

CONTAINER HANDBOOK



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Preface

The global economy depends on the smooth exchange of goods. Any damage results in a waste of resources. Loss prevention measures are not only economically necessary but also directly protect the environment.

Surveys of transport practice have revealed that almost seventy percent of all packed containers, swap-bodies, road and rail vehicles or other cargo transport units exhibit shortcomings in packing and load securing which could result in damage. The aim of this section of the Container Handbook, "Securing the product in the container", is to prevent damage due to negligent packing and inadequate load securing.

The author's original intention was to present mainly good examples of packing and to complement these some bad examples as a deterrent. However, the real situation was so bad that he was unfortunately compelled to write the Handbook in such a way that lessons could be learnt from the load securing errors which had been made. Detailed comments are provided as to how these errors could be remedied or avoided. The author very deeply regrets the fact that so very few properly secured container loads could be found in practice which could serve as good examples for a Handbook.

Even a Handbook which has been edited and updated over many years cannot take account of all the variants encountered in practice, and the present Handbook itself cannot make any claim to completeness, being less than comprehensive or perfect in many parts. Nevertheless, it is being made publicly available in its present form in the hope that it will make at least some contribution to preventing damage and loss. The author hopes that it will be possible gradually to update this Handbook so that it will become a useful source of advice to anyone responsible for packing and securing cargo transport units.

Comments

Quotations from laws, regulations and other rules were valid at the time when the text was written. One or another regulation may have been rescinded, supplemented or amended since then. Please bear this in mind appropriately.

1 Introduction

1.1 The history of the container In May 2001, Malcolm P. McLean, the "Father of Containerization", died aged eighty-seven. He used to say that he had the idea of rationalizing goods transport by avoiding the constant loading and unloading from one means of transport to another way back at the end of the 1930s at the port of Hoboken, when still operating as a small-scale hauler. To start with, McLean would load complete trucks onto ships, in order to transport them as close as possible to their destination. The development of standardized containers and trailers, moved by tractors, made it possible to ship just the trailers with the containers, so saving on space and costs. Later, the trailers were also left behind and the ships transported just the containers.

Shipowners were more than a little skeptical about McLean's idea. This prompted him to become a shipowner himself and he appropriately named his company Sea-Land Inc. At the end of the 1990s, McLean sold his company to the Maersk shipping company, but his company name lives on in the name Maersk Sealand.

In the literature, the "Ideal X" is mentioned as the first container freighter. This ship left Newark on 26th April 1956 carrying fifty-eight containers, which it transported to Houston. The first ship designed to carry only containers is the "Maxton", a converted tanker, which could carry sixty containers as deck cargo. That was in 1956.

Another decade passed before the first container ship moored in Europe. The first container on German soil was set down by the "Fairland" at Bremer Überseehafen on 6th May 1966. The first containers used by SeaLand in Northern Europe were 35' ASA containers, i.e. they were constructed to American standards. In other regions, 27' ASA containers and other ASA dimensions were often used. Shipowners in Europe and Japan quickly recognized the advantages of the container and also invested in the new transport technology.

Since American standards could only be applied with difficulty to conditions in Europe and other countries, an agreement was eventually reached with the Americans after painstaking negotiations. The resulting ISO standards provided for lengths of 10', 20', 30' and 40'. The width was fixed at 8' and the height at 8' and 8' 6". For land transport within Europe, agreement was reached on a 2.50 m wide inland container, which is mainly used in combined road/rail transport operations.

The majority of containers used worldwide today comply with the ISO standard, with 20'- and 40'-long containers predominating. For some years, the ISO standard has come repeatedly under pressure. As stowage factors increase for most goods, many forwarders want longer, wider and higher containers, preferably all at once. Some shipowners have given in to the pressure and containers of dimensions larger than provided for by the ISO standard are now encountered distinctly more frequently. "Jumbo" containers of 45' and 48' in length, widths of 8'6" (2.60 m) and heights of 9'6" (2.90 m) have been in existence for some years. Efforts to build even larger containers, e.g. 24' (7.43 m) and 49' (14.40 m) boxes 2.60 m wide and 2.90 m high, are mostly confined to the USA. Even 53' long containers have been approved for use for some time throughout the USA, while some states will even allow 57'. In Europe and on other continents, narrower roads are a limiting factor. Developing countries are understandably against changing the standards. More details are given in the section entitled "Container dimensions and weights".



1.2 Container flows The huge investments made in containerization have paid off and container traffic is still continuing to grow. Although growth will not be as unbridled as in the past, it will continue until all conventional transport operations have, within a container's limits of capacity and weight, been containerized.

By then, it is estimated that there will be some 8000 ships in operation with a total slot capacity of nine to ten million standard containers. There will be approximately the same number of containers ashore being packed or unpacked, awaiting stuffing or unstuffing or being transferred. The majority of these containers are standard 20' box containers. While there are special containers for many applications, growth rates for these are not significant.

From the standpoint of container traffic, it would be ideal for there to be a balance between incoming and outgoing containers in a particular region, not only in terms of numbers, but also in terms of container type and weight. Unfortunately, such a balance is not achievable. There will thus always be empty containers to be transported in one direction or another. From the shipping company's standpoint, general purpose containers usable in any circumstances would be a major advantage. Forwarders, on the other hand, would prefer special containers if they could be carried at identical cost, as packing and securing is much easier in a special container than in a standard container.

For example, steel sheet in coils can very quickly be loaded onto coil containers and straightforwardly secured. They are rather more difficult to pack and secure on flatracks, while they are particularly difficult to pack and secure in box containers. Shipowners accepting containers loaded with coils for transport to Colombia would, if the rolls of sheet steel were shipped in coil containers, also have to take a large number of empty standard ventilated containers to Colombia in order to transport coffee from Colombia to Europe. Moreover, the coil containers, which are of no further use in Colombia, would have to be transported

empty to somewhere where they could be used again. As a result, steel sheet in coils will be transported to Colombia in "coffee containers" which are less suitable for carrying such cargoes.

Another example: in order to save on the higher freight costs associated with using tank containers, flexitanks are placed inside normal standard box containers, the walls of which are frequently damaged by surging of the liquid in the flexitanks.

A further example: containers exported from Europe to East Asia are, on average, heavier than those imported from East Asia. If it is to be possible to export the bulkier cargoes from East Asia, empty containers will have to be transported to East Asia. If many 40' containers are required to carry "light" cargoes from East Asia to Europe, it is sensible also to use these containers in Europe to carry "heavy" cargoes to East Asia. Users of these containers get plenty of transport space, the volume of which is not actually required, plus a "securing problem" because such containers cannot be tightly packed.

The majority of the world's container stocks are owned by shipping companies. Quite a few are, however, leased in both large and small numbers to shipowners or other interested parties by leasing companies. Some forwarders ship goods in their own containers, but these are generally special containers for bulk cargoes, tank containers for chemicals or beverages or coil containers for the steel industry etc.

1.3.1.1 Container-carrying vessels, part 1

Preface

Anyone using containers for maritime transport should have at least some kind of idea of what kinds of vessels are used for this purpose. When people who are not shipping professionals read press articles about gigantic new container ships, they find it hard to imagine that such ships could experience problems at sea. It is very often also forgotten that even containers which have been carried for the vast majority of their voyage on ultra-modern ships will have to be carried for the remainder of their voyage, quite possibly highly adventurously, on very different kinds of ships. This section of the Container Handbook is thus intended to provide a brief overview of the different kinds of ships which may be used to carry containers. Reference should be made to the appropriate specialist literature if detailed information is wanted or required.

Ships - general

Ships may be distinguished on the basis of various different criteria.For example, by

- type of propulsion;
- region of service;
- function;
- tonnage or measurement;
- arrangement of decks or superstructures etc.

Type of propulsion will not be a major concern for most maritime shipping customers. In most cases, users will assume that the goods will be carried by motor or turbine ships. The following and similar abbreviations are often found in the shipping documents prefixing the ship's designation: MS = motor ship; TS = turbine ship; CMV = container motor vessel; CTV = container turbine vessel. However, it is still good to know whether containers will be carried onwards with other

vessels, perhaps even sailing ships or open flatboats. This is not uncommon in some parts of the world, for example in the Indonesian archipelago.

Differentiation by region of service is often clear simply from the ship's name. Examples are lakers (for use on the Great Lakes and St. Lawrence Seaway), coasters (for coastal shipping), European inland waterway vessels, ocean-going vessels etc. For shipping professionals, the name is enough to give them a picture of the nature and appearance of the ship and how it accommodates cargo etc.

A ship's function is also generally reflected in its name, for example underwater vehicle, fishing vessel, tugboat, buoy-laying vessel, warship or the like. As their name would suggest, feeder ships, for example, carry goods for onward carriage by other ships.

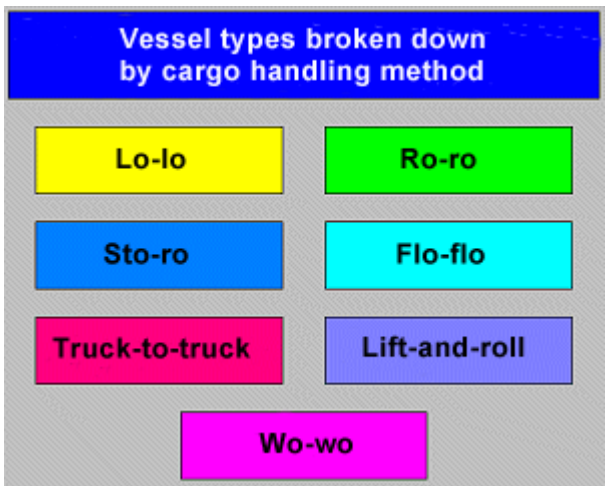
Differentiation by tonnage, measurement, arrangement of superstructures etc. is generally only of interest to the specialist. Laypeople will be largely unconcerned whether goods are being carried on a full scantling, open-deck, shelter-deck or flush-deck vessel, a three-island or any other kind of vessel, although knowing the kind of vessel makes it possible to draw important conclusions about the type of carriage, transport risks, handling stresses etc.

The interested layperson should, however, be aware that gross or net register tonnages are not directly indicative of the size of a vessel, while the more recent terms gross and net tonnage are little more help.

Every shipper or charterer should know the term deadweight, which is the ship's payload in metric tons. And it certainly does no harm to know that the ship's displacement or displacement tonnage is its total weight, i.e. the sum of the weight of the empty, operational ship plus all permitted payload.

This section of the Container Handbook will now outline some essential distinguishing features of those merchant ships which carry containers and comparable "combined transport units". Press articles often refer to the "type of freight" in this connection, but strictly speaking this is incorrect as freight is the amount of money the shipowner or carrier receives for transporting the cargo.

Before taking a closer look at various types of ship, a breakdown by handling method may be helpful:



Breakdown by handling method

Lo/lo stands for lift-on/lift-off The cargo is lifted in and out of the ship (loaded and unloaded) using

on-board lifting gear or loading gear, such as derricks, on-board cranes or gantries, or also on-shore lifting gear. This is the traditional handling method and is used for most ships throughout the world.

Ro/ro stands for roll-on/roll-off, meaning that the cargo is moved on and off the ship on wheels. This is achieved in various different ways. Loaded trucks drive on/off ship under their own power, the driver either traveling with the truck and continuing onward carriage or leaving the truck to continue its journey unaccompanied. In either case door-to-door transport is possible. The truck may travel unaccompanied when driven by a driver under contract. Door-to-door transport is again possible. Trailers or chassis are driven on board with special terminal tractors. Roll trailers are packed at the port of departure, hauled on board with special ro/ro tractors, hauled off at the port of destination and unpacked there. A similar situation applies to cassettes or container bolsters packed in port, which are lifted up with special terminal vehicles and rolled on board and back off again. This method covers all types of ship involved, for example, in ferry traffic. Containers and swap-bodies are here (virtually) exclusively embarked and disembarked on roll trailers, chassis and similar means.

Sto/ro stands for stow and roll. In this case, the cargo is rolled on or off ship using one of the above methods, but is conventionally stowed when on board, usually by means of forklift trucks. This method is not used for container traffic.

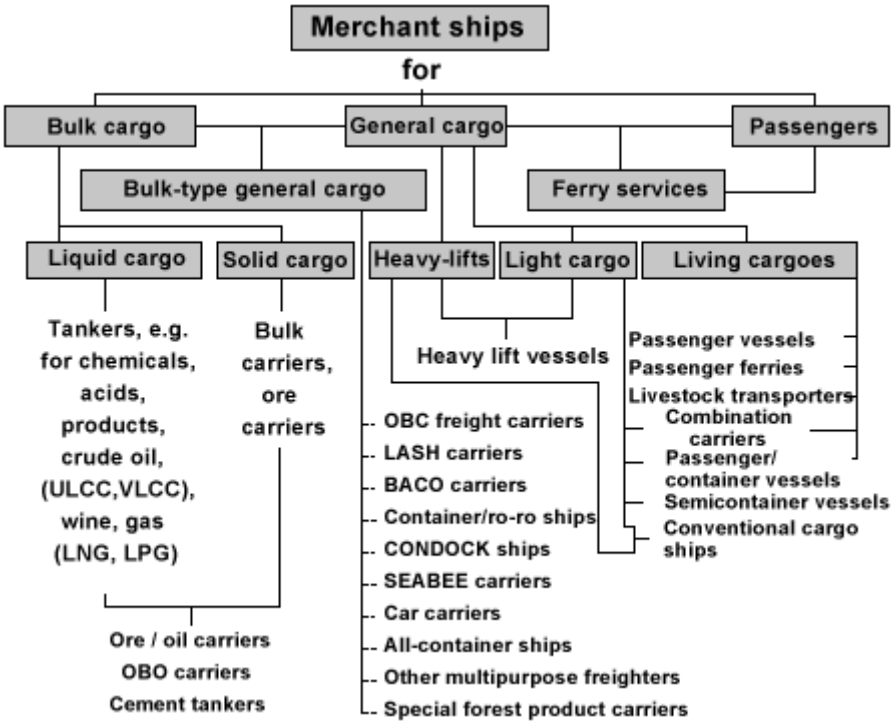
Flo/flo stands for float-on/float-off. Other variants are possible. Floating goods or goods loaded onto floating cargo carriers are floated in and out of dock-like holds in the ship. or Alternatively, the carrier vessel semisubmerges, moves under the cargo, refloats and lifts the cargo into the predetermined stowage space. The cargo is unloaded by performing the process in reverse. This method may be used for container transport if floating cargo carriers, such as barges, have already been loaded with containers.

In the **truck-to-truck** method, the cargo is set down using ground conveyors, such as forklift trucks, onto on-board lifts, raised/lowered to the appropriate loading level, where it is loaded using ground conveyors. Discharge proceeds in the reverse order. This method is not suitable for container traffic.

In the **lift-and-roll** method, the cargo is lifted on board with on-board loading gear or winch platforms and then rolled into place. This method is preferably used with a special type of barge carrier. This method is suitable for container traffic if the containers have previously been loaded onto or into the barges.

Wo/wo or walk-on/walk-off sounds comical, but is in fact the commonest handling method for livestock carriers. The animals walk onto and off the ship or into the containers or CTUs. The same principle applies to all passenger vessels.

A rough classification of ship type by kind of cargo carried could look as follows:



Overview of merchant ship types

The above list is not exhaustive, but does give a relatively good overview of common types of merchant vessel. In many ships, there is some overlap between the various options for carrying goods and the vessels cannot be assigned as strictly to one category or another as the list might suggest. There have always been many different kinds of vessel, but recent years have seen the introduction of many more. There is an unmistakable trend towards multipurpose ships. This makes it difficult to make general statements about what ships look like and how they are equipped.

Ships virtually always exhibit individual differences. Even sister and standard type vessels are not identical in every respect. In terms of naval architecture, there are no problems finding suitable vessels for cargo transport operations. Organizationally, however, it is more difficult to find the correct ship. It may be that certain vessels only serve specific ports or that certain cargoes can only be carried in ships of a particular nationality. One major issue is the increasing lack of skilled crews and stevedores in some parts of the world. In relation to container shipping, ro/ro and ferry traffic, packing and securing in and on cargo transport units is a significant problem. Non-seafarers underestimate the hazards of maritime transport and so for the most part pack and secure cargoes inadequately.

The following paragraphs contain some comments on a selection from the huge range of different ships which may be of interest to container importers and exporters. General cargo ships are only included to the extent that they also carry containers in many regions. For the most part, the many different kinds of vessels will be described only briefly.

At the beginnings of container traffic, most containers were carried on conventional **general cargo vessels**.

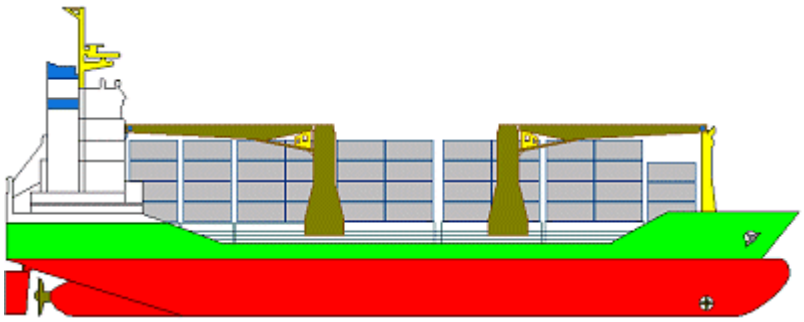


General cargo ship

Such vessels are designed to carry dry cargoes. Each hold comprises one or more relatively low 'tween decks and a lower hold. The ships generally have a relatively large quantity of light cargo handling gear. Virtually every ship is equipped with appropriate loading gear for heavy-lift cargoes in the central hatch area. Lockers are provided for carrying particularly valuable cargoes. Some ships also have relatively small capacity sweet oil tanks.

General cargo ships of this old design are no longer being built, but many are still in use throughout the world. The seakeeping ability of most such vessels at sea, low stowage heights and the like generally mean that carriage is safe and loss-free if individual containers are located in favorable stowage spaces and carefully secured. Further information in this connection is provided in the shipping stresses section.

Modern general cargo ships are built to perform different transport functions; to distinguish them from other multipurpose freighters, they are sometimes known as break-bulk freighters. In addition to the equipment which makes them suitable for carrying break-bulk cargoes, they generally also have facilities to allow them to accommodate containers. Such ships are of open construction, i.e. the hatch area is very large relative to the deck area. This ensures that lifting gear can gain direct access to containers. The same applies to general cargo or access is at least facilitated to such an extent that below deck stowage can (very largely) be avoided. Specific construction features may increase handling efficiency in port and reduce the loss ratio.



Multipurpose container vessel

Semi-container vessels are suitable for carrying both normal general cargo and containers. Hold dimensions, deck loading values, the load-carrying capacity of the loading gear etc. are tailored to the carriage of standard shipping containers. Such vessels have 'tween decks generally with flush-closing mechanical hatch covers.



