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Item 7 of the provisional agenda
Code of Practice for Packing of Cargo Transport Units

Code of Practice for Packing Cargo Transport Units – text prioritized in updates: blocking material and arrangements, dunnage bags

Note by the secretariat

I. Introduction

1. The United Nations Economic Commission for Europe (ECE) Working Party on Intermodal Transport and Logistics (WP.24) at its sixty-fourth session (Geneva, 20–22 October 2021) prolonged the informal pre-work on the Code of Practice for Packing Cargo Transport Units (CTU Code) for one more year to continue: (i) assess which areas of the CTU Code need to be prioritized in the updates, and (ii) consider text usage of the CTU Code in the mobile application.

2. Experts participating in the informal pre-work in the process of the assessment of the areas of the CTU Code where updates would be needed, among others, discussed issues such as: blocking material and arrangements and dunnage bags and considered possible new text developed on these issues to supplement the existing information in the Code.

3. This document presents changes for prioritization in updates on the issues referred above. In particular:

- Annex I presents changes to terms across the Code used in relation to blocking to achieve more text consistency. It further makes a proposal for changes to clause 2.3 on blocking material and arrangements. It also proposes to add references of techniques and devices used for blocking in other types of CTUs, and
- Annex II shows proposed additions to Appendix 4 of Annex 7, section 4 on cargo securing with dunnage bags.

4. Proposed additions to the exiting text of the CTU Code are marked as bold text, while text proposed for deletion is marked as strikethrough.

5. WP.24 is invited to review the proposals presented in annexes I to II and provide its feedback and guidance.

Annex I

Blocking material and arrangements

The following changes are proposed:

Preamble

The use of freight containers, swap bodies, vehicles or other cargo transport units substantially reduces the physical hazards to which cargoes are exposed. However, improper or careless packing of cargoes into/onto such units, or lack of proper blocking~~, bracing~~ and lashing, may be the cause of personal injury when they are handled or transported. In addition, serious and costly damage may occur to the cargo or to the equipment.

Chapter 6

6.2.11 Flatracks and platforms have a bottom structure consisting of at least two strong longitudinal H-beam girders, connected by transverse stiffeners and lined by solid wooden boards. For securing of cargo units, strong **anchor points**~~lashing brackets~~ are welded to the outer sides of the longitudinal bottom girders with an MSL of at least 30 kN according to the standard. In many cases the **anchor points**~~lashing points~~ have an MSL of 50 kN. Cargo may also be secured in longitudinal direction by **blocking against**~~shoring to~~ the end walls of flatracks. These end walls may be additionally equipped with lashing points of at least 10 kN MSL.

6.4.6 The curtain-sided swap body is designed similarly to a standard curtain side semi-trailer. It has an enclosed structure with rigid **or removable** roof and end walls and a floor. The sides consist of removable canvas or plastic material. The site boundary may be reinforced by ~~battens~~**removable stanchions**.

Chapter 7

7.2.5 Heavy items such as granite and marble blocks may also be packed into closed CTUs. However, this cargo cannot be simply stowed from wall to wall. ~~Bracing and blocking~~**Blocking** against the frame **of** the CTU and/or lashing to the securing points is necessary (see annex 7, ~~section~~ **clause** 4.~~3~~**4**). As the lashing capacity of the securing points in general purpose freight containers is limited, such standard containers might not be appropriate for certain large and heavy cargo items. Instead, platforms or flatracks could be used.

Annex 2

3.3.5 ~~A b~~**Bottom** sling**s are**~~is~~ used in connection with a cross beam spreader bar. The freight container ~~is~~**may be** lifted from the side apertures of the four bottom corner fittings by means of ~~slings which are connected to the corner fittings~~**lifting devices bearing on the bottom corner fittings only.** ~~by means of locking devices.~~ Hooks are not suitable for this connection. This method can be used for all freight container sizes in an empty or packed state. Packed freight containers the angle between the sling and the horizontal should not be less than 30° for 40 ft freight containers, 45° for 20 ft freight containers and 60° for 10 ft freight containers.

Annex 4

2.4 (table) Ts = Mass of the ~~securing and bracing~~ **cargo securing** materials

Annex 7

2.1.2 Timber planks or ~~scantlings~~**battens** may also be used for creating gaps between parcels of cargo in order to facilitate natural ventilation, particularly in ventilated container is. Moreover, the use of such dunnage is indispensable, when packing reefer containers. clause

2.3 Blocking ~~and bracing~~ material and arrangements

2.3.1 Blocking~~, bracing or shoring~~ is a securing method, where **either the cargo is stowed directly against strong structural elements of the CTU or additional materials**, e.g., timber beams and frames, empty pallets or dunnage bags **are used to** fill~~ed in the~~ gaps between the cargo and solid boundaries of the CTU or ~~into~~ gaps between different packages (see figure 7.3). Forces are transferred in this method by compression with minimal deformation. ~~Inclined bracing or shoring arrangements bear the risk of bursting open under load and should therefore be properly designed.~~ In CTUs with strong sides, **and where** ~~if~~possible, packages should be stowed tightly to the boundaries of the CTU on both sides, leaving the remaining gap in the middle. This reduces the forces to the ~~bracing~~ **blocking** arrangement, because lateral g-forces from only one side will need to be transferred at a time.

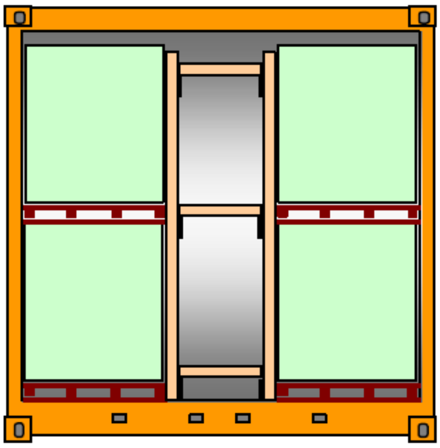

Figure 7.3 Centre gap with transverse ~~bracing~~ blocking

2.3.2~~2.3.9~~ The restrictions on the use of blocking ~~and bracing~~ materials with regard to quarantine regulations, in particular for wood or timber, should be kept in mind (see **clauses** ~~sections~~ 1.13 and 1.14 of this annex).

