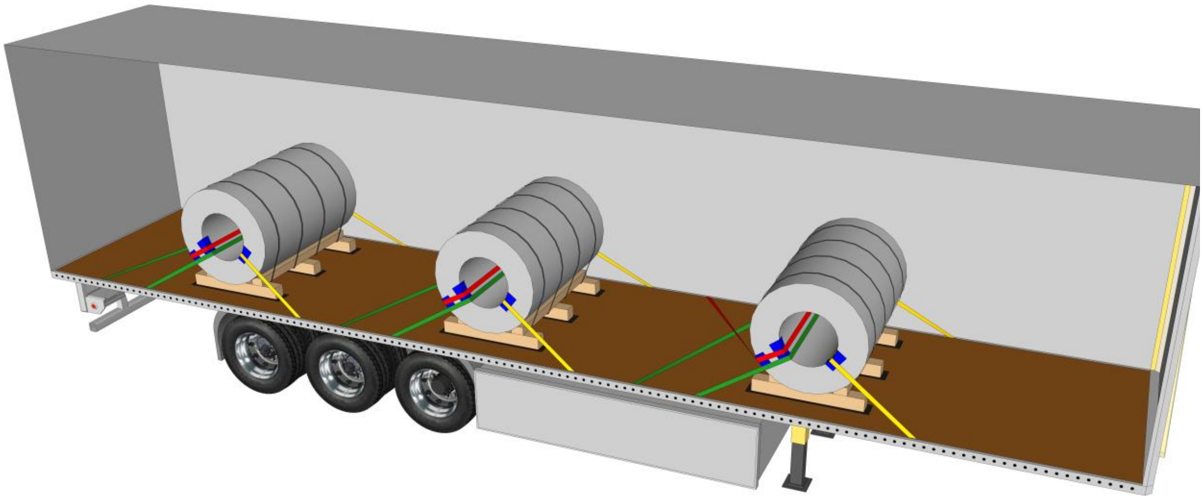
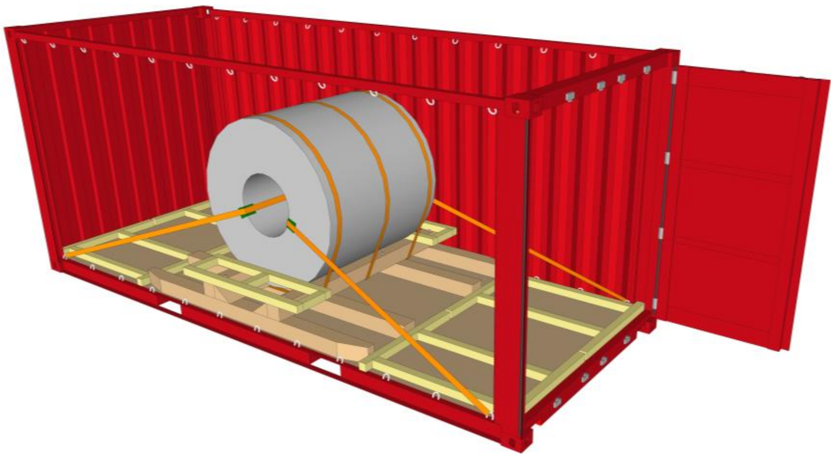
Handbook in

Cargo Securing





This handbook in cargo securing is developed in cooperation between Outokumpu and MariTerm AB.

Content

1. Introduction

This cargo securing handbook is developed in cooperation between Outokumpu BA Europe and MariTerm AB and are valid for loading and securing of Outokumpu cargo on all European Outokumpu sites and for all transporters, as well as subcontractors, involved in loading, unloading and transportation of Outokumpu products.

The purpose with this document is to achieve the following:

- Uniform systems for loading
- Uniform and safe systems for cargo securing
- Avoiding transport damages

The requirements in this document are Outokumpu's minimum demands to be fulfilled by the personnel and transporters handling Outokumpu cargo. The requirements are based on the following regulations/standards:

- The European standard EN 12195:2010 for road transport within Europe
- The national German standard VDI 2700 for road transports within Germany
- IMO/ILO/UN ECE Code of Practice for Packing of Cargo Transport Units (CTU Code) for sea transport and combined rail transports

Please note that these requirements do not in any way supersede regulations stipulated by various authorities. Where required by local legislation, national or regional regulations or standards shall also be complied with, in addition to these requirements. Some of the standards and regulations that may be applicable, as available on the date of publication of this document, are listed in Appendix 1 for information purposes.

The cargo securing of every cargo transport unit that is leaving an Outokumpu site must be inspected and recorded before departure. The purpose is to make sure that all the transporters are following these requirements. If changes are subsequently made to the load on behalf of the driver or his contractor (reloading, partial unloading, etc.), they must ensure that the load is secured in accordance with DIN EN 12195 or VDI 2700.

In case of rail transports, each railway operator has their own requirements, which must be complied with.

The document covers the modes of transport, cargo transport units (CTUs) and cargo types given below.

Modes of transport:

- Road
- Rail
- Sea
- Combined transports by road, rail or/and sea

Cargo transport units (CTUs):

- Standard trailers
- Coil-trailers
- Swap bodies
- Containers
- Rail-cars

Cargo types[1]:

- Coils, eye to front and side
- Coils on pallets, eye to front and side
- Coils on pallets, eye to sky
- Slabs
- Discs on pallets
- Sheets on pallets

2. Basic principles for cargo securing

The cargo shall always be secured during transport to prevent sliding and tipping in all directions in order to avoid accidents, injuries, cargo damages and thus delays. Sliding is generally a larger problem for cargo from Outokumpu than tipping but both must be checked before departure. When dimensioning cargo securing arrangements, the following aspects shall be given due consideration:

- The mode of transport and the expected accelerations throughout the journey
- The weight of the cargo
- The friction between the cargo and the platform as well as between layers
- The cargo’s dimensions, including centre of gravity
- The rigidity of the cargo and the integrity of the packing material
- The strength of the cargo securing equipment
- The strength of the walls of the cargo transport unit

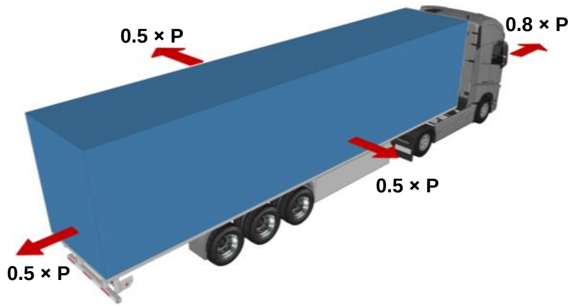
During transport, the cargo and the CTU are exposed to forces, which, depending on the transport, differ in magnitude in different directions. In case of a combined transport, the most critical combinations of horizontal and vertical acceleration in each direction for any leg of the journey must be observed.

[1] Any other cargo type not mentioned in the list is to be secured according to European Standard EN 12195-1:2010.

2.1 Forces acting on the cargo during transport

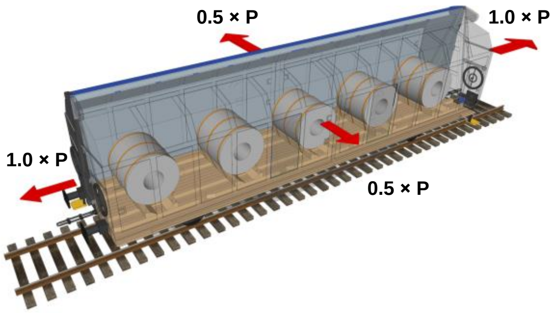
Cargo securing arrangements shall be designed to at least withstand the accelerations given in the figures below, see Appendix 2 for further information. The accelerations in the figures are expressed in parts of the weight of the cargo, P.

Road



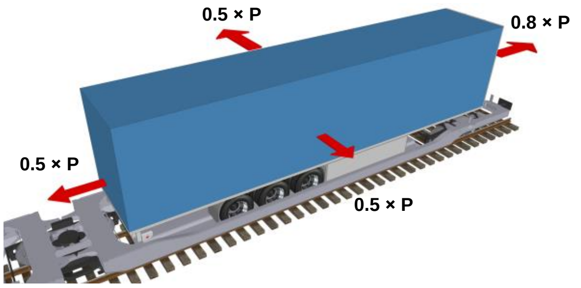
Forces in addition to the gravity force acting on cargo during road transport

Railway – block train



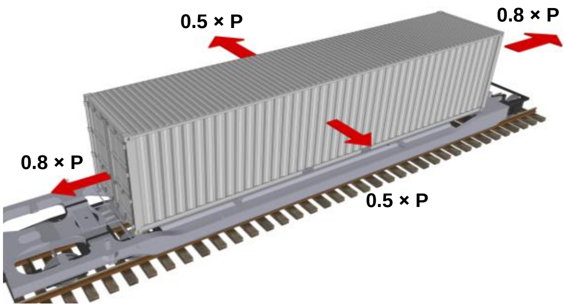
Forces affecting the cargo during rail transport in wagons in block trains not gravity shunted

Combined road/rail transport - trailer



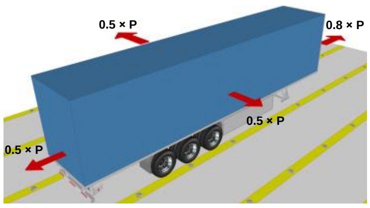
Dimensioning accelerations for the transport of semi-trailers in combined transport

Combined road/rail transport – container

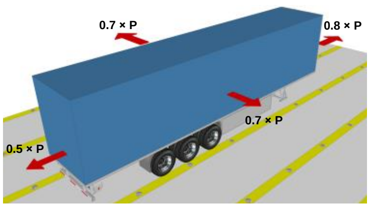


Dimensioning accelerations for the transport of containers and swap bodies in combined transport

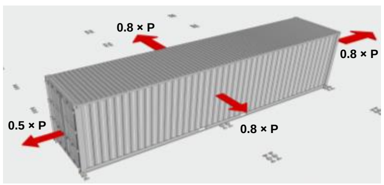
Combined road/sea area A transport - trailer



Combined road/sea area B transport – trailer



Combined road/sea area C transport - container



Dimensioning accelerations for the transport of semi-trailers and swap bodies in combined road/sea area A and B transport and containers in combined road/sea area C transport (please note that for sea transport a combination of horizontal and dynamic vertical accelerations might be the dimensioning case)

2.2 Sliding

Good friction helps preventing the cargo from sliding and reduces the demand for other cargo securing measures. Friction enhancing material, e.g. anti-slip mats, must be used! In addition, to achieve as high friction as possible, the following measures should, when practicable, be taken:

- Keep the platform dry and clean
- Avoid snow and ice on the platform and cargo

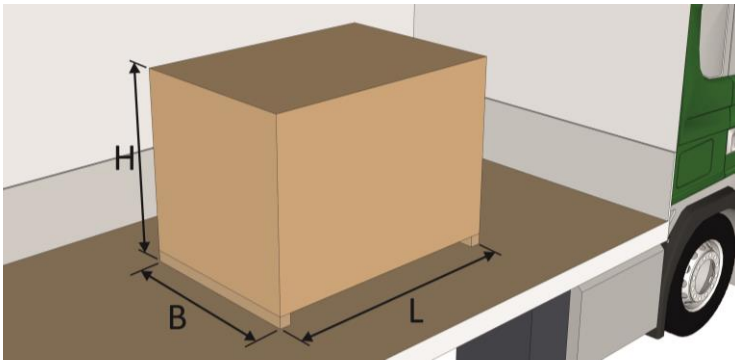
Friction factors for different material combinations may be taken from the table in Appendix 3.

2.3 Tipping

In order to avoid tipping, the dimensions of the cargo as well as its centre of gravity must be considered when deciding on the cargo securing method. High and narrow stows of cargo is more sensitive to tipping than low and wide ones.

Also, cargoes of irregular shape must be specially considered since those may have a narrow base or a centre of gravity which is displaced towards the top or either side and therefore have an increased risk of tipping.

For cargo with the centre of gravity in the geometrical centre, the tipping risk sideways is determined by the ratio of the height H and the width B of the cargo unit. In longitudinal direction it is the ratio between the height H and length L of the cargo unit that is decisive whether tipping risk exists or not.



Height, width and length of a cargo unit when the centre of gravity is positioned in the geometrical centre

When transporting by **road** and **rail** combined with transport in **sea area A**, there is a risk that the cargo will tip:

- sideways — if the height (H) is larger than 2 × width (B)
- forward — if the height (H) is larger than 1.25 × length (L)
- backward — if the height (H) is larger than 1.7 × length (L)

When transporting by **road** and **rail** combined with transport in **sea area B**, there is a risk that the cargo will tip:

- sideways — if the height (H) is larger than 1.4 × width (B)
- forward/backward — if the height (H) is larger than 1.0 × length (L)

When transporting by **road** and **rail** combined with transport in **sea area C**, there is a risk that the cargo will tip:

- sideways — if the height (H) is larger than 1.25 × width (B)
- forward/backward — if the height (H) is larger than 0.5 × length (L)

According to VDI 2700 for domestic German road transports the minimum requirement of stability for coils is to have a ratio of the coil width to the coil diameter of at least 0.66 when the coil is loaded eye to front and at least 0.55 when the coil is loaded eye to side. Coils which do not satisfy these requirements must be tied together with other coils to form a coil group and thereby jointly meet the minimum requirement. If this is not possible the coil will have to be supported against rolling or be secured by other means.

3. Cargo securing methods

Cargo is to be secured by blocking, lashing or mechanical locking or by a combination of these methods, in such a way that it is sufficiently prevented from sliding and tipping in all directions.

3.1 Blocking

Blocking is the primary method for securing cargoes and it is achieved by placing cargo in tight stows between strong walls of the cargo transport unit, stanchions or other blocking devices. If the cargo is blocked at the bottom only, it is prevented from sliding but not tipping. As a rule of thumb, bottom blocking devices should cover a height of at least 5 cm of the cargo. If the blocking device reaches up to the cargo’s centre of gravity, the cargo is also secured against tipping.

When allowed for by load distribution requirements, Outokumpu cargo are loaded against the headboard with sufficient strength and are tightly stowed throughout the length of the CTU.

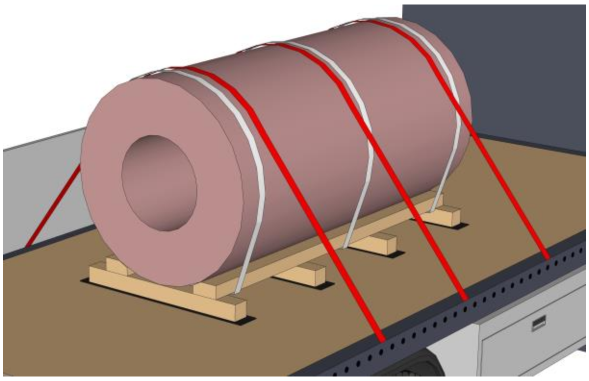
Cargo loaded against the headboard, tightly stowed throughout the length of the vehicle and blocked sideways by dunnage bags and the side walls of the vehicle (note that the side wall is transparent in the illustration)

Void spaces should be filled and may be favourably stuffed by dunnage bags, empty pallets inserted vertically or battens as necessary. Small gaps between unit loads and similar cargo items, which cannot be avoided and which are necessary for the smooth loading and unloading of the cargo, are acceptable and need not to be filled. The sum of void spaces in any horizontal direction shall not exceed 15 cm. However, between fragile cargoes or dense and rigid cargo items, such as steel products, void spaces should, as far as possible, be further minimized.

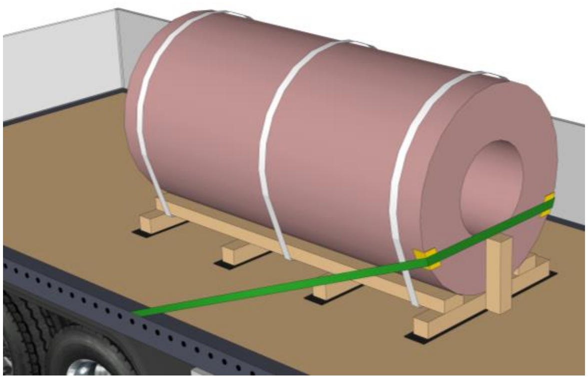
In case cargo is intended to be blocked against walls of road vehicles, these shall have a documented strength. This is extra important to observe for curtainsided vehicles.

