or to attain a more suitable aircraft CG according to the mission profile. For this, the following equation can be used (see Figure 4-16):

$$\text{LSW} \times \text{LSA} = \text{AGW} \times \text{CGC}$$

Abbreviations in the formula represent the following concepts:

- LSW : Load Shift Weight = weight of the load to be moved (in kg).
- LSA : Load Shift Arm = distance the load is to be moved (in meters).
- AGW : Aircraft Gross Weight (in kg).
- CGC : Center of Gravity Change after the load is shifted (in meters).

NOTE: LSA is expressed in meters to the hundredths, and resulting CGC in the aircraft is expressed in meters to the thousandths, in accordance with arm of an item (A) and center of gravity arm (CGA) in the aircraft (see paragraph 4.8.2).

This formula is based on M = W x A. The first term of the equation represents moments caused by load shifting (LSA-weight x LSA-arm). In the second term, the same amount of moments is expressed in relation to the whole aircraft (AGW-weight x CGC-arm). It is also necessary to determine in which direction the aircraft CG has to be changed (forward/aft).

Depending on the problem to solve and circumstances (which of the cargo items can be shifted, distance available in the aircraft for shifting, needed CG change, etc.), it is necessary to set or compute in advance three of the four variables. Since aircraft gross weight, including cargo, will be a fixed figure, it will be necessary to determine which of the remaining three variables is to be computed, and to establish the other two. To simplify its application at the time of finding the desired variable, and since aircraft CGC is proportional to the weight and arm of the shifted load, the equation can be rearranged into the following proportion:

$$\frac{\text{CGC}}{\text{LSA}} = \frac{\text{LSW}}{\text{AGW}}$$

$$\text{CGC} = \frac{\text{LSA} \times \text{LSW}}{\text{AGW}} \qquad \text{LSA} = \frac{\text{CGC} \times \text{AGW}}{\text{LSW}} \qquad \text{LSW} = \frac{\text{CGC} \times \text{AGW}}{\text{LSA}}$$

CGC must be obtained from aircraft CG expressed in terms of CGA. When starting from the aircraft CG expressed in terms of percent of MAC, it must be changed into CGA:

$$\%\ \text{MAC} = \frac{(\text{CGA} - \text{LEMAC}) \times 100}{\text{MAC}} \qquad \text{CGA} = \frac{\%\ \text{MAC} \times \text{MAC}}{100} + \text{LEMAC}$$

For the C-295, the formulas are the following:

$$\%\ \text{MAC} = \frac{(\text{CGA} - 11.115) \times 100}{2.561} \qquad \text{CGA} = \frac{\%\ \text{MAC} \times 2.561}{100} + 11.115$$

Taking the weight and balance computation example in Table 4-2, as a starting point, the following is an example of aircraft CGC calculation according to load shifting (see Figure 4-17).

EXAMPLE:

Resulting aircraft balance condition with the initial load distribution shown in Figure 4-17, according to computations in Table 4-1 (CGA = 11.78, 26.1% MAC) is considered to be too aft. With an aircraft gross weight (AGW) of 23083 kg, it is determined that takeoff should be at 20.5% MAC.

First, desired % MAC is changed into CGA:

$$\text{Desired CGA} = \frac{20.5 \times 2.561}{100} + 11.115 = 11.640$$

Difference between initial and desired CGA will be:

INITIAL CGA = 11.785; DESIRED CGA = 11.640

CGC = 11.785 – 11.640 = 0.145 m

Since it is intended to reach a more-forward balance condition, at the view of available space the most feasible load shifting operation seems to be moving vehicle 1 (LSW = 3500 kg) forward. Therefore, problem will involve calculating how far (LSA) this vehicle has to be shifted toward the nose of the aircraft.

$$\text{LSA} = \frac{\text{CGC} \times \text{AGW}}{\text{LSW}} \qquad \text{LSA} = \frac{0.145 \times 23083}{3500} = 0.96 \text{ m}$$

Given that CG of vehicle 1 was initially located on STA 8950, and to achieve the desired balance condition it has to be shifted 0.06 meters forward, new vehicle-1 CG position will be:

INITIAL STA = 8950; LSA = 0.96 m

New STA = 8950 - 960 = 7990

4.11 SHORING

Using shoring is placing pieces of wood beneath a load with different purposes. Main utility of shoring is that, by placing wooden planks beneath a cargo item, pressure exerted on the cargo floor decreases because weight is spread over a larger area (pressure = weight/surface), which allows carrying a load that exerts on the base support a higher pressure than normally would be allowed directly over the cargo floor. Using shoring can make the difference between carrying or not a particular cargo item, according to aircraft cargo floor capabilities detailed in Chapter 2 (see Figure 2-1 and Table 2-1).

The weight of a load resting on shoring is not spread equally over the entire surface of contact between the plank and the cargo floor. In general, shoring only increases the contact surface to the area circumscribed in a plane, drawn downward and outward from the perimeter line of contact between the load and plank, at a 45º angle, until it intersects the surface (cargo floor) over which the shoring rests.

The geometric shape of this spreading effect is shown in Figure 4-18. Assuming the shoring plank is 5 cm thick and the box is 30 cm long by 15 cm wide, the surface of contact between box and plank will be 30 x 15 cm, that is, 450 cm^2. Now, extend imaginary planes downward and outward from the outer edges of the bottom of the box, at 45º angles. The delimited area by these imaginary planes will be 40 x 25 cm, a total of 1000 cm^2. In this particular case, the resulting area of contact, after including shoring effect, is more than twice the original, although increase will not always be so great, and will depend upon the geometric shape of the base support. What has happened in this example is that the area over which the weight is distributed has been increased by the addition of a border 5 cm wide, all around the surface of contact between the box and the shoring. This border increase, in length and width, is equal to the shoring thickness.

The direct addition of the plank thickness to the length and thickness of the geometric shape of the base support is usually applicable to all cases. Since area increase is only obtained around the border of the surface of contact, the larger the object whose contact pressure is intended to decrease, the smaller the proportion of increase of area of contact. Shoring 5 cm thick beneath a square box 30 cm wide will increase the contact surface by 78%, by adding 700 cm^2 to the initial 900 cm^2. The same plank shoring 5 cm thick under a square box 150 cm wide will increase the contact area by approximately 14%, by adding only 3100 to the initial 22500 cm^2.

<u>NOTE:</u> Plywood panels may be used as shoring. To replace a plank 5 cm (2 in.) thick, three plywood panels 19 mm (¾ in.) thick are required, stacked on top of each other.

4.11.1 Types of shoring

Depending on the problem to be solved, the different types of shoring that may be used during the loading operation, and/or in flight are the following:

4.11.1.1 <u>SHORING FOR WEIGHT SPREADING (PLANK SHORING)</u>

Plank shoring is used to spread the weight of the load over a larger area, exploiting the increase of area of contact effect in a 45º angle, thus decreasing the pressure exerted by the load over the cargo floor.

4.11.1.2 <u>ROLLING SHORING</u>

Before certain vehicles can be loaded, it is necessary to cover the floor with wood to protect it against possible damage caused by chains, metallic studs, or other gripping devices which may be found in the wheels or treads of the vehicles (Figure 4-19). It is also necessary to protect the cargo floor if the vehicle to be loaded is equipped with steel wheels and, in some cases, if it is equipped with hard rubber tires. At first, this may seem a different problem from that of weight distribution previously discussed, but it is actually the same. Wheels equipped with these kind of gripping devices cause damage on the cargo floor, because the vehicle rests on the chains or studs, and so weight is concentrated on a very small area. Steel rims and hard rubber tires concentrate weight on very small areas, nearly a tangency line with the cargo floor. In these cases, use planks of shoring at least 2 cm (¾ in.) thick (Table 2-1). Planks used as shoring should be thick enough for cleats or lugs to sink into them, and shoring used for wheeled loads on hard rubber or steel tires should cover the cargo floor wide enough, to avoid exceeding load per linear centimeter on all the rolling path of the vehicles, until their final position for flight on the cargo cabin.

<u>CAUTION:</u> REGARDLESS OF CONTACT PRESSURE, VEHICLES WITH CLEATS OR STUDS NOT COVERED WITH RUBBER, OR WITH RUBBER PADS SO EXCESSIVELY WORN THAT METAL PARTS MAY CONTACT THE CARGO FLOOR, SHALL BE SHORED DURING ONLOADING/OFFLOADING AND FLIGHT.

4.11.1.3 <u>PARKING SHORING</u>

Parking shoring is used under the wheels of vehicles requiring shoring at their final position for flight. Generally, vehicles requiring rolling shoring for the loading operation also require parking shoring. Parking shoring is also used under the tongue or retractile supports of trailer-type vehicles, before they are extended and rested on the cargo floor (Figure 4-20).

4.11.1.4 SLEEPER SHORING

Sleeper shoring (Figure 4-21) is used to prevent rocking of a vehicle whose tires or suspension system may not withstand G forces encountered during flight in turbulence, causing tiedowns to come loose. A tire failure may result, and the rim can contact the cargo floor, causing important damage. This kind of shoring is placed between the cargo floor and a structural part of the vehicle, such as the main frame or leaf springs. It can also be used between different parts of equipment that are spring-mounted to prevent them from rocking in flight.

4.11.1.5 BRIDGE SHORING

Bridge shoring (Figure 4-22) is used to transmit to stronger areas of the cargo floor the weight of objects which, because of their dimensions, would rest weaker zones, and could exceed their limitations.

CAUTION: WHEN USING SLEEPER OR BRIDGE SHORING, OBSERVE BULK CARGO FLOOR LIMITS IN LIEU OF WHEELED CARGO LIMITS.

4.11.1.6 APPROACH SHORING

Approach shoring (Figure 4-23) is used under the ramp and/or auxiliary loading ramps to reduce ramp slope when vehicles cannot overpass the ramp crest, or they may strike the cargo cabin overhead. In this case, equal thickness of shoring must be placed beneath the auxiliary loading ramps and the scuff plate on the bottom of the ramp to achieve a constant ramp slope.

4.11.2 Computing contact pressure

To determine whether an object may be transported or not directly over the cargo floor on a particular zone, it is necessary to identify the cargo category limitation, according to the type of support (bulk, concentrated, wheeled, etc.). Next, it is required to compute the surface of contact, and to change it into appropriate reference units (cm^2), taking into account geometric shape and number of supports; and to know the weight born by each support.

$$\text{Pressure} = \frac{\text{Weight on support}}{\text{Support surface}}$$

In calculations, and to obtain figures that may be compared to cargo floor capabilities depicted in Table 2-1, the following rounding off criteria should be followed:

A. Surface is expressed to whole numbers and never increased, regardless of tenth figures: 24.99 is rounded down to 24. The reason for this is not to increase artificially the contact surface by rounding up, thus decreasing the resulting contact pressure.

B. Pressure is expressed to the tenths and rounded up with any figure in the hundredths. 32.11 is rounded up to 32.2.

4.11.2.1 CALCULATING CONTACT PRESSURE FOR BULK OR CONCENTRATED CARGO

The method for calculating contact pressure, without or with shoring, for bulk or concentrated cargo, as appropriate, depends upon the geometric shape of the base support, or number and shape of supports, and shown in Figure 4-24.

NOTE: Planks used as shoring to decrease contact pressure must have, at least, the required dimensions to achieve the effect of weight distribution in a 45º angle, all around the perimeter of the object whose weight is intended to spread (perimeter dimensions plus twice shoring thickness).

NOTE: Using planks slightly longer and wider than those strictly necessary will not provide additional contact surface, but it will make it easier to position the object without requiring a big adjusting effort.

4.11.2.2 CALCULATING CONTACT PRESSURE FOR PNEUMATIC TIRES

When required to observe wheeled cargo limitations shown in Figure 2-1, compute contact pressure as shown in Figure 4-25.

4.11.2.3 DETERMINING SHORING FOR HARD RUBBER OR STEEL WHEELS

Determine shoring requirements for this kind of wheels in accordance with Table 2-1.

4.12 CARGO RESTRAINT

All items in the aircraft are subjected to forces caused by aircraft movement (flight in turbulence, direction and speed changes, takeoffs, landings, etc.). These forces, which are stronger in certain directions, will tend to shift cargo unless it is firmly secured to the aircraft. Since the aircraft and its cargo move forward very fast during normal flight conditions, the cargo will tend to keep moving forward if the aircraft suddenly slows down. This tendency to keep moving forward (inertia) is the strongest force that usually acts on the cargo. Other forces that may be generated are: an aft force, which tends to move the cargo towards the rear of the aircraft; a lateral force, which tends to move cargo away from the longitudinal axis of the aircraft; and a vertical force, which tends to raise the cargo or to press it against the cargo cabin floor. Shifting of cargo in flight, even small items, may change the aircraft balance condition, injure passengers, or damage aircraft equipment.

All cargo and items in the aircraft must be restrained so they will not shift during any flight condition. Forces caused by different flight conditions tend to move the cargo in a forward, aft, lateral (side-to-side), or vertical direction, or in any combination of them (see Figure 4-26). These forces are directly proportional to the cargo's weight. An item in static condition is subjected to a force equal to its weight, that is, the force of gravity (1 G). The ratio between the cargo's weight and the maximum force that will act in each direction is called the load factor, expressed in Gs, representing times the item's weight is multiplied due to forces acting on it.

4.12.1 Restraint criteria

Restraint criteria define the amount of restraint to apply to each cargo item, based on its weight, to counteract the dynamic forces imposed upon each unit due to a change in motion (takeoff, climb, descent, slow down, speed up, landing). The constant used to define the restraint criteria for each direction of movement is the load factor (the ratio between the item's weight and the force acting on it in each direction). Restraint must be sufficient to withstand the greatest load that may be encountered. These loads are expressed in terms of cargo weight times the load factor. If a cargo unit is subjected to a force equal to 1.5 times its weight, it must be restrained for a load factor of 1.5 to prevent it from shifting.

Counteracting forces, in terms of restraint applied to the cargo to keep it from moving, are identified by the direction in which the cargo would move if it were not secured. Forward restraint prevents the cargo from moving forward, aft restraint prevents the cargo from moving rearward, lateral restraint prevents side-to-side movement, and vertical restraint prevents the cargo from rising from the cargo floor. Expressed in terms of force of gravity units or load factors (G), minimum restraint criteria are as follows:

A. Forward (FWD): 3.0 G

B. Rearward (AFT): 1.5 G

C. Sideward (LAT): 1.5 G

D. Vertical (VER): 2.0 G

4.12.2 Fundamental principles of cargo restraint

The most suitable method for securing a cargo item varies considerably from case to case, depending on dimensions, weight, geometric shape, position in the aircraft, etc. In all instances, sufficient and adequate restraint will be achieved by observing the following general rules:

A. Cargo must be secured so it will not move in any of the following directions (see Figure 4-26):

- Upward.
- Sideward.
- Forward or rearward.
- Turning.
- Tipping over sideward.
- Tipping over forward or rearward.

B. When securing stacked boxes, it is important that the stack is prevented from collapsing due to tension applied on tiedowns. In addition to possible damage on the load, shifting of a single box may loosen all the tiedowns (see Figure 4-27).

C. A fundamental rule for achieving sufficient strength of tiedown is that the strap or chain leads-off in the general direction of the force to be counteracted (see Figure 4-28). Mathematical calculation proving this principle is illustrated in Figure 4-29: a strap whose rated strength is 1000 lb (454 kg) will only be able to restrain 34.9 lb (15.8 kg) at a 1º force application angle while, with a 30º angle, a restraint of 1000 lb (454 kg) is achieved.

D. For proper understanding of the above example, it is remarkable that the two portions of strap located on both sides of the force application point provide effective restraint so, for calculations, strap rated strength is doubled (2 x 1000 lb). Therefore, when a single tiedown is placed around a cargo unit, and is symmetrically installed on both sides, the value of the tiedown is doubled with respect to the direction of movement to be neutralized, although no restraint is achieved in other directions.

E. When a tiedown is attached directly to a cargo item and not simply passed over or around it, restraint is achieved for more than one direction, depending on the rated strength of the tiedown, and the angle of pulloff from the attaching points. By varying the angle of attachment, a tiedown can be secured to the cargo so that restraint can be expected to be available simultaneously in three directions. Figure 4-30 illustrates this principle.

F. The point of attachment of a tiedown to a cargo unit must be strong enough to withstand the loads intended to be counteracted. A tiedown device must not be attached to any convenient protrusion or ring on a cargo item without taking its strength into account.

G. For proper cargo restraint and neglecting friction, tiedown shown in example A in Figure 4-31 is satisfactory to prevent vertical movement, but it cannot be expected to provide forward, aft nor lateral restraint. To achieve restraint in any of these directions, the tiedown should be installed as shown in example B. Restraint in all three directions is achieved by installing tiedowns as shown in example C.

H. Tiedown devices must always be installed in pairs, symmetrically, and be of the same kind (straps or chains) and rated strength (see Figure 4-32). Unsymmetrical installation of tiedowns may permit such a load distribution that can finally result in tiedown failure. This failure would also result from the different load-deflection caused by elastic performance of dissimilar materials, or of identical materials of different length. Any material subjected to a tensioning load will stretch a given percentage of its length, thus, the greater the length, the greater the potential amount of stretch in the unsymmetrical tiedown. If two tiedowns of the same kind and rated strength are used to restrain a load in a given direction, and one tiedown is longer than the other, the longer tiedown, with its greater stretch potential, will allow the shorter tiedown to assume most of any load that may be developed. If, as a result, the shorter tiedown comes to assume a load greater than its rated strength and fails, the longer tiedown will be subjected to the full load, and it is very likely that it will fail too. In the event of using different materials, nylon tiedown devices stretch more readily than metallic and, under tension, almost immediately let the metallic device assume most of the load. Therefore, when two or more tiedowns are required to restrain a cargo item in a given direction, all tiedowns must be of the same kind and must be installed approximately with the same length.

I. The center of gravity of an item is the point of application of the resultant of all forces acting on the item. Therefore, when tiedowns are attached to the cargo item, the lines of action of the tiedowns should intersect above the cargo center of gravity, as shown in Figure 4-33. Tying down in such a way will reduce the tendency of cargo to overturn when combined upward and sideward forces are experienced.

J. Always consider the weakest point strength as the rated strength of the whole tiedown device. A 10000 lb strap attached to a pallet tiedown ring will have a rated strength equal to 7500 lb. A 5000 lb strap fastened to a CHADS tiedown ring (15000 lb) will provide only 5000 lb of restraint. A removable 10000 lb tiedown ring installed on a center frame-track crossing point will provide only 5000 lb of restraint.

4.12.3 Restraint in several directions

(See Figure 4-30)

A tiedown device develops its whole strength of tiedown when it counteracts a force exerted parallel to it. When an end of the tiedown is attached to the cargo unit, and the other is attached to a cargo floor tiedown ring, as shown in detail 2, the longitudinal force will be exerted parallel to the length of the device, and all its rated strength will be available to prevent cargo from moving in the longitudinal direction. Since it is seldom possible to install a tiedown as shown in details 1 and 2, attachment to the cargo item is usually accomplished to a point located above the cargo floor, as depicted in detail 3. When it is so fastened, the tiedown distributes its strength to prevent the cargo item from moving longitudinally and vertically, but not laterally. A tiedown device installed as shown in detail 4 provides simultaneous restraint in three directions: forward, vertical and lateral. Aft restraint is achieved by connecting tiedowns symmetrically, in pairs, to the front end of the cargo unit.

4.12.4 Calculating tiedown restraint

(See Figure 4-34)

NOTE: For calculations, effective strength of tiedown, cargo item weight, and required restraint are expressed in pounds, since tiedown device manufacturers establish rated strengths in these units. For distances in calculations, it makes no difference using metric or English units, since results are ratios without specific units of measurement.

NOTE: For location and restraint capacities of available tiedown rings in the aircraft, refer to CHAPTER 2 - DESCRIPTION OF AIRCRAFT FEATURES.

As stated above, rated strength of a tiedown is based on its resistance against a force exerted parallel to it. On the other hand, a tiedown can provide restraint in more than one direction, depending on its arrangement. To compute effective strength in each of the three directions, it is necessary to measure four distances, A, B, C and D in Figure 4-34. These measurements match the following concepts:

- AD = Actual tiedown length.
- AB = Longitudinal effective length (forward or aft).
- EB = Lateral effective length.
- ED = Vertical effective length.

After these distances have been obtained, “restraint ratios” in each direction must be determined, that is, the quotient between tiedown effective and actual length. These ratios are expressed to the hundredths and are never rounded up, in spite of figures in the thousandths.

$$\text{Restraint ratio} = \frac{\text{Effective length}}{\text{Tiedown length}}$$

NOTE: Measurements for computing restraint ratios can be obtained in metric or English units, without affecting the resulting quotient.

Next, computed restraint ratio for each direction is multiplied by the rated strength of the tiedown device being used, or by that of the weakest point used in attachment:

$$\text{Achieved restraint} = \text{Restraint ratio} \times \text{Rated strength}$$

Figure 4-34 shows an example of calculation of tiedown restraint in each of the different directions.

4.12.5 Effect of installing tiedown devices at angles

(See Figure 4-35)

Tiedowns attached to a cargo unit at a point located above the cargo floor form three angles: the first with the longitudinal plane (longitudinal angle), the second with a plane perpendicular to the longitudinal axis (lateral angle), and the third with the cargo floor (vertical angle). The longitudinal angle is formed by the tiedown and the line parallel to the longitudinal axis passing by the point of the cargo floor to which the tiedown is attached. The lateral angle is formed by the tiedown and the line perpendicular to the longitudinal axis passing by the point of the cargo floor to which the tiedown is attached. The vertical angle is formed by the tiedown and the cargo floor. Each of these angles corresponds to each of the three directions in which the tiedown provides restraint simultaneously, and its value determines the amount of restraint achieved in each of the three directions.

As practical, forward and aft tiedowns should be installed at equal longitudinal, lateral and vertical angles to obtain the greater possible restraint in all directions, using as few tiedowns as possible. Tiedowns fastened at longitudinal and vertical angles of 30º provide the best performance for achieving satisfactory restraint in all directions, so tiedowns should be installed as close to a 30º angle as possible. Starting from a constant longitudinal angle, increasing the vertical angle will increase vertical restraint, but will decrease the amount of lateral and longitudinal restraint. Keeping a constant vertical angle, increasing or decreasing the longitudinal angle will not affect the amount of vertical restraint, but it will affect the longitudinal and lateral restraint, increasing one while decreasing the other.

4.12.6 Determining type and number of tiedowns

The type of tiedown devices to be used when securing a cargo item should be determined based on its weight, shape and dimensions. Nylon tiedowns (straps) should be used when securing fragile loads, provided straps do not pass over sharp edges. Metallic tiedowns (chains) are more suitable for restraining vehicles. If circumstances dictate securing vehicles by means of straps, those having an operational safety clip both on the hook and ratchet end should be used, to prevent rocking of the suspension system from releasing the tiedown. When determining the type of tiedowns to be used, rated strength of the attaching points to the aircraft and the cargo unit should also be taken into account, since the strength of restraint will be given by that of the weakest point.

When computing the number of required tiedowns, it is advisable to start with required forward restraint (3G, three times cargo unit weight), and aft restraint (1.5 G). Next, achieved restraint per tiedown should be computed, following the method described in paragraph 4.12.4. Number of required tiedowns will be the quotient resulting from dividing required restraint in each direction by achieved restraint per tiedown. Increase one tiedown if result is an odd number. Last, check if already installed tiedowns satisfy required lateral and vertical restraint. If not, number of tiedowns must be increased, always in pairs, until the required amount of restraint is reached.

Example:

A cargo unit weighing 3100 kg (7500 lb) is to be secured in the aircraft. 10000 lb rated strength straps are to be used, and restraints achieved per tiedown in each direction are those obtained in the example in Figure 4-34. The following table summarizes results from computations:

RESTRAINT CRITERIA	REQUIRED RESTRAINT	RESTRAINT ACHIEVED PER TIEDOWN	NUMBER OF TIEDOWNS		RESTRAINT ACHIEVED
			REQUIRED	USED	
FWD 3G	7500 x 3.0 = 22500 lb	7400 lb	4	4	29600 lb
AFT 1.5G	7500 x 1.5 = 11250 lb	7400 lb	2	2	14800 lb
LAT 1.5G	7500 x 1.5 = 11250 lb	4400 lb	3	3*	13200 lb
VER 2G	7500 x 2.0 = 15000 lb	5000 lb	3	6*	30000 lb

* Straps already installed forward and aft, which also act LAT and VER.

Table 4-3 Example of computing number of tiedowns

Thus, it will be necessary to install four straps forward and two aft, achieving lateral and vertical restraint without installing any additional straps.

NOTE: For practical purposes, it will only be necessary to perform detailed restraint calculations when preparing tiedown patterns for specific or airlift/airdrop rigging procedures. Following the 30º longitudinal and vertical angle guideline, it is achieved 75% of the tiedown rated strength longitudinally, 43% laterally, and 50% vertically. A 10000 lb strap fastened to a 10000 lb floor tiedown ring, and to an equal or stronger attaching point on the load, provides 7500 lb longitudinal, 4300 lb lateral, and 5000 lb vertical. Therefore, in most cases, it will be satisfactory to follow this tiedown arrangement, and to compute number of tiedowns required IAW these percentages.

4.12.7 Summary of tiedown rules

The following rules and guidelines summarize all factors to be taken into account when tying down cargo:

A. Always compute the required number of tiedowns.

B. For a given restraint direction, tiedowns shall be of the same kind. For forward and aft restraint, tiedowns must be installed in pairs and symmetrically with respect to the longitudinal axis of the aircraft. For this, removable tiedown rings must be installed symmetrically on the restraint tracks, or symmetrical CHADS tiedown rings shall be used.

C. Apply aft restraint keeping the same angle as for forward tiedowns.

D. Required restraint should be achieved by using as few tiedowns as possible.

E. Install at least a pair of tiedowns forward and another pair aft of the center of gravity of the item, if it is located far from its geometric center.

F. Consider the weakest point strength as the rated strength of the whole tiedown set.

G. If two tiedowns are fastened to the same tiedown ring or load attaching point, compute half the attaching point strength as the rated strength of each tiedown.

H. Tiedowns shall be tightened so they achieve maximum restraint without damaging the cargo or overstretching the tiedown device.

I. Especially for wheeled loads, adjust the final tension on the tiedowns when there are installed, at least, two tiedowns forward and two aft. Otherwise, the load will shift towards the tensioning direction.

J. Use nylon straps on boxes or other items that may be easily crushed.

K. Do not apply straps on sharp edges. Cushion any point expected to damage or cut the strap.

L. Tiedowns installed for restraint in opposite directions, and especially for straps, should not cross or contact each other. If the crossing point causes a change in the path of the tiedown to the attaching point, the restraint provided by the tiedown will be reduced due to its length defined as effective, that must be measured from the point at which the tiedown changes direction. In addition, straps can fail due to friction caused by shaking in flight.

M. When stacking boxes, the strongest should be placed at the bottom. If the most fragile boxes are placed at the bottom, they may be crushed, causing one or more of them to shift and slackening the tiedowns, letting all boxes loose.

N. It is advisable to palletize and secure with nets any load composed by parcels and small boxes. If that is not possible, boxes should be grouped and compacted together by means of straps and restraint should be applied afterwards (see Figure 4-31).

O. For securing vehicles, nylon straps may be used provided they have an operable safety clip on both ends.

P. Do not use damaged straps or chain devices with the locking mechanism or safety clip in bad condition.

Q. When a tiedown is fastened to a point in the main frame of a cargo unit (ring, hole, etc.) restraint is achieved in more than one direction (forward, lateral, and vertical).

R. A tiedown placed around a cargo unit and installed symmetrically on both sides, doubles its strength in the main restraint direction, although it does not provide restraint in other directions.

S. When tying down vehicles, do not apply more than half the required restraint to the axles. The reason for this is that, when a load is developed, the bodywork may detach from the main frame, or consistent structure in the bottom of the vehicle, so the bodywork must also be restrained.

T. Some vehicles, such as trailers, engine dollies, etc. have heavy main parts that are not fastened together good enough to withstand in-flight loads, so they must be considered separately when tying down.

U. Tiedowns installed on vehicles must be routed so they do not touch hydraulic lines and/or electrical cables.

V. Any cargo placed inside the vehicles for airlift shall be restrained to the vehicle to meet the same restraint criteria as for the vehicle to the aircraft. As a general rule, a vehicle will not carry in flight more than a third of its maximum on-the-ground weight carrying capacity, or the maximum weight specified in the vehicle's manual as cross country maximum weight.

W. Tiedowns installed to restrain cargo to the aircraft ramp while it is open should be checked after ramp closure.

X. Before opening the ramp, remove any tiedowns that may have been installed after closure, and are attached to the cargo floor and the ramp floor or pallet locked on the ramp.

4.12.8 Restraint harness

When tying down bulky cargo units that do not have suitable attaching points, securing to the cargo floor or pallet may be accomplished by means of a restraint harness, rigged with straps or chains, as shown in Figure 4-36. When properly installed, the restraint harness provides satisfactory lateral restraint, besides of longitudinal (forward or aft) and vertical. Measurement of tiedown length to compute effective restraint will be made from the point at which the tiedown changes direction in its routing to the attaching point to the cargo floor or pallet ring, on both sides. Supplemental straps or chains may be installed to achieve additional vertical restraint.

4.13 GENERAL LOADING PROCEDURES

This part of the chapter contains instructions, methods, and general considerations for onloading different types of cargo in the aircraft. At the end of the chapter, there is an amplified checklist to be followed step by step, which summarizes information presented in the following paragraphs.

4.14 LOADING METHODS

The loading method selected for a specific cargo unit will usually depend on its dimensions, weight, and physical characteristics. All cargo to be airlifted will be loaded in the aircraft by one of the two following methods: straight-in loading over the horizontally-positioned ramp, from a truck or auxiliary loading vehicle (forklift or cargo loader), or rolling the load up the inclined ramp until its position for flight inside the aircraft, using the auxiliary loading ramps. Palletized cargo, bulky cargo, or wheeled loads can be winched into the aircraft using the internal electric winch or an external winch-mounted vehicle (internal or external winching). Self-propelled vehicles may be loaded into the cargo cabin by driving them up the inclined ramp until their position for flight, using the power of their own engine (self-propelled), or winched by their own winch (self-winched).

<u>WARNING:</u> LOADING OR OFFLOADING WHILE THE AIRCRAFT IS BEING REFUELED INVOLVES AN IMPORTANT RISK OF FIRE. REFER TO APPLICABLE REGULATIONS.

<u>CAUTION:</u> DO NOT CHOCK THE NOSE WHEELS. ROCKING OF THE FUSELAGE DURING LOADING CAUSES THE NOSE WHEELS TO MOVE BACK AND FORTH SLIGHTLY. IF THEY ARE CHOCKED, THE NOSE LANDING GEAR MAY BE DAMAGED.

<u>CAUTION:</u> IF USE OF THE HEATING SYSTEM IN FLIGHT IS ANTICIPATED, DO NOT STACK LOADS SENSIBLE TO HEAT CLOSER THAN 50 CM (20 IN.) TO THE HEATING OUTLETS.

4.15 SUPPORTING THE AFT END OF THE AIRCRAFT

(See Figure 4-37)

The aft end of the aircraft must be properly supported to present a stable platform during the transition of the load from the auxiliary loading vehicle (horizontal ramp), or the parking ground (inclined ramp) to the cargo cabin. Furthermore, suddenly placing a certain amount of weight over the ramp in the horizontal position may cause the nose wheels to rise if the aft end of the fuselage is not firmly supported against the ground by means of the fuselage support legs. The procedure for supporting the aft end of the aircraft depends on the loading method used.

<u>CAUTION:</u> DO NOT CHOCK THE NOSE LANDING GEAR WHEN PERFORMING THESE PROCEDURES OR DURING LOADING/OFFLOADING.

4.15.1 Supporting the aft fuselage (horizontal ramp)

This method is mainly used when loading palletized cargo from an auxiliary loading vehicle (cargo loader or forklift, see also paragraph 4.20). Perform the following steps:

A. Make sure that the telescopic bars are connected.

B. Open and lock the cargo door, and open the ramp to the horizontal position.

C. Install the fuselage support legs as indicated in paragraph 3.10.

D. Adjust the height of the fuselage support legs.

CAUTION: DO NOT EXERT EXCESSIVE PRESSURE AGAINST THE GROUND FOR EASE OF REMOVING THE FUSELAGE SUPPORT LEGS AFTER LOADING IS COMPLETE.

CAUTION: LEAVE SLIGHT DISTANCE OR DO NOT LEAVE ANY DISTANCE BETWEEN THE FUSELAGE SUPPORT LEGS AND THE GROUND, ESPECIALLY IF LARGE CARGO ITEMS ARE TO BE LOADED. ROCKING OF THE FUSELAGE UNDER STRONG WIND CONDITIONS, OR DUE TO WEIGHT IMPOSED ON THE RAMP MAY CAUSE THE LOAD TO STRIKE THE AIRCRAFT.

4.15.2 Supporting the fuselage when using the auxiliary loading ramps (horizontal ramp)

This method is mainly used when loading wheeled cargo directly from an auxiliary loading vehicle over the ramp in the horizontal position with the cargo winch. The auxiliary loading ramps are used to bridge the gap between the bed of the vehicle and the cargo ramp (see also paragraph 4.20). Perform the following steps:

A. Make sure that the telescopic bars are connected.

B. Open and lock the cargo door, and open the ramp to the horizontal position.

C. Install the auxiliary loading ramps as indicated in paragraph 3.9.2.

D. Install the fuselage support legs as indicated in paragraph 3.10. Do not adjust the height of the supports at this time.

E. Raise the aircraft ramp high enough so that the auxiliary loading ramps do not contact the rear end of the vehicle from which the load will be inserted.

F. Using extreme caution, direct the driver to approach the vehicle slowly to the aircraft ramp.

G. Adjust the height of the auxiliary loading vehicle until it is slightly below the auxiliary loading ramps.

H. Lower the ramp until the auxiliary loading ramps rest on the bed of the auxiliary loading vehicle.

  CAUTION: DO NOT EXERT EXCESSIVE PRESSURE WITH THE AUXILIARY LOADING RAMPS AGAINST THE VEHICLE BED. STOP LOWERING THE RAMP WHEN THE TAIL SECTION OF THE AIRCRAFT RISES SLIGHTLY.

  CAUTION: THE AUXILIARY LOADING RAMPS MUST OVERLAP THE LOADING VEHICLE BED BY A MINIMUM OF 10 CM (4 IN.).

I. If required, adjust the height of aircraft ramp and the loading vehicle to get a level loading platform.

J. Adjust now the height of the fuselage support legs.

CAUTION: DO NOT EXERT EXCESSIVE PRESSURE AGAINST THE GROUND FOR EASE OF REMOVING THE FUSELAGE SUPPORT LEGS AFTER LOADING IS COMPLETE.

CAUTION: LEAVE SLIGHT DISTANCE OR DO NOT LEAVE ANY DISTANCE BETWEEN THE FUSELAGE AND THE GROUND, ESPECIALLY IF LARGE CARGO ITEMS ARE TO BE LOADED. ROCKING OF THE FUSELAGE UNDER STRONG WIND CONDITIONS, OR DUE TO WEIGHT IMPOSED ON THE RAMP MAY CAUSE THE LOAD TO STRIKE THE AIRCRAFT.