Semi-container vessel

All-container ships are in principle of open construction as it must be possible to gain direct access to each container with lifting gear such as top spreaders and similar gear. In order to obtain smooth, squared holds, these vessels are often constructed with a double hull. Any holds which are unsuitable for carrying containers are often fitted out as tanks. There are no 'tween decks. All-container ships primarily carry containers and are specially equipped for this purpose.

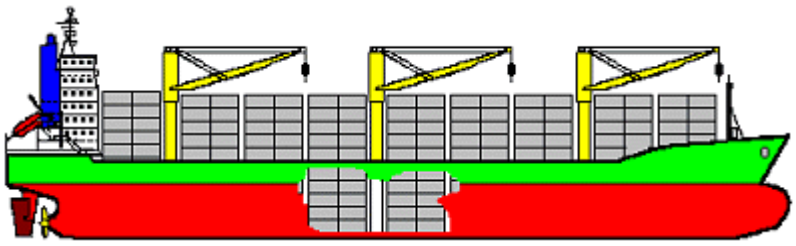
If the ports of the region of service are equipped with sufficiently powerful lifting gear, container ships are generally operated without loading gear. In other regions of service, container ships too need loading gear in the form of derricks, cranes or gantries.

Particular attention must be paid to the hydrodynamic design of container ships which operate at high cruising speeds. The tall, heavy deck loads cause problems with righting capacity. In order to ensure adequate stability, most all-container ships thus have to carry special solid or liquid ballast and/or be broader amidships. The capsize risk of the vessels can be kept within acceptable limits by high values of the roll moment of inertia. Large ballast capacities and high power pumps are absolutely essential, both for trimming the ships and for offsetting longitudinal bending moments. Shipbuilders can tailor characteristics by selecting appropriate ratios between length, beam, molded depth, draft and other dimensions.

The deadweight and hold capacity of container ships may also be stated in metric tons and cubic meters. The number of available slots for 20' or 40' containers, however, is more meaningful. TEU means "Twenty foot Equivalent Unit", while FEU means "Forty foot Equivalent Unit". More details are given in the section entitled "Container traffic terminology".

All-container ships are divided into generations depending upon their container capacity. Roughly speaking, the generations can be divided as follows:

1st Generation	**up to**	**1,000 TEU**
2nd Generation	**up to**	**2,000 TEU**
3rd Generation	**up to**	**3,000 TEU**
4th Generation	**more than**	**3,000 TEU**
5th Generation	**more than**	**6,000 TEU**
6th Generation	**more than**	**8,000 TEU**



Second generation container ship

This Figure shows a second generation container ship. This is a Bremer Vulkan standard vessel which was built in various sizes over several generations. (BV 1000, BV 1600, BV 1800, BV 1800 S, BV 1900 and BV 2200, 2200 OH and BV 3800). The variant shown has on-board lifting gear.



Third generation container ship

CTV "Bremen Express" is a third generation vessel and has a container capacity of 2,950 TEU, while CMV "Frankfurt Express", which was built in 1981, has a capacity of more than 3,400 TEU.



Fourth generation container ship

One of the first fourth generation vessels, which have slots for more than 4,000 TEU, was put into service by American President Lines.

Hapag-Lloyd's Hannover Express class container ships, which were put into service in 1992, are similar to the American President Line vessels and were designed as Panamax ships. Technical data:

Class: GL + 100 A 4 E + MC AUT "container ship"

Length overall	294.00	m
Length between perpendiculars	281.60	m
Molded beam	32.25	m
Depth to main deck	21.40	m
Design draft	12.00	m

Maximum draft	13.52	m
Deadweight, 12.00 m draft	52,600	metric tons
Deadweight, 13.52 m draft	64,500	metric tons
Cruising speed	23	kn
Cruising range	24,000	sm
Fuel consumption at 12 m draft and 23 kn	138	metric tons/day
as above with auxiliary diesel engines	148	metric tons/day
Container capacity on deck	2,125	TEU
Container capacity below deck	2,282	TEU
Total container capacity	4,407	TEU
Reefer connections on deck	348	units
Reefer connections below deck	104	units
Total reefer connections	452	units
Main engine: MAN B&W 9K 90 MC + TCS (Hyundai license)		
Power output at 93 rpm	36,500	kW
Power output at 93 rpm	49,640	HP
Diesel generators, total of 4, of which 2 Daihatsu/Taiyo	2,200	kW
Diesel generators, total of 4, of which 2 Daihatsu/Taiyo	1,650	kW
Emergency diesel generator, one	350	kW
Total diesel generator power output	8,050	kW
Bow thruster, power output	2,500	kW
Bow thruster, thrust	324,000	kN
Heavy oil tank capacity	7,360	m^3
Diesel oil tank capacity	360	m^3
Ballast water tank capacity	16,770	m^3
Fresh water tank capacity	280	m^3

Approx. 48.25% of the containers can thus be carried on deck and approx. 51.75% below deck. A special design makes it possible to carry up to eleven rows of containers below deck and up to thirteen rows on deck up to heights of ten tiers below deck and five tiers on deck. The forebody has twenty-nine bays available, while the afterbody has six. The versatility of the ships is enhanced by the possibility of lowering "flaps" in the guide system so that containers can be stopped at a certain height. Ordinary general cargo can be stowed in the resultant holds. This option is, however, also available in other ships. Hapag-Lloyd was the first to install the system on the "Humboldt-Express". In order, as required by regulations, to be able to transport hazardous cargo containers of certain classes below deck, five holds are specially fitted out for this purpose. Better segregation also

makes it possible to increase the dangerous goods capacity in general relative to other ships.

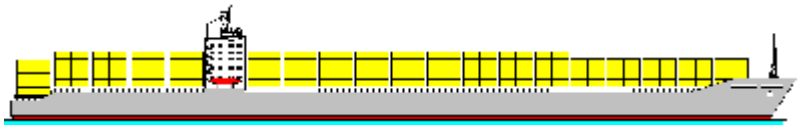
There is a huge variety of different container ships in operation, as is shown, for example, by the ten new container vessels built in 1998 in Japan for the United Arab Shipping Company (UASC), Kuwait, each with a slot capacity of 3,802 TEU, 2,068 TEU of which, or 54.4% of the containers, can be carried in the hold.

Vessel characteristics:

Length overall	276.5	m
Length between perpendiculars	259.9	m
Beam	32.2	m
Molded depth	21.2	m
Design draft	12.5	m
Propulsion	34,348	kW
Speed	24.1	kn

When loading container vessels, the ship's command must comply with the maximum stacking load of the containers. This is especially important with the latest design of "hatchless" container ships. According to ISO minimum requirements, six fully loaded containers can be stacked one on top of the other. However, many containers are designed for a stack height of nine or more full containers.

In 1998, the first container ships with slot capacities of more than 6,000 TEU came into service. Examples are the "Karen Maersk", "Regina Maersk" and the Maersk shipping company's "Sovereign Maersk", which has a stated capacity of 6,600 TEU. With a length of 347 m, a beam of 42.8 m and a design draft of 14.50 m, it may be assumed that this vessel actually has a slot capacity of the order of 8,000 TEU.



Silhouette of a 5th generation container ship



Aftermost container bay on the "Regina Maersk "

In the silhouette, the containers in the aftermost bay are stacked "only" five high, while in the photograph of the Regina Maersk it can be seen that they have been stacked as high as six high on deck. The Møller group shipping company currently known as Maersk-SeaLand is the world's largest container ship operator.

November 2001 saw the launch of what is, to date, Hapag-Lloyd's largest container ship, the "Hamburg-Express". With a length of 320 meters and a beam of 42.8 meters, seventeen containers can be stowed side by side across a single bay. Molded depth is 24.5 meters, which means that containers can be stacked nine high in the hold. When fully laden, the ship has a draft of 14.5 m.

The freighter can carry 7,500 standard containers (TEU) or 100,000 metric tons, a distinct increase over earlier vessels. Propulsion is provided by a 68,640 kilowatt marine diesel engine, corresponding to approx. 93,000 horsepower, which is capable of propelling these giant container vessels at a cruising speed in excess of 25 knots. Three further vessels in this series are to be delivered by spring 2003.

2002 itself saw the launch of what are to date the world's largest container ships of approx. 8,000 TEU.

Container ships of the future with lengths of approx. 400 m and a capacity of approx. 12,000-14,000 TEU are no longer purely in the realms of fantasy. Future generations of container ships with capacities of more than 15,000 TEU and lengths exceeding 400 m are already on the drawing board. These colossi will probably have beams of 64 m, and will require drafts of approx. 18 - 21 m. Such vessels would not at present be able to call at any European ports.

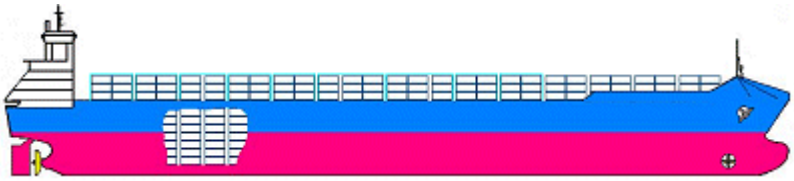
It remains to be seen whether such vessels can be operated economically. It is indisputable that transport costs per container or "slot costs" will drop in line with "economies of scale". A fundamental requirement for still larger ships is regular and continual growth in cargo volumes to be carried on the relevant routes. Such growth is also anticipated in coming years. However, it should not be forgotten that operating risks increase hand in hand with vessel size. Such still larger ships will have longer container handling times. In order to cut operating costs, the still larger vessels will have to lengthen their sailing intervals, i.e. they will call into fewer ports than the smaller vessels. As a result, more containers will have to be transported in precarriage and onward carriage operations to and from the ports which they do serve. Many other factors will also have to be taken into account, but these are outside the scope of this Container Handbook.



Delivery of super post Panamax gantries to the Stromkaje at Bremerhaven.

The North Sea Terminal Bremerhaven (NTB), for example, has already adjusted to the dimensions of future vessels. These "super post Panamax" container gantry cranes were installed as long ago as 2000 and are capable of handling vessels with up to twenty-two containers stowed side by side. With raised crane jibs, the gantries are more than 110 meters high and weigh approx. 1,600 metric tons.

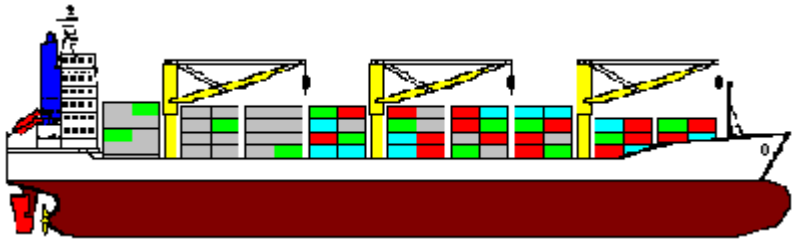
1.3.1.2 Container-carrying vessels, part 2



Hatchless container ship with rain roofs

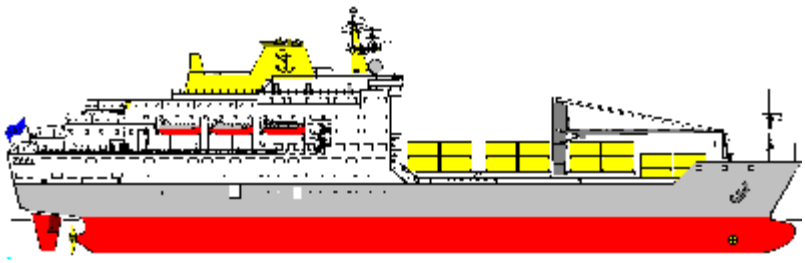
Hatchless container ships first appeared around the beginning of the 1990s. They were intended to make cargo handling more economic. In 1993 and 1994, Howaldstwerke-Deutsche Werft AG (HDW) delivered four hatchless container ships to the Swiss shipping company Norasia Line. These vessels were equipped with an innovative cargo protection system. These 2,780 TEU vessels are a further development of the "ship of the future". Except for holds 1 and 2, which are equipped with pontoon hatch covers to allow the carriage of hazardous materials, these vessels have no hatch covers. Since, on their usual route between Europe and Far East, these vessels are exposed to heavy tropical rain, the shipping company decided to equip holds 3 to 7 with twelve rain protection roofs of lightweight steel construction. Each rain roof rests on the transverse coaming of the container cell guides and is secured by rapid fastenings. The coamings extend in each case up to the highest container which, in some holds, amounts to twelve tiers. Before and after cargo handling, the roofs have to be removed and replaced by on-shore lifting gear. Moreover, the roofs constitute part of the aerodynamic hull shape. Windtunnel testing revealed that the shape of the forecastle deck in conjunction with the rain roofs and the deckhouse will save fuel. The rain roofs protect not only the stowed containers, but the ship as well, as large quantities of rain water in the holds cause stability problems. Other owners of "open top" container ships use high power bilge pumps to combat this

problem.



Reefer container vessel

Reefer container vessel: Reefer container vessel: almost all container ships have separate connections for refrigerated containers. If these connections are present in relatively large numbers and in a certain ratio to the total TEU capacity, this is reflected in the ship's designation.



Container passenger vessel

Container passenger vessels are a relatively recent phenomenon. In certain countries such as China, Indonesia, Russia and others, they are becoming increasingly important in coastal or island traffic.



Feeder ship off the Stromkaje at Bremerhaven

Feeder ships: These ships carry containers between major container terminals and other ports which are not served by the major shipping lines. Most Indian ports, for example, are served by feeder ships from Colombo, while the ports of western Denmark are served from Bremerhaven. The term "feeder ship" provides no indication as to the size of the vessels, nor as to whether they are equipped with on-board lifting gear. Most feeder ships, however, are relatively small or medium-sized vessels.

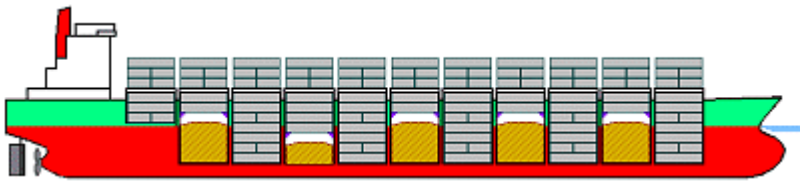
The vessels used in feeder service to and from container ports are often customized, as least when

put in service. For example, a ship built in 1998 for Caribbean container trade has the following data:

Length	90.95	m
Beam	15.40	m
Molded depth	7.35	m
Draft	5.65	m
Deadweight	4,150	tdw
Container capacity	312	TEU
Engine power	3,520	kW
Speed	15	kn
Loading gear: on-board cranes	2	units

Ore Bulk Container carrier: The multipurpose "OBC" freight carriers developed in the former GDR are highly versatile. The abbreviation stands for Ore, Bulk and Container. Double hull construction means that all the internal surfaces of the hold are smooth. Since these vessels are fitted with high capacity on-board electrohydraulic cranes with a long reach, even poorly equipped ports can be served. In one specific class of vessel, alternate holds (I, III and V) are suitably reinforced for carrying ore. Due to their high strength and large hatches without tween decks, these vessels are well suited to carrying rolling mill products and long goods.

A half-height, double-walled longitudinal girder fitted below deck acts as a grain bulkhead. With the exception of hazardous materials and cement, all possible kinds of bulk cargoes may thus be carried. 576 TEU can be stowed in the holds and on deck. There are also thirty-six reefer connections available.



Open bulk container carrier

Open bulk container carriers also have several unusual features which make such vessels highly versatile, even suiting them for container traffic. These bulk carriers are designed like pure container ships, i.e. a very large proportion of the deck area can be opened and the hatch lengths are arranged in a 40 foot grid. Structures delimiting the hold, such as double bottoms, transverse bulkheads and wing bulkheads are designed to withstand the pressure applied by bulk cargoes. Smooth walls and floors are required to allow straightforward loading and unloading with grabs and wheel loaders, which is why the container foundations are recessed in the double bottom and the ISO holes are covered with plastic or steel lids.

In the vessel shown, containers can be stowed up to seven high in the holds. The stacks are secured

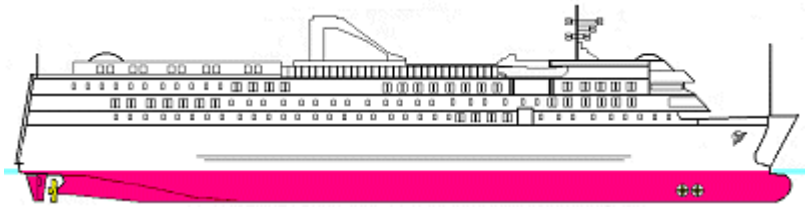
at the bottom by twist locks in the tank deck. Container guides providing lateral restraint are folded out from the bulkheads. In each hold, three blocks are formed using single and double stacking cones, with container guides providing guidance and restraint in two planes, so making it possible to withstand the forces arising when the vessel rolls. Such stacking aids are generally provided between the 3rd and 4th and between the 5th and 6th tiers of containers and are sized in line with the maximum admissible container corner loading of 600 kN. A combination of general cargo and/or bulk cargo plus containers may also be stowed in the holds. This is achieved by folding "container brackets" out from the bulkheads onto which a maximum of four tiers of containers, each applying a load of 300 kN, may be loaded over the bulk cargo or general cargo.

As has already been mentioned, ro/ro stands for **roll-on/roll-off**, i.e. it is a description of how the cargo is handled. The type of cargo being carried is not automatically known as it may comprise any kind of rolling cargo or cargo which has been made rollable. In many cases ro/ro ships also carry other cargoes without this being clear from the vessel's designation.

There is, however, one feature common to all ro/ro ships - they can be loaded via bow, stern or side ports. If the ships have several decks, access is provided by elevators or ramps.

Ferries are equipped to carry both passengers and rolling cargo, which may comprise automobiles, trucks, chassis, trailers or railroad vehicles. In many cases, cargo is carried on "cassettes" which are packed and unpacked in port and transferred on and off the vessel with special tractors. Containers are only loaded or unloaded indirectly using roll trailers or the like. Stern, bow and/or side ports ensure rapid cargo handling. In many types of vessel, a one-way system is used, ensuring "first in first out" traffic flow.

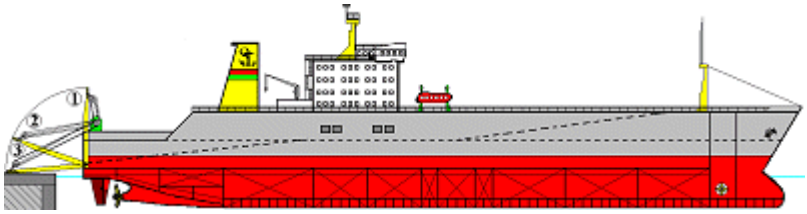
In ferry transport, a distinction is drawn between accompanied vehicles, where the driver drives on board, travels with the vehicle and drives off again, and unaccompanied vehicles. Only auxiliary loading gear is usually present.



