Chapter 9. Packing cargo into CTUs

9.1 Planning of packing

9.1.1 Packers should ensure that:

- The packing process is planned in advance as far as practical;
- Incompatible cargoes are segregated;
- Special handling instructions for certain cargoes are observed;
- The maximum permitted payload is not exceeded;
- Restrictions for concentrated loads are complied with;
- Restrictions for eccentricity of the centre of gravity are complied with;
- The cargo and securing materials complies with the International Standards for Phytosanitary Measures[11] when applicable.

9.1.2 To carry out effective planning, packers should follow the provisions of annex 7, section 1.

9.2 Packing and securing materials

9.2.1 Packers should ensure that securing materials are:

- Strong enough for the intended purpose;
- In good order and condition without tears, fractures or other damages;
- Appropriate to the CTU and goods to be carried;
- In compliance with the International Standards for Phytosanitary Measures No.15[11].

9.2.2 More information on packing and securing materials is provided in annex 7, section 2 and in the appendices to annex 7.

9.3 Principles of packing

9.3.1 Packers should ensure that:

- The load is properly distributed in the CTU;
- Stowage and packing techniques are suitable to the nature of the cargo;
- Operational safety hazards are taken into account.

9.3.2 In order to comply with the obligations in 9.3.1 packers should follow the provisions of annex 7, section 3 and the appendices to annex 7.

9.4 Securing cargo in CTUs

9.4.1 The packers should ensure that:

- Tightly arranged cargoes are so stowed in CTUs that boundaries of the CTU are not overstressed;
- In the case of CTUs with weak or without boundaries sufficient securing forces are produced by the cargo securing arrangement;
- Packages of greater size, mass or shape are individually secured to prevent sliding and, when necessary, tilting;
- The efficiency of the cargo securing arrangement is properly evaluated.

9.4.2 In order to comply with the obligations in 9.4.1 the packer should follow the provisions of annex 7, section 4 and the appendices to annex 7.

9.4.3 Additional advice for the evaluation for certain cargo securing arrangements may be found in annex 7, appendix 4.

[11] International Standards for Phytosanitary Measures, No. 15 Regulation of wood packaging material in international trade, 2009 (ISPM 15).

2.4 Lashing materials and arrangements

2.4.1 Lashings transfer tensile forces. The strength of a lashing may be declared by its breaking strength or breaking load (BL). The maximum securing load (MSL) is a specified proportion of the breaking strength and denotes the force that should not be exceeded in securing service. The term lashing capacity (LC), used in national and regional standards, corresponds to the MSL. Values for BL, MSL or LC are indicated in units of force, i.e. kilonewton (kN) or dekanewton (daN).

2.4.2 The relation between MSL and the breaking strength is shown in the table below. The figures are consistent with Annex 13 of the IMO Code of Safe Practice for Cargo Stowage and Securing. Corresponding relations according to standards may differ slightly.

Material	MSL
shackles, rings, deck eyes, turnbuckles of mild steel	50% of breaking strength
fibre ropes	33% of breaking strength
web lashings (single use)	75% of breaking strength[1]
web lashings (reusable)	50% of breaking strength
wire ropes (single use)	80% of breaking strength
wire ropes (reusable)	30% of breaking strength
steel band (single use)	70% of breaking strength[2]
chains	50% of breaking strength
[1] Maximum allowed elongation 9% at MSL.	
[2] It is recommended to use 50%.	

2.4.3 The values of MSL quoted in the table above rely on the material passing over smooth or smoothed edges. Sharp edges and corners will substantially reduce these values. Wherever possible or practicable, appropriate edge protectors should be used (see figures 7.11 and 7.12).

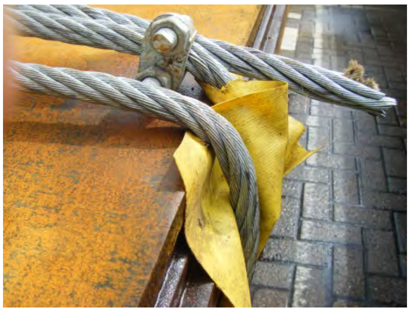


Figure 7.11 Poor edge protection

Figure 7.12 Edge protectors

2.4.4 Lashings transfer forces under a certain elastic elongation only. They act like a spring. If loaded more than the specific MSL, elongation may become permanent and the lashing will fall slack. New wire and fibre ropes or lashings may show some permanent elongation until gaining the desired elasticity after repeated re-tensioning. Lashings should be given a pre-tension, in order to minimize cargo movement. However, the initial pre-tension should never exceed 50% of the MSL.

2.4.5 Fibre ropes of the materials manila, hemp, sisal or manila-sisal-mix and moreover synthetic fibre ropes may be used for lashing purposes. If their MSL is not supplied by the manufacturer or chandler, rules of thumb may be used for estimating the MSL with d = rope diameter in cm:

Natural fibre ropes:	$MSL = 2 \cdot d^2$ [kN]
Polypropylene ropes:	$MSL = 4 \cdot d^2$ [kN]
Polyester ropes:	$MSL = 5 \cdot d^2$ [kN]
Polyamide ropes:	$MSL = 7 \cdot d^2$ [kN]

Composite ropes made of synthetic fibre and integrated soft wire strings provide suitable stiffness for handling, knotting and tightening and less elongation under load. The strength of this rope is only marginally greater than that made of plain synthetic fibre.

2.4.6 There is no strength reduction to fibre ropes due to bends at round corners. Rope lashings should be attached as double, triple or fourfold strings and tensioned by means of wooden turn sticks. Knots should be of a professional type, e.g. bowline knot and double half hitch[3]. Fibre ropes are highly sensitive against chafing at sharp corners or obstructions.

2.4.7 Web lashings may be reusable devices with integrated ratchet tensioner or one-way hardware, available with removable tensioning and lockable devices. The permitted securing load is generally labelled and certified as lashing capacity LC. There is no rule of thumb available for estimating the MSL due to different base materials and fabrication qualities. The fastening of web lashings by means of knots reduces their strength considerably and should therefore not be applied.