2.3.3 **Temporary wooden structures used for blocking should be so designed that they primarily transfer the forces from the cargo to the boundaries of the CTU by means of compressions of the timber and not rely on their bending strength or the strength of the joints of the different components. Those forces** ~~Forces being transferred by bracing or shoring~~ needs to be dispersed at the points of contact by suitable ~~cross-beams,~~ **spreader beam** unless a point of contact represents a strong structural member of the cargo or the CTU. Softwood timber ~~cross-~~spreader beams should be given sufficient overlaps at the shor~~e~~**ing beam** contact points. For the assessment of bedding and blocking arrangements the nominal strength of timber should be taken from the following table **7.1**:

	Compressive strength normal to the grain	**Compressive strength parallel to the grain**	**Bending strength**
Low quality	0.3 kN/cm²	2.0 kN/cm²	2.4 kN/cm²
Medium quality	0.5 kN/cm²	2.0 kN/cm²	3.0 kN/cm²

Table 7.1

2.3.4 A ~~bracing or shoring arrangement~~ **temporary wooden structure** should be designed and completed in such a way that it remains intact and in place, also if compression is temporarily lost. This requires suitable ~~uprights~~ **supports** or benches supporting the actual ~~shores~~**blocking elements**, a proper joining of the elements by nails or clamps and the stabilising of the arrangement by diagonal braces as appropriate (see figure~~s~~ 7.4~~ and 7.5~~). **Inclined blocking arrangements bear the risk of bursting open under load and should therefore be properly designed.**

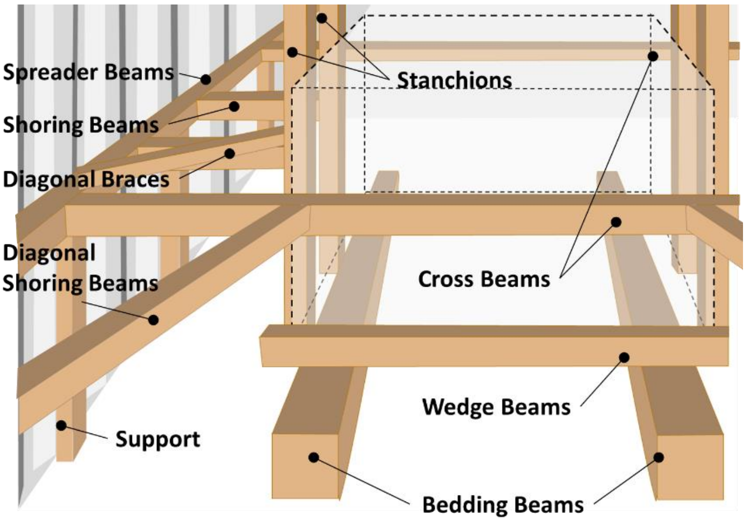

Figure 7.4 Components of a temporary wooden blocking arrangement

Guide to components:

Shoring beams are generally under compression
Spreader and bedding beams run longitudinally
Stanchions stand vertically
Cross beams and door shoring bars run transversally

~~2.3.4 Transverse battens in a CTU, intended to restrain a block of packages in front of the door or at intermediate positions within the CTU, should be sufficiently dimensioned in their cross section, in order to withstand the expected longitudinal forces from the cargo (see figure 7.6). The ends of such battens may be forced into solid corrugations of the side walls of the CTU. However, preference should be given to brace them against the frame structure, such as bottom or top rails or corner posts. Such battens act as beams, which are fixed at their ends and loaded homogeneously over their entire length of about 2.4 metres. Their bending strength is decisive for the force that can be resisted. The required number of such battens together with their dimensions may be identified by calculations, which is shown in appendix 4 to this annex.~~

~~Figure 7.6 General layout of fence battens for door protection in a CTU~~

2.3.5 Blocking ~~by nailed-on scantlings~~ **that is secured using mechanical fastenings on bedding or spreader beams** should be used for minor securing demands only. **The different types of fixing will provide a range of shear strength,** depending on the **type, configuration and** size of the ~~nails~~ **fastener** used. **For example,** ~~the shear strength of such a blocking arrangement secured using nails may be estimated to take up a blocking force between 1 and 4 kN per nail. Nailed~~**nailed** on wedges may be favourable for blocking round shapes like pipes. Care should be taken that wedges are cut in a way that the direction of grain supports the shear strength of the wedge. Any such timber beams or wedges should only be nailed to bedding beams or timbers placed under the cargo **(see figure 7.5)**. Wooden floors of closed CTUs are generally not suitable for nailing. Nailing to the softwood flooring of flatracks or platforms and open CTUs may be acceptable with the consent of the CTU operator ~~(see figure 7.7)~~.

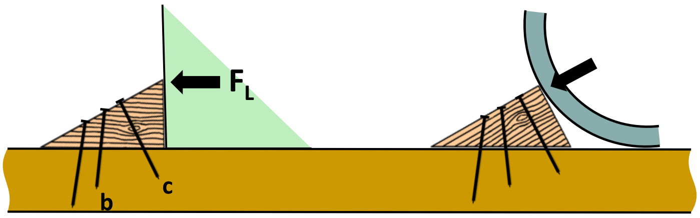

Figure 7.~~7~~**5** Properly cut and nailed wedges

2.3.6 **Joints in blocking arrangements fail when the lateral load exceeds the strength of the mechanical fastener, often resulting in the blocking beam or wedge rotating and levering the fastening out. To prevent this, the correct type of mechanical fastenings must be selected and correctly inserted. The most common fastening used in fabrication packing framework is the nail due to its ease of availability and use. Nailed joints rely on three basic elements:**

- **The size and shape of the nail**
- **The penetration of the nail**
- **The timber used for blocking**

2.3.6.1 The size of the nail is measured by its diameter and length. The most commonly used nail has a smooth shank and round in cross section. Other shapes and designs are available and may improve the effectiveness of the joint. When deciding on the size of the nail and its effectiveness the loads that the joint is subjected to and the effectiveness of the two timber elements need to be considered:

1. Nails in use are subjected either to withdrawal loads or lateral loads (as shown in figures 7.6 and 7.7), or a combination of the two. Both withdrawal load and lateral load are affected by the wood, the nail, and the condition of use.