3.2 Lashing

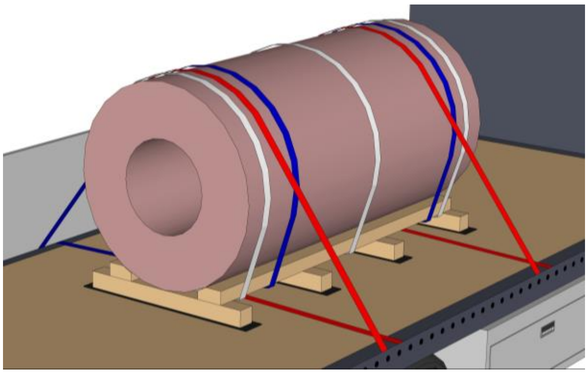
Cargo may be secured by several different lashing methods, as shown in the examples in the figures below.



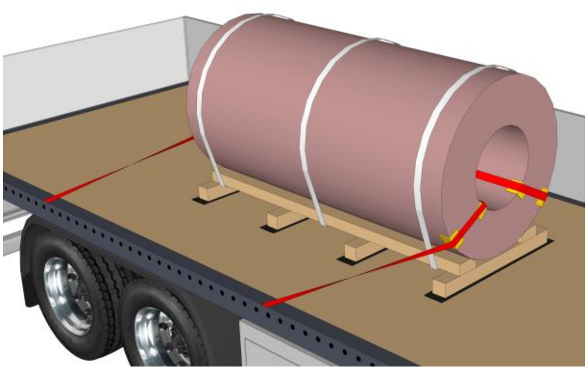
Top-over lashing



Spring lashing



Half-loop lashing



Loop-spring lashing

It must be noted that top-over lashing is a frictional lashing method which is designed to increase the pressure between the cargo and the platform, whereas the other methods are direct lashings. Top-over lashings utilize the pre-tension in the equipment achieved by the tensioning device. The other methods on the other hand, make full use of the safe working load in the lashings since they are further tightened if the cargo begins to move.

Requirements for lashing points on road vehicles according to the European standard EN 12640 is found in Appendix 6.

4. Cargo securing equipment

When securing Outokumpu cargo, only cargo securing equipment of known strength, quality and correct marking shall be used. All equipment shall be in good, fully working condition and inspected prior to use. Note that lashings with any damages according to Appendix 5 will be refused.

Care shall be taken not to combine, in an inappropriate way, lashing equipment with different strength and elongation characteristics on the same cargo unit. Furthermore, the equipment may not be applied in such a way that it damages the cargo.

The strength of cargo securing equipment may be expressed in various ways, depending on the manufacturer and the country of origin, as shown in the table below.

Strength	Explanation	Common denominations
Breaking strength	The load at which new, unused equipment of that kind may break at testing	**BL** - Breaking Load **MBL** - Minimum Break Load **BS** - Breaking Strength
Safe working load	The load to which the equipment may safely be subjected to when applied	**LC** - Lashing Capacity **MSL** - Maximum Securing Load **SWL** - Safe Working Load **WLL** - Working Load Limit
Pre-tension	The tension achieved in a lashing when applying normal hand force to the tensioning device or by applying a powered tensioning device according to suppliers instruction	**STF** - Standard Tension Force

Corner protectors must always be used.

4.1 Web lashings

Web lashings are produced in a great variety of material, dimensions and strengths. Both single use and re-usable equipment is available. Lashings intended for single use are delivered with a detachable tensioning device and loose hooks and locking devices. They are most commonly used in containers and on flat racks.

Lashings intended for re-use are delivered as a complete set and this equipment is the most common on trucks and trailers. When securing Outokumpu cargo with re-usable equipment, all lashings shall be in good condition and show limited wear only, see Appendix 5. Knots shall not be used to fasten or repair re-usable lashings.

Lashings shall be applied and, where possible, checked during the voyage in such a way that it is ensured that they remain well tightened throughout the transport. Web lashings must be protected from sharp corners by corner protectors.

When securing Outokumpu cargo, web lashings with a Lashing Capacity (LC) of 2 500 daN (kg) and a pre-tension (S_{TF}) of 350 daN should be used as a minimum.

An example of a marking of a web lashing is shown and described in Appendix 4.

A list of typical damages to lashing equipment is shown in Appendix 5.

4.2 Chain lashings

Chain lashings are typically used for securing heavy coils. The lashing fittings to which the chain is fastened must have at least the same strength as the chain itself.

Note that chain lashings shall only be used when decent corner protections are used!

Just like web lashings, chain lashings come in a variety of dimensions and sizes. Their strength is decided by the link diameter and the steel grade. Chain lashings may be tightened either with a turn buckle or a lever arm.

An example of a marking of a chain lashing is shown and described in Appendix 4.

Chain with turn buckle

Chain with lever arm tensioner

Short linked chains are heavier per meter but are useful if the lashing have to pass over a sharp corner since the short links bend less easily than those on a long linked chain.

Broken links due to bending over at sharp corners

Before use, chain lashings used to secure Outokumpu cargo shall be inspected for any visible damages that may weaken the lashing, such as bent links, deformed hooks or significant link wear. Any deficiencies found should result in the lashing being rejected, see Appendix 5.

Lashings shall be applied and, where possible, checked during the voyage in such a way that it is ensured that they remain well tightened throughout the transport.

4.3 Corner protectors

Corner protections shall always be used. They are typically made of rigid plastic, plastic-coated cardboard, wood or light metal and for Outokumpu cargo they shall be used to protect the lashings from sharp edges.

4.4 Dunnage bags

Dunnage bags may be used to fill void spaces in cargo transport units with strong walls, e.g. containers, to ensure a tight stow. The blocking capacity of a dunnage bag depends on its strength and its contact areas against the wall and/or the cargo units. If the gap is too large, the bag becomes very round, and the contact area becomes too small. There is thus a maximum gap that each size of bag may fill without losing to much effect. Typically, smaller bags may fill a gap of about 20 to 30 cm while larger bags may fill a gap between of about 40 to 50 cm. The dimensioning table below should be used to select the most suitable dunnage bag for the intended application.

Don't put dunnage bags in too large void spaces, since this results in a very small contact area against the wall and cargo units.

The supplier's instructions shall be observed to ensure correct filling pressure. If the pressure is too low the bag might fall down and if it is too high the bag may burst or it may damage the cargo or cargo transport unit. See further instructions for filling pressure in Appendix 10.

When dunnage bags are used to block cargo in several layers they should primarily be placed in the upper part of the section and must block at least 50 % of the weight in the cargo section.

Dunnage bags should preferable not be in contact with the floor. Nor should they be used to block the cargo against the roof in the cargo transport unit the container doors.

Dunnage bags are sensitive to sharp edges and must be protected from these by means of thick cardboard or wooden boards.

It is not allowed to use two dunnage bags against each other or to fold bags in order to fill out large gaps.

Don't put two bags against each other in one void space

Blocking of upper layers with at least 50 % of the weight in the cargo section.

Don't put dunnage bags against the roof

Don't put dunnage bags directly against the doors

The table below shows the cargo weight that can be blocked using dunnage bags in containers. The relation between the width of the load, the gap per side and the blocked weight is based on dunnage bags with a bursting pressure of 2.5 bar at a gap of 10 cm. Common load widths 200, 150 and 125 cm are marked in grey.

Load width [cm]	Gap per side [cm]	Heavy 60×110 [tonnes]	Heavy 85×120 [tonnes]	Heavy 120×180 [tonnes]	Heavy 120×240 [tonnes]
220	7	18.7	31.1	71.1	96.3
210	12	13.5	24.0	58.6	80.4
200	17	9.2	18.1	47.6	66.3
190	22	5.9	13.2	38.1	53.8
180	27	3.3	9.3	29.9	42.9
170	32	1.5	6.1	23.0	33.6
160	37	0.2	3.8	17.1	25.6
150	42	-	2.1	12.4	18.9
140	47	-	0.9	8.6	13.4
130	52	-	0.2	5.6	9.0
125	54.5	-	-	4.4	7.2

Dimensioning table: Secured cargo weight in tonnes for dunnage bags of varying sizes applied in different gaps

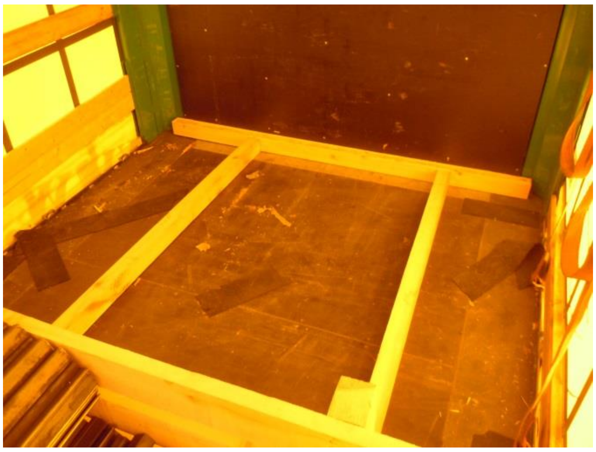
4.5 Anti-slip material

Since the friction between the cargo and the surface is of decisive importance for whether the cargo will slide or not when exposed to forces, the highest possible friction is desirable. Therefore, anti-slip material should be used between the cargo and the loading surface as well as between cargo units, where practical. The anti-slip material used between the cargo and loading surface should be minimum 8 mm thick.

The friction factor for the anti-slip material against all other surfaces must be at least 0.6.

4.6 Blocking by timber

Wooden constructions of various types, site-built or prefabricated, can advantageously be used for blocking.



Wooden constructions for the blocking of cargo

In order not to create point loads, cross battens should be used as supports between spacer battens and cargo as well as against the walls of the cargo transport unit. The timber dimension in both simple and more extensive blocking arrangements should be at least about 50 × 100 mm (2" × 4). When dimensioning wooden blocking arrangements, the following values can be assumed for the nominal strength of the timber:

	Pressure strength perpendicular to wood fibres [kN/cm^2]	**Pressure strength parallel to wood fibres** [kN/cm^2]	**Bending strength** [kN/cm^2]
Construction timber	0.5	2.0	3.0
Other timber	0.3	2.0	2.4

When loading in containers cargo of limited weight can be blocked against longitudinal movements by inserting transverse battens into the corrugations of the container. The battens are held up by vertical planks or ropes. Normally, battens of dimension 100 × 100 mm (4" × 4) are used. Such a batten can block maximum 5 tonnes of cargo against longitudinal movement. The blocking effect is greater the closer the floor the batten is placed.

For more information about blocking, please see Appendix 9 – Blocking and bedding arrangement by timber.

In order to avoid the spread of insect pests when exporting cargo outside Europe, timber products used for packaging or blocking must be heat treated and labelled according to the ISPM 15 standard. Detailed instructions and requirements are normally available at the agriculture authority.

Example of marking of wood that has been heat treated

5. Types of cargo

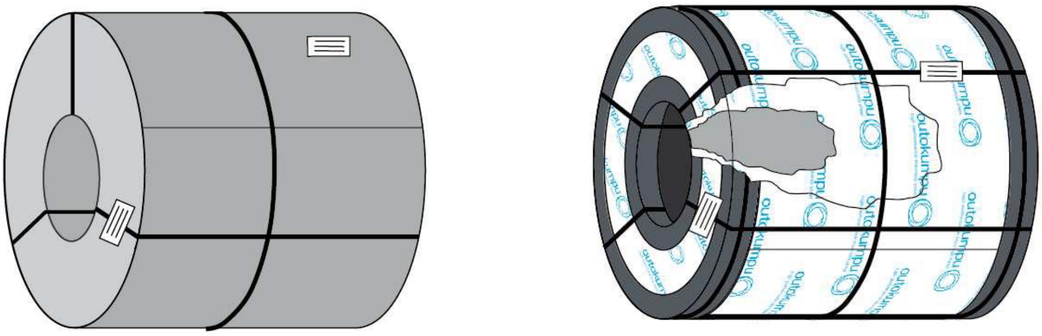
This document covers the cargo securing of the following types of Outokumpu cargo:

1. Coils, eye to front and side
2. Coils on pallets, eye to front and side
3. Coils on pallets, eye to sky
4. Slabs
5. Discs on pallets
6. Sheets on pallets

Below is a short description of the different types of cargo.

5.1 Coils, eye to front and side

The most common way to transport steel coils is to load them standing on their mantle surface with the eye to the front or to the side. Coils from Outokumpu weighing more than 10 – 12 tonnes are transported in built-in coil cradles. Vehicles/containers/railway waggons may be equipped with built-in coil cradles.

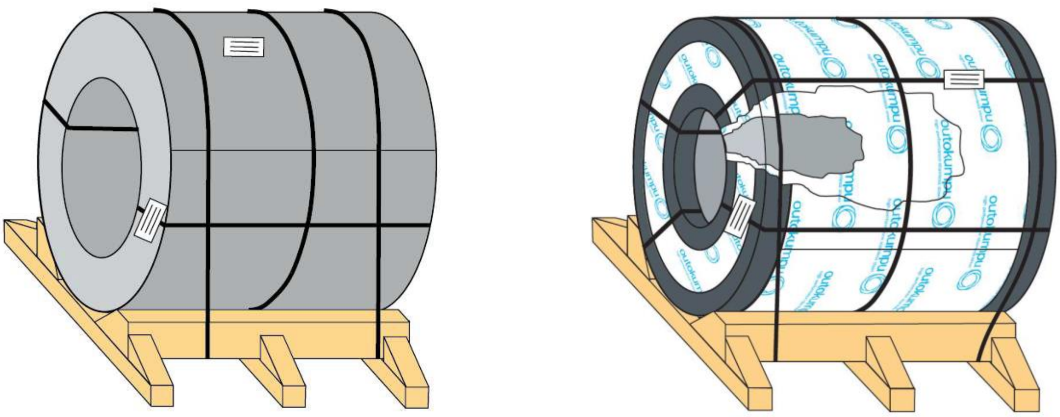


Coils weighing more than 10 – 12 tonnes are to be loaded in built- in coil cradles, with the eye to front or to side

5.2 Coils on pallets, eye to front and side

The common practice for small coils from Outokumpu, weighing less than 10 - 12 tonnes and loaded standing on their mantle surface, is to be transported with the eye to the front or to the side in a pallet/cradle.

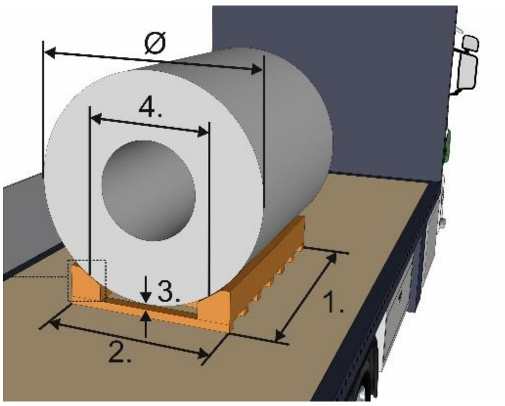
There are multiple types of coil pallets in which the coils are placed for transport.



Small coils are to be loaded in coil pallets

For small coils a coil pallet shall be used. The coil pallet is preferable designed as follows:

1. the wedges on which the coil rests must extend over the full length of the coil
2. the wedges must be fastened with a fixed distance
3. the construction must be stable and the coil must rest on the wedges with at least 20 mm clearance
4. the distance between the wedges must correspond to at least 60% of the diameter of the coil

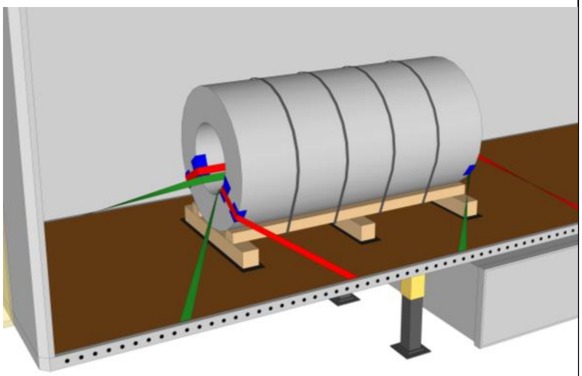


Design of coil pallet for steel coils

6.1.2 Rule-of-thumb for tipping

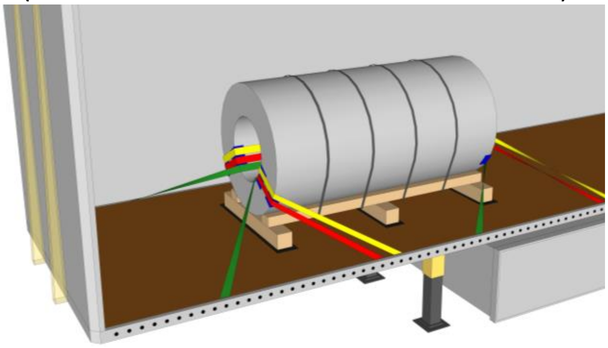
Coils loaded eye-to-front on pallets are to be secured with direct lashings that simultaneously act as both spring lashings and half-loop lashings. However, to avoid excessive tipping of narrow coils within the lashings, the minimum width of a coil secured with different number of lashings must be checked against the rule-of-thumb below.

