cordstrap

CTU CODE

A BASIC GUIDE BY CORDSTRAP

CONTENTS

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 personnel injury when they are handled or transported. In addition, serious and costly damage may occur to the cargo or to the equipment.

The types of cargoes carried in freight containers has expanded over many years and innovations such as use of flexitanks and developments allow heavy, bulky items which were traditionally loaded directly into the ships' hold (e.g. stone, steel, wastes and project cargoes), to be carried in cargo transport units.

The person who packs and secures cargo into/onto the cargo transport unit (CTU) may be the last person to look inside the unit until it is opened at its final destination. Consequently, a great many people in the transport chain will rely on the skill of such persons, including:

- Road vehicle drivers and other road users when the unit is transported by road;
- Rail workers, and others, when the unit is transported by rail;
- Crew members of inland waterway vessels when the unit is transported on inland waterways;
- Handling staff at terminals when the unit is transferred from one transport mode to another;
- Dock workers when the unit is loaded or unloaded;
- Crew members of a seagoing ship during the transport operation;
- Those who have a statutory duty to inspect cargoes; and
- Those who unpack the unit.

All persons, such as the above, passengers and the public, may be at risk from a poorly packed freight container, swap body or vehicle.

CHAPTER 1. INTRODUCTION

1.1 SCOPE

1.1.1 The aim of this IMO/ILO/UNECE Code of Practice for Packing of Cargo Transport Units (CTU Code) is to give advice on the safe packing of cargo transport units (CTUs) to those responsible for the packing and securing of the cargo and by those whose task it is to train people to pack such units. The aim is also to outline theoretical details for packing and securing as well as to give practical measures to ensure the safe packing of cargo onto or into CTUs.

1.1.2 In addition to advice to the packer, the CTU Code also provides information and advice for all parties in the supply chain up to and including those involved in unpacking the CTU.

1.1.3 The CTU Code is not intended to conflict with, or to replace or supersede, any existing national or international regulations which may refer to the packing and securing of cargo in CTUs, in particular existing regulations which apply to one mode of transport only, e.g. for transport of cargo in railway wagons by rail only.

1.2 SAFETY

1.2.1 Improperly packed and secured cargo, the use of unsuitable CTUs and the overloading of CTUs may endanger persons during handling and transport operations. Improper declaration of the cargo may also cause dangerous situations. The misdeclaration of the CTU's gross mass may result in the overloading of a road vehicle or a rail wagon or in the allocation of an unsuitable stowage position on board a ship thus compromising the safety of the ship.

1.2.2 Insufficient control of humidity may cause severe damages to and collapse of the cargo and cause also the loss of the stability of the CTU.

1.3 SECURITY

1.3.1 It is important that all personnel involved in the packing, security sealing, handling, transport and processing of cargo are made aware of the need for vigilance and the diligent application of practical procedures to enhance security, in accordance with national legislation and international agreements.

1.3.2 Guidance on the security aspects of the movement of CTUs intended for carriage by sea may be found in a variety of documents including the International Convention for the Safety of Life at Sea (SOLAS), 1974, as amended; the International Ship and Port Facility Security (ISPS) Code; the ILO/IMO Code of Practice on Security in Ports; and the Standards and the Publicly Available Specifications developed or being developed by the International Organization for Standardization (ISO) to address cargo security management and other aspects of supply chain security. Furthermore, the World Customs Organization (WCO) has developed a SAFE Framework of standards to secure and facilitate global trade.

1.4 HOW TO USE THE CTU CODE

1.4.1 This Code comprises 13 chapters. Most of them refer to one or more annexes which is highlighted in the text where applicable. Further practical guidance and background information are available as informative material[1], which does not constitute part of this Code. Table 1 at the end of this chapter provides a summary of contents.

1.4.2 More information on the consequences of improper packing procedures is provided in informative material IM1.

1.4.3 Following the introduction in Chapter 1, Chapter 2 lists definitions of terms which are used throughout the Code. Chapter 3 provides an overview of basic safety issues related to the packing of CTUs, briefly described as "dos and don'ts". Detailed information on how to comply with these "dos" and how to avoid the "don'ts" are contained in the following chapters and in the related annexes.

1.4.4 Chapter 4 identifies the chains of responsibility and communication for the principle parties in the supply chain and is supplemented with Annex 1 on information flow and, particularly for terminal operators, with Annex 2 on the safe handling of CTUs. Information on typical documents related to transport may be obtained from informative material IM2.

[1] Available at www.unece.org/trans/wp24/guidelinespackingctus/intro.html.

1.4.5 Chapter 5 (general transport conditions) describes the acceleration forces and the climatic conditions to which a CTU is exposed during transport. Annex 3 provides additional guidance on the prevention of condensation damages.

1.4.6 Chapter 6 (CTU properties), Chapter 7 (CTU suitability) and chapter 8 (arrival, checking and positioning of CTUs) should be considered to select the appropriate CTU for the cargo to be carried and to ensure that the CTU is fit for its intended purpose. Additional guidance to these topics is provided in Annex 4 (approval plates), Annex 5 (receiving CTUs) and annex 6 (minimizing the risk of recontamination). More information on the properties of the various CTU types is provided in informative material IM3, more information on species of concern regarding recontamination may be obtained from informative material IM4.

1.4.7 Chapter 9 (packing cargo into CTUs) is the core chapter of this Code dealing with the actual packing operation. This chapter directs the user to the related provisions in Annex 7, where detailed information on load distribution, securing arrangements, capacity of securing devices and methods for the evaluation of the efficiency of a certain securing arrangement are provided. This annex is supplemented with appendices on packaging marks, friction factors and on calculations for load distribution and cargo securing. Guidance for working on the top of tank CTUs or solid bulk CTUs is provided in annex 8. To facilitate the evaluation of the efficiency of cargo securing arrangements, one sound practical tool is the "quick lashing guide" provided in informative material IM5. In addition, very detailed information on intermodal load distribution is provided in informative material IM6. Information on manual handling of cargo is provided in informative material IM7. Information on the transport of perishable cargo is provided in informative material IM8.

1.4.8 Chapter 10 provides additional advice on the packing of dangerous goods. Chapter 11 describes the actions required on the completion of packing. Information on CTU seals is provided in informative material IM9.

1.4.9 Chapter 12 contains advice on the receipt and unpacking of CTUs and is supplemented with Annex 5 (receiving CTUs) and Annex 9 (fumigation). Additional information on the testing of gases is provided in informative material IM10.

1.4.10 Chapter 13 outlines the required qualification of personnel engaged in the packing of CTUs. The topics for consideration in a training programme are listed in Annex 10.

1.5 STANDARDS

Throughout this Code and in its annexes and appendices, any national or regional standards are referenced for information only. Administrations may substitute other standards that are considered equivalent.

CHAPTER 4. CHAINS OF RESPONSIBILITY AND INFORMATION

Note: Definitions are given in chapter 2.

4.1 CHAIN OF RESPONSIBILITY

4.1.1 In general, transport operations using CTUs in particular, involve various parties each of whom have a responsibility to ensure that the cargo is transported through the supply chain without incident. Notwithstanding any national legislation or contracts between the involved parties the chain of responsibility discussed below identifies functional responsibilities of the parties involved.

4.1.2 Although the carrier generally, in a contract of carriage is responsible under that contract to deliver the cargo in the same condition as received, it is the shipper who should deliver a cargo which is safe and suitable for transport. Thus, the shipper remains responsible for any deficiency of the CTU that is a result of poor packing and securing. However, when the shipper is neither the packer nor the consignor, the packer and the consignor should fulfil their obligation to the shipper ensuring that the CTU is safe for transport. If not the shipper may hold those parties responsible for any faults or deficiencies that can be attributed to poor packing, securing, handling or reporting procedures.

4.1.3 Within this chain of responsibilities, each party in the chain should comply with their individual responsibilities and in doing so increase safety and reduce the risk of injury to persons involved in the supply chain.

4.1.4 All persons involved in the movement of CTUs also have a duty to ensure, in accordance with their roles and responsibilities in the supply chain, that the CTU is not infested with plants, plant products, insects or other animals, or that the CTU is not carrying illegal goods or immigrants, contraband or undeclared or misdeclared cargoes.

4.1.5 The supply chain is a complex operation and individual modes of transport may have defined terms for parties within the supply chain which are not consistent with other modes of transport.

4.1.6 A single entity may undertake one or more of the functions listed below. The flow of information between the functions is discussed further in Annex 1.

4.2 FUNCTIONS WITHIN THE SUPPLY CHAIN

Between the different functions involved in an intermodal transport chain, the tasks are assigned as follows:

4.2.1 The CTU operator is responsible for providing CTUs that:

- Are fit for purpose;
- Comply with international structural integrity requirements;
- Comply with international or national safety regulations;
- Are clean, free of cargo residues, noxious materials, plants, plant products and visible pests.

4.2.2 The consignor is responsible for:

- Correctly describing the goods including the mass of the total payload;
- Notifying the packer/shipper of any unusual transport parameters of individual packages, for example, the offset of the centre of gravity or transport temperatures which should not be exceeded or undercut;
- Ensuring that packages and unit loads are suitable to withstand the stresses which are to be expected under normal transport conditions;
- Providing all the information that is required for proper packing;
- Ensuring that goods in packages and unit loads are adequately secured to prevent damage during transport;
- Ensuring that goods are ventilated so that any noxious or harmful gases are permitted to vent off before packing;
- Ensuring that dangerous goods are correctly classified, packed and labelled;
- Ensuring the dangerous goods transport document is completed, signed and transmitted to the packer, forwarder, shipper (if not the consignor) and carrier as applicable.

4.2.3 The packer is responsible for:

- Ensuring that the CTU is checked before packing and that the condition of the CTU is suitable for the cargo to be transported;
- Ensuring that the floor of the CTU is not overstressed during packing operations;
- Ensuring that the cargo is correctly distributed in the CTU and properly supported where necessary;
- Ensuring that the CTU is not overloaded;
- Ensuring that the cargo is sufficiently secured in the CTU;
- Ensuring that measures are put in place to prevent the movement of plants, plant products and visible pests, such as closing doors and tarpaulins once packing has started but not taking place and lights that minimize the attraction of insects;
- Properly closing the CTU and sealing it, when required, and reporting seal details to the shipper. CTUs used for international transport should be sealed;
- Fitting marks and placards to the CTU as required by dangerous goods regulations;
- Fitting the fumigation mark if any fumigant has been used as part of the packing process;
- Accurately determining the gross mass[3] of the CTU and transmitting it to the shipper;
- Ensuring that no incompatible dangerous goods are packed. Account should be taken of all dangerous goods legislations during the complete transport chain;
- Providing the container/vehicle packing certificate (new document or signed statement in the dangerous goods transport documentation as appropriate) and forwarding any documentation to the shipper.

4.2.4 The packer should also pass on information relating to any freight container with a reduced stacking capacity (less than 192,000 kg marked on the CSC safety approval plate)[4], to the shipper.

The shipper is responsible for ensuring that:

- The work distribution concerning packing and securing is clearly agreed and communicated to the consignor and carrier/carriers;
- A suitable CTU is used for the intended cargo for the intended transport;
- A CTU is requested which is safe for transport and is clean, free of cargo residues, noxious materials, plants, plant products and visible pests before being supplied to the consignor or packer;
- Suitable modes of transport are selected to minimize the risk of accidents and damages for the actual cargo;
- All required documents are received from the consignor and from the packer;
- The cargo inside the CTU is fully and accurately described;
- The gross mass of the CTU is accurately determined;
- The accurate description of the cargo[5] is communicated to the carrier as early as required by the carrier;
- The verified gross mass is communicated to the carrier as early as required by the carrier;
- In case of dangerous goods, the transport document and (for sea transport) the packing certificate is transmitted to the carrier before the transport commences respectively as early as required by the carrier;
- In the case of temperature controlled goods, the correct temperature set point is entered into the control unit and onto the transport/shipping documents;
- Ensuring that a seal, where required, is affixed immediately upon completion of the packing of the CTU;
- The seal number, where required, is communicated to the carrier;
- Any extraordinary properties such as reduced stacking capacity or out of gauge are communicated to the carrier;
- The shipper's declaration is accurate;
- Shipping instructions are despatched to the carrier on time and that the CTU meets the outbound delivery window;
- The CTU arrives at the terminal before the stated cargo cut off time;
- The information concerning the consignment, description of packages and, in the case of freight containers, the verified gross mass is transmitted to the consignee.