Ferry with bow and stern doors

Many passenger/railroad ferries and ferries capable of carrying both railroad vehicles and trailers, chassis or other road vehicles are in service in short-sea ro/ro traffic in the North Sea, Baltic and also Mediterranean.

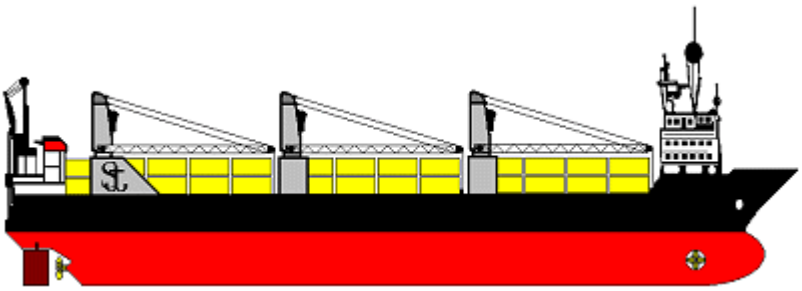
These vessels have bow thrusters to ensure rapid berthing and casting off. Maneuvering is often facilitated by pitch propellers or a multiscrew design of the vessel. Ferries are often symmetrical in structure and may be operated and accessed from either end. Special cargo securing systems are provided, but are often used only in poor weather. Most cargo damage and sinkings are caused by inadequate stowage and securing on the vehicles, as has been shown by many incidents of loss and accidents in recent years.



Container-ro/ro ship

Container-ro/ro ships (conro) carry both containers and rolling cargo. Ro/ro cargoes are mainly loaded below deck, while containers are primarily stowed on deck. In some vessels, e.g. ACL or Polish Ocean Line, special container shafts are provided in the forward third of the ship to accommodate containers below deck. In regions of service with high cargo volumes, container handling is carried out by on-shore gantry cranes. The ships rarely have their own loading gear. The "Finnsailor" is one such ship which carries rolling or rollable cargo below deck and containers, plant, general cargo etc. on deck. However, these facts were not taken into account by the shipyard when determining the ship's designation.

Ro/ro-lo/lo carriers are ships which are capable of loading and stowing cargoes both via ramps using roll-on/roll-off methods and with on-board lifting gear using the lift-on/lift-off method. Such vessels accordingly also have upper deck hatches and, in some cases, holds divided by transverse bulkheads.



Ro/ro-lo/lo Carrier



Ro/ro-lo/lo-container ship

This double hull ship is an example of a **ro/ro-lo/lo-container vessel**. It has a ro/ro component in the form of a stern door. On the port side it has an internal vehicle ramp to provide access to the two 'tween decks. The fitted on-board cranes allow containers to be handled in ports without on-shore lifting gear.

Barge carriers are specialized container transport vessels. Barge carriers are very largely capable of operating independently of ports, they depend on relatively calm areas of water or "floating areas" for transferring the barges. This fact explains the great strategic significance of the system because barges can be set down and picked up at virtually any coast. Barge transport operations are only worthwhile between economic areas which have virtually identical volumes of goods passing in each direction, and in particular where inland waterways lead inland so that good use can be made of the advantages of the floating containers. The high cost of building the ships and the capital expenditure for three sets of barges mean that such systems are not economically viable everywhere. There are various different systems:



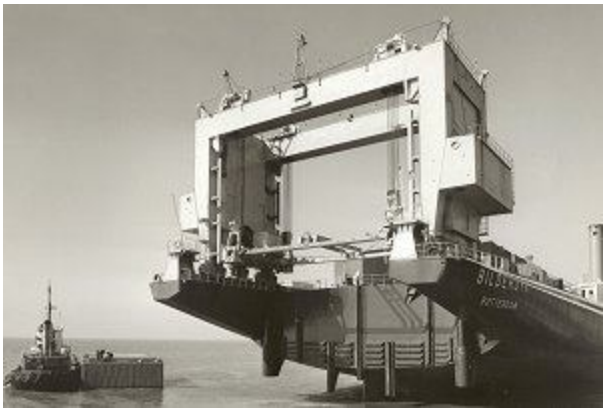
LASH carrier

LASH stands for **L**ighters **A**board **SH**ip. In the LASH system, barges are carried athwartships in holds and on deck. The barges are picked up and set down at the stern by the LASH's on-board gantry crane using spreaders. Distinguishing external features of these carriers are the far forward location of the superstructures or deck houses, the location of the exhaust stacks to the aft and sides, the stern outriggers and the large gantry crane with a lifting capacity of more than 500 metric tons. This type of vessel hit the headlines some years ago with the sinking of the "München". Twenty-six vessels of this class are still in operation worldwide. Deadweight is approx. 43,000 metric tons, i.e. approx. 73 - 83 barges can be carried in addition to equipment, bunker fuel and stores.



Embarking LASH barges in the floating area

The dimensions of the barges are 18.50 m x 9.50 m x 3.90 m. Fully laden, the draft is 2.61 m. With a tare weight of approx. 140 metric tons, the deadweight of the barges is 376 metric tons. The difference in draft between bow and stern or "trim" must not exceed one foot as the barges otherwise can no longer be lifted by the spreader.



Stern embarkation of LASH barges by gantry crane

Special framework platforms have been developed so that not all goods need to be carried in the barges with their high tare weight. Floored platforms of this kind are available for general cargo, automobiles etc., while there are also floorless versions for containers. For cargo handling purposes, these platforms are set down on "feeder" barges which are towed to and from the ship. The framework platforms are also handled by the gantry crane.



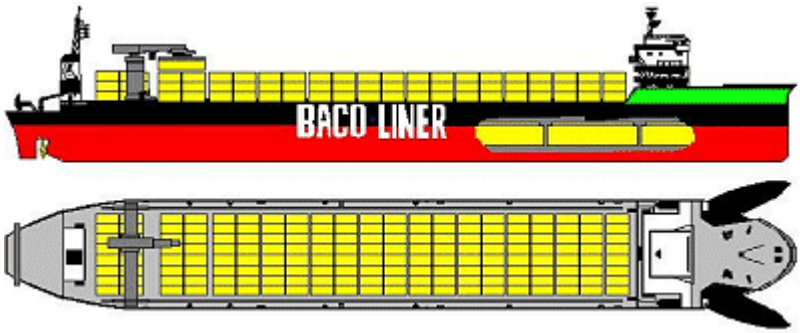
SEABEE carrier in a floating area

SEABEE carriers are capable of embarking barges at the stern using winch-driven lift platforms with a load-carrying capacity of more than 2,000 metric tons. Barges are loaded, usually in pairs, by being floated into the dock-like afterbody of the ship over the lowered lifting platforms, then lifted up to deck height, from where they are rolled into the ship on very flat rail-mounted trolleys. This type of transfer is thus known as "lift and roll". The Lykes Line's SEABEE ships can stow thirty-eight barges on three decks. Special fittings allow the upper deck to be loaded with containers instead of barges. SEABEE ships are able to carry containers and other cargoes on deck, but these ships do not have on-board lifting gear for such cargoes.



Floating a barge over the lowered winch platform

SEABEE barges measure 29.72 m x 10.67 m x 5.18 m. With a tare weight of 171.5 metric tons, the unladen draft is 0.62 m. With a full payload of 844 metric tons, the maximum draft is 3.22 m. There may be slight differences depending upon the particular type and lighter. The barges can accommodate six FEU or twelve TEU. Sixteen FEU can be located on the barge's hatch covers.



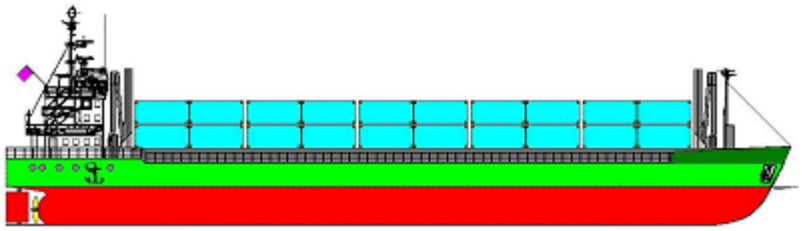
Side view and plan view of a BACO liner

BACO liners (barge/container liners) operate in accordance with the dock principle. In this German-developed system, the barges are floated through bow doors into the carrier, which has been lowered by taking on ballast. Once the bow doors have been closed, the water is pumped out of the dock and the barges are secured with special fittings. The special BACO barges measure 24 m x 9.50 m and, at a deadweight of 800 metric tons, have a draft of 4.10 m. However, the particular dimensions of the carrier ships are such that other types of barge and even inland waterway vessels and lighters can also be carried. Several tiers of containers can be carried on deck and be loaded and unloaded with on-board lifting gear.

CONDOCK is derived from container and dock ship. A large hold can be loaded with rolling cargo via a stern ramp as well as from above using the lo/lo method. These vessels have their own, very high capacity lifting gear for carrying heavy-lift cargoes. Containers can be carried in three tiers on deck. By flooding their ballast tanks, they can be lowered in the water like floating docks, and can take on floating cargoes. The dimensions of those vessels which are in service are such that LASH, BACO and sometimes even SEABEE barges can be accommodated. This class of vessel is still more versatile. Its gantry cranes are capable of handling individual items of cargo of up to 1,000

metric tons by the lo/lo method. Using the ro/ro method, heavy items of up to 2,000 metric tons can be loaded into the hold via a 20 m x 10 m ramp, while heavy and bulky items can be rolled on deck via two stern outriggers and self-propelled bogies. Floating cargo can be stowed either in the hold using the flo/flo method or on deck using the piggyback system.

The following examples are intended to illustrate how good design can enormously increase the versatility of modern ships.



Coastal motor vessel capable of navigating the Rhine and canals

Coastal motor vessels capable of navigating the Rhine and canals have a continuous box shaped cargo hold and a deadweight of 1,550 metric tons. The essential difference between other classes of sea/river-going vessels resides in this vessel's crane, which is of collapsible construction and so does not exceed the maximum height for navigating the Rhine and canals. The vessel's hatch covers can accommodate 20' or 40' containers in several bays. The wheel house can be lowered and raised hydraulically, while the masts can be folded down.

The majority of the **inland waterway motor vessels** in service in Germany are used to carry dry cargoes. Lengths vary between 38.50 m and 110 m, beams between 5 m and 11 m and drafts between 2 m and 3.50 laden. The deadweight of such vessels is between 220 metric tons and 3,000 metric tons. Many of these vessels are equipped to carry containers. Some **single hold motor freighters** have been specially tailored to the conditions prevailing on the Rhine on the way to Basel. They have the largest possible hold volume for light bulk cargoes, but can also carry heavy-lifts and bulky cargoes. Heavy goods can be rolled from land via an external ramp onto the forebody, from where they can be rolled into the hold via an internal ramp with a gradient of 5°. Low loaders, trailers or other special purpose trucks and crawlers can be used for this purpose. Loading and unloading operations can be assisted by hydraulic equipment, trim tanks and a pump system.

1.3.2 Positioning and securing of containers on board

Introductory remarks

This section is intended to provide the interested layperson with some basic information about how to stow and secure containers on board ocean-going vessels, so as to give him/her a better idea of the problems involved and possibly of how to select the appropriate carrier. Those actually involved with securing containers on board ships should refer to other specialist literature.

General on-board stowage

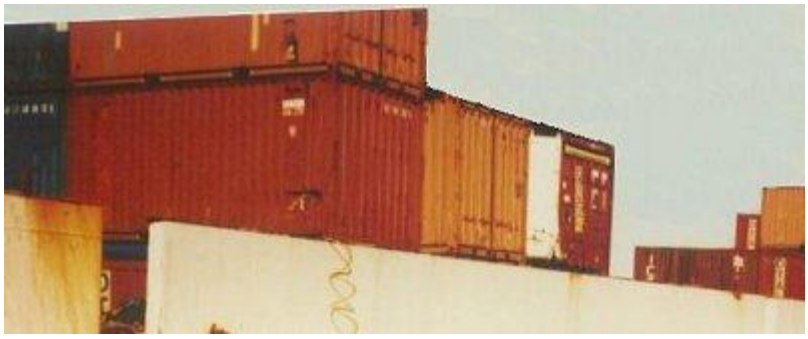
On most ships which are specially designed for container traffic, the containers are carried lengthwise:



Containers stowed lengthwise fore and aft stowage on board a ship

This stowage method is sensible with regard to the interplay of stresses in rough seas and the loading capacity of containers. Stresses in rough seas are greater athwartships than fore and aft and the loading capacity of container side walls is designed to be higher than that of the end walls.

However, on many ships the containers are stowed in athwartships bays or are transported athwartships for other reasons. This must be taken into consideration when packing containers and securing cargo.



Containers stowed athwartships (athwartships stowage) on board a ship

This stowage method is **not** sensible with regard to the stresses in rough seas and the loading capacity of containers. Stresses in rough seas are greater athwartships than fore and aft but the loading capacity of container end walls is lower than that of the side walls.



Containers stowed both ways on board ship

Even unusual stowage methods like this, where some of the containers are stowed athwartships and others fore and aft, are used, but they require greater effort during packing and securing operations.

The above two pictures show how important it is to find out about the various carriers and their way of transporting containers, either in order to rule out certain modes of transport or to be able to match cargo securing to mode of transport. If the method of transporting a container is not known, then packing and securing have to be geared to the greater stresses.

General securing information

When securing containers on board, the stresses resulting from the ship's movements and wind pressure must be taken into account. Forces resulting from breaking-wave impact can only be taken into account to a certain degree. All the containers on board must be secured against slippage and toppling, with care being taken to ensure that the load-carrying parts of the containers are not loaded beyond admissible levels.

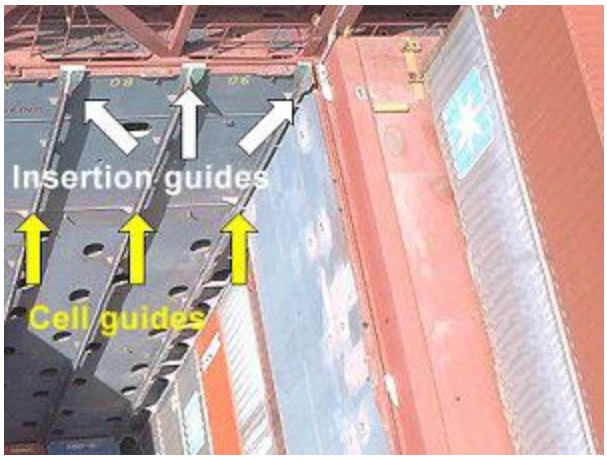
Except in the case of individually carried containers, securing is effected by stacking the containers in vertical guide rails or by stowing them in stacks or blocks, the containers being connected together and fixed to parts of the vessel.

Securing in vessel holds by cell guides alone



Cell guides in an all-container ship

Virtually all all-container ships are provided with cell guides with vertical guide rails as securing means for hold cargoes. The greatest stress the containers are exposed to stems from stack pressure. Since the containers are not connected together vertically, lateral stress is transmitted by each individual container to the cell guides When positioned in such cell guides, individual containers are not usually able to shift. If the corner posts of one of the containers at the bottom of a stack collapse under excessive pressure, containers stowed above it generally suffer only slight damage. The risk of damage to containers in adjacent stacks is kept within tight limits.



Guide rails of two adjacent slots

The containers are guided by these rails of the cell guides during loading and unloading. The photo shows clearly that the upper ends of the guide rails each take the form of insertion guides.

Securing in vessel holds by cell guides and pins

Feeder ships, multipurpose freighters and container ships in certain regions have to be particularly flexibly equipped, in order to be able to carry containers of different dimensions. To this end, convertible stowage frames have been developed, in which 20', 24½', 30', 40', 45', 48' and 49' containers may be stowed securely without appreciable delay.

Most of these frames are produced as panels which are brought into the required positions by cranes. At the bottom they mainly have fixed cones, which engage in pockets welded into the tank top area. At the sides, the frames are secured by pins, which engage in bushes which are let into the wing bulkheads. Such frames are often man-accessible, so that the containers can be locked in place

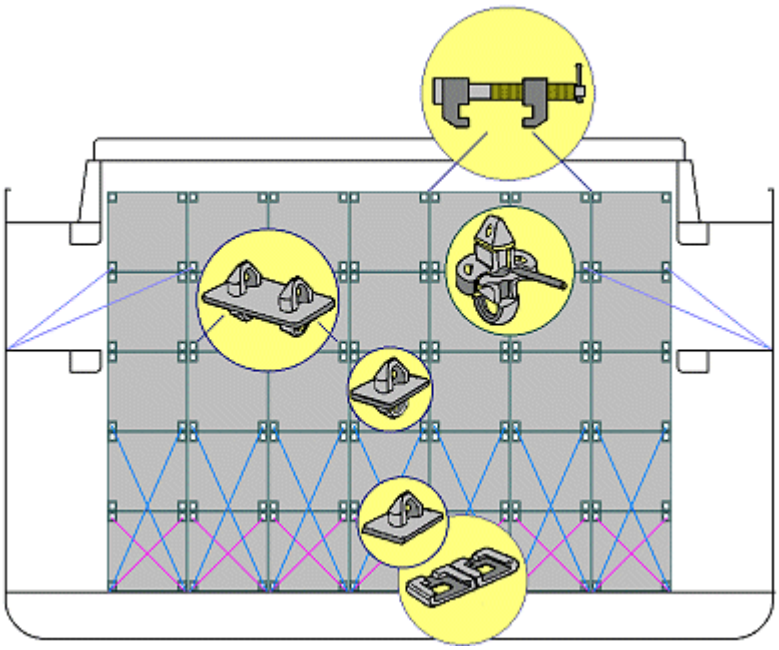
by means of pins.

If it is necessary to be able to carry containers 2,500 mm wide, the frames are arranged on the basis of this dimension. To secure standard containers of normal width, closure rails are then fitted on both sides of the guide rails by means of screw connections. If necessary, these adapters may be removed.

Removable container guides have also been developed and constructed for multipurpose freighters, reefer vessels and the like. Such guides allow containers to be carried in regular or insulated holds without any risk of damage to the holds themselves. If other cargoes are carried, the stowage guides may be removed using ship's or shore-based loading or lifting gear and deposited in special holders on deck.