Four half-loop spring lashings
(two directed forward and two backward)



$$minimum\ width\ [mm] = \frac{weight\ [kg]}{5}$$

Six half-loop spring lashings
(four directed forward and two backward)



$$minimum\ width\ [mm] = \frac{weight\ [kg]}{10}$$

If the width in mm for a coil is less than its weight in kg divided by 5 or 10 respectively, the coil is instead to be transported in a coil-trailer.

Alternatively, the minimum width of the coil can be taken from the diagram below.

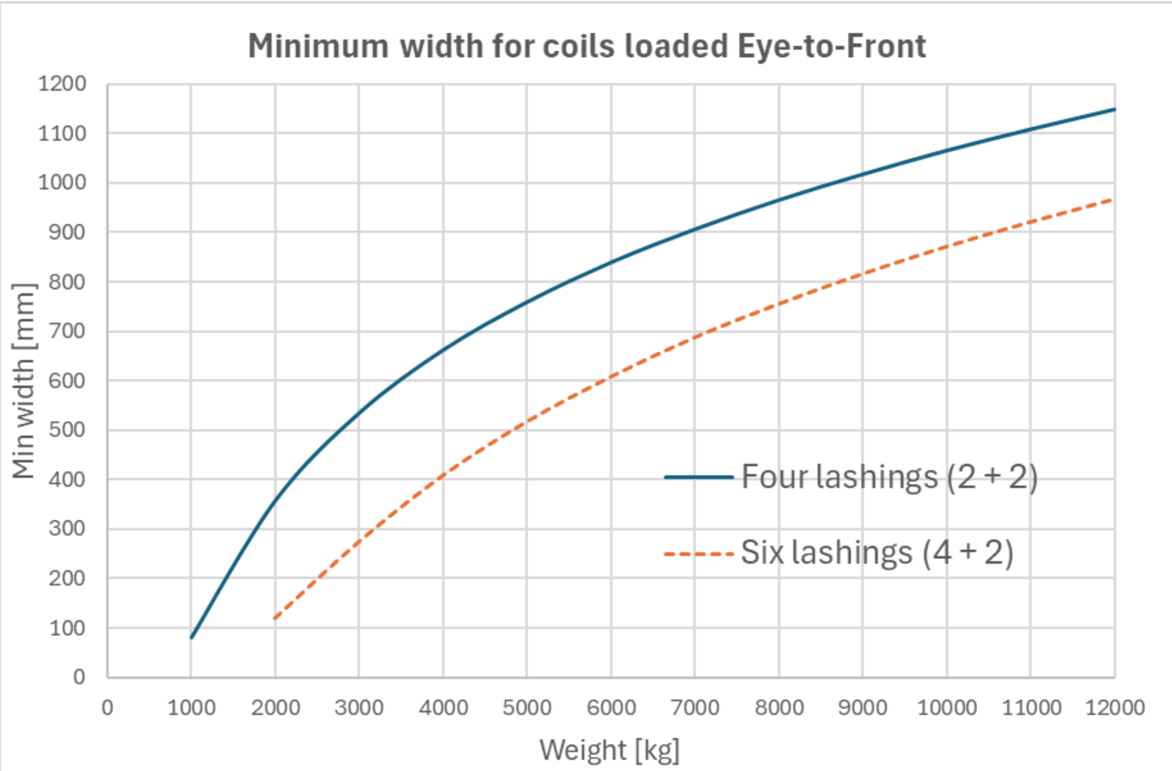


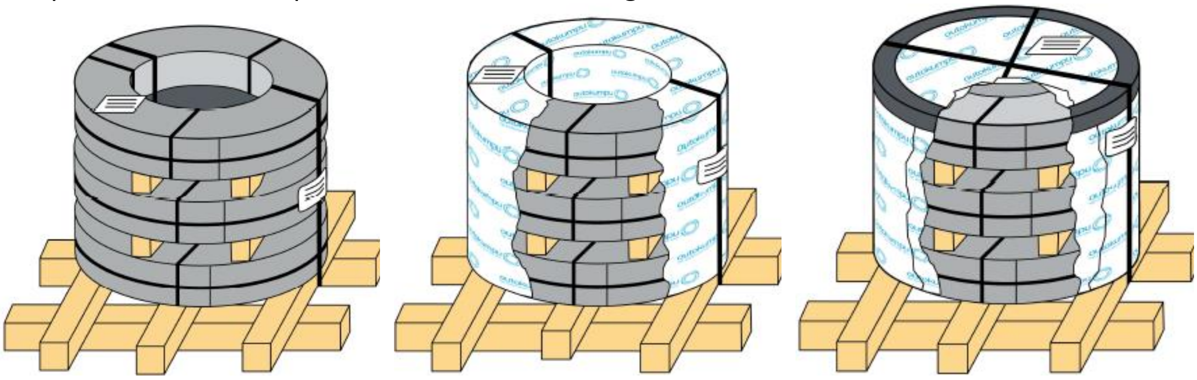
Diagram showing the minimum width of coils loaded eye-to-front on pallets to avoid tipping with different lashing arrangements

If the coil is too narrow, it should be transported in a coil-trailer, see section 6.2.

5.3 Coils on pallets, eye to sky

Coils loaded eye to sky are always transported on pallets with intermediate timber between the layers and with cross strips around both the coils and the pallets and longitudinal strips around the coil. Each site has different strapping materials and machines that is resulting in different packaging, with or without foil, circumference of corrugated plastics and outer edge protections.

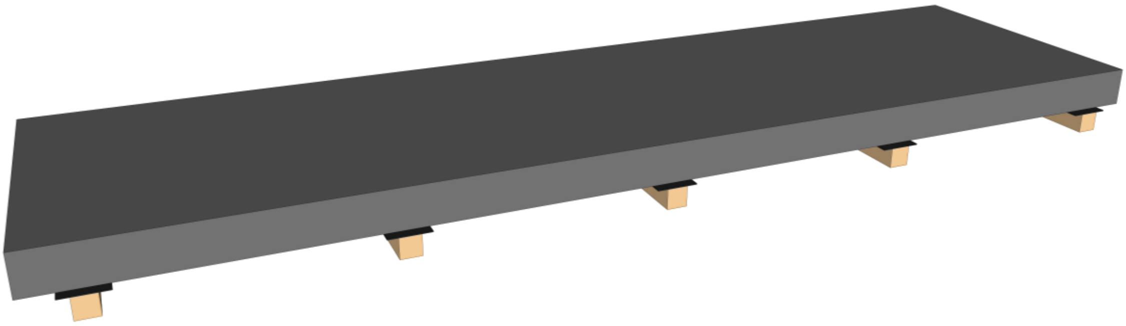
The pallet is strong enough to withstand the forces occurring during transport and during transport, the coils and pallet are seen as one cargo unit.



Coils loaded eye to sky on pallets with different strapping and packaging

5.4 Slabs

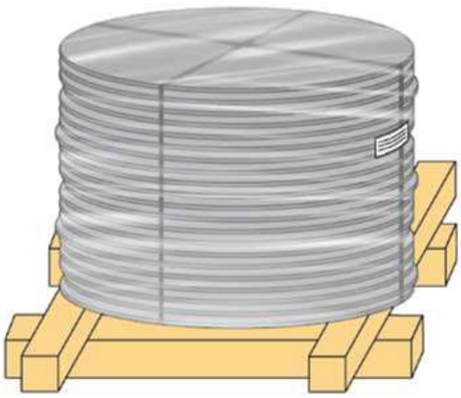
The steel slabs are placed on wooden battens and wooden battens are used between each layer. Anti-slip mats are used between all contact surfaces.



Slabs placed on wooden battens

5.5 Discs on pallets

Discs on pallets are loaded on pallets with cross strips around the coils and with transparent foil. The pallet is strong enough to withstand the forces occurring during transport and during transport, the coils and pallet are seen as one cargo unit.

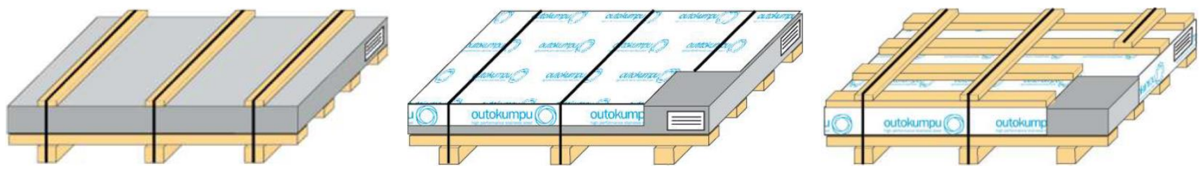


Discs on pallet with cross strips around the coil and transparent foil

5.6 Sheets on pallets

Sheets are loaded on pallets with cross strips around the pallets and with and without foil and/or wooden cover.

The sheets are packed for sufficient rigidity before loading on the pallet and the pallet is strong enough to withstand the forces occurring during transport.



Sheets loaded on pallets with different strapping and packaging

6. Specific requirements for CTUs

How suitable different types of CTUs are depends on the type of cargo to be transported and the mode of transport to be used. Below the specific requirements for the different types of CTUs used when transporting Outokumpu cargo is described.

When loading cargo it is important to make sure that the cargo is weather protected. It is also important to notice that the cargo can be affected by local weather conditions with various temperature, precipitation and humidity of the air.

6.1 Trailers

The following general requirements should be set on trailers:

- The platform, landing legs and headboard are undamaged
- The road vehicle is weatherproof and it is possible to close and seal it, which means that doors, drop sides, tarpaulins, laths and tarpaulin sealings shall be undamaged

- Any structure used for blocking of the cargo shall have sufficient strength[2]
- The cargo area including the platform shall be undamaged
- The cargo area shall be clean, dry and free from odour, frost, ice and snow
- The road vehicle is equipped with a sufficient amount of cargo securing equipment. The pre-tension in the lashings is at least S_{TF} 350 daN (kg).
- Securing points intended for securing of the cargo shall be sufficiently strong for the intended lashing equipment[3]
- In case of sea transport, trailers shall be equipped with required amount of 12 tonnes external securing fittings for the securing of the unit in ferry traffic

Minimum amount of external lashing points per trailer side:

total weight up to 20 tonnes	*- 2 pcs*
total weight between 20 and 30 tonnes	*- 3 pcs*
total weight between 30 and 40 tonnes	*- 4 pcs*

- Invalid labels shall be removed or masked
- Vehicles transported by rail shall be marked with the required code sign
- Vehicles transported by rail shall fulfil the requirements from the rail administrations and/or rail operator regarding the strength of the stake body structure

6.1.2 Strength of body structure

The European standard EN 12642 provides test criteria for verifying that the strength of the body structure on road vehicles meets minimum requirements to enable them to be used for securing cargo by blocking during road transport. However, the standard differentiates between Code L, standard vehicle bodies, and Code XL, reinforced vehicle bodies. Outokumpu cargo shall be transported in XL units.

The test criteria for XL-vehicles allows for most types of palletized cargo to be blocked against the body structure in all directions.

A vehicle tested in accordance with the Code XL requirements in the standard shall be fitted with a yellow marking plate with black text, providing details according to the example to the left below. The marking plate to the right below is according to the 2006 version of the standard. It provides less information but it is the most prevalent on the roads today.

[2] For European transport, the strength of headboard, drop sides and rear wall should fulfil the European standards EN 283, EN 12642 L or EN 12642 XL.
[3] For European transport, the strength, number and placement of securing points should fulfil the European standard EN 12640.

Name of manufacturer	EN 12642-XL		
Vehicle body in compliance with	P (27 000 kg) (P is the test value)		
Loading height up to	200 mm	800 mm	Max height
Front wall	18 100 daN	15 700 daN	13 500 daN
Rear wall	–	–	8 100 daN
Side walls	–	12 600 daN	10 800 daN
Number of laths per section	3 aluminum / wood		

Fahrzeugaufbau entspricht	EN 12642-XL
Véhicule conform à la norm	
Vehicle body in compliance with	
Mustermann AG	**2006**

Marking plates for vehicles built according to the EN 12642 XL from 2016 (left) and 2006 (right)

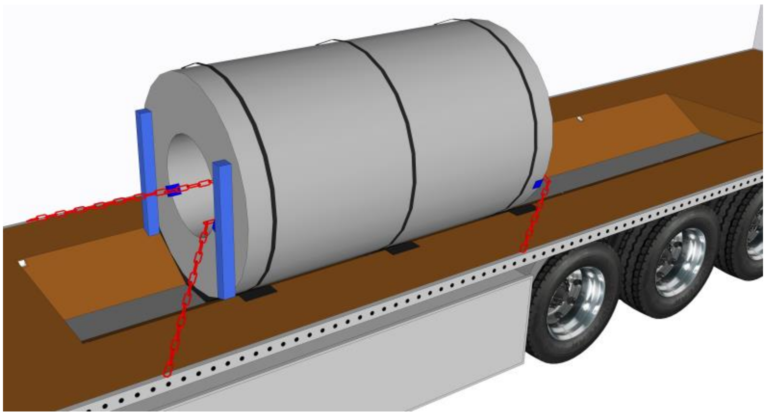
Please note: The cargo weight considered during testing of XL vehicles may not be equal to the payload and only cargo weighing up to the test value P may be blocked against the superstructure without additional securing.

6.2 Coil-trailers

A coil-trailer is a trailer with a built-in cradle for transport of coils, among others. The general requirements are the same as for an ordinary trailer, including the strength of the body structure, see chapter 6.1.

Coil-trailers offer safe and efficient transport of various steel goods such as coils. The trailers have special coil wells in the floor that give the coils a firm hold under a wide variety of conditions.

When coils weighing more than 10 tonnes shall be loaded and transported in trailers, it is recommended to be in coil-trailers with a built-in cradle, see the sketch below. For coils weighing more than 12 tonnes this is a requirement.



A coil weighing more than 12 tonnes loaded in a coil-trailer

6.3 Containers

Cargo to be transported outside Europe are usually shipped in containers, or on flat racks. The container is an ISO-certified CTU with standardized dimensions and characteristics originating in the USA, which makes it different from a standard European trailer. The lashing points in a container are not as strong as in a trailer (see Appendix 7) and with a smaller internal width, EUR pallets do not fit into a container in the same way as in a trailer.

It is therefore more difficult to achieve a tight loading in a container and there is therefore often more free space left that must be filled.

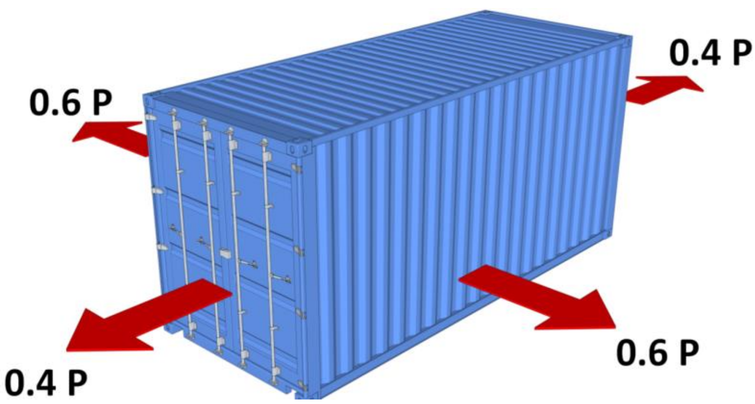
Otherwise, from a cargo securing point of view, the container is a great CTU with strong construction details such as walls, ends and doors that are dimensioned to secure the cargo against. The cargo securing methods used in a container are therefore somewhat different from the methods used in a trailer or on a flat rack. The main principle is to block the cargo, that is, to place the cargo against the inner end of the container, its walls and against the doors and then fill any free space with dunnage bags, empty pallets, battens, H-braces or other filling material. Due to the limited strength of the securing points in a container lashing is not recommended or should at least be avoided for securing of heavy cargo.