2.4.8 The elastic elongation of web lashings, when loaded to their specific MSL should not exceed 9%. Web lashings should be protected against chafing at sharp corners, against mechanical wear and tear in general and against chemical agents like solvents, acids and others.

2.4.9 Wire rope used for lashing purposes in CTUs for sea transport consists of steel wires with a nominal BL of around 1.6 kN/mm^2 and the favourite construction 6 x 19 + 1FC, i.e. 6 strands of 19 wires and 1 fibre core (see figure 7.13). If a certified figure of MSL is not available, the MSL for one-way use may be estimated by MSL = $40 \cdot d^2$ [kN]. Other available lashing wire constructions with a greater number of fibre cores and less metallic cross section have a considerably lesser strength related to the outer diameter. The elastic elongation of a lashing wire rope is about 1.6% when loaded to one-way MSL, but an initial permanent elongation should be expected after the first tensioning, if the wire rope is new.

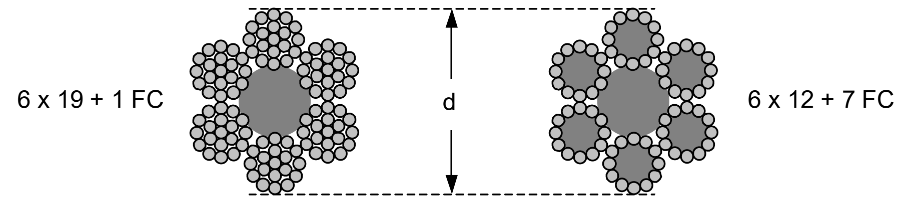


Figure 7.13 Typical lashing wire rope construction

2.4.10 Narrow rounded bends reduce the strength of wire ropes considerably. The residual strength of each part of the rope at the bend depends on the ratio of bend diameter to the rope diameter as shown in the table below.

ratio: bend diameter/rope diameter	1	2	3	4	5
residual strength with rope steady in the bend	65%	76%	85%	93%	100%

Bending a wire rope around sharp corners, like passing it through the edged hole of an eye-plate, reduces its strength even more. The residual MSL after a 180° turn through such an eye-plate is only about 25% of the MSL of the plain rope, if steady in the bend.

[3] Knots will reduce the strength of the rope.

2.4.11 Wire rope lashings in sea transport are usually assembled by means of wire rope clips. It is of utmost importance that these clips are of appropriate size and applied in correct number, direction and tightness. Recommended types of such wire rope lashing assemblies are shown in figure 7.14. A typical improper assembly is shown in figure 7.15.

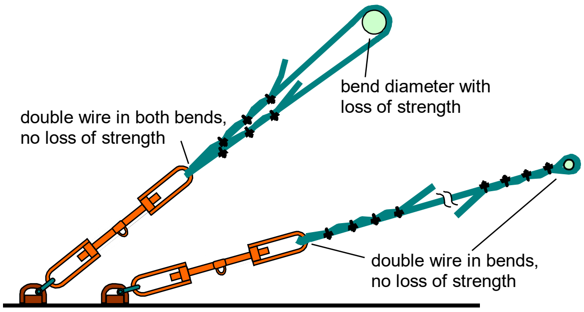


Figure 7.14 Recommended assemblies for wire rope lashing

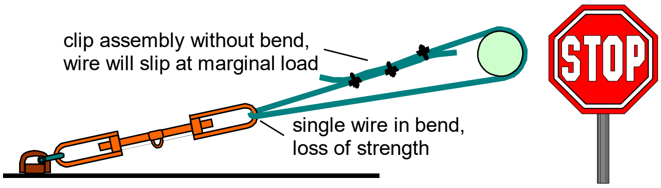


Figure 7.15 Improper assembly for wire rope lashing

2.4.12 Tensioning and joining devices associated with wire rope lashings in sea transport are generally not standardized. The MSL of turnbuckles and lashing shackles should be specified and documented by the manufacturer and at least match the MSL of the wire rope part of the lashing. If manufacturer information is not available, the MSL of turnbuckles and shackles made of ordinary mild steel may be estimated by $MSL = 10 \cdot d^2$ [kN] with d = diameter of thread of turnbuckle or shackle bolt in cm.

2.4.13 Wire rope lashings in road transport are specified as reusable material of distinguished strength in terms of lashing capacity (LC), which should be taken as MSL. Connections elements like shackles, hooks, thimbles, tensioning devices or tension indicators are accordingly standardized by design and strength. The use of wire rope clips for forming soft eyes has not been envisaged. Assembled lashing devices are supplied with a label containing identification and strength data (see figure 7.16). When using such material, the manufacturer's instructions should be observed.

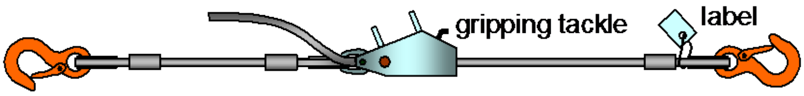


Figure 7.16 Standard wire lashing used in road transport with gripping tackle

2.4.14 Lashing chains used in sea transport are generally long link chains of grade 8 steel. A 13 mm chain of grade 8 steel has a MSL of 100 kN. The MSL for other dimensions and steel qualities should be obtained from the manufacturer's specification. The elastic elongation of the above long link chains is about 1% when loaded to their MSL. Long link chains are sensitive against guiding them around bends of less than about 10 cm radius. The favourite tensioning device is a lever with a so-called climbing hook for re-tightening the lashing during service (see figure 7.17). Manufacturer's instructions and, when existing, national regulations on the use of the tensioning lever and re-tensioning under load should be strictly observed.