Securing in vessel holds by conventional securing and stacked stowage

On older, conventional general cargo vessels and multipurpose freighters, stacked stowage methods are used in the hold, combined with various securing methods:



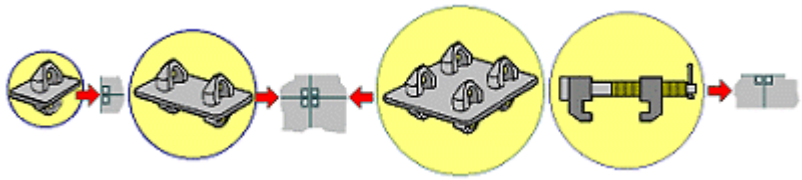
Example of stacked stowage with conventional securing

The lower containers stand on foundations capable of withstanding the stack pressures which arise. Dovetail foundations, into which sliding cones fit, are provided to prevent slippage. The containers are connected together by single or double stacking cones or twist locks. The entire stack or container block is lashed using lashing wires or rods and turnbuckles. This system entails a lot of lashing work and material and, moreover, is less secure than securing in cell guides.

Securing in vessel holds by block stowage and stabilization

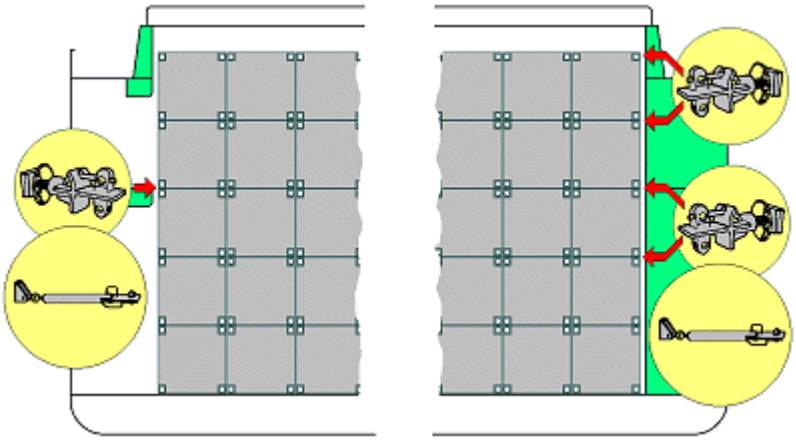
This securing method is found less and less frequently, but it is still found on some conbulkers and

other multipurpose freighters. Containers are interconnected horizontally and vertically using single, double and possibly quadruple stacking cones. The top tiers are connected by means of bridge fittings.



Fastening containers together

To the sides, the containers are supported at their corner castings with "pressure/tension elements".



Examples of block stowage method with stabilization

This type of container securing has two marked disadvantages:

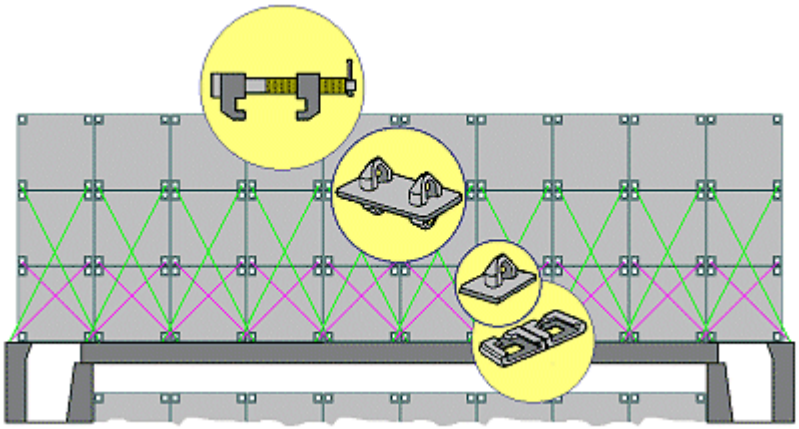
- If an individual container breaks, it is not just one container stack which is affected, but the whole container block.
- Due to dimensional tolerances and wear and tear to the stacking cones, the entire block can move constantly in rough seas. This causes the intermediate stacking cones to break and an entire block may collapse.

Securing on deck using container guides

On some ships, containers are also secured on deck in cell guides or lashing frames. Some years ago, Atlantic Container Lines used only cell guides on deck. Certain ships belonging to Polish Ocean Lines had combined systems. In other ships, cell guides can be pushed hydraulically over the hatch cover as soon as loading below deck is completed and the hatches have been covered up.

Securing on deck using block stowage securing

This method was used a lot in the early days of container ships, but has been used less and less in recent years for economic reasons.



Example of block stowage securing on deck

The containers in the bottom layer are positioned in socket elements or on fixed cones. Double stacking cones are used between the layers and the corner castings of adjoining containers are connected at the top by bridge fittings. The containers are held together over the entire width of the ship or hatch cover by cross lashings. A distinct disadvantage of this method is reduced flexibility when loading and unloading, since adjoining containers have always to be moved as well if access to a particular container is required.

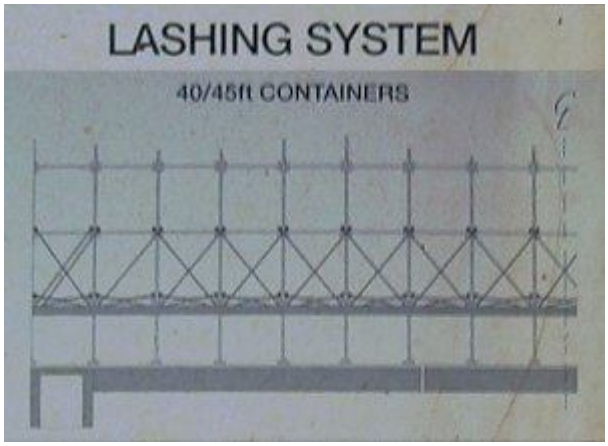
Numerous variants, not listed any greater detail here, are available for attaching the lashings. Sometimes the lashings from different stacks cross one another.



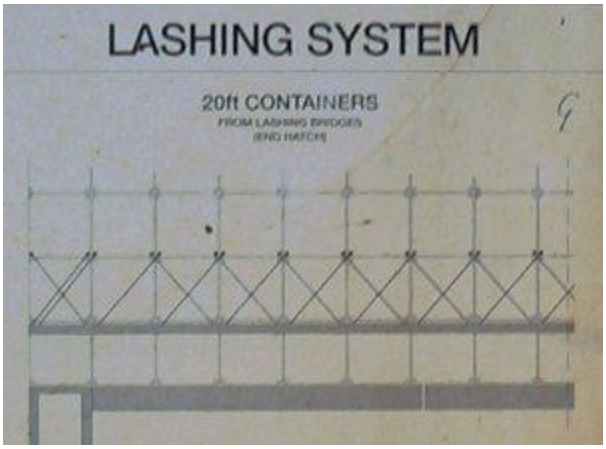
Crisscross lashings from different container stacks

This securing method is being used increasingly in very large container ships.

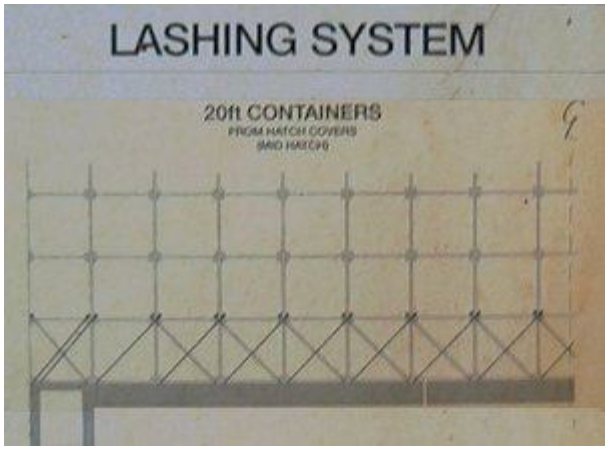
Instructions for lashing on board ships are displayed in obvious places.



Lashing system for 40' and 45' containers



Lashing system for 20' containers from the lashing bridges of the end hatches

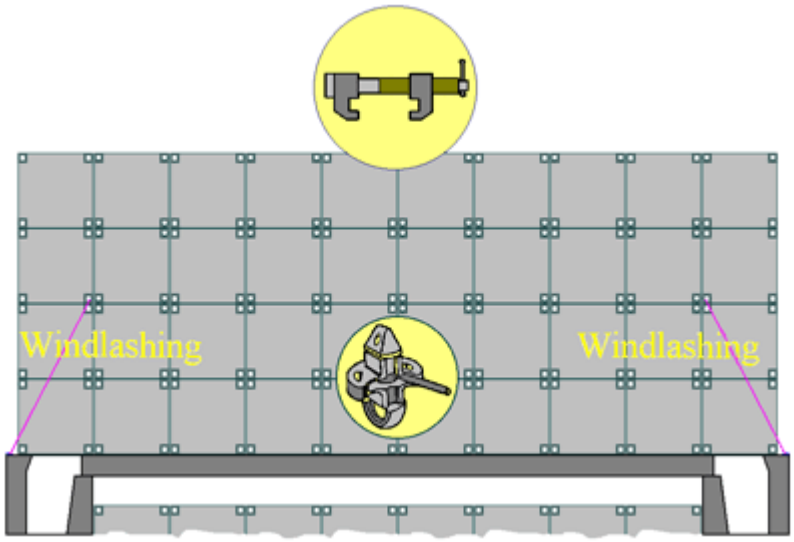


Lashing system for 20' containers from the hatch covers of the middle hatches

Securing on deck using stacked stowage securing

This securing method is the one used most frequently. Cargo handling flexibility is its key advantage. The containers are stacked one on top of the other, connected with twist locks and lashed vertically. No stack is connected with any other stack. The container lashings do not cross over the

lashings from other stacks, except for the "wind lashings" on the outer sides of the ship.



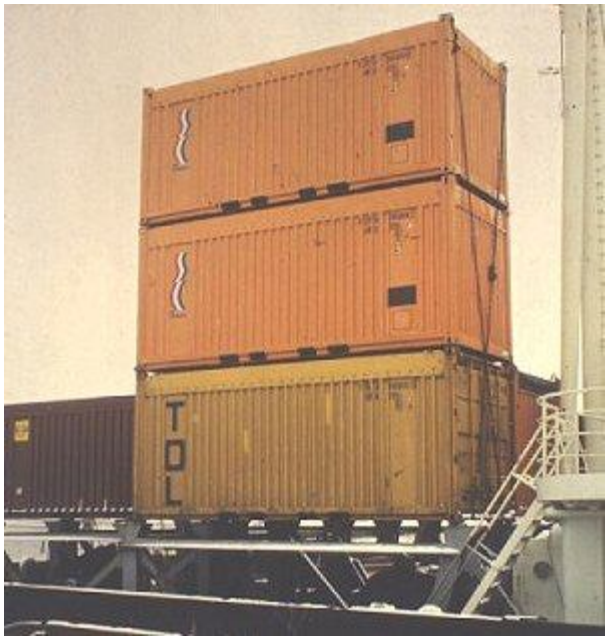
Principle of stacked stowage securing



Securing of on-deck containers with lashing rods and twist locks



Securing of on-deck containers with twist locks and chains



Securing of a 3-tier stack on board a semi-container ship

Obviously, a container stack of this kind can topple if it is not adequately secured.

An absence of special equipment for securing containers and unfavorable stowage spaces increase the risk for container cargoes. "Sloppy" carriers should be avoided wherever possible. This applies quite generally, not only to the operators of aging ships. Timely information about as many as of the circumstances and procedures encountered during carriage as possible can be extremely useful.

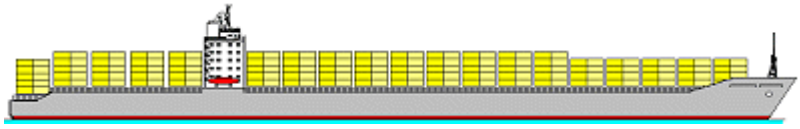
1.3.3 Container stowage plans Working stowage plans are drawn up to assist in advance planning. Master plans definitively document the positioning of containers on board.

The bay-row-tier system follows a system of numerical coordinates relating to length, width and height. The stowage space of the container on board the ship is unambiguously stated in numbers and is (almost always) recorded in the shipping documents. It is then also possible to establish at a later date where the container was carried during maritime transport.



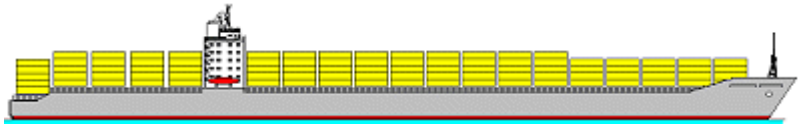
Principle of bay-row-tier coordinates

According to this principle, bays are the container blocks in the transverse direction, rows are the lengthwise rows and tiers are the vertical layers.



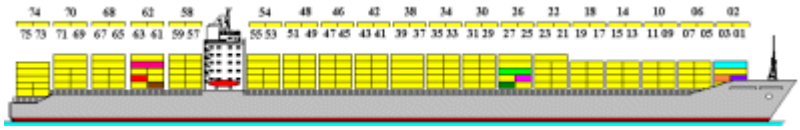
Thirty-eight 20' container bays on a ship

Theoretically, the thirty-eight bays could be numbered continuously from 1 to 38. However, that would only be sensible if only 20' containers could actually be loaded.



Nineteen 40' container bays on a ship

If the ship could only transport 40' containers, the nineteen bays could be numbered continuously from 1 to 19.

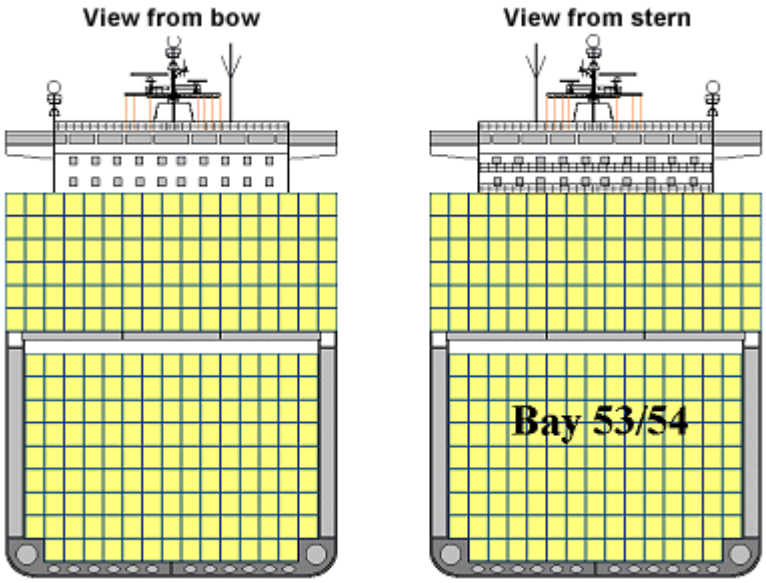


Bay numbering system

Since, however, the ship can transport both 20' and 40' containers, the bay spaces for 20' containers are numbered throughout fore to aft with odd numbers, i.e. in this case 01, 03, 05 and so on up to 75. The bay spaces for 40' containers are numbered throughout with even numbers: 02, 04, 06 and so on up to 74.

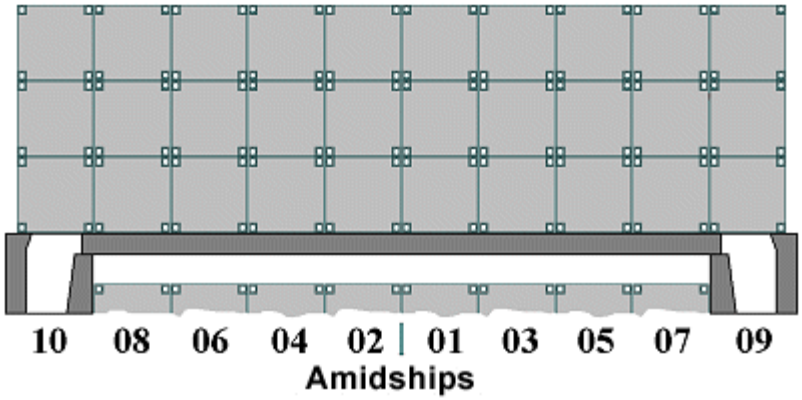
The purple 20' container in the first bay has the bay number 01. The light-brown 20' container in the second bay has the bay number 03 and the light-blue 40' container, which occupies a space in the first and second bays, has the bay number 02. The magenta-colored container has the bay number 25, the dark-green number 27 and the light-green number 26.

To illustrate a cross-section through a bay, one needs to imagine that one is standing in front of or behind the ship.



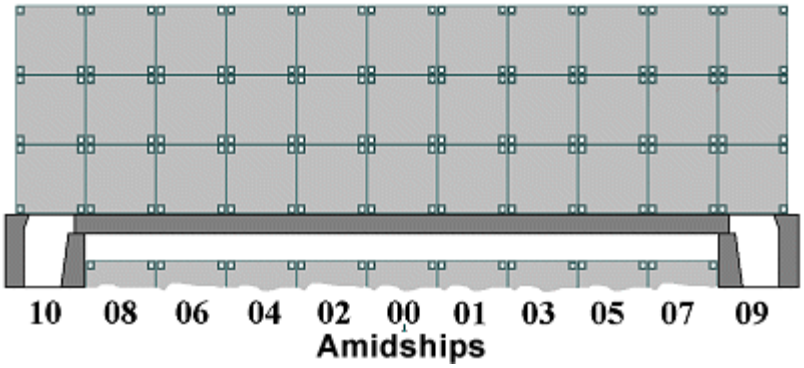
In the case of bay plans, the respective bay is always viewed from behind.

The rows of containers on a ship are numbered with even numbers from the center leftward and odd numbers from the center rightward.



Row numbering where there is an even number of rows

Where there is an odd number of rows, the middle row is numbered 00.



Row numbering where there is an odd number of rows



Numbering of the port rows on board ship

On close inspection, the photograph shows left-hand row 16, which is designed to be filled with containers only on deck, and rows 14, 12, 10, 08, 06, which may be filled both on deck and in the holds. Rows 04, 02, 00, 01 and 03 are likewise designed to be occupied in the hold and on deck. However, the hatch covers are already on in this case.



Numbering of the starboard rows on board ship

Rows 05, 07, 09, 11 and 13 are still empty in this bay. Row 15 is designed only for on deck

occupation, and is still free in this bay.