The following general requirements should be set on containers:

- The container shall fulfil standard ISO 1496-1 for containers
- The frame work of the container shall be undamaged
- The container shall be weather tight and it shall be possible to seal it when closed, which means that walls, floor, roof, doors, door sealing as well as possible tarpaulin cover with sealing shall be undamaged
- The cargo area including the floor shall be undamaged
- The cargo area shall be clean, dry and free from odour
- Ventilation openings shall be undamaged
- Corner castings shall be undamaged
- The container shall be marked with safety plate in accordance with the Container Safe Convention (CSC)
- Invalid labels shall be removed or masked

6.3.1 Strength of container walls

The side and end walls of the container are designed to withstand an evenly distributed internal load where P is the maximum permissible load weight (payload).



Maximum permissible evenly distributed load on the container walls in shares of the payload P

It is important to be properly prepared and to plan the loading in containers to get an optimal loading pattern, weight distribution and cargo securing. The doors may be used for blocking in most cases, but the cargo must be prevented from falling out when the doors are opened. Note that dunnage bags must never be placed directly against the doors of the cargo transport unit because the doors then risk being pushed up with a violent force. Also note that, according to North America regulations, it is not permitted to use the doors for cargo securing during rail transport. Dunnage bags that are to fill void space longitudinally are therefore preferably placed inside the last section of the cargo transport unit.

7. Specific principles for cargo securing in different CTUs

Different CTUs provide specific principles and conditions for cargo securing for different modes of transport and different types of cargo.

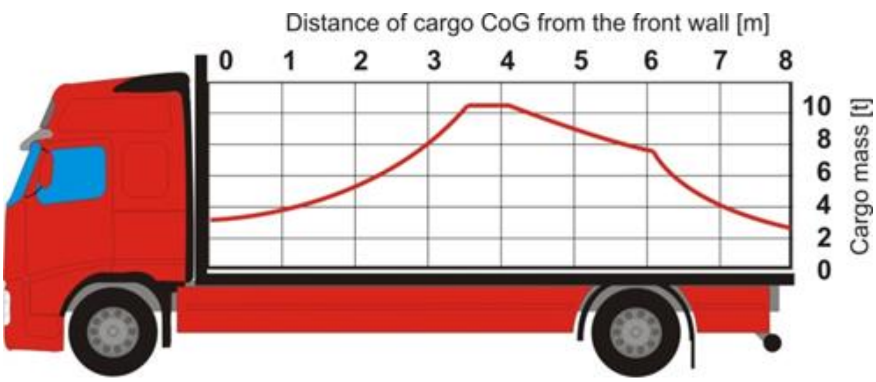
Common for all transports is that the cargo should always be loaded in a way that facilitates easy unloading.

7.1 Cargo securing in trailers

During road transport the greatest forces arise during braking and thus more cargo securing is needed in forward direction than sideways and backwards. Therefore, it is recommended to block the cargo in forward direction, i.e. by tight stowage against the headboard, stanchions, other cargo, etc, in trailers.

When loading a trailer, it is important to ensure that a correct load distribution and axle load is obtained and that the maximum dimensions and gross weight is not exceeded. Minimum axle loads should also be considered to ensure adequate stability, steering and braking, as either foreseen by law or the vehicle manufacturer.

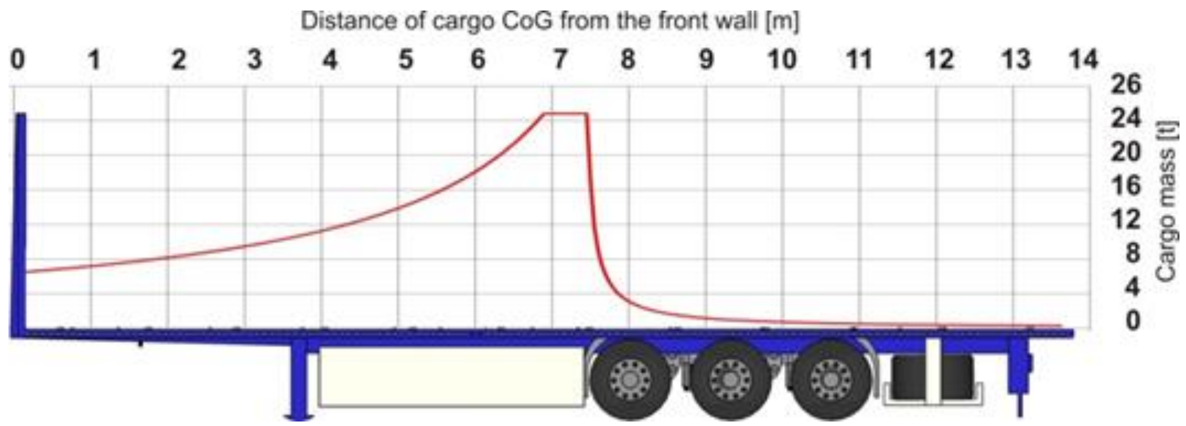
Vehicles are particularly sensitive to the position of the centre of gravity of the load, due to specified axle loads for maintaining steering and braking ability. Such vehicles may be equipped with specific diagrams, see typical examples below for a 2-axle truck and a 3-axle semitrailer, which show the permissible pay load as a function of the longitudinal position of its centre of gravity. Generally, the maximum pay load may be used only when the centre of gravity is positioned within narrow boundaries about half the length of the loading space.



Load distribution diagram for a typical 18 t 2-axle truck

Load distribution diagrams should be provided by the vehicle or body manufacturer but can also be calculated based on the vehicle's geometry, minimum and maximum axle loads, distribution of the tare weight on the different axles as well as the maximum payload, either by a spreadsheet calculation or by simple software tools. Such software is available on the internet, for free or very cheaply.

Distribution of load in accordance with the vehicles load distribution diagram will help not to exceed the vehicle's maximum permissible axle loads.



Load distribution diagram of typical 13.6 m 3-axle semitrailer

It is also important to load the cargo so that it can be safely and simply unloaded upon arrival. The cargo must be secured so that there is no risk of it falling out when the doors are opened.

Two examples of calculation of the centre of gravity of the load in a 13.6 m 3-axle semitrailer and a 40 ft container are shown in Appendix 11.

7.2 Cargo securing in coil-trailers

Just like for the trailer, the greatest forces arise in forward direction and cargo is recommended to be blocked in forward direction. It is also important to ensure that a correct load distribution and axle load is obtained, see section 7.1 above.

Medium and heavy coils that are to be transported in a trailer must be transported in a coil-trailer with a built-in cradle. The coil-trailer will prevent the telescopic effect and the coil from sliding and rolling. The coil is blocked sideways and in the longitudinal direction the vehicle is often equipped with strong supports which are placed horizontally or vertically in front of the coil.

Coils which do not satisfy the minimum requirement of stability, see section 5.2, must be supported against rolling or be secured by stanchions or other similar methods.

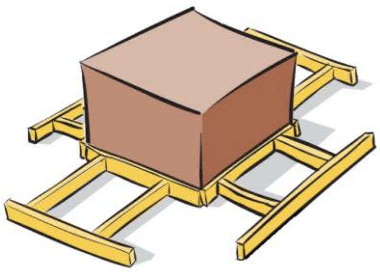
7.3 Cargo securing in containers

The principles for cargo securing in containers differs from the principles in trailers. The main principle in containers is to use blocking against the framework of the container; the inner wall, side walls and doors and to use filling material for void spaces. Due to the limited strength of the securing points in a container, see Appendix 7, lashing in containers is not recommended or should at least be avoided for securing of heavy cargo.

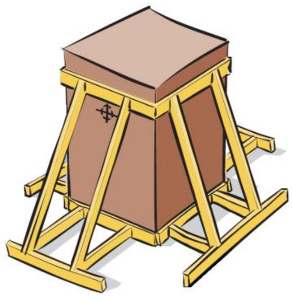
As a container normally is transported on road as well as on sea, and sometimes even on rail, the securing arrangement must be designed for accelerations, and corresponding forces that might arise during the actual combination of transports that is 0.8 × the weight of the cargo, both sideways and in longitudinal direction.

To prevent sliding the cargo may be bottom blocked by H-frames according to the principle in the figure below to the left. For strength in H-frames and required dimensions of the timber, see Appendix 9.

To prevent tipping in longitudinal and transverse direction, diagonal timber supports could be applied according to the principle in the figure below to the right. To save space, these supports could alternatively be horizontal and be placed between cargo and the corner posts of the container.



Bottom blocking by H-frames

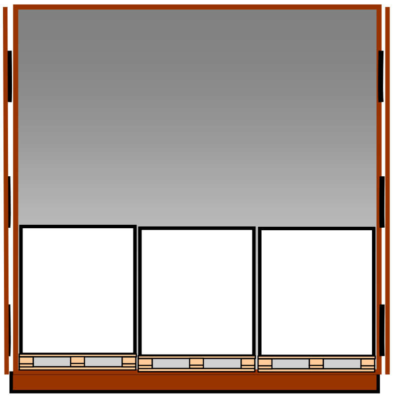


Diagonal timber supports to prevent tipping

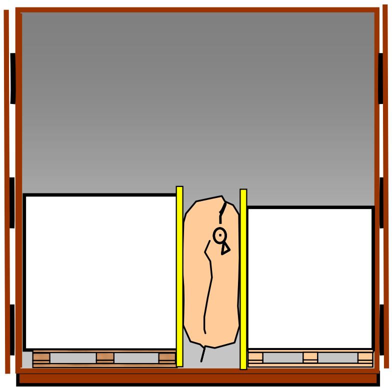
As an alternative to diagonal timber supports to prevent tipping sideways the void space between the container sides and the cargo can be filled. Note that vertical timbers must be placed from floor to roof against the container sides to avoid spot loads on the sides.

Accordingly, the best way of securing cargo in containers is to block it against the long sides and gables. Also, the doors may be used for blocking (except for rail transport in North America) but note that the cargo must be prevented from falling out when the doors are opened.

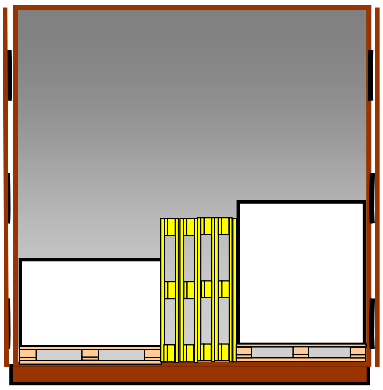
Blocking sideways: Void spaces are to be filled with dunnage bags, empty pallets or timber, or by a combination of these measures. Note that the filling material should be placed in the middle of the container so that the forces on the material are from the cargo on one side only. Below some principles are shown.



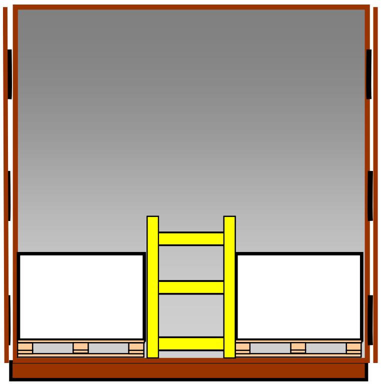
Totally blocked cargo



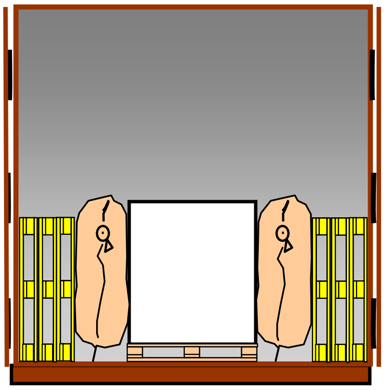
Blocking with dunnage bags (and boards, if required)



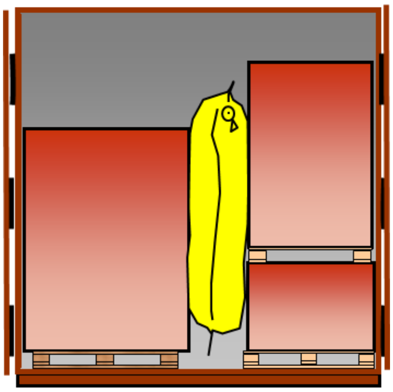
Blocking with empty pallets



Blocking with timber (H-frames)



Blocking with dunnage bags and empty pallets



Blocking with dunnage bags

Blocking with dunnage bags

Blocking with timber


Blocking of machinery parts with timber

When using dunnage bags, it is important to protect the bags from sharp edges and corners with for example boards or empty pallets. Note that the maximum void space to fill with a dunnage bag is about 40 cm.

Blocking in longitudinal direction: If possible due to weight distribution, the cargo is to be stowed tightly to the inner wall of the container. The cargo items are then to be stowed tightly without any void space in longitudinal direction. Any void space in longitudinal direction is to be filled with dunnage bags, empty pallets or timber, or by a combination of these measures.

Blocking with timber

Blocking with empty pallets

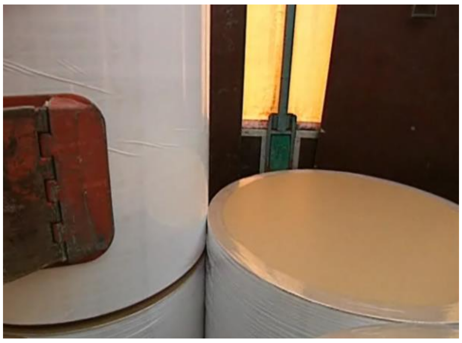
Blocking with a dunnage bag in the second last section

Blocking with dunnage bags and timber

Dunnage bags must never be placed directly against the doors of the cargo transport unit because the doors then risk to be pushed up with a violent force. Dunnage bags that are to fill void space longitudinally are therefore preferably placed inside the last section of the cargo transport unit. See further instructions for dunnage bags in section 6.4.

Broken layers of cargo can be blocked against sliding forward and backward in the cargo transport unit by so-called threshold blocking. A threshold blocking can be achieved either by an elevation of other cargo or by means of empty pallets, battens, boards, etc.


Threshold created by using empty pallets under cargo units with the same height

Threshold created by using cargo units with different heights


Upper layer blocked with boards and battens

In containers, the centre of gravity of the load cannot be displaced more than 5% of the container length from the container's half length. As a rule of thumb, this may be achieved by not loading more than 60 % of the cargo weight in one half and not less than 40 % in the other. This corresponds to a maximum deviation of 0.60 m of the total centre of gravity of the load from the container's half length in a 40 ft container and 0.30 m in a 20 ft container.

Weight distribution in a container

Furthermore, transport operators may according to SOLAS[4] request a verified gross mass (VGM) of containers. This may be provided either by weighing the container after loading or by summarizing the tare weight of the container, the weight of all cargo items as well as any additional securing or packing material used.

8. Inspection before and after loading

The CTU shall be visually checked before the loading of the cargo is started. The check may be performed according to the checklist in Appendix 12 and 13. The transport operator shall at least provide a CTU that:

- Is in good condition
- Is suitable for the intended voyage
- Is suitable for the cargo and weatherproof when so required
- Provides suitable access to the cargo for loading and unloading
- Has a floor which is strong enough to support the cargo and any equipment needed to load or unload the cargo
- Provides suitable means of securing the cargo
- Have sufficiently strong walls with a documented strength if it is intended to use these to block the cargo any direction.

When anything is unclear the person responsible at the shipping department shall be consulted for decision on whether the CTU can be accepted, has to be rectified or refused. If the CTU is refused the transport company has to be informed accordingly.

In general, the CTU shall be in good condition and the cargo space shall be clean and free from fixed or loose protruding details that can damage the cargo.

[4] Safety of Life at Sea – IMO Resolution MSC.404(96)

Closed CTUs must be sufficiently weatherproof to minimize the risk of damaging the cargo. The cargo securing of each outbound transport must be inspected by qualified persons to ensure that the cargo securing complies with current regulations and standards. The inspection includes a visual check of the lashing equipment (see chapter 4), and verification whether anti-slip mats and edge protectors have been used. The cargo securing inspection will be documented, and pictures will be taken.

Appendix 1 – Regional and national standards

Below regional and national standards are given for road, rail and sea transport respectively.

