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Group of Experts for the revision of the IMO/ILO/UNECE Guidelines for Packing of Cargo Transport Units

Second session
Geneva, 19-20 April 2012
Item 3 of the provisional agenda
Updates on the 1st draft of the Code of Practice (COP)

Comments (Germany) submitted on the Code of Practice for packing of Cargo Transport Units (CTU Code)

Note by the Secretariat

1. Per the Secretariat request on 21 March, 2012 to the Group of Expert on submitting comments and suggestions on the circulated draft COP in advance to the second session of the Group of Experts (19-20 April, 2012), the Group of Experts may wish to consider the proposal of Germany reproduced below, and decide as appropriate.

Code of Practice for packing of cargo Transport units (CTU Code)

Comment of Germany to document EG GPC No.3 (2012)

1 General remark

The delegation of Germany thanks the coordinator for presenting the first draft. However, it has to be noted that this draft, as presented now, was mainly drafted by the coordinator alone and has not been discussed in the Correspondence Group. Therefore, it is considered necessary to have an in-deep discussion on the structure and on the contents of this draft, during the second session of the Group of Experts.

The main issues which need to be discussed are:

- The structure of the draft does not follow the structure as it was agreed in the first round of the Correspondence Group.

- Many sections of the proposed text appear to be more a training handbook than a Code of Practice. It is our understanding, that the text in the CoP should be concise, clear and unambiguous.

To further explain our understanding, Germany herewith submits a proposal for chapter 4 (general transport conditions) and a proposal for chapter 10 (packing cargo into CTUs). These proposals are enclosed as annex 1 and annex 2 to this document. It should be noted that the proposal for chapter 10 in annex 2 is not finalized. Most of the illustrations still need to be worked out. It might also be necessary to slightly amend some parts of the texts. An updated version will be available for the second session of the group of experts.

With respect to the packing of dangerous goods (chapter 11 of the agreed structure), Germany proposes to include additional subsections dealing with the stacking of dangerous goods packages and with the segregation between dangerous goods and foodstuffs. The amended chapter 11 including this additional text is attached as annex 3 to this document.

With respect to the completion of packing (chapter 12 of the agreed structure) it is proposed to include a subsection on the determination of the correct gross mass of the CTU. It is our understanding that the documentation which has to be provided by the packer of a CTU should state the verified gross mass. The amended chapter 12 including this additional text is attached as annex 4 to this document.

2 The proposed chapter 4

The proposed chapter 4 is based upon section 1 of the present Guidelines. The table of accelerations has been amended as follows:

- For road transport, the acceleration in forward direction has been amended to 0.8 g. This is the value which has been proved by various tests and is used in the European standard 12195-1:2010. The acceleration in sideway direction has been increased to 0.6 g for goods which are liable to tilt. This is to consider dynamic tilting moments caused by lateral inclination during cornering or fast change of traffic lanes. In other words, to consider the rotational inertia in conjunction with angular accelerations resulting from the rolling oscillation of the vehicle around the longitudinal axis.
- For rail transport, the values for wagons subject to shunting are no longer included, as these high accelerations are not applicable for combined transport. Furthermore, only specially equipped wagons and specific cargoes (e.g. solid bulk) are capable to

bear such high accelerations of 4 g. Neither the walls of containers and swap bodies nor commonly used packages are capable to absorb the forces generated by such acceleration.

- The present Guidelines show the dynamic variation of the static gravity force as a footnote. To give a better understanding how to apply these dynamic variations, the proposal shows the minimum vertical acceleration. The vertical acceleration multiplied with the mass of the cargo results to its weight. This value is needed to calculate the effect of internal friction. A weight which is reduced by the dynamic effects of vertical acceleration will reduce the effect of friction and thus increase the outlay for cargo securing. For rail transport, the present Guidelines apply the reduced vertical acceleration only for securing in sideway direction. However, the regulations of the International Union of Railways (UIC) require the application of the reduced vertical acceleration in forward and aft direction as well (Agreement governing the exchange and use of wagons between Railway Undertakings – RIV 2000, Annex II). Therefore, the proposal shows both alternatives in square brackets. The Group of Experts is invited to consider this issue and to decide as appropriate.

- For sea transport, the present Guidelines show acceleration coefficients for the Baltic Sea, the North Sea and for unrestricted traffic. However, as there are other sea areas where the meteorological and oceanographic conditions are similar to those conditions in European marginal seas, it is proposed to discriminate the sea areas by their significant wave heights. The significant wave height in the western Baltic Sea has been evaluated to be < 1.5 m, whereas the significant wave height in the North Sea has been found to be < 4 m. This gives a criterion which might be used as well in other sea areas of the world.

3 The proposed chapter 10

This proposal was developed based upon section 3 of the present Guidelines. To give more advice to the users of the Code of Practice, detailed information on the securing capacity of the various securing materials and devices have been included. In addition, clear advice is given how to calculate the proper load distribution and how to evaluate the efficacy of a cargo securing arrangement.

To consider the effect of friction, the efficacy of a certain securing arrangement has to be evaluated using the friction coefficients which will be defined in Annex 6 of the Code of Practice. Experience shows that it might be difficult to define exact values for friction, thus it could be more appropriate to define a certain range with an upper and lower value. There are two alternatives how to use this range:

- First alternative: The upper value may be used for flexible cargoes, which tend to deform under external load, while the lower value should be used for stiff units, each with the given combination of materials.
- Second alternative: The upper value may be used for cargoes secured by blocking or by friction lashings, while the lower value should be used for units secured by direct lashings, each with the given combination of materials.

The proposal shows both alternatives. The Group of Experts is invited to discuss this issue, maybe in a later session.

4 The proposed chapters 11 and 12

This proposal was developed based upon sections 3.3 and 4 of the present Guidelines. As already decided by the first session of the Group of Experts, the text gives, with respect to the packing of dangerous goods, only general advice. For all details there are references to the applicable dangerous goods regulations.

The proposal shows proposed text for a packing certificate, even for CTU which do not contain dangerous goods. This proposal is based on the consideration that in all cases where CTU are loaded on board a ship, the packer of the CTU has to provide certain information, i.e. on the identification number of the CTU, the seal number, any extraordinary dimensions, such as overheight and overwidth, and on the gross mass of the unit. As there definitely is information that needs to be transmitted, either by a paper or electronically, it might be appropriate, to require also a declaration of the packer that the cargo was securely packed. The Group of Experts is invited to discuss this approach.

5 Proposals for the structure of the Code

During discussion in the Correspondence Group a preliminary outline of the Code was drafted. It is supposed that this outline will be further discussed in the second session of the Group of Experts. The German delegation is of the opinion that

- any redundancy between the various chapters and sections of the Code of Practice should be avoided as far as possible; when necessary references to the relevant parts should be used
- the general transport conditions should better be placed before the CTU properties; thus chapter 3 and 4 might be mutually exchanged.

4 GENERAL TRANSPORT CONDITIONS

4.1 Within the supply chain, there are a number of different stresses acting on the cargo. These stresses can be grouped in mechanical and climatic stresses. Mechanical stresses are forces acting on the cargo under specific transport conditions. Climatic stresses are changes of climatic conditions including extremely low or high temperatures.

4.2 During transport various forces will act on the cargo. The force acting on the cargo is the mass of the cargo (m) which is measured in kg, multiplied by the acceleration (a) which is measured in m/s²

$$\mathbf{F = m \cdot a}$$

Accelerations to be considered during transport are the gravitational acceleration (a = g = 9.81 m/s²) and accelerations caused by typical transport conditions such as by the braking of a road truck, by a rapid change of traffic lanes or by the movement of a ship in heavy sea. These accelerations are expressed as product of the gravitational acceleration (g) and a specific acceleration coefficient, e.g. 0.8 g.

4.3 To prevent a cargo from movement, the cargo has to be secured in longitudinal and in transverse direction (see chapter 10). The following tables provide the applicable acceleration coefficients for the different modes of transport and for the various securing directions.

Road transport					
Securing in	**Acceleration coefficients**				
	longitudinally		transversely		Minimum vertically down
	forward	rearward	sliding	tilting	
Longitudinal direction	0.8	0.5	-	-	1.0
Transverse direction	-	-	0.5	0.6	1.0

Rail transport (combined transport)				
Securing in	**Acceleration coefficients**			
	longitudinally		transversely	Minimum vertically down
	forward	rearward		
Longitudinal direction	1.0	1.0	-	[1.0] [0.7]
Transverse direction	-	-	0.5	[1.0] [0.7]

Sea transport					
Significant wave height in sea area		**Securing in**	**Acceleration coefficients**		
			longitudinally	transversely	Minimum vertically down
1	$H_{s90} \leq 1.5$ m	Longitudinal direction	0.3	-	0.5
		Transverse direction	-	0.5	1.0
2	1.5 m $< H_{s90} \leq 4$ m	Longitudinal direction	0.3	-	0.3
		Transverse direction	-	0.7	1.0
3	$H_{s90} > 4$ m	Longitudinal direction	0.4	-	0.2
		Transverse direction	-	0.8	1.0

4.4 For road and rail transport, the effect of short term impact or vibrations should always be considered. Therefore, whenever the cargo cannot be stowed tightly between the walls of a cargo transport unit, securing measures such as blocking or lashing are always required. The gravitational force alone, even when combined with a high friction coefficient (see chapter 10 and annex 6), does not sufficiently secure the cargo.