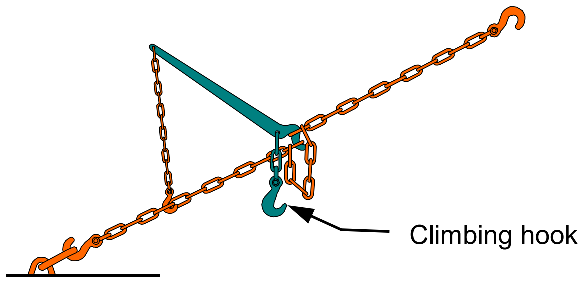


Figure 7.17 Long link lashing chain with lever tensioner

2.4.15 Chain lashings used in road and rail transport according to European standards are mainly short link chains. Long link chains are generally reserved for the transport of logs. Short link chains have an elastic elongation of about 1.5%, when loaded to their MSL. The standard includes various systems of tensioners, specially adapted hooks, damping devices and devices to shorten a chain to the desired loaded length. Chain compound assemblies may be supplied with a label containing identification and strength data (see figure 7.18). Manufacturer's instructions on the use of the equipment should be strictly observed.

Figure 7.18 Standard chain lashing with shortening hook

2.4.16 Steel band for securing purposes is generally made of high tension steel with a normal breaking strength of 0.8 to 1.0 kN/mm^2. Steel bands are most commonly used for unitizing packages to form greater blocks of cargo (see figure 7.19). In sea transport, such steel bands are also used to "tie down" packages to flatracks, platforms or roll-trailers. The bands are tensioned and locked by special manual or pneumatic tools. Subsequent re-tensioning is not possible. The low flexibility of the band material with about 0.3% elongation, when loaded to its MSL, makes steel band sensitive for loosing pre-tension if cargo shrinks or settles down. Therefore, the suitability of steel band for cargo securing is limited and national restrictions on their use in road or rail transport should always be considered. The use of steel bands for lashing purposes should be avoided on open CTUs as a broken lashing could be of great danger if it hangs outside the CTU.

Figure 7.19 Metal ingots unitized by steel banding (securing not completed)

2.4.17 Twisted soft wire should be used for minor securing demands only. The strength of soft wire lashings in terms of MSL is scarcely determinable and their elastic elongation and restoring force is poor.

2.4.18 Modular lashing systems with ready-made web lashings are available in particular for general purpose freight containers, to secure cargo against movement towards the door. The number of lashings should be calculated depending on the mass of the cargo, the MSL of the lashings, the lashing angle, the friction factor, the mode of transport, and the MSL of the lashing points in the freight container.

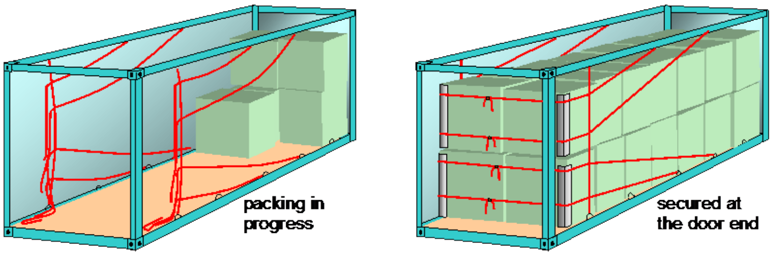


Figure 7.20 Modular lashing system

2.4.19 In the example shown in figure 7.20, the lashings are connected to the lashing points of the CTU with special fittings and are pre-tensioned by means of buckles and a tensioning tool. More information may be obtained from the producers or suppliers of such modular systems.

3 Principles of packing

3.1 Load distribution

3.1.1 Freight containers, flatracks and platforms are designed according to ISO standards, amongst others, in such a way that the permissible payload P, if homogeneously distributed over the entire loading floor, can safely be transferred to the four corner posts under all conditions of carriage. This includes a safety margin for temporary weight increase due to vertical accelerations during a sea passage. When the payload is not homogeneously distributed over the loading floor, the limitations for concentrated loads should be considered. It may be necessary to transfer the weight to the corner posts by supporting the cargo on strong timber or steel beams as appropriate (see figure 7.21).

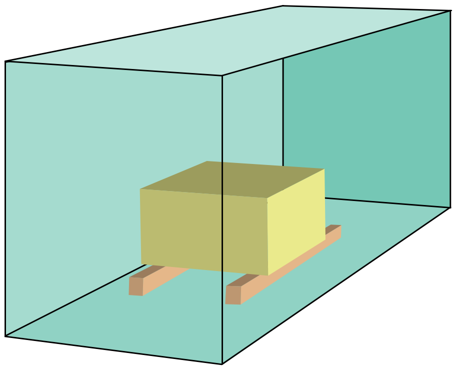


Figure 7.21 Load transfer beams

3.1.2 The bending strength of the beams should be sufficient for the purpose of load transfer of concentrated loads. The arrangement, the required number and the strength of timber beams or steel beams should be designed in consultation with the CTU operator.

3.1.3 Concentrated loads on platforms or flatracks should be similarly expanded by bedding on longitudinal beams or the load should be reduced against the maximum payload. The permissible load should be designed in consultation with the CTU operator.

3.1.4 Where freight containers, including flatracks or platforms, will be lifted and handled in a level state during transport, the cargo should be so arranged and secured in the freight container that its joint centre of gravity is close to the mid-length and mid-width of the freight container. The eccentricity of the centre of gravity of the cargo should not exceed ±5% in general. As a rule of thumb this can be taken as 60% of the cargo's total mass in 50% of the freight container's length. Under particular circumstances an eccentricity of up to ±10% could be accepted, as advanced spreaders for handling freight containers are capable of adjusting for such eccentricity. The precise longitudinal position of the centre of gravity of the cargo may be determined by calculation (see appendix 4 to this annex).

3.3.5 If CTUs are to be packed with forklift trucks from the side, significant lateral impact forces to the CTU should be avoided. Such lateral forces may occur when packages or overpacks are pushed across the loading area. If, during such operations, there is a risk of turning the CTU over packers may consider packing either from both sides to the centre line of the CTU or by using forklift trucks with higher capacity and long forks, which would permit accurate placement without pushing.