Road

EU: ***Crossborder traffic***

- The EU Directive (2014/47/EU) about the technical roadside inspection of the roadworthiness of commercial vehicles came into force in May 2014. Member States had to implement it into their national legislation by May 2017 and start applying it by May 2018.

  https://ec.europa.eu/transport/road_safety/topics/vehicles/cargo_securing_loads

Standards in directive 2014/47/EU:	EN 12195-1	Calculation of lashing forces
	EN 12195-2	Web lashings made from man-made fibres
	EN 12195-3	Lashing chains
	EN 12195-4	Lashing steel wire ropes
	EN 12640	Lashing points
	EN 12641	Tarpaulins
	EN 12642	Strength of vehicle body structure
	ISO 1161, ISO 1496	ISO container
	EN 283	Swap bodies
	EUMOS 40509	Transport packaging
	EUMOS 40511	Poles – stanchions

- EU Best Practice Guidelines on Cargo Securing for Road Transport, May 2014

EU: ***Domestic traffic***

- **Sweden:** TSFS 2017:25
- **Norway:** Föreskrift om bruk av køretøy: FOR-1990-01-25-92
- **Denmark:** BEK nr. 1306 af 07/09/2020
- **Finland:** TRAFICOM/605158/03.04.03.00/2021
- **Germany:** VDI 2700
- **Belgium:** Verkeersreglement KB 01/12/1975
- **Austria:** Kraftfahrgesetz 1967
- **Poland:** Dziennik Ustaw 2018; poz. 361
- **Slovakia:** 134/2018 Z.z.

North America:
- North American Cargo Securement Standard, September 2010

Australia:
- National Road Commission – Load restrain Guide, 3rd edition 2018

New Zeeland:
- Truck Loading Code, 2017

Railway

Europe:
- UIC Loading Guidelines (UIC - the International Union of Railways)

North America:
- AAR Regulations

Australia:
- ARA Regulations

Sea

International – IMO:
- IMO/ILO/UN ECE Code of Safe Practice for Packing of Cargo Transport Units (CTU Code)
- IMO Model course 3.18

	Friction	Securing requirements	Acceleration factors for road transport (in parts of gravity acceleration 1g = 9.81 m/s²)	Safety factor	Deviation from securing regulations/ recommendations allowed
International CTU Code	0.3/0.2/0.1 or actual	General	Forward: 0.8 g Rearward: 0.5 g Sideways: 0.5 g Vertical: -	Specified for top-over lashing only	Arrangements to be individually designed; by detailed calculations or according to the Quick Lashing Guide
Europe Crossborder traffic	Actual may be used	General	Forward: 0.8 g Rearward: 0.5 g Sideways: 0.5* g Vertical: -	Specified in EN 12195-1: 2010	Yes, the system should be designed according to basic parameters
Germany Domestic transports	Actual may be used	General	Forward: 0.8 g Rearward: 0.5 g Sideways: 0.5* g Vertical: -	Not specified in VDI 2700 part 2	Arrangements should be designed according to VDI 2700 part 2
Sweden Domestic transports	Actual may be used	General	Forward: 0.8 g Rearward: 0.5 g Sideways: 0.5 g Vertical: -	Specified in EN 12195-1: 2010	Yes, the system should be designed according to basic parameters
Finland Domestic transports	Actual may be used	General	Forward: 0.8 g Rearward: 0.5 g Sideways: 0.5 g Vertical: -	Specified in EN 12195-1: 2010	Yes, the system should be designed according to basic parameters
North America	No values are specified	Min four lashings required	Forward: 0.8 g Rearward: 0.5 g Sideways: 0.5 g Vertical: 0.2 g	Not specified	Yes, as no detailed regulations exist
Australia	Actual or a conservative value	Detailed	Forward: 0.8 g Rearward: 0.5 g Sideways: 0.5 g Vertical: 0.2 g	Not specified	Yes, if following the basic accelerations and meeting the performance standards
New Zealand	Actual may be used	Detailed	Forward: 1.0 g Rearward: 0.5 g Sideways: 0.5 g Vertical: 0.2 g	Not specified	Yes, if loaded on a special purpose vehicle

*) *See further information on the accelerations for tipping in Appendix 2*

Below a small compilation of the details regarding cargo securing of some of the regulations for road mentioned above is shown.

Appendix 2 – Forces acting on cargo during transport

Cargo securing arrangements shall be designed to at least withstand the accelerations given for different modes of transport and regulations in the tables below. The accelerations in the tables are expressed in parts of g (gravity acceleration: 1 g = 9.81 m/s²).

Acceleration coefficients c_x, c_y och c_z according to the CTU Code:

Road transport				
Securing in	Acceleration coefficients			
	Longitudinally (c_x) forward	Longitudinally (c_x) rearward	Transversely (c_y)	Minimum vertically down (c_z)
Longitudinal direction	0.8	0.5	-	1.0
Transverse direction	-	-	0.5	1.0

Rail transport (combined transport)				
Securing in	Acceleration coefficients			
	Longitudinally (c_x) forward	Longitudinally (c_x) rearward	Transversely (c_y)	Minimum vertically down (c_z)
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 (c_x)	Transversely (c_y)	Minimum vertically down (c_z)
A	$H_s \leq 8$ m	Longitudinal direction	0.3	-	0.5
		Transverse direction	-	0.5	1.0
B	8 m < $H_s \leq 12$ m	Longitudinal direction	0.3	-	0.3
		Transverse direction	-	0.7	1.0
C	$H_s > 12$ m	Longitudinal direction	0.4	-	0.2
		Transverse direction	-	0.8	1.0

The different sea areas are defined according to the table below:

A	B	C
$H_s \leq 8$ m	8 m < $H_s \leq 12$ m	$H_s > 12$ 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

Acceleration coefficients c_x, c_y och c_z according to the European standard EN 12195-1:2010

Road transport:

Securing in	Acceleration coefficients				
	c_x, longitudinally		c_y, transversely		c_z, vertically down
	forward	rearward	sliding only	tilting	
longitudinal direction	0,8	0,5	—	—	1,0
transverse direction	—	—	0,5	0,5/0,6 [a]	1,0

The footnote a in the table above refers to section 5.1 in EN 12195-1:2010:

The number of lashing devices to be used for unstable goods in combination with frictional lashing (top-over lashing), should be the largest of the following two calculations:

c_y = 0.5 calculated with $F_T = S_{TF}$
c_y = 0.6 calculated with $F_T = 0.5\ LC$

In case of the direct lashing method the calculation should be used based on:

c_y = 0.5 calculated with $F_R = LC$

Rail transport:

Securing in	Acceleration coefficients				
	c_x, longitudinally		c_y, transversely	c_z, minimum vertically down	
	sliding	tilting		sliding	tilting
longitudinal direction	1,0	0,6	—	1,0	1,0
transverse direction	—	—	0,5	0,7	1,0

Sea transport:

Sea area	Securing in	Acceleration coefficients		
		c_x, longitudinally	c_y, transversely	c_z, minimum vertically down
A	longitudinal direction	0,3	—	0,5
	transverse direction	—	0,5	1,0
B	longitudinal direction	0,3	—	0,3
	transverse direction	—	0,7	1,0
C	longitudinal direction	0,4	—	0,2
	transverse direction	—	0,8	1,0

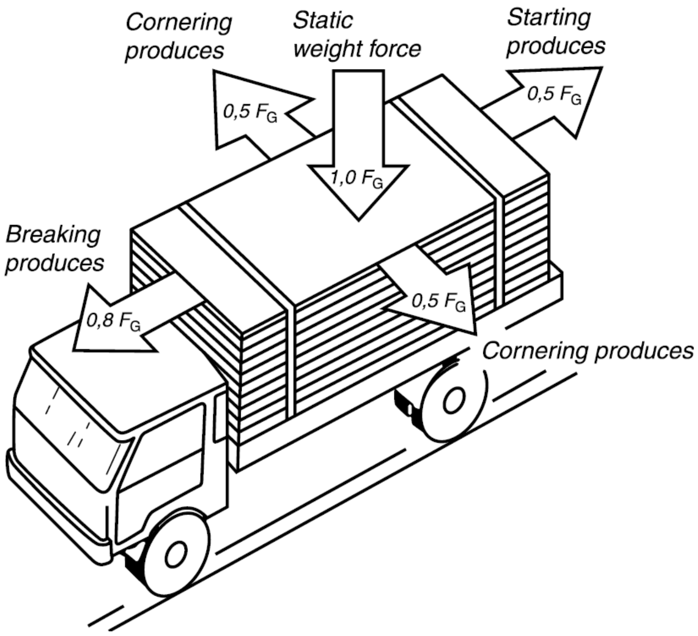
NOTE See IMO/ILO/UNECE, Guidelines for packing of cargo transport units (CTUs).

A Baltic Sea bordered in west by Jylland and in north by a line between Lysekil and Skagen.

B West of Sea area A bordered in north by a line between Kristiansand and Montrose, in west by UK and in south by a line between Brest and Land's End as well as the Mediterranean Sea.

C Unrestricted.

Accelerations according to the national German standard VDI 2700



In addition, a factor for rolling to the sides of 0.2 · F_G is to be considered if goods are unstable and likely to tilt.

Appendix 3 – Friction factors

Friction factors for different material combinations may be taken from the table below. The values are taken from the CTU Code and standard EN 12195-1:2010.

Material combination in contact surface	Dry	Wet
Sawn timber/wooden pallet		
Sawn timber/wooden pallet - fabric base laminate/plywood	0.45	0.45
Sawn timber/wooden pallet - grooved aluminium	0.4	0.4
Sawn timber/wooden pallet - stainless steel sheet	0.3	0.3
Sawn timber/wooden pallet - shrink film	0.3	0.3
Planed wood		
Planed wood - fabric base laminate/plywood	0.3	0.3
Planed wood - grooved aluminium	0.25	0.25
Planed wood - stainless steel sheet	0.2	0.2
Plastic pallet		
Plastic pallet - fabric base laminate/plywood	0.2	0.2
Plastic pallet - grooved aluminium	0.15	0.15
Plastic pallet - stainless steel sheet	0.15	0.15
Cardboard (untreated)		
Cardboard – cardboard	0.5*	-
Cardboard - wooden pallet	0.5*	-
Steel and sheet metal		
Steel crate - fabric base laminate/plywood	0.45	0.45
Steel crate - grooved aluminium	0.3	0.3
Steel crate - stainless steel sheet	0.2	0.2
Unpainted metal with rough surface - unpainted rough metal	0.4*	-
Painted metal with rough surface - painted rough metal	0.3*	-
Painted metal with smooth surface - painted smooth metal	0.2*	-
Metal with smooth surface - metal with smooth surface	0.2*	-
Anti-slip material		
Rubber	0.6	0.6
Other material	as certified or tested	

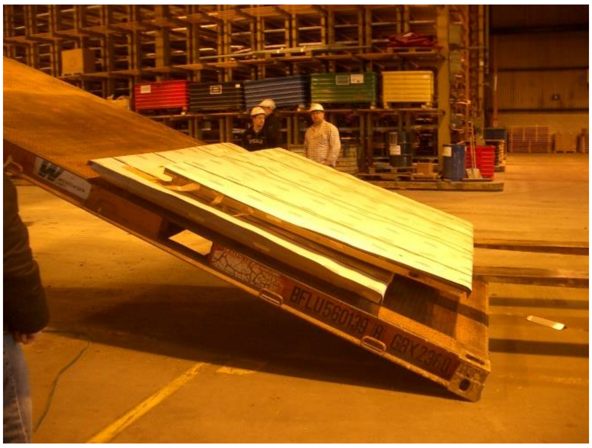
*) *Value according to the CTU Code*

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 for sea transport and 0.2 for road transport should be used. If the surface contacts are not swept clean, the maximum allowable friction factor of 0.3/0.2 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.

The following friction factors have been measured during cargo securing training in Avesta, Sweden, 2008-03-12--14:

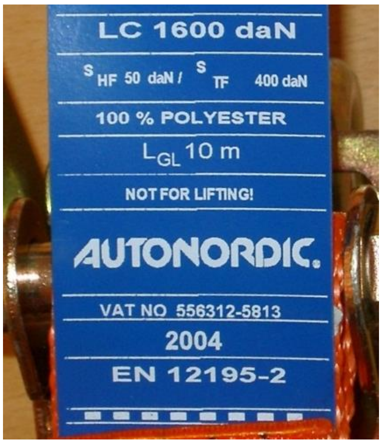
Product and surface	Friction factor
Coils with plastic wrapping – wooden crate (dry surfaces)	0.3
Sheet – sheet (dry surfaces)	0.4



Appendix 4 – Marking of web and chain lashings according to EN 12195-2--3

Marking of web lashings according to European standard EN 12195-2



1 daN ≈ **1 kg**

LC = *Lashing capacity* = 1 600 kg

S_{HF} = *Standard hand force* = 50 kg
Force for which the tensioner is dimensioned

S_{TF} = *Standard tension force* = 400 kg
Force obtained in the lashing

Marking of chain lashings according to standard EN 12195-3

1 daN = **1 kg**

10 kN ≈ **1 tonnes**

LC = *Lashing capacity* **= 63 kN ≈ 6.3 tonnes**

S_{TF} = *Standard tension force* **= 1 600 daN = 1 600 kg**

The allowed lashing force is 50 % of the breaking load, MBL. Breaking load for this chain is thus 12.6 tonnes.

Please note that different denominations are used in different standards for the allowable force in a lashing, considering a safety factor against ultimate failure. The EN 12195 series refers to the allowable lashing force as Lashing Capacity, LC, while the CTU Code uses the term Maximum Securing Load, MSL. American standards use Working Load Limit, WLL. The term Safe Working Load, SWL, is used for lifting equipment.

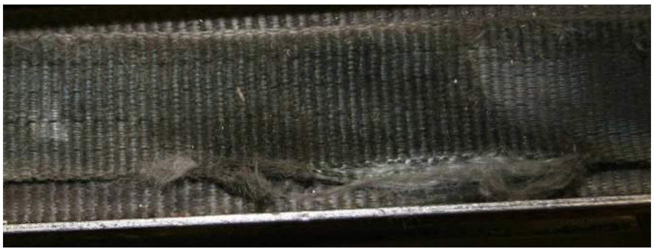
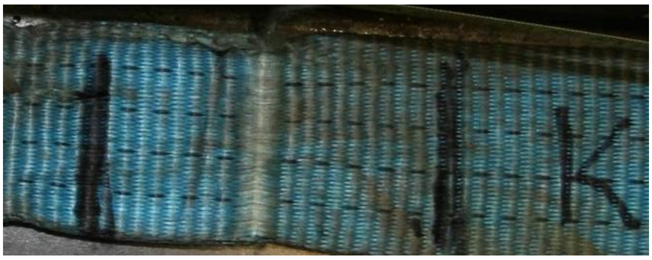
Appendix 5 – Typical damage to lashing equipment

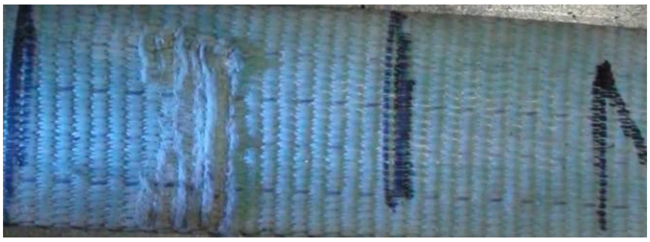
Web lashings

Web lashings found to be damaged should be treated as garbage and should be scrapped if any of the following damages (edge, cut, brake, tear, wear and dirt) are visible:

- Cut damages on the surface of more than 10% of the width.
- If chemicals or high heat have created damages.
- The seams show damages or the thread is cut on several places.
- If there is a knot on the webbing which cannot be untied.
- The webbing is dirty (cannot determine the colour of the web) and generally torn (fibres all over the surface being napped).
- Widespread friction damages.
- Not readable or missing label/marking with stated MBL alternatively MSL.
- Swollen to such extent that use is difficult.

Below different types of web lashing damages are described along with examples showing the maximum allowed level of damage per type:

Type of damage	Examples showing maximum allowed damage:
Edge damage Cut of fibres on the side of the webbing.	
Cut damage Cut mainly of longitudinal fibres on the surface.	
Brake damage Compression of the webbing by high pressure.	

Tear damage Damage of transverse fibres	
Wear damage Damages caused by friction.	
Dirt level Original colour not clearly visible.	

If deformations on the tensioner itself or the hooks are noted, the equipment must be discarded or the deformed parts must be replaced.