4.2.5 The road haulier is responsible for:
- Confirming that the gross mass, length, width and height of the vehicle are within the national road/highway regulations limits;
- Ensuring that the driver is able to get sufficient rest and does not drive when fatigued;
- Except when the CTU is a trailer, securing the CTU properly on the trailer or chassis;
- Moving the CTU in such a manner that there are no exceptional stresses placed on the CTU or the cargo.

4.2.6 The rail haulier is responsible for:
- Handling the CTU in a manner that would not cause damage to the cargo;
- Except when the CTU is a rail wagon, securing the CTU properly on the rail wagon.

4.2.7 The intermodal operator is responsible for:
- Ensuring that appropriate pest prevention methods are in place, which may include removal of muds and soils from the CTU;
- Complying with Annex 2.

4.2.8 The carrier is responsible for:
- Monitoring agreed temperatures in the CTUs where applicable and reacting to changes as appropriate;
- Securing the CTU on the means of transport;
- Transporting the CTU in compliance with agreements and all applicable regulations;
- Providing trained personnel to deal with all cargo types (break-bulk, bulk wet and dry cargoes, dangerous goods, out of gauge, refrigerated, uncontainerized).

4.2.9 The consignee/receiver of CTUs is responsible for:
- Not overstressing the floor of the CTU during unpacking operations;
- Correctly ventilating the CTU before entering;
- Confirming that the atmosphere within the CTU is not hazardous before permitting persons to enter it;
- Detecting any damage to the CTU and to notify the carrier;
- Returning the CTU to the CTU operator completely empty and clean, unless otherwise agreed;
- Removing all marks, placards or signs regarding the previous consignments.

4.2.10 Shippers of empty CTUs and operators of empty CTUs are encouraged to have practices and arrangements in place to ensure that they are empty.

4.2.11 All parties identified within section 4.2 should minimize the risk of recontamination of CTUs when in their custody. This may include the following:
- Implementation of appropriate pest management programs;
- Removal of any plants, plant products or visible pests taking into account the roles and responsibilities of each party within the supply chain and, further, the impossibility of inspecting the interior of closed and sealed CTUs for recontamination.

For more information see Annex 6.

4.2.12 All parties should ensure that the flow of information is transmitted to parties identified in the transport contract along the supply chain. The information should include:

- The identification, in accordance with a risk assessment[6], of risks to the integrity of the CTU that may be present for all or some part of the journey;
- CTU identification;
- Seal number (where required);
- Verified gross mass of the CTU;
- Accurate description of the cargo carried in the CTU;
- The correct description of dangerous goods;
- Correct and appropriate transport documentation;
- Any information required for safety, security, phytosanitary, veterinary, Customs or other regulatory purposes.

[3] The gross mass of the CTU needs to be verified before any transport operation commences. Incorrect gross masses are a hazard for any mode of transport. Therefore, the gross mass verification should be carried out before the unit leaves the premises of the packer. If a certain transport mode deems it necessary that a reverification has to take place when the CTU is transferred from one mode to another, this is beyond the scope of this Code and may be regulated in the regulations of that mode. Where a cargo is to be transported by road or rail only, the packer need only provide the mass of the cargo and any packing and securing material to the carrier when the tare of the transport vehicle is not known.

[4] As of January 1st 2012, all freight containers with reduced stacking or racking strength are required by the International Convention for Safe Containers (CSC) to be marked in accordance with the latest version of ISO 6346: Freight containers – Coding, identification and marking.

[5] A description of the cargo should include a description of the goods and the packaging, for example wine in a flexitank, hard frozen hanging beef sides or the number and type of packages. However, national and/or regional regulations may impose additional requirements for the scope and level of detail of cargo descriptions, including usage of Harmonized System (HS) codes.

[6] For example, ISO 31000 Risk management – Principles and guidelines.

CHAPTER 9. PACKING CARGO INTO CTUS

9.1 PLANNING OF PACKING

9.1.1 Packers should ensure that:

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

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

9.2 Packing and securing materials

9.2.1 Packers should ensure that securing materials are:

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

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

9.3 PRINCIPLES OF PACKING

9.3.1 Packers should ensure that:

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

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

9.4 Securing cargo in CTUs

9.4.1 The packers should ensure that:

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

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

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

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

ANNEX 7. PACKING AND SECURING CARGO INTO CTUS

1. PLANNING OF PACKING

1.1 When applicable, 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 7 of this Code). Deficiencies should be rectified before packing starts.

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

1.3 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 should be segregated.

1.4 In order to avoid cargo damage from moisture in closed CTUs during long voyages, 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 timber planks and bracings, pallets or packagings 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 are to be used, the necessary absorption capacity should be calculated. More information may be found in Annex 3.

1.5 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.

Note: See appendix 1 to this annex for further details on packaging marks.

1.6 Where packing results in stacks of packages, the strength of the individual packages should be capable of supporting those placed above them. Care should be taken that the stacking strength of packages is appropriate for the stack design.

1.7 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 the CTU is opened should definitely be avoided.

1.8 The mass of the planned cargo should not exceed the maximum payload of the CTU. In the case of freight containers, this ensures that the permitted maximum gross mass of the freight container, marked on the CSC safety approval plate, will not be exceeded. For CTUs not marked with their maximum permissible gross mass or payload, these values should be identified before packing starts.

1.9 Notwithstanding the foregoing, any limitation of height or mass 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 mass limits may be considerably lower than the permitted gross mass referred to above.

1.10 When a heavy package with a small "footprint" will be shipped in a CTU, the concentrated load should be transferred to the structural transverse and longitudinal bottom girders of the CTU (see Section 3.1 of this annex for details).

1.11 In longitudinal direction the centre of gravity of the packed cargo should be within allowed limits. In transverse direction the centre of gravity should be close to the half width of the CTU. In vertical direction the centre of gravity should be 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/carriers. In case of CTUs, which will 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 Appendix 4 to this annex).

1.12 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.

1.13 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, bracings and packaging materials to be free of bark.

1.14 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:

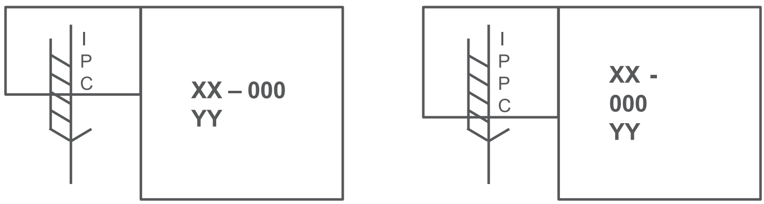


Figure 7.1 Phytosanitary mark

The marks indicating that wood packaging and dunnage material has been subjected to approved phytosanitary treatment in accordance with the symbols shown in figure 7.1 will have the following components:

1.14.1 Country code

The country code should be the International Organization for Standardization (ISO) two letter code (shown in the figure as "XX").

1.14.2 Producer/treatment provider code

The producer/treatment provider code is a unique code 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 (shown in the figure as "000").

1.14.3 Treatment code

The treatment code (shown as "YY" in the figure) shows the abbreviation for the approved measure used (HT for heat treatment, MB for fumigation with methyl bromide). In Europe the letters "DB" can be added where debarking has been done.

Note: Treatment should be carried out before the packaging and dunnage material is packed into the CTU. In situ treatment is not permitted.

[1] Secretariat of the International Plant Protection Convention, Food and Agriculture Organization of the United Nations: Regulation of wood packaging material in international trade.

1.15 Damaged packages should not be packed into a CTU, unless precautions have been taken against harm from spillage or leakage (see also Chapter 10 of this Code on dangerous goods). The overall capability to resist handling and transport stresses should be ensured.

1.16 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.

2. PACKING AND SECURING MATERIALS

2.1 Dunnaging and separating material

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; and
- Timber planks or plywood against sweat water running down the sides of the CTU.

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 containers. Moreover, the use of such dunnaging is indispensable, when packing reefer containers.

2.1.3 Timber planks, plywood sheets or pallets may be used to equalize loads within stacks of cargo parcels and to stabilize these stacks against dislocation or collapse. The same material may be used for separating packages, which may damage each other or even for installing a temporary floor in a CTU for eliminating inappropriate stack loads to the cargo (see figure 7.2).

Figure 7.2 Timber temporary floor

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

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

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 1.13 and 1.14 of this annex).

2.2 FRICTION AND FRICTION INCREASING MATERIAL

2.2.1 For handling and packing of cartons and pushing heavy units a low friction surface may be desirable. However, for minimizing 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.

2.2.2 The magnitude of the vertical friction forces between a cargo item and the stowage ground depends on the mass of the item, the vertical acceleration coefficient and a specific friction factor μ, which may be obtained from Appendix 2 to this annex.

Friction force:
$FF = \mu \cdot cz \cdot m \cdot g$ [kN], with mass of cargo [t] e g = 9.81 [m/s2]

2.2.2.1 The factors presented in appendix 2 are applicable for static friction between different surface materials. These figures may be used for cargoes secured by blocking or by friction lashings.

2.2.2.1 For cargoes secured by direct securing, a dynamic friction factor should be used with 75% of the applicable static friction factor, because the necessary elongation of the lashings for attaining the desired restraint forces will go along with a little movement of the cargo.

2.2.2.3 The friction values given in Appendix 2 to this annex are valid for swept clean dry or wet surfaces free from frost, ice, snow, oil and grease. When a combination of contact surfaces is missing in the table in Appendix 2 or if the friction factor cannot be verified in another way, the maximum friction factor to be used in calculations is 0.3. If the surface contact is not swept clean, the maximum friction factor to be used is 0.3 or the value in the table, when this is lower. If the surface contacts are not free from frost, ice and snow a friction factor μ = 0.2 should be used unless the table shows a lower value. For oily and greasy surfaces or when slip sheets have been used a friction factor μ = 0.1 should be used. The friction factor for a material contact can be verified by static inclination or dragging tests. A number of tests should be performed to establish the friction for a material contact (see Appendix 3 to this annex).

2.2.3 Friction increasing materials like rubber mats, sheets of structured plastics or special cardboard may provide considerably higher friction factors, which are declared and certified by the manufacturers. However, care should be taken in the practical use of these materials. Their certified friction factor 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.

2.3 BLOCKING AND BRACING MATERIAL AND ARRANGEMENTS

2.3.1 Blocking, bracing or shoring is a securing method, where e.g. timber beams and frames, empty pallets or dunnage bags are filled into gaps between 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, 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 arrangement, because lateral g-forces from only one side will need to be transferred at a time.

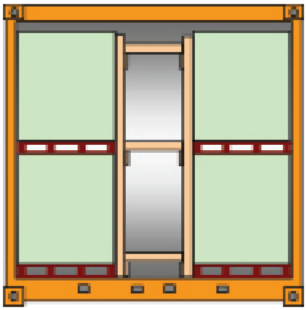


Figure 7.3 Centre gap with transverse bracing

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. Softwood timber cross-beams should be given sufficient overlaps at the shore contact points. For the assessment of bedding and blocking arrangements, the nominal strength of timber should be taken from the following table:

	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

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 clamps and the stabilizing of the arrangement by diagonal braces as appropriate (see figures 7.4 and 7.5).