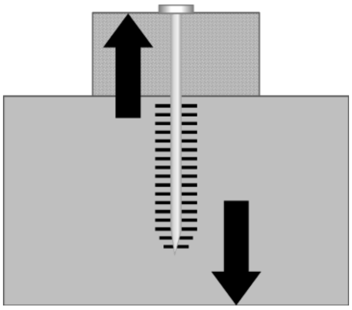

Figure 7.6 Withdrawal loads

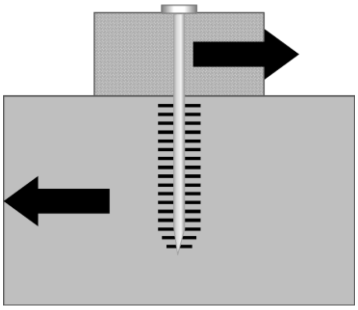

Figure 7.7 Lateral loads

2. Any lateral load on a blocking element that is affixed using nails will result in the hole formed in the timber as the nail in driven in will distort and the blocking element rotates, thus levering out the nail (see figure 7.8). As shown in Figure 7.9, the force required to extract the nail diminishes significant already at relatively small displacements, but the effect is less prominent for ringed or spiral nails.

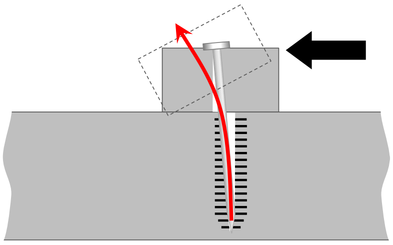

Figure 7.8 Lateral displacement and effect on nail

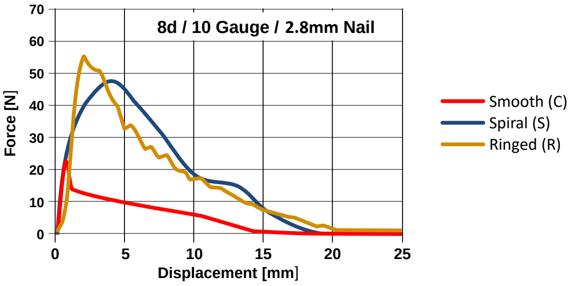

Figure 7.9 Extraction force vs displacement

3. Blocking arrangements that rely on nailed joints should primarily be used for taking up lateral loads on the nails and be sufficiently strong to not allow any significant displacement of the wooden components. Table 7.2 gives the approximate blocking capacity for nails of various sizes with sufficient penetration.

Nail diameter [mm]	Approximate blocking capacity per nail [daN]
3	90
4	120
5	150

Table 7.2 Approximate lateral blocking capacity of nails with various diameters and sufficient penetration

2.3.6.2 Depth of penetration

1. The lateral nail load is also related to the depth of penetration of the nail in the foundation member or member receiving the point. There are two general rules for the depth of penetration:

(a) The depth of penetration generally recommended for plain-shank nails to develop full load varies but is about 14 times the nail diameter for the softer woods[1].

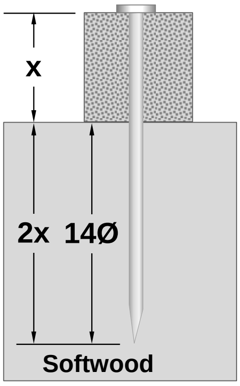

Figure 7.10 Depth of penetration

(b) The depth of penetration can also be calculated so that the shank penetrates to a depth of twice the thickness of the affixed member. Thus, the length of the nail should, if possible, be three times the thickness of the blocking element to be attached and that the nail is fully driven in.

2.3.6.3 Finally the effectiveness of the nail will depend on the timber used and it should be properly seasoned:

- **It should be clean, dry, and free from dry rot, knotholes, infestation, and splits which will affect its strength or interfere with proper nailing.**
- **Dry timber (at approximate moisture content 15 to 25 percent) is an excellent securing material. It is much lighter than wet or green timber. This is very important when weight limitations are to be considered.**
- **The use of green or wet timber should always be avoided.**
  - **Such timber quickly loses most of its strength and can contain 30 to 50 percent moisture depending upon the species.**
  - **Green and wet timber will emit a heavy concentration of moisture which may cause water or sweat damage, moulding, or cargo staining**
  - **Shrinkage of green timber in drying loosens the nails, and the movement of the container during transportation often causes nails to work out. This results in a reduction of cargo security in the container and eventual breakdown of the holding system.**

2.3.6.4 As it has been shown the use of nails to provide resistance to lateral forces within a blocking arrangement is very limited and it is therefore recommended that nails are

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[1] The most common used timbers for blocking arrangements are softwoods such as Douglas Fir, Larch, Scots Pine and Spruce.

used to secure blocking elements in place, but where they are required to provide the lateral resistance the largest diameter of nail available should be used.

~~2.3.6~~**2.3.7** ~~In the case of form locking~~**When cargo units are blocked against each other**, void spaces should be filled and may be favourably stuffed by empty pallets inserted vertically and tightened by additional timber battens as necessary. Materials which may deform or shrink permanently, like rags of gunny cloth or solid foam of limited strength, should not be used for this purpose. Small gaps between unit loads and similar cargo items, which cannot be avoided and which are necessary for the smooth packing and unpacking of the goods, are acceptable and need not be filled. The sum of the void spaces in any horizontal direction should not exceed 15 cm. However, between dense and rigid cargo items, such as steel concrete or stone, void spaces should be further minimised, as far as possible.