4.15.3 Supporting the fuselage when using the auxiliary loading ramps (sloped ramp)

This method is mainly used when loading wheeled cargo from the ground up the sloped ramp, either self-propelled or winched. The auxiliary loading ramps are used to bridge the gap between the ground and the cargo ramp (see also paragraph 4.21). Perform the following steps:

A. Disconnect and stow the telescopic bars.

B. Open and lock the cargo door, and open the ramp to the full open position.

C. Install the auxiliary loading ramps as indicated in paragraph 3.9.1.

D. Install the fuselage support legs as indicated in paragraph 3.10. Do not adjust the height of the supports at this time.

E. If required, raise the aircraft ramp and install approach shoring as depicted in Figure 4-23.

F. Lower the ramp until it contacts the ground/approach shoring.

CAUTION: DO NOT EXERT EXCESSIVE PRESSURE WITH THE RAMP AGAINST THE GROUND. STOP LOWERING THE RAMP WHEN THE TAIL SECTION OF THE AIRCRAFT RISES SLIGHTLY.

G. Adjust now the height of the fuselage support legs.

CAUTION: DO NOT EXERT EXCESSIVE PRESSURE AGAINST THE GROUND FOR EASE OF REMOVING THE FUSELAGE SUPPORT LEGS AFTER LOADING IS COMPLETE.

CAUTION: LEAVE SLIGHT DISTANCE OR DO NOT LEAVE ANY DISTANCE BETWEEN THE FUSELAGE AND THE GROUND, ESPECIALLY IF LARGE CARGO ITEMS ARE TO BE LOADED. ROCKING OF THE FUSELAGE UNDER STRONG WIND CONDITIONS, OR DUE TO WEIGHT IMPOSED ON THE RAMP MAY CAUSE THE LOAD TO STRIKE THE AIRCRAFT.

4.16 BULK CARGO PLACED DIRECTLY ON THE CARGO FLOOR

Airlift of non-wheeled cargo units resting directly on the cargo floor is not a practical method, as it requires a considerable amount of time an effort to evenly distribute all cargo over the floor and secure it properly. Whenever possible, these loads should be rigged on HCU-6/E pallets. When adequate means to rig the load on pallets are not available, weight should be distributed over as much of the cargo floor as possible, in order to observe bulk cargo floor capacities (see CHAPTER 2 - DESCRIPTION OF AIRCRAFT FEATURES) and a large piece of cargo should be selected to be positioned as a forward barrier. When the entire load consists of boxes, small containers, or other fragile items, a wooden or plywood skidboard can be used as a forward barrier. For ease of achieving the required restraint, cargo should not be distributed continuously over the entire length of the cargo cabin unless the cargo length is such that it extends the entire cargo cabin, in this case regularly spaced breaks in the load should be made, by means of barriers or separate tiedowns. The most suitable method to obtain forward and aft restraint for large cargo units resting directly on the cargo floor is the restraint harness (see Figure 4-36).

4.17 HAZARDOUS MATERIALS

Airlift, onloading and offloading of hazardous materials must be accomplished in accordance with ICAO regulations and other MAJCOM approved directives. According to their nature and hazard, there are different categories of hazardous materials, so loads including this kind of materials must be checked to ensure they are properly rigged, packed, labeled, and accompanied by appropriate documentation.

Hazardous materials must be positioned in the aircraft as far to the heating outlets as possible, and in such a way that they are easily accessible in flight without requiring moving any other load. Loads containing hazardous materials shall be placed as aft as possible to facilitate jettisoning in the event of an in-flight emergency.

NOTE: According to ICAO regulations, the agency or unit shipping the cargo is responsible for properly classifying and packing loads including hazardous materials, as well as filling in the appropriate Shipper's Declaration for Dangerous Goods.

4.18 FUELED ITEMS

WARNING: SAFETY MUST BE GUARANTEED WHEN AIRLIFTING ITEMS THAT CONTAIN OR HAVE CONTAINED FUEL. ITEMS THAT NOT CONTAIN THE APPROPRIATE AMOUNTS OF FUEL, OR HAVE NOT BEEN PREPARED PROPERLY FOR AIR SHIPMENT MAY CAUSE FUEL SPILLAGE OR FLAMMABLE FUMES IN FLIGHT, SO THEY WILL BE REJECTED FOR AIRLIFT.

WARNING: PERMISSIBLE AMOUNTS OF FUEL PRESENTED IN THIS PARAGRAPH REFER TO AIRLIFT OF ITEMS THAT REQUIRE FUEL FOR FUNCTIONING IMMEDIATELY AFTER OFFLOAD. SPECIFIC AIRLIFT OF FUEL WILL BE ACCOMPLISHED BY OBSERVING PERMISSIBLE AMOUNTS AND USING APPROVED CONTAINERS, ACCORDING TO ICAO REGULATIONS.

CAUTION: VEHICLES PRESENTING CHRONIC FUEL AND/OR OIL SPILLAGE OR LEAKAGE WILL BE DRAINED, PURGED, AND VENTED FOR AIRLIFT.

Airlift of vehicles or equipment that require fuel for functioning, and are required for use immediately after offload presents the problem of the possibility of spilling fuel, or yielding toxic or flammable fumes. During pressurized flight, fuel and fumes inside tanks increase their volume as aircraft differential pressure increases. To preclude these situations, any cargo that contains or has contained fuel shall meet the requirements depicted in the following paragraphs.

4.18.1 Preparation operations

Operations mentioned in preparation requirements are as follows:

A. Draining: allowing fuel contained in the system (tank and/or ducts) to exit under the force of gravity.

B. Purging: forcing as much as possible remaining fuel to exit the system.

C. Venting: keeping the fuel system open to air until every possibility of producing fumes is excluded.

NOTE: Draining, purging and venting should be performed as specified in the vehicle/equipment manual or documentation. The shipping unit or organization is responsible for preparing the equipment.

4.18.2 Self-propelled vehicles

Check that level in each of the engine fuel-supplying tanks of the vehicles to be airlifted is within the following limitations:

A. Normal conditions (logistic airlift), ½ total tank capacity.

B. As an exception, under necessary mobility or contingency conditions (tactical airlift, real contingency situations, etc.).

   1. Vehicles on the cargo cabin: ¾ tank total capacity.

   2. Vehicles with an axle resting on the aircraft ramp: ½ total tank capacity.

      NOTE: Vehicles or equipment carried on the aircraft ramp will be positioned so the tank-filling spout is toward the higher end of the ramp when it is closed.

4.18.3 Ground support equipment (GPUs, generators, hydraulic mules, etc.)

A. Normal conditions: drained, purged, and vented. Diesel vehicles will be drained, but purging is not required.

B. Exception under necessary mobility or contingency conditions: ½ total tank capacity.

C. Fuel tanks mounted on single axle units that will be disconnected from their prime mover, with the tongue or center support resting directly on the cargo floor (including the aircraft ramp)

   1. Normal conditions: drained, purged, and vented.

   2. Mobility or contingency: purging is not required.

NOTE: Airlift of this type of vehicles with fuel in the tank, when the tongue or center support rests directly on the cargo floor, may cause the maximum tongue load on the center strip to be exceeded (see Figure 2-1). Shifting of the liquid in flight will uncontrollably transmit the weight of the fuel to the cargo floor center strip.

4.18.4 Tanker-type vehicles

Vehicles with a tank for carrying liquids will be airlifted with the liquid transport tank drained, purged, and vented, as required.

NOTE: Most tanker-type vehicles (self-propelled or trailer) are not designed and certified for airlift with liquid in the transport tank. Structural integrity of these vehicles is not guaranteed under the G forces experienced in flight. In addition, partially filling the tank would cause balance and aircraft control problems due to shifting of the liquid in flight.

4.18.5 Fuel cans

Cans for carrying additional fuel, airlifted along with the vehicles, will be of an airlift-approved type and will be filled up to 2.5 cm (1 in.) below the lowest filling neck threads.

4.18.6 Aircraft engines

Aircraft engines will be airlifted drained as much as possible, and all ducts shall be capped. Aircraft engines shall be prepared for airlift in accordance with procedures shown in their specific documentation.

4.18.7 Aircraft fuel tanks

Aircraft fuel tanks will be airlifted drained, purged, and vented, or with their preserving liquid inside, according to airlift preparation procedures shown in their specific documentation.

4.18.8 Fuel spillage

Should fuel spillage happen in the aircraft during loading, following actions shall be taken:

A. Restrict the use of electric equipment to the minimum. Do not turn lights or equipment on or off, since both actions may cause sparks.

B. Vent the aircraft by opening immediately all doors, side hatch, and windows in the flight station.

C. Wipe spilled fuel with absorbing material. Take out of the aircraft and dispose of materials used for wiping fuel as soon as possible.

NOTE: If spillage occurs in flight, besides of restricting the use of electric equipment and wiping as much spilled fuel as possible, perform the smoke and fumes elimination emergency procedure, as directed by the aircraft's commander (refer to Aircraft Operations Manual).

4.19 VISUAL SIGNALS

Guiding the driver by means of previously-agreed hand or light signals is a prime requisite in approaching auxiliary loading vehicles to the aircraft, or while loading wheeled cargo items. Turns must be made in the direction of the extended hand or light. It is the responsibility of the guide to signify, by extended arm or light, the direction the vehicle driver is to turn. It is the responsibility of the driver to follow exactly the guide's commands. Figure 4-38 shows an example of signals or visual indications to be used during vehicle guidance.

CAUTION: SINCE THE GUIDE IS NORMALLY FACING THE DRIVER, THE PERSON DIRECTING THE OPERATION SHALL EXERCISE CARE NOT TO MAKE THE DRIVER CONFUSED WHEN RENDERING TURN-LEFT OR TURN-RIGHT SIGNALS. WHETHER THE VEHICLE IS BACKING OR MOVING FORWARD, THE DRIVER MUST ALWAYS TURN THE STEERING IN THE DIRECTION OF THE GUIDE'S EXTENDED HAND OR LIGHT.

The loadmaster is responsible for directing or designing the person who will direct the operation. If the dimensions of the vehicle dictate, safety observers will be stationed at strategic points to keep the guide informed about clearances, critical points, and any other factors throughout the operation. The vehicle driver will follow only the guide's indications.

4.20 LOADING PROCEDURES WITH AUXILIARY VEHICLES

Loading of pallets and wheeled items presenting problems of contact with the ramp crest or the cargo cabin overhead is normally accomplished from an auxiliary loading vehicle, with the ramp in the horizontal position. The load is put inside the aircraft by pushing or winching. Extreme care must be taken to avoid striking the aircraft during vehicle approach, and final height adjustments to level the auxiliary vehicle bed and the aircraft ramp, for which a chock should always be placed as a safety stop between the vehicle wheels and the aircraft.

At the time of transferring the load to the aircraft, the bed of the vehicle from which it is to be onloaded must be slightly higher than the aircraft ramp crest. A difference of approximately 5 cm (2 in.) is acceptable, but if the difference in height is greater, adjustments must be made to reduce the difference between the vehicle bed and the cargo cabin floor. If the difference between the ramp and the vehicle bed height is greater than 5 cm (2 in.), compensating adjustments must be made by raising or lowering the aircraft ramp, or by raising or lowering the vehicle bed.

WARNING: DO NOT EXCEED RATED LIFTING CAPACITY OF THE VEHICLE. PLACING BALLAST ON THE REAR END OF THE VEHICLE TO COUNTERACT THE TIPPING-OVER TENDENCY IS ABSOLUTELY FORBIDDEN.

When loading from a truck, cargo loader, forklift, or any other auxiliary loading equipment, open the ramp and cargo door and perform the following steps.

CAUTION: KEEP THE MAIN GEAR CHOCKS IN PLACE, SLIGHTLY AWAY FROM THE WHEELS, UNTIL COMPLETING THE LOADING OPERATION. DO NOT CHOCK THE NOSE WHEELS.

A. Install the fuselage support legs, as indicated in paragraph 3.10 and, if required, the auxiliary loading ramps, as indicated in paragraph 3.9, as applicable (see paragraph 4.15.1 and paragraph 4.15.2).

B. Place chocks on the ground, between the ramp and the auxiliary loading vehicle, far enough of the ramp to prevent the vehicle from backing into the aircraft for the event of brake failure, or driver's loss of steering control.

C. If the auxiliary loading ramps are going to be used with the ramp in the horizontal position, raise the aircraft ramp far enough so that the auxiliary loading ramps do not contact the rear end of the vehicle from which the load will be inserted.

D. Using extreme caution, direct the driver to approach slowly the vehicle to the aircraft ramp, and align the center of the load with the cargo cabin centerline.

E. Direct the driver to keep the brakes set, and chock the vehicle to prevent it from moving and striking the aircraft.

CAUTION: IF A FORKLIFT IS BEING USED, USE EXTREME CARE TO AVOID STRIKING THE CARGO DOOR WITH THE MAST DURING HEIGHT ADJUSTMENTS.

F. Adjust the height of the vehicle bed so it is slightly higher than the aircraft ramp.

CAUTION: ENSURE THE AFT OF THE AIRCRAFT IS FIRMLY SUPPORTED. IF THE TOP OF THE VEHICLE IS VERY CLOSE TO THE CARGO DOOR AFTER FINAL HEIGHT ADJUSTMENTS, AND THE AFT OF THE AIRCRAFT IS NOT PROPERLY SUPPORTED, THE CARGO DOOR MAY CONTACT THE TOP OF THE VEHICLE WHEN CARGO WEIGHT IS PLACED ON THE RAMP, DUE TO FUSELAGE ROCKING.

G. If required, lower the ramp until the auxiliary ramps rest on the loading vehicle. The auxiliary ramps must overlap the loading vehicle at least 10 cm (4 in.).

H. Transfer the cargo to the aircraft, and position and secured it in the desired locations.

WARNING: WHEN TRANSFERRING VEHICLES TO THE CARGO CABIN, ALL PERSONNEL MUST KEEP AFT OF THE ITEM BEING LOADED AT ALL TIMES, NEVER FORWARD OR ALONGSIDE. ALWAYS INSERT THE LOAD BY PUSHING ON THE ITEM, BECAUSE PERSONNEL MIGHT TRIP ONTO THE ROLLERS, AND BE RUNNED OVER BY THE LOAD. IF AT ANY TIME THE LOAD IS REQUIRED TO BE PULLED, USE EXTREME CAUTION.

I. If the auxiliary loading ramps have been used, raise the ramp slightly so the vehicle can be driven away.

J. Remove chocks and drive the vehicle away.

K. Detach and stow the auxiliary loading ramps.

4.21 GENERAL VEHICLE LOADING PROCEDURES

If dimensions permit, vehicles or wheeled loads can be loaded into the aircraft up the inclined ramp, either self-propelled or winched. Loading of vehicles may become a very hard task if they allow very little clearance inside the aircraft. Before actually beginning the loading operation, vehicle dimensions should be checked for any possible ramp crest contact or projection problems. Whenever possible, vehicles should be backed into the aircraft so they may be driven forward for offloading and to facilitate jettisoning if such action becomes necessary.

Vehicles must be aligned with the auxiliary loading ramps, and lateral separation between the ramps must be adjusted to the proper vehicle axle width. Vehicles to be driven into the aircraft will have the transmission set in the lowest gear, and the transfer case of auxiliary transmission in low range, if they have that feature, so this will allow a better steering control and smoother starts and stops. If vehicle axle width is close to that available in the cargo cabin within the CHADS rails (218 cm, 85 in., see Figure 2-4), it is preferable to use the aircraft winch, since very little room will be available for steering adjustments.

During vehicle loading, observers must be stationed to keep watch on critical points and clearances to the aircraft structure. Before starting the operation, maneuvers to perform and visual signals must be agreed with the driver and safety observers. The driver must obey the guide's instructions only, and must not make steering adjustments by himself.

CAUTION: LOADING AND OFFLOADING OF VEHICLES MUST BE ACCOMPLISHED AT A MODERATE SPEED.

CAUTION: DO NOT DEFLATE VEHICLE TIRES IN ANY CASE. REDUCTION AT RANDOM OF NOMINAL PRESSURE DECREASES TIRE INTERNAL CONSISTENCY. DURING FLIGHT THROUGH TURBULENCE, TIRE DEFLATION MAY CAUSE THE TIRE SEAL TO BREAK, ALLOWING THE RIM TO CONTACT THE CARGO FLOOR. DURING LOADING/OFFLOADING, VEHICLES WITH DEFLATED TIRES MAY NOT TRACK STRAIGHT, THUS PERMITTING THE VEHICLE TO STRIKE THE AIRCRAFT, ESPECIALLY IF DIMENSIONS ARE VERY TIGHT.

NOTE: Internal pressure in pneumatic tires may be set to lower if a specific internal pressure for airlift has been established and properly certified, according to vehicle characteristics. Airlift internal tire pressure must guarantee that contact and steering control problems mentioned above are not encountered.

4.21.1 Weight and CG

The unit using the vehicle is responsible for determining the weights on the wheels and per axle by actually weighing the vehicle, as well as for computing and marking its CG (see paragraph 4.9). Weights shown in the vehicle manual shall not be used. If the vehicle is to carry a load when it is in the aircraft, weighing must be performed with its load inside. In all cases, actual vehicle gross weight must be known. Wheel and axle weights, as well as contact pressures must be within allowable limits of the cargo floor.

CAUTION: TANDEM AXLES LESS THAN 90 CM (35 IN.) APART WILL BE CONSIDERED AS A SINGLE AXLE REGARDING FLOOR LOADING CAPACITIES AND CG COMPUTATIONS, SO REFERENCE DISTANCE WILL BE MEASURED FROM THE TANDEM AXLE PIVOT POINT, AND WEIGHT WILL BE THE SUM OF BOTH AXLE WEIGHTS.

4.21.2 Loads on or inside the vehicle

As a general rule, the maximum weight of the load to be carried on or inside a vehicle in the aircraft is 1/3 the weight indicated in its manual as maximum payload weight. Off-road vehicles may be airlifted with their maximum cross-country load weight. Loads placed on or inside the vehicle must be tied down to the vehicle to meet the same restraint criteria as for cargo to the aircraft.

4.21.3 Wheeled cargo in turbulence

When vehicles are airlifted through turbulence, or sharp changes in direction, speed or altitude are experienced, wheeled cargo is subjected to forces that may allow pneumatic tires and suspension system to compress, thus slackening tension on tiedowns. The spring-like effect caused by the recovery of the suspension system, pneumatic tires, and tiedown in subsequent movements, acting simultaneously at the same time in the same direction, may result in abnormal loads imposed on tiedown rings, devices, and cargo attachment points, or cause the vehicle to strike the aircraft structure. When flight through turbulence is expected, sleeper shoring must be used between the floor of the aircraft and the vehicle chassis or suspension (see Figure 4-21), especially when airlifting heavy vehicles. Sleeper shoring will be placed as flush as practical with the chassis, and secured to prevent movement.

WARNING: WHEN SECURING WHEELED CARGO, TIEDOWN DEVICES HAVING AN OPERABLE SAFETY CLIP ON BOTH SIDES SHALL BE USED.

CAUTION: IF VEHICLE WEIGHT RESTS COMPLETELY ON THE SLEEPER SHORING, COMPUTE CONTACT PRESSURE AND COMPARE TO BULK OR PALLETIZED CARGO FLOOR CAPABILITIES (SEE FIGURE 2-1).

4.21.4 General procedures

Before starting the loading operation, check vehicle dimensions to determine if there may be ramp crest contact or projection problems (see paragraph 4.6). Some vehicles may be reduced in height by removing components, such as cover bows, antennas, etc. Removing bumpers may reduce vehicle length. However, width can seldom be reduced.

WARNING: WHEN LOADING SELF-PROPELLED VEHICLES, ENSURE PROPER VENTILATION OF THE CARGO CABIN IS ACHIEVED BY OPENING THE CREW DOOR, SIDE ESCAPE HATCH, AND FLIGHT STATION WINDOWS. PROLONGED EXPOSURE TO CARBON MONOXIDE FUMES MAY BE PROVEN FATAL.

CAUTION: BRAKES ON ALL VEHICLES MUST BE CHECKED FOR PROPER OPERATION PRIOR TO DRIVING INTO THE AIRCRAFT.

A. Determine whether the use of approach and/or rolling shoring is necessary, or loading with the ramp in the horizontal position with the auxiliary loading ramps is required.

   CAUTION: PRIOR TO LOADING VEHICLES, ENSURE THE CHASSIS HEIGHT AND WHEEL WIDTH DOES NOT PERMIT CONTACT WITH THE INTERMEDIATE ROLLER TRAYS. REMOVE ROLLER TRAYS AS REQUIRED.

B. Check gross weight, axle weights, tire pressure, and contact pressure.

C. Ensure any load carried over or inside the vehicles is properly restrained.

D. Check that fuel levels in tanks are within the limits specified in paragraph 4.18.

E. Close both paratroop doors and fold door handles. Ensure all seats in the path of the vehicle are secured in the upright position, and if required, remove static line anchor cables.

F. Drive the vehicle into the aircraft, take it to its preplanned position, and install initial restraint.

WARNING: ONCE THE VEHICLE IS POSITIONED IN THE AIRCRAFT, THE DRIVER WILL REMAIN AT THE CONTROLS UNTIL, AT LEAST, A PAIR OF TIEDOWNS FORWARD AND AFT HAVE BEEN INSTALLED.

G. Direct the driver to cut off engine and set the parking brake.

WARNING: DIESEL AND MULTI-FUEL VEHICLES WITH AUTOMATIC TRANSMISSION WILL BE AIRLIFTED WITH GEAR IN PARK, AND THOSE WITH MANUAL TRANSMISSION IN NEUTRAL. GASOLINE-POWERED VEHICLES WITH AUTOMATIC TRANSMISSION WILL BE AIRLIFTED WITH THE GEAR LEVER IN PARK, AND THOSE WITH MANUAL TRANSMISSION IN THE LOWEST GEAR.

H. Complete vehicle restraint.

4.22 GENERAL WINCHING PROCEDURES

The cargo winch is used for loading in the aircraft cargo units, usually wheeled, that are too large or too heavy to be loaded by other means. Winching is a suitable method for loading trailers, aircraft engines on shipping dollies, auxiliary equipment, etc. Loading is possible by using any of the following methods: internal winching using the aircraft electric winch, external winching using a vehicle-mounted winch outside the aircraft, and vehicle self-winching.

WARNING: ANY PERSON HANDLING A WINCH CABLE MUST WEAR GLOVES AND EYE PROTECTION TO PREVENT INJURY FROM BROKEN CABLE STRANDS AND WIRES. KEEP THE BODY OUT OF THE PATH OF THE CABLE FROM THE WINCH TO THE CARGO ITEM WHEN THE WINCH IS TURNED ON.

Before starting the winching operation, complete the prior to loading and general winching preparation checklists. All necessary auxiliary equipment should be ready, as well as shoring required for any of the vehicles. If the load includes more than one vehicle, the height of the ramp may need to be readjusted, and the auxiliary loading ramps may need to be laterally repositioned for each vehicle axle width. Aircraft electrical power will be connected when using the aircraft cargo winch. The winch cable shall be connected to the load by means of a bridle rigged with MB-1, 10000 lb chains, attached to two substantial-enough points, symmetrical with respect to the load longitudinal axis. Figure 4-39 shows how to rig the chain bridle and the cable winch attachment. Winching cable clearances can be checked by drawing-up slack after the hook has been attached to the load.

Before actually beginning the operation, the loadmaster will brief the loading crew about all factors involved. Vehicle winching must be closely coordinated by a loading crew of at least three people: a winch operator and two guides to judge clearances and to make all the necessary steering control adjustments. The winch operator must be in contact with the loading team through prearranged signals, and/or the aircraft interphone system. During winching operations, clearances between the winch cable, the vehicle, and/or the aircraft structure must be closely watched to prevent jamming of the cable. Once the vehicle is on the aircraft, wheel chocks will be used to prevent it from rolling beyond of control while initial restraint is being installed.

WARNING: THE USE OF WHEEL CHOCKS WHILE THE VEHICLE IS ON THE INCLINED AIRCRAFT RAMP IS FORBIDDEN. SHOULD THE LOADING OPERATION NEED TO BE STOPPED WHEN THE WHOLE OR PART OF THE VEHICLE IS ON THE RAMP, TEMPORARILY SECURE THE VEHICLE BY MEANS OF TIEDOWN DEVICES.

CAUTION: IF THE WHEELED LOAD HAS A HEIGHT ADJUSTING SYSTEM TO PREVENT CONTACT WITH CRITICAL POINTS, ONLY QUALIFIED PERSONNEL FOR OPERATING THE EQUIPMENT WILL HANDLE THESE SYSTEMS.

NOTE: When winching heavy cargo items into the aircraft, it may be needed to chock the aircraft main gear wheels tight, or to set the parking brake. Only qualified personnel are cleared for operating the aircraft parking brake.

If the wheeled load consists of a trailer vehicle (guns, auxiliary equipment, etc.), it will be necessary to make adjustments on the steering to keep the vehicle centered. In these instances, a steering control yoke will be improvised from tiedown devices. Steering adjustments will be then made by pulling from one side of the yoke while loosening on the other. By winching very slowly there will be enough time to accomplish any required adjustment.

WARNING: THE STEERING CONTROL DEVICE SHALL ALWAYS BE POSITIONED AFT, SO PERSONNEL STEERING ARE NOT ENDANGERED BY BREAKAGE OF THE WINCH CABLE, OR SUDDEN WINCH FAILURE. AT NO TIME PERSONNEL WILL BE IN THE PATH OF THE LOAD, BETWEEN THE CARGO ATTACHING POINT OF THE CABLE AND THE WINCH, OR DIRECTLY AFT OF THE ITEM BEING LOADED.

CAUTION: IF A SELF-PROPELLED VEHICLE IS TO BE WINCHED, THE DRIVER SHALL BE WARNED NOT OPERATE THE BRAKES UNTIL DIRECTED.

When heavy pallets or airdrop platforms are to be loaded into the aircraft, the cargo winch may be used for loading over the ramp in the horizontal position. For attachment of the winch cable, a chain bridle will be installed using two pallet side tiedown rings (see Figure 4-40). Using a single attaching point may cause the winch cable to break if the pallet/platform becomes misaligned and jams in the CHADS rails while it is being transferred to the aircraft ramp.

WARNING: USE EXTREME CAUTION WHEN WINCHING AIRDROP PLATFORMS (HE OR LAPE). ONCE THE PLATFORM IS IN THE AIRCRAFT, CHECK IT ROLLS BACK AND FORTH SMOOTHLY WITHOUT WINCH ASSISTANCE.

Offload of pallets or wheeled cargo across the ramp in the horizontal position will be accomplished by pushing it onto the auxiliary offloading vehicle. Aircraft winch will only be used for offloading down the inclined ramp. However, when the winch was used for onloading with the ramp in the horizontal position, it is advisable to have the aircraft winch ready in case the load becomes misaligned during offload, and it is required to retrieve it back into the cargo cabin for proper alignment.

4.22.1 Loading with the aircraft cargo winch (internal winching)

WARNING: INSPECT THE AIRCRAFT WINCH IN ACCORDANCE WITH PARAGRAPH 3.8.2 BEFORE USING IT FOR LOADING OPERATIONS.

WARNING: DO NOT IMPOSE A LOAD HIGHER THAN 1000 KG (2200 LB) ON THE AIRCRAFT CARGO WINCH IN STRAIGHT PULL. REFER TO PARAGRAPH 4.22.6 AND TABLE 4-4 TO DETERMINE IF A CARGO ITEM IS WITHIN WINCH CAPABILITIES.

CAUTION: DO NOT ALLOW THE CABLE TO DRAG ON THE CARGO RAMP, THE GROUND, OR ANY OTHER SURFACE THAT CAN CONTAMINATE OR DAMAGE THE CABLE.

A. Open the cover of the winch compartment on the cargo floor (STA 5644), and deploy the pulley assembly to its operation position.

B. Remove the hook and the cable from their stowage position and route the cable through the pulley. Close the cover.

NOTE: It is necessary to retract the pins of the pulley assembly keeper to position the cable through the pulley.

C. Connect the control pendant to the appropriate winch socket (see paragraph 2.19.5.4 and Figure 2-38).

D. Supply electrical power to the aircraft.

E. Energize the winch system by pressing the WINCH pushbutton on the ATTENDANT CONTROL unit at FR10.

NOTE: Make sure the CARGO WINCH circuit breaker, located on the L MISCELLANEOUS circuit breaker panel in the flight deck, is closed (see Figure 3-15).

F. Deflect the thumbwheel down toward the OUT position on the control pendant to reel out the cable to the load attaching point.

NOTE: While reeling out the cable, one person should maintain slight tension on the cable.

G. Adjust the position of the winch cable stop, as required.

H. Attach the hook to the cargo, as appropriate (see Figure 4-39).

I. Deflect the thumbwheel up toward the IN direction on the control pendant to remove slack from the cable. Check routing of the cable from the winch to the load attaching point.

CAUTION: IF WINCHING IS TO BE ACCOMPLISHED UP THE SLOPED RAMP, USE A PIECE OF WOOD UNDER THE CABLE TO PREVENT IT FROM DRAGGING ON THE RAMP CREST.

J. Deflect the thumbwheel up toward the IN direction on the pendant to pull the load into the cargo cabin. Greater deflection of the thumbwheel will increase the speed at which the load moves forward.

CAUTION: DO NOT ALLOW THE LOAD TO MOVE AT AN EXCESSIVE SPEED.

NOTE: If it is required to stop the winching operation while any portion of the load is still on the sloped ramp, release the thumbwheel to allow it to return to the OFF position. The mechanical brake will then operate, and the load will stop and remain in the same position until the thumbwheel is moved again. Turn the thumbwheel in the desired direction to resume winching.

NOTE: If the overtemperature warning light comes on during winching, finish the operation in course, and let the winch cool down for a few minutes.

K. When the cargo item is on the desired position in the cargo cabin, release the thumbwheel to allow it to return to the OFF position.

WARNING: IF AN IMMEDIATE STOP IS REQUIRED AND THE WINCH DOES NOT STOP WHEN THE THUMBWHEEL IS RELEASED, PRESS THE EMERGENCY STOP PUSHBUTTON ON THE PENDANT.

L. Repeat the operation for the remaining cargo items, as required.

4.22.2 External winching

When the aircraft winch is not operational, or for loads that exceed its capabilities, a winch mounted on a stationary vehicle outside the aircraft can be used for external winching (see Figure 4-41). Before starting the operation, pulling capabilities of the external winch must be checked to ensure it is suitable for the cargo item to be loaded. Operational checks must be accomplished, and winch cable condition as well. Snatch blocks used for transmitting the winch pull must be of the proper size to accommodate the winch cable according to its diameter.

4.22.3 Self-winching

A vehicle equipped with a winch may be loaded into the aircraft by using pull supplied by its own winch. For cable attachment, install a bridle with chains passing through two symmetrical tiedown rings on the CHADS rails, as shown in Figure 4-41. Snatch blocks must be of the proper size to accommodate the winch cable according to its diameter.

4.22.4 Winch cables

During initial checks of the aircraft winch, cable condition must be inspected in its overall length. No broken wires or kinks are allowed in the winch cable.

4.22.5 Pulley support keeper

During initial checks of the aircraft winch, keeper pins of the pulley assembly must be inspected. No more than 1 mm of wear is allowed in the pins.

4.22.6 Loading capabilities depending on ramp slope

(See Table 4-4)

Although the winch capacity in straight pull is 1000 kg, final cargo load will depend on its weight, aircraft ramp slope, and the friction coefficient applicable to the cargo item, based on its resting/rolling support. Table 4-4 shows friction coefficients and maximum winch pull for the different resting support types, according to ramp slope. Friction coefficients, all of them for wheeled or palletized cargo on rollers and less than one, increase the amount of weight that the winch can pull, while ramp slope decreases it. Figures given for the inclined ramp include the combined effect of these two factors.

A. To determine if a cargo item can be loaded into the aircraft using the winch with the ramp in the horizontal position, multiply the weight of the item, in kilograms, times the friction coefficient related to its rolling support. If the result is less than 1000, the item is within the aircraft winch capabilities.

B. When the cargo item is to be loaded up the inclined ramp, determine ramp slope by measuring the cargo floor height at ramp crest (see Figure 4-2). Compare measured height with those depicted in Table 4-4, and determine equivalent slope.

NOTE: If approach shoring is being used, subtract shoring thickness from measured height to determine slope. If measured height does not match any of the slopes in Table 4-4, use figures for the immediately higher angle shown.

RAMP CREST HEIGHT (CM)	115	120	125	130	136	140
RAMP SLOPE (DEGREES)	15º	16º	17º	18º	19º	20º
NOTE: Ramp slope values are round-off to the nearest value in degrees.						

ROLLING SUPPORT	FRICTION COEFFICIENT (FOR RAMP IN HORIZONTAL POSITION)	MAXIMUM WINCH CAPACITY (KG) IAW RAMP SLOPE					
		15º	16º	17º	18º	19º	20º
SOLID TIRES (HARD RUBBER OR METALLIC)	0.018	3620	3414	3230	3066	2919	2786
ROLLER CONVEYORS	0.020	3595	3391	3210	3048	2903	2772
PNEUMATIC TIRES	0.030	3475	3284	3115	2963	2825	2701

Table 4-4 Ramp slope and aircraft winch capabilities

4.23 GENERAL PALLETIZED CARGO LOADING PROCEDURES

NOTE: Capabilities, limitations, guidelines, and procedures for palletized cargo included in the following paragraphs refer only to airlift of pallets in the C-295.

The best method for the airlift of not-wheeled cargo in the C-295 is the use of sliding platforms (pallets). The use of HCU-6/E pallets allows preparing and restraining the load in advance, so reducing the time required for loading and offloading. When airlifting troops or passengers, preparing and securing baggage on a pallet in advance allow personnel to board the aircraft through the inclined ramp, and then the baggage pallet can be placed on the ramp as the last item to be loaded. The AM109 CHADS rails, along with the intermediate roller conveyor trays, permits introducing pallets until their final location for flight, meeting required restraint in all directions by locking them with the system detent locks.

4.23.1 HCU-6/E pallet

(See Figure 4-42)

The HCU-6/E is the unit of measure of the 463L cargo handling system. This pallet is constructed with two rust-proof aluminum plates sandwiched around a balsa wood core. The outer perimeter is framed by an indented hardened-aluminum lip, with notches every 25 cm (10 in.) for locking and restraining the pallet into the CHADS. In addition, the lip provides 22 tiedown rings for securing the cargo nets and attaching tiedown devices.

Dimensions and features of the HCU-6/E pallet are as follows:

- Outer dimensions: 2.74 m x 2.23 m (108 x 88 in.).
- Thickness: 5.7 cm (2.25 in.).
- Usable dimensions: 2.64 m x 2.12 m (104 x 84 in.).
- Allowable concentrated load: 17.6 kg/cm² (250 PSI).
- Empty-pallet weight: 132 kg (290 lb).
- Tiedown rings: 22, 7500 lb rated tiedown strength each.
- Locking indents: 40.

CAUTION: THE PALLET ITSELF SHALL NEVER BE USED AS SHORING, CONSTRUCTION WITHIN THE PALLET DOES NOT PROVIDE A LOAD SPREADING EFFECT.

4.23.2 HCU-6/E pallet capacities

For the C-295, maximum allowable cargo dimensions on a pallet are:

- Length: 2.64 m (104 in.).
- Width: 2.13 m (84 in.).
- Height within the cargo cabin (from pallet top surface): 1.62 m (64 in.).
- Height within the ramp area (from pallet top surface): 139 cm at the forward end, 71 cm at the aft end. Refer to Figure 4-43 to determine maximum allowable height for intermediate positions.