4.5 The significant wave height (H_{s90}) is the average of the highest one-third (33%) of waves (measured from trough to crest) that is not exceeded during 90% of a year. The allocation of geographic sea areas to the respective significant wave heights is shown in the following table.

1	**2**	**3**
$H_{s90} \leq 1.5$ m	1.5 m < $H_{s90} \leq 4$ m	$H_{s90} > 4$ m
Western Baltic Sea (Belts and Sound and sea area W of 12°30’ E) Red Sea Persian Gulf	North Sea (incl. Skagerak and Kattegat) Central and Eastern Baltic Mediterranean Sea Gulf of Aden Bay of Bengal Sea of Japan East China Sea Central Atlantic Ocean* (between 30°N and 30 °S) Central Indian Ocean* (between 5°N and 20°S) Central Pacific Ocean* (between 20°N and 30°S) *marginal seas within these latitudes are included unless specified in area 1	Northern Atlantic Ocean** (> 30°N) Southern Atlantic Ocean** (> 30°S) Arabian Sea (between 50°E and 75°E and > 5°N) Southern Indian Ocean** (> 20°S) Northern Pacific Ocean** (> 20°N) Southern Pacific Ocean** (> 30°S) **marginal seas within these latitudes are included unless specified in area 1 or 2

Sources:

- *The Royal Netherlands Meteorological Institute (KNMI):*
  The KNMI/ERA-40 Wave Atlas, derived from 45 years of ECMWF reanalysis data
  (ed. S.Caires, A.Stern, G.Komen and V.Swail), last updated 2011,
  Significant wave heights, corrected ERA-40, 90% quantiles, monthly statistics 1971 – 2000
- *For North Sea and Baltic Sea:*
  Maritime and Coast Guard Agency, United Kingdom
  Merchant Shipping Notice 1790 Appendix 3, published 2005

4.5 During longer voyages, climatic conditions (temperature, humidity) are likely to vary considerably. These may affect the internal conditions in a CTU which may give rise to condensation on cargo or internal surfaces (see Annex 3).

4.6 Whenever a specific cargo might be damaged if it is exposed to extremely high or low temperatures, the use of special equipment capable of being heated or refrigerated, as appropriate, should be considered (see chapter 8).

Annex 2 Proposal of Germany for chapter 10 of CoP

10 Packing cargo into CTUs

10.1 Measures and conditions before packing

10.1.1 Qualification of planners and packers

10.1.1.1 Persons responsible for planning and supervision of packing should be fully knowledgeable about all technical, legal and commercial requirements of this task and on all risks and dangers involved. They should know the customary terminology in order to communicate effectively with shippers, forwarders and the persons who do the actual packing.

10.1.1.2 Personnel engaged in the actual packing should be trained and skilled in doing this work and understand the relevant terminology in order to comply with the instructions of the planner. They should be aware of the risks and dangers involved.

10.1.1.3 Persons responsible for planning and supervision of packing as well as personnel responsible for the actual packing should receive appropriate education and training for their tasks before they do the work with immediate responsibility. Such training should consist of appropriate short courses, following the guidance given in chapter 17, and of a sufficient period of practical assistance to experienced planners or packers.

10.1.2 Planning of packing

10.1.2.1 Planning of packing should be conducted as early as possible and before packing actually commences. Foremost, the fitness of the envisaged CTU should be verified (see chapter 9). Any deficiencies must be rectified before packing may start.

10.1.2.2 Planning should aim at producing either a tight stow, where all cargo parcels are placed tightly within the boundaries of the side- and front walls of the CTU, or a secured stow, where cargo units do not fill the entire space and must therefore be secured within the boundaries of the CTU by lashing or blocking.

10.1.2.3 The compatibility of all items of cargo and the nature, i.e., type and strength, of any packages or packaging involved should be taken into account. The possibility of cross-contamination by odour or dust, as well as physical or chemical compatibility, should be considered. Incompatible cargoes must be segregated.

10.1.2.4 In order to avoid cargo damage from moisture, care should be taken that other wet cargoes, moisture inherent cargoes or cargoes liable to leak are not packed together with cargoes susceptible to damage by moisture. Wet dunnage, pallets or packaging should not be used. In certain cases, damage to equipment and cargo by condensed water dripping from above may be prevented by the use of protective material such as polythene sheeting. However, such sheeting or wrapping may promote mildew and other water damage, if the overall moisture content within the CTU is too high. If drying agents shall be used, the necessary absorption capacity should be calculated. More information may be found in Annex 3 of this code.

10.1.2.5 Any special instructions on packages, or otherwise available, should be followed, e.g.:

- cargoes marked "this way up" should be packed accordingly;
- maximum stacking height marked should not be exceeded.

10.1.2.6 Consideration should be given to potential problems, which may be created for those persons who unpack the CTU at its destination. The possibility of cargo falling out when doors are opened must definitely be excluded.

10.1.2.7 The mass of the planned cargo should not exceed the maximum payload of the CTU. In the case of containers, this ensures that the permitted maximum gross mass of the container, marked on the CSC Safety Approval Plate (see Annex 7.2), will not be exceeded. For CTUs not marked with their maximum permissible gross mass or payload, these values should be identified before packing starts.

10.1.2.8 Notwithstanding the foregoing, any limitation of height or weight along the projected route that may be dictated by regulations or other circumstances, such as lifting, handling equipment, clearances and surface conditions, should be complied with. Such weight limits may be considerably lower than the permitted gross weight referred to above.

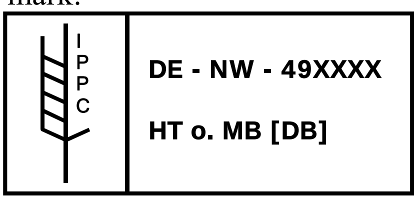
10.1.2.9 When a heavy cargo unit with a small "footprint" shall be shipped in a CTU, the concentrated load must be transferred to the structural transverse and longitudinal bottom girders of the CTU in such a way, that the stresses in those girders do not exceed the stresses, which would be induced by a homogeneous full payload. In most cases this may be achieved by spreading the concentrated load over a greater area with bedding the cargo on timber beams or steel beams in a suitable manner (see also Section 10.3 for details).

10.1.2.10 The centre of gravity of the packed cargo should be at or near the longitudinal centreline of the CTU and below half the height of the cargo space of the unit. If these conditions cannot be met, suitable measures should be taken to ensure the safe handling and transporting of the CTU, e.g. by external marking of the centre of gravity and/or by instructing forwarders. In case of CTUs, which shall be lifted by cranes or container bridges, the longitudinal centre of gravity should be close to a position at half the length of the CTU (see also Section 10.3 for details).

10.1.2.11 If the planned cargo of an open-topped or open-sided CTU will project beyond the overall dimensions of the unit, suitable arrangements should be made with the carriers or forwarders for accommodating compliance with road or rail traffic regulations or advising on special stowage locations on a ship.

10.1.2.12 When deciding on packaging and cargo-securing material, it should be borne in mind that some countries enforce a garbage and litter avoidance policy. This may limit the use of certain materials and imply fees for the recovery of packaging at the reception point. In such cases, reusable packaging and securing material should be used. Increasingly, countries require timber dunnage and packaging materials to be free of bark.

10.1.2.13 If a CTU is destined for a country with wood treatment quarantine regulations, care should be taken that all wood in the unit, packaging and cargo complies with the International Standards for Phytosanitary Measures, No. 15 (ISPM 15).[1] This standard covers packaging material made of natural wood such as pallets, dunnage, crating, packing blocks, drums, cases, load boards and skids. Approved measures of wood treatment are specified in Annex I of ISPM 15. Wood packaging material subjected to these approved measures should display the following specified mark:



[1] Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations: Guidelines for Regulation Woods Packaging Material in International Trade.

In this mark, the first line shows the ISO two letter country code followed by a unique number assigned by the national plant protection organization to the producer of the wood packaging material, who is responsible for ensuring that appropriate wood is used. The second line shows the abbreviation for the approved measure used (HT for heat treatment, MB for fumigation with methyl bromide). Where debarking is required the letters DB should be added to the abbreviation of the approved measure.

10.1.2.14 Damaged packages should not be packed into a CTU, unless precautions have been taken against harm from spillage or leakage (see also Section 11 for dangerous goods). The overall capability to resist handling and transportation stresses must be ensured.

10.1.2.15 The result of planning the packing of a CTU may be presented to the packers by means of an oral or written instruction or by a sketch or even scale drawing, depending on the complexity of the case. Appropriate supervision and/or inspection should ensure that the planned concept is properly implemented.