~~2.3.7~~**2.3.8** Gaps between cargo that is stowed on and firmly secured to pallets (by lashings or by shrink foil), need not to be filled, if the pallets are stowed tightly into a CTU and are not liable to tipping (see figure 7.~~8~~**11**). Securing of cargo to pallets by shrink foil wrapping is only sufficient if the strength of the foil is appropriate for above purpose. It should be considered that in case of sea transport repetitive high loadings during bad weather may fatigue the strength of a shrink foil and thereby reduce the securing capacity.

Figure 7.~~8~~**11** Cargo firmly secured to pallets by textile lashings

~~2.3.8~~**2.3.9** If dunnage bags are used for filling gaps[2], the manufacturer's instructions on filling pressure and the maximum gap should be accurately observed. Dunnage bags should not be used as a means of filling the space at the doorway, unless precautions are taken to ensure that they cannot cause the door to open violently when the doors are opened. If the surfaces in the gap are uneven with the risk of damage to the dunnage bags by chafing or piercing, suitable measures should be taken for smoothing the surfaces appropriately (see figures 7.~~9~~**12** and 7.~~10~~**13**). The blocking capacity of dunnage bags should be estimated by multiplying the nominal burst pressure with the contact area to one side of the blocking arrangement and with a safety factor of 0.75 for single use dunnage bags and 0.5 for reusable dunnage bags (see appendix 4 to this annex).

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[2] Dunnage bags (inflated by air) should not be used for dangerous goods on US railways.

Figure 7.~~9~~**12** Gap filled with central dunnage bag

Figure 7.~~9~~**13** Irregular shaped packages blocked with dunnage bags

2.3.10 Road vehicles may be prepared to accept different types of demountable blocking devices, such as stanchions or blocking cross beams. Such devices may be marked with their Blocking Capacity (BC), indicating the maximum ability to take loading distributed over the device's full height and width during sustained use. Stanchions are exerted to a bending moment which depends on the height of the load. Blocking beams are typically restricted by the strength of the fittings on each side the CTU (see figures 7.14 and 7.15)

Figure 7.14 Floor mounted stanchions

Figure 7.15 Blocking cross beams

Clause 4 Securing of cargo in CTUs

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 **(see 4.1.7)**. 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 pretension 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 **clause** ~~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 lashing will also contribute to minimising cargo motions, but the pre-tension should never exceed 50% of the MSL of the lashing. Direct securing by stiff pressure elements (~~shores~~ **shoring beams** or stanchions) or by locking devices (locking cones or twist-locks) will not allow significant cargo motion and should therefore be preferred method of direct securing.

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. **Where this is not possible the following should apply:**

4.1.7.1 Blocking should be braced against structurally significant components of the CTU, which may be corner posts and bottom rails.

4.1.7.2 Additional shoring may be made against the boundary side and front walls so long as the forces are distributed by spreader beams as shown in Figure 7.40 and Figure 7.41

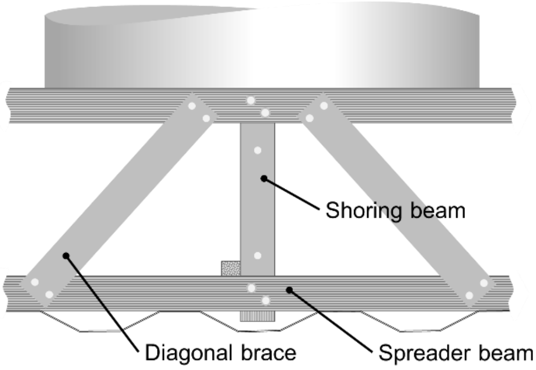


Figure 7.40 Boundary blocking arrangement

Figure 7.41 Boundary blocking arrangement

4.1.7.3 The CTU doors may be tested to withstand a force equivalent to a percentage of the CTU's payload, however, for cargoes that are liable to collapse, such as bulk materials (solids and liquids), small hand-packed packaged and pallets with low integral stability, the doors should not be used as the only mean to constrain the cargo as there is a risk of the cargo falling onto those who open the CTU for inspection or unpacking. In such cases the cargo should in addition be restrained by spring lashing (see Figure 7.58), a modular lashing system (see Figure 7.26) or using shoring bars / rear false bulkhead (see clause 5.3.3.4).

4.1.7.4 Cargo should never be secured by blocking or lashing against the CTU roof except for designs that permit this method of securing.

4.~~2~~**3** Tightly arranged cargoes

4.~~2~~**3**.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~~**3**.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 **clause** ~~section~~ 3.~~2~~**4** 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 **clause** ~~subsections~~ 2.3.~~6~~**7** to 2.3.~~8~~**10** of this annex). Direct contact of cargo items with CTU boundaries may require an interlayer of protecting material (see **clause** ~~section~~ 2.1 of this annex).

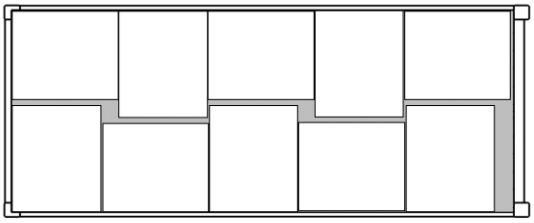


Figure 7.~~29~~**42** Packing 1,000 x 1,200 mm unit loads into a 20-foot container

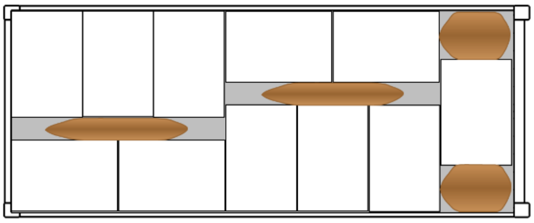


Figure 7.~~30~~**43** Packing 800 x 1,200 mm unit loads into a 20-foot container

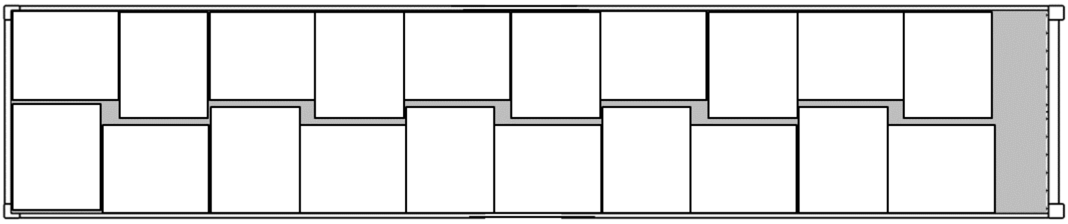


Figure 7.~~31~~**44** Packing 1,000 x 1,200 mm unit loads into a 40-foot container

Note: The void areas (grey shaded) shown in figures 7.~~29~~**42** to 7.~~31~~**44** should be filled when necessary (see **clause**~~subsection~~ 2.3.~~6~~**7** of this annex).