WARNING: WHEN DISTRIBUTING CARGO ON PALLETS, LIMITATIONS ESTABLISHED ON APPLICABLE REGULATIONS, REGARDING SAFETY AISLES, UNOBSTRUCTED EMERGENCY EXITS, AND SAFETY MARGINS MUST BE OBSERVED. THE AIRCREW MUST HAVE ACCESS TO THE AFT OF THE AIRCRAFT IN ALL CASES.

The C-295 can accommodate four HCU-6/E pallets within the cargo cabin, plus one on the ramp. Maximum gross weight for each of the pallets in the cargo cabin is 2640 kg (5808 lb), including the weight of the pallet, cargo nets, and all installed tiedown devices. Maximum gross weight for the ramp pallet is 1000 kg (2200 lb). For each particular mission, maximum combined weight and pallet distribution will depend on maximum takeoff weight (MTOW) and aircraft balance.

Figure 4-44 depicts individual centroids for a complete load of pallets locked into the AM109 CHADS. There is a 25.4 cm (10 in.) clearance for shifting the complete set of pallets forward or aft. Space between two consecutively locked pallets is 2 in. (5 cm approximately). When less than a complete load is airlifted, individual pallets may be locked every 25.4 cm (10 in.). Centroid position for the ramp pallet is fixed.

If cargo dimensions require, pallets may be joined together by means of pallet couplers. The use of couplers allows locking married pallets into the CHADS, as the 2 in. gap between consecutive pallets is maintained. In this case, individual pallet weight must be computed from combined weight for observing allowable cargo floor capacities and limitations.

4.23.3 Cargo nets

Cargo nets may be used for securing cargo to the pallets. Two green, side nets HCU-7/E are installed around the sides of the pallet, and a yellow, top net HCU-15/C is installed across the top. When properly secured, the set provides all necessary restraint for palletized cargo weighing up to 2640 kg (5808 lb). These three nets weigh 29.5 kg (65 lb). Procedures for attaching cargo nets to 463L pallets are as follows:

A. Spread two green side nets (HCU-7/E) around the pallet. Beginning at any corner, fasten consecutively attaching hooks of one of the nets to D-rings around the pallet, so that the last net attaching hook matches the last pallet D-ring at the corner opposite diagonally to the beginning corner.

B. Repeat the operation with the second side net, beginning on the side having the opposite type fastening devices to the first installed net.

C. Raise and pull both nets tight as high as possible, and attach each hook at the end of the net to each of the metallic rings on the beginning end of the other net. When all hooks have been fastened, tighten them evenly to get a compact block.

D. Fold and secure net webbing excess towards the load. Do not allow loose net webbing to remain outside the load.

E. Throw yellow top net (HCU-15C) over the load, and connect each fastening device to a side net ring, as low as possible. Tighten evenly all webbing.

WARNING: HOOK FASTENING DEVICES SHALL NEVER BE CONNECTED DIRECTLY TO SIDE NET WEBBING OR TO THE BOTTOM ROW OF SIDE NET RINGS.

F. When the cargo profile is so low that the top net cannot be tightened, install seven CGU-1/B as alternate vertical restraint, attached to side net metallic rings as high as possible, so that at least three straps are installed longitudinally. All straps should be interlaced so that all cargo is vertically restrained.

G. When loading small packages or baggage on a pallet, and/or the load is so low that side nets cannot be installed, the top net may be used provided the following conditions are met:

   1. Top net bottom bellyband shall be positioned no less than 20 cm (8 in.) above the pallet top surface.

   2. Cargo weight shall not exceed 757 kg (1666 lb).

   3. If the load weighs more than 757 kg (1666 lb), additional CGU-1/B straps shall be installed to meet all required restraint.

   4. All top net hooks will be fastened to pallet D-rings.

CAUTION: DO NOT USE NETS WITH HOOKS OR FASTENING DEVICES MISSING, OR HAVING DAMAGED OR BROKEN WEBBING.

4.23.4 Placing cargo on pallets

CAUTION: WHEN PALLETIZING CARGO, DO NOT EXCEED LOAD PER ROLLER STATION LIMITATIONS SHOWN IN FIGURE 2-1.

A. Cargo will be distributed so the pallet CG falls within the limits shown in Figure 4-45.

B. Heavier loads or cargo packed in rigid containers will be placed on the pallet base. Lighter loads or cargo packed in crushable containers will be placed on top of the load.

C. Small wheeled loads (hydraulic jacks, oil carts, compressors, etc.) will be individually secured to the pallet with straps or MB-1 chains before installing cargo nets.

D. Cargo will be placed within the vertical stacking lines of the usable surface boundaries, so it does not protrude from the pallet side edges.

E. For airlifting stacked empty pallets, place at least three longitudinal rows of lumber to separate the stacked pallets from the pallet serving as the base support.

4.23.5 Precautions for palletized cargo

Observe the following precautions when loading palletized cargo:

A. Pallets must be clean of grease, mud, etc.

B. Do not accept bowed pallets, or those having broken panels, missing or broken D-rings, or deteriorated balsa wood core. Check condition of indents on both sides of the pallet to allow correct engagement of CHADS detent locks.

C. Restraint of oversized loads or cargo placed on married pallets will be accomplished by means of tiedown devices. Using restraint harnesses (see Figure 4-36) is an acceptable method for achieving all required restraint with palletized loads.

   WARNING: CHECK RESTRAINT INSTALLED ON PALLETS THAT HAVE BEEN PREVIOUSLY AIRLIFTED IN AIRCRAFT HAVING A 274 CM (108 IN.) WIDE DUAL RAIL SYSTEM. APPLY ADDITIONAL TIEDOWNS TO ACHIEVE REQUIRED FORWARD RESTRAINT.

D. Auxiliary loading equipment suitable for handling HCU-6/E pallets consists of cargo loaders and forklifts with rollerized tines, compatible with the 463L cargo handling system or, if these are not available, any other piece of equipment having a loading bed equipped with rollers, and adjustable in height to that of the C-295 ramp in the horizontal position.

   WARNING: DO NOT ATTEMPT TO LOAD PALLETS/PLATFORMS WHOSE WEIGHT OR DIMENSIONS EXCEED THE RATED CAPACITIES OF THE FORKLIFT/CARGO LOADER BEING USED. OVERLOAD MAY CAUSE THE VEHICLE TO FAIL, CAUSING INJURY TO PERSONNEL AND/OR DAMAGE TO THE AIRCRAFT.

E. When transferring pallets or platforms to the cargo cabin, all personnel must keep aft of the item being loaded at all times, never forward or alongside.

F. Always transfer the pallet by pushing on it, because personnel might trip onto the roller trays, and be runned over by the pallet. If at any time the pallet is required to be pulled, use extreme caution.

G. For winching pallets or platforms into the cargo cabin, follow procedures depicted in paragraph 4.22.

4.24 LOADING AND OFFLOADING WITH THE AM109 CHADS

The following procedures must be accomplished for loading the pallets/airdrop platforms into the aircraft, whether the cargo is to be airdropped or airlifted to a terminal point.

NOTE: These procedures mainly cover the sequence for handling the AM109 system controls. For step-by-step procedures for loading palletized cargo, refer to the amplified checklist at the end of this chapter.

4.24.1 General

Before actually starting the loading operation, perform the following preliminary steps:

A. Check that all CHADS components (roller-trays, siderails, etc.) are properly installed.

B. Make sure that the system works properly by performing an operational checkout.

C. Perform cargo load planning to satisfy all center of gravity requirements and floor load limits, as specified in this chapter.

D. Ensure the cargo floor is clear of obstructions for the loading operation.

   NOTE: Depending on the height and width of the load, close both paratroop doors and fold in door handles; ensure all seats in the path of the pallets are secured in the upright position; if required, remove static line anchor cables.

E. Check all ramp lock-flange assemblies are fully retracted on both sides.

F. Install at least two pallet stops forward of the preplanned position for the front end of the first pallet, to serve as a safety barrier forward during loading.

4.24.2 Loading pallets/platforms

Load pallets/airdrop platforms as follows:

A. Remove the safety pin from the logistics control box and move the control handle to the RELEASE position.

B. Move the airdrop control handle to the REL position.

C. Check detents on both sides are fully retracted.

D. Identify the position for each pallet/platform on the cargo cabin according to load planning previously performed.

E. Lock the logistics (left-hand side) detent latches as each pallet/platform is loaded and taken into position. To lock the logistics detent latches, proceed as follows:

   1. Move the left-hand side control handle to the FULL LOCK position.
   2. Move the left-hand side control handle to the position corresponding to the aft-most detent being used to restrain the just-loaded pallet.
   3. Insert the safety pin in the holes immediately forward of the position of the logistics control handle.

CAUTION: DO NOT FORCE THE CONTROL HANDLE IN ANY DIRECTION.

F. Visually inspect all left detents beside the loading pallet are fully engaged and visible in the indents.

G. Repeat preceding steps for the remaining pallets/platforms, as appropriate.

H. Move the left control handle to the FULL LOCK position and insert the safety pin.

I. Move the airdrop control handle to the LOCK position and insert the safety pin.

J. Visually inspect all right-hand detents beside the loading pallet are fully engaged and visible in the indents.

NOTE: If a right-hand or left-hand detent lock fails to engage the pallet/platform indent, a fore and aft movement of the pallet/platform may be required to engage the lock.

K. If palletized cargo is to be carried on the ramp, load the pallet onto the ramp. Match the pallet indents with the lock-flanges and manually engage all lock-flanges on both sides of the pallet.

NOTE: Ramp lock-flanges are individually engaged into the pallet indents from outside of the aircraft with the ramp open.

L. Move/install pallet buffer stops at the first available position forward of the front end of the forward-most pallet/platforms.

4.24.3 Offloading pallets/platforms

Offload pallets/airdrop platforms as follows:

A. Open the ramp and cargo door.

B. Direct the offloading vehicle into position.

C. If palletized cargo is on the ramp, release lock-flanges on both sides by moving release handles up and aft. Offload the pallet onto the offloading vehicle.

NOTE: All lock-flanges on each side are simultaneously unlocked by pulling on the corresponding release handle.

D. After the ramp pallet has been offloaded, move the airdrop control handle (right side) to the REL position to offload pallets in the cargo cabin.

E. On the logistics control box (left side), remove the safety pin and insert it into the appropriate position, aft of that matching the detent locks restraining forward pallets.

F. Move the logistics control handle forward to disengage the desired amount of detent locks.

WARNING: DO NOT RELEASE PALLET OR PLATFORM UNLESS SECURED TO PREVENT PALLET FROM ROLLING FREE IN AIRCRAFT.

G. Offload the pallet onto the offloading vehicle.

H. Repeat steps E through G to unload remaining pallets in the cargo cabin.

NOTE: If a new loading operation is not to be accomplished, move control handles on both siderail assemblies to the FULL LOCK and LOCK position. Stow safety pin on both sides.

4.25 LOAD PLANNING

Before starting any mission, it is necessary to determine the most suitable loading method and the distribution of all cargo items in the aircraft. For this, it is necessary to take into account not only the load distribution itself to achieve a good aircraft balance, but also factors such as available auxiliary loading equipment at origin and destination, stop-overs, mission schedule, possible emergencies, etc. A load plan can be as easy as mentally determining where to position the only pallet to be airlifted, or require precise calculations for a mission with several loads for different destinations, and with long lasting flight legs. Good load planning will save worktime, having a bearing on higher agility and safety throughout the mission.

Load distribution must be preplanned so that loaded aircraft gross weight and balance are within permissible limits during all flight phases, from takeoff until landing. The most common procedure for load distribution is placing heaviest items in the aircraft centre (STA 11600 to 11800), and placing afterwards lighter loads evenly forward and aft.

Load planning should include the following steps:

A. Ensure cargo is prepared for airlift according to appropriate directives.

B. Check if the load includes hazardous materials.

C. Classify all cargo items by categories (palletized, wheeled, etc.) at the time of establishing a loading sequence to avoid unnecessary cargo cabin configuration changes. If the load includes mixed palletized and wheeled cargo, or winching is required, removal of roller trays should be considered when determining the loading sequence.

D. Determine an optimum balance condition according to the mission profile.

E. In the event of heavy or bulky loads creating critical point problems, use the aircraft diagram or appropriate tables and graphics to determine in advance shoring requirements and the best loading method.

F. Select the most suitable loading method according to cargo nature and auxiliary loading equipment available at origin and destination.

G. Distribute the load considering in-flight jettisoning.

H. If required, evaluate different load arrangements and select the most appropriate.

I. To achieve the desired aircraft balance condition, it is very useful to perform numerical computations of load shifting effect, as shown in paragraph 4.10.

J. Determine the number, type, and arrangement of tiedown devices required to meet all restraint criteria.

4.26 AMPLIFIED LOADING/OFFLOADING CHECKLIST

The following amplified checklist summarizes information presented in preceding paragraphs, and provides a step-by-step guide for all loading and offloading operations.

NOTE: Refer to CHAPTER 7 - AIRDROP OF PERSONNEL AND EQUIPMENT for aircraft preparation for personnel and/or cargo airdrop.

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AMPLIFIED LOADING/OFFLOADING CHECKLIST

4.26.1 AM109 CHADS PREFLIGHT CHECKLIST

WARNING: A COMPLETE PREFLIGHT INSPECTION OF THE CHADS MUST BE ACCOMPLISHED PRIOR TO DEPARTURE FROM HOMEBASE. FAILURE TO PERFORM A COMPLETE OPERATIONAL CHECKOUT PRIOR TO USING IT COULD RESULT IN DAMAGE TO THE CARGO, AIRCRAFT, AND INJURY OR DEATH TO PERSONNEL.

NOTE: If any portion of this operational check fails, stop checking and notify Maintenance.

NOTE: These preflight checks are not required on local flights that do not require the use of the CHADS.

1. Airdrop (right hand) control handle..LOCK
   A. Remove the safety pin. Move the right control handle to REL position, and then to LOCK position.

      CAUTION: THE CONTROL HANDLE SHOULD MOVE SMOOTHLY FROM REL TO LOCK POSITION. IF RESISTANCE IS ENCOUNTERED, RETURN THE HANDLE TO THE APPROXIMATE VERTICAL POSITION AND THEN BACK TO LOCK. DO NOT ATTEMPT TO FORCE THE HANDLE TO THE LOCK POSITION.

2. Logistic (left hand) control handle ....FULL LOCK
   A. Remove the safety pin and move left control handle to the RELEASE position and then to the FULL LOCK position.
   B. Check the control handle latch pin is seated in the FULL LOCK detent.

      CAUTION: THE CONTROL HANDLE SHOULD MOVE SMOOTHLY FROM THE RELEASE TO THE FULL LOCK POSITION. DO NOT FORCE THE HANDLE IN ANY DIRECTION.

3. Airdrop (right hand) siderails and locks ....CHECKED
   A. Proceeding forward to aft, check the following on the right-hand side rails:
      1. Mounting bolts installed in each mounting hole in the assemblies and splice fittings are properly seated.
      2. Siderails aligned in a straight line.
      3. Each lock-detent body is fully extended. Lock cam in each lock is as shown in Figure 4-46.
      4. Detent-lock does not retract when manually pushed.

         CAUTION: DO NOT KICK THE DETENT LOCKS TO CHECK THAT THEY DO NOT RETRACT. FORCE EXERTED BY DOING SO MAY ALTER ADJUSTMENTS OF THE ASSEMBLY.

      5. No break link is installed in any of the airdrop lock boxes.

4. Logistic (left hand) siderails and locks..CHECKED

   A. Proceeding aft to forward, check the following on the left-hand side rails:

      1. Mounting bolts installed in each mounting hole in the assemblies and splice fittings are properly seated.

      2. Siderails aligned in a straight line.

      3. Each lock-detent body is fully extended, alignment marks on lock-cam match for each lock number as shown in Figure 4-47.

      4. Detent does not retract when manually pushed.

         CAUTION: DO NOT KICK THE DETENT LOCKS TO CHECK THEY DO NOT RETRACT. FORCE EXERTED BY DOING SO MAY ALTER ADJUSTMENTS OF THE ASSEMBLY.

5. Airdrop (right hand) control handle...REL

   A. Check control handle latch pin engages the detent of the selected position.

   B. Proceeding forward to aft, check all right-hand locks are fully retracted and do not protrude out from the siderail assemblies.

6. Airdrop (right hand) control handle...LOCK, THEN AD

   A. Move the right control handle to LOCK and then to AD position.

   B. Check all right-hand locks release and retract simultaneously.

7. Logistic (left hand) control handle and locks.............. CHECKED FOR OPERATION

   A. Starting from the FULL LOCK position, move the Logistics control handle through all marked positions, and visually check each lock retracts in the appropriate position.

      NOTE: The marked positions designate which locks should be released when the control handle latch pin is seated in the detent associated with the chosen marked position. All locks not designated for release at a particular position must remain locked.

   B. At each selected position, check each lock cam and verify the configuration is as shown in Figure 4-47.

      NOTE: As detents are sequentially retracted, the last detent remaining locked must have the lock cam aligned with the last reference mark. This guarantees that the last detent locked in each of the selected positions on the left control handle is sufficiently supported by the lock cam, thereby providing maximum restraint.

   C. Momentarily stow logistic control handle at RELEASE position.

   D. Move the control handle to the FULL LOCK position. Check all locks engage.

8. Logistic (left hand) control handle .... RELEASE
   A. Move control handle to the RELEASE position.
   B. Proceeding forward to aft, check all left-hand locks are fully retracted and do not protrude out from the siderail assemblies.
   C. Install the safety pin in position 1.
9. Ramp siderail assemblies .... CHECKED
   A. Check all screws on both ramp siderails are installed and fully seated.
   B. Open the ramp, and manually engage all lock-flanges on both sides.
   C. Pull up both ramp release handles.
   D. Check all lock-flanges on both sides are fully disengaged.
   E. Stow both ramp release handles in their horizontal position, resting on their stops.
10. Roller trays on ramp and cargo cabin .... CHECKED
   A. Check roller trays are firmly attached to restraint tracks.
   B. Check offset trays on ramp and end of cargo cabin are properly positioned.
   C. Ensure all roller trays are properly spaced by checking they are installed on restraint-track reference marks.
11. Pallet buffer stops .... CHECKED
   A. Check four pallet stops are serviceable and installed/available on board, as required.
12. AM109 preflight checklist .... COMPLETE

<u>NOTE:</u> If loading is not to be accomplished immediately after preflight, move both airdrop and logistic control handles to FULL LOCK and LOCK position. Stow safety pins on both sides.

4.26.2 LOAD PLANNING

1. Dimensions, individual and total weight, nature of cargo to be airlifted..... OBTAINED
2. Dimensions and critical points .... CHECKED
   A. Check if cargo dimensions are compatible with those usable in the aircraft.
   B. Determine if cargo item creates contact or overhead projection problems, and if approach shoring is required.
3. Desired aircraft balance condition .... DETERMINED
   A. Determine desired aircraft balance condition IAW mission profile.

4. Aircraft limitations .... CHECKED
   A. With total payload weight, check aircraft weight limitations are not exceeded for this particular mission (zero fuel weight, maximum takeoff and landing weight).
5. Placement of hazardous materials .... DETERMINED
   A. Plan placement of hazardous materials as aft as possible for ease of jettisoning.
   B. Plan placement of hazardous materials far enough from heat outlets, and so that they are easily accessible without moving any other cargo.
6. Loading sequence .... DETERMINED
   A. Plan onload sequence considering offload, auxiliary loading equipment, stopovers, etc.
   B. Contemplate in-flight jettisoning when determining loading sequence.
7. Cargo floor limitations .... CHECKED
   A. Checked selected location for each cargo units against cargo floor limitations (weight per pallet, axle, on the ramp, etc.).
8. Resulting aircraft balance condition .... COMPUTED
   A. Compute resulting aircraft balance condition, both for takeoff and landing with positions selected for each cargo item.
   B. If resulting balance condition is not satisfactory, rearrange load distribution as required.
9. Final load distribution .... DETERMINED

4.26.3 GENERAL LOADING PREPARATION

1. Systems, auxiliary equipment, and aircraft configuration .... CHECKED
   A. Check all systems required for the mission (winch, CHADS, etc.) work properly.
   B. Check appropriate aircraft equipment for quantity of tiedown devices, removable rings, auxiliary loading ramps, etc., according to mission requirements.
   C. Check aircraft configuration (seats, rollers, etc.) fits mission requirements.
2. Cargo door and ramp .... OPEN
   A. Open cargo door and ramp. Position ramp in the horizontal position or open to the ground, as required.
   B. Install the aft fuselage support legs IAW paragraph 4.15.
   C. If required, install the auxiliary loading ramps.

NOTE: Before opening, gather from cargo door all stowed equipment required for the loading operation (auxiliary loading ramps, tiedown devices, etc.)

3. Cargo documentation .... CHECKED

   A. Check cargo documentation, according to applicable regulations.

4. Engine, brakes, and tire pressure .... CHECKED

   A. Check engine and brakes of auxiliary loading vehicle/vehicles to be loaded work properly.

   B. Check tire pressure on vehicles to be onloaded is correct for airlift, as directed in paragraph 2.4.3.1

5. Fueled items .... CHECKED

   A. Check fuel quantities in tanks of vehicles or wheeled cargo to be airlifted are according to paragraph 4.18.

   B. Check aircraft engines or other items susceptible of containing trapped fuel have been drained, purged, and vented, as required.

   C. Check aircraft fuel tanks have been drained, purged, and vented, or have their preserving liquid inside.

   D. Check cans for carrying additional fuel are of an airlift-approved type and are filled up to 2.5 cm (1 in.) below the lowest filling neck threads.

   E. Items yielding strong fuel odors will be rejected for airlift.

   WARNING: SAFETY MUST BE GUARANTEED WHEN AIRLIFTING ITEMS THAT CONTAIN OR HAVE CONTAINED FUEL. ITEMS THAT NOT CONTAIN THE APPROPRIATE AMOUNTS OF FUEL, OR HAVE NOT BEEN PREPARED PROPERLY FOR AIR SHIPMENT MAY CAUSE FUEL SPILLAGE OR FLAMMABLE FUMES IN FLIGHT, SO THEY WILL BE REJECTED FOR AIRLIFT.

   CAUTION: VEHICLES PRESENTING CHRONIC FUEL AND/OR OIL SPILLAGE OR LEAKAGE WILL BE DRAINED, PURGED, AND VENTED FOR AIRLIFT.

6. Fuel, battery, and oil caps .... TIGHTENED

   A. Check all caps are firmly closed.

   B. For vehicles having pressure-type fuel system, the fuel tank cap will be placed in the semi-locked position.

7. Tanker-type vehicles .... CHECKED

   NOTE: Most tanker-type vehicles (self-propelled or trailer) are not designed and certified for airlift with liquid in the transport tank. Structural integrity of these vehicles is not guaranteed under the G forces experienced in flight. In addition, partially filling the tank would cause balance and aircraft control problems due to shifting of the liquid in flight.

8. Weight, dimensions, and CG .... OBTAINED
    A. Check weight and CG marking, as outlined in paragraph 4.9.
9. Contact pressures.. COMPUTED
10. Shoring requirements .... DETERMINED
11. Hazardous materials.. CHECKED
    A. Check for the presence of dangerous materials, compatibility, packing, labeling, etc., according to ICAO regulations and other applicable directives.
12. General cargo condition.. CHECKED
    A. Check package condition.
    B. Check cargo for soil contamination and pests.
    C. Check vehicles for leakage (oil, fuel, hydraulic fluid, etc.)
13. Equipment on shipping dollies/additional cargo on vehicles...................... CHECKED
    A. Ensure engines, propellers, etc. are firmly secured to shipping dolly with attaching fittings or tiedown devices.
    B. Check all cargo on or in vehicles does not exceed maximum allowable weight for airlift and it is properly restrained.
14. Chocks for main and nose gear .... SEPARATE/ CHECKED
    A. Position main landing gear chocks slight apart from wheels.
    B. Remove nose landing gear chocks (if required).

4.26.4 VEHICLE ONLOADING

1. General loading preparation checklist .... COMPLETE

    NOTE: Close both paratroop doors and fold in door handles. Ensure all seats in the path of the vehicle are secured in the upright position and, if required, remove static line anchor cables and intermediate roller trays.

2. Auxiliary loading ramps aligned for axle width... CHECKED
3. Ventilation.. CHECKED
    A. Ensure proper ventilation in the cargo cabin by opening crew door, side escape hatch, and flight deck windows, as required.
4. Loading crew duties..ASSIGNED, PERSONNEL BRIEFED
    A. Position observers to watch critical points and clearances to aircraft structure.
    B. Brief vehicle driver about the operation and visual signals to be used.
    C. Make it clear to driver and loading crew who the person directing is, and to follow only his/her instructions.

5. Vehicles to be loaded/prime mover aligned, low gear, four-wheel drive .... CHECKED

   CAUTION: IF A TRAILER IS TO BE LOADED ATTACHED TO ITS PRIME MOVER, ENSURE IT HAS ENOUGH PULLING POWER FOR THE OPERATION UP THE INCLINED RAMP.

   NOTE: If slippery ramp conditions exist, use the aircraft winch for the loading operation.

6. Vehicles on board, transmission and gear lever as required .... ACCOMPLISHED

   A. Diesel and multi-fuel vehicles with automatic transmission: gear in PARK or equivalent position.

   B. Diesel and multi-fuel vehicles with manual transmission: neutral.

   C. Gasoline-powered vehicles with automatic transmission: PARK.

   D. Gasoline-powered vehicles with manual transmission: lowest gear.

      NOTE: If an axle is placed on the aircraft ramp, ensure filler neck is above fuel tank with the ramp closed.

7. Brakes and ignition .... SET, OFF

   WARNING: VEHICLE DRIVER MUST REMAIN AT VEHICLE CONTROLS WHILE INITIAL SAFETY RESTRAINT IS APPLIED.

8. Tiedown .... COMPUTED, INSTALLED, CHECKED

9. Vehicle onloading checklist .... COMPLETE

10. After Loading checklist .... COMPLETE

4.26.5 GENERAL WINCHING PREPARATION

1. Aircraft electrical power .... CONNECTED

2. Winch .... CHECKED

   A. Unwind winch cable and check cable condition, cargo hook attachment and hook keeper condition.

   B. For external or self-winching, check vehicle winch and cable condition.

      WARNING: WINCH CABLE MUST NOT HAVE KINKS OR BROKEN WIRES.

3. Operational checkout .... ACCOMPLISHED

   A. Check aircraft/vehicle winch works properly in both directions.

4. Loading crew duties .... ASSIGNED, PERSONNEL BRIEFED

   A. Position observers to watch critical points and clearances to aircraft structure.

   B. Brief loading crew about the operation and visual signals to be used.

   C. Make it clear to the person steering and rest of loading crew who the person directing is, and to follow only his/her instructions.

5. Cargo cabin and ramp area .... CLEAR OF OBSTACLES
6. Steering yoke..INSTALLED (If required)
7. Aft fuselage support legs ....INSTALLED
   A. If onloading is to be accomplished across the ramp in the horizontal position, support the aft fuselage IAW paragraph 4.15.2.
8. Approach shoring ....IN PLACE (If required)
   A. If required, place approach shoring under ramp scuff plate (see Figure 4-23).
9. Auxiliary loading ramps...INSTALLED
   A. Install auxiliary loading ramps, centered and aligned for proper axle width.
   B. If required, place approach shoring under auxiliary loading ramps (see Figure 4-23).
10. Chocks .... AVAILABLE

WARNING: THE USE OF CHOCKS WHILE THE VEHICLE IS ON THE INCLINED AIRCRAFT RAMP IS FORBIDDEN. SHOULD THE LOADING OPERATION NEED TO BE STOPPED WHEN THE WHOLE OR PART OF THE VEHICLE IS ON THE RAMP, TEMPORARILY SECURE THE VEHICLE BY MEANS OF TIEDOWN DEVICES.

NOTE: Once the vehicle is on board, chock the vehicle while initial safety restraint is applied, to prevent vehicle from rolling out of control.

4.26.6 INTERNAL/EXTERNAL/SELF-WINCHING

WARNING: THE STEERING CONTROL DEVICE SHALL ALWAYS BE POSITIONED AFT, SO PERSONNEL STEERING ARE NOT ENDANGERED BY BREAKAGE OF THE WINCH CABLE, OR SUDDEN WINCH FAILURE. AT NO TIME PERSONNEL WILL BE IN THE PATH OF THE LOAD, BETWEEN THE CARGO ATTACHING POINT OF THE CABLE AND THE WINCH, OR DIRECTLY AFT OF THE ITEM BEING LOADED.

WARNING: IF WINCHING PALLETIZED CARGO IS REQUIRED, A CHAIN BRIDLE SHALL BE INSTALLED USING TWO PALLET SIDE TIEDOWN RINGS (SEE FIGURE 4-40). USING A SINGLE ATTACHING POINT MAY CAUSE THE WINCH CABLE TO BREAK IF THE PALLET/PLATFORM BECOMES MISALIGNED AND JAMS IN THE CHADS RAILS WHILE IT IS BEING TRANSFERRED TO THE AIRCRAFT RAMP.

WARNING: USE EXTREME CAUTION WHEN WINCHING AIRDROP PLATFORMS (HE OR LAPE). ONCE THE PLATFORM IS IN THE AIRCRAFT, CHECK IT ROLLS BACK AND FORTH SMOOTHLY WITHOUT WINCH ASSISTANCE.

1. General winching preparation checklist...COMPLETE
2. Winching vehicle (external winching only)... POSITIONED
   A. Position winching vehicle IAW Figure 4-41.

3. Vehicle to be loaded ....ALIGNED

   A. Line up wheels of vehicle to be winched with auxiliary loading ramps. If required, re-adjust auxiliary loading ramps to proper axle width.

   B. If vehicle is to be self-winched, align it IAW Figure 4-41.

4. Snatch blocks ....INSTALLED (If required)

   A. External or self-winching: install snatch block IAW Figure 4-41.

   CAUTION: SNATCH BLOCKS MUST BE OF THE PROPER SIZE TO ACCOMMODATE WINCH CABLE ACCORDING TO ITS DIAMETER.

5. Cable-to-load attachment..ACCOMPLISHED

   A. Attach cable to load IAW Figure 4-39.

   B. For winching pallets or airdrop platforms, attach hook to a chain bridle rigged across two side rings, IAW Figure 4-40.

   WARNING: LOAD ATTACHING POINTS MUST BE SUBSTANTIAL ENOUGH TO WITHSTAND WINCH PULL. INSPECT ATTACHING POINTS FOR CRACKS, POOR WELDS, ETC. IF NECESSARY, INSTALL A CHAIN BRIDLE ON TWO LOAD SYMMETRICAL POINTS.

6. Cable slack removed (initial tension), snatch block, cable-to-load attachment, and cable path ....CHECKED

7. Vehicle/load on board, vehicle brake set, initial restraint installed ....COMPLETE

   CAUTION: IF A SELF-PROPELLED VEHICLE IS TO BE WINCHED, THE DRIVER SHALL BE WARNED NOT TO OPERATE THE BRAKES UNTIL DIRECTED.

   NOTE: When onloading multiple items, stop winching after first item has climbed up the inclined ramp, and is in a horizontal attitude in the cargo cabin. Unfasten cable from item and push load to its intended position. Lay cable on the cargo floor as aft as possible. This will ease extension and attachment of cable to subsequent items.

8. Remaining items to be loaded .... ON BOARD

   A. Repeat preceding steps to onload remaining cargo items to be loaded.

   NOTE: When winching multiple pallets/airdrop platforms, place a length of 550 lb nylon cord along the length of the cargo floor before loading previous pallets(s). Use the cord to pull the winch cable beneath the loaded pallet(s) for subsequent winching.

9. Load restraint/locking of pallets..COMPUTED, COMPLETE

10. Winching checklist ....COMPLETE

11. After Loading checklist...COMPLETE

4.26.7 PALLETIZED OR FLOOR CARGO ONLOADING

WARNING: PRIOR TO BEGINNING THE ONLOADING OPERATION, INSTALL AT LEAST TWO PALLET STOPS FORWARD OF THE PREPLANNED POSITION FOR THE FRONT END OF THE FIRST PALLET, TO SERVE AS A SAFETY BARRIER FORWARD DURING LOADING.

CAUTION: PALLET LOADERS EQUIPPED WITH ROLLERS OR FORKLIFTS WITH ROLLERIZED TINES SHOULD BE USED WHEN LOADING PALLETIZED CARGO. IN THOSE INSTANCES WHEN PALLET LOADER OR FORKLIFTS WITH ROLLERIZED TINES ARE NOT AVAILABLE, EXTREME CARE MUST BE TAKEN WHEN ONLOADING WITH BARE TINES.

NOTE: Close both paratroop doors and fold door handles. Ensure all seats in the path of the pallets are secured in the upright position and, if required, remove static line anchor cables.

1. Locks on both sides .... RETRACTED (As required)
   A. Unlock ramp locks on both sides.
   B. Unlock cargo cabin locks on both sides.
2. Aft fuselage support legs ....INSTALLED (As required)
   A. Depending on the loading operation to be accomplished (ramp in the horizontal, auxiliary loading ramps, etc.), support aft fuselage as outlined in paragraph 4.15.
3. Cargo cabin and ramp area ....CLEAR AND UNOBSTRUCTED
4. Pallet inspection ....COMPLETE
   A. Check condition of pallets IAW paragraph 4.23.5.
   B. Check cargo-to-pallet restraint.
   C. Check position of side pallet D-rings which do not have tiedowns attached.

      CAUTION: FOR EASE OF INFLIGHT JETTISONING IN THE EVENT OF AN EMERGENCY, LOWER OR SECURE IN THE VERTICAL POSITION ALL SIDE PALLET D-RINGS NOT IN USE FOR RESTRAINT.

      CAUTION: SIDE D-RINGS AT THE CORNERS OF THE PALLET OR TWISTED SIDE D-RINGS MAY INTERFERE IN LOCK ENGAGEMENT, SO IT IS ADVISABLE TO SECURE THEM IN THE VERTICAL POSITION BEFORE LOADING THE PALLET INTO THE AIRCRAFT.
5. Loading crew duties..ASSIGNED, PERSONNEL BRIEFED
   A. Position observers to watch critical points and clearances to aircraft structure.
   B. Brief driver of the auxiliary loading vehicle about the operation and visual signals to be used.
   C. Make it clear to the driver and rest of loading crew who the person directing is, and to follow only his/her instructions.

6. Chocks .... IN PLACE

   A. Place wheel chocks on the ground, between aircraft ramp and auxiliary vehicle, far enough to prevent the vehicle from striking aircraft in the event of brake failure or loose of steering control.

7. Loading vehicle..APPROACHED AND ALIGNED

8. Loading vehicle brake... SET

9. Auxiliary loading ramp ....INSTALLED (If required)

   A. If wheeled cargo is to be transferred from auxiliary vehicle, install auxiliary loading ramps.

10. Pallet, platform, or load... TRANSFERRED TO AIRCRAFT

    A. Transfer pallet/load to the cargo cabin, and take to preplanned position for airlift.

       <u>WARNING:</u> WHEN TRANSFERRING PALLETS, PLATFORMS, OR VEHICLES TO THE CARGO CABIN, ALL PERSONNEL MUST KEEP AFT OF THE ITEM BEING LOADED AT ALL TIMES, NEVER FORWARD OR ALONGSIDE. ALWAYS INSERT THE LOAD BY PUSHING ON THE ITEM, BECAUSE PERSONNEL MIGHT TRIP INTO THE INTERMEDIATE ROLLERS, AND BE RUNNED OVER BY THE LOAD. IF AT ANY TIME THE LOAD IS REQUIRED TO BE PULLED, USE EXTREME CAUTION.