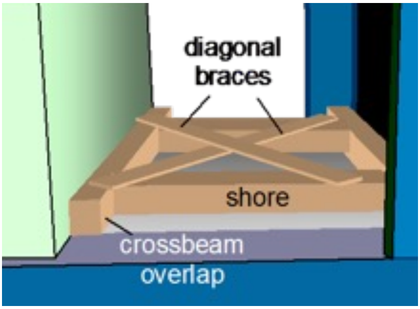


Figure 7.4 Shoring arrangement showing cross beam overlap and diagonal braces

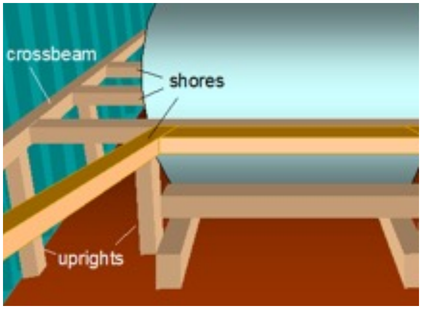


Figure 7.5 Shoring arrangement with uprights and crossbeam

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.

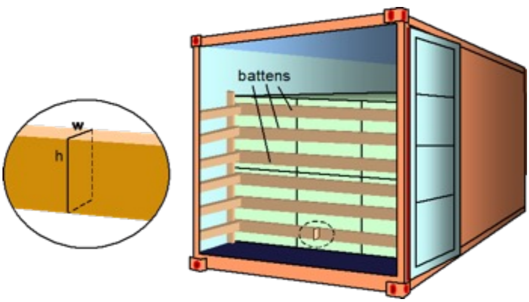


Figure 7.6 General layout of fence battens for door protection in a CTU

2.3.5 Blocking by nailed on scantlings 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 to take up a blocking force 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 timber battens or wedges should only be nailed to dunnage or timbers placed under the cargo. 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).

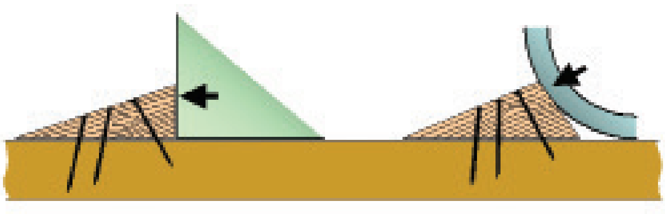


Figure 7.7 Properly cut and nailed wedges

2.3.6 In the case of form locking, void spaces should be filled and may be favourably stuffed by empty pallets inserted vertically and tightened by additional timber battens as necessary. Material 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 to be filled. The sum of 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 minimized, as far as possible.

2.3.7 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). 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 Cargo firmly secured to pallets by textile lashings

2.3.8 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 and 7.10). 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).

Figure 7.9 Gap filled with a central dunnage bag

Figure 7.10 Irregular shaped packages blocked with dunnage bags

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

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 1.13 and 1.14 of this annex).

2.4 LASHING MATERIALS AND ARRANGEMENTS

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

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

MATERIAL	MSL
Shackles, rings, deck eyes, turnbuckles of mild steel	50% of breaking strength
Fibre ropes	33% of breaking strength
Web lashings (single use)	75% of breaking strength[1]
Web lashings (reusable)	50% of breaking strength
Wire ropes (single use)	80% of breaking strength
Wire ropes (reusable)	30% of breaking strength
Steel band (single use)	70% of breaking strength[2]
Chains	50% of breaking strength

[1] Maximum allowed elongation 9% at MSL.

[2] It is recommended to use 50%.

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

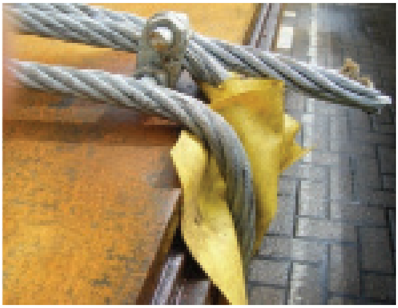


Figure 7.11 Poor edge protection

Figure 7.12 Edge protectors

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

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

Natural fibre ropes: MSL = 2 · d2 [kN]
Polypropylene ropes: MSL = 4 · d2 [kN]
Polyester ropes: MSL = 5 · d2 [kN]
Polyamide ropes: MSL = 7 · d2 [kN]

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

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

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

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

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

2.4.9 Wire rope used for lashing purposes in CTUs for sea transport consists of steel wires with a nominal BL of around 1.6 kN/mm2 and the favourite construction 6 x 19 + 1FC, i.e. 6 strands of 19 wires and 1 fibre core (see figure 7.13). If a certified figure of MSL is not available, the MSL for one-way use may be estimated by MSL = 40 · d2 [kN]. Other available lashing wire constructions with a greater number of fibre cores and less metallic cross section have a considerably lesser strength related to the outer diameter. The elastic elongation of a lashing wire rope is about 1.6% when loaded to one-way MSL, but an initial permanent elongation should be expected after the first tensioning, if the wire rope is new.

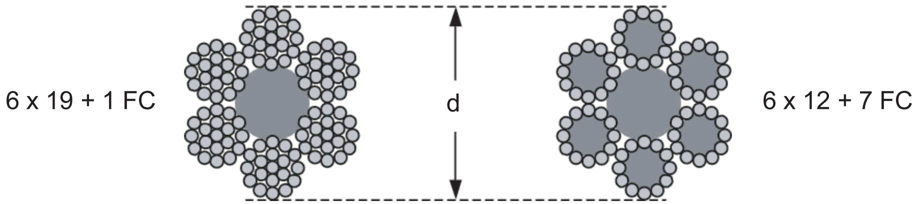


Figure 7.13 Typical lashing wire rope construction

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

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

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

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

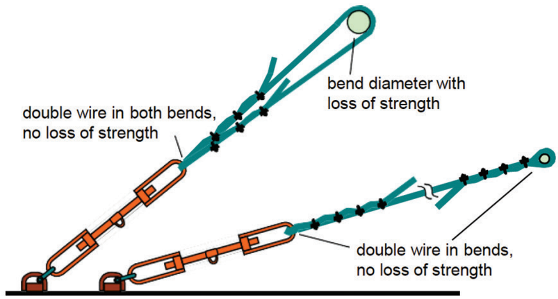


Figure 7.14 Recommended assemblies for wire rope lashing

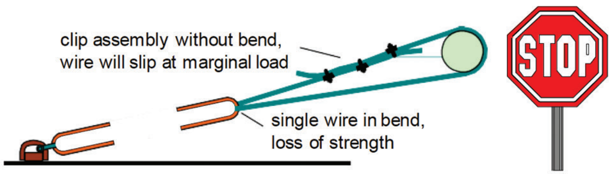


Figure 7.15 Improper assembly for wire rope lashing

2.4.12 Tensioning and joining devices associated with wire rope lashings in sea transport are generally not standardized. The MSL of turnbuckles and lashing shackles should be specified and documented by the manufacturer and at least match the MSL of the wire rope part of the lashing. If manufacturer information is not available, the MSL of turnbuckles and shackles made of ordinary mild steel may be estimated by MSL = 10 · d2 [kN] with d = diameter of thread of turnbuckle or shackle bolt in cm.

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

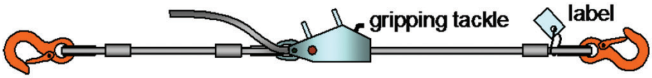


Figure 7.16 Standard wire lashing used in road transport with gripping tackle

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

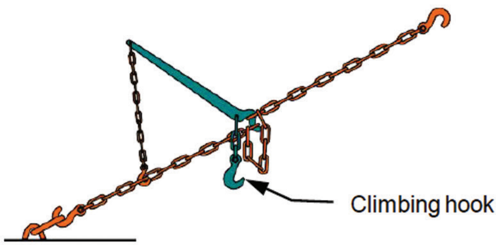


Figure 7.17 Long link lashing chain with lever tensioner

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

Figure 7.18 Standard chain lashing with shortening hook

2.4.16 Steel band for securing purposes is generally made of high tension steel with a normal breaking strength of 0.8 to 1.0 kN/mm2. Steel bands are most commonly used for unitizing packages to form greater blocks of cargo (see figure 7.19). In sea transport, such steel bands are also used to "tie down" packages to flatracks, platforms or roll-trailers. The bands are tensioned and locked by special manual or pneumatic tools. Subsequent re-tensioning is not possible. The low flexibility of the band material with about 0.3% elongation, when loaded to its MSL, makes steel band sensitive for loosing pre-tension if cargo shrinks or settles down. Therefore, the suitability of steel band for cargo securing is limited and national restrictions on their use in road or rail transport should always be considered. The use of steel bands for lashing purposes should be avoided on open CTUs as a broken lashing could be of great danger if it hangs outside the CTU.

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

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

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

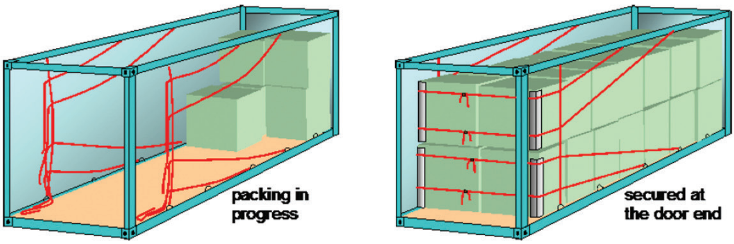


Figure 7.20 Modular lashing system

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

3. PRINCIPLES OF PACKING

3.1 Load distribution

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

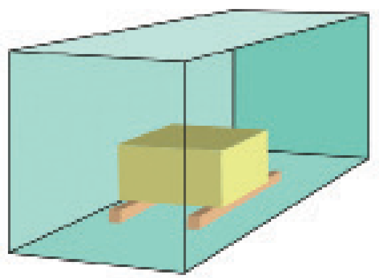


Figure 7.21 Load transfer beams

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

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

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

3.1.5 Roll trailers have structural properties similar to platforms, but are less sensitive to 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 also not as critical.

3.1.6 Swap bodies have structural properties similar to freight containers, but in most cases less tare weight and less overall strength. They are normally not stackable. The loading instructions given under subsection 3.1.2 and 3.1.5 should be applied to swap bodies as appropriate.

3.1.7 Road trucks and road trailers are in particular sensitive regarding the position of the centre of gravity of the cargo packed 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 cargo mass as a function of the longitudinal position of its centre of gravity. Generally, the maximum cargo mass may be used only when the centre of gravity (CoG) is positioned within narrow boundaries about half the length of the loading space (see figures 7.22 and 7.23).

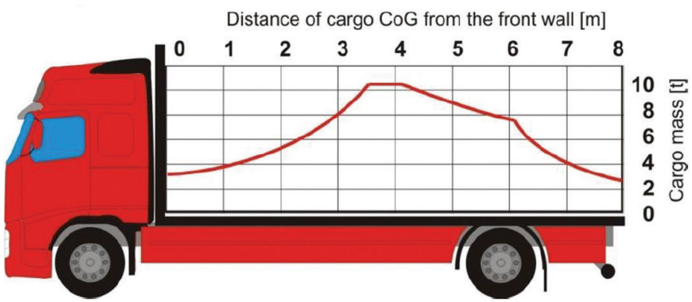


Figure 7.22 An example of a load distribution diagram for a rigid truck

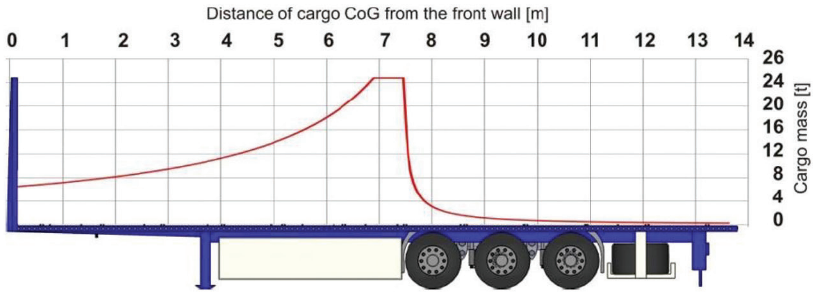


Figure 7.23 An example of a load distribution diagram for a semi-trailer

3.1.8 Railway routes are generally 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 should be observed in view of 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 axle/bogie loads. The proper loading of railway wagons should be supervised by specifically trained persons.