3.3.6 If persons need to access the roof of a CTU, e.g. for filling the CTU with a free-flowing bulk cargo, the load-bearing capability of the roof should be considered. Roofs of freight containers are designed for and tested with a load of 300 kg (660 lbs), which acts uniformly on an area of 600 x 300 mm (24 x 12 inches) in the weakest region of the roof (reference: CSC, Annex II). Practically, no more than two persons should work on a freight container roof simultaneously.

3.3.7 When loading or unloading heavy parcels with C-hooks through doors or from the sides of a CTU, care should be taken, that the transverse or longitudinal girders of the roof or side walls are struck neither by the hook nor the cargo. The movement of the unit should be controlled by appropriate means, e.g. guide ropes. Relevant regulations for the prevention of accidents should be observed.

4 Securing of cargo in CTUs

4.1 Aims and principles of securing

4.1.1 Arrangements or stacks of cargo items should be packed in a way so as not to deform and to remain in place and upright with no tilting by their static friction and by their inherent stability, while packing or unpacking a CTU is in progress. This guarantees the safety of packers before additional securing devices are put in place or after such devices have been removed for unpacking.

4.1.2 During transport the CTU may be subjected to vertical, longitudinal and transverse accelerations, which cause forces to each cargo item, which are proportional to its mass. It should not be assumed, that because a package is heavy, it will not move during transport. The relevant accelerations are outlined in chapter 5 of this Code in units of g, indicating the corresponding forces in units of weight of the distinguished cargo item. These forces may easily exceed the capability of static friction and tilting stability, so that cargo items may slide or tilt over. In addition, the CTU may be simultaneously subjected to temporary vertical accelerations, which cause a weight decrease, thereby reduce the friction and the inherent tilting stability, thus promoting sliding and tipping. Any securing of cargo should aim at the avoidance of such unwanted cargo behaviour. All parts of the cargo should remain in place and neither slide nor tip under the stipulated accelerations of the CTU during the intended route of transport.

4.1.3 Practical securing of cargo may be approached by three distinguished principles, which may be used individually or combined as appropriate:

- Direct securing is effected by the immediate transfer of forces from the cargo to the CTU by means of blocking, lashings, shores or locking devices. The securing capacity is proportional to the MSL of the securing devices;
- Friction securing is achieved by so-called tie-down or top-over lashings which, by their pre-tension, increase the apparent weight of the cargo and thereby the friction to the loading ground and also the tilting stability. The securing effect is proportional to the pre-tension of the lashings. Anti-slip material in the sliding surfaces considerably increases the effect of such lashings;
- Compacting cargo by bundling, strapping or wrapping is an auxiliary measure of securing that should always be combined with measures of direct securing or friction securing.

4.1.4 Lashings used for direct securing will inevitably elongate under external forces, thus permitting the package a degree of movement. To minimize this movement, (horizontal or lateral sliding, tipping or racking) it should be ensured that the:

- Lashing material has appropriate load-deformation characteristics (see section 2.4 of this annex);
- Length of the lashing is kept as short as practicable; and
- Direction of the lashing is as close as possible to the direction of the intended restraining effect.

A good pre-tension in lashings will also contribute to minimizing cargo motions, but the pre-tension should never exceed 50% of the MSL of the lashing. Direct securing by stiff pressure elements (shores or stanchions) or by locking devices (locking cones or twist-locks) will not allow significant cargo motion and should therefore be the preferred method of direct securing.

4.1.5 Lashings used for friction securing should be able to maintain the vital pre-tension for a longer period and should not fall slack from minor settling or shrinking of the cargo. Therefore synthetic fibre web lashings should be preferred to e.g. chains or steel band lashings. The pre-tension of tie-down lashings does in principle not fall under the limitation stated above for direct lashings, but will generally not be greater than 20% of the MSL of the lashing with manually operated tensioners. Care should be taken to establish this pre-tension on both sides of the lashing as far as is practical. For assessing a friction securing arrangement by calculation, the labelled standard pre-tension[4] should be used. If such marking is not available, a rule of thumb value of 10% of the breaking strength of the lashing, but not more than 10 kN, should be used for calculation.

4.1.6 Arrangements of direct securing devices should be homogeneous in a way that each device in the arrangement takes its share of the restraining forces appropriate to its strength. Unavoidable differences in load distribution within complex arrangements may be compensated for by the application of a safety factor. Nevertheless, devices of diverging load-deformation properties should not be placed in parallel, unless used for the distinguishable purposes of sliding prevention and tipping prevention. If, for instance, timber blocking and direct web lashing is used in parallel against sliding, the stiffer timber blocking should be dimensioned so as to resist the expected load alone. This restriction does not apply to the combination of tie-down lashings and e.g. timber blocking.

4.1.7 Any cargo securing measures should be applied in a manner that does not affect, deform or impair the package or the CTU. Permanent securing equipment incorporated into a CTU should be used whenever possible or necessary.

4.1.8 During transport, in particular at suitable occasions of a multimodal transport route, securing arrangements in CTUs should be checked and upgraded if necessary and as far as practicable. This includes re-tightening of lashings and wire rope clips and adjusting of blocking arrangements.

4.2 Tightly arranged cargoes

4.2.1 A vital prerequisite of cargo items for a tight stowage arrangement is their insensibility against mutual physical contact. Cargo parcels in form of cartons, boxes, cases, crates, barrels, drums, bundles, bales, bags, bottles, reels etc. or pallets containing the aforesaid items are usually packed into a CTU in a tight arrangement in order to utilize the cargo space, to prevent cargo items from tumbling around and to enable measures of common securing against transverse and longitudinal movement during transport.

4.2.2 A tight stow of uniform or variable cargo items should be planned and arranged according to principles of good packing practice, in particular observing the advice given in section 3.2 of this annex. If coherence between items or tilting stability of items is poor, additional measures of compacting may be necessary like hooping or strapping batches of cargo items with steel or plastic tape or plastic sheeting. Gaps between cargo items or between cargo and CTU boundaries should be filled as necessary (see subsections 2.3.6 to 2.3.8 of this annex). Direct contact of cargo items with CTU boundaries may require an interlayer of protecting material (see section 2.1 of this annex).