Chain lashings

If chain equipment has any of the following damages it shall not be used:

- links that has elongated more than 3 % of its original length
- links whose diameter has decreased by about 10 % of the original dimension
- links that are bent or have become deformed by sharp edges. However, if these links can be replaced, the remaining part of the chain can be retained.

Tension levers, turnbuckles and other tensioning devices for chains should be discarded if there are cracks in the material, if parts are missing or if they are abnormally worn.

Example of damaged chain link that means that the chain cannot be used

Appendix 6 – Provisions for lashing points according to EN 12640

The European standard, EN 12640, contains minimum requirements and testing of lashing points on vehicles.

According to the standard, the lashing point pairs shall be arranged in such a way that:

- the lashing point pairs are distributed evenly along the length of the CTU;
- the distance between two adjacent lashing points is not greater than 1000 mm;
- in the area above the axles, the distance between two adjacent lashing points is as close to 1 000 mm as practicable but in any case, is not greater than 1200 mm;
- the distance from front or rear end wall is not greater than 500mm.

The front wall should be equipped with at least two single lashing points or a multi point lashing system mounted symmetrically to the vehicle centre line.

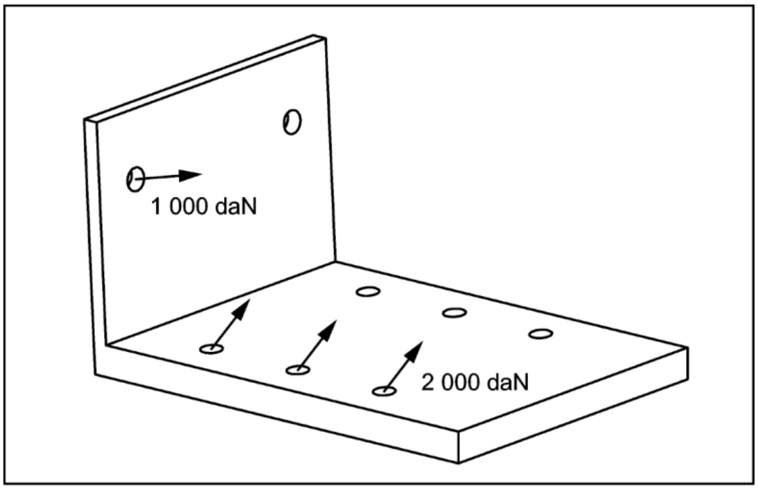
For vehicles with a total weight of over 12 tonnes, the lashing points must be designed for a lashing capacity of 2,000 kg.

The number of lashing point pairs *n* shall be determined by the highest result of the following:

- loading length in meters divided by 0.85;
- the payload in daN multiplied by 0.75 divided by LC in daN.

The number of lashing point pairs *n* shall be rounded down to next integer but not less than 2.

According to the standard, lashing points shall be fitted with one or more marking labels in accordance with the figure below in a clearly visible place. The LC in daN and the operational angles related to the corresponding lashing point shall be indicated on the label. The label shall have a blue background, white lettering and white border and a minimum size of 150 mm × 100 mm.



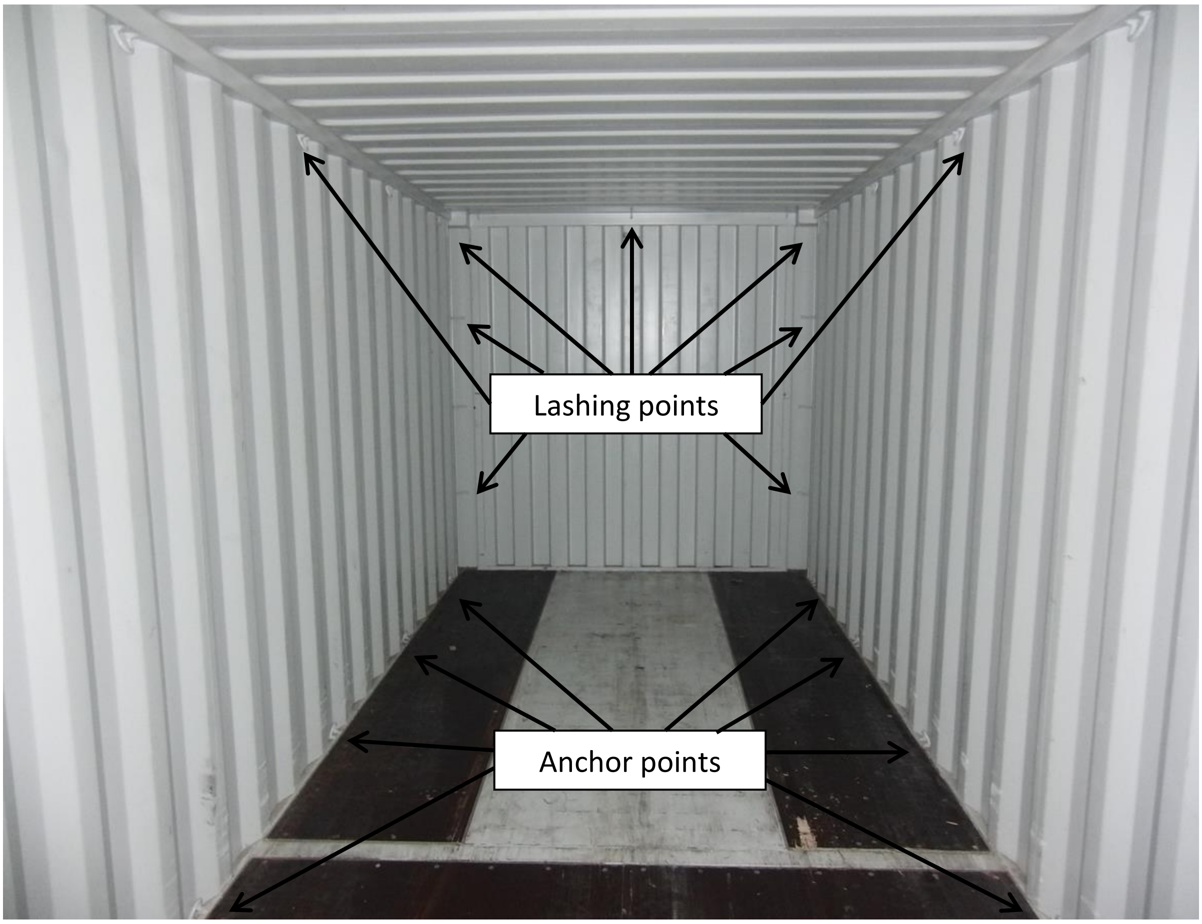
Example for label

Appendix 7 – Strength in container lashing fittings

For general purpose containers, cargo securing fittings are optional. However, when fitted, they shall comply with the requirements of Annex F of the container standard ISO 1496-1. This standard makes a separation between two types of fittings:

- **Anchor points** – Securing devices located in the base structure
- **Lashing points** – Securing devices located in any other part of the container

Each anchor point shall provide a minimum rated load of 1 000 kg in any direction.
Each lashing point shall provide a minimum rated load of 500 kg in any direction.



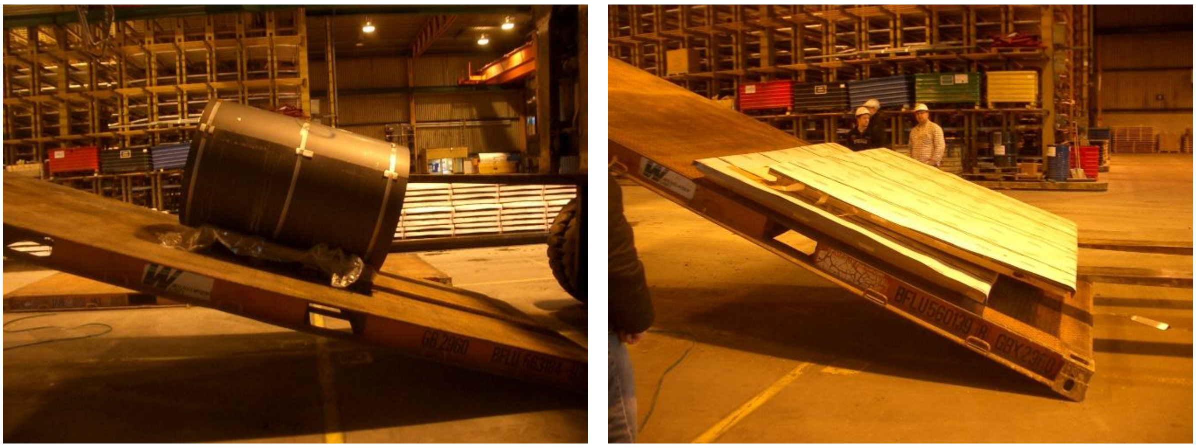
The typical number of anchor points according to ISO 1496-1 is:

- In 40 ft containers – 16
- In 20 ft containers – 10

The typical number of lashing points according to ISO 1496-1 is unspecified.

Appendix 8 – Practical tests

The transport stability of packages, the friction between surfaces and the efficiency of cargo securing arrangement can be tested with practical tests. The most common and simple method is to perform inclination tests, see photo examples of tests performed for Outokumpu.



Friction tests performed in Avesta, Sweden

Practical cargo securing arrangement tests and tests of bedding carried out in Avesta, Sweden

Appendix 9 – Blocking and bedding arrangement by timber

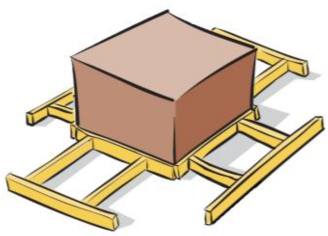
Blocking

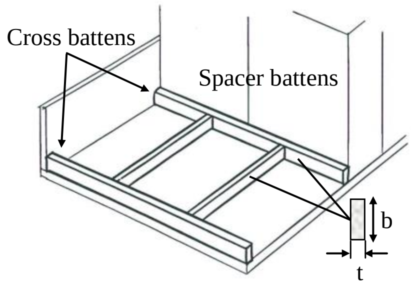
Due to the limited strength in container lashing fittings, see Appendix 7, they cannot be used for securing of heavy cargo.

Thus, heavy cargo has to be blocked to the framework of the container. And, when it comes to heavy cargo any void space should be avoided.

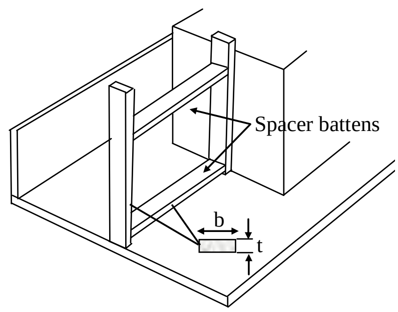
To prevent sliding the cargo may be bottom blocked by H-frames according to the principle in the figure to the left below.

The total compressive force, P, in tonnes of the blocking timber is derived from the following table. If the spacer battens are nailed to the platform and buckling is avoided, the blocking strength can always be taken from the column for L = 0.5.





Laying double H-frame



Standing double H-frame

Timber cross section t × b mm	Compressive force *P* (tonnes) of blocking for 2 spacer battens with varying lengths *L*					
	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m	3.0 m
25 × 50	2.6					
25 × 75	4.0					
50 × 50	7.5	5.3	3.0	1.7		
50 × 75	11.3	7.9	4.6	2.6	1.7	
50 × 100	15.1	10.6	6.1	3.4	2.2	
50 × 150	22.6	15.9	9.1	5.1	3.3	2.3
75 × 75	18.6	15.3	11.9	8.5	5.6	3.9
75 × 100	24.8	20.3	15.9	11.4	7.4	5.1
75 × 150		30.5	23.8	17.1	11.1	7.7
75 × 200			31.7	22.7	14.8	10.3
100 × 100		30.1	25.6	21.2	16.7	12.2
125 × 125					33.4	27.4

The compressive force *P* in above table is valid for two spacer battens. If three spacer battens are used instead of two the compressive force will increase the compressive force with 40 %, i.e. the values in above table will increase with a factor 1.4.

Required compressive force *P* is calculated according to the following formula:

$$P = m \cdot c_x \cdot g - m \cdot c_z \cdot g \cdot \mu$$

where *m* is the weight of the cargo, c_x the horizontal acceleration in longitudinal direction, *g* the gravity acceleration, c_z the vertical acceleration and μ the friction factor. Below is the weight that is blocked per spacer batten with length L shown for battens used at Outokumpu. At least two spacer battens must be used in cargo securing arrangements.

Timber design t x b mm	Cargo weight (tonnes) blocked per spacer batten with length L					
	0.5 m	1.0 m	1.5 m	2.0 m	2.5 m	3.0 m
50 × 50	7.5	5.3	3.0	1.7		
75 × 75	18.6	15.3	11.9	8.5	5.6	3.9

To prevent sliding the H-frames between the cargo and the container sides can be replaced by dunnage bags or timber filling the entire space.

Accordingly, the best way of securing cargo in containers is to block it against the long sides and gables. Also the doors may be used for blocking but note that the cargo must be prevented from falling out when the doors are opened.

Note that nails are used only to keep battens in place, not to cargo securing.

Bedding

Containers are designed to carry their full payload, including a vertical dynamic acceleration of 1 ± 0.8 g, uniformly distributed over the entire floor area.

The rules of thumb for calculating required distribution of concentrated loads presently in use are based solely on the uniformly distributed payload criteria. Although correct from that perspective, they provide solutions which are clearly not practical and that are not in line with what can be regarded as sufficient based on experience. If other test criteria for strength are also taken under consideration, it is shown that dry containers have a capacity to facilitated cargo weights close to or equal to the payload even if the weight is not uniformly distributed of the entire floor area.

Through practical tests, including those performed in Avesta, Sweden, it has been found that the sides of a container can take up much larger bending moments than what is created by the payload if it is uniformly distributed and thus the technique to distribute concentrated loads in a dry container, designed according to the standard, should be to transfer the load to the sides rather than spreading it out in longitudinal direction.

When nominating the minimum length of concentrated cargoes, the global strength, i.e. bending of the whole container resting on its corner fittings, need not be considered for all practical applications. Only the local strength, i.e. tension in the side walls, should be considered.

Concentrated cargo weights with lesser width than the container should be supported either by longitudinal support beams, thereby transferring the load to a greater part of the flooring structure, or by transverse support beams which transfers the loads to the side structure of the container. The latter is to be regarded as the preferred method.

Regarding the capability of the flooring to distribute forces in the transverse direction, it has been found that the real strength required by the wheel load test is larger than what the uniformly distributed payload requires for typical containers, especially for 40 feet containers. Due to nearly identical design, the same ability to resist bending can be assumed for both 20 and 40 feet containers when designing the required support under the load to distribute it to the container sides.

Principles for placement and dimensioning of bedding beams

Bedding can be done with beams placed in the containers longitudinal direction and this distribute the pressure from the goods on a larger number of cross beams in the container floor.

Alternatively, the bedding can be made with beams placed in the containers transverse direction and which distribute the load to the containers long sides, which in turn bring the load out to the end of the container.