4.~~2~~**3**.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**onnes**]

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**onnes**)

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~~**3**.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~~**false bulkheads of** ~~timber battens~~**cross beams** (see **clause**~~subsection~~ ~~2.3.4~~**X** of this annex) or by other suitable means~~,~~ ~~(see figure 7.32)~~. ~~Another option is the use of friction increasing material.~~ **When bracing against the rear corner frames, vertical timber battens (VB) should be inserted into the shoring slots between the slot bars and the bracing battens (BB) fitted against this. Where required nails or other fixings can be used to stabilise the bracing battens.**

4.~~2~~**3**.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~~**3**.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~~**45** to 7.~~36~~**48**).

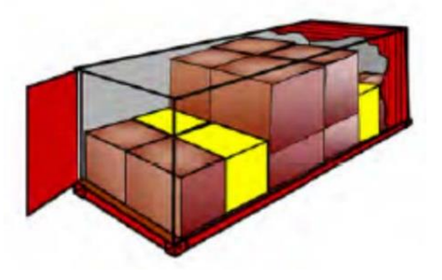


Figure 7.~~33~~**45** Threshold by height

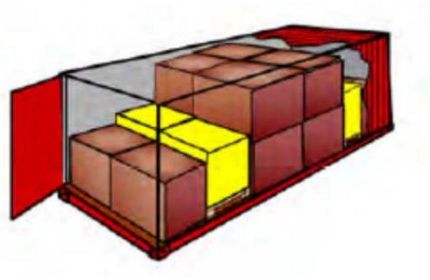


Figure 7.~~34~~**46** Threshold by elevation

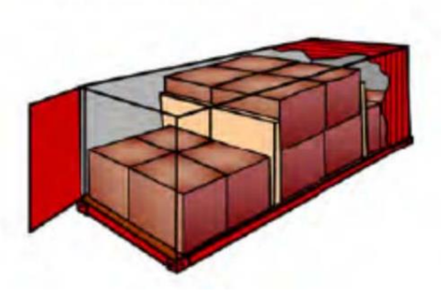


Figure 7.~~35~~**47** Threshold by board

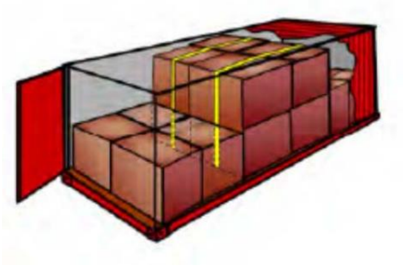


Figure 7.~~36~~**48** Round turn lashing

4.3.7 Transverse cross beams in a CTU, intended to restrain a block of packages in front of the door (see figure 7.49) or at intermediate positions within the CTU, should be sufficiently dimensioned in their cross section, in order to withstand the expected longitudinal forces from the cargo. Such members act as beams, which are fixed at their ends and loaded homogeneously over their entire length of about 2.4 metres. Their bending strength is decisive for the force that can be resisted. The required number of such battens together with their dimensions may be identified by calculations, which is shown in section 1 of appendix 4 to this annex. Wherever possible such battens should be braced against the solid frame structure, such as bottom or top rails or corner posts. While it is recognised that this type of blocking is not possible on all types of CTUs, any that has a shoring slot built into the rear frame can accommodate this blocking technique. Alternative blocking can be achieved by forcing the battens into the solid corrugations of the side walls of the CTU (see figure 7.50). However, since these methods have limited strength, they should be used in combination with friction increasing material and/or limited cargo weight. The blocking capacity, BC, of a 75 x 100 mm beam inserted into the corrugation of a container is 500 daN if it is placed at half the height of the container and 750 daN if it is placed at the floor.

Figure 7.49 Shoring bars inserted in the shoring slots and supported by uprights placed against the doors

Figure 7.50 Cross beams inserted in the corrugations supported by shoring beams against the doors at the hinges

4.3.8 When a temporary wooden structure is used to block the cargo against the end walls of platform and flatrack type CTUs, this should be supported against the corner posts and the shoring beams should be placed as far out towards the sides as the cargo permits (see figure 7.51). Stanchions, produced from wooden beams with a cross section of 75x75 mm, may often be inserted into pockets along the sides of the platforms to prevent the cargo from sliding sideways (see figure 7.52).

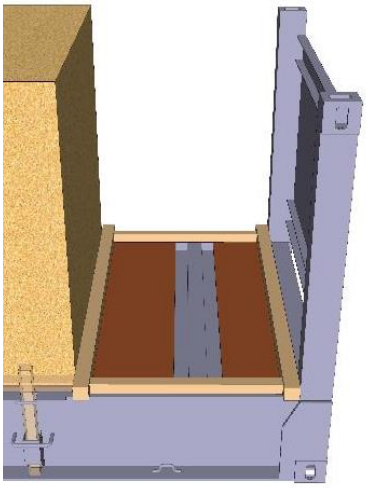


Figure 7.51 Wooden structure for blocking against the end wall of flat rack

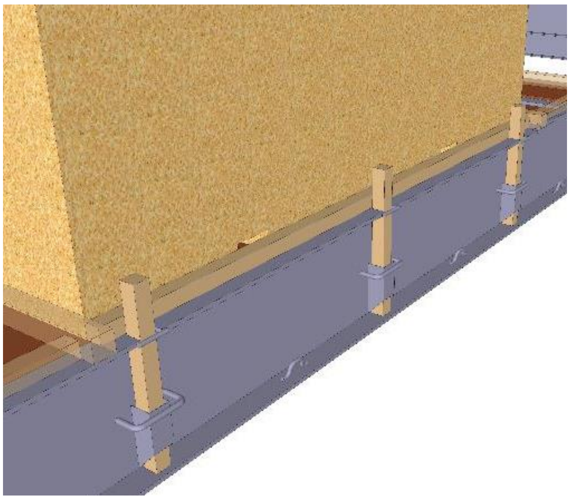


Figure 7.52 Stanchions preventing sideways sliding on platform CTUs

4.~~2~~**3**.~~7~~**9** 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:

$$c_{xy} \cdot m \cdot g \leq r_{xp} \cdot P \cdot g + \mu \cdot c_z \cdot m \cdot g + F_{sec}\ kN$$

Where:

F_{sec} = additional securing force

If a wall resistant coefficient is not specified in 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 addition 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 ~~the~~ is the total vertical force from the pretension. The vertical lashings F_v is 1.8 times the pretension of the lashing. The direct lashing arrangements μ should be set to 75% of the friction factor.

4.~~2~~**3**.~~8~~**10** 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:

$$c_{xy} \cdot m \cdot g \leq \mu \cdot c_z \cdot m \cdot g + F_{sec}\ kN$$

Where:

F_{sec} = additonal securing force

For Fsec, see **clause**~~subsection~~ 4.2.~~7~~**9**. 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~~**4** Individually secured packages and large unpackaged articles

4.~~3~~**4**.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~~**53**):

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

$c_{x,y}$ = 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]

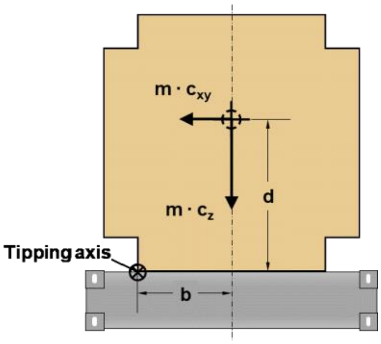


Figure 7.~~37~~**53** Tipping criterion

4.~~3~~**4**.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 **and/**~~, shores~~or blocking.

4.~~3~~**4**.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~~**4**.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~~**54**). 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~~**55**).

4.~~3~~**4**.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~~**56** to 7.~~43~~**59**)

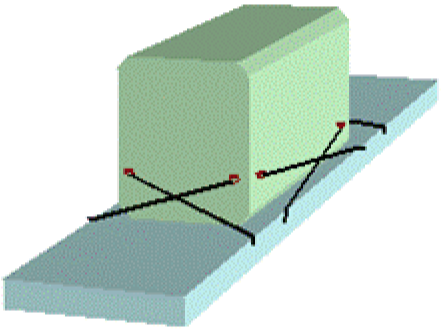


Figure 7.~~38~~**54** Direct lashing against sliding

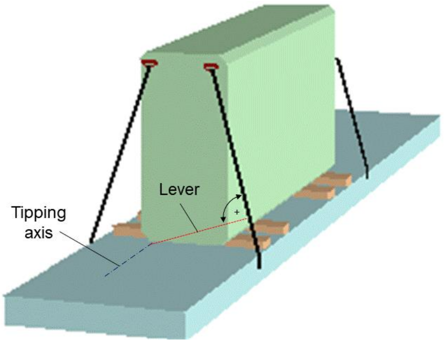


Figure 7.~~39~~**55** Direct lashing against tipping

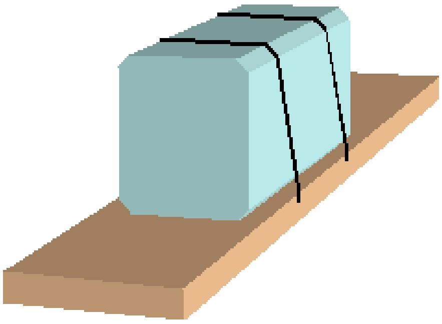


Figure 7.~~40~~**56** Top over lashing

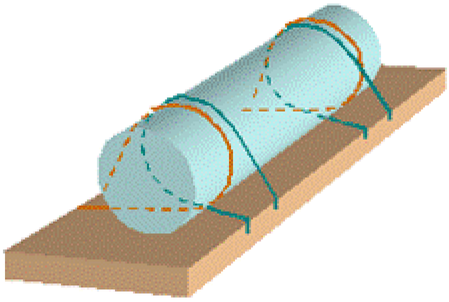


Figure 7.~~41~~**57** Vertical half-loop lashing

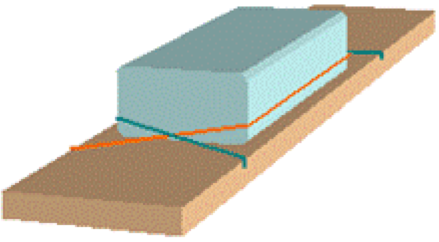


Figure 7.~~42~~**58** Horizontal half-loop lashing

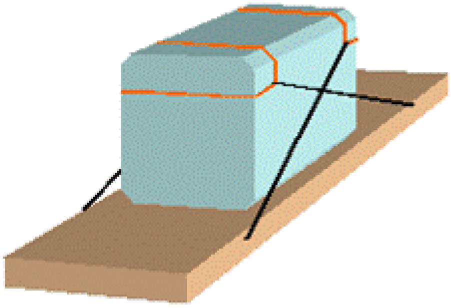


Figure 7.~~43~~**59** Spring lashing

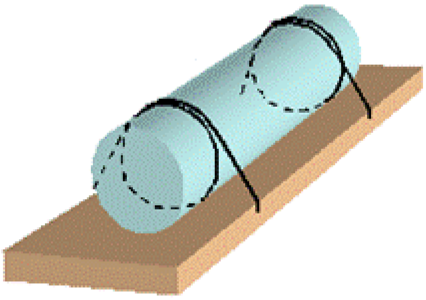


Figure 7.~~44~~**60** Silly-loop lashing

4.~~3~~**4**.3.1 Loop lashings with their ends fastened to either side (see figure 7.~~44~~**60**), 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~~**4**.3.2 Lashing corner fittings are available to provide alternative lashing to the spring lashing (see figure 7.~~43~~**59**).