10.1.3 Access to the CTU

10.1.3.1 After the CTU has been positioned for packing (see Section 9.2), a safe access must be provided. For loading a CTU by means of fork lift trucks, a bridging unit between the working ground or loading ramp and the CTU floor should be used. The bridging unit should have lateral boundaries and be safely connected to the CTU for avoiding dislocation of the bridging unit during driving operations.

10.1.3.2 If the CTU floor is at a height level different to that of the loading ramp, a hump may appear between the loading ramp and the bridging unit or between the bridging unit and the CTU floor. Care should be taken that the fork lift truck used keeps sufficient ground clearance over this hump. Lining the level differences with suitable timber material under the bridging unit should be considered.

10.1.3.3 If fork lift trucks are employed for packing, any roofs or covers of the CTU should be opened as necessary. Any movable parts of such roofs or covers should be removed or suitably secured in order to avoid interference with the loading procedure.

10.1.3.4 Packing of CTUs in poor day-light conditions may require additional lighting. Electric lighting equipment should be used under the strict observance of relevant safety regulations, in order to eliminate the risk of electric shocks or incentive sparks from defective cables or heat accumulation from light bulbs.

10.1.4 Manual handling of cargo

Relevant regulations on the use of personnel protection equipment (helmet, shoes, gloves and clothing) should be adhered to. Personnel should have been instructed on ergonomic aspects of manual lifting of weighty parcels. Weight limitations of parcels to be lifted and carried by persons should be observed.

10.1.5 Safe use of fork lift trucks (FLT)

10.1.5.1 FLTs, used for loading roofed CTUs, should have a short lifting mast and a low driver's overhead guard. If the lift truck operates inside the container, equipment with electric power supply should be used. FLTs operated by a combustion engine should comply with national combustion emission standards. FLTs with engines burning LPG-fuel should not be used below the ground level, in order to prevent the accumulation of explosive gas mixtures from unexpected leaks.

10.1.5.2 Container floors are built to withstand a maximum wheel pressure corresponding to an axle load of a fork lift truck of 5.460 kg or 2.730 kg per wheel (references: ISO 1496 and CSC, Annex II). Floors of swap bodies are built to withstand corresponding axle loads of 4.400 kg and wheel loads of 2.200 kg (reference: EN 283). Such axle loads are typical for FLTs with a lifting capacity of 2.5 tonnes.

10.1.5.3 Driving FLTs into swap-bodies, semi-trailers or other supported CTUs should be done slowly, in particular with careful starting and braking, in order to avoid dangerous horizontal forces to the supports of the CTU.

10.1.5.4 If CTUs are to be loaded with FLTs from the side, significant lateral impact forces to the CTU must be avoided. Such forces may particularly appear, when cargo units are pushed across the loading area. The risk of overturning the CTU may be minimised by either loading from both sides to the centre line of the CTU or by using FLTs with higher capacity and long forks, which make pushing dispensable.

10.1.6 Other packing techniques

10.1.6.1 If the roof of a CTU must be entered by persons, e.g. for filling the CTU with a free-flowing bulk cargo, the load-bearing capability of the roof should be observed. Roofs of 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 container roof simultaneously.

10.1.6.2 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 move of unit should be controlled by appropriate means, e.g. guide ropes. Relevant regulations for the prevention of accidents should be observed.

10.2 Packing and securing materials

10.2.1 Dunnaging and separating

10.2.1.1 Dunnaging materials should be used as appropriate for the protection of the cargo against water from condensed humidity, in particular by

- timber planks against water collecting at the bottom of the CTU,
- gunny cloth, paperboard or natural fibre mats against water dropping from the ceiling,
- timber planks or plywood against sweat water running down the sides of the CTU.

10.2.1.2 Timber planks or scantlings may also be used for creating gaps between parcels of cargo in order to facilitate natural ventilation, particularly in ventilated box containers. Moreover, the use of such dunnaging is indispensable, when packing reefer containers.

10.2.1.3 Timber planks or plywood sheets may be used to equalise loads within stacks of cargo parcels and to stabilise these stacks against dislocation or collapse. The same material may be used for separating cargo units, which may damage each other or even for installing a temporary "tween deck" in a CTU for eliminating inappropriate stack loads to the cargo.

Figure 10.xx: Temporary tween deck in a CTU

10.2.1.4 Cardboard or plastic sheathing may be used for protecting sensible cargo from dirt, dust or moisture, in particular while packing is still in progress.

10.2.1.5 Dunnaging material, in particular sheets of plastic or paper and fibre nets may be used for separating uniform cargo units, which are designated for different consignees.

10.2.1.6 The restrictions on the use of dunnaging materials with regard to quarantine regulations, in particular wood or timber, should be kept in mind (see Sections 10.1.2.12 and 10.1.2.13). More information on the use of dunnaging and separation materials may be found under www.containerhandbook.de.

10.2.2 Friction

10.2.2.1 For handling and packing of parcels and pushing heavy units a low friction may be desirable. However, for minimising additional securing effort, a high friction between the cargo and the stowage ground of the CTU is of great advantage. Additionally, good friction between parcels or within the goods themselves, e.g. powder or granulate material in bags, will support a stable stow.

10.2.2.2 The magnitude of friction forces between a cargo unit and the stowage ground depends on the weight of the unit and a specific friction coefficient μ, which may be obtained from the Annex 6 of this Code.

Friction force $\mathbf{F_F = \mu \cdot m \cdot g}$ [kN], with mass of cargo [t] and g = 9.81 [m/s^2].

The friction coefficients presented in Annex 6 are conservative and show a certain range of values for each distinguished combination of surface materials.

1. Alternative: The upper value may be used for flexible cargoes, which tend to deform under external load, while the lower value should be used for stiff units, each with the given combination of materials.

2. Alternative: The upper value may be used for cargoes secured by blocking or by friction lashings, while the lower value should be used for units secured by direct lashings, each with the given combination of materials.

10.2.2.3 The friction force is widely independent from the extent of the area of contact, i.e. the friction force cannot be increased by providing a greater contact area. However, a too small contact area may diminish the friction coefficient due to high pressure effects to the materials involved. It is therefore prudent to provide a contact area of reasonable extent. Friction coefficients may be further diminished, if the contact area is contaminated by sand, dust, traces of water, oil, grease, ice or snow. Good cleaning the stowage surface of a CTU before packing is therefore indispensable.

10.2.2.4 Friction increasing materials like rubber mats, sheets of structured plastics or special cardboard may provide considerably higher friction coefficients, which are declared and certified by the manufacturers. However, care should be taken in the practical use of these materials. Their certified friction coefficient may be limited to perfect cleanliness and evenness of the contact areas and to specified ambient conditions of temperature and humidity. The desired friction increasing effect will be obtained only if the weight of the cargo is fully transferred via the friction increasing material, this means only if there is no direct contact between the cargo and the stowage ground. Manufacturer's instructions on the use of the material should be observed.

10.2.3 Blocking and bracing

10.2.3.1 Blocking, bracing or shoring is a securing method, where timber scantlings are secured into gaps between cargo and solid boundaries of the CTU or into gaps between different cargo units. 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 avoided. If possible, cargo units 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 shoring arrangement, because lateral g-forces from only one side will need to be transferred at a time.

(Figure showing centre-line gap with bracing)

10.2.3.2 Forces being transferred by bracing or shoring need to be dispersed at the points of contact by suitable cross-beams, unless a point of contact represents a strong structural member of the cargo or the CTU. Cross-beams of conifer timber should be given sufficient overlaps at the shore contact points. The MSL of 0.3 kN/cm^2 vertical to the grain of the cross-beams determines the strength of the shoring arrangement.

(Figure showing cross beam with overlap)

10.2.3.3 A bracing or shoring arrangement 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 or benches supporting the actual shores, a proper joining of the elements by nails or cramps and the stabilising of the arrangement by diagonal braces as appropriate.
Nailing to the floor of containers, swap bodies or road vehicles should be strictly banned.

(Figure showing shoring arrangement with uprights, crossbeams and braces)

10.2.3.4 Transverse battens in a CTU, intended to restrain a block of cargo units 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. 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 attainable resistance forces F of one such batten may be estimated by the formula:

$$F = \frac{w^2 \cdot h}{90} \text{ [kN]}$$

w = thickness of batten [cm]
h = height of batten [cm]

The permissible bending stress of the timber has been assumed in the formula with 2 kN/cm^2. This applies to lower quality conifer timber. 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.

(Figure showing w, h and general layout of fence of battens)

10.2.3.5 Blocking by nailed on scantlings should be used for minor securing demands only. Depending on the size of the nails used, the shear strength of such a blocking arrangement may be estimated between 1 and 4 kN per nail. 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 scantlings or wedges should only be nailed to dunnage or timbers placed under the cargo. Wooden floors of closed cargo transport units are generally not suitable for nailing. Nailing to the soft wood floor of flatracks or platforms may be acceptable with the consent of the owner or operator of the flatrack or platform.