       <u>WARNING:</u> WHILE TRANSFERRING AND TAKING A PALLET TO ITS FINAL POSITION, USE EXTREME CAUTION TO AVOID MOVING IT AT AN EXCESSIVE SPEED.

       <u>CAUTION:</u> DO NOT USE CHADS LOCKS AS REFERENCE PALLET STOPS. STRIKING MAY RESULT IN DAMAGE TO THE CHADS.

11. Left side detents/restraint..LOCKED/ INSTALLED

    A. Lock left hand detents for pallet just loaded.

    B. Secure to floor cargo item just loaded.

12. Remaining pallets, platforms, or load...................... TRANSFERRED TO AIRCRAFT

13. CHADS right control handle.. FULL LOCKED

    <u>NOTE:</u> A slight forward and aft movement of pallets by the loading team may be required to achieve engagement of all right hand locks.

14. Positive engagement of locks on both sides .... CHECKED

    A. Check detents on both sides are visible in pallet indents.

       <u>NOTE:</u> If pallets cannot be locked with the CHADS, use tiedown rings and devices to secure pallets directly to cargo floor, IAW with general restraint principles.

15. Ramp detent lock-flanges ....ENGAGED

16. Pallet buffer stops .... INSTALLED

    WARNING: IF PERSONNEL IS TO BE CARRIED FORWARD OF THE PALLETS, INSTALL A PALLET BUFFER STOP ON EACH RESTRAINT TRACK (FOUR STOPS).

17. Palletized/floor cargo loading checklist .... COMPLETE
18. After Loading checklist .... COMPLETE

4.26.8 OFFLOADING PALLETS, VEHICLES, GENERAL CARGO

1. Offloading crew duties .... ASSIGNED, PERSONNEL BRIEFED
   A. Position observers to watch critical points and clearances to aircraft structure.
   B. Brief person steering about the operation and visual signals to be used.
   C. Make it clear to the person steering and rest of offloading crew who the person directing is, and to follow only his/her instructions.
2. Aft fuselage support legs .... INSTALLED (As required)
3. Auxiliary loading ramps .... INSTALLED (As required)
4. Offloading vehicle or equipment .... IN PLACE
5. Ventilation .... AS REQUIRED
6. Vehicle/cargo .... CHECKED (As required)
7. Cargo cabin and ramp area .... CLEAR OF OBSTACLES
8. Winch cable .... ATTACHED TO LOAD (As required)

   NOTE: Offload of pallets or wheeled cargo across the ramp in the horizontal position will be accomplished by pushing it onto the auxiliary offloading vehicle. Aircraft winch will only be used for offloading down the inclined ramp. However, when the winch was used for onloading with the ramp in the horizontal position, it is advisable to have the aircraft winch ready in case cargo becomes misaligned during offload, and it is required to retrieve it back into the cargo cabin for proper alignment.

9. Tiedowns .... REMOVED
10. CHADS locks on both sides .... UNLOCKED (As required)
    A. Offload ramp pallet.
    B. Right hand control handle RELEASE position.
    C. Unlock left-hand detent locks for the pallet to be offloaded with the logistic handle.
11. Offload .... COMPLETE
    A. Sequentially offload all pallets and/or vehicles.
12. Offload checklist .... COMPLETE

13. New onload/After Loading checklist ....COMPLETE

    A. If a new onloading operation is to be accomplished afterwards, refer to appropriate checklist.

    B. If a ferry flight is to be accomplished with the aircraft empty, perform appropriate steps from the After Loading checklist.

4.26.9 EMBARKING/DISEMBARKING PERSONNEL

1. Cargo cabin and ramp area .... CLEAR OF OBSTACLES
2. Ramp and cargo door/crew door... OPEN
3. Personnel ....ON BOARD/ DISEMBARKED

   WARNING: BEFORE STARTING PERSONNEL OFFBOARDING, CHECK PROPELLERS HAVE COME TO A COMPLETE STOP.

4. Seat belts ....AS REQUIRED
5. Passenger manifest ....CHECKED
6. Passenger briefing..COMPLETE
7. Baggage/ loose equipment .... SECURED/ OFFLOADED
8. Personnel embarking/disembarking checklist ....COMPLETE
9. After Loading checklist..COMPLETE

4.26.10 AFTER LOADING

1. Ramp and cargo door ....CLOSED AND CHECKED
2. Telescopic bars ....CONNECTED (If required)
3. Loose equipment .... STOWED, SECURED
4. Load condition ....CHECKED

   A. Check cargo for leaks or any other circumstance.

5. Cargo tiedown ....COMPLETE, CHECKED

   A. Check CHADS detent lock engagement and handle positions for all pallets in the cargo cabin and ramp.

   B. Check tiedowns for wheeled cargo and floor loads.

6. Cargo and passenger manifests ....CHECKED
7. Weight and balance form ....COMPLETE

   WARNING: FOR COMPUTING AND FILLING UP AIRCRAFT WEIGHT AND BALANCE FORM AFTER LOADING AND IMMEDIATELY BEFORE TAKEOFF, VISUALLY VERIFY ALL LOAD POSITIONS. DO NOT USE WEIGHT AND BALANCE DATA OBTAINED DURING LOAD PLANNING, SINCE ACTUAL LOAD POSITIONS MAY DIFFER FROM THOSE PREPLANNED.

8. After Loading checklist..COMPLETE

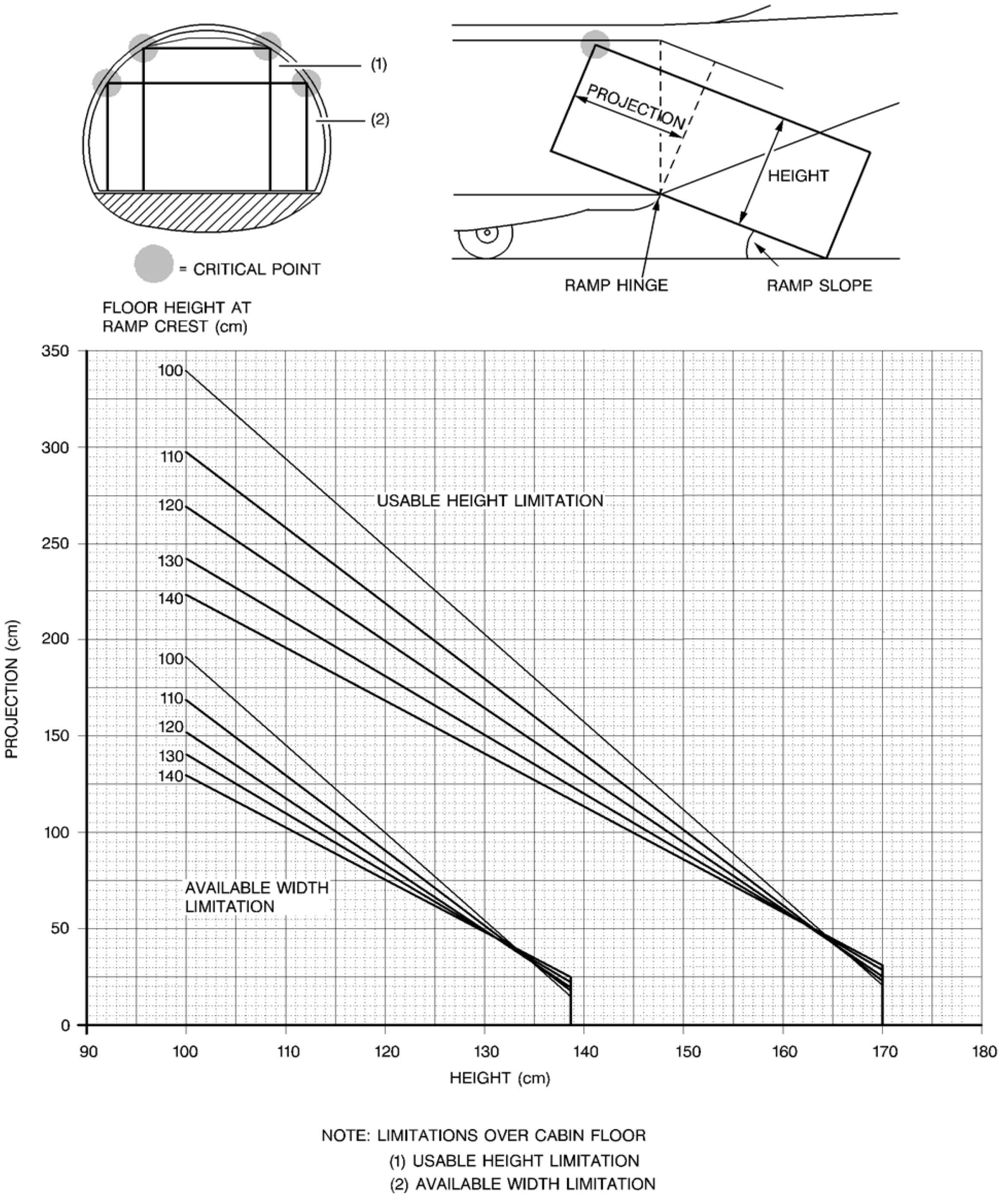


Figure 4-1 Overhead crated cargo projection

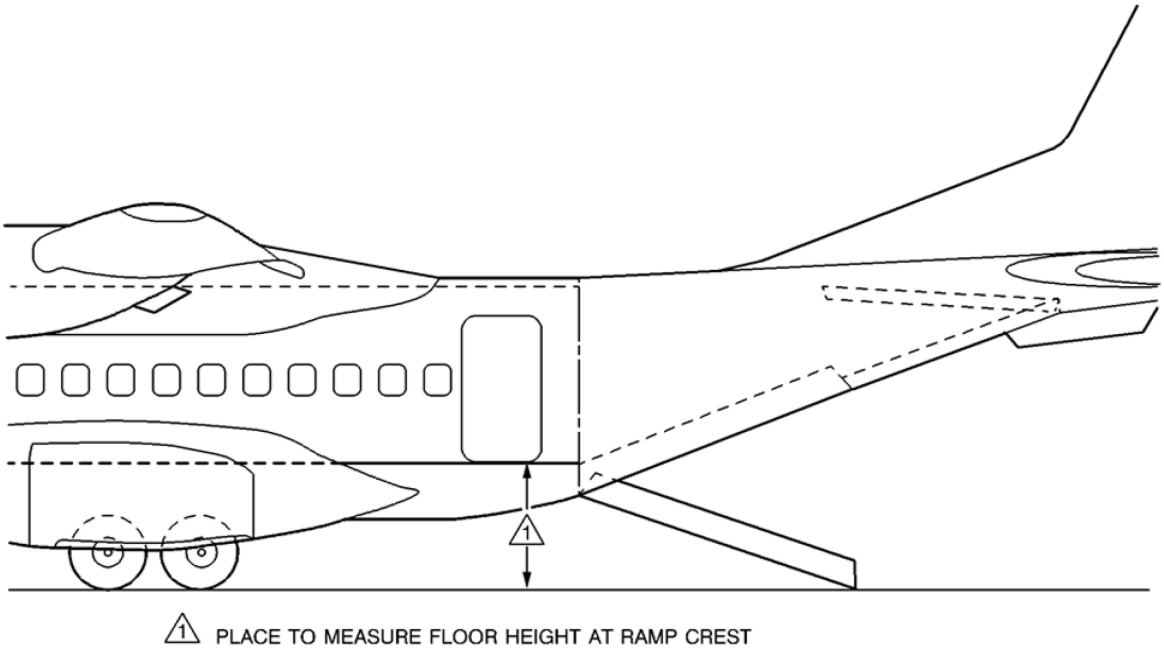
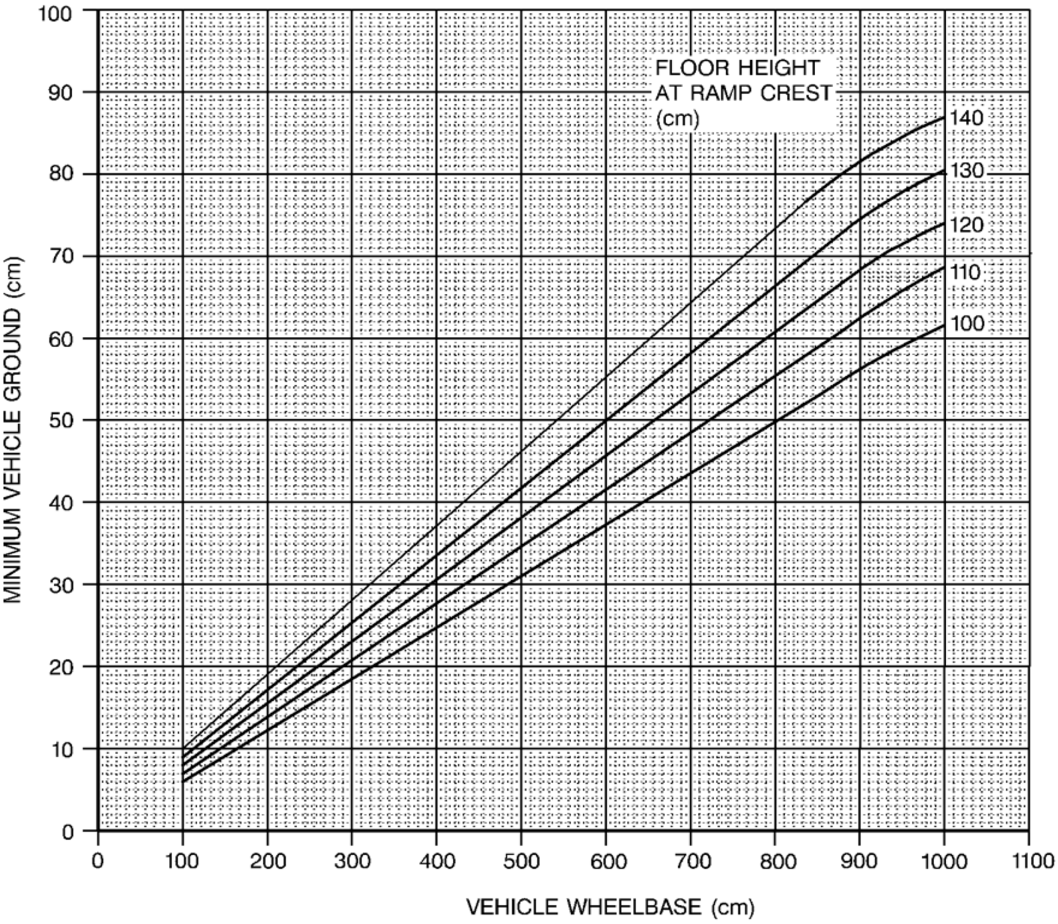


Figure 4-2 Measuring floor height



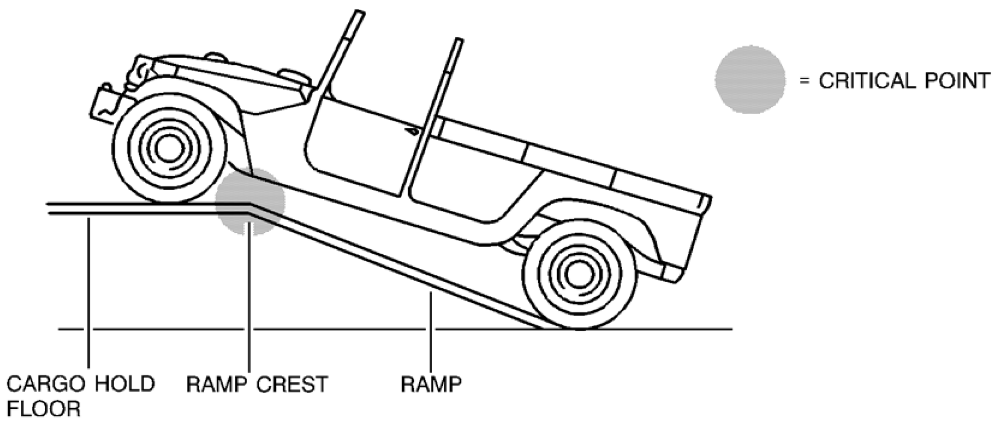


Figure 4-3 Ramp crest contact

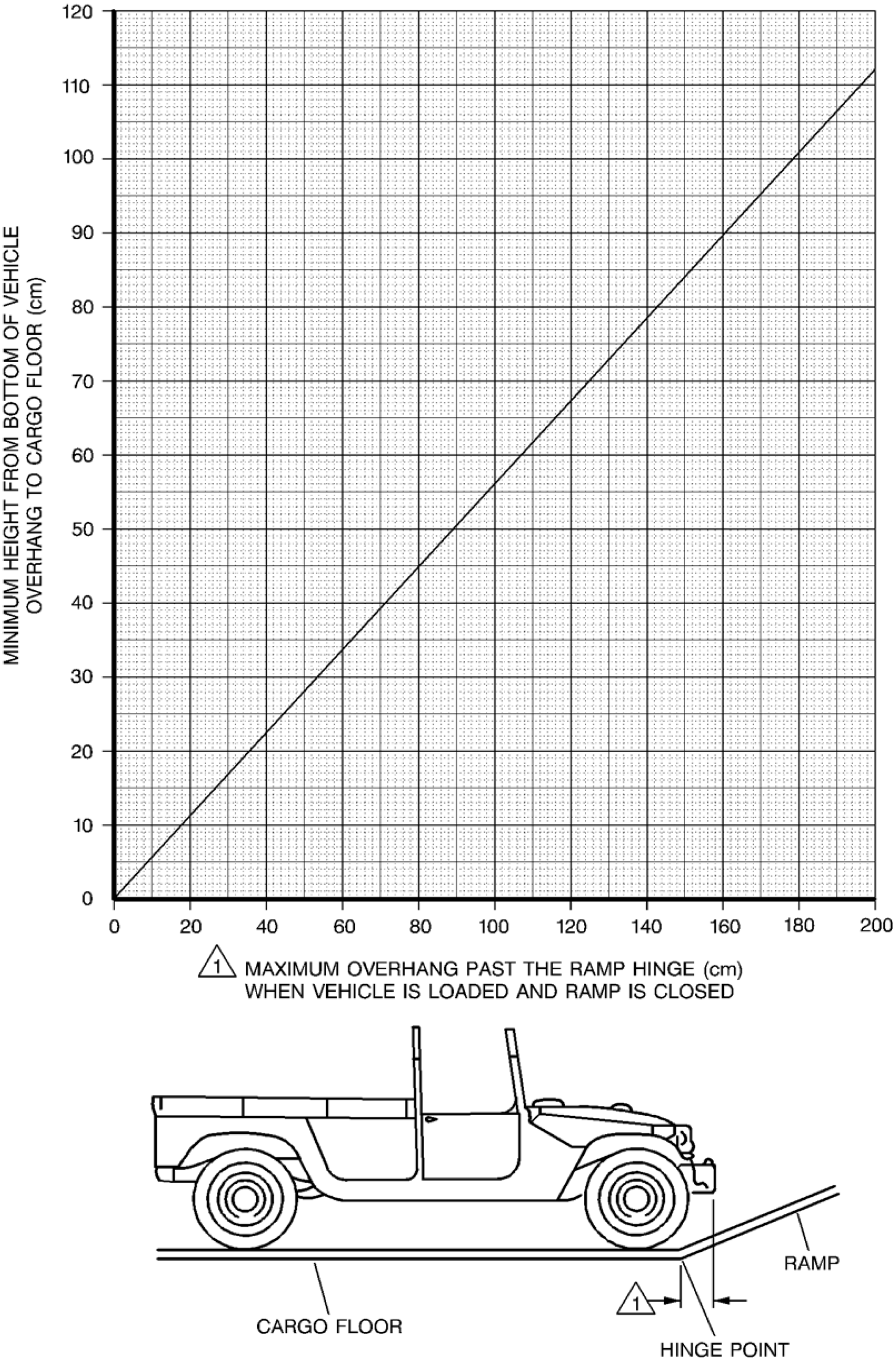


Figure 4-4 Overhang limits over the ramp closed

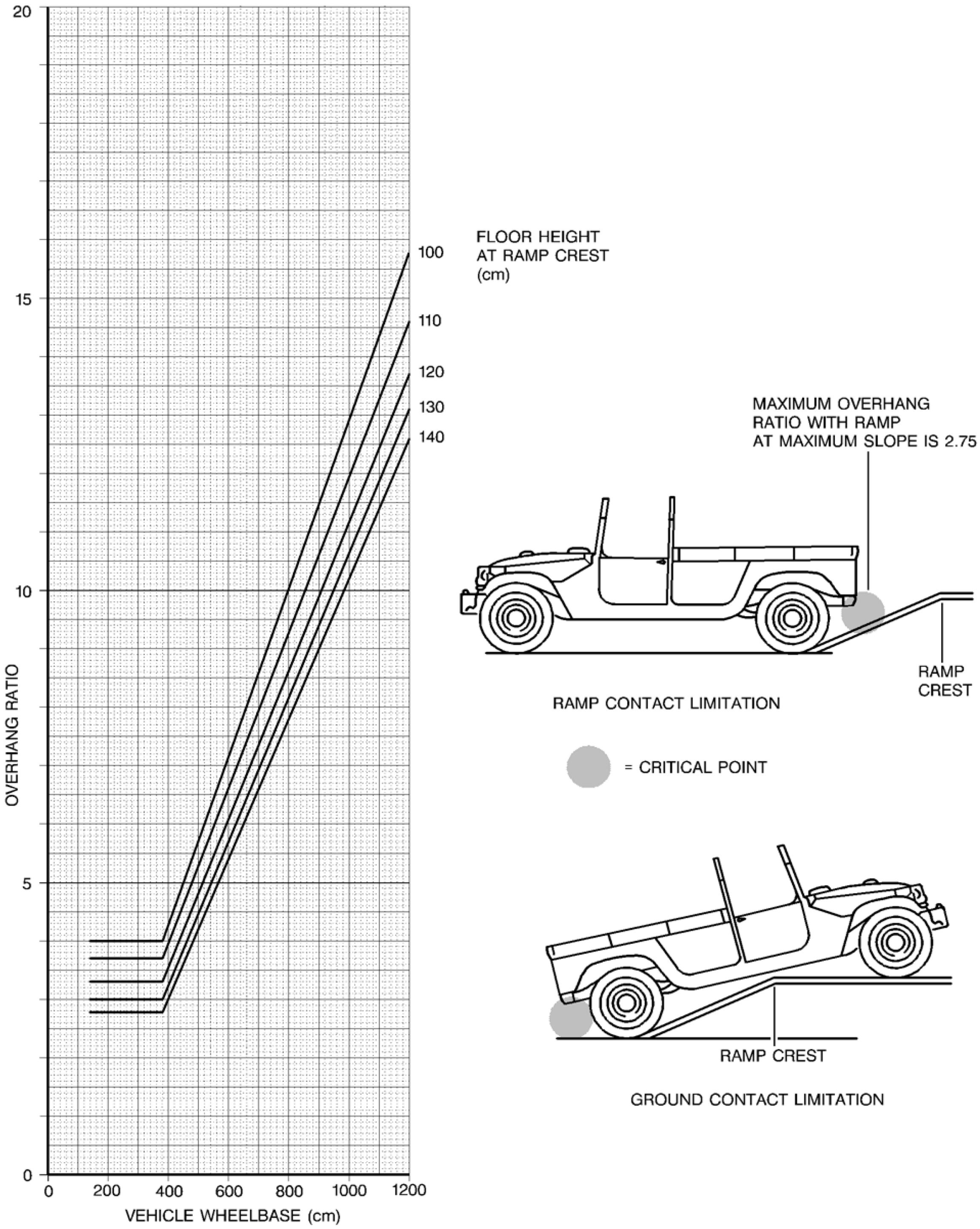
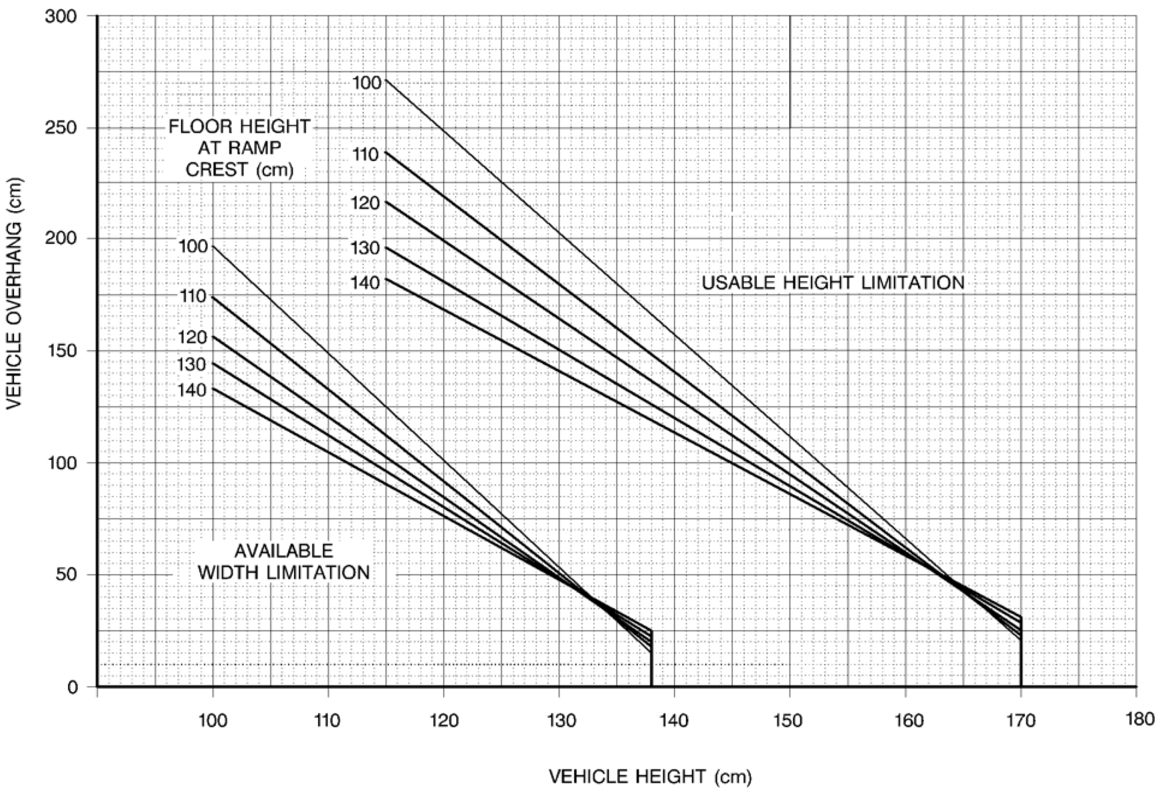