Row numbers of the aft bay of a ship

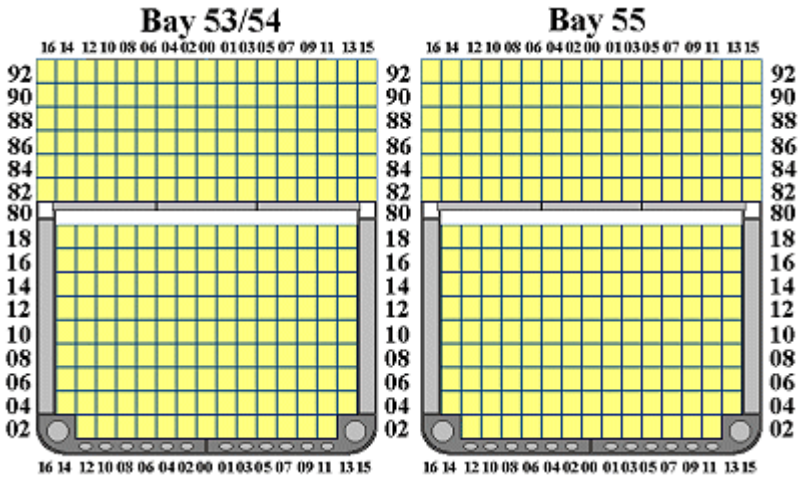
The container tiers are numbered with even numbers, starting from the bottom. The conventional way is start with 02 in the hold and then count up with 04, 06 etc. In the case of deck cargoes, it is conventional to start numbering with 80 or 82. There are sometimes slight differences between ships.



Numbering of horizontal container layers, or tiers

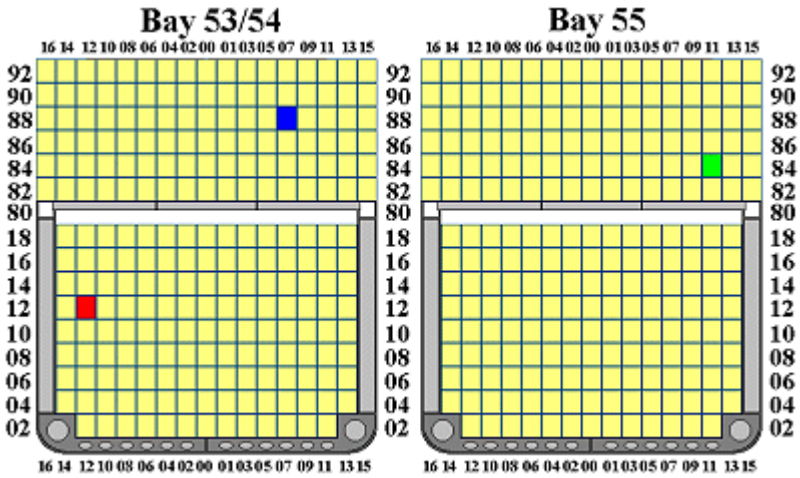
On this ship, the containers standing directly on the main deck are numbered 80 and those standing on the hatches are number 82. The number is incremented by two for each higher layer.

These bay, row and tier numbers are noted in the bay plans.



Bay plan

The loaded containers, with their alpha prefix, their container numbers, the port of destination or discharge and other important details are noted in the bay plans.



Color-labeled containers in a bay plan

According to the bay-row-tier system, the colored containers were given the following stowage space numbers:

- a 20' container in the red-colored slot: 531212
- a 40' container in the blue-colored slot: 540788
- a 20' container in the green-colored slot: 551184

The system illustrated is the most widely used. However, other numbering systems do exist, in which the coordinates are stated in a different order, for example row-bay-tier systems and similar combinations. On ro/ro ships, the slots are usually organized along lanes running lengthwise. In

individual cases and if required, such information may be obtained from shipping companies, cargo-handling companies or other competent persons.

1.4 Containers and insurance

1.4.1 General Approximately three sixths of all the containers used worldwide belong to leasing companies, another two sixths to shipping companies and the final sixth to other owners*.

1.4.2 Containers and cargo insurance In principle, cargo insurance only covers claims relating to material damage to goods.

Exceptionally, the proprietor's interest in the container as packaging may also be insured if a special agreement is reached or through inclusion thereof in the damage liability invoice value. Interest in a leased container is not in principle insured.

The purpose of packaging is to allow transport of goods and to protect them from possible damage. If the above aim has been fulfilled, it is most common for only the packaging to be damaged, and not the goods.

ADS 1919 or ADS 1973/1994 (ADS = Allgemeine Deutsche Seeversicherungsbedingungen [General German Marine Insurance Conditions]) and the DTV - Güterversicherungsbedingungen [Association of German Transportation Insurers - Cargo insurance conditions] do not include any particular provisions in this respect. The following may be inferred from the general principles of transport insurance law*:

If the packaging does not have any separate, intrinsic value, no independent loss may occur. Packing paper, which is discarded after the arrival of the cargo and suffers wear during transport, cannot therefore form the basis of a claim for damages. If the goods have reached their destination, the only relevant question is whether the goods have suffered loss and not whether the packaging is damaged. This also applies to cases.

Consideration can only be given to any such claim if the goods have depreciated in value solely as a result of the damage to the packaging. This is the case for example with preserved foods and certain branded goods. Another example is cement, which retains its normal commercial value only in its original bags. If cement which is in itself sound is sold in unmarked bags because the original bags have been damaged, it automatically suffers depreciation. In such cases, compensation may be paid despite the damage being limited to the bags.

Otherwise, compensation may only be paid for packaging damage if a separate value is assigned to the packaging either in the policy or in the invoice (e.g. barrels or containers). This only applies if the packaging is expected to have a longer service life than the duration of one transport operation.

A different matter entirely is the cost of repairing or replacing packaging, if this has to be performed en route. It may be possible to claim compensation for these costs, though not in the form of packaging losses but as loss minimization costs, which are expended to return the goods to a transportable state and to prevent losses on the remaining insured journey. For such a claim to be allowable, the packaging must have

been satisfactory at the start of the journey. If the journey is complete or the remainder of the journey is uninsured, the insurer will not meet such costs, because, the insurance contract having expired, no more insured losses can be incurred.

Because of the uncertainties involved in using cargo insurance to insure a container as packaging, it is better to provide separate hull insurance by way of special conditions for container insurance. As far as the proprietor's interest is concerned, double insurance cover may then be provided by the cargo insurance and the container & hull insurance.

1.4.3 Containers and container & hull insurance Containers cannot be easily defined as either hull or cargo. To distinguish them more readily from insurance for the container cargo, the special conditions are known as hull clauses. Nonetheless, the nature of the cargo remains the predominant factor, for which reason the special conditions should only be agreed in conjunction with DTV cargo insurance conditions.

In general, therefore, containers are not covered as packaging by cargo insurance, but instead by special all-risks insurance by way of special conditions for container insurance. However, compensation is only paid for damage to machinery and tarpaulins, if it is an immediate consequence of an accident involving the means of transport or of stranding.

The special conditions may also be applied to leased containers, if the lessee bears the risk. However, to clarify the situation, this should be expressly stated in the corresponding "written conditions".

1.4.4 Liability of transport company

1.4.4.1 Container provided by shipper Whether the shipper uses his own container or one borrowed, rented or leased from a third-party, he is using the container as packaging*.

The transport company is liable for material damage to the cargo and the container under the corresponding carriage conditions, since, when calculating liability, the gross weight is to be understood to mean the total weight including packaging.

1.4.4.2 Container provided by carrier There are several different conceivable situations, whether the carrier uses his own container or one borrowed, rented or leased from a third-party*:

Permanently mounted container

If the container is mounted permanently on the chassis of a truck. i.e. is completely fixed thereto, it fulfills the requirements of a fundamental component of the vehicle for the purposes of § 93 BGB [German Civil Code].

The transport company is liable for material damage to the cargo under the corresponding carriage conditions. This liability does not include the weight of the container, since the contract of carriage relates only to the cargo and not additionally to the container.

Leased containers

If, on the express wish of the shipper, the carrier makes available to said shipper a freely handleable container which is not connected permanently to the vehicle, for instance because the shipper's intention is for the container to be transferred between several means of transport during carriage, the carrier will generally demand additional remuneration for handover of the container. This gives rise to a leasing agreement between the carrier and the shipper.

The transport company is liable for material damage to the cargo under the corresponding carriage conditions.

Material damage to the container is covered by the content of the leasing agreement.

Containers as ancillary transportation equipment

If the carrier makes the container available to the shipper to simplify transport without any special additional agreement of the type mentioned above, the contract of carriage as a rule relates only to the transport of cargo in a vehicle suitable therefor.

The transport company is liable for material damage to the cargo under the corresponding carriage conditions. This liability does not include the weight of the container, since the contract of carriage relates only to the cargo and not additionally to the container.

1.5 Responsibility for packing

Storage, cargo handling and transport of goods are covered by both national and international regulations, which set out minimum requirements for treatment of goods, vehicle use etc. Public regulatory guidelines are supplemented by private agreements and terms and conditions of business. Careful packaging and marking of goods for dispatch should be accompanied by proper packing, stowing, securing and unpacking. When carrying hazardous materials, additional provisions must be taken into account with regard to packaging, labeling, documentation etc.

A high percentage of goods are intended for carriage by combined road, rail, water and air transport, whether through repeated transshipment or intermodally using containers, swap-bodies or other transport units. Packaging, labeling, stowage and securing deficiencies can generally only be established during dispatch by spot checks. Since minor carelessness may cause serious losses, expert packing and securing are essential for loss-free carriage.

This handbook pays particular attention to negligence with regard to dispatch, which may result in losses and/or (could) form the basis of compensation payments. It has as its central theme issues relating to transport legislation, some of which will be explained and commented on in more detail. The fundamental rules to which reference will frequently be made are contained in

CTU packing guidelines

Guidelines for the packing of cargoes, other than bulk cargoes, into or onto cargo transport units (CTUs) applicable to transport operations by all surface and water modes of transport

17th February 1999

These guidelines replace the revised container packing guidelines which previously applied.

The abbreviation CTU stands for "**C**argo **T**ransport **U**nit" and has the same meaning as the expression "**I**ntermodal **T**ransport **U**nit"/"ITU").



Empty containers at a sea port

The preamble of the CTU packing guidelines points out that the use of containers, swap-bodies, vehicles or other CTUs substantially reduces the physical hazards to which cargoes are exposed.



Inadequately secured cargo on a flatrack, loaded on a roll trailer

However, they also emphasize that improper or careless packing of cargoes into or onto CTUs or improper cargo securing may cause accidents with involving personal injury during handling or transport of CTUs.



Damage caused to several containers by inadequate cargo securing

It is also pointed out that considerable damage may additionally be caused to the cargo or CTU.



Container packer adding the finishing touches

It is also stressed that the person who packs and secures the cargo is often the last person able to look inside a CTU before it is opened by the receiver at its destination. The preamble actually states:

- *drivers of road vehicles and other road users if the CTU is transported by road;*
- *railroad employees and others, if the CTU is carried by rail;*
- *crews of inland waterway vessels, if the CTU is carried on inland waterways;*
- *handling staff at inland terminals when the CTU is transferred from one means of transport to another;*
- *dock workers when the CTU is loaded and discharged;*
- *ships' crews, who often accompany the CTU under the most severe transport conditions;*
- *those who unpack the CTU.*

All persons, such as the above and passengers, may be at risk from a poorly packed container, swap-body or vehicle, particularly one which is carrying dangerous cargoes.

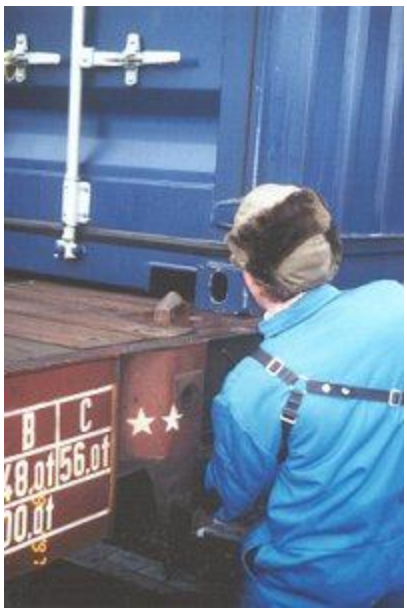
If containers have been closed with seals and locked, it is impossible for road vehicle drivers to check how well they have been packed and secured. Even if the transport units are freely accessible, it would still only be possible, for the most part, to inspect the cargo in the door area of box containers.



Truck combination with (safely packed) hazardous materials containers

Improperly packed containers could reduce the safety of road vehicles, e.g. due to weights shifting within the container, and encourage vehicles to overturn. Containers transported on trailers constitute a particular hazard if they are poorly packed and the cargo is inadequately secured.

Switchmen and other railroad employees are not responsible for checking that CTUs have been properly packed.
Their inspection duties may extend to the proper securing of CTUs on freight cars, but not to the situation inside locked CTUs. If deficiencies are detected in open CTUs, a responsible employee is sure to intervene.



Rail vehicle with container during switching

Poorly packed and inadequately secured cargoes may put not only the switchmen but also rail passengers and other innocent parties at risk.



Unsecured cargoes can put people's lives at risk.

Poorly secured cargoes have frequently been known to smash through the end walls of a CTU in the event of a switching impact or even through the side walls during carriage by rail.



Containers on an inland waterway vessel

Naturally, the crews of inland waterway vessels cannot be expected to inspect the CTUs delivered to them for secure packing.



Transfer of a container

Cargo handling crews at inland terminals are put at risk by poorly packed, inadequately secured CTU cargoes, if they have to transfer them from one means of transport to another, as are dock workers when loading and discharging the CTU.



Loading and discharging operations at the sea port

As far as marine transport is concerned, the ship's command does not have any possibility, on a day to day basis, of influencing how CTUs are packed or how cargoes are secured in them.



Captain of a container ship with visitors on the bridge

In the early days of container shipping, it was common practice for the cargo officer to carry out at least occasional spot checks at the ports on the containers delivered for shipment. Today, due to high cargo volumes, short laytimes in port and reduced crewing levels, this is possible only very occasionally. The long-established practice of having containers checked and inspected by experts employed by the shipping companies or loss adjusters instructed by the carriers has also mostly been abandoned for cost reasons. These days, containers are only occasionally inspected by experts before loading onto the ship.



Water police inspecting a trailer to be carried by ferry

Occasionally, authorities such as the water police carry out spot checks on CTUs carrying hazardous materials.

The results of such inspections are shocking. Around 70% of containers, swap-bodies, semitrailers and other "cargo transport units" reveal clear deficiencies.

From a legal standpoint, an inspection by the ship's command is unnecessary, since the people who pack a container are responsible for ensuring that all regulations are observed. In the case of containers carrying hazardous materials, such compliance must even be confirmed by a signature on the container packing certificate. Accordingly, in the case of FCL/FCL and FCL/LCL containers, the shipper is usually responsible. The bill of lading documents this in the "shipper's load, stowage and count" clause. In the case of LCL/FCL and LCL/LCL containers, those responsible are those instructed to pack. With regard to legal liability, they bear the consequences of any deficiencies or omissions, insofar as these are not caused by the customer, for example because the latter fails to pay for necessary work to be carried out or for securing or has only very specifically defined work carried out. If people or the environment are harmed by deficient container packing, those responsible may be prosecuted. The potential for risk is particularly great when packing hazardous materials.

Theoretically, it is only possible for the crew of a ship to inspect cargo securing where "open" CTUs are used, such as flatracks, platforms etc., and then only when the cargo is not additionally covered by tarpaulin or otherwise hidden from view.

Those who unpack a CTU are the last people in the transport chain who may be put at risk by packaging deficiencies, poor packing and inadequate cargo securing.



Forklift truck driver stripping a container

The CTU packing guidelines do not mention the danger to individuals who inspect CTUs in the course of their work, such as police, loss adjusters and cargo inspectors.



Motorway police inspecting containers

The container (picture to the right) is packed with hazardous materials. This should have been packed in the door area, but instead was "hidden" under other items of cargo and could not be found.

Without at this point going into individual paragraphs, articles or points of regulations, laws or guidelines, it should be noted that with this type of transport too it is the shipper's duty to ensure proper packing and securing.



Poorly packed, inadequately secured container loads may also put innocent third-parties at risk if shifting items of cargo smash through the container walls or cause a vehicle carrying the container to overturn.

Inadequately secured container load

Normally, a CTU trucker cannot be held liable for losses arising due to improper packing of containers, swap-bodies, semitrailers etc., if the latter are closed with seals and are loaded in operationally safe manner, which is the case if the vehicle is roadworthy and working safely. A trucker's contract of carriage usually applies only to transport of the CTU. His duty to load the CTU in operationally safe manner is fulfilled if the appropriate total weights and axle loads are complied with, appropriate locking of the CTU is ensured and hitching is performed correctly.

If a vehicle is sealed, the trucker does not have any way of influencing, supervising or even checking packing and securing of the load. Losses due to such deficiencies, or even to packaging deficiencies, cannot therefore lie within his area of responsibility, but instead lie squarely with the shipper.

If truckers notice obvious deficiencies when they take delivery of CTUs or later due to the driving behavior of their vehicle, they must respond accordingly, however. It is advisable to ask the shipper for information or instructions.

In the case of unsealed vehicles, an internal visual inspection is advisable. Any gross errors may then be discovered. In practice such inspections are hardly ever performed, but this may make the driver partly responsible.

The shipper must always ensure that cargoes are loaded and secured in such a manner as to be safe for transport, as he is not only liable for damage to the cargo but also for damage to the vehicle or injury to third-parties resulting from dereliction of his duty.

The following is stated in § 22 of the German road traffic code, para. 1:

> *(1) The load, together with clamping chains, gear and other loading equipment, must be stowed so as to be safe during transport and be secured especially so as to prevent it from falling off and from making avoidable noise.*

This paragraph is worded very generally and does not name any particular target individual or group. It must therefore be adhered to by all those responsible for loading road vehicles.