(Figures showing types of wedges and nailed scantlings)

10.2.3.6 Regular gaps between stacks of cargo units may be favourably stuffed by empty pallets inserted vertically and tightened by additional timber scantlings as necessary. Material which may deform or shrink permanently, like rags of gunny cloth or solid foam, should not be used for stuffing gaps.

10.2.3.7 Gaps between cargo, that is stowed on and firmly secured to pallets, need not to be filled, if the pallets are stowed tightly into a CTU and are not liable to tipping.

(Figure/photograph showing pallets stowed in a CTU)

10.2.3.8 If air bags are used for filling gaps, the manufacturer's instructions on filling pressure and the maximum gap width should be accurately observed. This includes the reduction of initial filling pressure, if a considerable rise in temperature inside the CTU during the forthcoming transport may be expected. Air 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 locking bars are released. If the surfaces in the gap are uneven with the risk of damage to the air-bags by chafing or piercing, suitable measures have to be taken for smoothing the surfaces appropriately.

(Figure showing air bag applications)

10.2.3.9 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 Sections 10.1.2.12 and 10.1.2.13). More information on practical aspects of blocking and bracing may be found under www.containerhandbook.de.

10.2.4 Lashing

10.2.4.1 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 European standards, corresponds to the MSL. Figures of BL, MSL or LC are indicated in units of force, i.e. kilo-Newton (kN) or deka-Newton (daN).

10.2.4.2 The relation between MSL and the breaking strength according to the Annex 13 of the IMO CSS-Code is shown in the table below. Corresponding relations according to European standards may differ slightly.

Material	MSL
shackles, rings, deckeyes, turnbuckles of mild steel	50 % of breaking strength
fibre ropes	33 % of breaking strength
web lashings	50 % of breaking strength
wire ropes (single use)	80 % of breaking strength
wire rope (re-useable)	30 % of breaking strength
steel band (single use)	70 % of breaking strength
chains	50 % of breaking strength

Table 10.xx: Relation between MSL and BL according to the CSS-Code, Annex 13

10.2.4.3 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 belts may show some permanent elongation until gaining the desired elasticity after repeated re-tensioning. Lashings should be given a pre-tension, in order to minimise cargo movement. However, the initial pre-tension should never exceed 50% of the MSL or LC.

10.2.4.4 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.

10.2.4.5 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. Fibre ropes are highly sensitive against chafing at sharp corners or obstructions.

10.2.4.6 Synthetic fibre belt lashings are mainly re-usable devices with integrated ratchet tensioner or one-way yard ware, available with combined tensioning and locking devices. The permitted securing load is generally labelled and certified as lashing capacity LC, which should be taken as MSL. There is no rule of thumb available for estimating the MSL due to different base materials and fabrication qualities. The fastening of lashing belts by means of knots reduces their strength considerably and should therefore not be applied.

10.2.4.7 The elastic elongation of synthetic fibre belts, when loaded to their specific LC, is generally around 4% of the length and shall not exceed 7% according to European standards. 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.

10.2.4.8 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. If a certified figure of MSL is not available, the maximum securing load 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 MSL, but an initial permanent elongation must be expected after the first tensioning, if the wire rope is new.

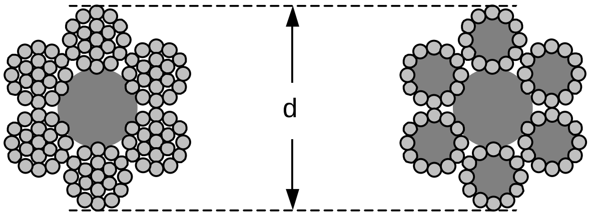


Figure 10.xx: Typical lashing wire rope constructions

10.2.4.9 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, even if steady in the bend.

10.3.4.10 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 10.xx. A typical improper assembly is shown in Figure 10.xx.

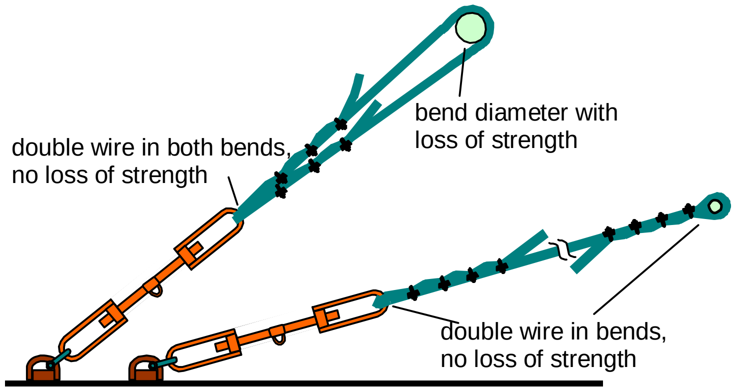


Figure 10.xx: Recommended assemblies of wire rope lashings

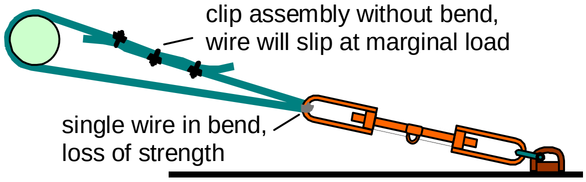


Figure 10.xx: Improper assembly of a wire rope lashing

10.2.4.11 Tensioning and joining devices associated to wire rope lashings in sea-transport are generally not standardised. 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.

10.2.4.12 Wire rope lashings in road transport according to European standards are specified as re-usable material of distinguished strength in terms of lashing capacity LC.

Connections elements like shackles, hooks, thimbles, tensioning devices or tension indicators are accordingly standardised 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. When using such material, the manufactures instructions should be observed.

(Figure showing standardised wire lashings in road transport)

10.2.4.13 Lashing chains used in sea-transport are generally long link chains of 13 mm steel diameter and MSL = 100 kN. The MSL for other dimensions figure 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. Manufacturer's instructions on the use of the tensioning lever and re-tensioning under load should be strictly observed.

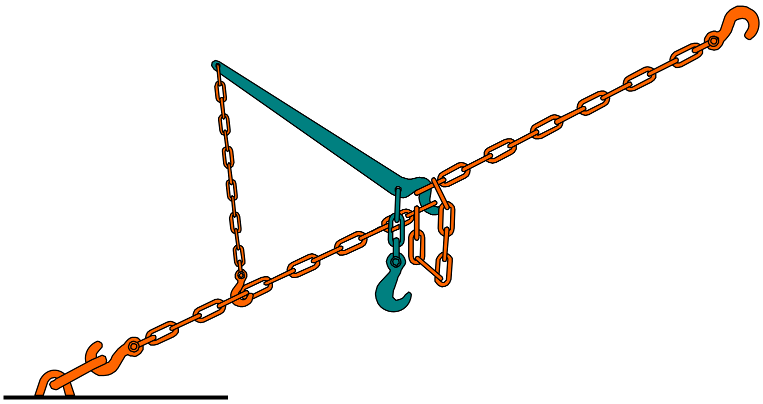


Figure 10.xx: Long link lashing chain with lever tightener

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

(Figure showing standardised chain lashings in road transport)

10.2.4.15 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 compacting cargo units to form greater blocks of cargo. In sea transport, such steel bands are also used to "tie down" cargo units 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.

(Figures showing steel band compacting)

10.2.4.16 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.

10.3 Principles of packing

10.3.1 Load distribution

10.3.1.1 Containers, flatracks and platforms are designed according to ISO standards 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 temporary weight increase due to vertical accelerations during a sea-passage. If a load cannot be homogeneously distributed over the loading floor, the permissible weight must either be reduced or the weight transfer to the corner posts must be supported by timber or steel beams placed under the cargo.