Figure 4-5 Overhang ramp and ground contact limitation



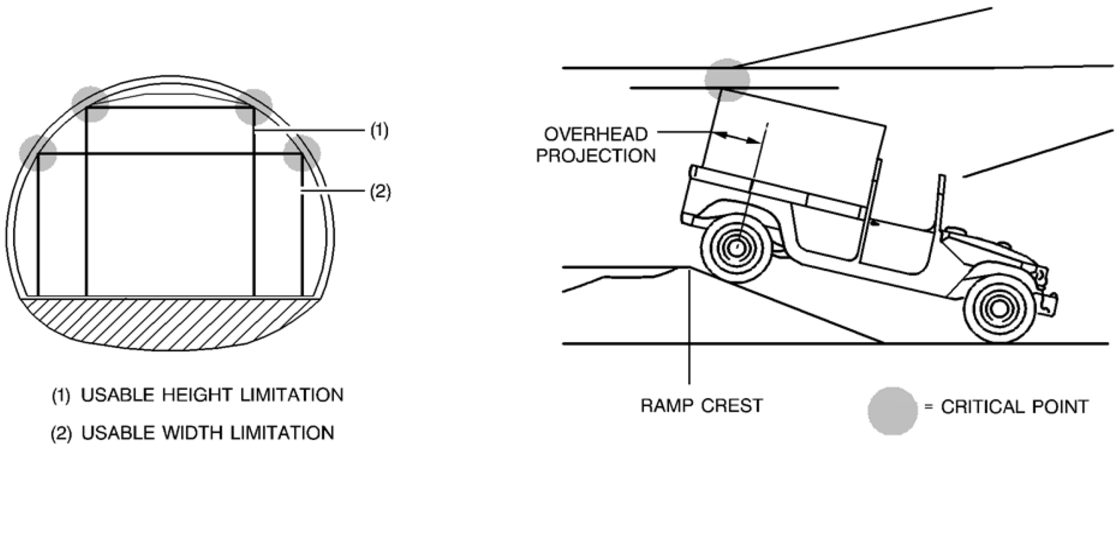


Figure 4-6 Vehicle overhead projection

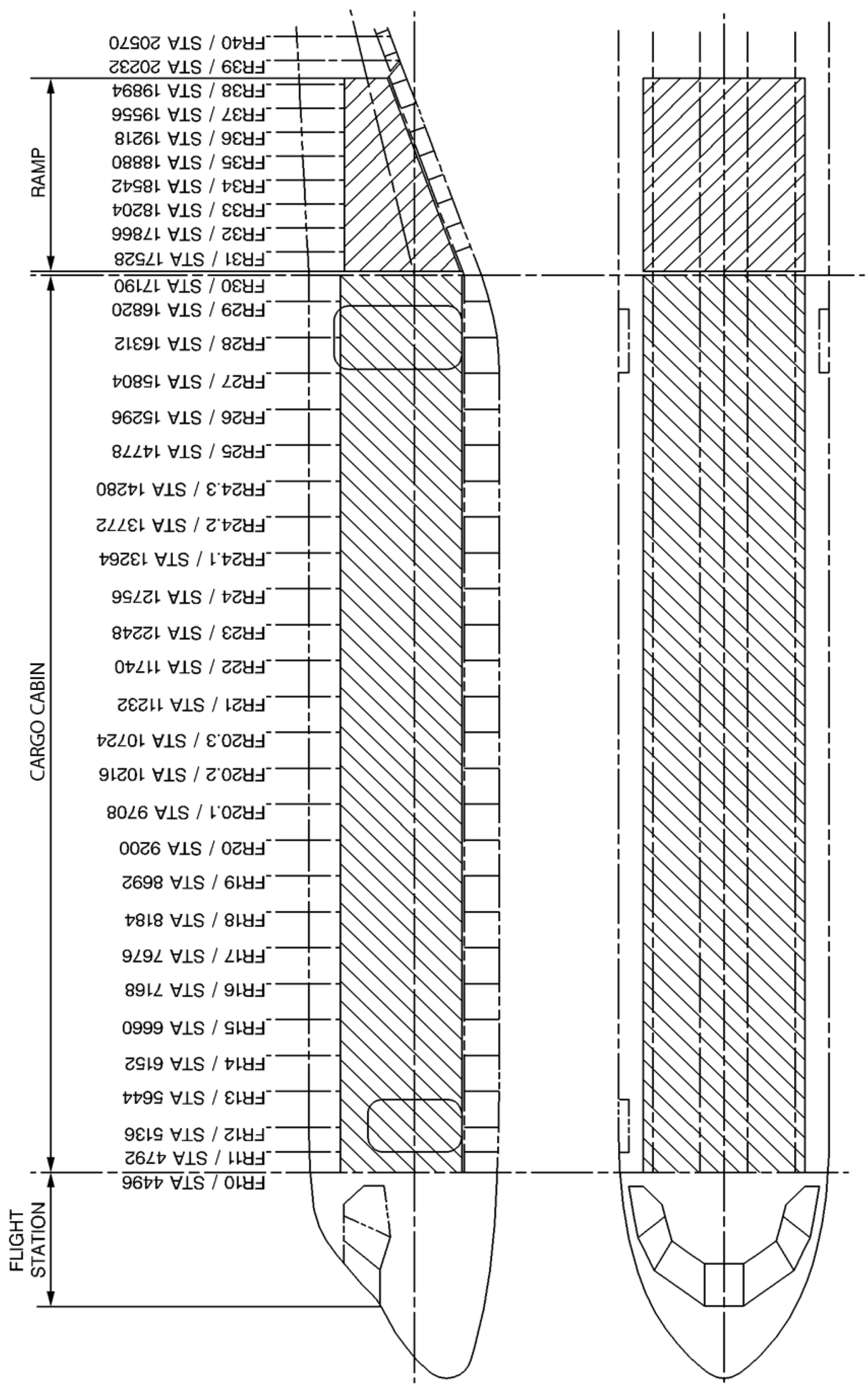


Figure 4-7 Cargo cabin diagrams

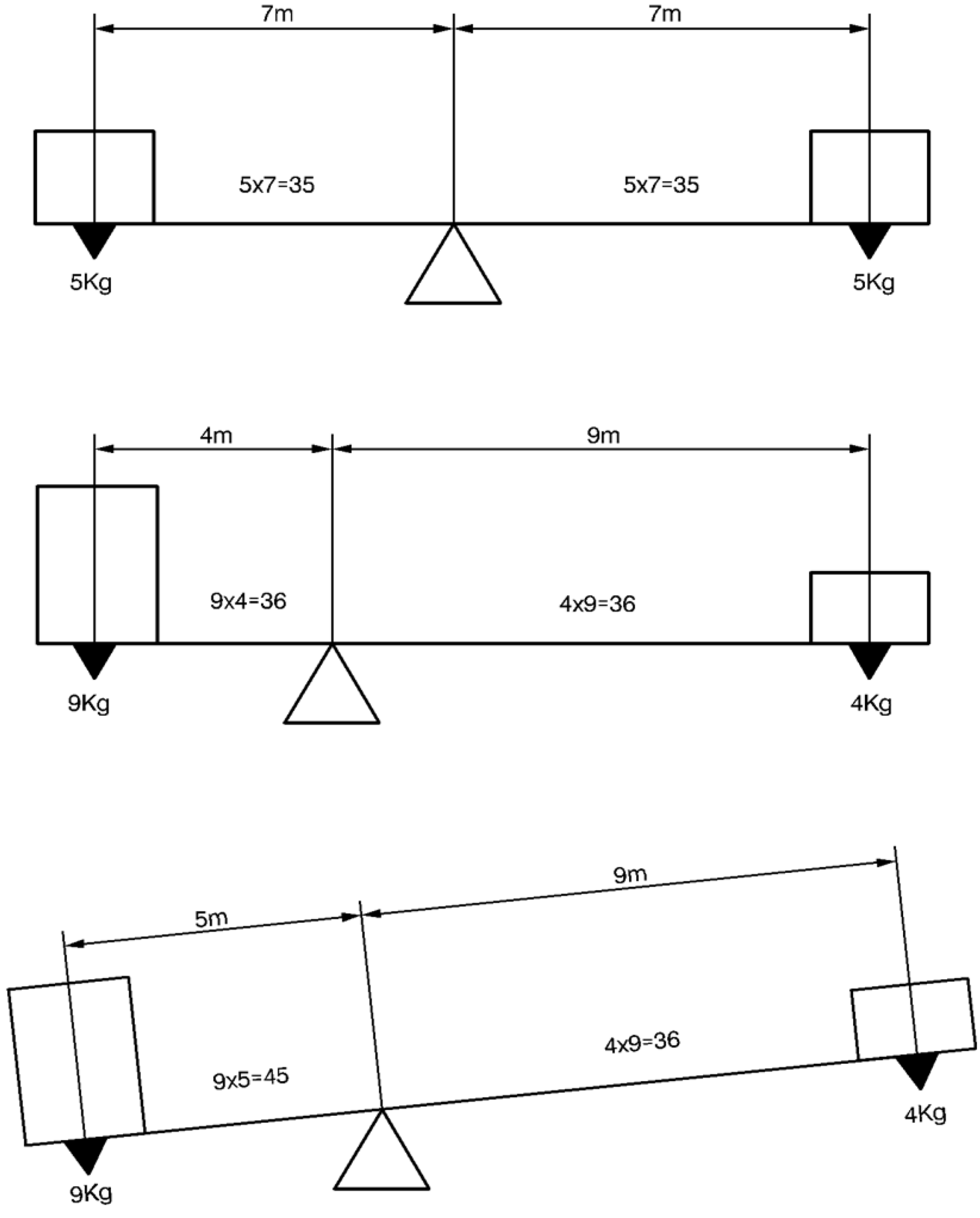


Figure 4-8 Balance in a seesaw

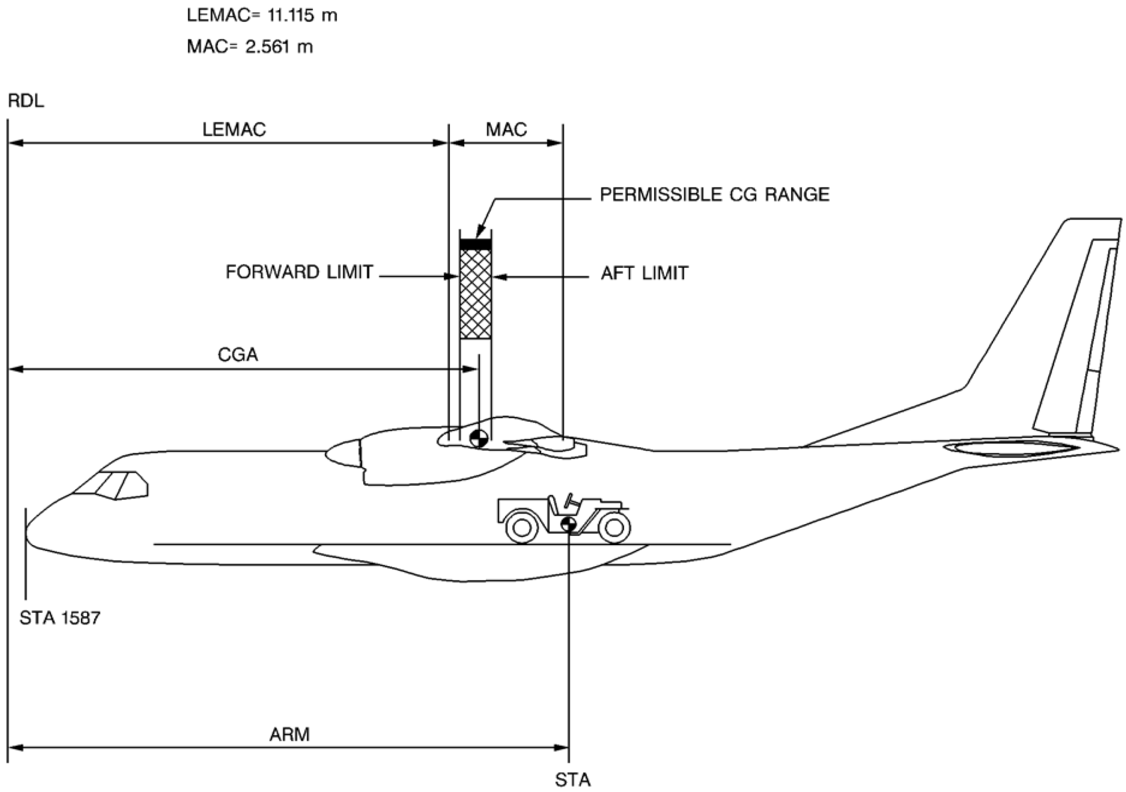


Figure 4-9 Concepts used in aircraft weight and balance calculations

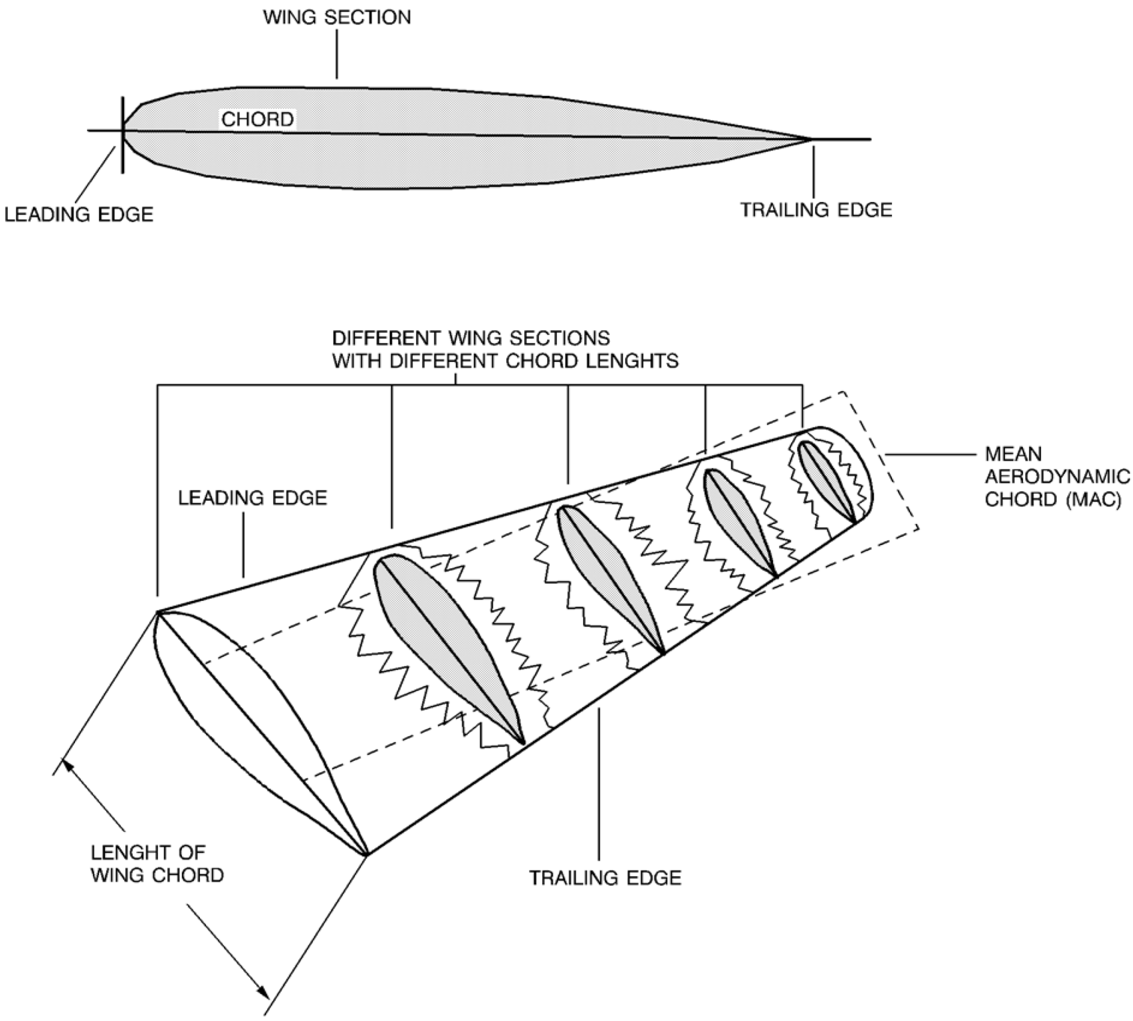


Figure 4-10 Mean aerodynamic chord (MAC)

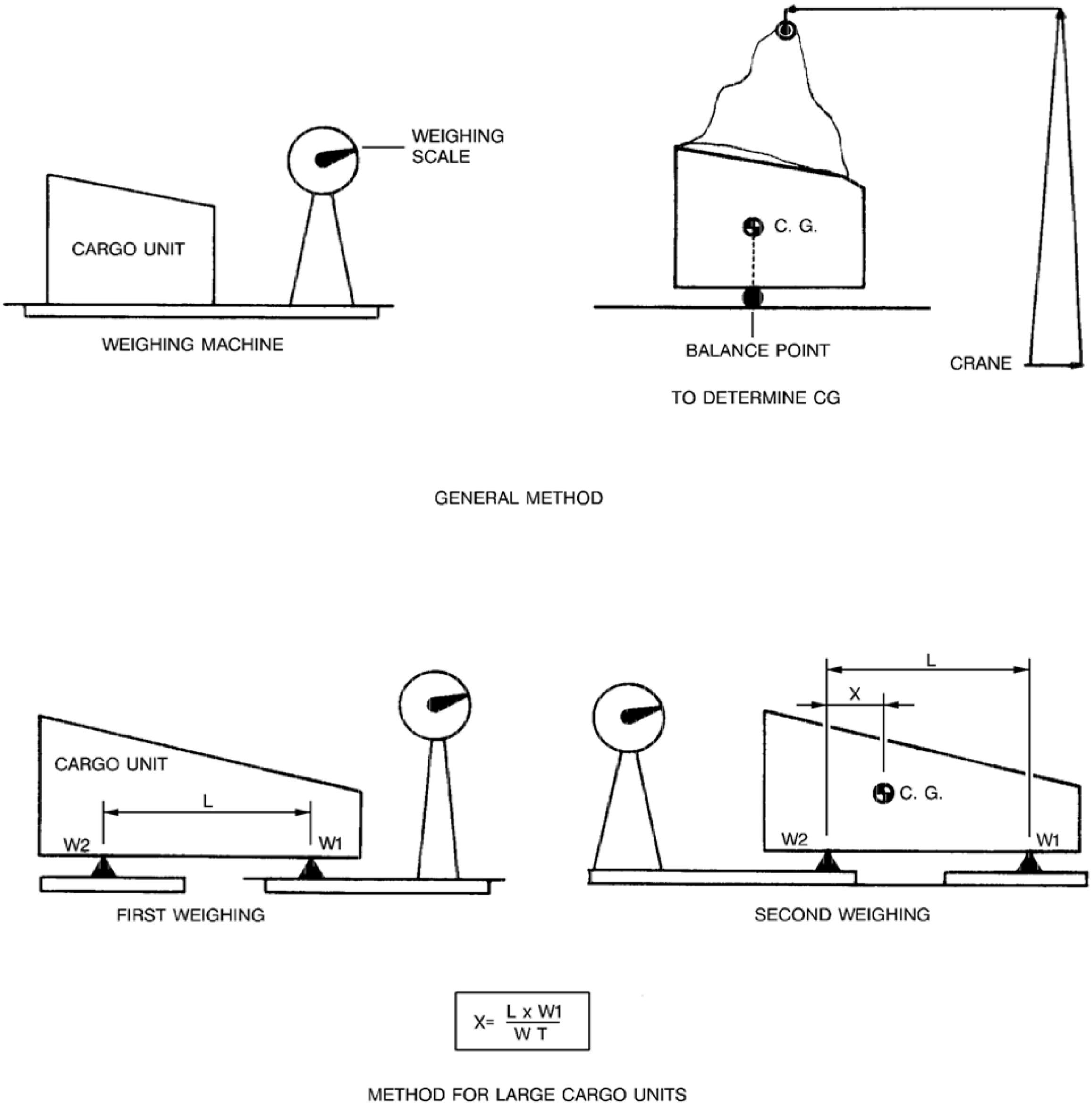


Figure 4-11 Determining cargo unit CG

REFERENCES

FB: FRONT BUMPER.
RB: REAR BUMPER.

DISTANCES

OAL: OVER ALL LENGTH. DISTANCE BETWEEN THE FRONT AND REAR EDGE.
FOH: FRONT OVERHANG. DISTANCE BETWEEN THE FRONT AXLE AND THE FRONT EDGE.
ROH: REAR OVERHANG. DISTANCE BETWEEN THE REAR AXLE AND THE REAR EDGE.
WB: WHEEL BASE, DISTANCE BEETWEEN AXLES (WHEELBASE).

WEIGHTS

FAW: FRONT AXLE WEIGHT.
RAW: REAR AXLE WEIGHT.
GW: GROSS WEIGHT.

CENTER OF GRAVITY

CG: CENTER OF GRAVITY.
CGFA: CENTER OF GRAVITY FROM THE FRONT AXLE.
CGFE: CENTER OF GRAVITY FROM THE FRONT END.

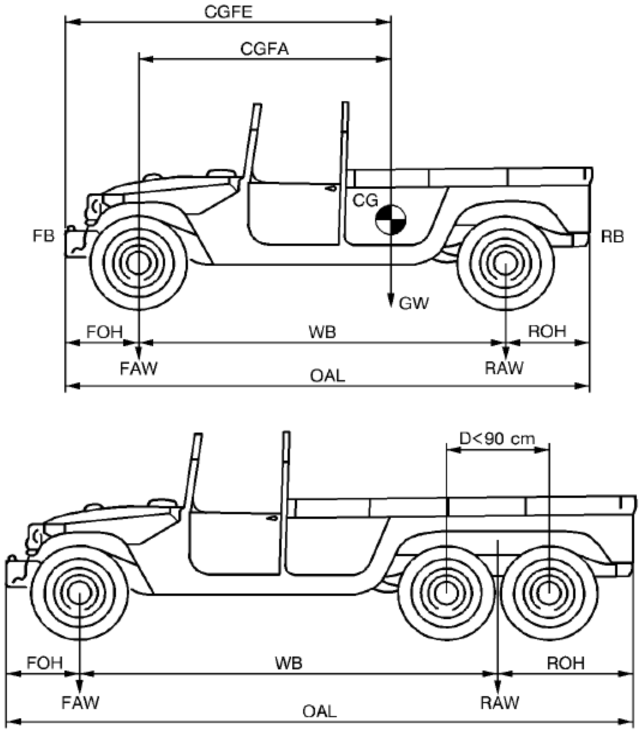
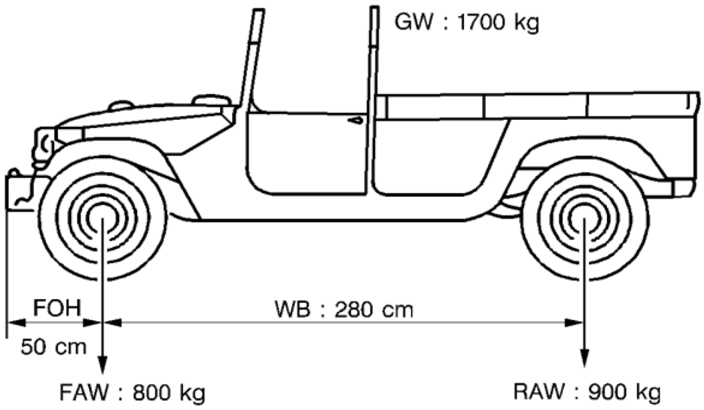


Figure 4-12 Abbreviations on vehicles



$$CGFA = \frac{RAW \times WB}{GW}$$

$$CGFA = \frac{900 \times 280}{1700} = 148 \text{ cm}$$

$$CGFE = CGFA + FOH$$

$$CGFE = 148 + 50 = 198 \text{ cm}$$

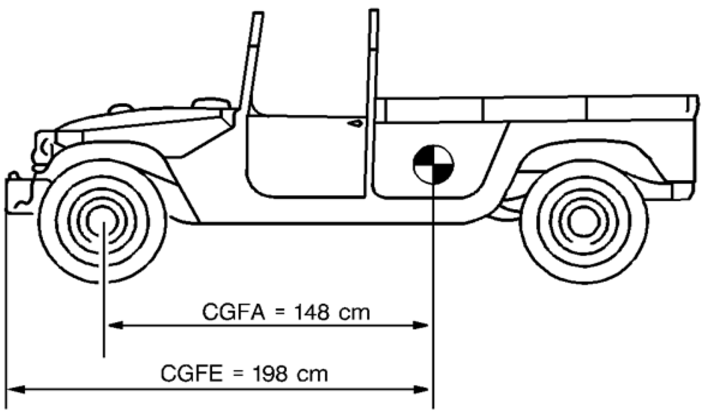
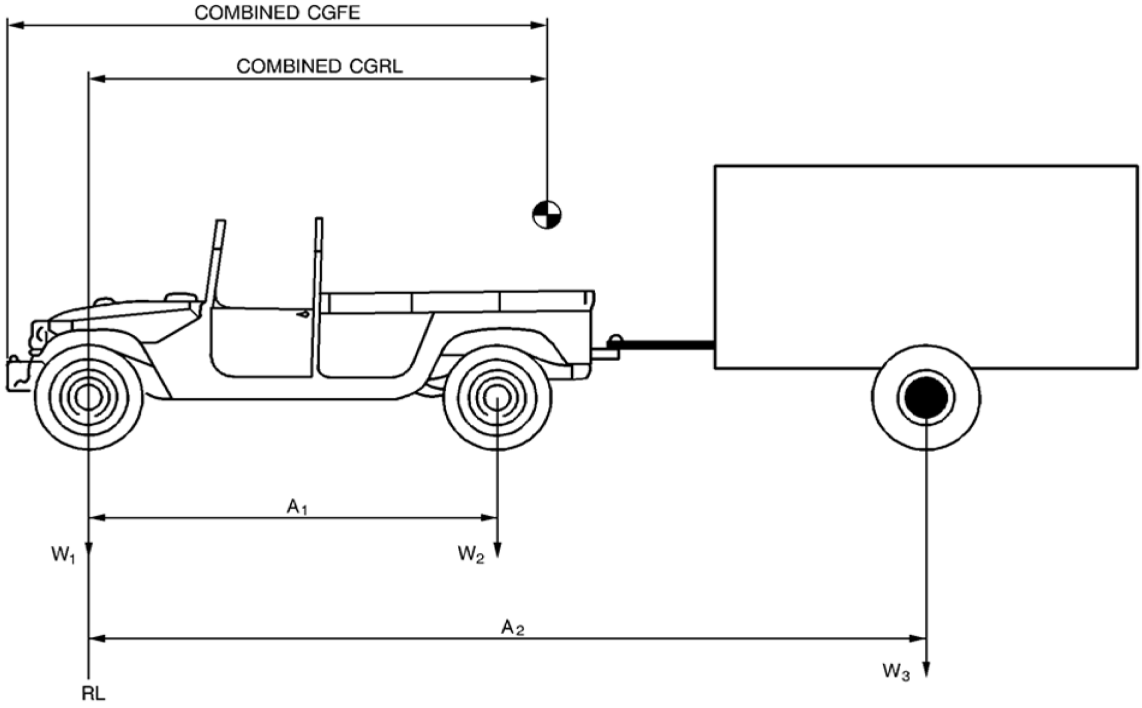


Figure 4-13 Determining vehicle CG



$$CGRL = \frac{(W_2 \times A_1)+(W_3 \times A_2)}{W_1 + W_2 + W_3}$$

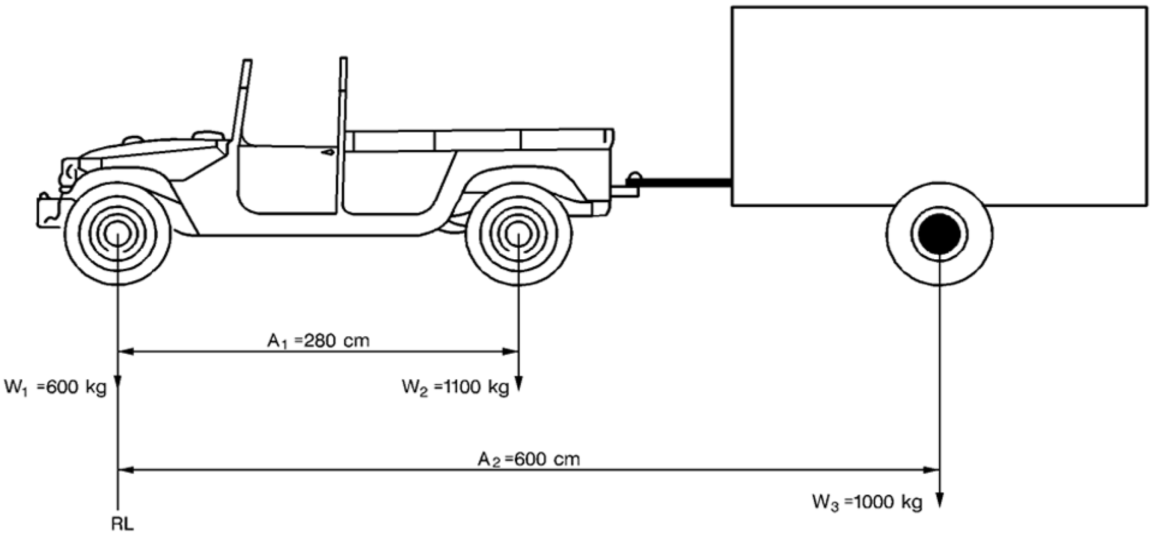
ABBREVIATIONS:

RL:	REFERENCE LINE.
W_1, W_2, W_3:	WEIGHT ON DIFFERENT AXLES.
A_1, A_2:	DISTANCES FROM AXLES TO REFERENCE LINE.

CGRL: CENTER OF GRAVITY FROM THE REFERENCE LINE.

CGFE: CENTER OF GRAVITY FROM THE FRONT END.

Figure 4-14 Determining tractor-trailer combined CG (Sheet 1 of 2)



$$CGRL = \frac{(W_2 \times A_1) + (W_3 \times A_2)}{W_1 + W_2 + W_3}$$

$$CGRL = \frac{(1100 \times 280) + (1000 \times 600)}{600 + 1100 + 1000} = \frac{308000 + 600000}{2800} = 324 \text{ cm}$$

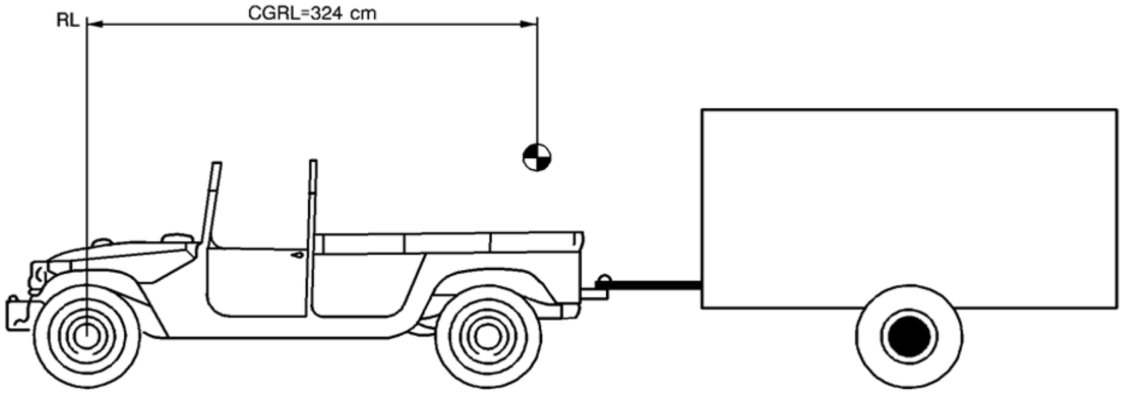
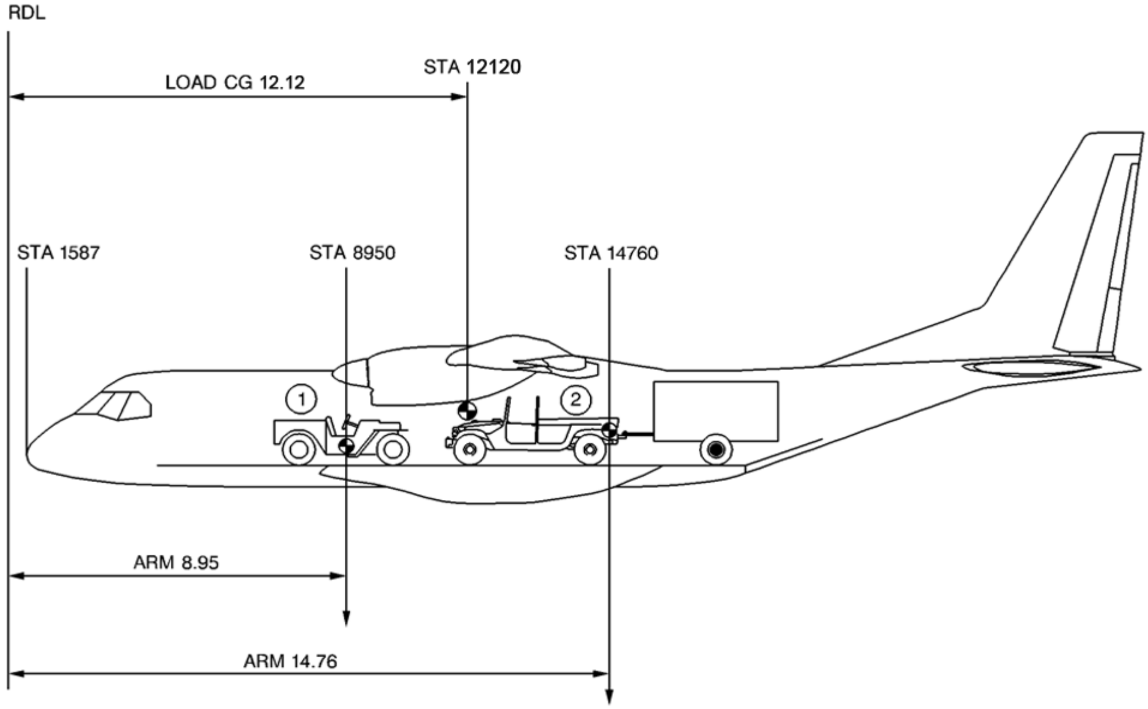


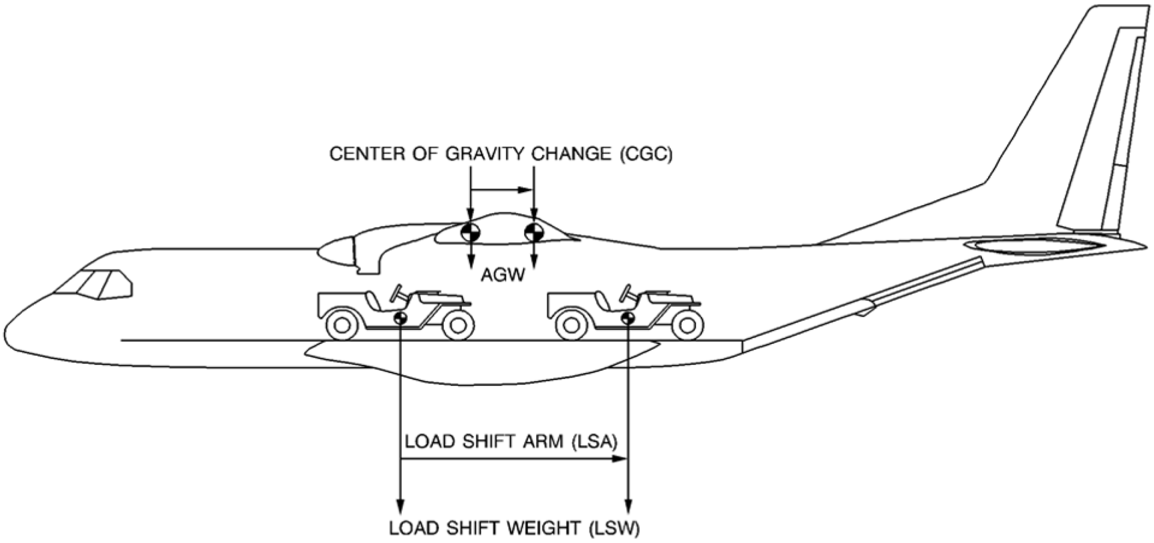
Figure 4-14 Determining tractor-trailer combined CG (Sheet 2 of 2)



ITEM	WEIGHT	ARM	MOMENTS
VEHICLE 1	3500	8.95	31325
VEHICLE 2	4200	14.76	61992
TOTAL	7700		93317

COMBINED LOAD CG = $\frac{93317}{7700}$ = 12.12 LOAD CG STA 12120

Figure 4-15 Determining combined load CG on the aircraft



$$\begin{array}{ccc} LSW \times LSA & = & AGW \times CGC \\ \downarrow & & \downarrow \\ MOMENTS & = & MOMENTS \end{array}$$

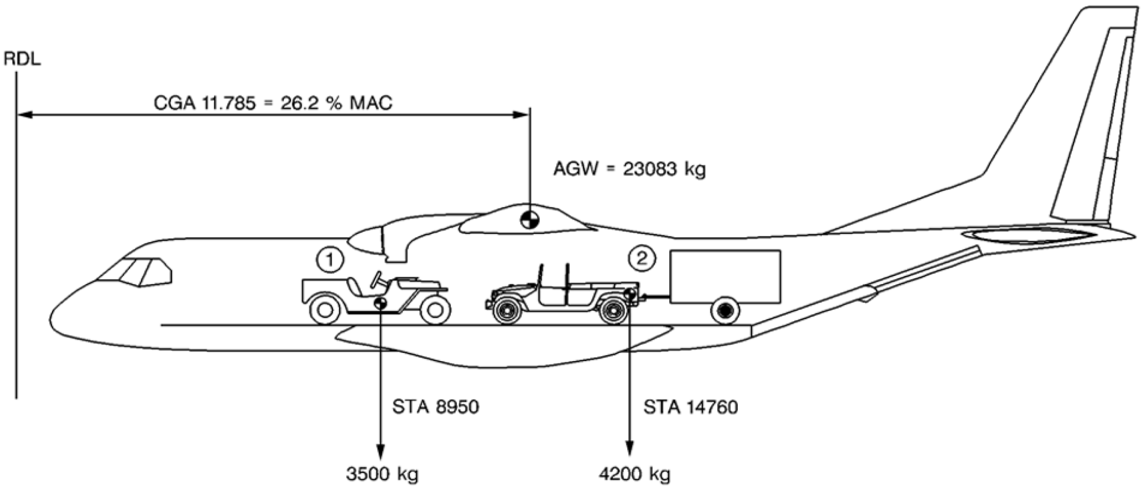
$$\frac{CGC}{LSA} = \frac{LSW}{AGW}$$

$$CGC = \frac{LSA \times LSW}{AGW} \; ; \; LSA = \frac{CGC \times AGW}{LSW} \; ; \; LSW = \frac{CGC \times AGW}{LSA}$$

ABBREVIATIONS:

LSW= LOAD SHIFT WEIGHT (KG)
LSA= LOAD SHIFT ARM (METERS)
AGW= AIRCRAFT GROSS WEIGHT (KG)
CGC= CENTER OF GRAVITY CHANGE (METERS)

Figure 4-16 Load shifting effect on aircraft balance



$$LSW \times LSA = AGW \times CGC$$

$$\downarrow \qquad \qquad \downarrow$$

$$MOMENTS = MOMENTS$$

$$LSA = \frac{CGC \times AGW}{LSW}\ ; \quad LSA = \frac{0.145 \times 23083}{3500} = 0.96 \text{ METERS}$$

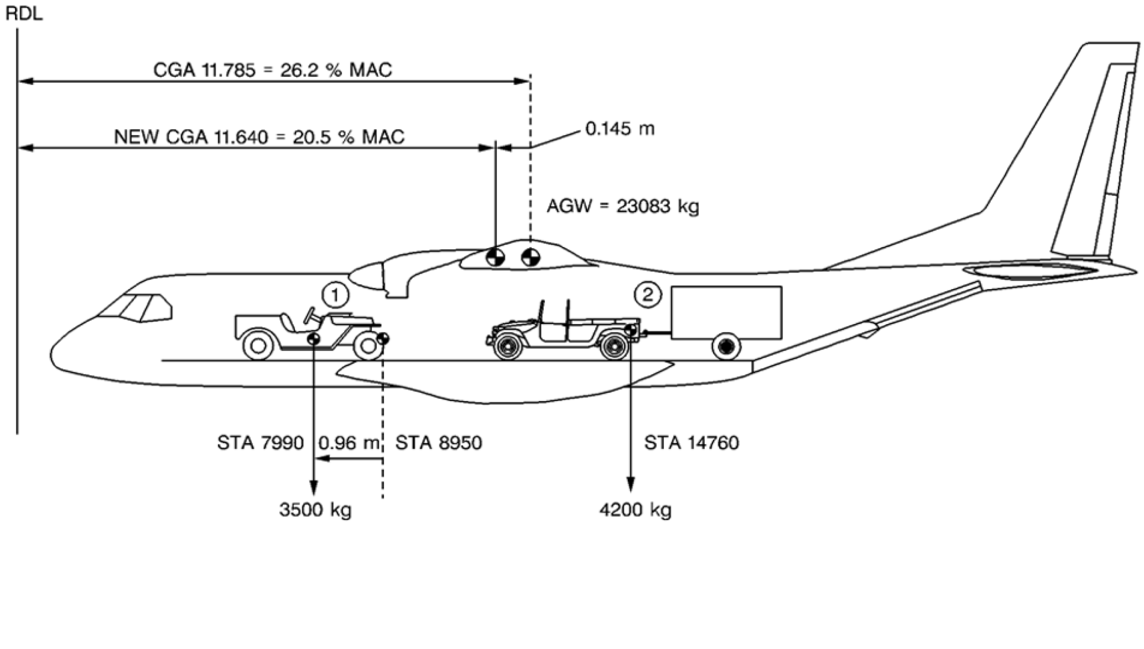


Figure 4-17 Load shifting effect on aircraft balance (example)