3.2 GENERAL STOWAGE/PACKING TECHNIQUES

3.2.1 Stowage and packing techniques should be suitable to the nature of the cargo with regard to weight, shape, structural strength and climatic conditions. This includes the proper use of dunnage material (see Section 2.1 of this annex), the selection of the appropriate method of mechanical handling and the proper stowage of vented packages. The concept of stowage should incorporate the feasibility of smooth unloading.

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, if possible, be stowed at the door end of the CTU.

3.2.3 When packing mixed cargoes, their compatibility should be considered. Irrespective of the regulations for the stowage of dangerous goods (see chapter 10 of this Code) 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 be placed near to clean and easily soiled cargoes like foodstuff in porous packaging;
- Cargoes emitting moisture should not be stowed on or near to cargoes sensitive to moisture;
- Odorous cargoes should not be stowed in the vicinity of cargoes easily absorbing odour;
- Incompatible cargoes should be packed into the same CTU only if their stow is appropriately separated and/or the goods are effectively protected by suitable sheathing material.

3.2.4 Stacking of sensitive cartons of uniform size and shape should be precise in a way that the mass from above is transferred to the vertical boards of the cartons below. If necessary, e.g. due to lateral leeway of the stack in the CTU, intermediate sheets of fibreboard, plywood or pallets should be placed between layers of the stack (see figures 7.24 and 7.25). Cartons 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 equalized by means of dunnage.

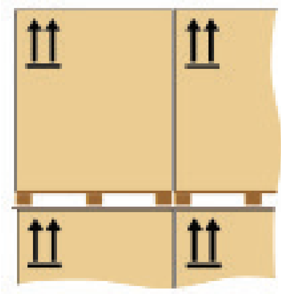


Figure 7.24 With intermediate board

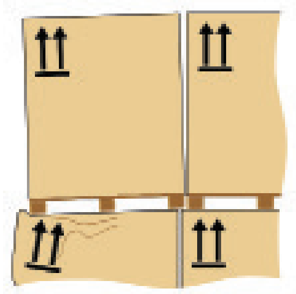


Figure 7.25 Without intermediate board

3.2.5 Packages 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 (see figure 7.26). 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 if the friction between the pipes is low.

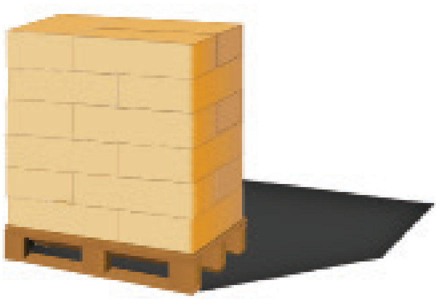


Figure 7.26 Cross-tie stowage

3.2.6 Uniform parcels like drums or standardized pallets should be packed in a way that minimizes lost space and provides a tight stow at the same time. Drums may be stowed either in regular lines, also called "soldier stowage", or into the vertical grooves, also called "offset stowage" (see figures 7.27 and 7.28). 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 standardized and adapted to the inner width and length of cargo spaces in road trucks, road trailers and swap bodies, but not throughout to the inner dimensions of freight containers.

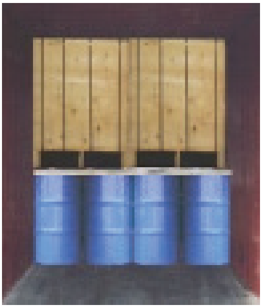


Figure 7.27 Mixed stow, dry over wet goods

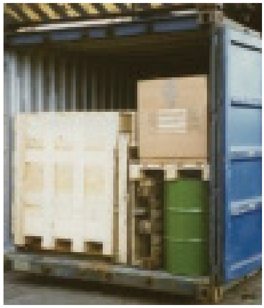


Figure 7.28 Mixed stow, use of pallets

3.3.4 Driving forklift trucks 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.

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

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

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

4. SECURING OF CARGO IN CTUS

4.1 Aims and principles of securing

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

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

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

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

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

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

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

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

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

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

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

[4] Standard tension force STF according to EN 12195-2

4.2 TIGHTLY ARRANGED CARGOES

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

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

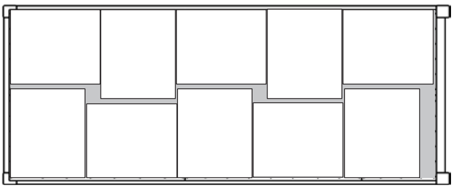


Figure 7.29 Packing 1,000 x 1,200 mm unit loads into a 20-foot container

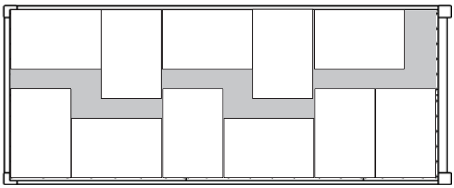


Figure 7.30 Packing 800 x 1,200 mm unit loads into a 20-foot container

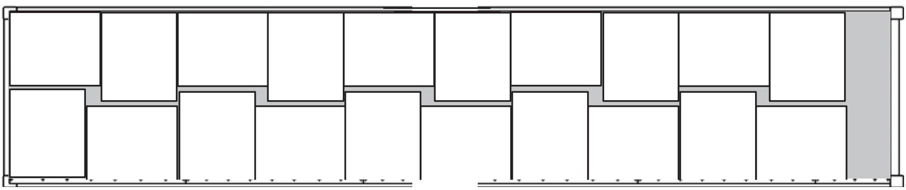


Figure 7.31 Packing 1,000 x 1,200 mm unit loads into a 40-foot container

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

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

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

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

m = mass of cargo packed [t]

g = gravity acceleration 9.81 m/s^2

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

P = maximum payload of CTU (t)

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

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

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

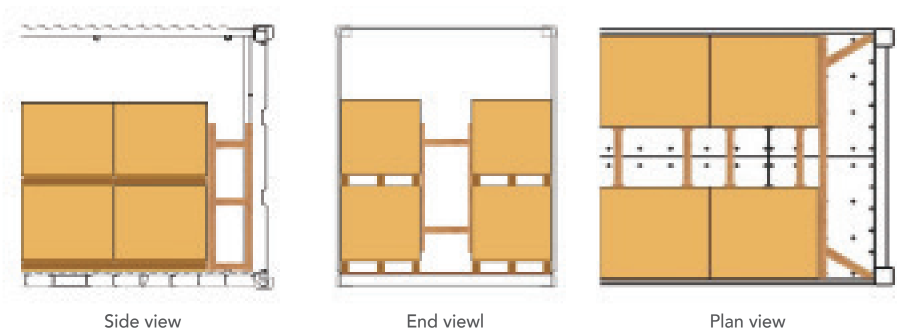


Figure 7.32 Blocking in a strong boundary CTU

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

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

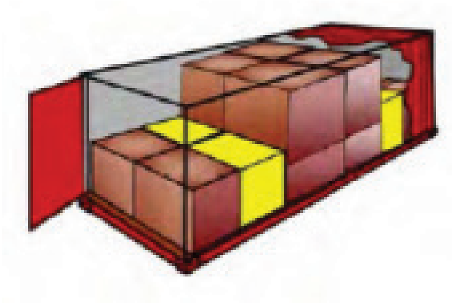


Figure 7.33 Threshold by height

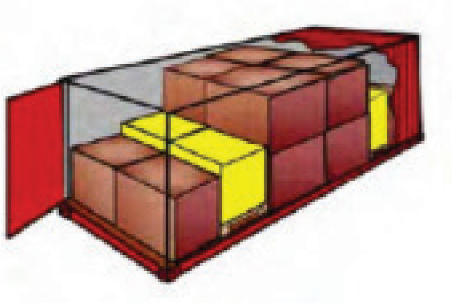


Figure 7.34 Threshold by elevation

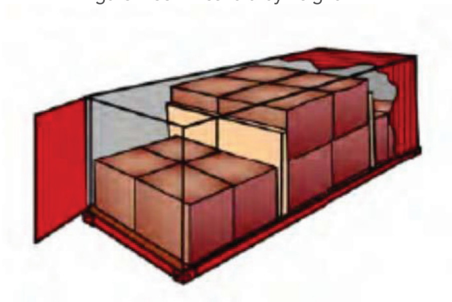


Figure 7.35 Threshold by board

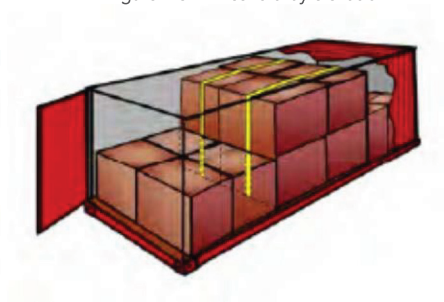


Figure 7.36 Round turn lashing

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

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

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

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

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

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

4.3 INDIVIDUALLY SECURED PACKAGES AND LARGE UNPACKAGED ARTICLES

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

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

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

d = vertical distance from centre of gravity of the unit to its tipping axis [m]

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

b = horizontal distance from centre of gravity to tipping axis [m]