10.3.1.2 ISO box-containers are sensible both in transverse and longitudinal direction against concentrated loads. A concentrated load must be placed on longitudinal beams. These beams should be spaced by the distance s and should have a minimum length t (Figure 10.xx). The distance s should be at least 0.8 m, but preferably 1 m or greater. The minimum length t should be the greatest of the three values of t_1, t_2 or t_3 determined as follows:

$t_1 = r$ [m] (for supporting the length of the cargo unit)

$t_2 = \frac{m \cdot L}{P_0} \cdot (2 - 0.87 \cdot s)$ [m] (for satisfying transverse strength requirements)

$t_3 = L \cdot (2 - \frac{P_0}{m})$ [m] (for satisfying longitudinal strength requirements)

r = bottom length of cargo unit in the container (footprint) [m]
m = mass of cargo unit [t]
P_0 = payload of container [t]
s = spacing distance of beams [m]
t = length of beams [m]
L = inner length of container [m]

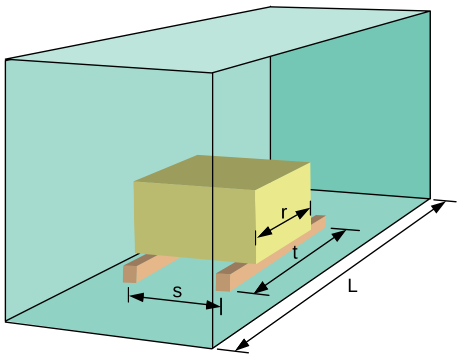


Figure 10.xx: Beams for load transfer in a box container

10.3.1.3 The strength and number of beams for load transfer must be suitable to this purpose. The required number n of beams should be determined by the formula:

$$n = 123 \cdot \frac{m \cdot (t - r)}{\sigma \cdot W}$$

σ = permissible bending stress in beam [kN/cm^2]
W = section modulus of beams [cm^3]

The permissible bending stress σ should be taken as 1 kN/cm^2 for timber beams and 15 kN/cm^2 for steel beams. Both figures contain reserves for temporary weight increase due to vertical accelerations during a sea-passage. The section modulus for each beam should be obtained from supplier's documents. The following tables may serve as a quick reference:

timber: dimensions [cm]	10 x 10	12 x 12	15 x 15	20 x 20	25 x 25
section modulus [cm^3]	152	260	508	1236	2450

steel: dimensions [cm]	12 x 12	14 x 14	16 x 16	18 x 18	20 x 20
section modulus [cm^3]	144	216	311	426	570

More information on the loading of box containers with heavy cargo units may be found under www.containerhandbook.de (Coils in Containers).

10.3.1.4 Concentrated loads on platforms or flatracks should be reduced against the permissible pay load. If the cargo unit is placed with its entire foot print over the length r on the platform, the permissible load P is:

$$P = P_0 \cdot \frac{L}{2 \cdot L - r} \text{ [t]}$$

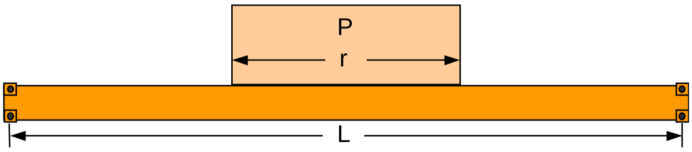


Figure 10.xx: Concentrated load of length s on an ISO-platform

If the cargo unit is stiff and stowed on transverse beddings that bridge the distance r on the platform, the permissible load P is:

$$P = P_0 \cdot \frac{L}{2 \cdot L - 2 \cdot r} \text{ [t]}$$ (Note: P must not exceed P_0 in this formula.)

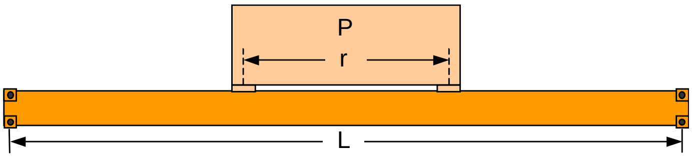


Figure 10.xx: Concentrated load on an ISO-platform bridging the distance r

P_0 = declared payload [t]
L = full length of loading floor [m]
r = length of cargo foot print or bridging distance[m]

10.3.1.5 Where containers, including flatracks or platforms, have to be lifted and handled in an even state during transport, cargo should be so arranged and secured in the container, that its joint centre of gravity is close to the mid-length and mid-width of the container. In no case should more than 60% of the load be concentrated in less than half of the length of a container measured from one end. This rule limits the longitudinal offset of the centre of gravity to about 27 cm in a 20' unit and to about 53 cm in a 40' unit. Carriers may permit specified exceedance of these figures under controlled conditions. In a box-container with transverse bottom girders, the above 60% rule may require appropriate measures for avoiding a transverse overloading (see 10.3.1.2 above). The precise longitudinal position of the centre of gravity of a loaded CTU may be obtained by the formula:

$$d = \frac{T \cdot 0.5 \cdot L + \sum(m_i \cdot d_i)}{T + \sum m_i}$$

d = distance of common centre of gravity from end of stowage area [m]
T = tare mass of CTU [t]
L = length of stowage area [m]
m_i = mass of individual cargo unit [t]
d_i = distance of centre of gravity of mass m_i from end of stowage area [m]

(Figure illustrating the determination of c.o.g. position)

10.3.1.6 Roll trailers have structural properties similar to ISO platforms, but are less sensible against concentrated loads due to the usual wheel support at about 3/4 of their length from the gooseneck tunnel end. As they are generally handled without lifting, the longitudinal position of the cargo centre of gravity is not critical.

10.3.1.7 Swap bodies have structural properties similar to ISO box-containers, but less tare weight and less overall strength. They are not stackable. The loading instructions given under 10.3.1.2 and 10.3.1.5 should be applied to swap bodies as appropriate.

10.3.1.8 Road trucks and road trailers are in particular sensitive regarding the position of the centre of gravity of the cargo loaded in them, due to specified axle loads for maintaining steering and braking ability. Such vehicles may be equipped with specific diagrams, which show the permissible pay load as a function of the longitudinal position of its centre of gravity. Generally, the maximum pay load may be used only when the centre of gravity is positioned within narrow boundaries about half the length of the loading space.

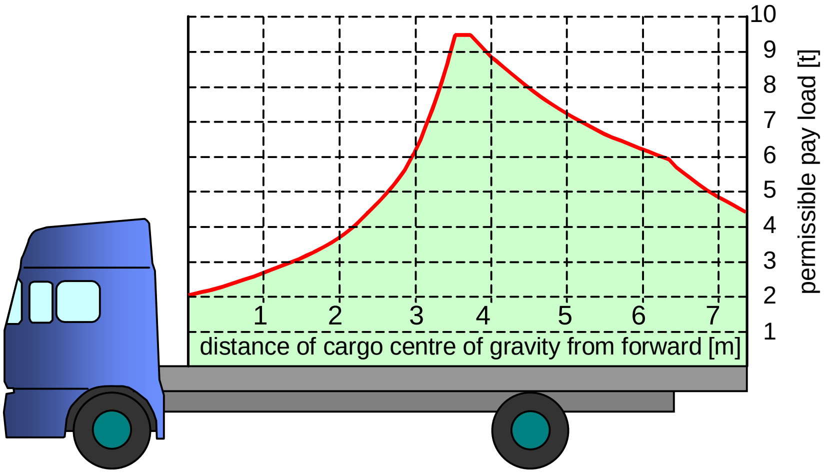


Figure 10.xx: Typical loading diagram of a road truck

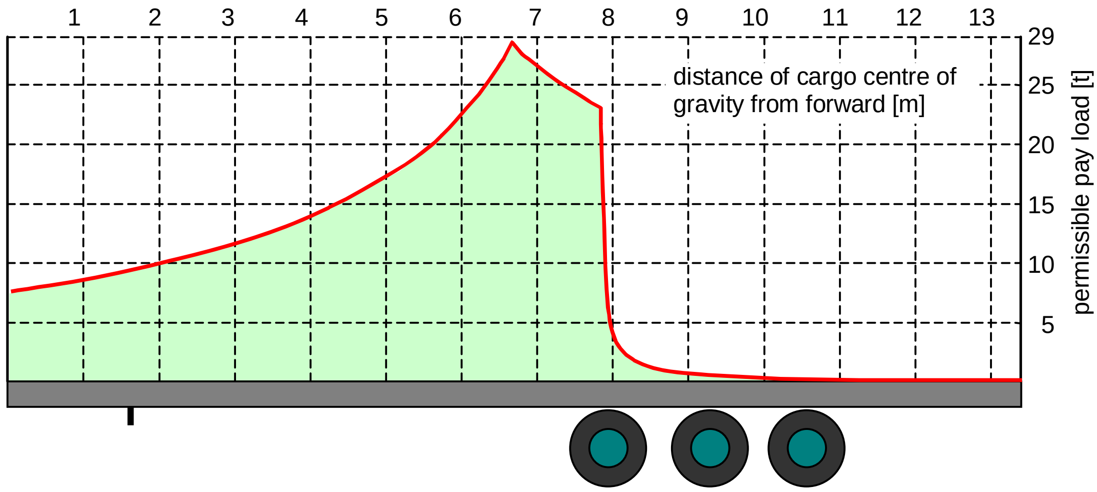


Figure 10.xx: Typical loading diagram of a road trailer

10.3.1.9 Railway routes are classified into line categories, by which permissible axle loads and loads per metre length of cargo space are allocated to each railway wagon. The applicable figures must be observed in view on the intended route of the wagon. Tolerable concentrated loads are graded depending on their bedding length. The appropriate load figures are marked on the wagons. The transverse and longitudinal deviation of cargo centre of gravity from wagon centre-lines is limited by defined relations of transverse wheel loads and longitudinal wheelset loads. The proper loading of railway wagons should be supervised by specifically trained persons.

10.3.2 General stowage/packing techniques

10.3.1.1 Stowage and packing techniques should be suitable to the nature of the cargo with regard to weight, shape, structural strength and climatic sensibility. This includes the proper use of dunnaging material (see 10.2.1), the selection of the appropriate method of mechanical handling and the provision of ventilation gaps, if applicable. The concept of stowage should incorporate the feasibility of smooth unloading.