4.~~3~~**4**.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 **clause**~~subsection~~ 4.1.4 of this annex should be followed.

4.~~3~~**4**.4 CTUs with strong cargo space boundaries favour the method of blocking ~~or shoring~~ for securing a particular package or article. This method will minimise 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 ~~a load~~ spreader~~ing~~ ~~cross~~ beams (see **clauses**~~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 **clause**~~subsection~~ 4.1.6 of this annex (see figure 7.~~45~~**61**). Articles with sensitive surfaces may rule out the blocking method and be should be secured by lashings only.

Figure 7.~~45~~**61** Transverse blocking of steel slab

4.~~3~~**4**.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 **clause**~~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 of flatbed CTUs, should not be secured solely by top-over lashings (see figure 7.~~46~~**62**). The use of half loops and/or spring lashings is strongly recommended (see figures 7.~~47~~**63** and 7.~~48~~**64**).

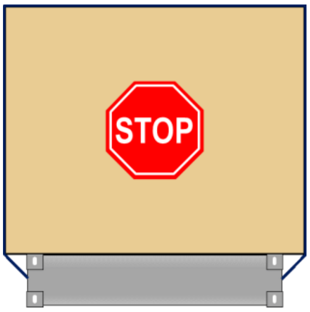


Figure 7.~~46~~**62** Top-over lashing

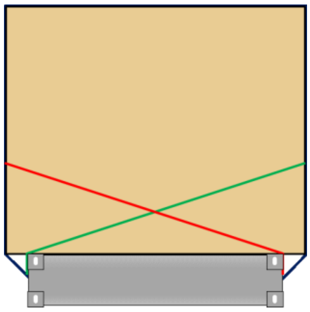


Figure 7.~~47~~**63** Top-over and horizontal half-loop

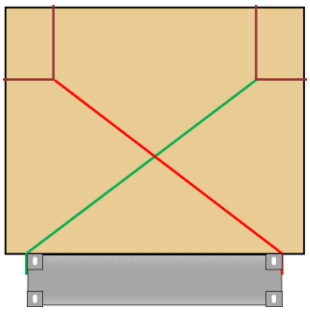


Figure 7.~~48~~**64** Transverse spring lashing

4.~~3~~**4**.6 Where horizontal half loops are used, a means should be provided to prevent the loops from sliding down the package/article.

4.~~3~~**4**.7 Alternatively an over-width package or article can be secured by half-loops over the corners as shown in figure 7.~~49~~**65**

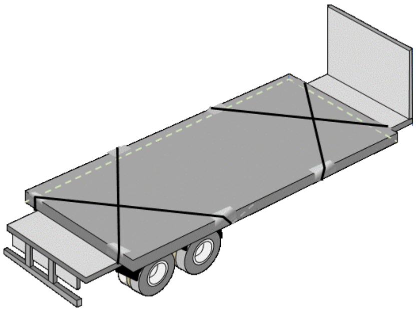


Figure 7.~~49~~**65** Over-width package secured by half-loops

4.**45** Evaluation of securing arrangements

(Renumbering of clauses)

4.**45**.2 The assessment of the securing potential includes the assumption of a friction factor, based on a combination of materials (see appendix 2 to this annex) and the character of the securing arrangement (~~subsection~~**clause** 2.2.2 of this annex), and, if applicable, the determination of the inherent tilting stability of the cargo (~~subsection~~**clause** 4.~~3~~**4**.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.

(Renumbering of clauses)

Annex 10 section 7 2nd bullet Blocking ~~and bracing~~**arrangements**

Annex II

Dunnage bags

The following changes are proposed to the Appendix 4 of Annex 7, section 4:

4 Cargo securing with dunnage bags

4.1 Introduction

4.1.1 Accelerations in different directions during transport may cause movements of cargo, either sliding or tipping. Dunnage bags, or air bags, used as blocking devices may be able to prevent these movements.

4.1.2 The size and strength of the dunnage bag are to be adjusted to the cargo weight so that the permissible ~~lashing~~ **Blocking C**apacity **(BC)** of the dunnage bag, without risk of breaking it, is larger than the force the cargo needs to be supported with:

BC ~~$F_{\text{DUNNAGE BAG}}$~~ $\geq F_{\text{CARGO}}$

4.2 Force on dunnage bag from cargo (F_{CARGO})

4.2.1 The maximum force, with which rigid cargo may impact a dunnage bag, depends on the cargo's mass, size and friction against the surface and the dimensioning accelerations according to the formulas below:

Sliding:

$$F_{\text{CARGO}} = m \cdot g \cdot (c_{x,y} - \mu \cdot 0.75 \cdot c_z) \text{ [kN]}$$

Tipping:

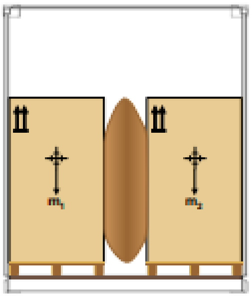
$$F_{\text{CARGO}} = m \cdot g \cdot (c_{x,y} - b_p/h_p \cdot c_z) \text{ [kN]}$$

where:
F_{CARGO} = force on the dunnage bag caused by the cargo ~~[t]~~ **[kN]**
m = mass of cargo [**tonnes**]
$c_{x,y}$ = Horizontal acceleration, expressed in *g*, that acts on the cargo ~~sideways~~ **in longitudinal or transverse**~~or in forward or backward~~ directions
c_z = Vertical acceleration that acts on the cargo, expressed in *g*
μ = Friction factor for the contact **surface** ~~area~~ between the cargo and the ~~surface~~ **cargo deck** or between different packages
b_p = Package width for tipping sideways, or alternatively the length of the cargo for tipping forward or backward
h_p = package height [m]

4.2.2 The load on the dunnage bag is determined by the movement (sliding or tipping) and the mode of transport that gives the largest force on the dunnage bag from the cargo.