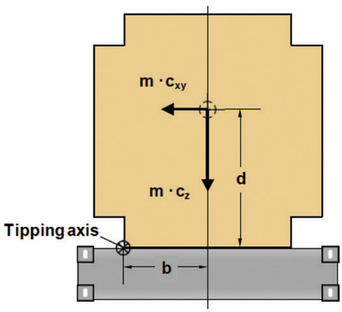


Figure 7.37 Tipping criterion

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

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

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

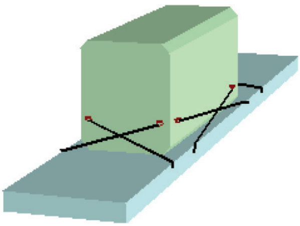


Figure 7.38 Direct lashing against sliding

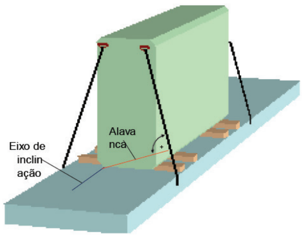


Figure 7.39 Direct lashing against tipping

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

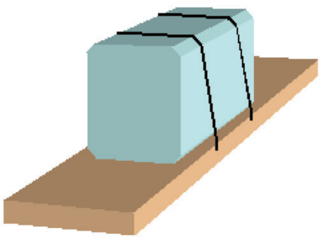


Figure 7.40 Top over lashing

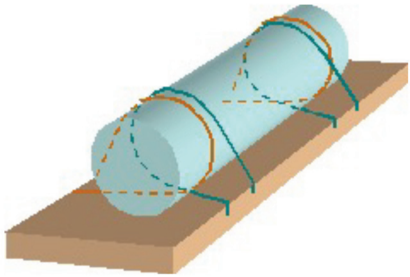


Figure 7.41 Vertical half-loop lashing

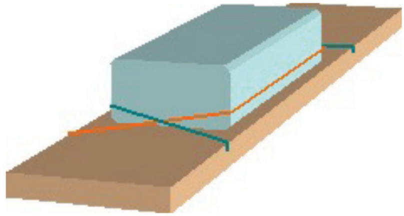


Figure 7.42 Horizontal half-loop lashing

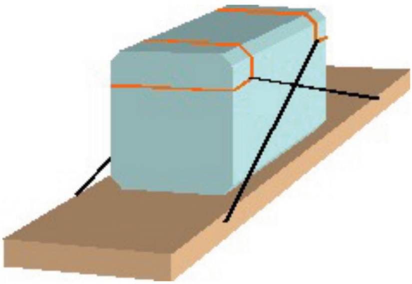


Figure 7.43 Spring lashing

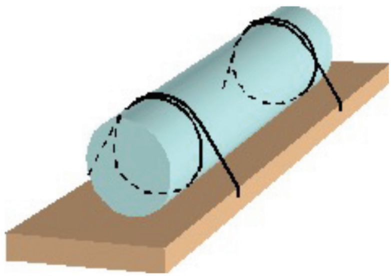


Figure 7.44 Silly-loop lashing

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

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

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

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

Figure 7.45 Transverse blocking of steel slab

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

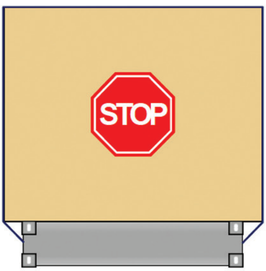


Figure 7.46 Top-over lashing

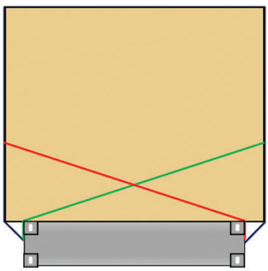


Figure 7.47 Top-over and horizontal half-loop

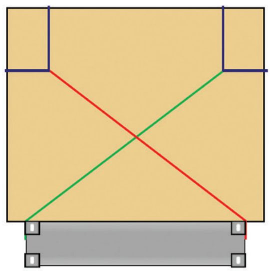


Figure 7.48 Transverse spring lashing

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

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

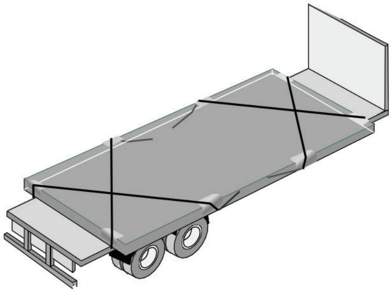


Figure 7.49 Over-width package secured by half-loops

4.4 Evaluation of securing arrangements

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

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

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

m = mass of cargo to be evaluated [t]

g = gravity acceleration 9.81m/s^2

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

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

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

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

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

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

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

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

5.1 PACKING BULK MATERIAL

5.1 Non-regulated liquids in tank CTUs

5.1.1 Tank CTUs filled with liquids having a viscosity less than 2,680 mm2/s at 20°C and to be transported by road, rail or sea should be filled to at least 80% of their volume for avoiding dangerous surging, but never more than 95% of their volume, unless specified otherwise. A filing ratio of maximum 20% is also accepted. A filling ratio of more than 20% and less than 80% should only be permitted when the tank shell is subdivided, by partitions or surge plates, into sections of not more than 7,500 l capacity.

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

5.1.3 For the transport of foodstuffs, the tank should comply with the following requirements:

- All parts of the tank which are in direct contact with the food stuff should be so conditioned that the overall food-grade property of the tank is guaranteed;
- The tank should be easily accessible and suitable for cleaning and disinfection;
- Inspection of the interior should be possible;
- The exterior should be conspicuously marked with a marking “FOR FOODSTUFFS ONLY” or with a similar wording.

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

5.2 LIQUIDS IN FLEXITANKS

5.2.1 Flexitanks used for the transport of bulk liquids by road, rail or sea should carry a label that confirms the type approval by a recognized consultative body. The flexitank manufacturer's fitting instructions should always be followed, and the cargo intended to be carried should be checked for compatibility with the material of the flexitank. The transport of dangerous goods in flexitanks is prohibited.

5.2.2 During transport the contents of a flexitank will be subject to dynamic forces without significant retention from friction. These forces will act upon the boundaries of the CTU and may cause damage or complete failure.

5.2.3 Therefore the payload of a CTU should be appropriately reduced, when it is used for carrying a loaded flexitank. The reduction depends on the type of CTU and on the mode of transport. When a flexitank is loaded into a general purpose CTU, the mass of the liquid in the flexitank should not exceed a value agreed with the CTU operator, to prevent the CTU from suffering bulging damages (see figure 7.50).

Figure 7.50 Damaged CTU side wall

5.2.4 Road vehicles intended to carry loaded flexitanks should have boundaries of a certified strength that is sufficient to confine the weight of the cargo under the accepted load assumptions. The certification of fitness of the vehicle should explicitly address the bulk transport of liquid under the assumption of zero-friction. Nevertheless, the lining of the bottom of the loading area with friction increasing material and the application of over-the-top fibre lashings every two metres is recommended for stabilizing the position and the strength of the flexitank.

5.2.5 Before being fitted with a flexitank, the CTU should be carefully inspected for structural integrity and fully functional locking bars for each door panel. The CTU should then be prepared by thorough cleaning, removing of all obstacles like protruding nails and by lining the bottom and walls with cardboard. In 40-foot containers plywood should be used for lining of the side walls in order to avoid bulging damage. The door end of the CTU should be reinforced by battens, fitted into suitable recesses, and by a strong lining of cardboard or plywood. If the flexitank is equipped with a bottom connection tube, this lining should have an aperture matching with the position of the tube in way of the right hand door. The empty flexitank should be unfolded and laid out accurately to facilitate a smooth filling process.

5.2.6 For filling an empty flexitank the left hand door of the CTU should be firmly closed so that the inserted barrier is appropriately supported (see figure 7.51). The flexitank should be filled at a controlled rate. The use of spill protection devices like collecting bag or drip tray is recommended. After filling and sealing the tank the door of the CTU should be closed and a warning label should be attached on the left hand door panel (see figure 7.52). No part of the flexitank or retaining battens or bulkhead should touch either door when fully loaded.

Figure 7.51 Container fitted with flexitank

Figure 7.52 Flexitank warning label

5.2.7 For unloading a flexitank, the right hand door of the CTU should be opened carefully for getting access to the top or bottom connection tube of the flexitank. The left hand door should be kept closed until the flexitank is substantially empty. The use of spill protection devices like collecting bag or drip tray is recommended. The empty flexitank should be disposed according to applicable regulations.

5.3 NON-REGULATED SOLID BULK CARGOES

5.3.1 Non-regulated solid bulk cargoes may be packed into CTUs provided the boundaries of the cargo spaces are able to withstand the static and dynamic forces of the bulk material under the foreseeable transport conditions (see Chapter 5 of this Code). Freight containers are equipped with shoring slots in the door corner posts which are suitable to accommodate transverse steel bars of 60 mm square cross section. This arrangement is particularly designed to strengthen the freight container door end for taking a load of 0.6 P, as required for solid bulk cargoes. These bars should be properly inserted. The relevant transport capability of the CTU should be demonstrated by a case-related certificate issued by a recognized consultative body or by an independent cargo surveyor. This requirement applies in particular to general purpose freight containers and to similar closed CTUs on road vehicles, which are not explicitly designed to carry bulk cargoes. It may be necessary to reinforce side and front walls of the CTU by plywood or chipboard facing in order to protect them from bulging or scratching (see figure 7.53).

Figure 7.53 Lining a 40-foot container with chipboard panels

5.3.2 The CTU intended to carry a bulk cargo should be cleaned and prepared adequately as described in subsection 5.2.5 of this annex, in particular if a cargo-specific liner will be used for accommodating bulk cargoes like grain, coffee beans or similar sensible materials (see figure 7.54).

Figure 7.54 CTU with liner bag for accommodating a sensitive bulk cargo

5.3.3 If crude or dirty material will be transported, the CTU boundaries should be lined with plywood or chipboard for avoiding mechanical wastage of the CTU. In all cases an appropriate door protection should be installed consisting of battens fitted into suitable recesses and complemented by a strong plywood liner (see figure 7.55).

Figure 7.55 CTU with wall liners and door barrier loaded with scrap

5.3.4 Scrap and similar waste material to be carried in bulk in a CTU should be sufficiently dry to avoid leakage and subsequent contamination of the environment or other CTUs, if stacked ashore or transported in a vessel.

5.3.5 Depending on the internal friction and the angle of repose of the solid bulk cargo, the CTU may be inclined to a certain degree, to facilitate the loading or unloading operation. However, it should always be ensured that the walls of the CTU are not overstressed by the filling operation. It is not acceptable to turn a CTU by 90° to an upright position for filling, unless the CTU is especially approved for this method of handling.

APPENDIX 1. PACKAGING MARKS

Note: The labels and marks required for the transport of dangerous goods can be found in the applicable dangerous goods transport regulations and are not included in this Code.

1. INTRODUCTION

1.1 Packages are often marked with handling instructions in the language of the country of origin. While this may safeguard the consignment to some extent, it is of little value for goods consigned to, or through, countries using different languages, and of no value at all if people handling the packages are illiterate.

1.2 Pictorial symbols offer the best possibility of conveying the consignor's intention and their adoption will, therefore, undoubtedly reduce loss and damage through incorrect handling.

1.3 The use of pictorial symbols does not provide any guarantee of satisfactory handling; proper protective packaging is therefore of primary importance.

1.4 The symbols shown in this annex are those most regularly exhibited. These and others are shown in ISO standard 780.[6]

2. SYMBOLS

2.1 Display of symbols

2.1.1 Symbols should preferably be stencilled directly on the package or may appear on a label. It is recommended that the symbols be painted, printed or otherwise reproduced as specified in this ISO standard. They need not be framed by border lines.

2.1.2 The graphical design of each symbol should have only one meaning; symbols are purposely designed so that they can also be stencilled without changing the graphics.

2.2 Colour of symbols

2.2.1 The colour used for symbols should be black. If the colour of the package is such that the black symbol would not show clearly, a panel of a suitable contrasting colour, preferably white, should be provided as a background.

2.2.2 Care should be taken to avoid the use of colours which could result in confusion with the labelling of dangerous goods. The use of red, orange or yellow should be avoided unless regional or national regulations require such use.

2.3 Size of symbols

For normal purposes the overall height of the symbols should be 100 mm, 150 mm or 200 mm. The size or shape of the package may, however, necessitate use of larger or smaller sizes for the symbols.

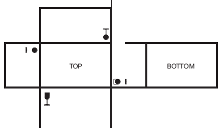
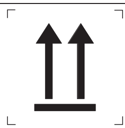
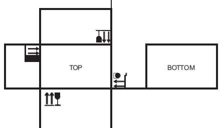
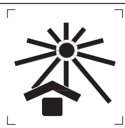
2.4 Positioning of symbols

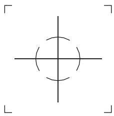
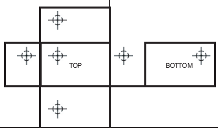
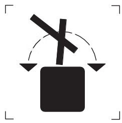
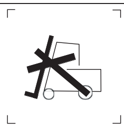
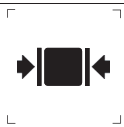
Particular attention should be paid to the correct application of the symbols, as faulty application may lead to misinterpretation. Symbols No. 7 and No. 16 should be applied in their correct respective positions and in appropriate respective places in order to convey the meaning clearly and fully.

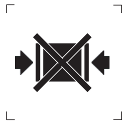
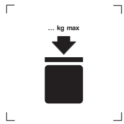
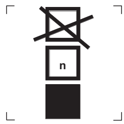
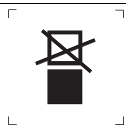
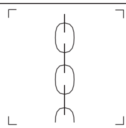
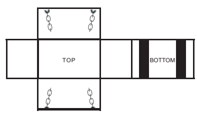
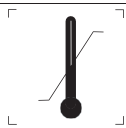
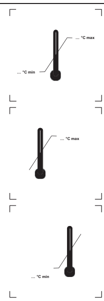
[6] ISO standard 780, Packaging – Pictorial markings for handling of goods.

3. HANDLING INSTRUCTIONS

Handling instructions should be indicated on transport packages by using the corresponding symbols given in the following table.