10.3.2.2 Any marking on parcels should be strictly observed. Cargoes marked "this way up" should not only be stowed upright but also kept upright during entire handling. Goods which may be subject to inspection by the carrier or by authorities, like dangerous goods or goods liable to customs duty, should be stowed at the door end of the CTU.

10.3.2.3 When packing mixed cargoes, their mutual compatibility should be observed. Irrespective the regulations for the stowage of dangerous goods (see chapter 11) the following general rules are applicable:

- Heavier cargoes should not be stowed on top of lighter cargoes. This will also provide for the centre of gravity of the CTU in a level not exceeding half the height of the CTU.
- Heavy units should not be stowed on top of fragile parcels.
- Sharp-edged pieces should not be stowed on top of units with weak surfaces.
- Liquid cargoes should not be stowed on solid cargoes.
- Dusty or dirty cargoes should not placed near to clean and easily soiled cargoes like foodstuff in porous packing.
- Cargoes emitting moisture should not be stowed on or near to cargoes sensible to moisture.
- Smelling cargoes should not be stowed in the vicinity of cargoes easily assimilating odour.
- Mutually incompatible cargoes should be loaded into the same CTU only, if their stow is appropriately separated and/or the goods are effectively protected by suitable sheathing material.

10.3.2.4 Stacking of sensible parcels of uniform size and shape should be precise in a way that the weight from above is transferred to the vertical boards of the parcels below. If necessary, e.g. due to lateral leeway of the stack in the CTU, intermediate sheets of fibreboard or plywood should be placed between layers of the stack. Parcels of irregular shape and/or size should be stacked only with due consideration of their structural hardiness. Gaps and irregularities of level should be stuffed or equalised by means of dunnage.

(Figure showing regular and irregular stacking)

10.3.2.5 Parcels with a less defined shape like bags or bales may be stacked in an interlocking pattern, also called cross-tie, thereby creating a solid pile that may be secured by blocking or fencing. Round longish units like pipes may be stacked into the grooves of the layer below. However, care should be taken of the lateral forces produced by top layers in the grooves of the bottom layers, which may locally overload the side walls of the CTU.

(Figure showing cross-tie stowage)

10.3.2.6 Uniform parcels like drums or standardised pallets should be packed in a way that minimises lost space and provides a tight stow at the same time. Drums may be stowed either in regular lines, also called "soldier packing", or into the vertical grooves, also called "offset packing". With small drums the offset packing is more effective, while with greater drum diameters the advantage may be with the soldier stow. Pallet dimensions are widely standardised and adapted to the inner width and length of cargo spaces in road trucks, road trailers and swap bodies, not to those of ISO containers.

(Figure showing typical stowage pattern of drums and pallets)

10.3.2.7 Near to completion of packing a CTU, care should be taken to build a firm face of the cargo so as to prevent a "fall out" when the doors are opened. If there is any doubt about the stability of the face, further steps should be taken such as strapping top layers of cargo back to securing points or building a timber fence between the rear posts. It should be borne in mind, that a container on a trailer usually inclines towards the doors aft and that cargo may move against the doors due to vibration induced shift or by jolts during transport.

10.4 Securing of cargo in CTUs

10.4.1 Aims of securing

10.4.1.1 Arrangements or stacks of cargo items shall be packed in a way so as to remain in place and upright by their static friction and by their inherent tilting 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 unloading.

10.4.1.2 During transport the CTU may be subjected to 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 cargo unit is heavy, it will not move during transport. The relevant accelerations are outlined in chapter [4] 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 must aim at the avoidance of such unwanted cargo behaviour. The cargo shall not slide or tip in transverse or longitudinal direction under the stipulated accelerations of the CTU during the intended route of transport.

10.4.1.3 Direct securing devices used for creating restraining forces must inevitably elongate or compress a little, thereby allowing an accordant mobility of the cargo. Such cargo motions in form of sliding, tipping or racking should be kept as small as possible by using securing devices of appropriate load/deformation characteristics (see chapter 10.2.4), by avoiding too long lashings and by applying securing devices in a direction as close as possible to the direction of the intended restraining force. A good pre-tension in lashings will also contribute to minimising cargo motions, but the pre-tension should never exceed 50% of the MSL or LC of the distinguished lashing.

10.4.1.4 Securing arrangements should be homogeneous in a way that each securing device in the arrangement take its share of the restraining forces appropriate to its strength. Arrangements consisting of 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 web lashing is used in parallel, the stiffer timber blocking must be dimensioned so as to resist the expected external forces alone.

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

10.4.2 Tightly arranged cargoes

10.4.2.1 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 utilise the cargo space, to beware cargo items from tumbling around and to enable measures of common securing against transverse and longitudinal movement during transport.

10.4.2.2 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 chapter 10.3.2 above. 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 paragraphs 10.2.3.6 to 10.2.3.8). Direct contact of cargo items with CTU boundaries may require an interlayer of dunnaging material (see 10.2.1).

10.4.2.3 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 applies to the confinement of tightly stowed cargo within strong cargo space boundaries:

$$c_{x,y} \cdot m \cdot g \leq r_{x,y} \cdot P_0 \cdot g + \mu \cdot c_z \cdot m \cdot g \text{ [kN]}$$

$c_{x,y}$ = horizontal acceleration coefficient in the relevant mode of transport (see chapter [4]),
m = mass of cargo loaded [t],
g = gravity acceleration 9.81 m/s^2,
$r_{x,y}$ = CTU wall resistance coefficient (see chapter [3]),
P_0 = maximum payload of CTU [t],
μ = applicable friction coefficient between cargo and stowage ground (see Annex 6),
c_z = vertical acceleration coefficient in the relevant mode of transport (see chapter [4]).

Critical situations may arise, e.g. with a fully loaded ISO box-container in road transport, where longitudinal securing must be able to withstand an acceleration of 0.8 g. The longitudinal wall resistance of $0.4 \cdot P_0$ must be combined with a friction coefficient of at least 0.4 for satisfying the securing balance. If a balance cannot be satisfied, the mass of cargo must be either reduced or longitudinally subdivided and secured by transverse fences of timber battens (see paragraph 10.2.3.4) or by other suitable means. Another option is the use of friction increasing material.

10.4.2.4 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 "tie-down" lashings. Such lashings should be guided over the block of cargo with suitable edge protectors and tightened by tensioners. The attained pre-tension in both ends of the lashing increases the downward force and thereby the friction between cargo and loading ground (see 10.2.2). For obtaining a reasonable securing effect from tie-down lashings, the friction coefficient between cargo and stowage ground may be increased by suitable material (see paragraph 10.2.2.4) and the inherent elasticity of the lashings should be able to maintain the pre-tension throughout the course of transport. The following balance applies to the confinement of tightly stowed cargo within weak cargo space boundaries:

$$c_{x,y} \cdot m \cdot g \leq r_{x,y} \cdot P_0 \cdot g + \mu \cdot c_z \cdot m \cdot g + F_{sec} \text{ [kN]} \quad (F_{sec} = \text{additional securing force})$$

If a wall resistance coefficient is not specified for the distinguished CTU, it should be set to zero. Further options of additional securing 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.

10.4.2.5 CTUs **without boundaries** are in principle not a good option for transporting and securing tightly packed cargoes, notwithstanding the lack of protection against environmental impacts. If such CTUs are used for this purpose, the entire securing effect must be accomplished by securing measures like tie-down lashings, friction increasing material and, if the CTU is a flatrack, by longitudinal blocking against the end-walls. The following balance applies for the carriage of tightly stowed cargo on a CTU without cargo space boundaries:

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

It should be noted that without cargo space boundaries a minimum number of tie-down lashings may be necessary for avoiding migration of the cargo due to vibration of the CTU during transport, even in case of a friction coefficient that outnumbers the external acceleration coefficients.

10.4.3 Individually secured cargo units

10.4.3.1 Cargo units of greater size, mass or shape or units with sensible exterior facing, which does not allow direct contact to other units or CTU boundaries, must be individually secured. The securing arrangement must 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:

$$c_{x,y} \cdot d \geq c_z \cdot b \text{ [kN]}$$

$c_{x,y}$ = horizontal acceleration coefficient in the relevant mode of transport (see chapter [4]),
d = vertical distance from centre of gravity of the unit to its tipping axis [m],
c_z = vertical acceleration coefficient in the relevant mode of transport (see chapter [4]).
b = horizontal distance from centre of gravity to tipping axis [m].

(Figure for illustrating the tipping criterion)

10.4.3.2 Individually secured cargo units should preferably be secured by a direct securing method, i.e. by direct transfer of securing forces from the cargo unit to the CTU by means of lashings, shores or blocking devices. It should be noted that the effective strength of such a device is the strength of the weakest element within the device, which includes fastening points on the cargo unit as well as fastening points on the CTU. Cargo units without securing points should be either secured by "half-loop" lashings or by lashings fastened to "head-loops" or by shoring or blocking against solid structures of the CTU. Tie-down lashings, also called "friction-loops", and round-turn lashings, also called "silly-loops", do not provide a direct securing effect and should be avoided for individually secured cargo units.