[4] Standard tension force S_{TF} according to EN 12195-2

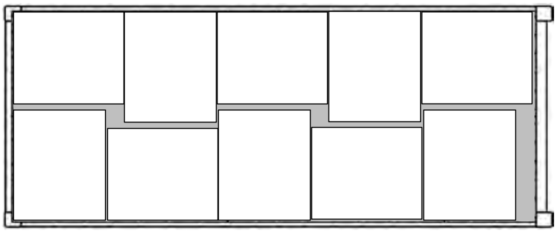


Figure 7.29 Packing 1,000 x 1,200 mm unit loads into a 20-foot container

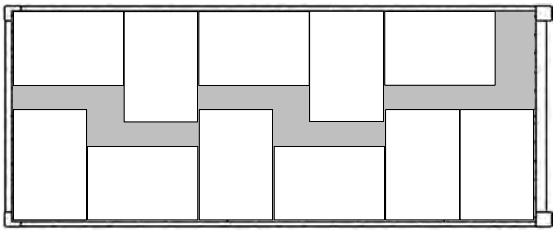


Figure 7.30 Packing 800 x 1,200 mm unit loads into a 20-foot container

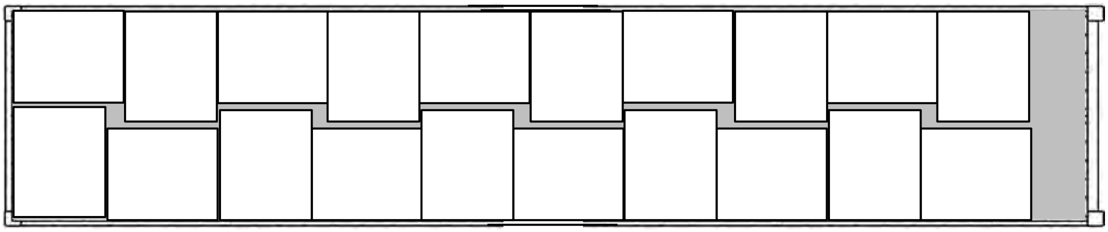


Figure 7.31 Packing 1,000 x 1,200 mm unit loads into a 40-foot container

Note: The void areas (grey shaded) shown in figures 7.29 to 7.31 should be filled when necessary (see subsection 2.3.6 of this annex)

4.2.3 CTUs with strong cargo space boundaries may inherently satisfy transverse and longitudinal securing requirements in many cases, depending on the type of CTU, the intended route of transport and appropriate friction among cargo items and between cargo and stowage ground. The following balance demonstrates the confinement of tightly stowed cargo within strong cargo space boundaries:

$$c_{x,y} \cdot m \cdot g \leq r_{x,y} \cdot P \cdot g + \mu \cdot c_z \cdot m \cdot g \text{ [kN]}$$

$c_{x,y}$ = horizontal acceleration coefficient in the relevant mode of transport (see chapter 5 of this Code)

m = mass of cargo packed [t]

g = gravity acceleration 9.81 m/s^2

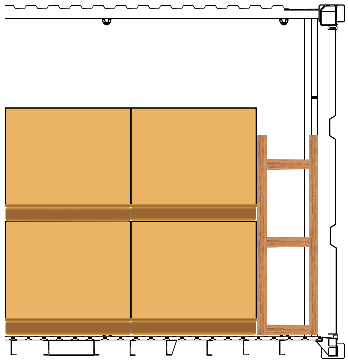
$r_{x,y}$ = CTU wall resistance coefficient (see chapter 6 of this Code)

P = maximum payload of CTU (t)

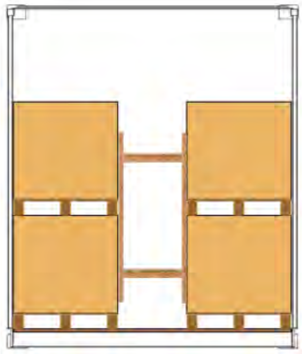
μ = applicable friction factor between cargo and stowage ground (see appendix 2 to this annex)

c_z = vertical acceleration coefficient in the relevant mode of transport (see chapter 5 of this Code)

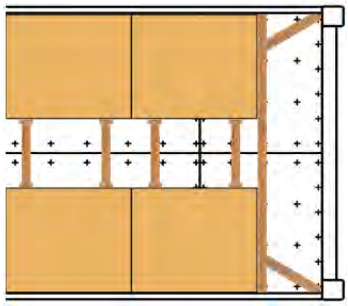
4.2.4 Critical situations may arise, e.g. with a fully packed freight container in road transport, where longitudinal securing should be able to withstand an acceleration of 0.8 g. The longitudinal wall resistance factor of 0.4 should be combined with a friction factor of at least 0.4 for satisfying the securing balance. If a balance cannot be satisfied, the mass of cargo should be reduced or the longitudinal forces transferred to the main structure of the container. The latter can be achieved by intermediate transverse fences of timber battens (see subsection 2.3.4 of this annex) or by other suitable means (see figure 7.32). Another option is the use of friction increasing material.



Side View



End View



Plan view

Figure 7.32 Blocking in a strong boundary CTU

4.2.5 When the door end of a CTU is designed to provide a defined wall resistance (e.g. the doors of a general purpose freight container (see chapter 6 of this Code), the doors may be considered as a strong cargo space boundary, provided the cargo is stowed to avoid impact loads to the door end and to prevent the cargo from falling out when the doors are opened.

4.2.6 Where there is the need to stack packages in an incomplete second layer at the centre of the CTU, additional longitudinal blocking can be adopted (see figures 7.33 to 7.36).