No.	Instruction/Information	Symbol	Meaning	Special Instructions
1	FRAGILE		Contents of the package are fragile therefore should be handled with care. 	Shown near the left hand upper corner on all four upright sides of the package.
2	USE NO HAND HOOKS		Hooks should not be used for handling packages	
3	THIS WAY UP		Indicates correct orientation of the package 	Shown as symbol No. 1. Where both symbols are required, symbol No. 3 will appear nearer to the corner
4	KEEP AWAY FROM SUNLIGHT		Package should not be exposed to sunlight.	
5	PROTECT FROM RADIOACTIVE SOURCES		Contents of the package may deteriorate or may be rendered totally unusable by penetrating radiation	
6	KEEP AWAY FROM RAIN		Package should be kept away from rain and dry	

No.	Instruction/Information	Symbol	Meaning	Special Instructions
7	CENTRE OF GRAVITY		Indicates the centre of gravity of the package	Where possible, "Centre of gravity" should be placed on all six sides but at least on the four lateral sides relating to the actual location of the centre of gravity 
8	DO NOT ROLL		Package should not be rolled	
9	DO NOT USE HAND TRUCK HERE		Hand trucks should not be placed on this side when handling	
10	USE NO FORKS		Package should not be handled by forklift trucks	
11	CLAMP AS INDICATED		Clamps should be placed on the sides indicated for handling	The symbol should be positioned on two opposite faces of the package so that it is in the visual range of the clamp truck operator when approaching to carry out operation. The symbol should not be marked on those faces of the package intended to be gripped by the clamps.

No.	Instruction/Information	Symbol	Meaning	Special Instructions
12	DO NOT CLAMP AS INDICATED		Package should not be handled by clamps on the sides indicated	
13	STACKING LIMITED BY MASS		Indicates the maximum stacking load permitted.	
14	STACKING LIMITED BY NUMBER		Maximum number of identical packages that may be stacked above, where “n” is the limiting number.	
15	DO NOT STACK		Stacking the package is not permitted and nothing should be placed on top.	
16	SLING HERE		Slings for lifting should be placed where indicated 	Should be placed on at least two opposite faces of the package
17	TEMPERATURE LIMITS		Indicates the temperature limit within which the package should be stored and handled.	

APPENDIX 2. FRICTION FACTORS

Different material contacts have different friction factors. The table below shows recommended values for the friction factors. The values are valid provided that both contact surfaces are "swept clean" and free from any impurities. The values are valid for the static friction. In case of direct lashings, where the cargo has to move little before the elongation of the lashings provides the desired restraint force, the dynamic friction applies, which is to be taken as 75% of the static friction.

MATERIAL COMBINATION IN CONTACT SURFACE	DRY	WET
SAWN TIMBER/WOODEN PALLET		
Sawn timber/wooden pallet against fabric base laminate/plywood	0.45	0.45
Sawn timber/wooden pallet against grooved aluminium	0.4	0.4
Sawn timber/wooden pallet against stainless steel sheet	0.3	0.3
Sawn timber/wooden pallet against shrink film	0.3	0.3
PLANED WOOD		
Planed wood against fabric base laminate/plywood	0.3	0.3
Planed wood against grooved aluminium	0.25	0.25
Planed wood against stainless steel sheet	0.2	0.2
PLASTIC PALLETS		
Plastic pallet against fabric base laminates/plywood	0.2	0.2
Plastic pallet against grooved aluminium	0.15	0.15
Plastic pallet against stainless steel sheet	0.15	0.15
CARDBOARD (UNTREATED)		
Cardboard against cardboard	0.5	-
Cardboard against wooden pallet	0.5	-
BIG BAG		
Big bag against wooden pallet	0.4	-
STEEL AND SHEET METAL		
Unpainted metal with rough surface against unpainted rough metal	0.4	-
Painted metal with rough surface against painted rough metal	0.3	-
Painted metal with smooth surface against painted smooth metal	0.2	-
Metal with smooth surface against metal with smooth surface	0.2	-

MATERIAL COMBINATION IN CONTACT SURFACE	DRY	WET
STEEL CRATES		
Steel crate against fabric based laminate/plywood	0.45	0.45
Steel crate against grooved aluminium	0.3	0.3
Steel crate against stainless steel sheet	0.2	0.2
CONCRETE		
Concrete with rough surface against sawn wood	0.7	0.7
Concrete with smooth surface against sawn wood	0.55	0.55
ANTI-SLIP MATERIAL		
Rubber against other materials when contact surfaces are clean	0.6	0.6
Materials other than rubber against other materials	As certified or tested according to Appendix 3	

Friction factors (μ) should be applicable to the actual conditions of transport. When a combination of contact surfaces is missing in the table above or if its friction factor cannot be verified in another way, the maximum allowable friction factor of 0.3 should be used. If the surface contacts are not swept clean, the maximum allowable friction factor of 0.3 or, when lower, the value in the table should be used. If the surface contacts are not free from frost, ice and snow a static friction factor of 0.2 should be used, unless the table shows a lower value. For oily and greasy surfaces or when slip sheets have been used a friction factor of 0.1 applies.

APPENDIX 3. PRACTICAL METHODS FOR THE DETERMINATION OF THE FRICTION FACTOR μ

To determine the friction factor μ two alternative methods are given. A practical approach to make an assumption on the applicable friction factor is the inclination test which can be carried out by any party involved in the packing of a CTU. The alternative method to determine the exact friction factor is the pulling test which however needs laboratory equipment.

1. INCLINATION TEST

The factor μ indicates how easily a cargo will slide if the cargo platform is tilted. A method to find μ is to incline a cargo platform carrying the cargo in question, and measure the angle (α) at which the cargo starts to slide. This gives the friction factor μ = 0,925 - tan α. Five tests should be done under practical and realistic conditions, the highest and lowest values should be ignored and the average of the remaining three used to determine the friction factor.

2. PULLING TEST

2.1 The test rig consists of the following components:
- Horizontal floor with a surface representing the cargo platform.
- Test device for tensile tests.
- Connecting device between the test equipment and the bottom of the package.
- PC based evaluation system.

The tensile device should comply with ISO standard 7500-1.

2.2 The test conditions should correspond to real ones; the contact surfaces should be swept clean and free from impurities. Tests should be executed in an atmospheric condition 5 in accordance with ISO 2233:2001 at a temperature of + 20°C and 65% relative humidity.

2.3 The pulling speed should be 100 mm /min, the sampling rate should be at least 50 Hz.

2.4 A measurement of pulling force and way of displacement is made with the same test object in one arrangement with a respective glide path of 50 mm to 85 mm for each stroke. At least three individual strokes should be carried out with an intermediate unloading of at least 30% of the pulling force per measurement (see also figure 7.56).

2.5 A measurement series consists of three measurements for each of three strokes. The test piece and/or anti slip material should be replaced for each measurement, so that any influence of material wear on the result of the measurement can be excluded.

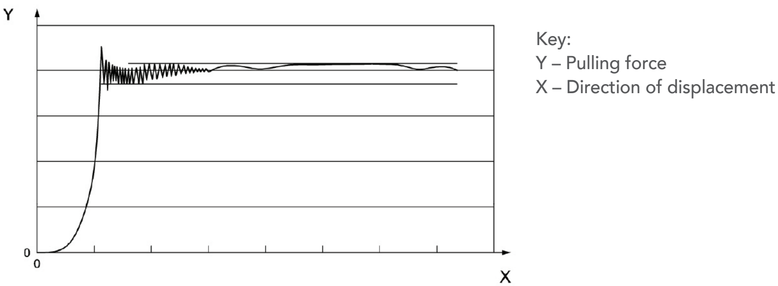


Figure 7.56

2.6 The friction factor μ should be determined according to the equation mentioned below, taking into account the three medium values of each of the three measurements:

$$\mu = (\text{força de tração} - 0{,}95) / (\text{peso} - 0{,}925)$$

2.7 For a most realistic determination of frictional forces and friction factors, multiple measurements series should be executed, each with different test samples for cargo area, anti-slip mat and load bearer or load.

2.8 If the measurement condition differs from what is specified above, the test conditions should be documented in the test report.

APPENDIX 4. SPECIFIC PACKING AND SECURING CALCULATIONS

1. RESISTIVITY OF TRANSVERSE BATTENS

The attainable resistance forces F of an arrangement of battens may be determined by the formula (see also figure 7.57):

$$F = n \cdot \frac{w^2 \cdot h}{28 \cdot L} \quad [kN]$$

n = number of battens

w = thickness of battens [cm]

h = height of battens [cm]

L = free length of battens [m]

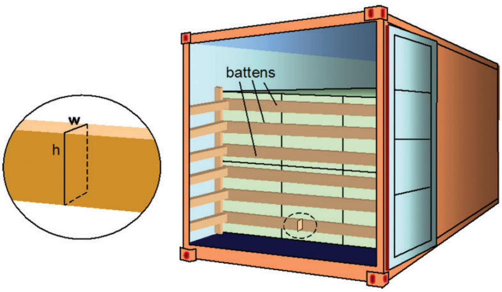


Figure 7.57 Transverse battens in an freight container

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

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

m = mass of cargo to be evaluated [t]

g = gravity acceleration 9.81m/s^2

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

2. BEDDING A CONCENTRATED LOAD IN A GENERAL PURPOSE FREIGHT CONTAINER OR ON A FLATRACK

Bedding arrangements for concentrated loads in general purpose freight containers and on flatracks should be designed in consultation with the CTU operator.

3. LONGITUDINAL POSITION OF THE CENTRE OF GRAVITY OF CARGO

The longitudinal position of the centre of gravity of the cargo should be used in connection with specific load distribution rules and diagrams of CTUs7. The longitudinal position of the centre of gravity of the cargo within the inner length of a packed CTU is at the distance d from the front, obtained by the formula (see also figure 7.58):

$$d = \frac{\sum (m_n \cdot d_n)}{\sum m_n}$$

d = distance of common centre of gravity of the cargo from the front of stowage area [m]

m_n = mass of the individual packages or overpack [t]

d_n = distance of centre of gravity of mass m_n from front of stowage area [m]

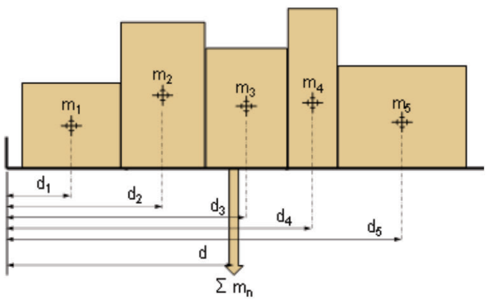


Figure 7.58 Determination of longitudinal centre of gravity

Example:

A 20-foot container is packed with five groups of cargo parcels as follows:

	m_n [t]	d_n [m]	$m_n \cdot d_n$ [t·m]
1	3.5	0.7	2.45
2	4.2	1.4	5.88
3	3.7	3.0	11.10
4	2.2	3.8	8.36
5	4.9	5.1	24.99
	$\Sigma m_n = 18.5$		$\Sigma(m_n \cdot d_n) = 52.78$

$$d = \frac{\Sigma (m_n \cdot d_n)}{\Sigma m_n} = \frac{52.78}{18.5} = 2.85 \text{ m}$$

[7] Examples of load distribution diagrams for vehicles are given in section 3.1 of this annex and examples of load distribution diagrams for containers, trailer and railway wagons are provided in informative material IM6 (available at www.unece.org/trans/wp24/guidelinespackingctus/intro.html).

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 capacity of the dunnage bag, without risk of breaking it, is larger than the force the cargo needs to be supported with:

FDUNNAGE BAG ≥ FCARGO

4.2 Force on dunnage bag from cargo (FCARGO)

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:	Tipping:
$F_{CARGO} = m \cdot g \cdot (c_{x,y} - \mu \cdot 0.75 \cdot c_z)$ [kN]	$F_{CARGO} = m \cdot g \cdot (c_{x,y} - b_p/h_p \cdot c_z)$ [kN]

F_{CARGO} =	force on the dunnage bag caused by the cargo [t]
m =	mass of cargo [t]
$c_{x,y}$ =	Horizontal acceleration, expressed in g, that acts on the cargosideways or in forward or backward directions
c_z =	Vertical acceleration that acts on the cargo, expressed in g
μ =	Friction factor for the contact area between the cargo and the surface 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 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 m1 or m2 (see figure7.59).