(Figures illustrating half-loop, head-loop, friction-loop and silly-loop lashings)

It should be noted that direct securing devices will necessarily need to elongate or compress in order to develop a restraining force. For minimising cargo mobility the advice given in paragraph 10.4.1.3 should be observed.

10.4.3.3 CTUs with **strong cargo space boundaries** favour the method of blocking or shoring for securing a particular cargo unit. 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 cross beams (see paragraphs 10.2.3.1 to 10.2.3.3). Very heavy cargo units, e.g. steel coils or blocks of marble, may require a combination of blocking and lashing. However, cargo units with sensible surface may rule out the blocking method and must be secured by lashings.

(Photographs illustrating blocking in a CTU)

10.4.3.4 CTUs with **weak cargo space boundaries** and CTUs **without boundaries** require predominantly the method of lashing to secure a particular cargo unit. Where applicable, blocking or shoring may be additionally applied, but not in parallel with lashings, bearing in mind that blocking or shoring provides a stiff load transfer behaviour, while lashings may need a greater leeway for attaining their desired securing capacity (see paragraph 10.4.1.4). Although the provision of good friction in the bedding of a cargo unit is recommended in any case, the use of tie-down lashings for sliding prevention is discouraged, in particular for cargo units of more than 1 t mass per metre length. Tie-down lashings may, however, be suitable for tipping prevention. In particular over-width box shaped cargo units, preferably shipped on ISO flatracks, ISO platforms or roll trailers, should not be secured solely by tie-down lashings. The use of half loops and/or head-loops is strongly recommended.

(Figures illustrating lashing concepts for over-width units)

10.4.4 Evaluation of securing arrangements

10.4.4.1 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 [4] of this Code, with the weight of the cargo unit or block of cargo units in question.

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

$F_{x,y}$ = expected external force [kN],
m = mass of cargo to be evaluated [t],
g = gravity acceleration 9.81 m/s^2,
$c_{x,y}$ = horizontal acceleration coefficient in the relevant mode of transport (see chapter [4]).

Chapter [4] 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 multi-modal 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.

10.4.4.2 The assessment of the securing potential includes the assumption of a friction coefficient, based on the combination of materials (Annex 6) and the character of the securing arrangement (paragraph 10.2.2.2), and, if applicable, the determination of the inherent tilting stability of the cargo (paragraph 10.4.3.1). Any other securing devices used for blocking, shoring or lashing should be estimated by their strength in terms of MSL or LC and relevant application parameters like securing angle, pre-tension and elasticity. These figures are required for evaluating the securing arrangement.

10.4.4.3 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.

10.4.4.4 Standardised 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. Such methods may be directed to distinguished modes of transport, the use of customary securing devices and variable parameters of application. Reference:

- IMO Model Course 3.18, Safe Packing of CTUs, Quick Lashing Guides A, B, C.

10.4.4.5 The evaluation of securing arrangements may be carried out by balancing forces and moments by an elementary calculation. However, the method used should be approved and suitable to the purpose. References:

- IMO CSS-Code, Annex 13, for sea transport,
- European Standard EN 12195-1, 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.

10.4.4.6 The suitability of a specific securing arrangement may be evaluated and approved by a type-test. A simple form of such a type-test is the tilting test, which may be carried out by means of a dump truck. The tilting test is primarily used for assessing the adequacy of sub-arrangements like the compacting and fastening of small cargo items on pallets. The test may be used to demonstrate resistance against any specified external acceleration. The corresponding test-angle depends on the existing friction coefficient for a sliding resistance test, or on the relation b/d for a tipping resistance test. Reference:

- European Standard EN 12195-1, Annex D2.

11 ADITIONAL ADVICE ON THE PACKING OF DANGEROUS GOODS

11.1 General

11.1.1 The advice of this section applies to cargo transport units in which dangerous goods are packed. It should be followed in addition to the advice given elsewhere in this Code of Practice.

11.1.2 International (and often national) transport of dangerous goods may be subject to several dangerous goods transport regulations, depending on the origin, final destination and the modes of transport used.

11.1.3 For intermodal transport, involving several modes of transport other than by sea, the rules and regulations applicable depend on whether it is a national movement or international transport or transport within a political or economic union or trading zone.

11.1.4 Transport of dangerous goods by road, rail or inland waterways may be subject to various regulations and agreements. Examples are:

- European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR);
- Regulations concerning the International Carriage of Dangerous Goods by Rail (RID); and
- Title 49 of the Code of Federal Regulations of the United States.

11.1.5 Most national and international regulations are based on the United Nations Recommendations on the Transport of Dangerous Goods (Orange Book). However, national rules, applicable to domestic transport, may differ from international regulations.

11.1.6 For maritime transport, the provisions of the International Maritime Dangerous Goods Code (IMDG Code) apply. The IMDG Code provides detailed provisions on all aspects of the transport of packaged dangerous goods by sea.

11.1.7 Dangerous Goods are classified into hazard classes. Some of these are subdivided into divisions. All details are set forth in the applicable dangerous goods regulations as mentioned above. The shipper is responsible that packages with dangerous goods bear the appropriate labels and marks.

11.1.8 Under certain conditions, the dangerous goods regulations provide exemptions from some requirements if the dangerous goods are transported in “limited quantities” or excepted quantities”. Further details are set forth in the applicable dangerous goods regulations.

11.2 Before packing

11.2.1 The IMDG Code and other international and national regulations require that the shipper provides transport information on each dangerous substance, material or article. This information shall include at least the following basic items:

- the UN Number;
- the Proper Shipping Name (including the technical name, as applicable);

- the class and/or division (and the compatibility group letter for goods of class 1);
- subsidiary risks when assigned;
- the packing group when assigned;
- the total quantity of dangerous goods (by volume or mass, and for explosives the net explosive content); and
- the number and kind of packages.

Other items of information may be required, depending on the mode of transport and the classification of the goods (e.g., flashpoint for transport by sea). The various items of information required under each regulation and applicable during intermodal transport operations should be provided so that appropriate documentation may be prepared for each shipment.

11.2.2 The shipper should also ensure that dangerous goods are classified, packaged, packed, marked, labelled, placarded and provided with the required signs, in accordance with the applicable regulations. A declaration by the shipper that this has been carried out is normally required. Such a declaration may be included with the required transport information.

11.2.3 The shipper should also ensure that the goods to be transported are authorized for transport by the modes to be used during the transport operation. For example, self-reacting substances and organic peroxides requiring temperature control are not authorized for transport by rail under the RID regime. Certain types of dangerous goods are not authorized to be transported on board passenger ships and therefore the requirements of the IMDG Code should be carefully studied.

11.2.4 Current versions of all applicable regulations should be easily accessible and referred to during packing to ensure compliance.

11.2.5 Dangerous goods should only be handled, packed and secured by trained personnel. Supervision by a responsible person who is familiar with the legal provisions, the risks involved and the measures that should be taken in an emergency is required.

11.2.6 Suitable measures to prevent fires should be taken, including the prohibition of smoking in the vicinity of dangerous goods.

11.2.7 Packages of dangerous goods should be examined and any found to be damaged, leaking or sifting should not be packed. Packages showing evidence of staining, etc., should not be packed without first determining that it is safe and acceptable to do so. Water, snow, ice or other matter adhering to packages should be removed before packing. Substances that have accumulated on drum heads should initially be treated with caution in case they are the result of leakage or sifting of contents. If pallets have been contaminated by spilt dangerous goods they should be destroyed by appropriate disposal methods to prevent use at a later date.

11.2.8 If dangerous goods are palletized or otherwise unitized they should be compacted so as to be regularly shaped, with approximately vertical sides and level at the top. They should be secured in a manner unlikely to damage the individual packages comprising the unit load. The materials used to bond a unit load together should be compatible with the substances unitized and retain their efficiency when exposed to moisture, extremes of temperature and sunlight.

11.2.9 An overpack and unit load should be marked and labelled, as required for packages, for each item of dangerous goods contained in the overpack or unit load unless markings and labels representative of all dangerous goods in the overpack or unit load are clearly visible. An overpack, in addition, should be marked with the word "OVERPACK" unless markings and labels representatives of all dangerous goods as required for packages in the overpack are visible.

11.2.10 The stowage and method of securing of dangerous goods in a cargo transport unit should be planned before packing is commenced.

11.3 Packing

11.3.1 Special care should be taken during handling to avoid damage to packages. However, if a package containing dangerous goods is damaged during handling so that the contents leak out, the immediate area should be evacuated until the hazard potential can be assessed. The damaged package should not be shipped. It should be moved to a safe place in accordance with instructions given by a responsible person who is familiar with the risks involved and knows the measures that should be taken in an emergency.