4.2.3 Only the cargo mass that actually ~~impacts~~**acts on** the dunnage bag that should be used in the above formulas. If the dunnage bag is used to prevent movement forwards, when breaking for example, the mass of the cargo behind the dunnage bag should be used in the formulas.

4.2.4 If the dunnage bag instead is used to prevent movement sideways, the largest total mass of the cargo that either is on the right or left side of the dunnage bag should be used, that is, either the mass m_1 or m_2 (see figure 7.~~59~~**94**).



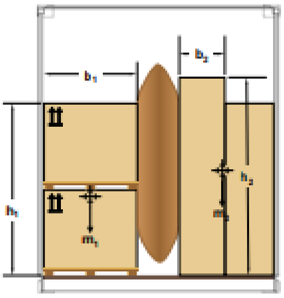


Figure 7.~~59~~**94** Equal height packages

Figure 7.~~60~~**95** Unequal height packages

4.2.5 In order to have some safety margin in the calculations, the lowest friction factor should be used, either the one between the cargo in the bottom layer and the platform or between the layers of cargo.

4.2.6 If the package on each side of the dunnage bag has different forms, when tipping the relationship between the cargo width and height of the cargo stack that has the smallest value of b_p / h_p is chosen.

4.2.7 However, in both cases the total mass of the cargo that is on the same side of the dunnage bag should be used, that is, either the mass m_1 or m_2 in figure 7.~~60~~**95**.

4.3 ~~Permissible load on~~**Blocking Capacity of** the dunnage bag (**BC**~~F$_{DB}$~~)

4.3.1 The force that the dunnage bag is able to ~~take up~~ withstand**, i.e. its Blocking Capacity**, depends on the area of the dunnage bag which the cargo is resting against and the maximum allowable working pressure. The force of the dunnage bag is calculated from:

BC~~F$_{DB}$~~ $= A \cdot 10 \cdot g \cdot P_B \cdot SF$ [kN]

where:

BC~~F$_{DB}$~~ = force that the dunnage bag is able to take up without exceeding the maximum allowable pressure**, i.e its Blocking Capacity** (kN)

P_B = bursting pressure of the dunnage bag [bar]

A = contact area between the dunnage bag and the cargo [m^2]

SF = safety factor

0.75 for single use dunnage bags

0.5 for reusable dunnage bags

4.4 Contact area (A)

4.4.1 The contact area between the dunnage bag and the cargo depends on the size of the bag before it is inflated and the gap that the bag is filling. This area may be approximated by the following formula:

$$A = (b_{DB} - \pi \cdot d/2) \cdot (h_{DB} - \pi \cdot d/2)$$

where:

b_{DB} = width of dunnage bag [m]

h_{DB} = height of dunnage bag [m]

A = contact area between the dunnage bag and the cargo [m2]

d = gap between packages [m]

$\pi = 3.14$

4.4.2. In order to provide a sufficient contact area, neither the width nor the height of the dunnage bag should be less than 2.5 times the size of the filled gap.

4.4.3 When a dunnage bag is used to secure a load, its working height must not exceed the height of the cargo or the boundary wall of an open vehicle. The maximum permissible height of a dunnage bag can be determined depending on the height of the cargo by using the following formula:

$$\mathbf{h_{DB} = h + (\pi - 1) \cdot d / 2}$$

where:

h_{DB} = height of dunnage bag [m]
h = height of cargo [m]
d = gap between packages [m]
$\pi = 3.14$

4.5 Pressure in the dunnage bag

4.5.1 **To be fully effective the dunnage bag must be inflated to its operating pressure, taking into account the climatic conditions along the route of the CTU and in accordance with the manufacturer's recommendations.** ~~Upon application of~~**This may require that** the dunnage bag ~~it~~ is filled to a slight overpressure **so that if the ambient pressure rises or the air temperature falls there is no risk that the dunnage bag may become loose**. ~~If this pressure is too low there is a risk that the dunnage bag may come loose if the ambient pressure is rising or if the air temperature drops.~~ Conversely, if the filling pressure is too high there is a risk of the dunnage bag bursting or damaging the cargo if the ambient pressure decreases, or if the air temperature rises.

4.5.2 The bursting pressure (PB) of a dunnage bag depends on the quality and size of the bag and the gap that it is filling. The pressure exerted on a dunnage **bag** by the cargo forces should never be allowed to approach bursting pressure of the bag because of the risk of failure. A safety factor should, therefore, be incorporated and, if necessary, a dunnage bag with a higher bursting pressure selected.

4.5.3 Dunnage bags mark with Level 1 to 5 according to the Association of American Railroads criteria have the following minimum bursting pressure:

Level 1 - 0.55 bar

Level 2 - 1.2 bar

Level 3 - 1.7 bar

Level 4 - 2.1 bar

Level 5 - 1.5 bar

Level 1 to 4 dunnage bags are tested at a gap of 30 cm while Level 5 dunnage bags are tested at a gap of 46 cm.

4.6 Recommended marking for dunnage bags

Blocking capacity in tonnes of various size dunnage bags marked Level 3 and having a bursting pressure of 1.7 bar at a gap of 30 cm.

Fillable gap size	**Bursting pressure**	**Dunnage bag dimension (cm)**				
		60 x 100	**100 x 120**	**100 x 150**	**120 x 200**	**120 x 250**
10 cm	**2.3 bar**	**4.2**	**10**	**13**	**22**	**28**
20 cm	**2.0 bar**	**1.9**	**6.0**	**8.1**	**15**	**19**
30 cm	**1.7 bar**	**n/a**	**3.3**	**4.6**	**9.5**	**13**
45 cm	**1.3 bar**	**n/a**	**n/a**	**n/a**	**4.1**	**5.6**

Table 7.14 Blocking capacity example