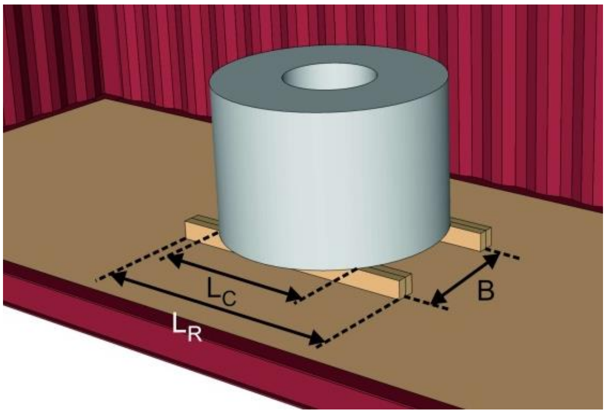
Dimensioning of longitudinal bedding beams

Minimum length

The minimum length L_R of longitudinal bedding beams is determined by:

- Cargo weight: m in tonnes
- Lateral distance between the beams: B in meters

The minimum length of the beams, L_R, is first determined using the following table:



Minimum length for longitudinal beams, L_R (m)					
Breadth between beams B [m]	**Cargo weight m (tonnes)**				
	5	**10**	**15**	**20**	**25**
0.50	1.4	2.7	4.1	5.4	
0.75	1.2	2.3	3.5	4.7	5.8
1.00	1.0	2.0	2.9	3.9	4.9
1.25		1.6	2.4	3.2	3.9
1.50		1.2	1.8	2.4	3.0
1.75			1.2	1.7	3.0

Dimensions of the longitudinal bedding beams

The dimensions of the longitudinal bedding beams are then determined by the following parameters:

- Cargo weight: m in tonnes
- The lateral distance between the beams: B in meters
- Length of bedding beams: L_R in meters
- Loaded length of the beams: L_C in meters

The minimum dimensions of **two square wooden beams** as a function of beam length L_R, loaded length L_C and cargo weight m is shown in the following table:

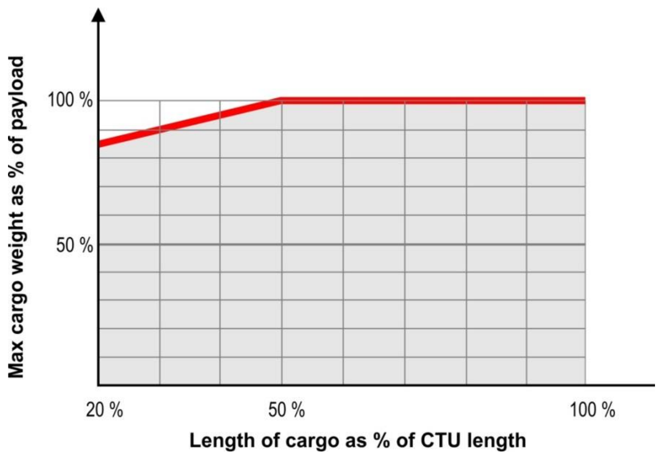
Minimum dimensions for 2 longitudinal beams, h × h (mm)						
Beam length L_R (m)	Loaded length L_C (m)	Cargo weight m (tonnes) 5	10	15	20	25
1.5	0.5	100 × 100	125 × 125	150 × 150	150 × 150	175 × 175
	1.0	100 × 100	125 × 125	125 × 125	150 × 150	150 × 150
2.0	0.5	125 × 125	150 × 150	175 × 175	200 × 200	200 × 200
	1.0	100 × 100	125 × 125	125 × 125	150 × 150	150 × 150
2.5	0.5	150 × 150	175 × 175	200 × 200		
	1.0	100 × 100	150 × 150	150 × 150	175 × 175	200 × 200
	1.5	100 × 100	125 × 125	125 × 125	150 × 150	150 × 150
3.0	1.0	125 × 125	150 × 150	175 × 175	200 × 200	
	1.5	125 × 125	150 × 150	175 × 175	175 × 175	200 × 200
	2.0	100 × 100	125 × 125	150 × 150	175 × 175	175 × 175
3.5	1.0	150 × 150	175 × 175	200 × 200		
	1.5	125 × 125	150 × 150	175 × 175	200 × 200	200 × 200
	2.0	100 × 100	125 × 125	150 × 150	150 × 150	175 × 175
4.0	1.0	150 × 150	200 × 200			
	1.5	125 × 125	175 × 175	200 × 200	200 × 200	
	2.0	125 × 125	150 × 150	175 × 175	175 × 175	200 × 200
5.0	1.0	175 × 175				
	1.5	150 × 150	200 × 200			
	2.0	150 × 150	175 × 175	200 × 200		

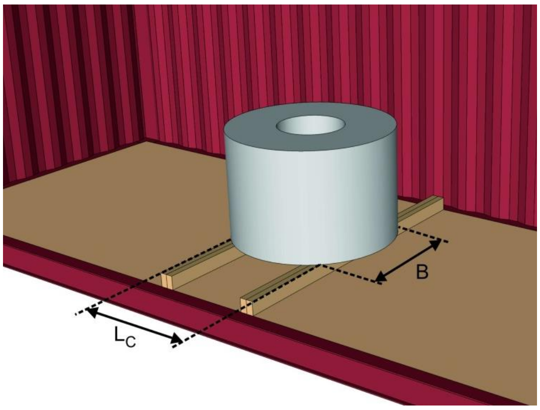
The minimum dimensions of **four square wooden beams** as a function of beam length L_R, loaded length L_C and cargo weight m is shown in the following table:

Minimum dimensions for 4 longitudinal beams, h × h (mm)						
Beam length L_R (m)	Loaded length L_C (m)	Cargo weight m (tonnes) 5	10	15	20	25
1.5	0.5	75 × 75	100 × 100	125 × 125	125 × 125	150 × 150
	1.0	75 × 75	100 × 100	100 × 100	125 × 125	125 × 125
2.0	0.5	100 × 100	125 × 125	150 × 150	150 × 150	150 × 150
	1.0	75 × 75	100 × 100	100 × 100	125 × 125	125 × 125
2.5	0.5	100 × 100	150 × 150	150 × 150	175 × 175	175 × 175
	1.0	100 × 100	100 × 100	125 × 125	150 × 150	150 × 150
	1.5	75 × 75	100 × 100	100 × 100	125 × 125	125 × 125
3.0	1.0	100 × 100	125 × 125	150 × 150	150 × 150	175 × 175
	1.5	100 × 100	125 × 125	125 × 125	150 × 150	150 × 150
	2.0	75 × 75	100 × 100	125 × 125	125 × 125	150 × 150
3.5	1.0	100 × 100	150 × 150	150 × 150	175 × 175	200 × 200
	1.5	100 × 100	125 × 125	150 × 150	150 × 150	150 × 150
	2.0	75 × 75	100 × 100	100 × 100	125 × 125	150 × 150
4.0	1.0	125 × 125	150 × 150	175 × 175	200 × 200	200 × 200
	1.5	100 × 100	125 × 125	150 × 150	175 × 175	175 × 175
	2.0	100 × 100	125 × 125	125 × 125	150 × 150	150 × 150
5.0	1.0	150 × 150	175 × 175	200 × 200		
	1.5	125 × 125	150 × 150	175 × 175	200 × 200	200 × 200
	2.0	100 × 100	150 × 150	150 × 150	175 × 175	8” × 8

Dimensioning of transverse bedding beams

As an alternative to longitudinal bedding, the weight of the goods can be distributed to the strong side structure of the container with transverse beams. These must be placed with a space, L_C, of at least 80 cm or according to the following diagram, based on the weight of the cargo:





For goods that have a weight that corresponds to the maximum weight that the container can load, the side must be loaded over a length that is at least half the length of the container. Required beam dimensions of square transverse beams are determined using the tables below:

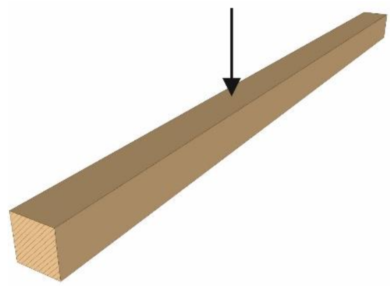
Minimum dimensions for 2 transverse beams, h × h (mm)					
Loaded breadth B (m)	**Cargo weight m (tonnes)**				
	5	**10**	**15**	**20**	**25**
0.50	75 × 75	200 × 200			
0.75	75 × 75	175 × 175			
1.00	75 × 75	150 × 150	200 × 200		
1.25	75 × 75	100 × 100	175 × 175	200 × 200	
1.50	75 × 75	75 × 75	125 × 125	175 × 175	200 × 200
1.75	75 × 75	75 × 75	75 × 75	100 × 100	150 × 150

Minimum dimensions for 3 transverse beams, h × h (mm)					
Loaded breadth B (m)	**Cargo weight m (tonnes)**				
	5	**10**	**15**	**20**	**25**
0.50	75 × 75	125 × 125	200 × 200		
0.75	75 × 75	100 × 100	175 × 175	200 × 200	
1.00	75 × 75	75 × 75	150 × 150	175 × 175	200 × 200
1.25	75 × 75	75 × 75	100 × 100	150 × 150	175 × 175
1.50	75 × 75	75 × 75	75 × 75	100 × 100	150 × 150
1.75	75 × 75	75 × 75	75 × 75	75 × 75	75 × 75

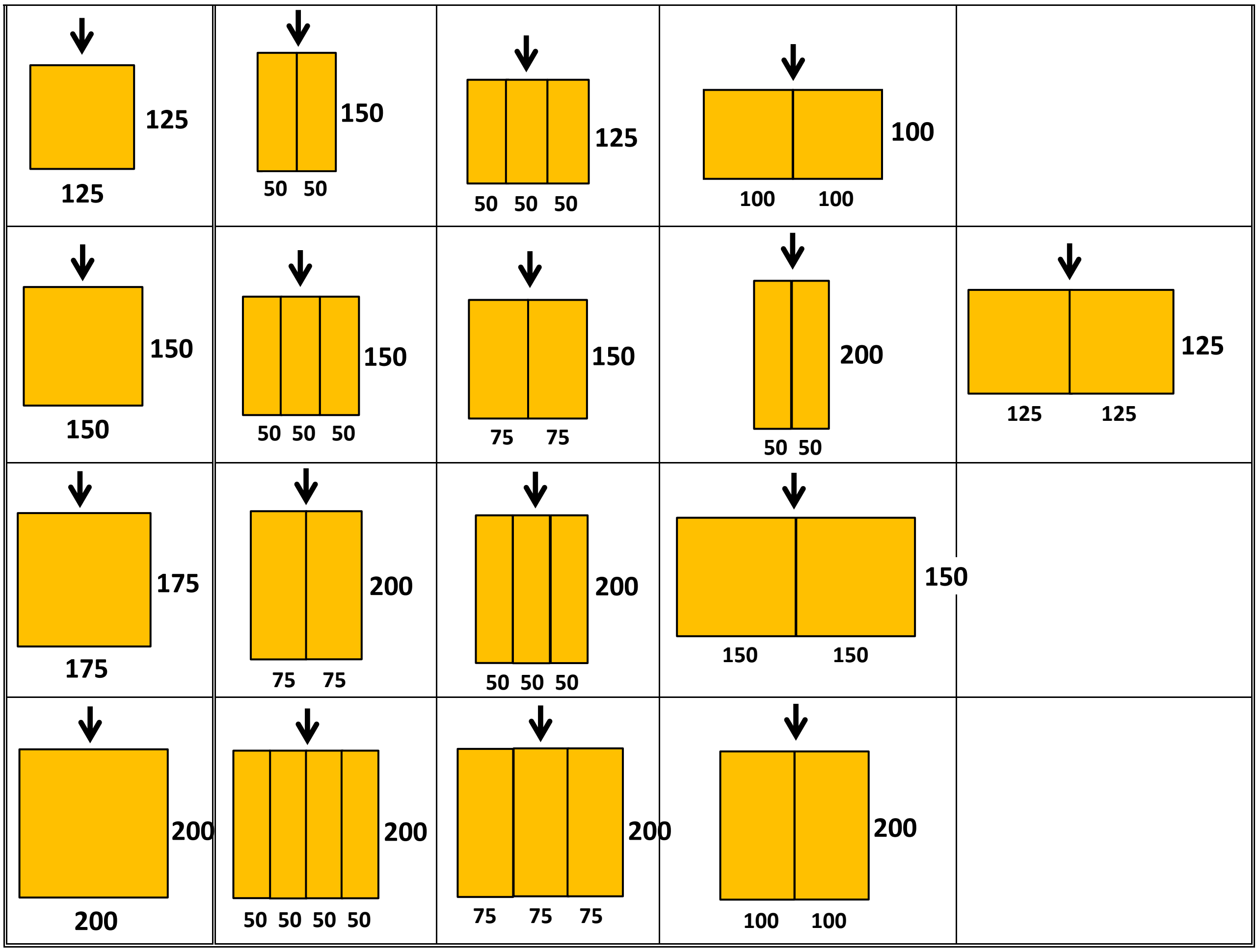
Substitution tables for bedding beams

Downward pressure in the middle of the beam.

The beams in the left column can be substituted for the beams in the right columns if the force to which the beams are subjected is directed downwards as shown to the right.



Downward pressure in the middle of the beam					
Beam dimension	**Can be replaced with the following beams**				
75 75	75 37 37	75 25 25 25	100 37 37	100 50 50	
100 100	100 50 50	125 37 37	100 37 37 37	100 25 25 25 25	


125
125
150
50 50
125
50 50 50
100
100 100
150
150
150
50 50 50
150
75 75
200
50 50
125
125 125
175
175
200
75 75
200
50 50 50
150
150 150
200
200
200
50 50 50 50
200
75 75 75
200
100 100

Appendix 10 – Cargo securing with dunnage bags

Dunnage bags may be used as blocking device in cargo securing arrangements.

Please note that dunnage bags primarily should be placed in the upper part of a section. Dunnage bags should not be on the floor, preferably not against the roof in the cargo transport unit and never be placed directly against container doors. Further, dunnage bags are sensitive to sharp edges and must be protected from these by means of thick cardboard or wooden boards.

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:

$$F_{dunnage\ bag} \geq F_{cargo}$$

The following describes how these forces are calculated and what characteristics and conditions that determine the magnitude of these forces.

Note that this instruction is general and that dunnage bags should be chosen in consultation with the supplier.

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

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

Sliding:

$$F_{cargo} = M \cdot [a_h - \mu \cdot 0.7 \cdot a_v]$$

Tipping:

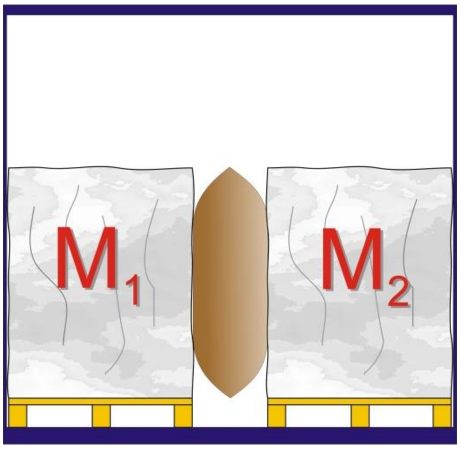
$$F_{cargo} = M \cdot [a_h - B/H \cdot a_v]$$

where F_{cargo} = *The force in tonnes on the dunnage bag caused by the cargo*
M = *Cargo weight in tonnes*
a_h = *Horizontal acceleration, expressed in g, that acts on the cargo sideways or in forward or backward directions*
a_v = *Vertical acceleration that acts on the cargo, expressed in g*
μ = *Static friction for the contact area between the cargo and the surface or between different cargo units*
B = *Width of the cargo stack for tipping sideways, or alternatively the length of the cargo for tipping forward or backward*
H = *Height of the cargo stack*

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

It is the cargo weight only that actually impacts the dunnage bag that shall to be used in the above formulas. The movement forward, when breaking for example, the weight of the cargo behind the dunnage bag is to be used in the formulas.

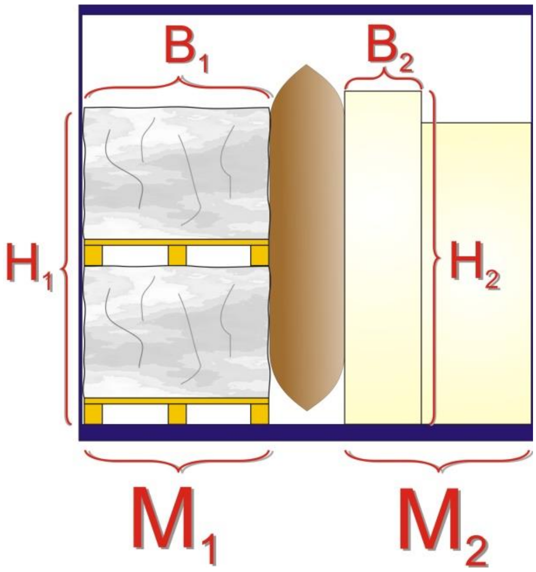
If the dunnage bag instead is used to prevent movement sideways, the largest total weight of the cargo that either is on the right or left side of the dunnage bag is to be used, that is, either the weight M1 **or** M2, see the illustration to the right.



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

If the cargo unit 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 have the meest value of B/H is chosen.

However, in both cases the total weight of the cargo that is on the same side of the dunnage bag is to be used, that is, either the weight M1 **or** M2 in the sketch to the right.