11.3.2 If a leakage of dangerous goods presents safety or health hazards such as explosion, spontaneous combustion, poisoning or similar danger, personnel should immediately be moved to a safe place and the Emergency Response Organization notified.

11.3.3 Dangerous goods should not be packed in the same cargo transport unit with incompatible goods. In some instances even goods of the same class are incompatible with each other and should not be packed in the same unit, e.g., acids and alkalis of class 8. The requirements of the IMDG Code concerning the segregation of dangerous goods inside cargo transport units are usually more stringent than those for road and rail transport. Whenever an intermodal transport operation does not include transport by sea, compliance with the respective inland transport regulations may be sufficient. However, if there is any possibility that a part of the transport operation will be by sea, the segregation requirements of the IMDG Code should be strictly complied with.

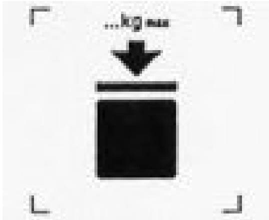
11.3.4 Some dangerous goods have to be segregated from foodstuffs by a certain distance within the cargo transport unit or are even prohibited in the same unit. More advice is to be found in the applicable dangerous goods regulations.

11.3.5 When dangerous goods are being handled, the consumption of food and drink should be prohibited.

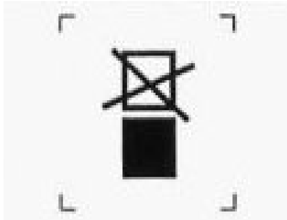
11.3.6 Packages marked with orientation arrows should be packed with the arrows pointing upwards. Vented packages should be packed in such a way that the vents will not be blocked.

11.3.7 Drums containing dangerous goods should always be stowed in an upright position unless otherwise authorized by the Competent Authority.

11.3.8 Standard packagings such as drums, jerricans and boxes approved for the transport of dangerous goods are tested for a stacking height of 3 meters. The stacking test is carried out with the static gravity of 1 g (9.81 m/s^2). In case of sea transport it should be considered that, due to the dynamic variation of vertical acceleration, the maximum value could be up to 1.8 g (see section 4.3). Therefore, it may be necessary to ensure stability of such stack by introducing dunnage or solid flooring between tiers of such stow. Intermediate bulk containers (IBC) are not all suitable for stacking. IBC which are manufactured or repaired after 1 January 2011 are marked with a pictogram showing either the maximum permitted stack load or an indication that the IBC cannot be stacked, as follows:



IBC capable of being stacked (stack load indicated in kg)



IBC not capable of being stacked

For IBC manufactured before that date, the approval marking on the IBC should be checked to find out whether the IBC can be stacked and, if so, for what stacking load it was tested. More details can be found in [chapter 6.5 of] the applicable dangerous goods regulations.

11.3.9 Dangerous goods consignments which form only part of the load of a cargo transport unit should, whenever possible, be packed adjacent to the doors with markings and labels visible. Particular attention is drawn to 10.3.2.7 concerning the securing of cargo by the doors of a unit.

11.3.10 The number of packages containing dangerous goods in excepted quantities in any cargo transport unit is limited to a maximum of 1,000.

Annex 4 Proposal of Germany for chapter 12 of CoP

12 ON COMPLETION OF PACKING

12.1 Closing the CTU

12.1.1 After closing the doors, it should be ensured that all closures are properly engaged and secured. If the doors of a cargo transport unit are locked, the means of locking shall be such that, in case of emergency, the doors can be opened without delay. Where cargo transport units have hinged or detachable fittings, a check should be made that they are properly secured, with no loose equipment likely to cause a hazard during transport.

12.1.2 Cargo transport units in international trade should be sealed with a seal bearing a unique identification number. Many countries require by national legislation that such seals shall meet the standard of ISO 17712:2010. ISO 17712:2010 establishes uniform procedures for the classification, acceptance and withdrawal of acceptance of mechanical seals on freight containers, bulk railcars and truck trailers. It provides a single source of information on mechanical seals which are acceptable for securing cargo transport units in international commerce. The purpose of mechanical seals is, as part of a security system, to determine whether a cargo transport unit has been tampered with, i.e. whether there has been unauthorized entry into the cargo transport unit through its doors. Seals meeting the standard of ISO 17712:2010 shall comply with certain criteria for strength and durability so as to prevent accidental breakage, early deterioration (due to weather conditions, chemical action, etc.) or undetectable tampering under normal usage.

12.1.3 Where security devices, beacons or other tracking or monitoring equipment are used, they should be securely installed to the cargo transport unit and, when equipped with a source of energy, they should be of a certified safe type[2]. It should be noted that the International Convention for the Safety of Life at Sea (SOLAS) requires that no sources of ignition shall be present in enclosed cargo spaces where highly flammable dangerous goods are stowed.

12.2 Marking and placarding

12.2.1 The applicable dangerous goods regulations require that placards (enlarged labels), marks and other signs are affixed to the surfaces of a cargo transport unit. The specifications of these placards, marks and signs and the locations where they have to be affixed are described in detail in the applicable dangerous goods regulations.

12.2.2 The applicable dangerous goods regulations may require specific warning signs for cargo transport units which contain solid carbon dioxide (CO_2 – dry ice) or other expendable refrigerant used for cooling purposes. The sign aims to warn of the possibility of an asphyxiating atmosphere.

12.2.3 The applicable dangerous goods regulations may require specific warning signs for cargo transport units under fumigation. The details of marking and further instructions for the handling of such cargo transport units are set forth in the applicable dangerous goods regulations.

[2] Refer to the Recommendations published by the International Electrotechnical Commission, in particular, to publications IEC 60079 and IEC 60092.

12.3 Documentation

12.3.1 In particular for sea transport, the packer should calculate the correct gross mass of the loaded cargo transport unit. For this purpose he should obtain from the shipper a detailed packing list stating the masses of all packages and other cargo items. The gross mass of the cargo transport unit is the sum of the masses of all cargo items which have been packed, the mass of all stowage and securing material, such as pallets, dunnage or timber used for blocking, and the tare mass of the cargo transport unit. Alternatively, the gross mass of the loaded cargo transport unit may be verified by weighing the unit on a calibrated scale.

12.3.2 The packer of the cargo transport unit should inform the shipper or those responsible to contract the shipment with the carrier on the identification number of the cargo transport unit (container number or vehicle number as appropriate), on the gross mass of the unit and on the identification number of the seal, thus to ensure that the gross masses and the identification numbers are included in all transport documents, such as bills of lading, way bills, consignment notes or cargo manifests.

12.3.3 Whenever the cargo projects beyond the overall dimensions of the cargo transport unit the information described in 12.3.2 should state the exact overheight, overwidth or overlength, as appropriate.

12.3.4 In addition, whenever dangerous goods are packed into a cargo transport unit the IMDG Code and other transport regulations require that those responsible for the packing of the cargo transport unit shall provide a "container/vehicle packing certificate" specifying the identification number of the container or the vehicle and certifying that the packing operation was carried out in accordance with the requirements of the applicable dangerous goods regulations. For all details of documentation, the relevant dangerous goods regulations shall be referred to.

12.3.5 Cargo transport units for which a packing certificate for dangerous goods is not required and which are intended to be loaded onto a ship in maritime trade should be provided with a "cargo stowage and securing declaration", stating that the cargo in the cargo transport unit has been properly stowed and secured for the intended sea voyage. This declaration should state

- the identification number of the cargo transport unit
- the place and date of loading
- a short description of the commodity(ies)
- the verified gross mass of the cargo transport unit
- if applicable, any overheights, overwidth or overlength,
- the wording "I hereby declare that the cargo in the above-mentioned cargo transport unit has been properly stowed and secured for transport by sea, taking into account the Code of Practice for packing of cargo in transport units and that the gross mass of the unit has been properly calculated or verified by weighing."
- the name of signatory
- place and date; and
- signature on behalf of the packer.

Such certificate may be presented by means of EDP or EDI transmission techniques, the signature may be electronic signature or may be replaced by the name in capitals of the person authorized to sign.

12.3.6 The “container/vehicle packing certificate” mentioned in 12.3.4 is a mandatory document for dangerous goods under SOLAS chapter VII regulation 4. For other cargoes not meeting the definition of dangerous goods in SOLAS chapter VII, the provisions of SOLAS chapter VI regulation 5 apply, where it is required that cargo and cargo units shall be so packed and secured within a cargo transport unit as to prevent, throughout the sea voyage, damage or hazard to the ship and persons on board. The “cargo stowage and securing declaration” mentioned in 12.3.5 is not a mandatory document under SOLAS convention. Such declaration is recommended in chapter 2 of the Code of Safe Practice for Cargo Stowage and Securing of the International Maritime Organization, only when road vehicles are used as cargo transport units. However, individual carriers might require this declaration from shippers to provide evidence that the packer of a cargo transport unit complied with the requirements of SOLAS Chapter VI regulation 5.