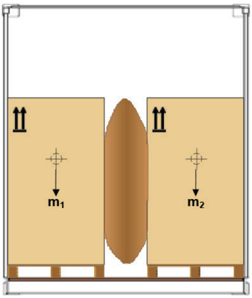


Figure 7.59 Equal height packages

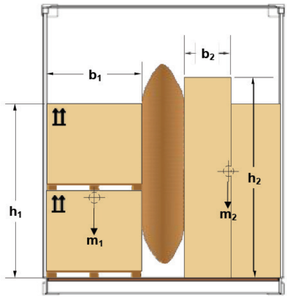


Figure 7.60 Unequal height packages

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 bp / hp 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 m1 or m2 in figure 7.60.

4.3 PERMISSIBLE LOAD ON THE DUNNAGE BAG (FDB)

4.3.1 The force that the dunnage bag is able to take up 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:

$$F_{DB} = A \cdot 10 \cdot g \cdot P_B \cdot SF \text{ [kN]}$$

F_{DB} = force that the dunnage bag is able to take up without exceeding the maximum allowable pressure (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:

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

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

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

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

d = gap between packages [m]

π = 3.14

4.5 PRESSURE IN THE DUNNAGE BAG

4.5.1 Upon application of the dunnage bag it is filled to a slight overpressure. 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 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.

APPENDIX 5. PRACTICAL INCLINATION TEST FOR DETERMINATION OF THE EFFICIENCY OF CARGO SECURING ARRANGEMENTS

1. The efficiency of a securing arrangement can be tested by a practical inclining test in accordance with the following description.
2. The cargo (alternatively one section of the cargo) is placed on a road vehicle platform or similar and secured in the way intended to be tested.
3. To obtain the same loads in the securing arrangement in the inclining test as in calculations, the securing arrangement should be tested by gradually increasing the inclination of the platform to an angle, α, in accordance with the diagram below.
4. The inclination angle that should be used in the test is a function of the horizontal acceleration cx,y for the intended direction (forward, sideways or backward) and the vertical acceleration cz.

(a) To test the efficiency of the securing arrangement in the lateral direction, the greatest of the following test angles should be used:
- The angle determined by the friction factor μ (for the sliding effect), or
- The angle determined by the ratio of $\frac{B}{n \cdot H}$ (for the tilting effect).

(b) To test the efficiency of the securing arrangement in the longitudinal direction, the greatest of following test angles should be used:
- The angle determined by the friction factor μ (for the sliding effect), or
- The angle determined by the ratio of $\frac{L}{H}$ (for the tilting effect).

5. The lowest friction factor, between the cargo and the platform bed or between packages if over-stowed should be used. The definition of H, B, L and n is according to the sketches in figures 7.61 and 7.62.

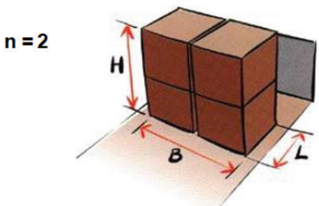


Figure 7.61
Package or section with the centre of gravity close to its geometrical centre (L/2, B/2, H/2). The number of loaded rows, n, in above section is 2. L is always the length of one section also when several sections are placed behindeach other.

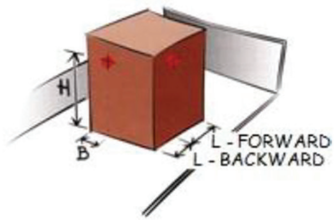


Figure 7.62
Package with the centre of gravity away from its geometrical centre.

The required test angle α as function of $c_{x,y}$ (0.8 g, 0.7 g and 0.5 g) as well as μ, $\frac{B}{n \cdot H}$ and $\frac{L}{H}$ when c_z is 1.0 g is taken from the diagram shown in figure 7.63 or from the table below.

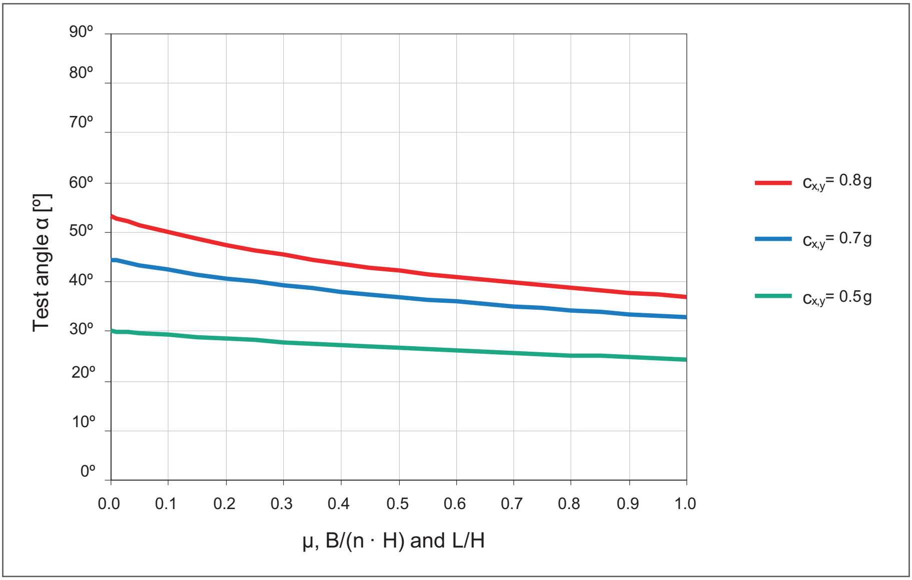


Figure 7.63

Example:

If μ and $\frac{B}{n \cdot H}$ is 0.3 at accelerations sideways at transport in sea area B (c_y = 0.7 g) the cargo securing arrangement should be able to be inclined to approximately 39°, according to the diagram.

In the table below the inclination α is calculated for different γ factors at the horizontal accelerations ($c_{x,y}$ = 0.8 g, 0.7 g and 0.5 g and c_z = 1.0 g).
The γ factor is defined as follows:
μ, B/(n · H) and L/H, as required in section 4 of this appendix.

ah / γ factor	0,8 g	0,7 g	0,5 g
	Required test angle α in degrees		
0.00	53.1	44.4	30.0
0.05	51.4	43.3	29.6
0.10	49.9	42.4	29.2
0.15	48.5	41.5	28.8
0.20	47.3	40.7	28.4
0.25	46.3	39.9	28.1
0.30	45.3	39.2	27.7
0.35	44.4	38.6	27.4
0.40	43.6	38.0	27.1
0.45	42.8	37.4	26.8
0.50	42.1	36.9	26.6
0.55	41.5	36.4	26.3
0.60	40.8	35.9	26.0
0.65	40.2	35.4	25.8
0.70	39.7	35.0	25.6
0.75	39.2	34.6	25.3
0.80	38.7	34.2	25.1
0.85	38.2	33.8	24.9
0.90	37.7	33.4	24.7
0.95	37.3	33.1	24.5
1.00	36.9	32.8	24.3

6. The securing arrangement is regarded as complying with the requirements if the cargo is kept in position with limited movements when inclined to the prescribed inclination α.
7. The test method will subject the securing arrangement to stresses and great care should be taken to prevent the cargo from falling off the platform during the test. If large masses are to be tested the entire platform should be prevented from tipping as well.

Figure 7.64

Figure 7.65

8. Figure 7.64 and figure 7.65 show tests to confirm the securing arrangements of a large package for acceleration forces in longitudinal and transverse directions.

CHAPTER 5. GENERAL TRANSPORT CONDITIONS

5.1 Within the supply transport chain, there are a number of different stresses acting on the cargo. These stresses may be grouped into 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.

5.2 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 or ton, multiplied by the acceleration (a) which is measured in m/s^2 :

$$F = m \cdot a$$

Acceleration considered during transport are the gravitational acceleration ($a = g = 9.81\ m/s^2$) and acceleration caused by typical transport conditions such as by the braking or rapid change of traffic lanes by a road vehicle or by the motions of a ship in heavy sea. These accelerations are expressed as product of the gravitational acceleration (g) and a specific acceleration coefficient (c) e.g. a = 0.8 g.

5.3 The following tables provide the applicable acceleration coefficients for the different modes of transport and for the various securing directions. To prevent a cargo from movement, the cargo has to be secured in longitudinal and transverse direction according to the worst combination of horizontal and corresponding vertical accelerations. The securing arrangement has to be designed to withstand the forces due to accelerations in each horizontal direction (longitudinal and transverse) separately (see chapter 9 and annex 7).

ROAD TRANSPORT				
	Acceleration coefficients			
Securing in	Longitudinally (cx)		Transversely (cy)	Minimum vertically down (cz)
	forward	rearward		
Longitudinal direction	0.8	0.5	-	-
Transverse direction	-	-	0.5	1.0

RAIL TRANSPORT (COMBINED TRANSPORT)				
	Acceleration coefficients			
Securing in	Longitudinally (cx)		Transversely (cy)	Minimum vertically down (cz)
	forward	rearward		
Longitudinal direction	0,5 (1,0)†	0,5 (1,0)†	-	1,0 (0,7)†
Transverse direction	-	-	0.5	1,0 (0,7)†

† The values in brackets apply to shock loads only with short impacts of 150 milliseconds or shorter, and may be used, for example, for the design of packaging.

SEA TRANSPORT					
Significant wave height in sea area		**Securing in**	**Acceleration coefficients**		
			Longitudinally (cx)	Transversely (cy)	Minimum vertically down (cz)
A	Hs ≤ 8 m	Longitudinal direction	0.3	-	0.5
		Transverse direction	-	0.5	1.0
B	8 m < Hs ≤ 12 m	Longitudinal direction	0.3	-	0.3
		Transverse direction	-	0.7	1.0
C	Hs > 12 m	Longitudinal direction	0.4	-	0.2
		Transverse direction	-	0.8	1.0

5.4 The effect of short term impact or vibrations should always be considered. Therefore, whenever the cargo cannot be secured by blocking, lashing is required to prevent the cargo from being significantly displaced, taking into account the characteristics of the cargo and the mode of transport. The mass of the cargo alone, even when combined with a high friction coefficient (see appendix 2 to annex 7), does not sufficiently secure the cargo as the cargo can move due to vibrations.

5.5 The significant 20-years return wave height (Hs) is the average of the highest one-third of waves (measured from trough to crest) that is only exceeded once in 20 years. The allocation of geographic sea areas to the respective significant wave heights is shown in the following table:

A	B	C
Hs ≤ 8 m	**8 m < Hs ≤ 12 m**	**Hs > 12 m**
Baltic Sea (incl. Kattegat) Mediterranean Sea Black Sea Red Sea Persian Gulf Coastal or inter-island voyages in following areas: Central Atlantic Ocean (between 30°N and 35°S) Central Indian Ocean (down to 35°S) Central Pacific Ocean (between 30°N and 35°S)	North Sea Skagerak English Channel Sea of Japan Sea of Okhotsk Coastal or inter-island voyages in following areas: South-Central Atlantic Ocean (between 35°S and 40°S) South-Central Indian Ocean (between 35°S and 40°S) South-Central Pacific Ocean (between 35°S and 45°S)	unrestricted

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, Hs 100-yr return values, 1958 – 2000

5.6 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).

5.7 Whenever a specific cargo might be damaged when exposed to high or low temperatures during transport, the use of a CTU specially equipped for keeping the cargo temperature within acceptable limits should be considered (see Chapter 7).

ANNEX 3. PREVENTION OF CONDENSATION DAMAGES

1. INTRODUCTION

Condensation damage is a collective term for damage to cargo in a CTU from internal humidity especially in freight containers on long voyages. This damage may materialize in form of corrosion, mildew, rot, fermentation, breakdown of cardboard packaging, leakage, staining, chemical reaction including self-heating, gassing and auto-ignition. The source of this humidity is generally the cargo itself and to some extent timber bracings, pallets, porous packaging and moisture introduced by packing the CTU during rain or snow or packing in an atmospheric condition of high humidity and high temperature. It is therefore of utmost importance to control the moisture content of cargo to be packed and of any dunnage used, taking into consideration the foreseeable climatic impacts of the intended transport.