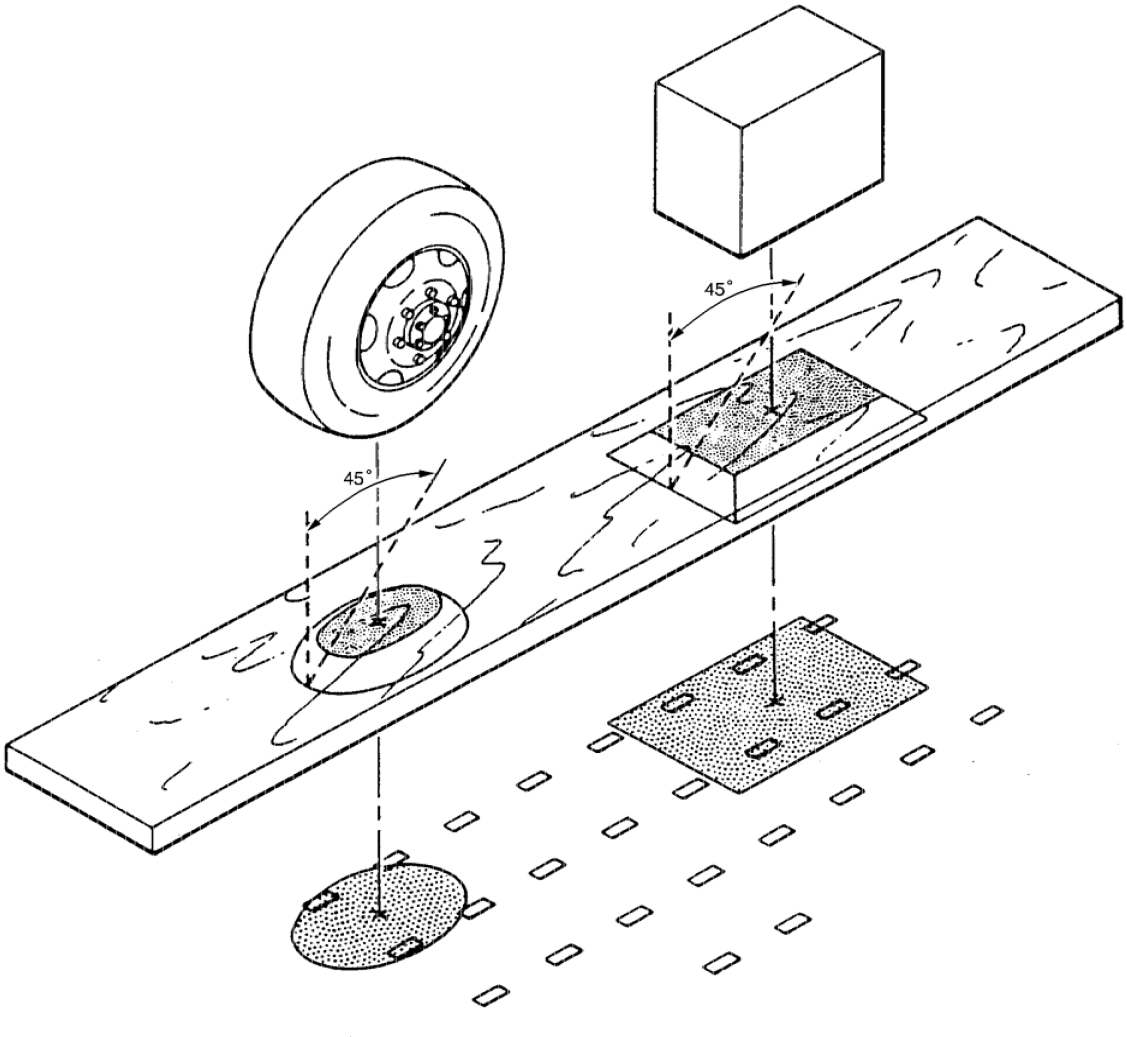


Figure 4-18 Load shoring effect on cargo floor

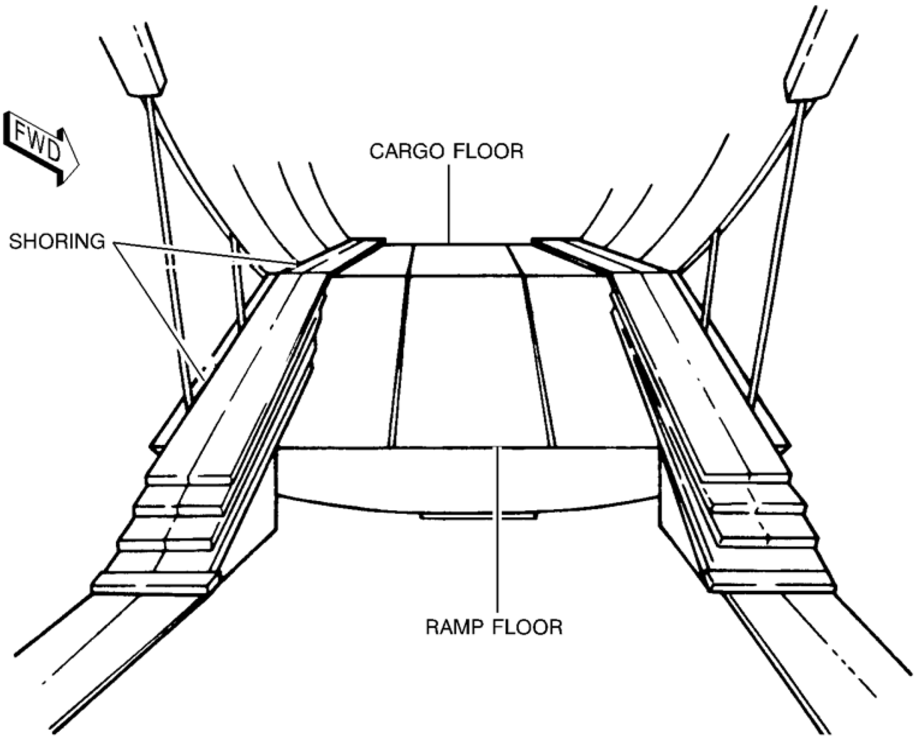


Figure 4-19 Rolling shoring

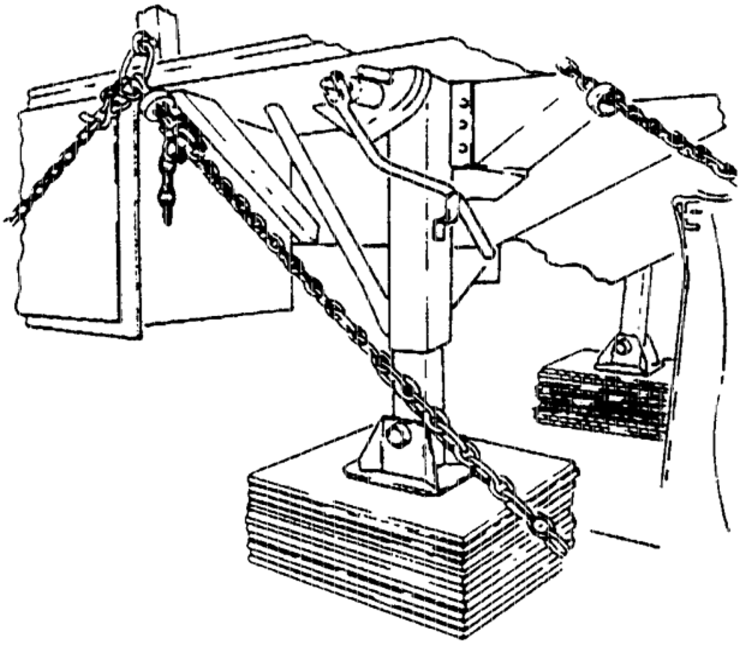
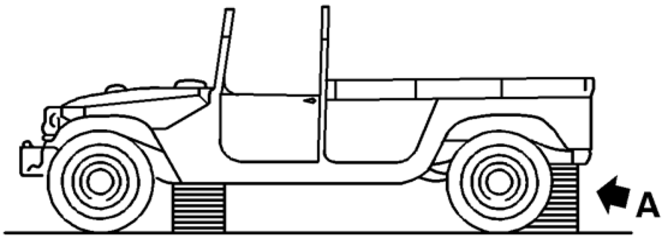
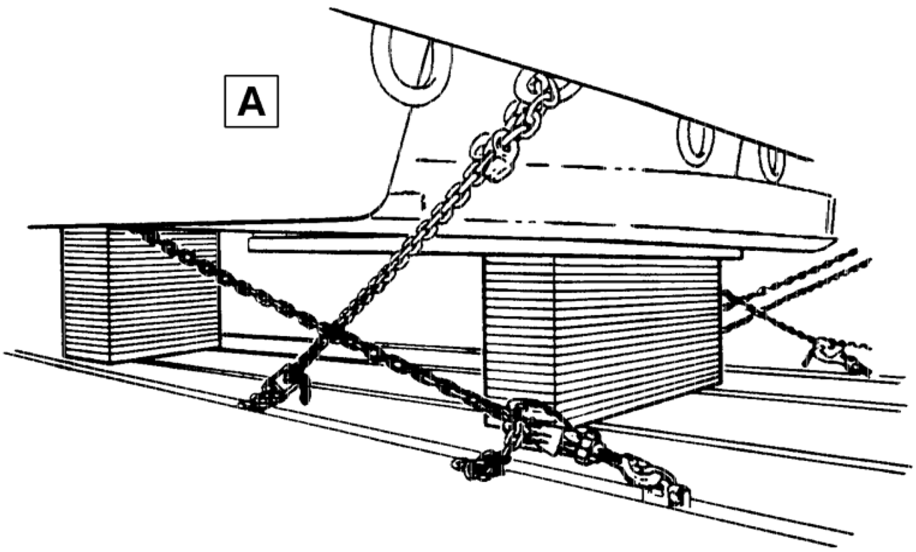


Figure 4-20 Parking shoring





SHORING UNDER A VEHICLE FRAME

Figure 4-21 Sleeper shoring

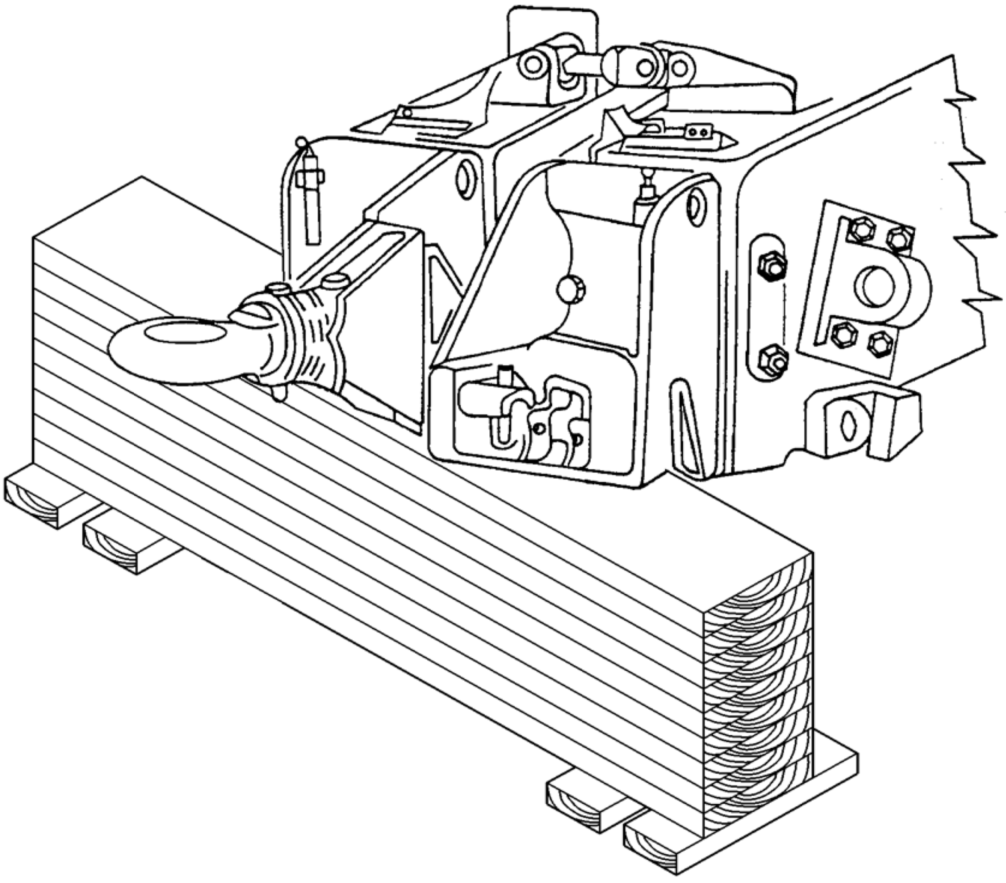


Figure 4-22 Bridge shoring

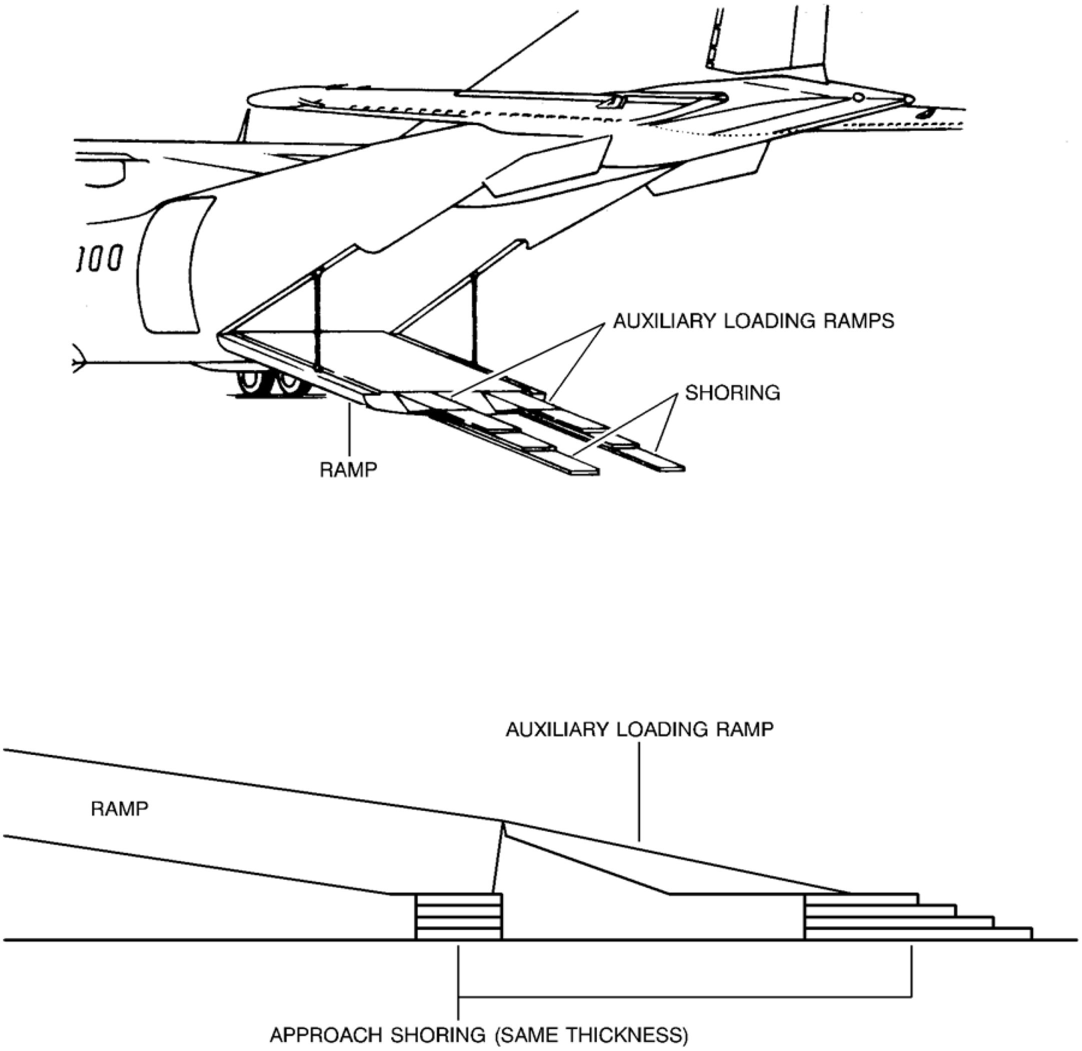
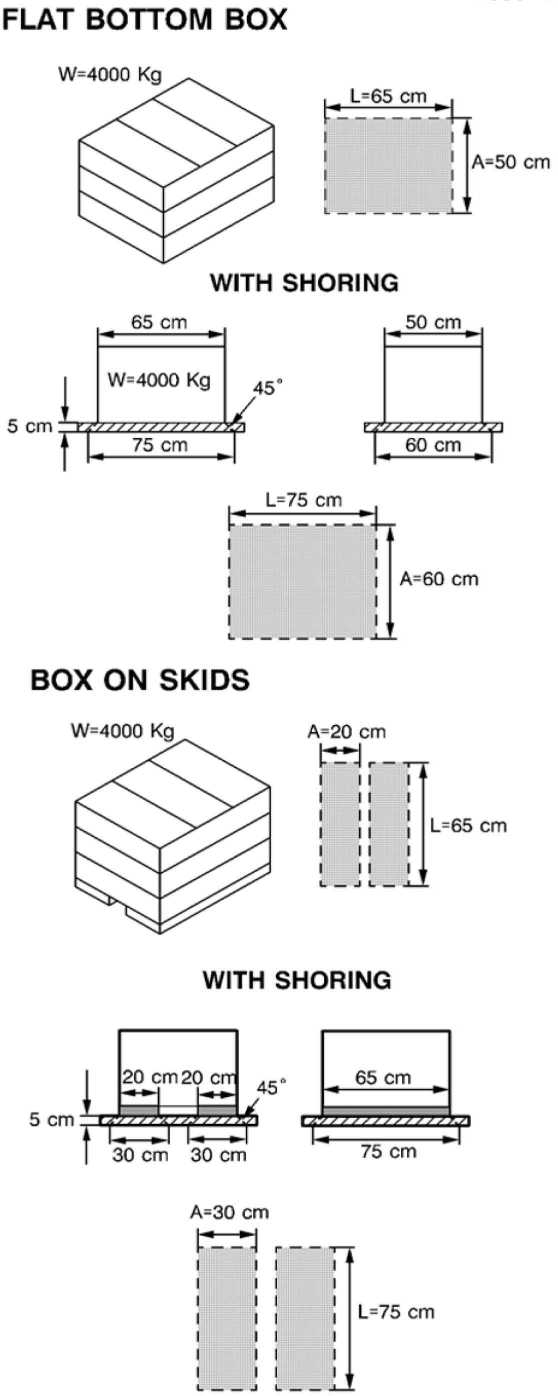


Figure 4-23 Approach shoring

$$\text{PRESSURE} = \frac{\text{WEIGHT (W)}}{\text{SURFACE (S)}}$$



FLAT BOTTOM BOX

S=LxA; S=65x50=3250 cm^2

$P=\frac{W}{S}$; $P=\frac{4000}{3250}$ = 1.23 ROUND OFF= 1.3Kg/cm^2

WITH SHORING

S=LxA; S=75x60=4500 cm^2

$P=\frac{W}{S}$; $P=\frac{4000}{4500}$ = 0.88 ROUND OFF=0.9 Kg/cm^2

BOX ON SKIDS

S=LxAxN° SKIDS; S=65x20x2=2600 cm^2

$P=\frac{W}{S}$; $P=\frac{4000}{2600}$ = 1.53 ROUND OFF=1.6 Kg/cm^2

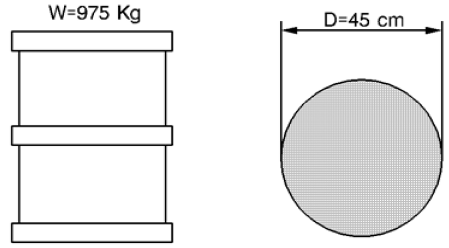
WITH SHORING

S=LxAxN° SKIDS; S=75x30x2=4500 cm^2

$P=\frac{W}{S}$; $P=\frac{4000}{4500}$ = 0.88 ROUND OFF=0.9 Kg/cm^2

Figure 4-24 Calculating contact pressure and shoring effect (Sheet 1 of 2)

FLAT BOTTOM DRUM (CIRCULAR SUPPORT)

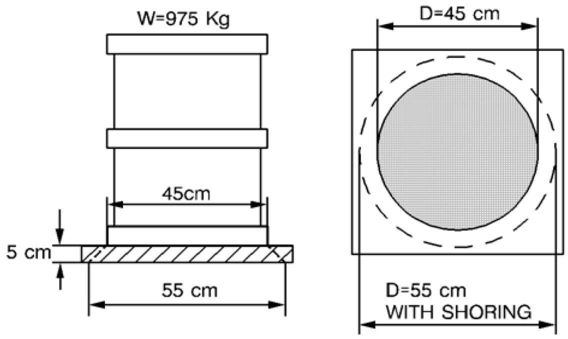


$R=\frac{D}{2}$; $R=\frac{45}{2}=22.5$ cm

$S=\pi \times R^2$; $S=3.14\times(22.5)^2=1589.62$ ROUND OFF=1589 cm^2

$P=\frac{W}{S}$; $P=\frac{975}{1589}=0.61$ ROUND OFF=0.7 Kg/cm^2

WITH SHORING

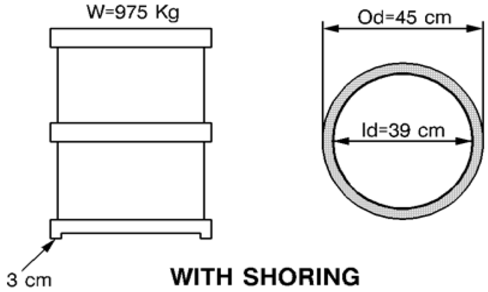


$R=\frac{D}{2}$; $R=\frac{55}{2}=27.5$ cm

$S=\pi \times R^2$; $S=3.14\times(27.5)^2=2374.62$ ROUND OFF=2374 cm^2

$P=\frac{W}{S}$; $P=\frac{975}{2374}=0.41$ ROUND OFF=0.5 Kg/cm^2

DRUM WITH A RING (ANNULUS)

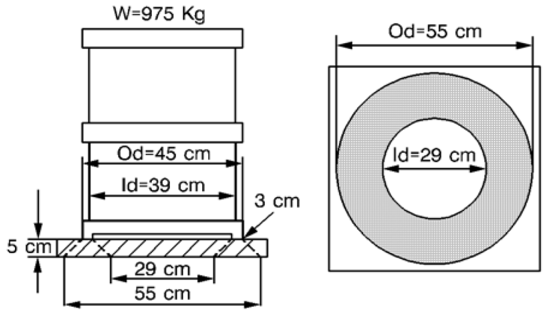


S=(OUTER DIAMETER^2 - INNER DIAMETER^2)x0.785

$S=(45^2-39^2)\times0.785=395.64$ ROUND OFF=395 cm^2

$P=\frac{W}{S}$; $P=\frac{975}{395}=2.46$ ROUND OFF=2.5 Kg/cm^2

WITH SHORING



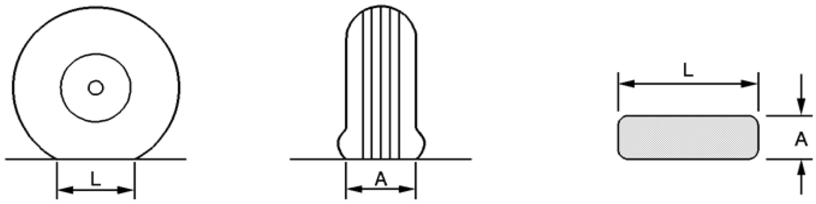
S=(OUTER DIAMETER^2 - INNER DIAMETER^2)x0.785

$S=(55^2-29^2)\times0.785=1714.44$ ROUND OFF=1714 cm^2

$P=\frac{W}{S}$; $P=\frac{975}{1714}=0.56$ ROUND OFF=0.6 Kg/cm^2

Figure 4-24 Calculating contact pressure and shoring effect (Sheet 2 of 2)

CONTACT SURFACE AND WEIGHT PER WHEEL



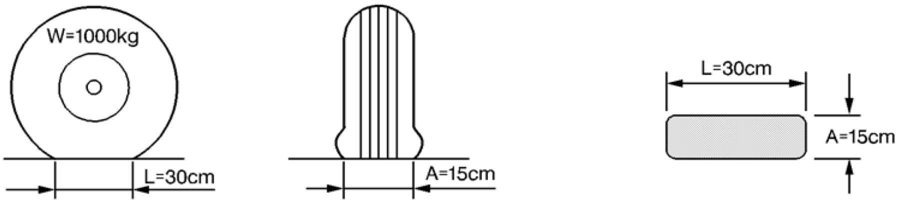
STEP 1: PLACE THE VEHICLE ON A FLAT SURFACE AND MARK WHEEL BORDER, AS SHOWN. MOVE THE VEHICLE.

STEP 2: CONTACT SURFACE WILL HAVE AN ELLIPTICAL SHAPE; MEASURE DIMENSIONS "L" AND "A".

STEP 3: COMPUTE CONTACT SURFACE BY MEANS OF THE FORMULA: S=LxAx0.785.

STEP 4: COMPUTE WEIGHT PER WHEEL: WEIGHT PER WHEEL= $\frac{\text{WEIGHT ON AXLE}}{\text{NUMBER OF WHEELS}}$

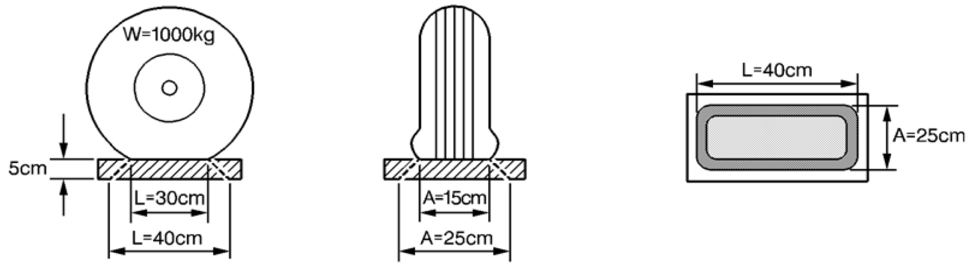
CONTACT PRESSURE WITHOUT SHORING



S= LxAx0.785; S= 30x15x0.785= 353.25 ROUND OFF= 353cm^2

PRESSURE= $\frac{W}{S}$;P= $\frac{1000}{353}$ = 2.83 ROUND OFF= 2.9 Kg/cm^2

CONTACT PRESSURE WITH SHORING



S= LxAx0.785; S= 40x25x0.785= 785cm^2

PRESSURE= $\frac{W}{S}$;P= $\frac{1000}{785}$ = 1.27 ROUND OFF= 1.3 Kg/cm^2

Figure 4-25 Calculating contact pressure and shoring effect on pneumatic tires

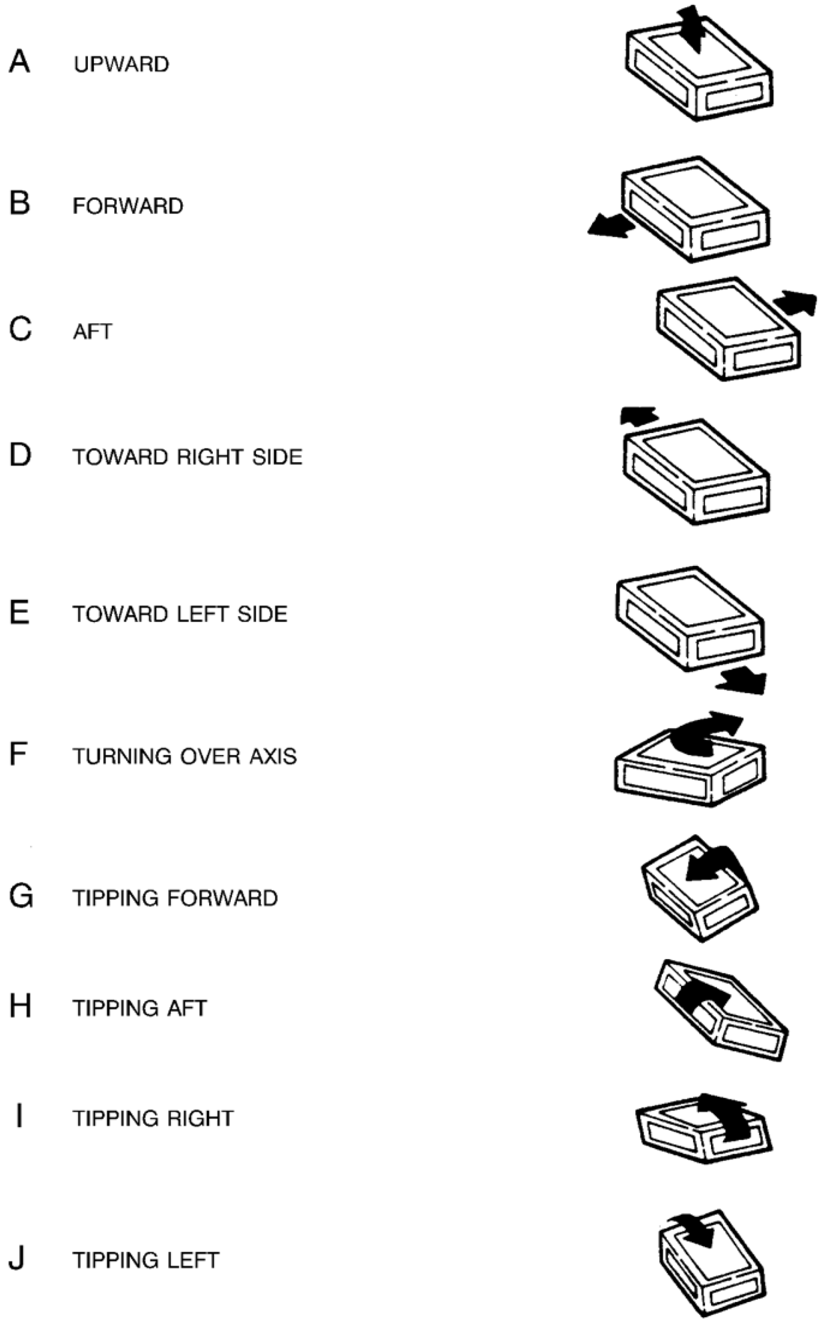


Figure 4-26 Cargo movements to be restrained

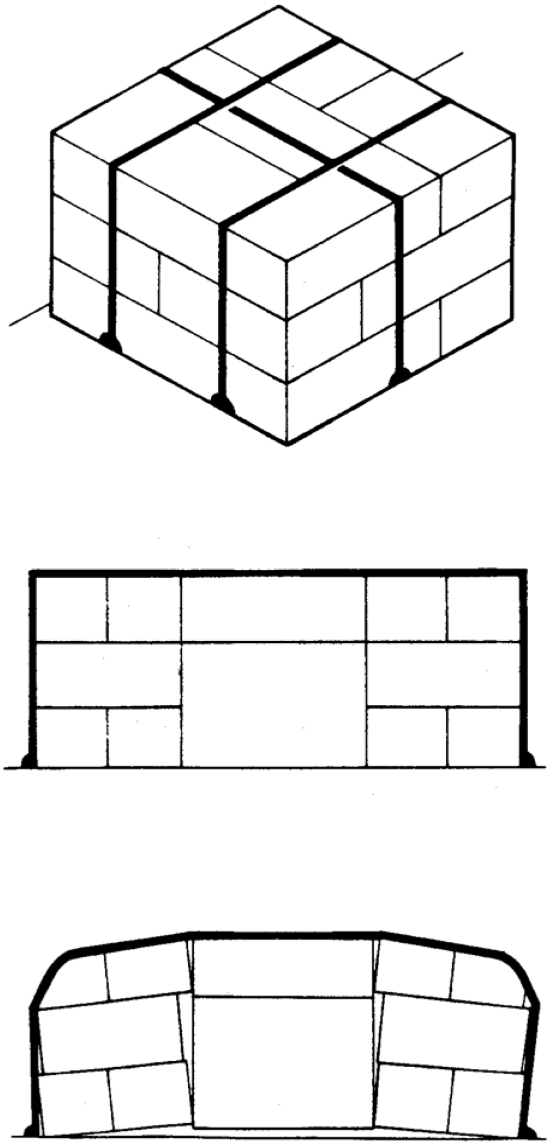


Figure 4-27 Tension on tiedowns

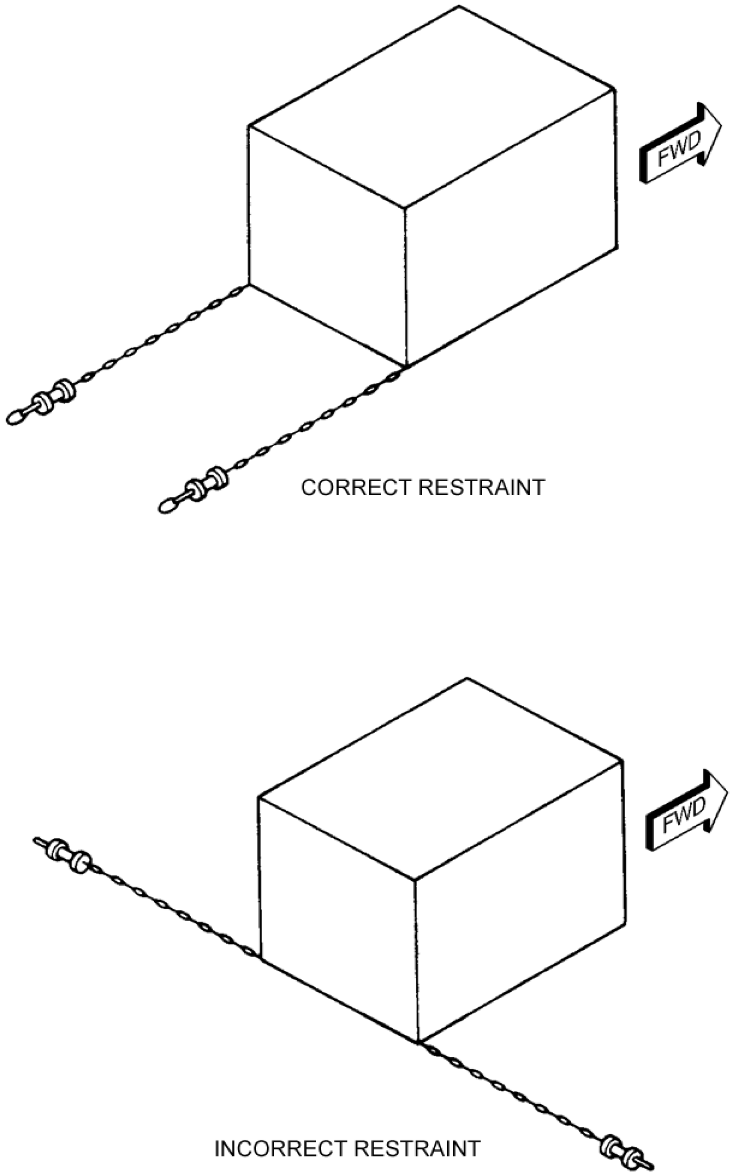


Figure 4-28 Tiedowns in direction of movement

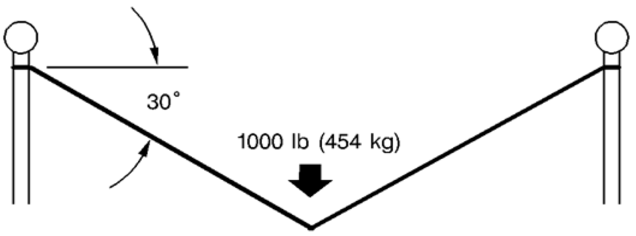
WEBBING STRENGTH 1000 lbs (454 Kg)
ATTACHING - POINT ANGLES 1°