2 Causes of damage/loss during transport

2.1 **Loss prevention through** training

The section "Scope" of the CTU packing guidelines contains an important statement:

> *These Guidelines, which are not all-inclusive, are essential to the safe packing of CTUs by those responsible for the packing and securing of the cargo and by those whose task it is to train people to pack such units. Training is essential if safety standards are to be maintained.*

According to section 7.2 of the CTU packing guidelines, this is a management responsibility:

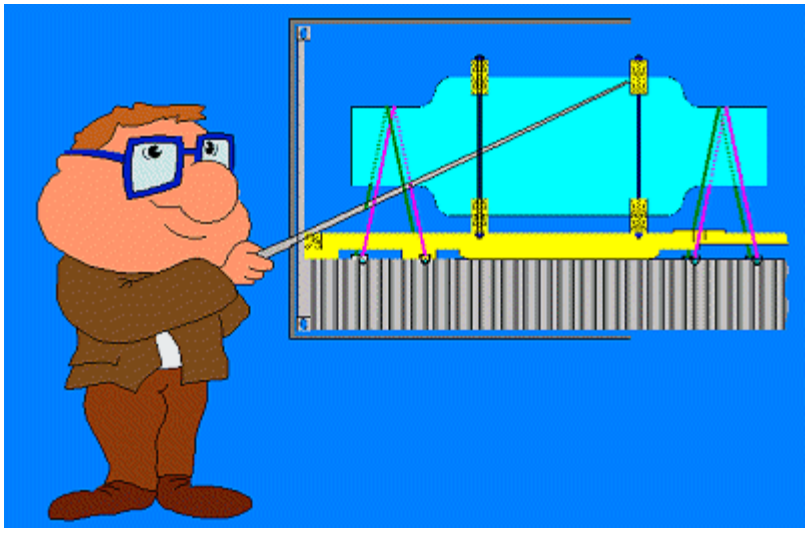
> *Management should ensure that all personnel involved in the packing of cargo in CTUs or in the supervision thereof are adequately trained and appropriately qualified, commensurate with their responsibilities within their organization.*

Section 7.3 states the following requirement for personnel:

> *All persons engaged in the transport or packing of cargo in CTUs should receive training on the safe packing of cargo in CTUs, commensurate with their responsibilities.*

Section 7.4 relates to training, the various subsections providing as follows:

7.4.1 General awareness/familiarization training:
All persons should receive training on the safe transport and packing of cargo, commensurate with their duties. The training should be designed to provide an appreciation of the consequences of badly packed and secured cargo in CTUs, the legal requirements, the magnitude of forces which may act on cargo during road, rail and sea transport, as well as basic principles of packing and securing of cargoes in CTUs.
7.4.2 Function-specific training:
All persons should receive detailed training concerning specific requirements for the transport and packing of cargo in CTUs which are applicable to the functions that they perform.
7.4.3 Verification:
The adequacy of the knowledge of any person to be employed in work involving the packing of cargo in CTUs should be verified or appropriate training provided. This should be supplemented by periodic training, as deemed appropriate by the regulatory authority.
7.5 Recommended course syllabus - overview:
The adequacy of the knowledge of any persons to be employed in work involving the packing of cargoes in CTUs should be verified, in the absence of which appropriate training is considered essential and should be provided. The function-specific training should be commensurate with the duties required to be performed by an individual in the packing and securing of cargo in CTUs. Topics for consideration, to be included in the training as appropriate, are given in Annex 6.



Annex 6

Topics to be included in a training programme for the packing and securing of cargoes in cargo transport units (CTUs)

1 Consequences of badly packed and secured cargo

1.1 Injuries to persons and damage to the environment

1.2 Damage to ships and CTUs

1.3 Damage to cargo

1.4 Economic consequences

Many may still remember the case of the French container ship "Sherbro" which lost a number of containers overboard in the English Channel. As a result, hundreds of thousands of plastic sachets containing the pesticide Apron plus entered the sea and were subsequently washed up on the coasts of France, the Netherlands and Germany.





Injuries to persons and damage to the environment may be the result.



Damage to ships and CTUs



Damage to cargo



Economic consequences

2 Liabilities
- 2.1 Different parties involved in cargo transport
- 2.2 Legal responsibility
- 2.3 Goodwill responsibility
- 2.4 Quality assurance

3 Forces acting on the cargo during transport
- 3.1 Road transport
- 3.2 Rail transport
- 3.3 Sea transport

4 Basic principles for cargo packing and securing
- 4.1 Prevention from sliding
- 4.2 Prevention from tipping
- 4.3 Influence of friction
- 4.4 Basic principles for cargo securing

- 4.5 Dimensions of securing arrangements for combined transportation

5 CTUs - types
- 5.1 Containers
- 5.2 Flats
- 5.3 Swap-body
- 5.4 Road vehicles
- 5.5 Rail cars/wagons

6 Cargo care consciousness and cargo planning
- 6.1 Choice of transport means
- 6.2 Choice of CTU type
- 6.3 Check of CTU prior to packing
- 6.4 Cargo distribution in CTUs
- 6.5 Requirements from the receiver of cargo regarding cargo packing
- 6.6 Condensation risks in CTUs
- 6.7 Symbols for cargo handling

7 Different methods for cargo packing and securing
- 7.1 Lashing
- 7.2 Blocking and bracing
- 7.3 Increasing friction

8 Equipment for securing and protection of cargo
- 8.1 Fixed equipment on CTUs
- 8.2 Reusable cargo securing equipment
- 8.3 One-way equipment
- 8.4 Inspection and rejection of securing equipment

9 Packing and securing of unitized cargo (bulk)
- 9.1 Cases (boxes)
- 9.2 Palletized cargoes
- 9.3 Bales and bundles
- 9.4 Bags on pallets
- 9.5 Flexible IBCs
- 9.6 Slabs and panels

9.7 Barrels
9.8 Pipes
9.9 Cartons

10 Packing and securing of non-unitized cargo (break-bulk)
10.1 Different types of packaged cargoes loaded together
10.2 Packing of heavy and light cargoes together
10.3 Packing of rigid and non-rigid cargoes together
10.4 Packing of long and short cargoes together
10.5 Packing of high and low cargoes together
10.6 Packing of liquid and dry cargoes together

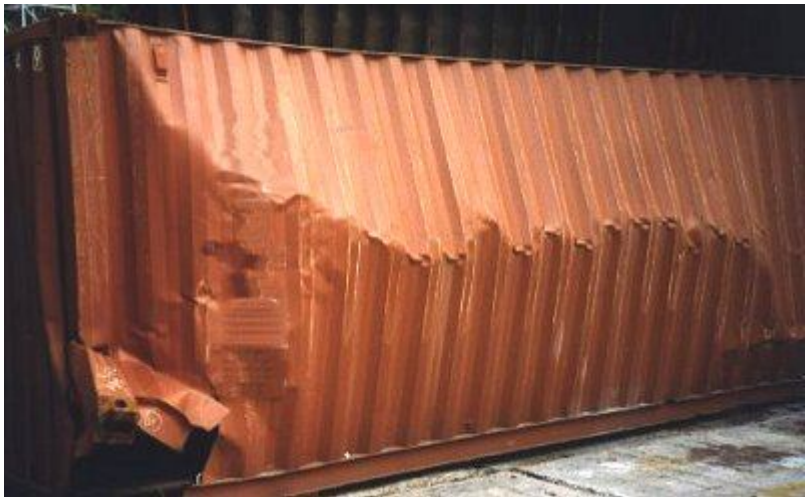
11 Packing and securing of paper products
11.1 General guidelines for the packing and securing of paper products
11.2 Vertical rolls
11.3 Horizontal rolls
11.4 Sheet paper on pallets

12 Packing and securing of cargo requiring special techniques
12.1 Steel coils
12.2 Cable drums (reels)
12.3 Wire coils
12.4 Steel slabs
12.5 Steel plates (sheet)
12.6 Big pipes
12.7 Stone blocks
12.8 Machines

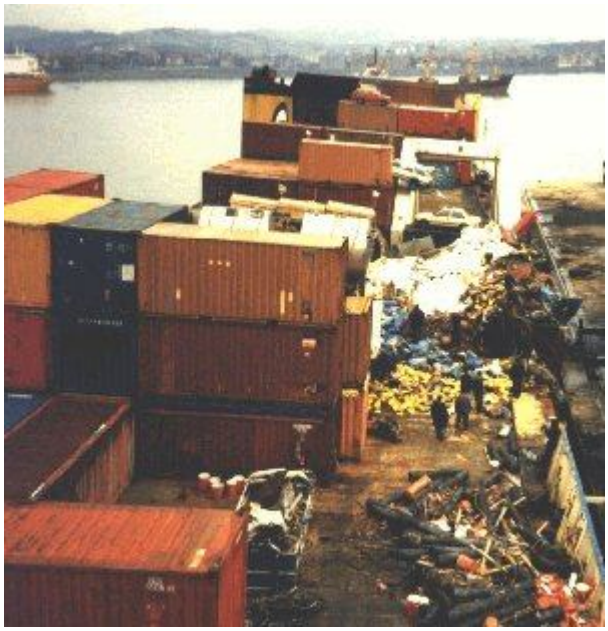
13 Packing and securing of dangerous cargoes
13.1 Regulations for the transport of dangerous cargoes
13.2 Definitions
13.3 Packing regulations
13.4 Packing, separation and securing
13.5 Labeling and placarding
13.6 Information transfer when transporting dangerous cargoes
13.7 Liabilities

Comprehensive and regularly recurring training sessions are necessary in order to ensure sufficient familiarity. On request, the German Insurance Association (GDV e.V.) can supply the names of training organizations which carry out or assist with internal and external training.

2.2 Damage - risks - countermeasures



The cargo in this container had obviously not been sufficiently secured. As a result, the container was destroyed from the inside.



Considerable damage to the cargo and the ship itself due to inadequate cargo securing



Cargo from the destroyed containers on deck



It is essential to avoid even the smallest gaps.



A cargo unit (at the top) has been packed with gaps on both sides. Moreover, the cargo unit was inappropriately unitized.



Perfect example of how to fill gaps (to the left)

2.3 Shipping stresses - general information

Shipping stresses must in general be divided into two main groups:

- avoidable shipping stresses
- unavoidable shipping stresses

Avoidable shipping stresses are attributable to human shortcomings. Incidents of damage often occur because the cargo has been inadequately packed, stowed or secured or because equipment has been used incorrectly. The CTU packing guidelines also attempt to counter these human causes by providing in Annex 6 a list of topics to be included in a training program for the packing and securing of cargoes in cargo transport units (CTUs), which requires in point 3 that packers be instructed as to the forces acting on the cargo during transport, whether by road, rail or sea. This requirement stated in the CTU packing guidelines deserves strong support as observation of day-to-day practice reveals a frightening lack of knowledge in precisely this area.

Unavoidable shipping stresses are determined by the nature of the transport operation and lie largely outside the sphere of human influence.

Very large numbers of incidents of damage are attributable to the fact that many of those involved in shipping are unaware of shipping stresses or assess them incorrectly. This ought not to be the case as information of this kind is available from many different sources. Section 1 "General conditions" in the CTU packing guidelines provides important information about how cargoes are affected particularly during voyages. Information about road, rail and inland waterway transport and about cargo handling is also provided. In addition, the German vehicular accident prevention regulations (BGV D 29) and VDI guidelines also state values for road transport. Values for the stresses arising in rail transport may be

obtained from publications from the German railroad company Deutsche Bahn AG or the UIC.

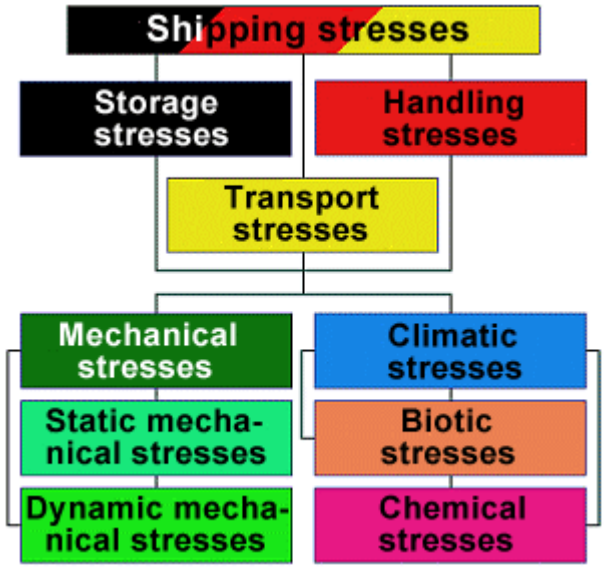
It is not without reason that the CTU packing guidelines contain the following important statement in the point Scope:

> *These Guidelines are not intended to conflict with, or to replace or supersede, any existing regulations or recommendations which may concern the carriage of cargo in CTUs.*

In other words, there is no intention to reinvent the wheel in the CTU packing guidelines; much of the information they provide has already been published in other guidelines and specialist publications.

> ***Carriage** denotes the movement of cargo using one or more modes of transport.*

The terms "carriage" and "shipping" are superordinate terms covering storage, handling and transport and any associated operations.
The stresses arising during shipping may thus be summarized as shown below:



Overview of shipping stresses

It is extremely difficult to put exact values on storage, handling and transport stresses because they are determined by many different parameters. In addition to the stresses shown in the overview, other factors of course also play a part, such as the means of transport used, the selected routes, the nature of the roads and railroads or the particular weather conditions prevailing during maritime transport.

Protection from shipping damage may be provided with regard to economic viability without consequently being less effective. Effective and economic protective measures can be implemented if enough is known about the stresses to which the cargo is exposed during transport.

As experience has shown and measurements have confirmed, the shipping stresses of different modes of transport differ markedly. Nevertheless, there are similarities and common features which should be taken into account in the following explanations.

However, it is not feasible to generalize about transport operations, each one will be somewhat different and will also be affected by randomly occurring factors. The better trained are those involved, the better will they be able assess the transport risks and take effective action to counter them. Training and quality control are two key concepts which should play a central part in cargo securing.

2.3.1 Static mechanical shipping stresses

Static mechanical stresses primarily cause damage due to harmful levels of pressure. In the transport sector, cargoes are often thought of only as light or heavy, so neglecting the fact that these are relative terms which it is highly advisable to verify.

$$\text{Pressure} = \frac{\text{Force}}{\text{Area}}$$

Stated using conventional abbreviations:

(p for pressure, F for force and A for area)

$$p = \frac{F}{A}$$

The official SI unit of calculation is the pascal, which is a pressure of one newton per square meter (Pa = N/m²). This very small unit is rarely used for practical calculations. Atmospheric pressures are calculated in hectopascals (hPa), while tire pressures, stacking pressures etc. are usually calculated in kilopascals (kPa) or megapascals (MPa).

In the pressure formula, force is above the fraction line, which means that, given an identical area, a larger force will result in a larger pressure. Area is beneath the fraction line, i.e. the smaller the area, the greater the pressure and vice versa.

If the maximum permitted stack pressure in containers is not known, it may relatively easily be determined. Point 3.1.7 of the CTU packing guidelines provides an indirect indication of how this is done:

> *Stowage planning should take account of the fact that CTUs are generally designed and handled assuming the cargo to be evenly distributed over the entire floor area. Where substantial deviations from uniform packing occur, special advice for preferred packing should be sought.*

The permitted payload in a container is the net mass which is obtained when the tare weight is deducted from the maximum gross mass. The following worked examples are for two different 20' and 40' containers:

Payload in kilograms	Force in newtons	Internal length in meters	Internal width in meters	Pressure in pascals	Pressure in kilopascals
18,370	180,209.70	5935	2370	12,811.77	12.81
21,780	213,661.80	5895	2393	15,146.08	15.15
26,700	261,927.00	12,033	2352	9,254.84	9.25
29,650	290,866.50	12,069	2350	10,255.45	10.26

Example calculation of permitted stack pressure in containers

In the literature, values of 14 kN/m² for 20' containers and of 10 kN/m² for 40' containers are frequently stated as maximum floor loading values. However, as has been shown, this value varies from container to container and may easily be calculated. The maximum stack pressure in a container would be the same as the maximum container floor loading value if the container were packed absolutely evenly.

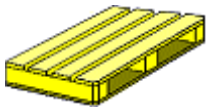
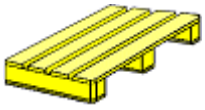
Official pressure units are only very rarely used for calculations in the transport sector. Since it is masses which are handled, pressure is often assumed to be the product of dividing mass by area:

Instead of the official units, units such as kg/ cm², kg/m², metric tons/m² or the English-speaking world's psi (pounds per square inch) are used. While, strictly speaking, this is incorrect, such units are widely used in practice and are more readily comprehensible to many of the personnel involved. The following relations apply when converting such units into the official units and vice versa.

- Hectopascals (hPa) correspond to the old unit millibar (mbar).
- One bar corresponds to 100 kPa or 0.1 MPa.
- Kilogram/square centimeter (kg/cm²) roughly corresponds to one bar or 100 kPa or 0.1 MPa.
- One kilogram/square centimeter corresponds to 10 metric tons/m²
- One kilopascal (kPa) = 1000 N/m² and corresponds to 100 kg/m² or 0.1 metric tons/m².
- One kilogram/square centimeter roughly corresponds to 14 lb/square inch (psi).

A forklift truck tire pumped up to a pressure of 8.5 bar accordingly has a pressure of 85 kPa, 0.085 MPa or, roughly, 8.5 kg/cm² or 85 metric tons/m². In the English-speaking world, the tire is at a pressure of 119 psi.

The stacking crush pressure is the pressure exerted by an item of cargo on underlying items of cargo or components.

Pallet structure	Force in newtons	Area of base in m²	Crush pressure kN/m² = kPa
	9,810	1000	9.81
	9,810	0.432	22.71
	9,810	0.288	34.06

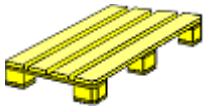
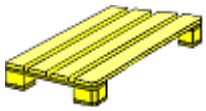
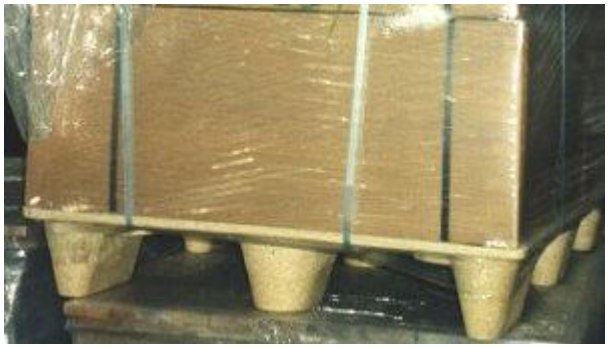
	9,810	0.0864	113.54
	9,810	0.0576	170.31

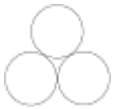
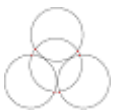
Table: Crush pressures for different pallets

Crush pressures are significantly higher for some pressboard pallets and similar types. Unless appropriate measures are taken to distribute the pressure, it is not possible to guarantee that transport will proceed without damage.



Elevated stacking crush pressures due to small contact areas

Extremely high pressures may occur if buckets, pails, barrels and similar cargoes are packed without an intermediate layer. For example, if a barrel of a mass of 183.5 kg and a total area of the barrel rim of 90 cm² is placed on the floor, a pressure of 200 kN is generated. Assuming the barrel rim to have a width of 0.5 cm, offset stowage of another barrel on top will result in a contact area of 0.00015 m², generating a pressure of 12,000 kPa.