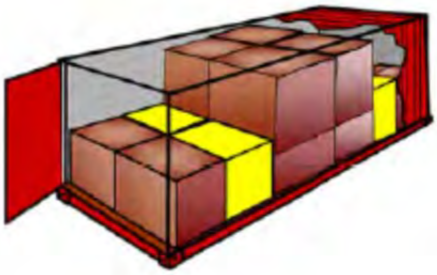


Figure 7.33 Threshold by height

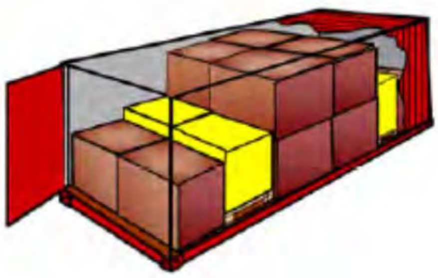


Figure 7.34 Threshold by elevation

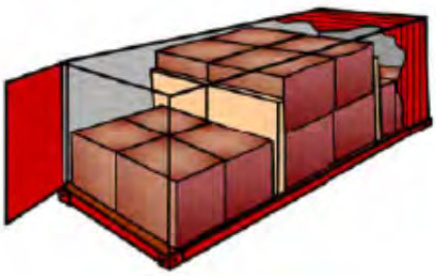


Figure 7.35 Threshold by board

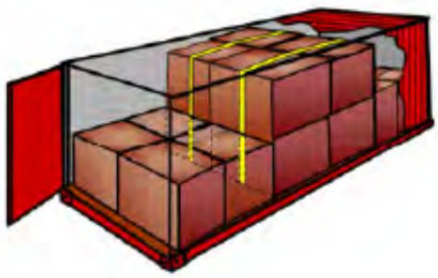


Figure 7.36 Round turn lashing

4.2.7 CTUs with weak cargo space boundaries like certain road vehicles and swap bodies will regularly require additional securing measures against sliding and tipping of a block of tightly stowed cargo. These measures should also contribute to compacting the block of cargo. The favourite method in this situation is friction-securing by so-called top-over lashings. For obtaining a reasonable securing effect from friction lashings, the friction factor between cargo and stowage ground should be sufficient and the inherent elasticity of the lashings should be able to maintain the pre-tension throughout the course of transport. The following balance demonstrates the confinement of tightly stowed cargo within weak cargo space boundaries and an additional securing force against sliding:

$$c_{x,y} \cdot m \cdot g \leq r_{x,y} \cdot P \cdot g + \mu \cdot c_z \cdot m \cdot g + F_{sec} \quad \text{[kN]} \quad (F_{sec} = \text{additional securing force})$$

If a wall resistance coefficient is not specified for the distinguished CTU, it should be set to zero. The additional securing (F_{sec}) may consist of blocking the base of the cargo against stronger footing of the otherwise weak cargo space boundary or bracing the block of cargo against stanchions of the cargo space boundary system. Such stanchions may be interconnected by pendants above the cargo for increasing their resistance potential. Alternatively, the additional securing force may be obtained by direct securing methods or top-over lashings. F_{sec} per top-over lashing is: $F_V \cdot \mu$, where F_V is the total vertical force from the pre-tension. For vertical lashings F_V is 1.8 times the pre-tension in the lashing. For direct lashing arrangements μ should be set to 75% of the friction factor.

4.2.8 On CTUs without boundaries the entire securing effect should be accomplished by securing measures like top-over lashings, friction increasing material and, if the CTU is a flatrack, by longitudinal blocking against the end-walls. The following balance demonstrates the securing of tightly stowed cargo on a CTU without cargo space boundaries:

$$c_{x,y} \cdot m \cdot g \leq \mu \cdot c_z \cdot m \cdot g + F_{sec} \quad \text{[kN]} \quad (F_{sec} = \text{additional securing force})$$

For F_{sec}, see subsection 4.2.7. It should be noted that even in case of a friction factor that outnumbers the external acceleration coefficients, without cargo space boundaries a minimum number of top-over lashings is imperative for avoiding migration of the cargo due to shocks or vibration of the CTU during transport.

4.3 Individually secured packages and large unpackaged articles

4.3.1 Packages and articles of greater size, mass or shape or units with sensitive exterior facing, which does not allow direct contact to other units or CTU boundaries, should be individually secured. The securing arrangement should be designed to prevent sliding and, where necessary, tipping, both in the longitudinal and transverse direction. Securing against tipping is necessary, if the following condition is true (see also figure 7.37):

$$c_{x,y} \cdot d \geq c_z \cdot b$$

$c_{x,y}$ =	horizontal acceleration coefficient in the relevant modes of transport (see chapter 5 of this Code)
d =	vertical distance from centre of gravity of the unit to its tipping axis [m]
c_z =	vertical acceleration coefficient in the relevant modes of transport (see chapter 5 of this Code)
b =	horizontal distance from centre of gravity to tipping axis [m]

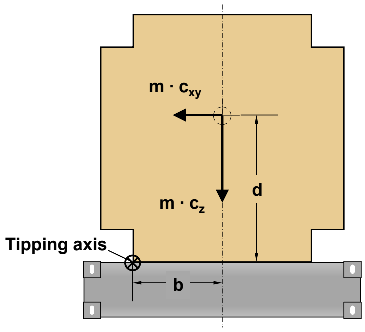


Figure 7.37 Tipping criterion

4.3.2 Individually secured packages and articles should preferably be secured by a direct securing method, i.e. by direct transfer of securing forces from the package to the CTU by means of lashings, shores or blocking.

4.3.2.1 A direct lashing will be between fixed fastening points on the package/article and the CTU and the effective strength of such a lashing is limited by the weakest element within the device, which includes fastening points on the package as well as fastening points on the CTU.

4.3.2.2 For sliding prevention by lashings the vertical lashing angle should preferably be in the range of 30° to 60° (see figure 7.38). For tipping prevention the lashings should be positioned in a way that provides effective levers related to the applicable tipping axis (see figure 7.39).