ENGLISH UNITS

MAXIMUM LOAD = 2 x 1000 x sin 1°
= 2 x 1000 x 0.01745 = 34.9 lb

METRIC UNITS

MAXIMUM LOAD = 2 x 454 x sin 1°
= 2 x 454 x 0.01745 = 15.8 Kg



WEBBING STRENGTH 1000 lbs (454 Kg)
ATTACHING - POINT ANGLES 30°

ENGLISH UNITS

MAXIMUM LOAD = 2 x 1000 x sin 30°
=2 x 1000 x 0.5 = 1000lb

METRIC UNITS

MAXIMUM LOAD = 2 x 454 x sin 30°
= 2 x 454 x 0.5 = 454 Kg

Figure 4-29 Restraint depending on angles

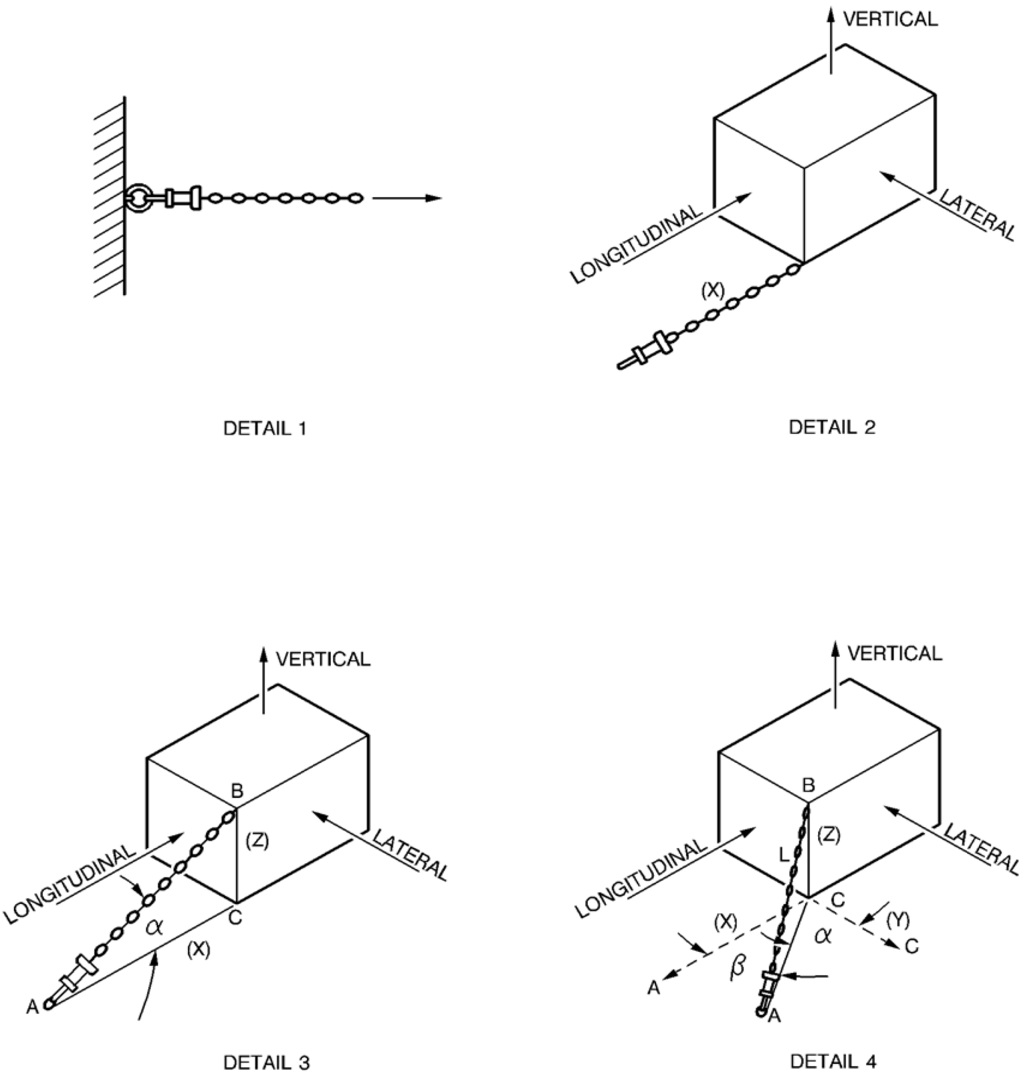


Figure 4-30 Restraint achieved in several directions

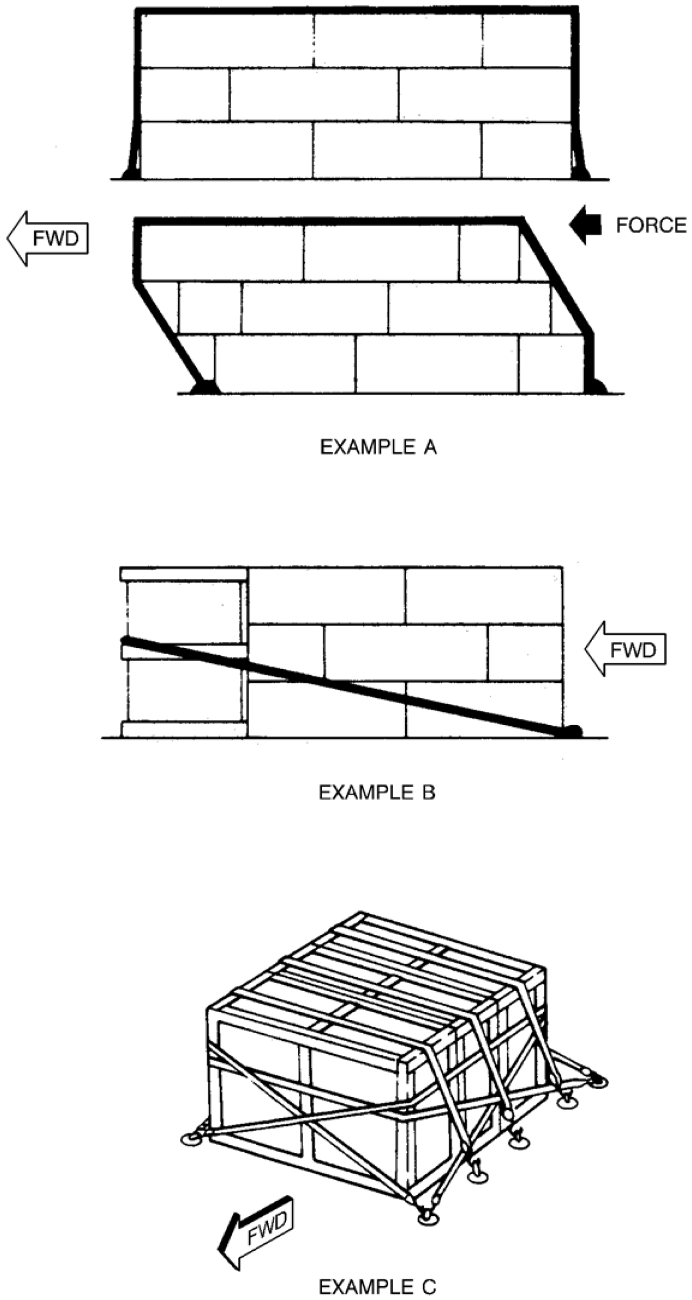


Figure 4-31 Effect of enveloping tiedowns on cargo movement

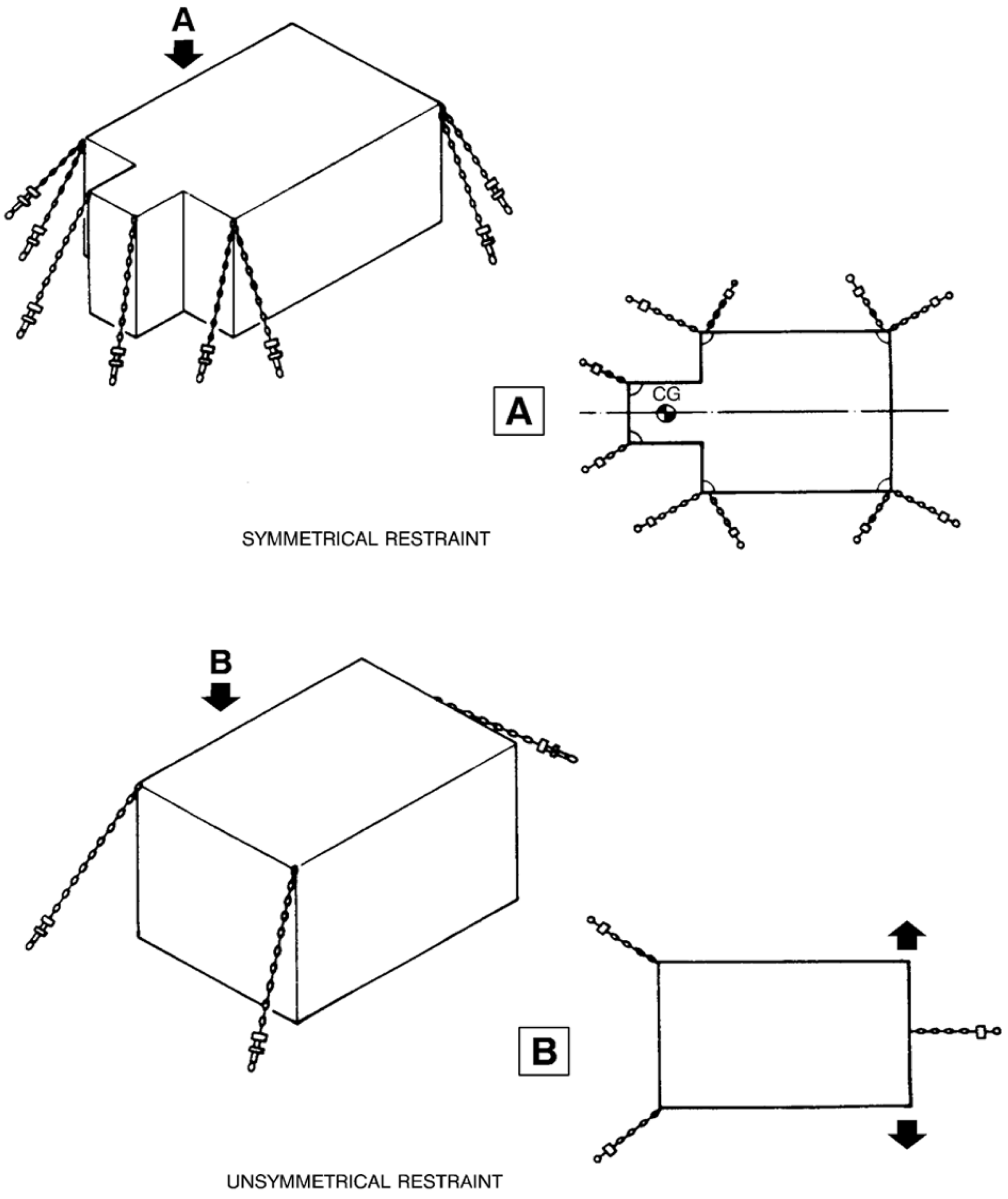


Figure 4-32 Symmetry on tiedown installation

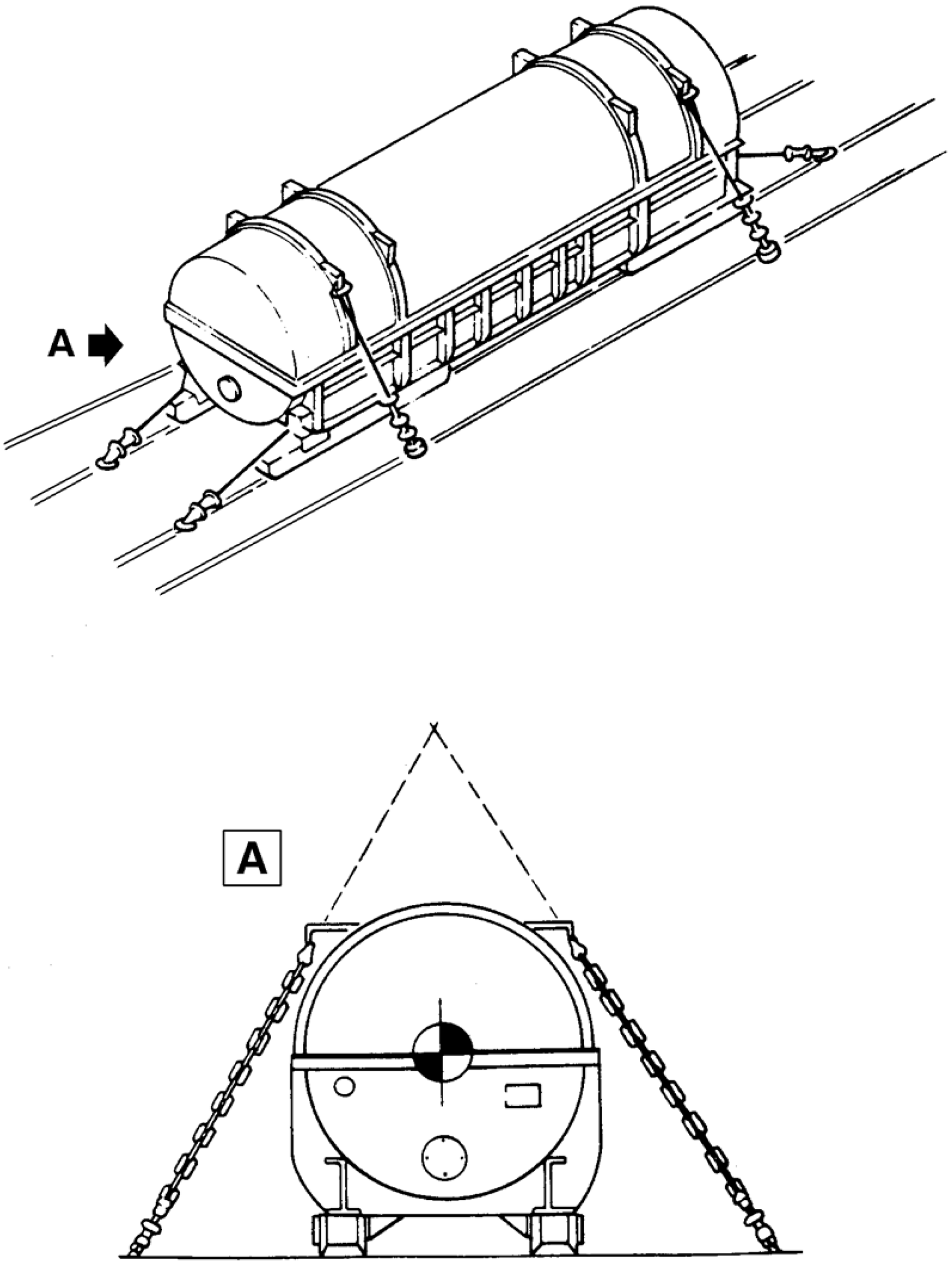
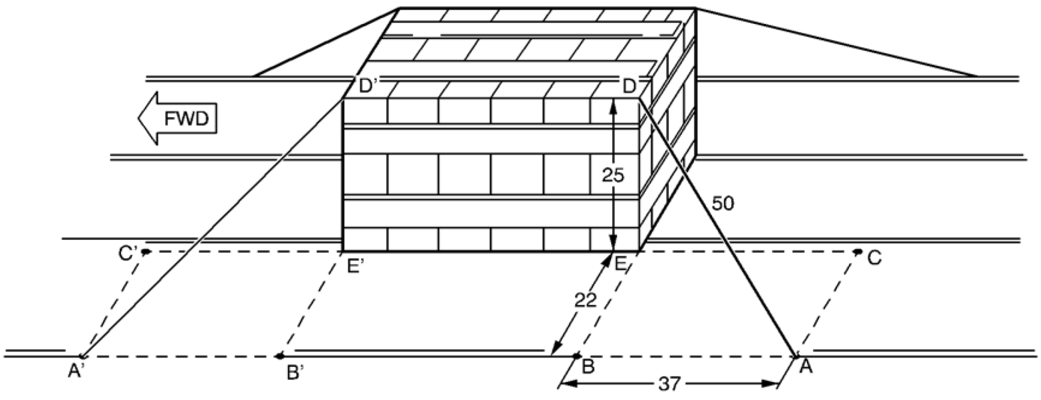


Figure 4-33 Tying down high cargo units



$$\text{RESTRAINT RATIO} = \frac{\text{EFFECTIVE LENGTH}}{\text{TIEDOWN LENGTH}}$$

ACHIEVED RESTRAINT = RESTRAINT RATIO x TIEDOWN STRENGTH

TIEDOWN DEVICES: 10000-POUND STRAPS

1.- LONGITUDINAL RESTRAINT (FORWARD OR AFT)

TIEDOWN LENGTH $\overline{AD}$ = 50; EFFECTIVE LENGTH $\overline{AB}$ = 37

RESTRAINT RATIO = $\frac{37}{50}$ = 0.74; ACHIEVED RESTRAINT = 0.74 x 10000 = 7400 lbs

2.- LATERAL RESTRAINT:

TIEDOWN LENGTH $\overline{AD}$ = 50; EFFECTIVE LENGTH $\overline{EB}$ = 22

RESTRAINT RATIO = $\frac{22}{50}$ = 0.44; ACHIEVED RESTRAINT = 0.44 x 10000 = 4400 lbs

3.- VERTICAL RESTRAINT:

TIEDOWN LENGTH $\overline{AD}$ = 50; EFFECTIVE LENGTH $\overline{ED}$ = 25

RESTRAINT RATIO = $\frac{25}{50}$ = 0.5; ACHIEVED RESTRAINT = 0.5 x 10000 = 5000 lbs

Figure 4-34 Calculating tiedown restraint

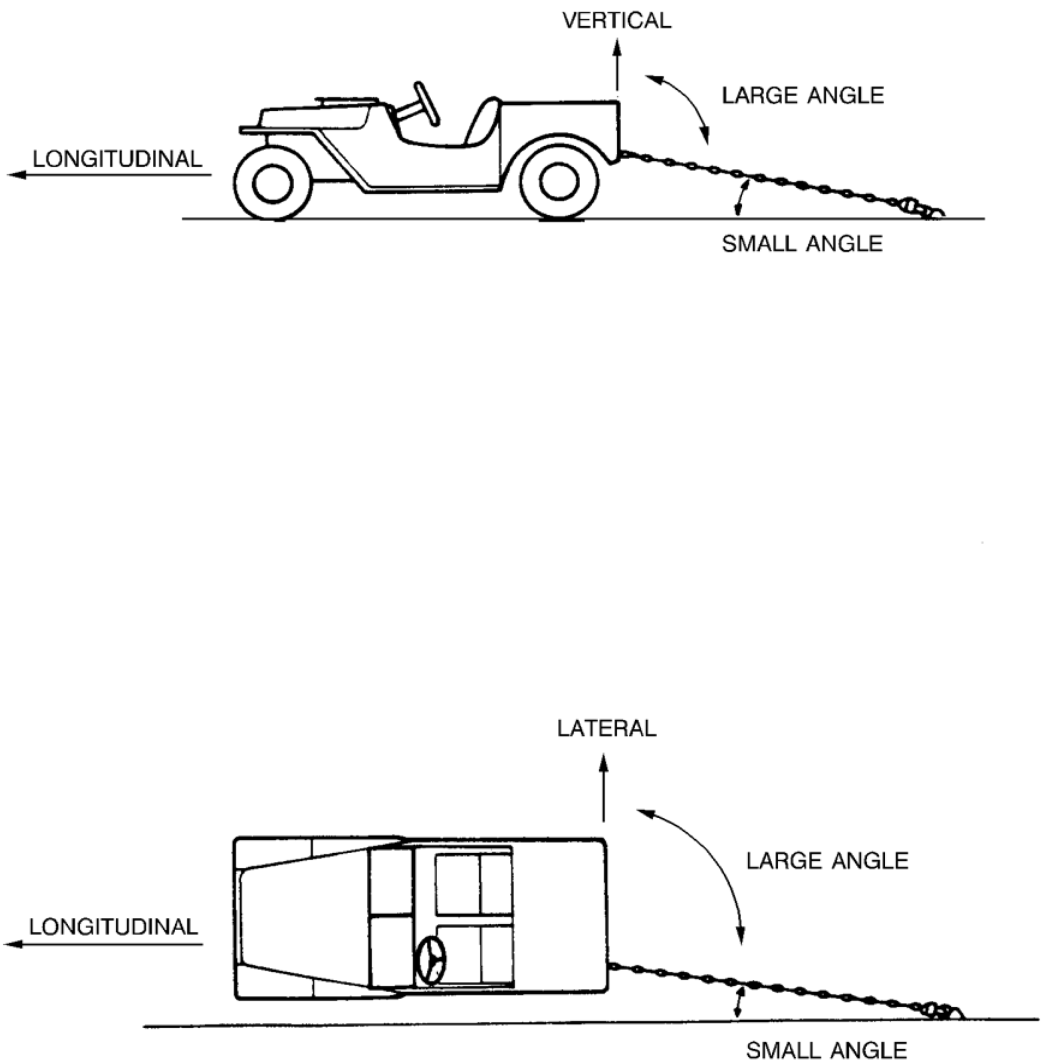


Figure 4-35 Angle effect on cargo restraint

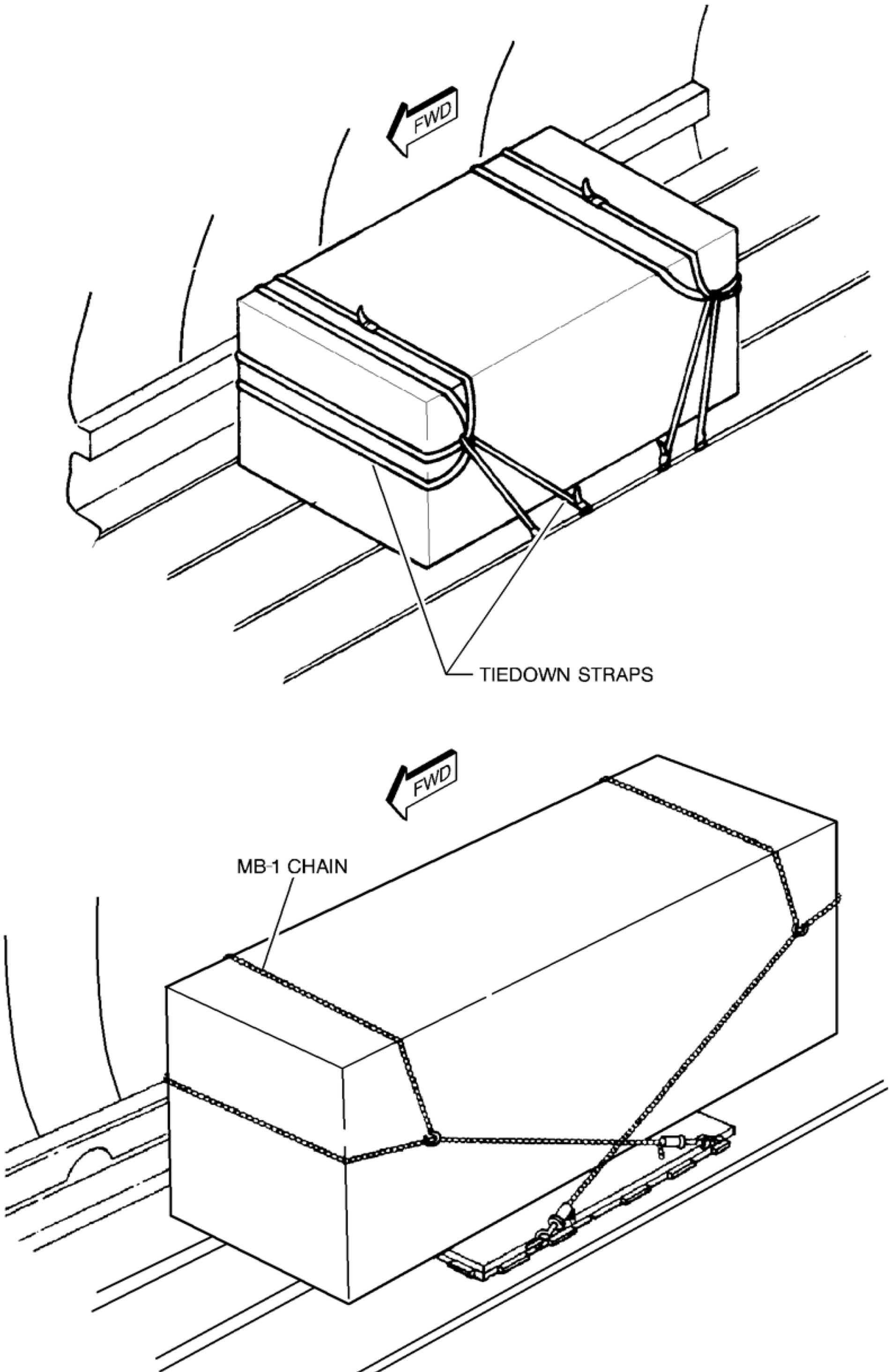


Figure 4-36 Restraint harness

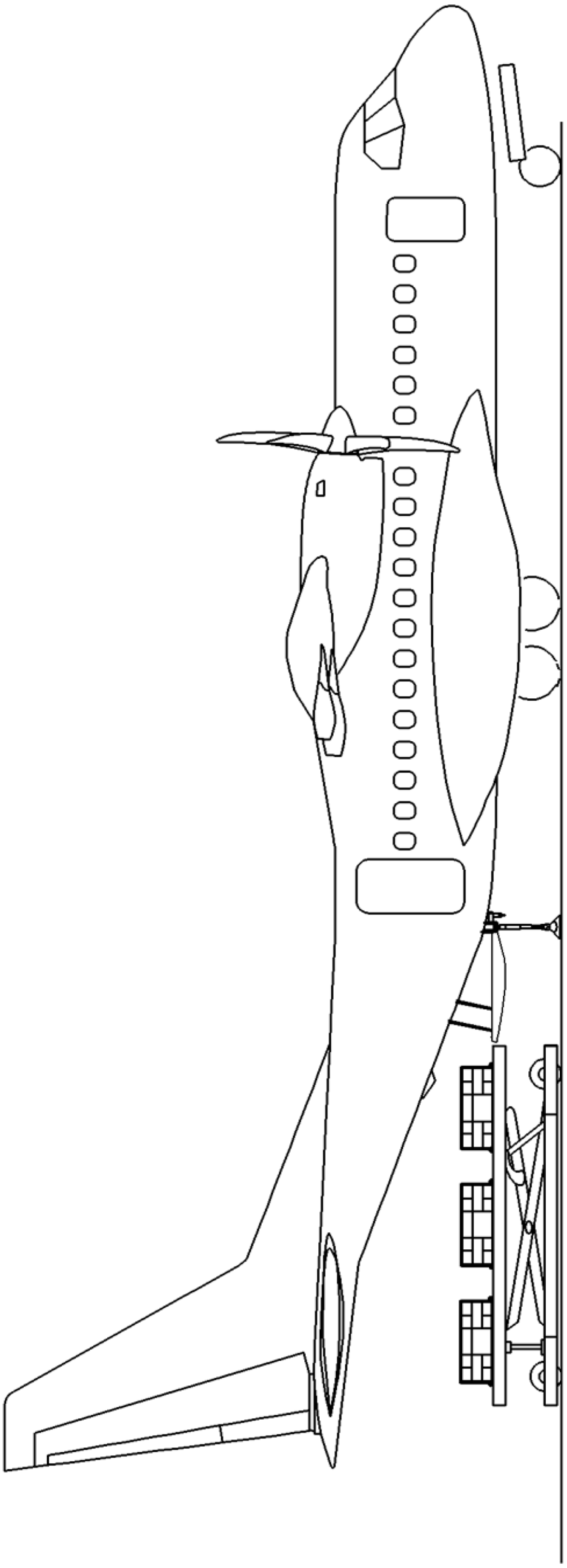


Figure 4-37 Fuselage support with auxiliary loading ramps (Sheet 1 of 3)

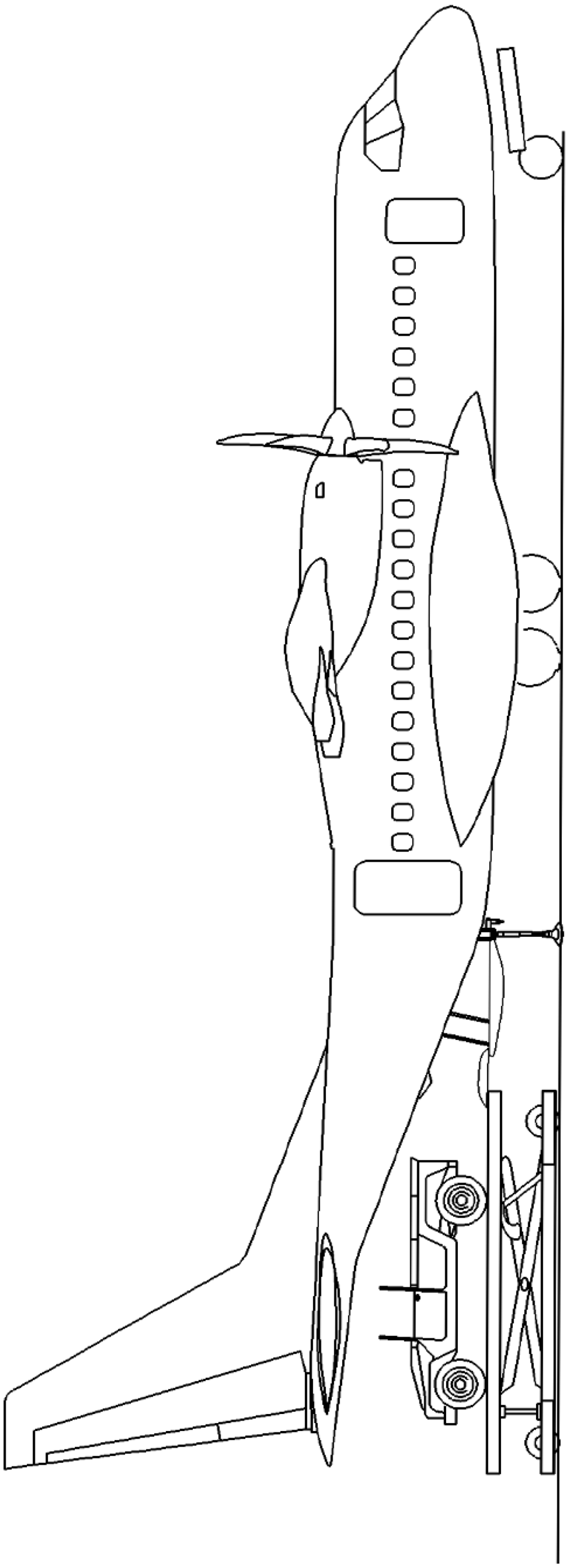


Figure 4-37 Fuselage support with auxiliary loading ramps (Sheet 2 of 3)

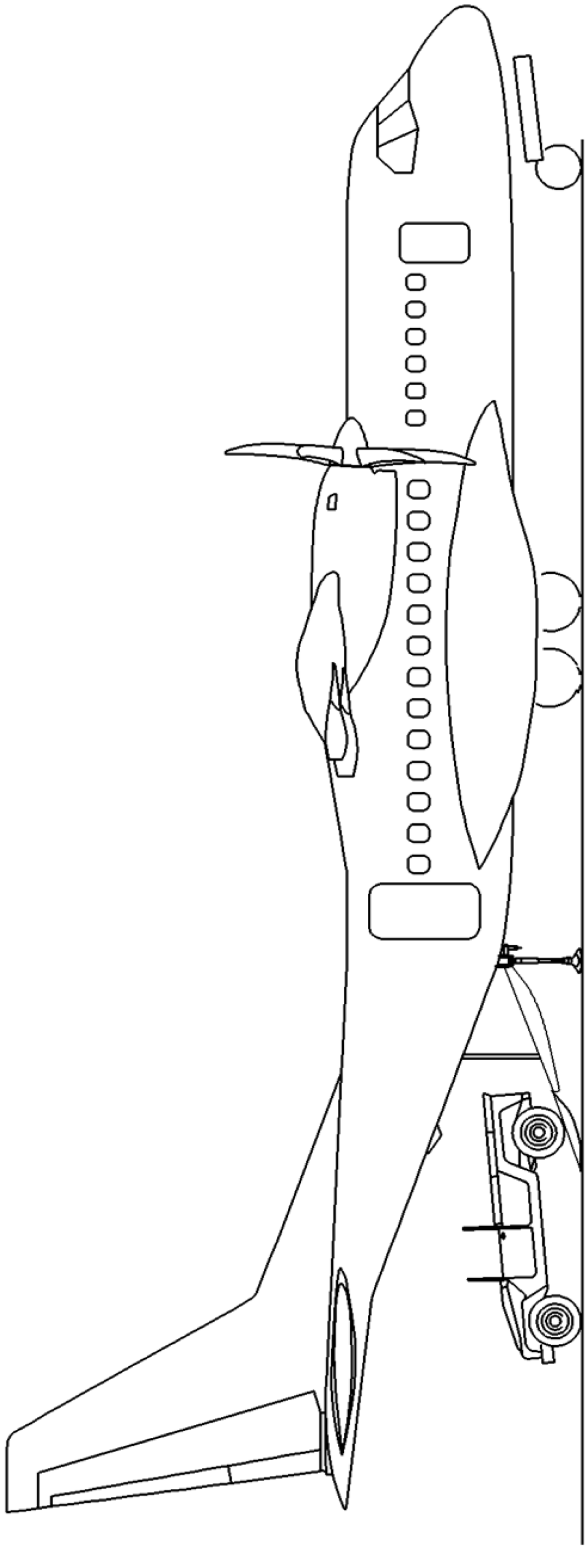


Figure 4-37 Fuselage support with auxiliary loading ramps (Sheet 3 of 3)

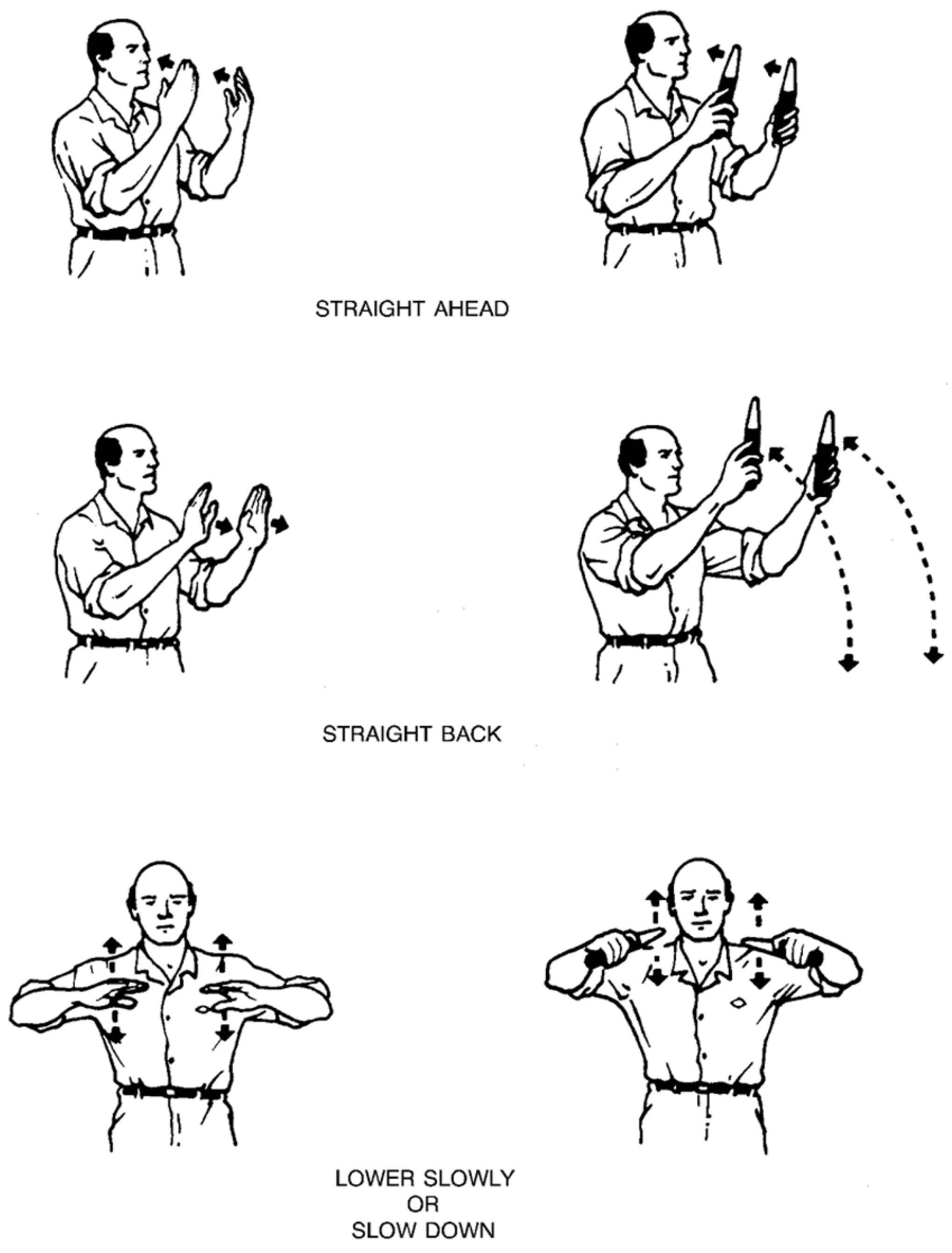


Figure 4-38 Hand signals (Sheet 1 of 2)