Type of packing / contact areas		Force [N]	Area [m²]	Pressure [kPa]
		1,800	0.0090	200
		1,800	6 x 0.5 cm x 0.5 cm = 1.5 cm 0.00015 m²	12,000

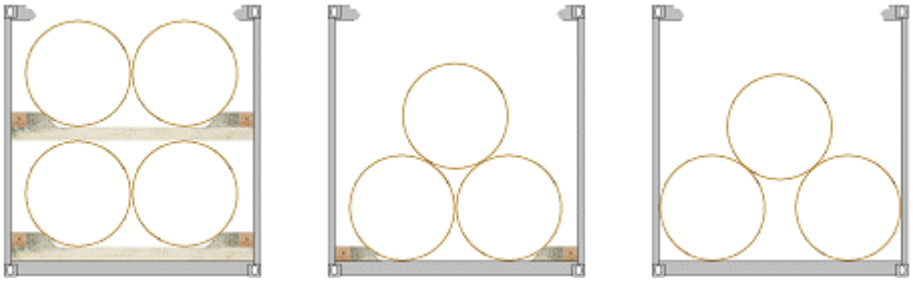
The only way forwarding personnel can prevent damage due to static mechanical stresses is by taking steps to distribute the pressure, as it is not possible to modify the shipping packages themselves or to change the masses involved. However, many warehouses and packing centers do

not hold stocks of appropriate materials in the form of walking boards, hardboard, wooden dunnage etc. Appropriate intermediate layers are often not used due to ignorance, for reasons of false economy or other motives.

It is essential to take the nature of the shipping packages into account. A skilled appraisal of the external appearance, such as the base of cases, cargo units and pallets, can provide valuable information as to how to load them. Efficient handling methods using lifting gear or ground conveyors usually require the use of beams or squared lumber beneath or between the items of cargo and such use can produce damaging levels of pressure.

Even strapping packages may cause damage due to excessive pressure if edge protectors are not used to distribute the pressure in order to offset the weakness of the packages.

Very high pressures are generated by narrow or point bearing areas. Negative effects are magnified by multiple tiers or the angles of rest which arise, for example, when stowing pipes, rolls or similar cargoes.

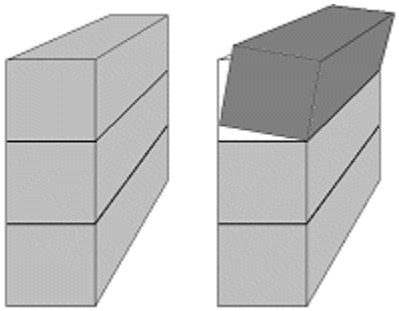


Packing in tiers **Cantline 1** **Cantline 2**

Packing in tiers generates extremely high pressures, as the pipes are only bearing on narrow strips corresponding to the edge lengths of the lumber. The resultant stack pressures are distinctly higher than in either of the two cantline stows. Due to the greater angles of rest or spread, cantline stow 2 generates greater forces than cantline stow 1. Further explanations in this respect may be found in the section, "Basic stowage methods".

The crush pressures bearing down on underlying layers of packages or the container floor is increased by the ship's motion. It is often forgotten that pressure does not only act downwards from above due to the force of gravity, but may also act laterally due to dynamic stresses. In this case, the packages are pressed against one another or the container walls. This pressure and in particular slipping and subsequent collision of inadequately secured packages may result in damage.

Very few packers anticipate "home-grown" static mechanical stresses due to inadequate cargo securing, but such stresses are predictable: if cargo stacks can move, critical and dangerously high pressures may arise as tipping occurs due to the resultant very small contact area.



"Home-grown" static mechanical stresses

The reduction in contact area with a simultaneous increase in pressure may cause the edges of the packages to cave in, resulting in damage to the shipping packages and collapse of the stack. In particularly unfavorable cases, this may result in the loss of whole batches or even of the container.

The actual tipping, collision or collapse of packages will be addressed in the dynamic mechanical shipping stresses section.

2.3.2 Dynamic mechanical shipping stresses

In relation to dynamic stresses, a primary distinction is drawn between vibration and jolting. In physical terms, the two phenomena are similar, but the distinction is made because they differ in their effects on packages and means of transport.

Vibration comprises periodic oscillations which generally occur in large numbers, such as vehicle or engine vibration, movement of ship in rough seas etc.

Jolting comprises occasional events, as may be observed on impact, dropping or tipping. Bumping, kicking or switching impacts are all words which paint a sufficiently clear picture.

The absolute magnitude of both types of stress is measured from their amplitude. For vibration, the second important parameter is frequency, i.e. the number of periodically repeating oscillations within a specific period [cycles/second]. For jolting, pulse duration and frequency are the other determining factors in addition to amplitude.

Dynamic mechanical shipping stresses are accordingly primarily caused by acceleration arising from changes in direction or speed. Acceleration values are particularly high if these changes occur very rapidly. The formulae clarify the relationship:

$$\text{Linear acceleration} = \frac{\text{Change in speed}}{\text{Time}}$$

since

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

, it follows that linear acceleration may be calculated from the following formula:

$$\text{Linear acceleration} = \frac{\text{Distance}}{\text{Time x Time}} = \frac{\text{Distance}}{\text{Time}^2}$$

$$a = \frac{\Delta V}{\Delta t} = \frac{s}{t \times t} = \frac{s}{t^2} \left[\frac{m}{s^2} \text{ or } \frac{km/h}{s} \right]$$

If a car accelerates from 0 km/h to 108 km/h in 12 seconds, its speed has changed by 9 km/h or 2.5 m/s each second.
Its acceleration, a, is thus 9 km/h/s or, stated in other terms:
2.5 m/s·s or 2.5 m/s If a truck traveling at a speed of 90 km/h takes five seconds to come to a standstill, it is decelerating at 18 km/h per second or 5 m/s per second. This is precisely the braking deceleration of 5 m/s² specified in the German road traffic licensing regulations (StVZO) and German accident prevention regulations.

A ship which, while pitching in a heavy sea, suffers a loss of speed from 21 knots to 9.3 knots within 2 seconds undergoes negative acceleration of
-11.7 kn/2 s = -5.85 kn/s = -10.834 km/h/s = -3 m/s² and is thus decelerated.

Acceleration arising from a change in direction may be calculated in accordance with the following formula:

$$\text{Radial acceleration} = \frac{\text{Speed}^2}{\text{Curve radius}}$$

If a road vehicle takes a tight curve with a curve radius of 20 m at a speed of 36 km/h, which corresponds to 10 m/s, it undergoes radial acceleration of 5 m/s².

Driving through potholes also causes radial acceleration because there is a change in direction from the horizontal to the vertical and back again. In vehicles with poor shock absorption, this causes considerable acceleration as the curve radii are very small and the speeds at which they are driven through are relatively high. In this case, only the suspension and other design parameters protect the vehicle and its load from severe damage. In roll trailers without suspension, rough ground in the terminal may result in high levels of acceleration and consequent damage to the cargo. It is a relatively frequent occurrence for shipping packages to fall off the trailers during such transport operations within cargo handling facilities.



The action of gravity subjects any object on the earth to downwards acceleration, which is known as acceleration due to gravity. The value of this acceleration is constant. Acceleration due to gravity, rounded to two decimal places, is 9.81 m/s² and is designated 1 g. For rough calculations, 1 g may also be assumed to have a value of 10 m/s².

In order to appreciate quite what an acceleration of 1 g means, imagine a road vehicle accelerating from 0 km/h to just about 106 km/h in 3 seconds. The calculation is as follows:

$$a = \frac{\Delta v}{\Delta t} = \frac{105.948\ \cancel{km} \cdot 1000\ m \quad \cancel{h}}{3\ s \quad \cancel{h} \quad \cancel{km}\ 3600\ s} = 9.81\ \frac{m}{s^2}$$

If the magnitude of an acceleration is known, the force it applies to a mass may be calculated from Newton's second law of motion:

Force = Mass · Acceleration

The formulae are conventionally written:

$F = m \cdot a \quad [N = kg \cdot m/s^2] \quad \text{or} \quad [kN = t \cdot m/s^2]$

$F = m \cdot g \quad (g = 9.81\ m/s^2)$

On earth, force and weight are physically identical. As a result of acceleration due to gravity, an object of a mass of 100 kg exerts a force of F = 100 kg x 9.81 m/s² = 981 N on whatever is supporting it. Stated in other units, this force amounts to 98.1 daN (decanewtons) or 0.981 kN (kilonewtons).

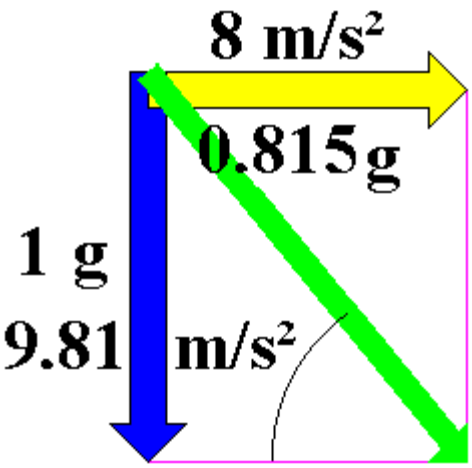
Weight-force should accordingly be taken to mean the force with which an object is attracted by the earth's gravity. This force always acts perpendicularly downwards. The formula used is as above, but replacing the general abbreviation F for Force with G.

$G = m \cdot a \quad [N = kN \cdot m/s^2] \quad \text{or} \quad [kN = t \cdot m/s^2]$

Some publications, such as for example the VDI Guidelines, mention normal force and the abbreviation F is provided with the index N, giving FN = normal force.

Force and acceleration are vector quantities, i.e. quantities in which both magnitude and direction

must be stated. Acceleration due to gravity g, however, is always in the same direction as weight.



A motorcycle rider traveling around a corner with a radius of 50 m at 72 km/h will experience radial acceleration of 8 m/s²
(ar= v²/t = 20 m/s x 20 m/s / 50 m = 8 m/s²).

Composition of forces in a parallelogram of forces

The blue vector of acceleration due to gravity of 1 g or 9.81 m/s² acts perpendicularly downwards, the yellow vector of radial acceleration of 8 m/s² acts horizontally in the direction of the curve and corresponds to 81.5% of acceleration due to gravity (0.815 g). The green vector is the resultant acceleration of 12.658 m/s². The direction of the resultant vector is also described as the apparent vertical.



A motorcycle rider must lean into the curve by 39.2°, relative to the vertical, in order to offset this force. His motorcycle will then be at an angle of 50.8° to the horizontal (tan \alpha; = 9.81 m/s² ÷ 8 m/s² = 1.22625) and he will be pressed down towards the ground with approx. 1.3 times his normal force (12.658 m/s² ÷ 9.81 m/s²).

If, instead of being stated in m/s², acceleration values are given in fractions or multiples of acceleration due to gravity (g), the forces may be determined with sufficient accuracy directly in decanewtons (daN), if mass is stated in kilograms (kg).

If the mass is located within a frame of reference under acceleration, the vector exhibits an inertia force acting on the mass in the opposite direction to the acceleration. An example of this is the automobile driver who, on accelerating, is pressed back into his seat (positive acceleration and negative inertia force) or, on braking, is pulled forward (negative acceleration and positive inertia force).

Friction forces are passive forces, which come into play when objects on a substrate are to be set in motion by forces (static friction) or are to be kept in motion (sliding friction and rolling friction). Static friction also comes into play when the direction of motion of an object (already subject to sliding or rolling friction) is changed. An automobile cornering is a good example, as all that keeps the vehicle on its desired path is the sufficient static friction of the tires (in reality, the phenomena at play are more complex than shown here). Friction forces counteract incident forces. The following formulae may be used to calculate the size of friction forces.

Static friction = Normal force perpendicular to sliding surface · Friction coefficient for static friction

$$f_0 = n \cdot \mu_0$$

Sliding friction = Normal force perpendicular to sliding surface · Friction coefficient for sliding friction

$$f = n \cdot \mu$$

The normal force perpendicular to the sliding surface may be stated in N, daN, kN or similar units of force. Since the various coefficients of friction are dimensionless, the determined friction force has the same calculation dimension as for the normal force perpendicular to the sliding surface.

Since friction is of great significance to cargo securing, more detailed explanations will be provided in another section.

Vibration and jolting of the vehicles and equipment used, together with the fundamental and resonant vibration of goods, packaging and cushioning material together largely define the risk of damage to which the goods are exposed during carriage. The magnitude of the **pulses**, i.e. the duration of forces or velocity of masses, is of vital significance in this connection.

Note: If sensitive goods are to be packaged and carried without suffering damage, it is essential to be aware not only of the frequency spectra which arise during storage, handling and transport but also of the natural frequencies of the goods being shipped, the shipping packages, cushioning material etc. In the high frequency range, extremely high acceleration values of several dozen to a few hundred g have been measured. However, due to the mass inertia of the shipping packages, such short duration impacts rarely cause damage due to inadequate cargo securing. However, the consignor must provide appropriate packaging for sensitive goods in order to mitigate such vibration. In the low frequency range, acceleration values encountered during transport and handling are of the order of some fractions of a g to several g. The longer period of action may result in shifting of the cargo and consequent mechanical damage. These low "normal values" applying to cargo securing on or in vehicles are stated by various organizations. Those involved with shipping should be aware of usual g values.

The effects of dynamic mechanical shipping stresses are frequently underestimated, despite the

"normal values" being widely available or easily obtainable. The CTU packing guidelines contain various comments on this issue.

Note: The following comments may be made regarding the tables shown in section 1.9 of the CTU packing guidelines: the wording/notation is incorrect in that forces are stated in the column headings, while the level of acceleration caused by such forces is stated in the associated fields. If forces are the intended meaning, "g" as a measure of acceleration due to gravity of 9.81 m/s² ought to be replaced by "G" as a unit for the normal force. If, however, the values in the table are intended to indicate the level of acceleration, the word "forces" in the column headings ought in each case to be replaced by "acceleration". The same applies to the wording of the footnotes to the tables.

2.3.3 Mechanical stresses in maritime transport

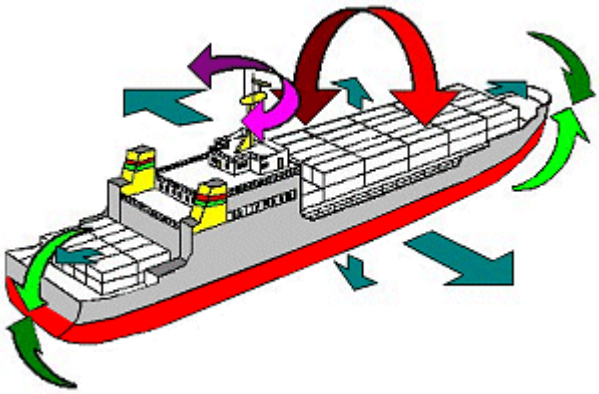
Section 1 "General conditions" in the CTU packing guidelines clearly states, for example in point 1.1:

> *Voyages are made in a variety of weather conditions which are likely to exert a combination of forces upon the ship and its cargo over a prolonged period. Such forces may arise from pitching, rolling, heaving, surging, yawing or swaying or a combination of any two or more.*

Point 1.2 continues:

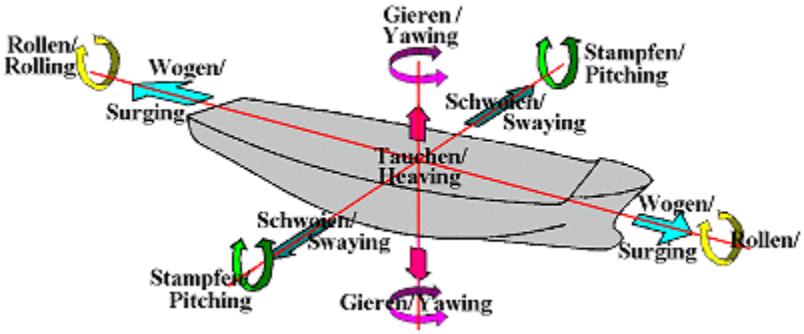
> *Packing and securing of cargo into/onto a CTU should be carried out with this in mind. It should never be assumed that the weather will be calm and the sea smooth or that securing methods used for land transport will always be adequate at sea.*

The acceleration values to be anticipated in maritime transport depend on the shape of the surface or sub-surface vessel, its beam, the position of the center of gravity and center of buoyancy and similar parameters which determine the behavior of ships at sea.



Ship movement at sea

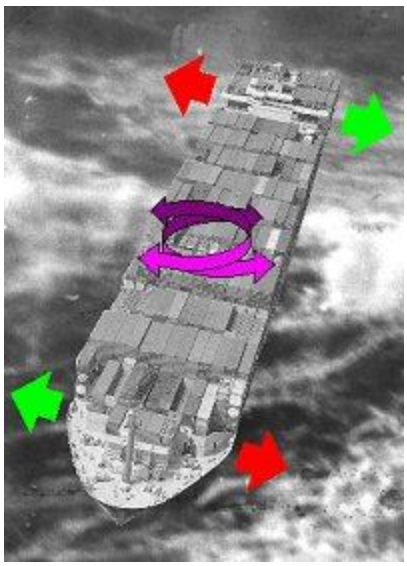
All kinds of ship movement may be divided into three types of linear motion and three types of rotational motion.



Linear motion	Rotational motion
Surging is motion along the longitudinal axis.	Rolling is motion around the longitudinal axis.
Swaying is motion along the transverse axis.	Pitching is motion around the transverse axis.
Heaving is motion along the vertical axis.	Yawing is motion around the vertical axis.

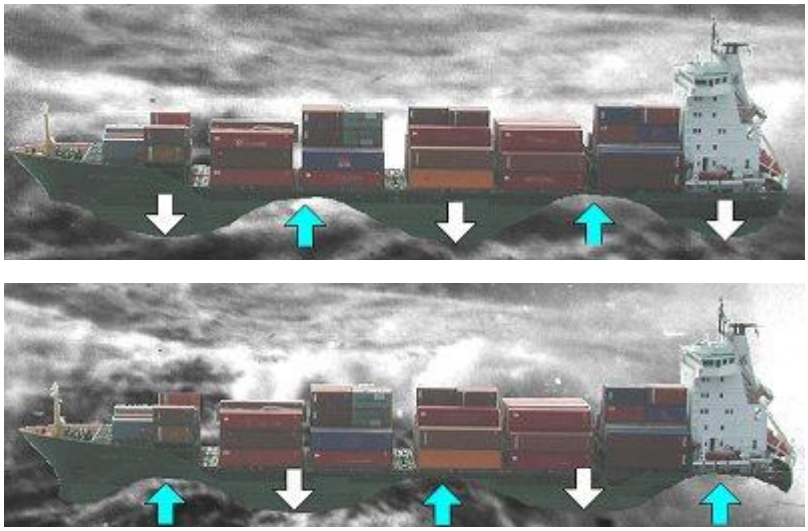
Summary of ship movement

It can in general be stated that the outwardly directed centrifugal accelerations brought about by any rotational motion are not significant. This accordingly applies to yawing, pitching and rolling.



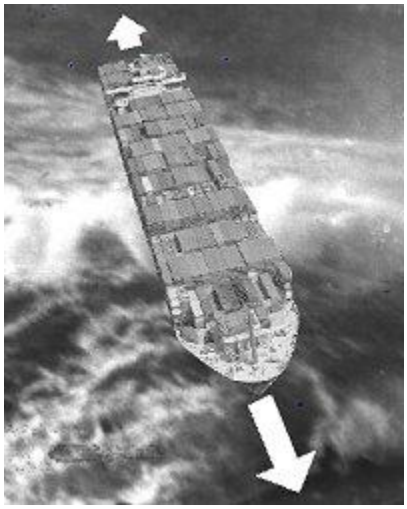
Yawing is motion around the ship's vertical axis.