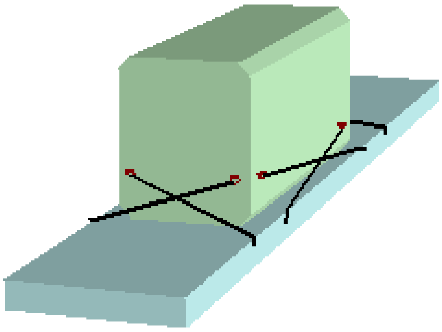


Figure 7.38 Direct lashing against sliding

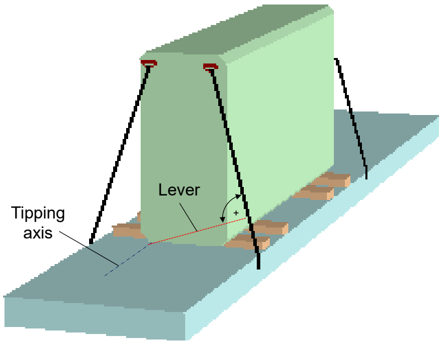


Figure 7.39 Direct lashing against tipping

4.3.3 Packages and articles without securing points should be either secured by shoring or blocking against solid structures of the CTU or by top-over, half-loop or spring lashings (see figures 7.40 to 7.43).

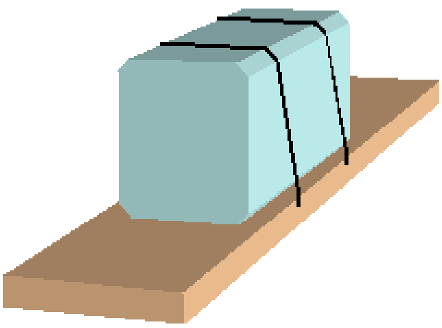


Figure 7.40 Top over lashing

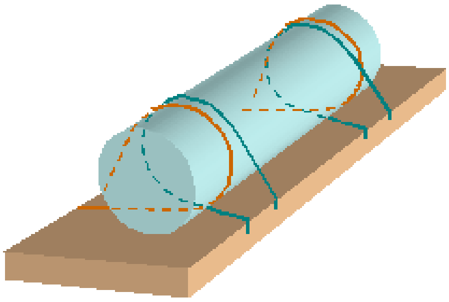


Figure 7.41 Vertical half-loop lashing

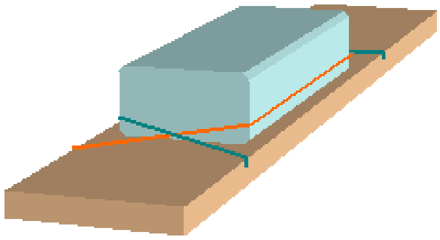


Figure 7.42 Horizontal half-loop lashing

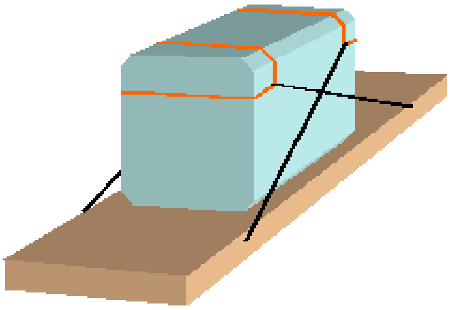


Figure 7.43 Spring lashing

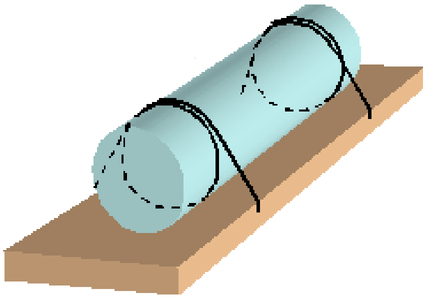


Figure 7.44 Silly-loop lashing

4.3.3.1 Loop lashings with their ends fastened to either side (see figure 7.44), also called "silly-loops", do not provide any direct securing effect and may permit the package/article to roll and therefore are not recommended

4.3.3.2 Lashing corner fittings are available to provide alternative lashing to the spring lashing (see figure 7.43).

4.3.3.3 Any lashing method adopted will require that the lashing material stretches in order to develop a restraining force. As the material relaxes, the tension in the lashing will slowly reduce, therefore it is important that the guidance given in subsection 4.1.4 of this annex should be followed.

4.3.4 CTUs with strong cargo space boundaries favour the method of blocking or shoring for securing a particular package or article. This method will minimize cargo mobility. Care should be taken that the restraining forces are transferred to the CTU boundaries in a way that excludes local overloading. Forces acting to CTU walls should be transferred by means of load spreading cross beams (see subsections 2.3.1 to 2.3.3 of this annex). Very heavy packages or articles, e.g. steel coils or blocks of marble, may require a combination of blocking and lashing, however with observation of the restrictions lined out in subsection 4.1.6 of this annex (see figure 7.45). Articles with sensitive surfaces may rule out the blocking method and should be secured by lashings only.

Figure 7.45 Transverse blocking of steel slab

4.3.5 Individual securing of packages or articles in CTUs with weak cargo space boundaries and in CTUs without boundaries requires predominantly the method of lashing. Where applicable, blocking or shoring may be additionally applied, but if used in parallel with lashings, the restrictions set out in subsection 4.1.6 of this annex should be observed. Although the provision of good friction in the bedding of a package or article is recommended in any case, the use of top-over lashings for sliding prevention is discouraged unless the cargo has limited mass. Top-over lashings may be suitable for tipping prevention. In particular over-width packages or articles, often shipped on flat bed CTUs, should not be secured solely by top-over lashings (see figure 7.46). The use of half loops and/or spring lashings is strongly recommended (see figures 7.47 and 7.48).