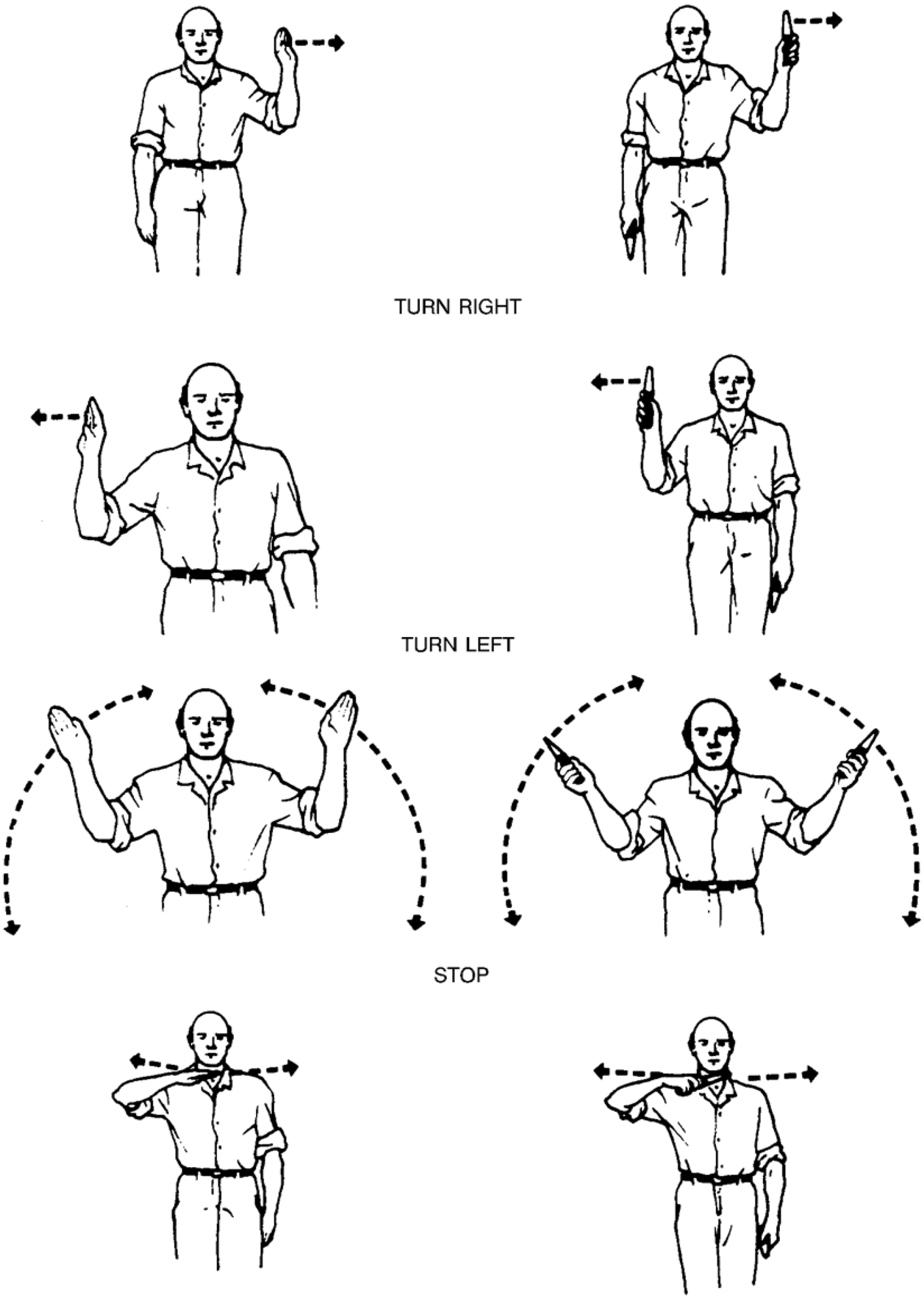
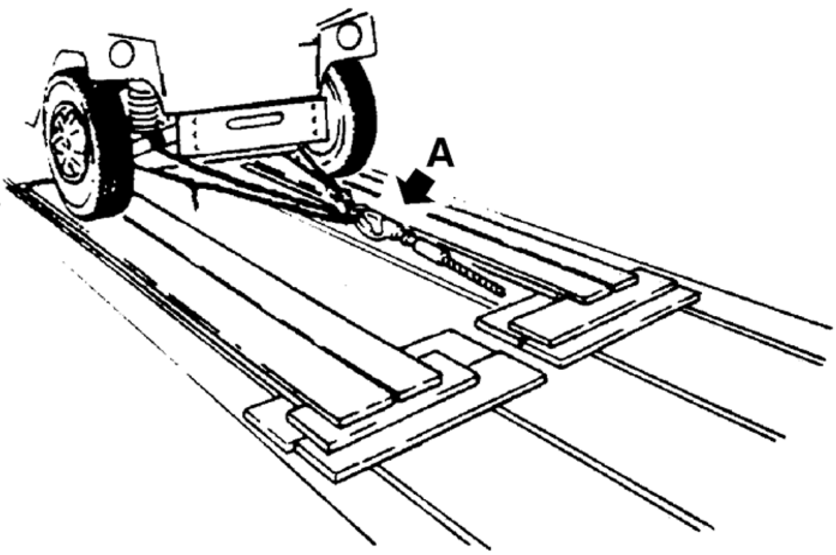
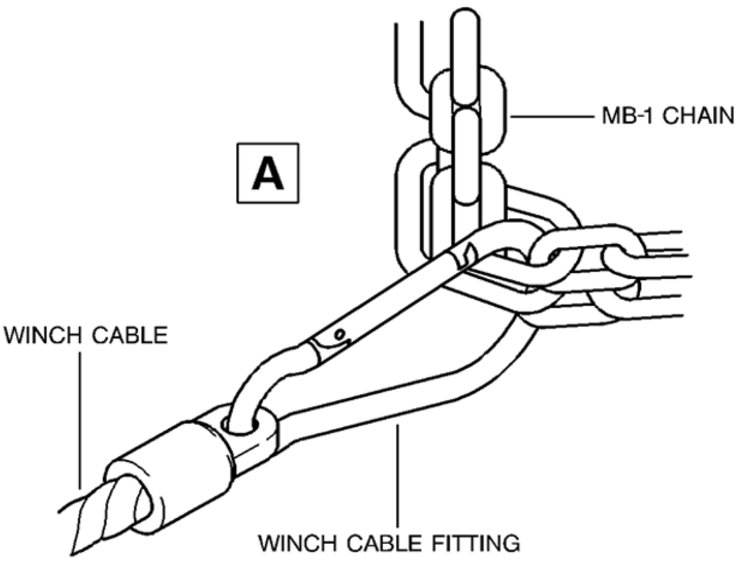


Figure 4-38 Hand signals (Sheet 2 of 2)

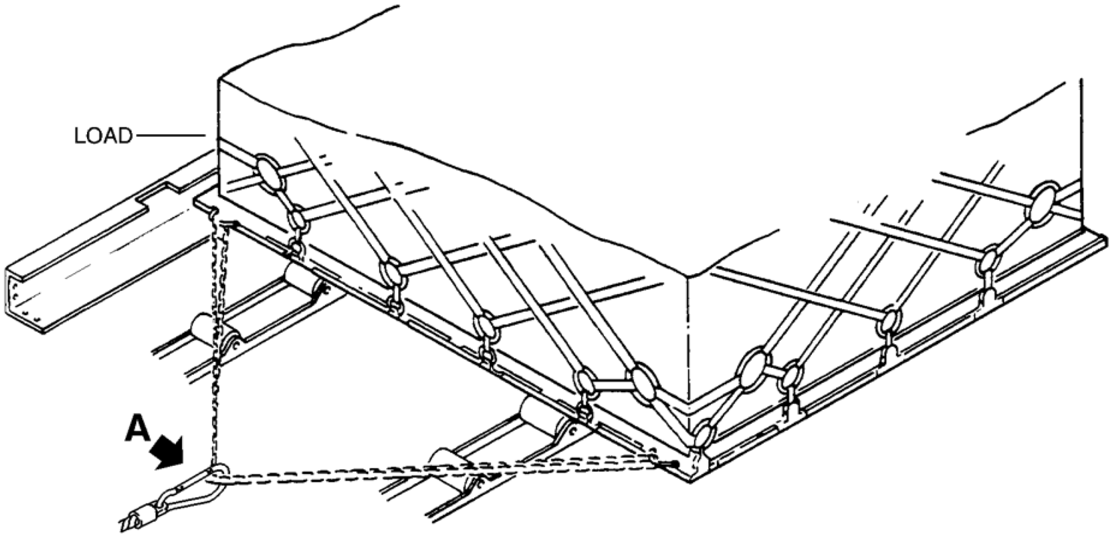


WINCH CABLE ATTACHMENT TO LOAD

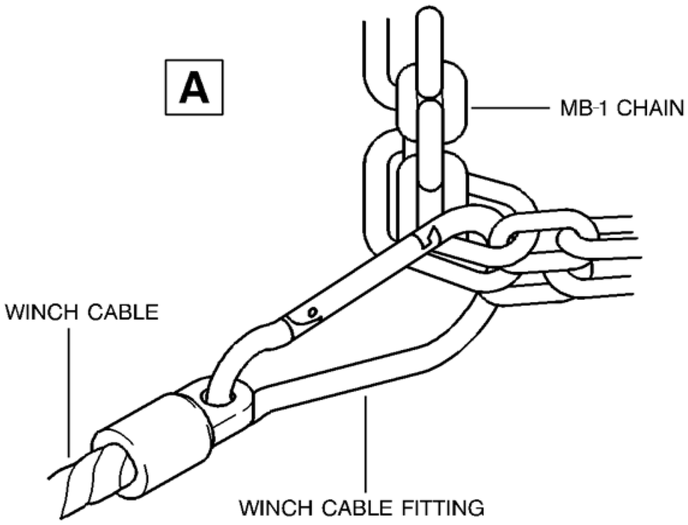


DETAIL OF ATTACHMENT OF WINCH CABLE TO MB-1 CHAIN

Figure 4-39 Attaching winch cable to load



INSTALLATION OF MB-1 CHAIN



DETAIL OF ATTACHMENT OF WINCH CABLE TO MB-1 CHAIN

Figure 4-40 Winching palletized cargo

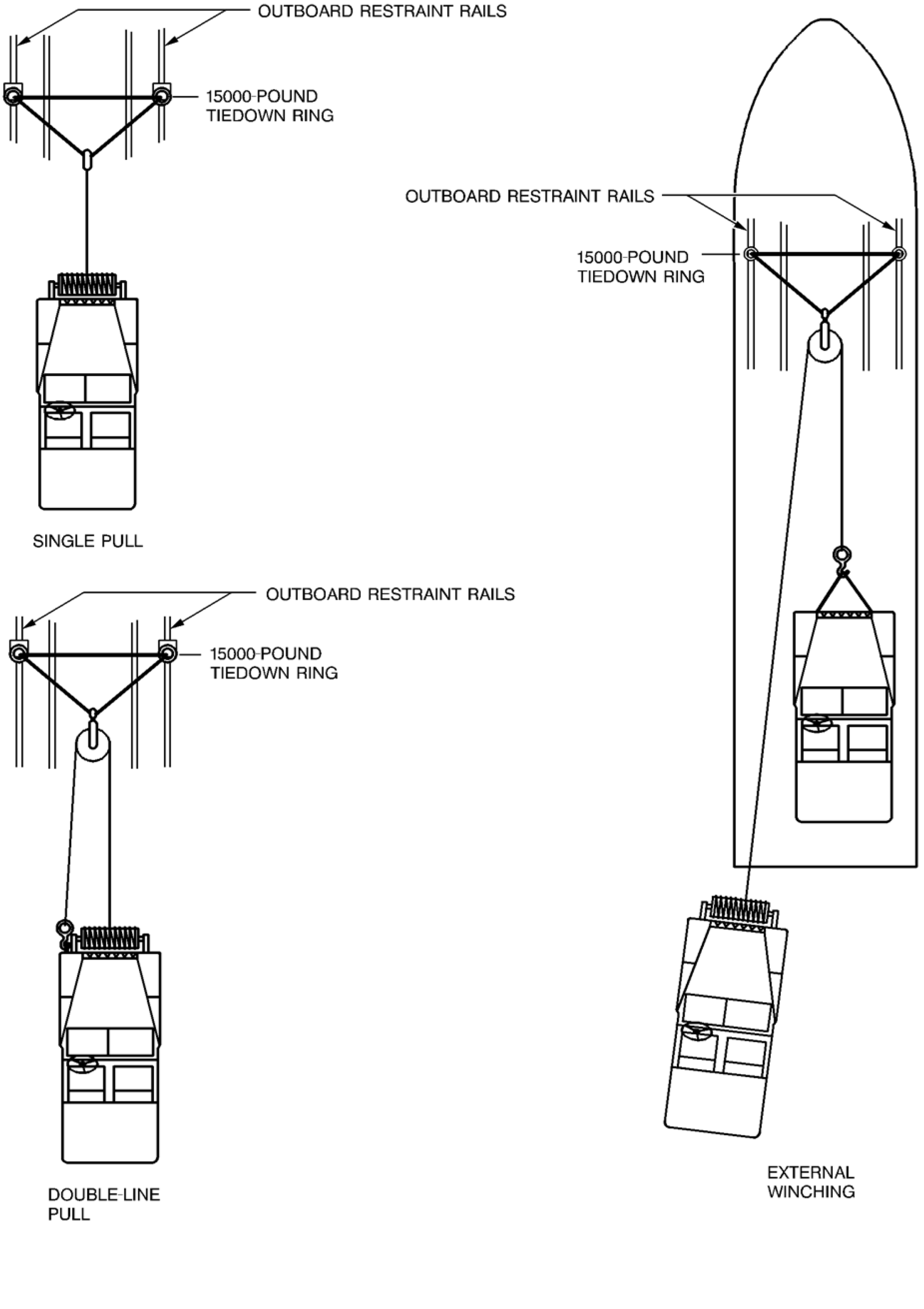


Figure 4-41 External/self-winching

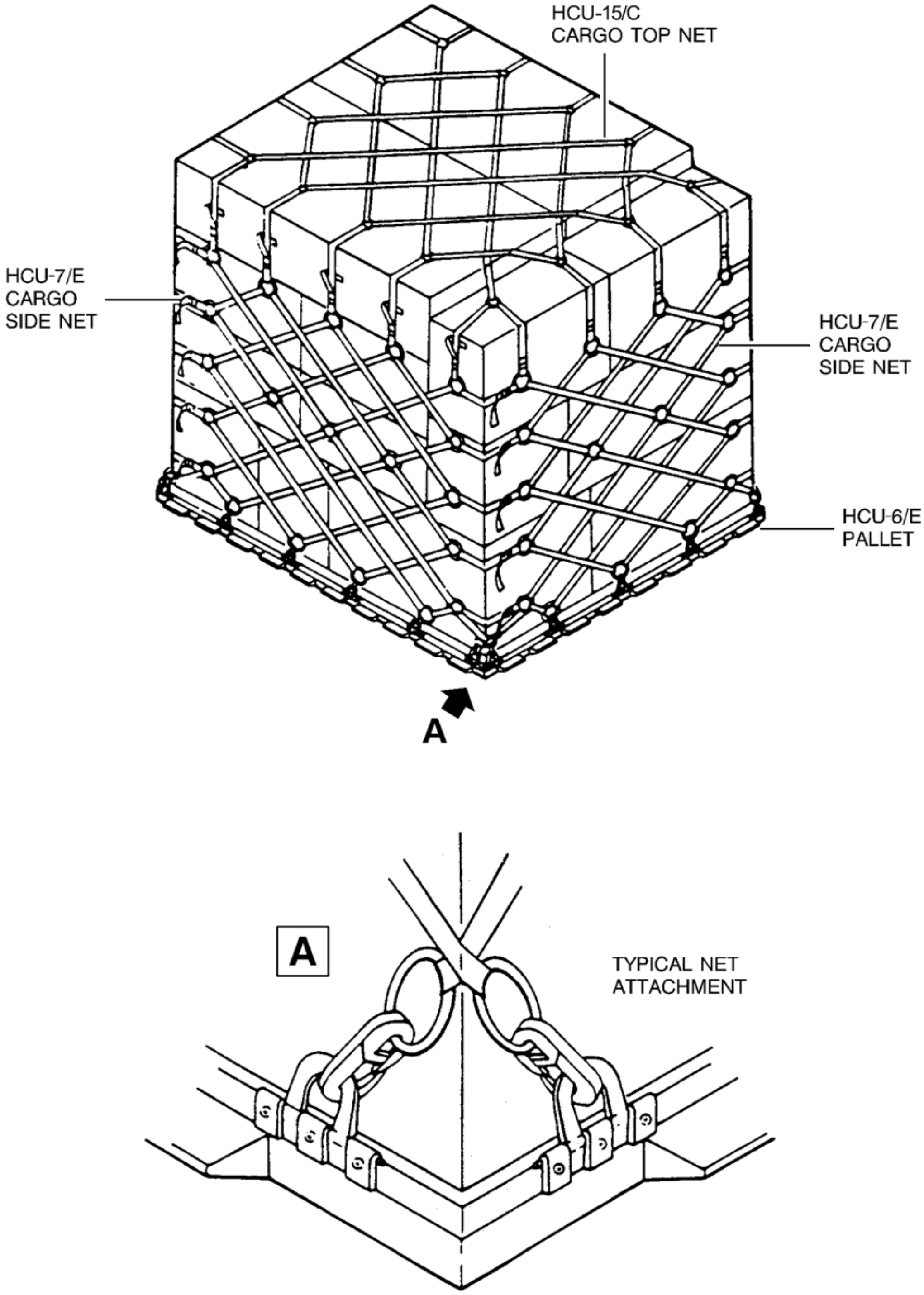
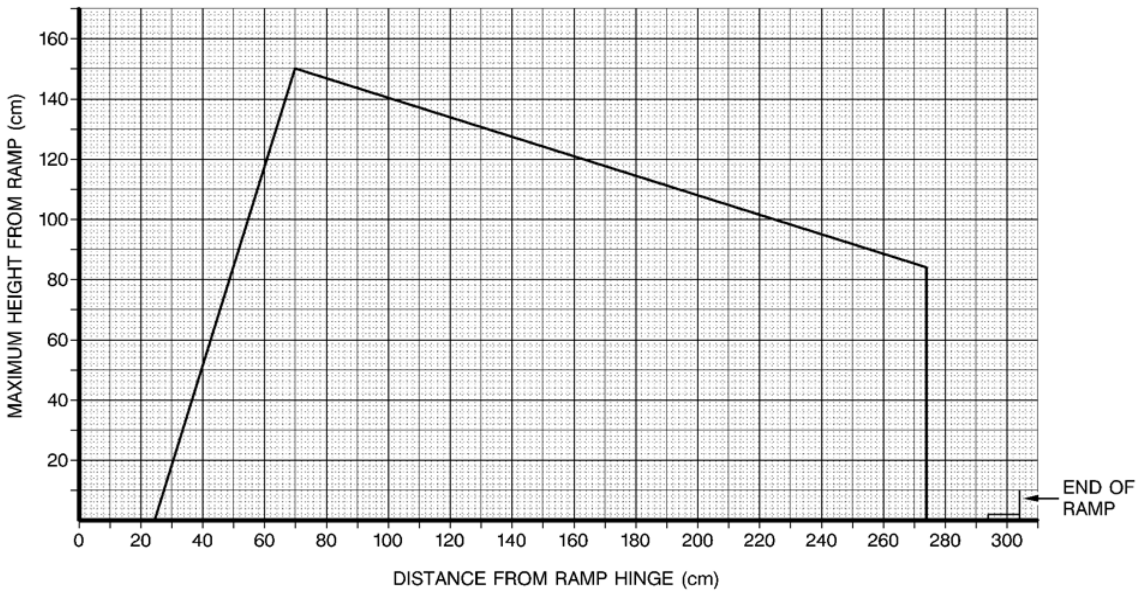


Figure 4-42 Pallet HCU-6/E

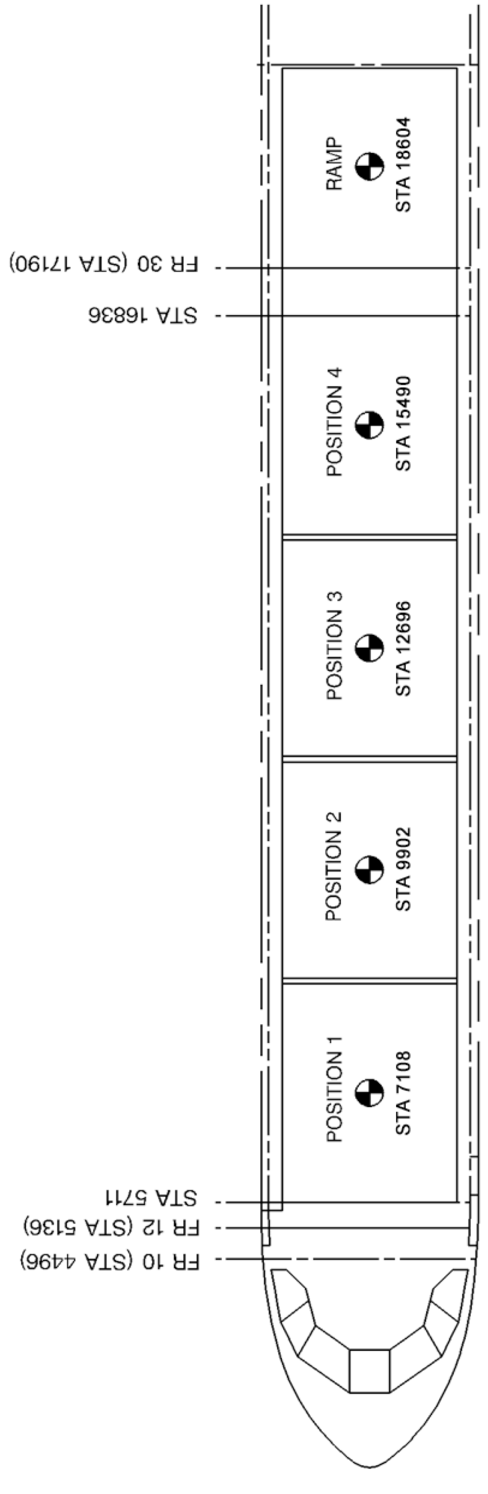


NOTE: DISTANCE FROM RAMP HINGE WITH THE RAMP OPENED, AND MEASURED FROM THE AFT END OF THE CARGO CABIN FLOOR, SO LOAD DOES NOT PROTRUDE INTO THE CARGO CABIN WHEN CLOSING THE RAMP.

NOTE: FOR LOADS ON HCU-6/E PALLETS, SUBTRACT 11 CM FROM HEIGHT READING ON GRAPHIC.

NOTE: FOR LOADS ON THE INTERMEDIATE CONVEYOR TRAYS, SUBTRACT 5 CM FROM HEIGHT READING ON GRAPHIC.

Figure 4-43 Height limitation for loads on the ramp



CENTROIDS NOTED WITH PALLETS IN CENTER POSITION

GAP BETWEEN PALLETS IN CONSECUTIVE POSITIONS 5cm (2 inches)

WITH A COMPLETE LOAD, PALLETS MAY BE LOCKED IN CENTROIDS SHOWN $\pm$ 25.4 (10 inches), EXCEPT RAMP PALLET

WITH A LOAD OF LESS THAN 4 PALLETS ON THE CARGO CABIN, PALLETS MAY BE LOCKED EVERY 25.4 cm (10 inches)

Figure 4-44 Pallet positions

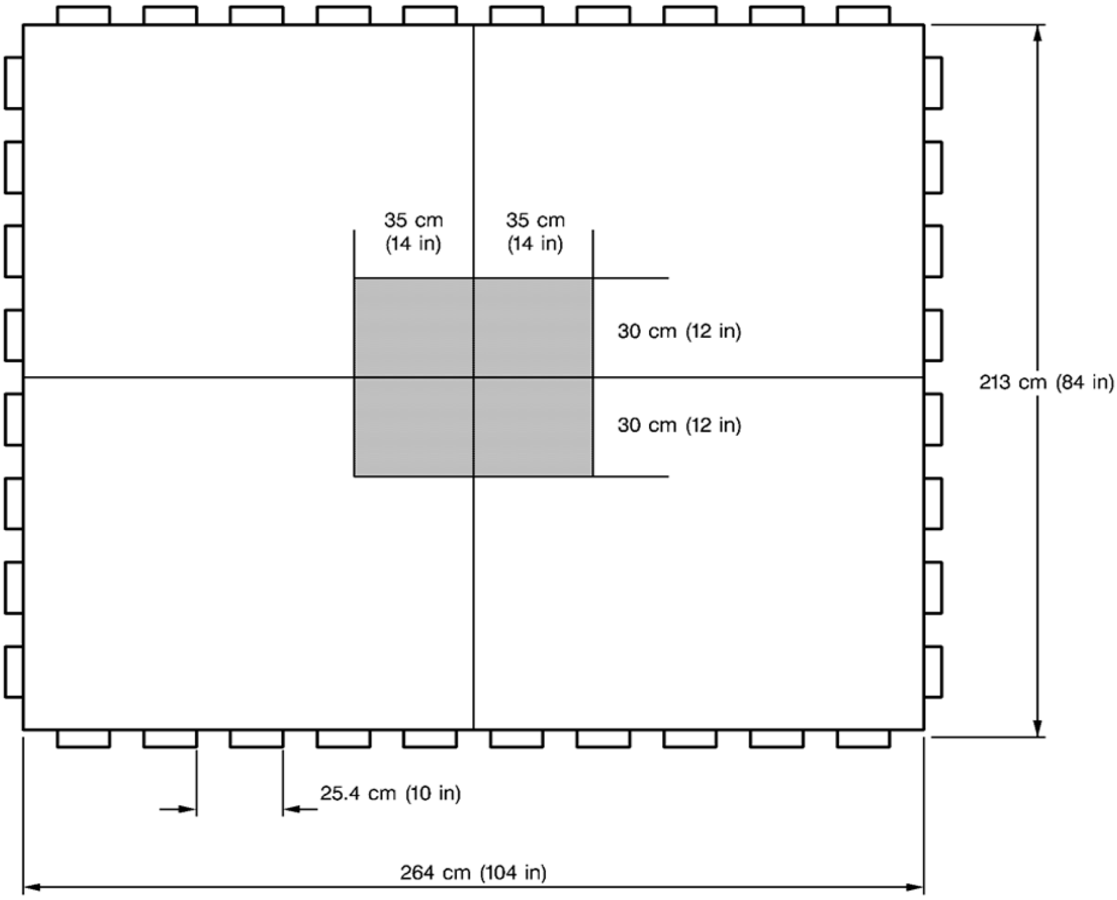


Figure 4-45 Pallet CG position limits

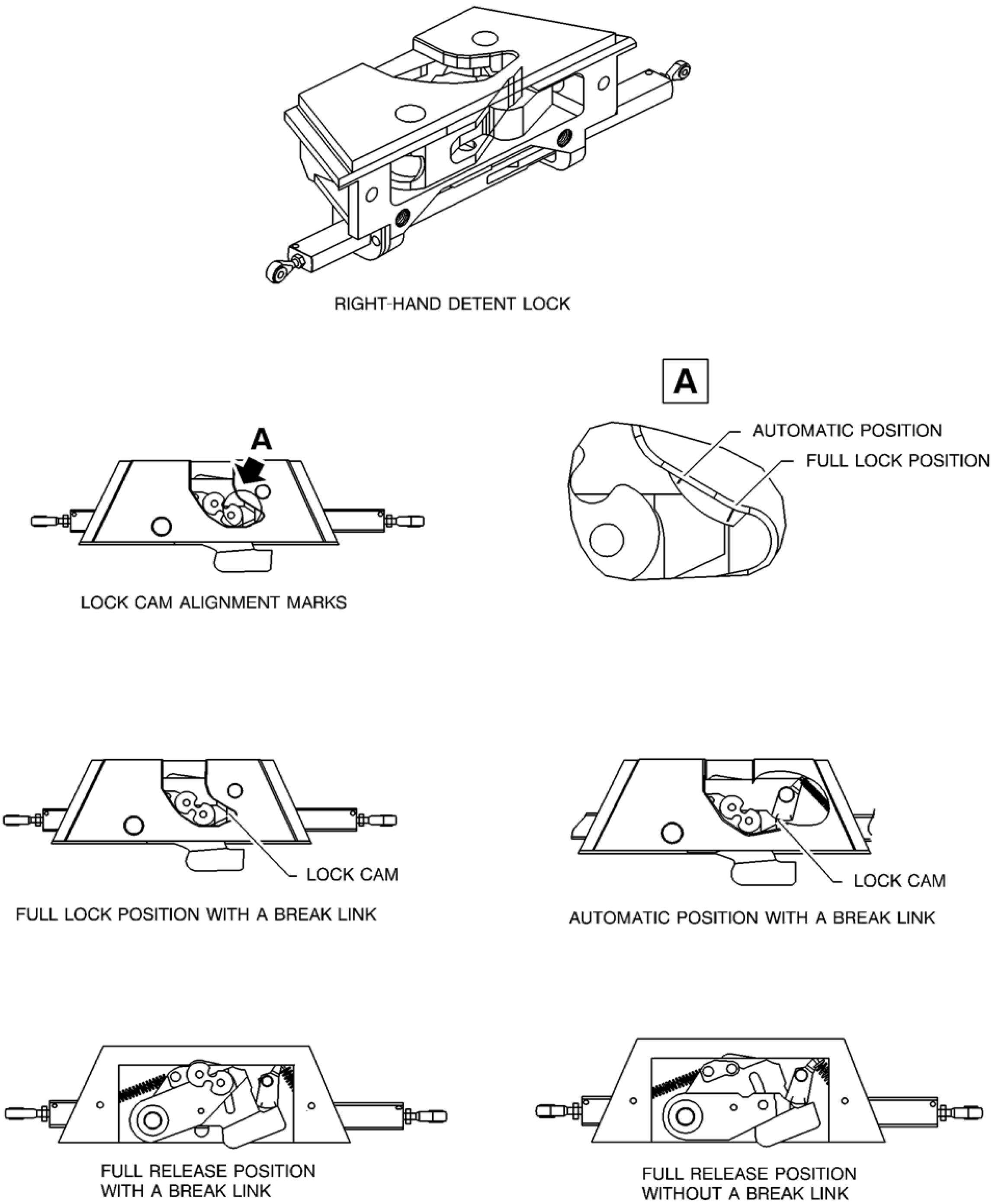


Figure 4-46 Right-hand detent locks

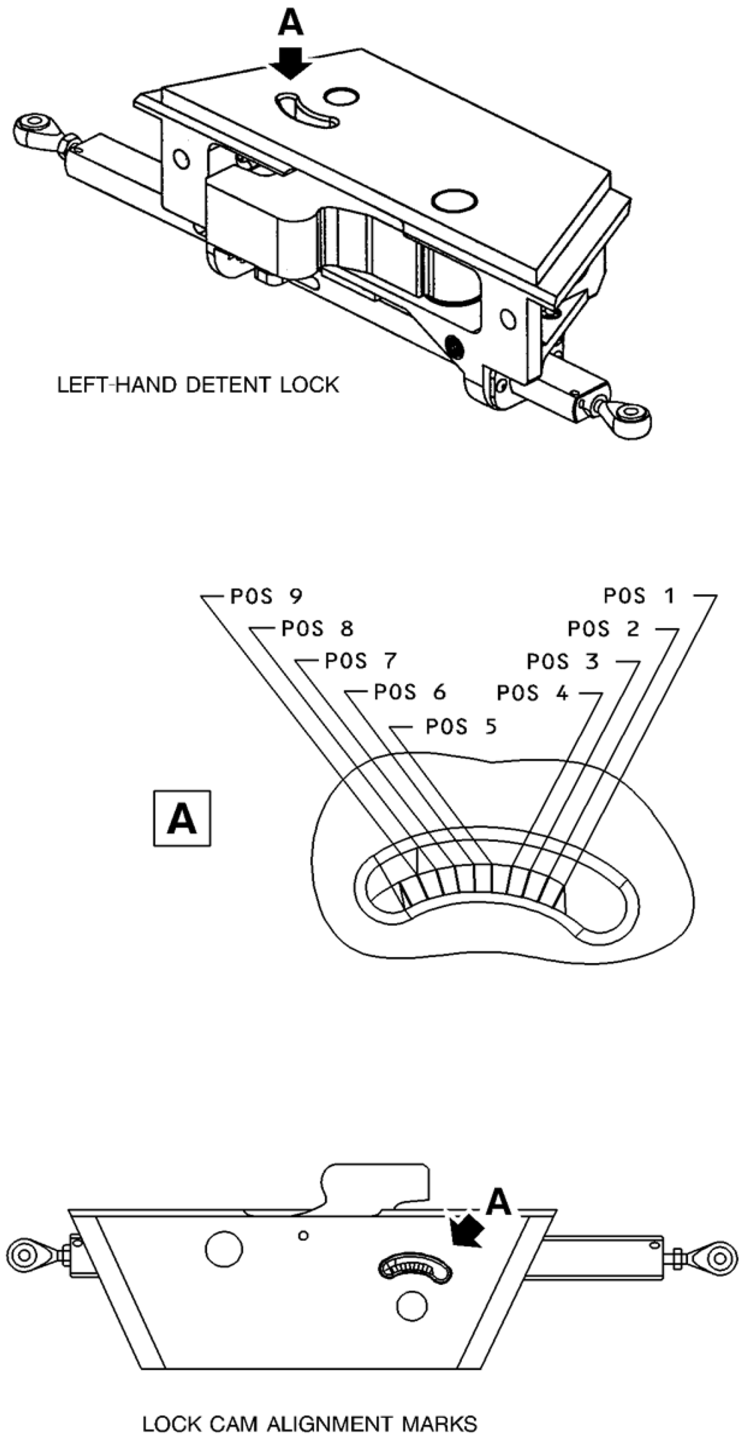


Figure 4-47 Left-hand detent locks