2. DEFINITIONS

For the assessment of the proper state of "container-fitness" of the cargo to be packed and for the understanding of typical processes of condensation damage the most relevant technical terms and definitions are given below:

Absolute humidity of air	Actual amount of water vapour in the air, measured in g/m3 or g/kg.
Condensation	Conversion of water vapour into a liquid state. Condensation usually starts when air is cooled down to its dew point in contact with cold surfaces.
Corrosion threshold	A relative humidity of 40% or more will lead to an increasing risk of corrosion of ferrous metals.
Crypto climate in the container	State of relative humidity of the air in a closed container, which depends on the water content of the cargo or materials in the container and on the ambient temperature.
Daily temperature variation in the container	Rise and fall of temperature in accordance with the times of day and often exaggerated by radiation or other weather influences.
Dew point of air	Temperature below the actual temperature at which a given relative humidity would reach 100%. Example: The dew point of air at a temperature of 30°C and 57% relative humidity (= 17.3 g/m3 absolute humidity) would be 20°C, because at this temperature the 17.3 g/m3 represent the saturation humidity or 100% relative humidity.
Hygroscopicity of cargo	Property of certain cargoes or materials to absorb water vapour (adsorption) or emit water vapour (desorption) depending on the relative humidity of the ambient air.
Mould growth threshold	A relative humidity of 75% or more will lead to an increasing risk of mould growth on substances of organic origin like foodstuff, textiles, leather, wood, ore substances of non-organic origin such as pottery.
Relative humidity of air	Actual absolute humidity expressed as percentage of the saturation humidity at a given temperature. Example: An absolute humidity of 17.3 g/m3 in an air of 30°C represents a relative humidity of 100 · 17.3 / 30.3 = 57%.

Saturation humidity of air	Maximum possible humidity content in the air depending on the air temperature (2.4 g/m3 at -10°C; 4.8 g/m3 at 0°C; 9.4 g/m3 at 10°C; 17.3 g/m3 at 20°C; 30.3 g/m3 at 30°C; see figure 3.1 below).
Sorption equilibrium	State of equilibrium of adsorption and desorption at a given relative humidity of the ambient air and the associated water content of the cargo or material.
Sorption isotherm	An empirical graph showing the relation of water content of a cargo or material to the relative humidity of the ambient air. Usually the adsorption process is used to characterize the above relation. Sorption isotherms are specific for the various cargoes or materials (see figure 3.2 below).
Water content of cargo	Latent water and water vapour in a hygroscopic cargo or associated material, usually stated as percentage of the wet mass of cargo (e.g. 20 t cocoa beans with 8% water content will contain 1.6 t water).

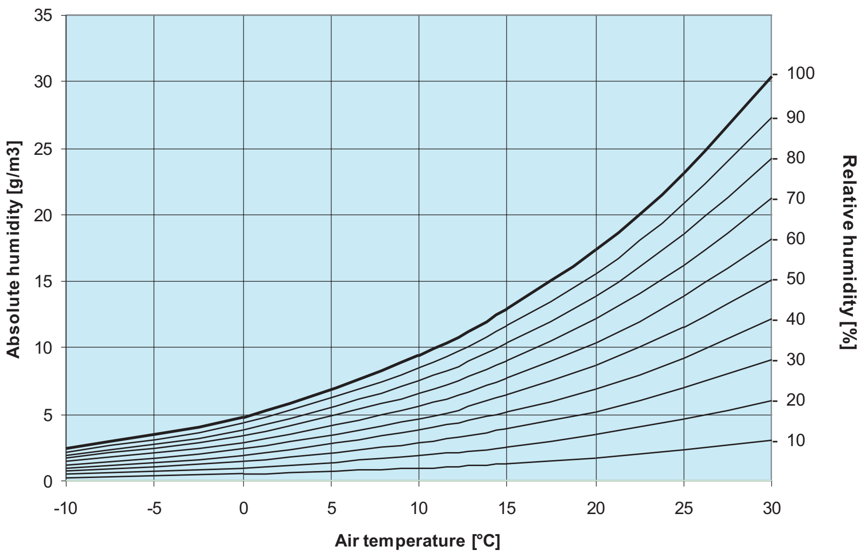


Figure 3.1 Absolute and relative humidity

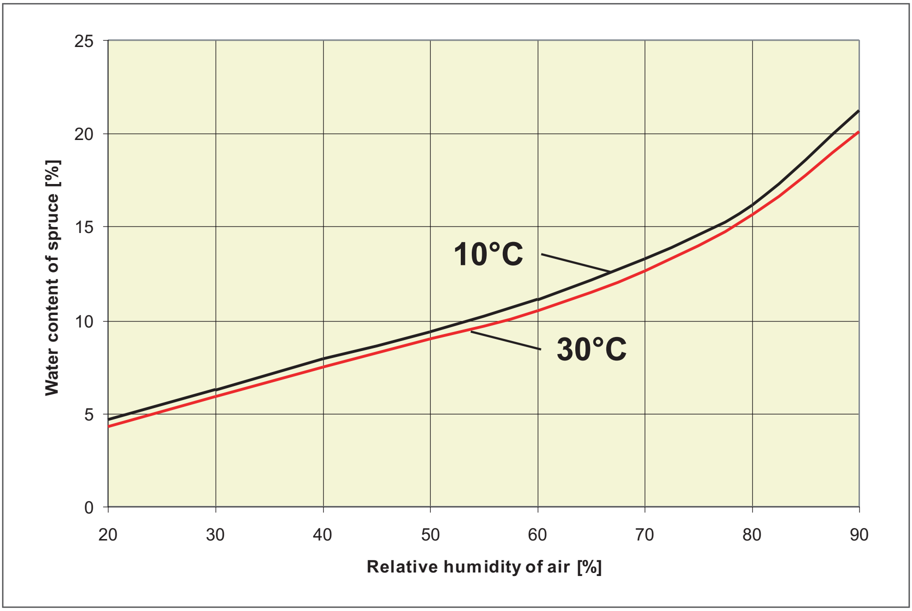


Figure 3.2 Sorption isotherms of Sitka spruce

3. MECHANISMS OF CONDENSATION

3.1 Closed CTUs, in particular closed freight containers, packed with a cargo that contains water vapour, will quickly develop an internal crypto climate with a distinguished relative humidity in the air surrounding the cargo. The level of this relative humidity is a function of the water content of the cargo and the associated materials of packaging and dunnage, following the specific sorption isotherms of the cargo and associated materials. A relative humidity of less than 100% will prevent condensation, less than 75% will prevent mould growth and less than 40% will prevent corrosion. However, this protective illusion is only valid as long as the CTU is not subjected to changing temperatures.

3.2 Daily temperature variations to CTUs are common in longer transport routes, in particular in sea transport, where they also depend largely on the stowage position of the CTU in the ship. Stowage on top of the deck stow may cause daily temperature variations of more than 25 °C, while positions in the cargo hold may show marginal variations only.

3.3 Rising temperatures in a CTU in the morning hours will cause the established relative humidity of the air to drop below the sorption equilibrium. This in turn initiates the process of desorption of water vapour from the cargo and associated materials, thus raising the absolute humidity in the internal air, in particular in the upper regions of the CTU with the highest temperature. There is no risk of condensation during this phase.

3.4 In the late afternoon the temperature in the CTU begins to decline with a pronounced drop in the upper regions. In the boundary layer of the roof, the air reaches quickly the dew point at 100% relative humidity with immediate onset of condensation, forming big hanging drops of water. This is the formidable container sweat which will fall down onto the cargo and cause local wetting with all possible consequences of damage. Similarly, condensate on the container walls will run down and may wet the cargo or dunnage from below.

3.5 The condensed water retards the overall increase of the relative humidity in the air and thereby decelerates the absorption of water vapour back into the cargo and associated materials. If this temperature variation process is repeated a number of times, the amount of liquid water set free by desorption may be considerable, although some of it will evaporate during the hot phases of the process.

3.6 A quite similar mechanism of condensation may take place if a freight container with a warm and hygroscopic cargo, e.g. coffee in bags, is unloaded from the ship but left unopened for some days in a cold climate. The cargo will be soaked by condensation from the inner roof of the freight container.

3.7 Notwithstanding the above described risk of container sweat due to the daily temperature variation, an entirely different type of condensation may take place if cargo is transported in a closed CTU from a cold into a warm climate. If the CTU is unpacked in a humid atmosphere immediately after unloading from the vessel, the still cold cargo may prompt condensation of water vapour from the ambient air. This is the so-called cargo sweat, which is particularly fatal on metal products and machinery, because corrosion starts immediately.

4. LOSS PREVENTION MEASURES

4.1 Corrosion damage: Ferrous metal products, including machinery, technical instruments and tinned food should be protected from corrosion either by a suitable coating or by measures which keep the relative humidity of the ambient air in the CTU reliably below the corrosion threshold of 40%.

4.2 The moisture content of dry dunnage, pallets and packing material can be estimated as 12% to 15%. The sorption isotherms for those materials show that with this moisture content the relative humidity of the air inside the CTU will inevitably establish itself at about 60% to 75% after closing the doors. Therefore additional measures like active drying of the dunnage and packing material or the use of desiccants (drying agents in pouches and other passive methods for moisture capture) should be taken, in combination with a sealed plastic wrapping.

4.3 Fibreboard packaging and dunnage when used in association with dangerous goods should undergo water resistance test using the Cobb method as specified in ISO 535[1].

[1] EN 20535:1994, ISO 535:1991 Paper and board - Determination of water absorptiveness - Cobb method

4.4 Mould, rot and staining: Cargoes of organic origin, including raw foodstuff, textiles, leather, wood and wood products, or substances of non-organic origin such as pottery, should be packed into a CTU in "container-dry" condition. Although the mould growth threshold has been established at 75% relative humidity, the condition "container-dry" defines a moisture content of a specific cargo that maintains a sorption equilibrium with about 60% relative humidity of the air in the CTU. This provides a safety margin against daily temperature variations and the associated variations of relative humidity. Additionally, very sensitive cargo should be covered by unwoven fabric (fleece) which protects the cargo top against falling drops of sweat water. The introduction of desiccants into a CTU containing hygroscopic cargo, that is not "container-dry", will generally fail due to the lack of sufficient absorption capacity of the drying agent.

4.5 Collapse of packing: This is a side effect of moisture adsorption of usual cardboard that is not waterproof. With increasing humidity from 40% to 95% the cardboard loses up to 75% of its stableness. The consequences are the collapse of stacked cartons, destruction and spill of contents. Measures to be taken are in principle identical to those for avoiding mould and rot, or the use of "wet strength" cardboard packaging.

4.6 Unpacking

4.6.1 Goods packed in a cold climate on arrival in a warm climate with higher absolute humidity should be delayed until the goods have warmed up sufficiently for avoiding cargo sweat. This may take a waiting time of one or more days unless the goods are protected by vapour tight plastic sheeting and a sufficient stock of desiccants. The sheeting should be left in place until the cargo has completely acclimatized.

4.6.2 Hygroscopic goods packed in a warm climate on arrival in a cold climate with low absolute humidity should be unpacked immediately after unloading from the vessel, in order to avoid cargo damage from container sweat. There may be a risk of internal cargo sweat when the cargo is cooled down too quickly in contact with the open air, but experience has shown that the process of drying outruns the growth of mould, if the packages are sufficiently ventilated after unpacking.

The Passion to Protect

Cordstrap do Brasil
Av: Prefeito Luiz Latorre, 9450
Condominio Master Business Park
Jundiai - SP
CEP 13209-430 Brasil

t +55 51 3074 7007