Permissible load on the dunnage bag ($F_{dunnage\ bag}$)

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:

$$F_{dunnage\ bag} = A \cdot 10 \cdot P_B \cdot SF$$

where $F_{dunnage\ bag}$ = *The force in tonnes that the dunnage bag is able to take up without exceeding the maximum allowable pressure*

P_B = *Bursting pressure of the dunnage bag in bar*

A = *Contact area between the dunnage bag and the cargo in m^2*

SF = *Safety factor:*

0.75 for single use dunnage bags

0.5 for reusable dunnage bags

Contact area (A)

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

$$A = (b - \pi \cdot d/2) \cdot (h - \pi \cdot d/2)$$

where b = *Width of the dunnage bag in m*
h = *Height of the dunnage bag in m*
d = *The gap that the bag is filling*
π = *3.14*

Pressure in the dunnage bag

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 come loose if the ambient pressure is rising or if the air temperature drops. Inversely, if the filling pressure is too high there is a risk of the dunnage bag to burst or to damage the cargo if the ambient pressure decreases, or if the air temperature rises.

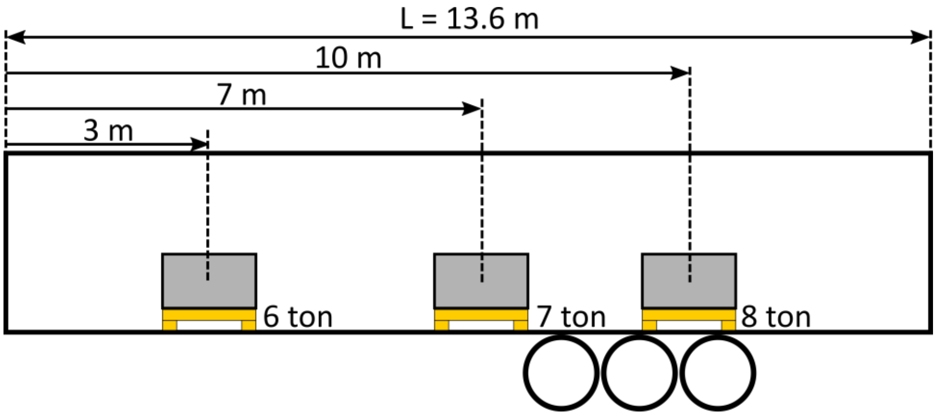
The **bursting pressure (P_B)** of a dunnage bag depends on the quality, size and the gap that the bag is filling. The pressure that the dunnage bag is experiencing as a result of forces acting from the cargo may never come close to bursting pressure as the bag is in danger of bursting and thus a safety factor of 2 against bursting shall be used.

Appendix 11 – Examples of calculation of the centre of gravity

Example 1 – 13.6 m 3-axle semitrailer

A 13.6 m 3-axle semitrailer is loaded with three coils as shown below.

The centre of gravity of the three coils loaded on the semitrailer, measured from the headboard to the left, is calculated by summing the weight of each coil and its centre of gravity distance from the headboard and this sum is divided by the entire load weight on the semitrailer.



Calculation of the centre of gravity of the load

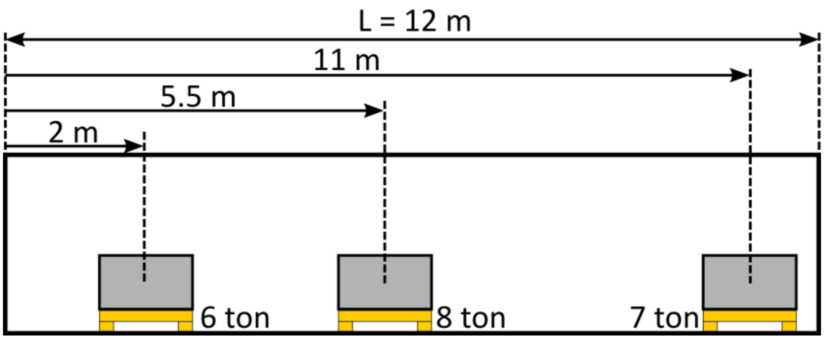
With the values in the example this will be:

$$\frac{(6 \times 3) + (7 \times 7) + (8 \times 10)}{6 + 7 + 8} = 7\ m$$

The centre of gravity of the loaded semitrailer is therefore 7 m from the headboard, which is acceptable according to the typical load distribution diagram for a 13.6 m 3-axle semitrailer, see section 7.1.

Example 2 – 40 ft container

A 40 ft container is loaded with three packages as shown below. The loading may result in an uneven distribution of the load in the container. Can this uneven load be accepted?



Calculation of the current uneven load distribution in a container

In order to calculate the loaded container's centre of gravity position measured from the container end, the products are summed by the weight of each cargo unit and its centre of gravity distance from the container end and this sum is divided by the entire load weight in the container.

With the values in the example this will be:

$$\frac{(6 \times 2) + (8 \times 5.5) + (7 \times 11)}{6 + 8 + 7} = 6.33\ m$$

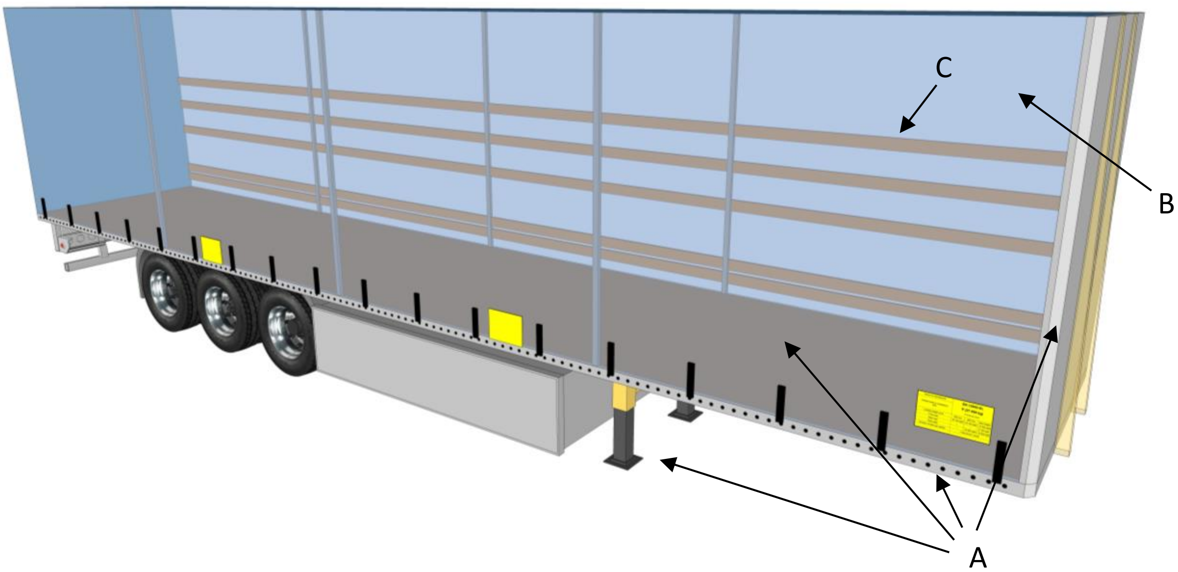
The centre of gravity of the loaded container is therefore 6.33 m from the container end.

If the length of the container is 12 m, the centre is 6 m from the container end.

The centre of gravity of the three packages is thus 6.33 - 6 = 0.33 m from the centre, which is less than the maximum allowed centre of gravity deviation, which is 0.60 m for a 40 ft container.

Conclusion: The uneven distribution of load can be accepted!

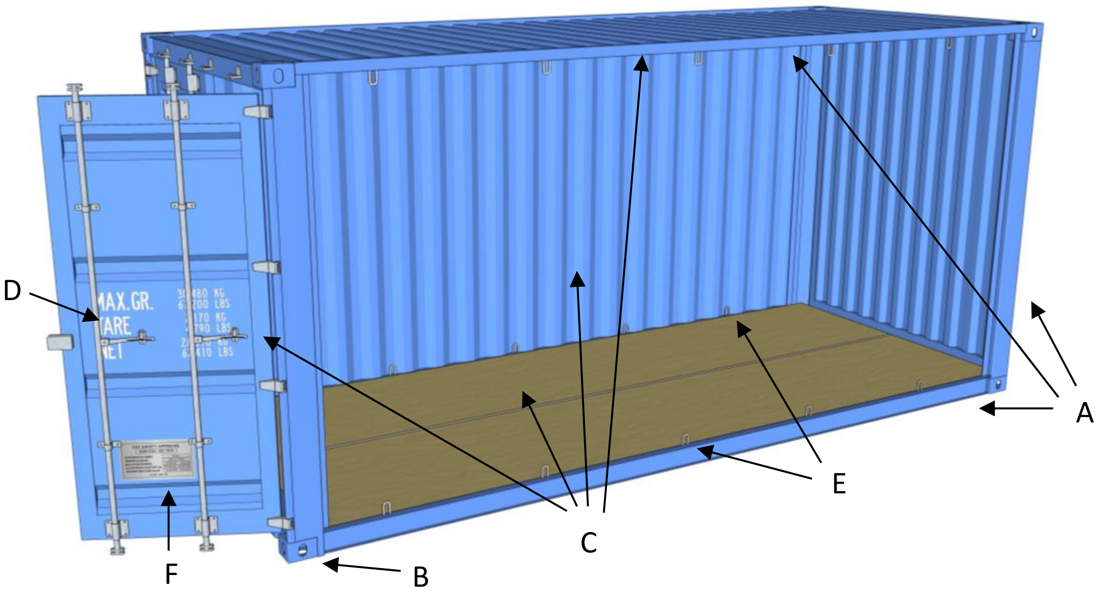
Appendix 12 – Checklist for inspection of trailers



Checklist trailers and swap bodies		Yes	No	Comments
1	Are the platform, landing legs, the head board, alongside and crossways beams undamaged? (A)			
2	Are sideboards, cover laths, canopy, canopy seal and possible centre and side stanchions undamaged and complete? (B and C)			
3	Is the CTU weatherproof?			
4	Is the cargo area undamaged?			
5	Is the cargo area clean, dry and free from residue and odour?			
6	Does the CTU have functioning and undamaged cargo securing equipment?			
7	Is the CTU equipped with unbroken internal lashing points for securing of cargo?			
8	Does the CTU have enough numbers of unbroken external lashing points?			
9	Are the corner castings on the swap body undamaged?			
10	Are there pockets for dangerous goods labels? Are non-actual labels removed or masked?			
Extra checkpoints for transport by railway				
11	Is there a UIC code number plate?			
12	Are the TIR-line and the sealing line correctly applied?			
13	Does the lock for the landing legs function and is the canopy unsplit?			

Date ______________ **Number of CTU** _____________ **Sign** ______________

Appendix 13 – Checklist for inspection of containers



	Checklist containers	Yes	No	Comments
1	Is the framework undamaged? (A)			
2	Are the corner castings undamaged? (B)			
3	Are the walls, floor, roof, doors, door sealing's and possible canopy and canopy seal undamaged? (C)			
4	Is the CTU weatherproof?			
5	Are the doors possible to close and are the packing's unbroken and soft? (D)			
6	Is the cargo area undamaged?			
7	Is the cargo area clean, dry and free from residue and odour from previous cargoes?			
8	Are the ventilation devices open and undamaged?			
9	Is the CTU equipped with undamaged and functioning lashing points? (E)			
10	Is the container marked with a safety approved plate, CSC? (F)			
11	Are non-actual labels removed and marked?			

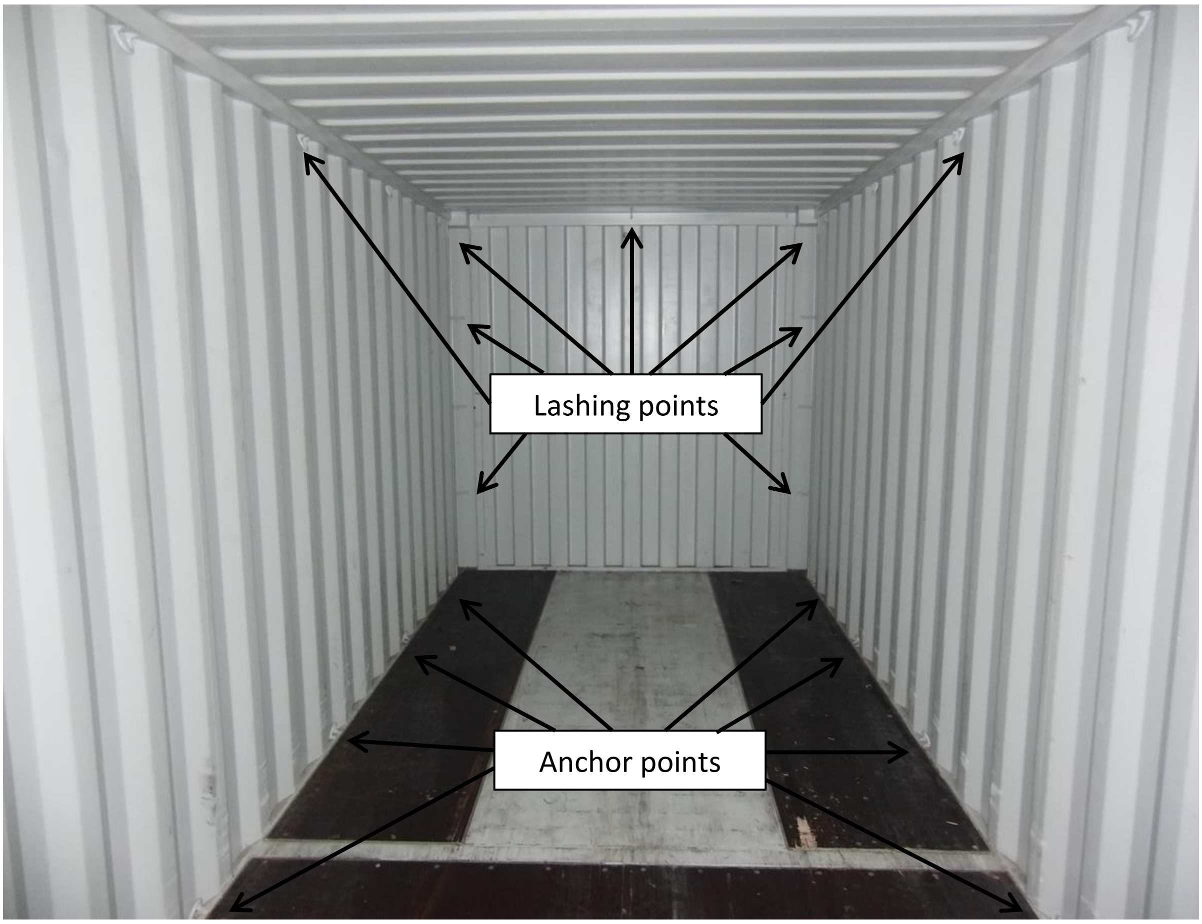
Date _______________ **Number of CTU** _______________ **Sign** _______________

Appendix 14 – Strength in container lashing fittings

For general purpose containers, cargo securing fittings are optional. However, when fitted, they shall comply with the requirements of Annex F of the container standard ISO 1496-1. This standard makes a separation between two types of fittings:

- **Anchor points** – Securing devices located in the base structure
- **Lashing points** – Securing devices located in any other part of the container

Each anchor point shall provide a minimum rated load of 1 000 kg in any direction.
Each lashing point shall provide a minimum rated load of 500 kg in any direction



The typical number of anchor points according to ISO 1496-1 is:

- In 40 ft containers – 16
- In 20 ft containers – 10

The typical number of lashing points according to ISO 1496-1 is unspecified.

Appendix 15 – Quick Lashing Guide

The three UN agencies IMO (International Maritime Organization), ILO (International Labor Organization) and UN ECE (Economic Commission for Europe) have developed the IMO/ILO/UNECE Code of Practice for Packing of Cargo Transport Units (CTU Code) for cargo securing inside CTUs. As part of the informative material of the Code, there are Quick Lashing Guides, applicable to different sea areas as well as road and combined rail transports, available through the link below.

https://en.mariterm.se/wp-content/uploads/2016/09/CTU-Code-Quick-Lashing-Guide-dec-2014.pdf

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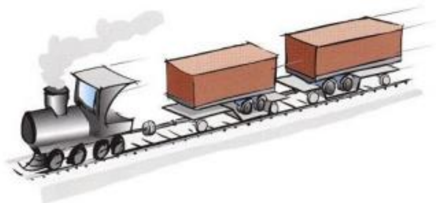
INFORMATIVE MATERIAL 5

QUICK LASHING GUIDE

Cargo securing on CTUs for transports on Road, Combined Rail and in Sea Area A, B & C



SEA AREAS

A	B	C
$H_s \le 8$ m	8 m < $H_s \le 12$ m	$H_s > 12$ 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

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