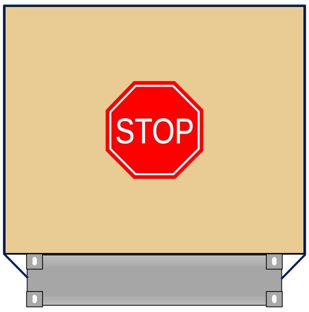


Figure 7.46 Top-over lashing

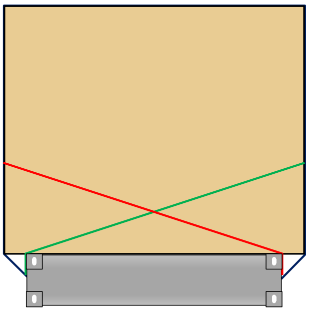


Figure 7.47 Top-over and horizontal half-loop

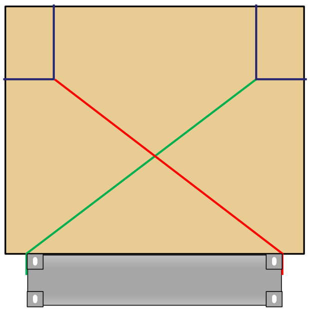


Figure 7.48 Transverse spring lashing

4.3.6 Where horizontal half loops are used, a means should be provided to prevent the loops from sliding down the package/article.

4.3.7 Alternatively an over-width package or article can be secured by half-loops over the corners as shown in figure 7.49.

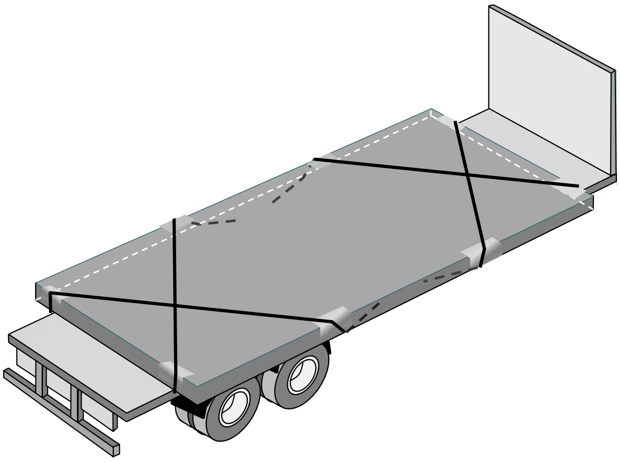


Figure 7.49 Over-width package secured by half-loops

4.4 Evaluation of securing arrangements

4.4.1 Evaluation of securing arrangements means making up a balance of expected external forces and moments against the securing potential of the planned or implemented securing arrangement. Expected external forces should be determined by multiplying the applicable acceleration coefficient, given in chapter 5 of this Code, with the weight of the package or block of packages in question.

$$F_{x,y} = m \cdot g \cdot c_{x,y} \quad [kN]$$

$F_{x,y}$ = expected external force [kN]

m = mass of cargo to be evaluated [t]

g = gravity acceleration 9.81m/s^2

$c_{x,y}$ = horizontal acceleration coefficient in the relevant mode of transport (see chapter 5 of this Code)

Chapter 5 distinguishes three modes of transport, road, rail and sea. The sea transport mode is further subdivided into three categories of severity of ship motions, aligned to the significant wave height of distinguished sea areas. Therefore the selection of the applicable acceleration factor requires the full information on the intended mode and route of transport. Due consideration should be given to possible multimodal transport, in order to identify the acceleration figures for the most demanding mode or leg of the transport route. These figures should be finally used for the evaluation of the securing arrangement.

4.4.2 The assessment of the securing potential includes the assumption of a friction factor, based on the combination of materials (see appendix 2 to this annex) and the character of the securing arrangement (subsection 2.2.2 of this annex), and, if applicable, the determination of the inherent tilting stability of the cargo (subsection 4.3.1 of this annex). Any other securing devices used for blocking, shoring or lashing should be estimated by their strength in terms of MSL and relevant application parameters like securing angle and pre-tension. These figures are required for evaluating the securing arrangement.

4.4.3 In many cases the evaluation of a securing arrangement may be accomplished by means of a simple rule of thumb. However, such rules of thumb may be applicable for certain distinguished conditions of transport only, e.g. for sea transport, and may overshoot or fall short in other conditions. It is therefore advisable to phrase such rules of thumb for distinguished modes of transport and use them accordingly. Any phrasing of a rule of thumb should undergo a first-time check by means of an advanced assessment method.

4.4.4 Standardized assessment methods for the evaluation of securing arrangements may consist of appropriate pre-calculated tables, based on balance calculations, which give quick answers regarding the adequacy of a securing arrangement[5]. Such methods may be directed to specific modes of transport.

4.4.5 Evaluation of securing arrangements may be carried out by balancing forces and moments by an elementary calculation. However, the particular method used should be approved and suitable for the intended purpose and mode of transport. Specific guidance may be found in the IMO Code of Safe Practice for Cargo Stowage and Securing (CSS Code) and in various other standards and guidelines issued by regional or national authorities and industry groups covering various modes of transport. References:

- IMO CSS Code, Annex 13, for sea transport;
- European standard EN 12195-1:2010, for road transport;
- International Union of Railways (UIC), Agreement governing the exchange and use of wagons between Railway Undertakings (RIV 2000) Annex II, for rail transport.

4.4.6 The suitability of a specific securing arrangement may be evaluated and approved by an inclination test. The test may be used to demonstrate resistance against any specified external acceleration. The corresponding test-angle depends on the existing friction factor for a sliding resistance test, or on the relation between the height and the width of cargo for a tipping resistance test (see appendix 5 to this annex).

5 Packing bulk material

5.1 Non-regulated liquids in tank CTUs

5.1.1 Tank CTUs filled with liquids having a viscosity less than 2,680 mm^2/s at 20°C and to be transported by road, rail or sea should be filled to at least 80% of their volume for avoiding dangerous surging, but never more than 95% of their volume, unless specified otherwise. A filing ratio of maximum 20% is also accepted. A filling ratio of more than 20% and less than 80% should only be permitted when the tank shell is subdivided, by partitions or surge plates, into sections of not more than 7,500 l capacity.

5.1.2 The tank shell and all fittings, valves and gaskets should be compatible with the goods to be carried in that tank. In case of doubt, the owner or operator of the tank should be contacted. All valves should be correctly closed and checked for leak tightness.

[5] One of the assessment methods is the Quick Lashing Guide that can be found in informative material IM 5 (available at www.unece.org/trans/wp24/guidelinespackingctus/intro.html).