Yawing involves rotation of the ship around its vertical axis. This occurs due to the impossibility of steering a ship on an absolutely straight course. Depending upon sea conditions and rudder deflection, the ship will swing around its projected course. Yawing is not a cause of shipping damage.

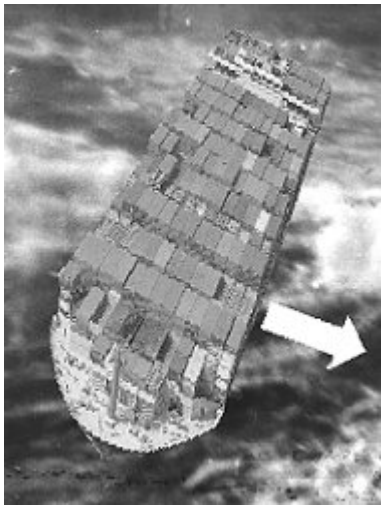


Heaving is motion along the ship's vertical axis.

Heaving involves upward and downward acceleration of ships along their vertical axis. Only in an absolute calm are upward and downward motion at equilibrium and the ship floats at rest. Buoyancy varies as a ship travels through wave crests and troughs. If the wave troughs predominate, buoyancy falls and the ship "sinks" (top picture), while if the wave crests predominate, the ship "rises" (bottom picture). Such constant oscillation has a marked effect on the containers and their contents.

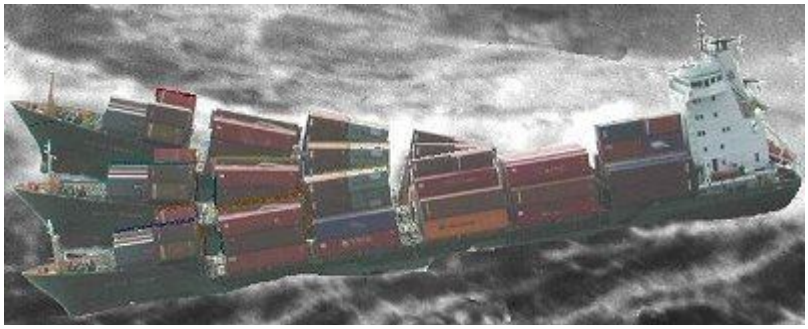


Surging is motion along the ship's longitudinal axis.



Swaying is motion along the ship's transverse axis.

In **surging** and **swaying**, the sea's motion accelerates and decelerates the ship forward and backward and side to side. Depending upon the lie of the vessel, these movements may occur in all possible axes, not merely, for example, horizontally. If a vessel's forebody is on one side of a wave crest and the afterbody on the other side, the hull may be subjected to considerable torsion forces.



Pitching is the movement of a ship around its transverse axis.

In **pitching** a ship is lifted at the bow and lowered at the stern and vice versa. Pitching angles vary with the length of vessel. In relatively short vessels they are 5° - 8° and sometimes more, while in very long vessels they are usually less than 5°. In a container ship 300 m in length with a pitching angle of 3°, a container stowed in the bay closest to the bow or stern at a distance of approx. 140 m from the pitching axis will cover a distance of 29 m within a pitching cycle, being raised 7.33 m upwards from the horizontal before descending 14.66 m downwards and finally being raised 7.33 m again and then restarting the process. During upward motion, stack pressures rise, while they fall during downward motion.





Rolling is the movement of a ship around its longitudinal axis, the rolling angle in this case being 10°.

Rolling involves side-to-side movement of the vessel. The rolling period is defined as the time taken for a full rolling oscillation from the horizontal to the left, back to horizontal then to the right and then back to horizontal. In vessels with a high righting capacity, i.e. stiff ships, rolling periods of ten seconds and below are entirely usual. Rolling angle is measured relative to the horizontal. Just in moderate seas, even very large vessels roll to an angle of 10°.





Rolling angles of 30° are not unusual in heavy weather.

In bad weather, angles of 30° are not unusual. Even the largest container ships must be expected to roll to such angles. Stabilizers and other anti-heeling systems may help to damp ship movements. However, not all systems are usable or sufficiently effective in bad weather.

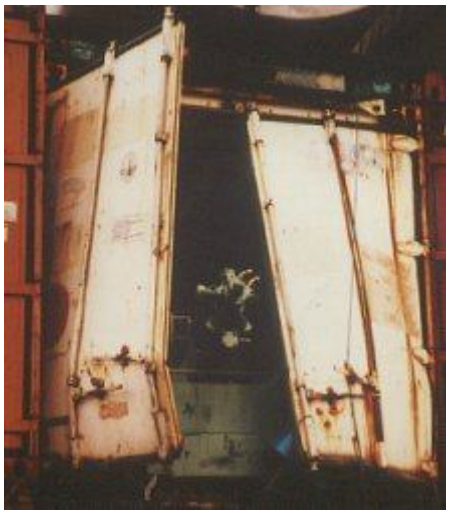


Rolling angle of 45°

On rare occasions, rolling angles may reach 45° and above. It is easy to imagine what that means for inadequately secured container cargoes.

Rolling and **pitching** of a vessel generate upward and downward acceleration forces directed tangentially to the direction of rotation, the values of which increase with distance from the rolling or pitching axis and are inversely proportional to the square of the rolling or pitching periods. At an identical distance from the axis, if the rolling or pitching period is halved, acceleration forces are quadrupled, while if the rolling or pitching period is doubled, acceleration forces are quartered. Rolling or pitching angles generate downslope forces. Steeper tilting, as occurs during rolling, promote cargo slippage. As already mentioned, the outwardly acting centrifugal accelerations generated by rotational motion are of no significance in rolling and pitching.

Overall, containers and packages may be exposed to such accelerations for very long periods when at sea. Moreover, the oscillations may be superimposed one on the other and be intensified.





Damage to containers in rolling motion, caused by inadequately secured cargo:

left: in a container stowed athwartships right: in a fore and aft stowed container

It must be emphasized that it was not the "hazards of the sea" which caused the damage, but instead inadequate securing inside the container. While such damage has indeed occurred in association with the rolling motion of the ship, the root cause is the "home-grown" acceleration forces arising from shortcomings in packing and securing.



Slamming describes the hydrodynamic impacts undergone by a ship.

Slamming is the term used to describe the hydrodynamic impacts which a ship encounters due to the up and down motion of the hull, entry into wave crests and the consequent abrupt immersion of the ship into the sea.

Vibration from the hull can be transferred to the cargo. Goods are exposed to stresses from the extremely low frequency oscillations generated by sea conditions and by higher frequency machinery and propeller vibration. Such risks can and must be avoided by using seaworthy shipping packages which are fit for purpose.

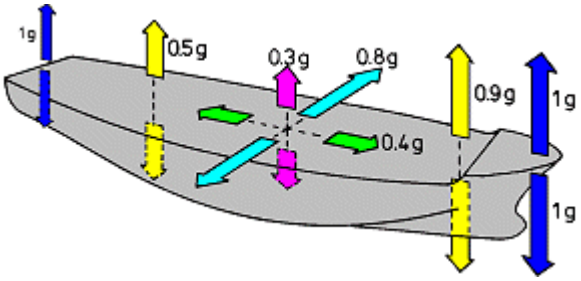
The **absolute acceleration values** encountered on board ship are not excessively high. In favorable stowage spaces, they may even be considerably lower than those encountered in land or air transport. In many cases, not even the values stated in the following Table occur. However, the frequency with which the motion occurs must definitely be borne in mind. At a rolling period of 10 s, a ship moves side to side 8640 times daily. Over several days' bad weather, the cargo will thus be exposed to alternating loads tens of thousands of times.

Mode of transport: ocean-going vessel	**Forward acting forces**	**Backward acting forces**	**Sideways acting forces**
Baltic Sea	0.3 g (b)	0.3 g (b)	0.5 g
North Sea	0.3 g (c)	0.3 g (c)	0.7 g
Unrestricted	0.4 g (d)	0.4 g (d)	0.8 g
1 g = 9.81 m/sec² The above values should be combined with static gravity force of 1.0 g acting downwards and a dynamic variation of:			
	(b)= ±0.5g	(c)= ±0.7g	(d)= ±0.8g

Extract from a Table in the CTU packing guidelines

In relation to the Table, it is stated in point 1.7 of the CTU packing guidelines that examples of accelerations are given which could arise during transport operations:

However, national legislation or recommendations may require the use of other values.
The values stated in footnotes (a), (b) and (c) in principle describe accelerations in the vertical direction. Such accelerations are particularly high in pitching and rolling movements and, in exposed positions in very bad weather, can easily reach 1 g. The CTU packing guidelines here state the maximum at 0.8 g. Vertical acceleration reduces friction forces and increases stack pressure.



Overview of acceleration forces prevailing on board a ship

Annex 13 of the CSS Code contains tables for determining acceleration forces as a function of stowage space on board, the ship's length and speed. However, these tables are not suitable for use when packing CTUs and securing cargoes in or on CTUs, specifically for the following reasons:

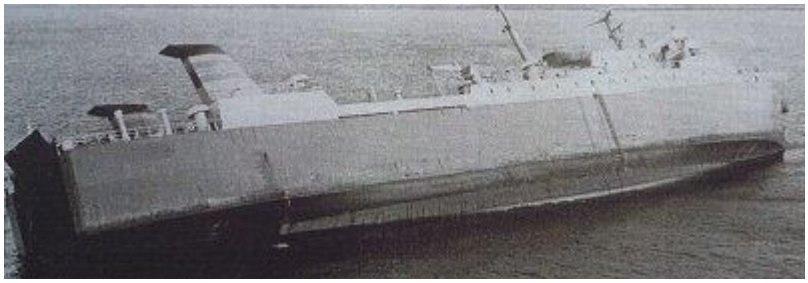
If containers, road vehicles, rail cars or the like and road trailers, roll trailers and semitrailers are loaded inland for maritime transport, their ultimate stowage space on board is unknown. The least favorable conditions should thus always be taken into account. As a rule of thumb, loads of 1 g in the vertical direction and 0.8 g in the horizontal direction should be anticipated for worldwide transport. The shipowner will not accept any attempt by the shipper to specify a particular container slot in advance. Even notes on the bill of lading requiring loading below deck are ineffective. All shipping packages must accordingly be constructed so as to be able to withstand 0.8 times the weight of all adjacently stowed cargo and twice the mass of the cargo loaded on top. If this is not the case, appropriate protective measures must be taken. Additional rigid receptacles, frames, false decks and similar measures may be helpful.

Modern cargo handling procedures and the ships developed for this purpose have made maritime transport faster and cheaper and, in particular, have reduced cargo handling stresses in port. In order to ensure great flexibility in terms of loading and unloading, modern ships, in particular ro/ro freighters and ferries, inevitably have poorer seakeeping ability than conventional general cargo or heavy-lift vessels.

For reasons of stability during loading, they require a high righting capacity. As "stiff" vessels they initially oppose heeling movements with a very high righting moment. The high roll moment of inertia of these vessels entails shorter rolling periods and high transverse acceleration forces. Due to the particular nature of ro/ro shipping, the ship's command is not generally able to influence the stability behavior of these ships by adjusting the weight distribution. The risk of accidents is particularly high because, given the large free surfaces in the ship, overturning cargo and the possible consequent ingress of water may result in an abrupt capsize. Most readers will remember major accidents of this kind. Inadequate cargo securing in transport receptacles such as containers, swap-bodies etc. may consequently have a very significant impact on ship safety.



Ro/ro freighter listing as a result of water ingress



Free surfaces on board always increase the risk of capsize.

"Home-grown" acceleration forces in maritime transport are the commonest cause of cargo damage on board ship.



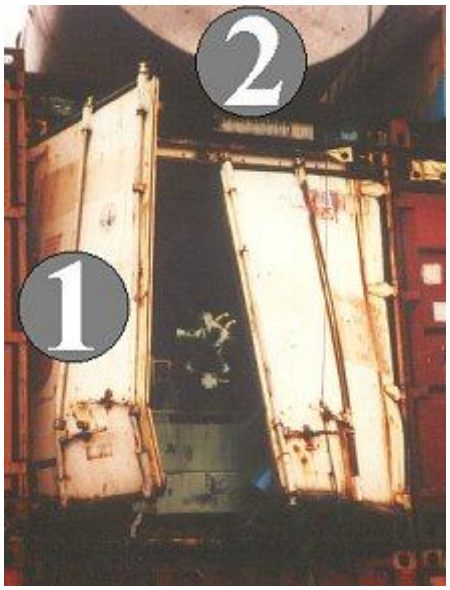
Damage caused by "home-grown" acceleration forces

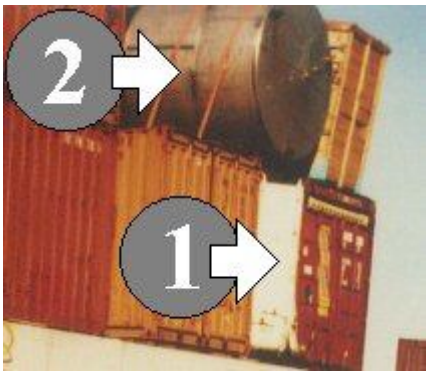
Because container packers do not have the appropriate knowledge and skills, they underestimate the effect of gaps in the stow. The consequent motion has a devastating effect on the cargo.



Damage caused by "home-grown" acceleration forces

"Home-grown" acceleration can readily be identified on board ship if the stowage spaces have been subjected to similar forces, but only some of the goods have suffered damage. It is even clearer when goods stowed in an exposed location remain undamaged, while other goods suffer damage despite being exposed to lower acceleration forces. The cases on the platform at the top left were exposed to higher acceleration forces than the cargoes in the containers, which were stowed beneath or further inwards. Although the cases were only secured with a single belt each, they have only shifted slightly, while the containers and their contents have been completely destroyed.

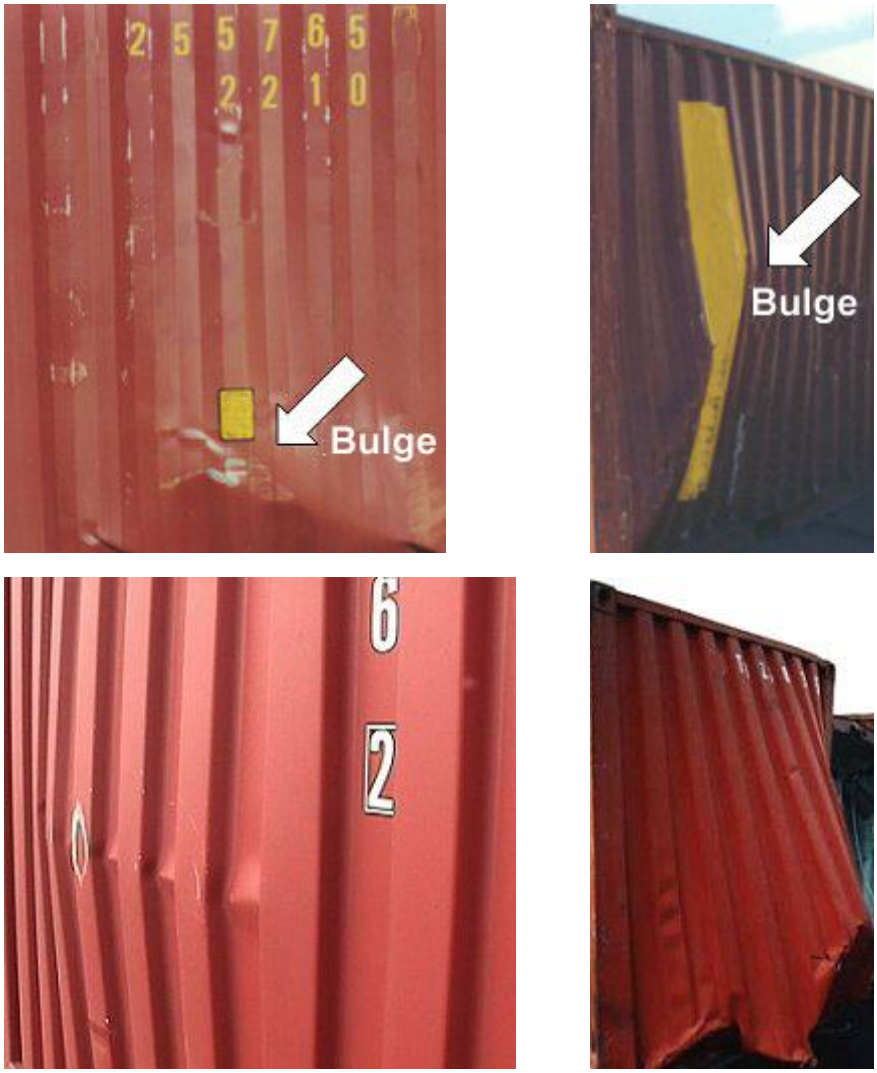




Effects of "home-grown" acceleration forces

In the lower container (1), the poorly secured machine has been set in motion and has forced the container doors open. The tank on the platform (2) stowed above is secured with only two belts and thus also inadequately. Nevertheless, it has withstood the acceleration forces and has slipped only a little. This is a clear indication that the acceleration forces were still relatively slight.

The following pictures clearly show the results of home-grown acceleration forces. It should be noted that almost all of the containers have been exposed to stresses from the inside outwards, i.e. they have bulges rather than dents.



Bulges in containers as a result of home-grown acceleration forces



Container "ripped apart" as a result of home-grown acceleration forces

The fiber structure of the plywood walls of the container in the picture above clearly reveals that the

forces were acting from the inside outwards. The container was destroyed by gaps in the stow. These gaps resulted in extremely high acceleration forces and shocks.




Damage as a result of home-grown acceleration forces

Annex 13 of the CSS Code provides tools to assist in calculating **wind pressure and the effects of spray**. The details provided in this publication may possibly be of assistance in dimensioning cargo securing on open containers such as flatracks, platforms etc., but they are otherwise of interest only to the ship's command, but not to container packers working inland. As a rough guide, wind pressure may be estimated, for example for fastening tarpaulins etc., at 100 daN/m². Closed containers are spray-tight provided that they have no technical defects.



Effects of breaking-wave impact

Cargoes stowed on deck may be exposed to **breaking-wave impact**. Even for experts, the magnitude of these forces and their effects are difficult to estimate. Additional securing measures cannot prevent such effects or only to a very limited extent. While securing can never withstand breaking-wave impact, cargoes on open containers should, as a precaution, be secured against floating away.

In conventional shipping, damage prevention is the responsibility of the ship's command. Responsible ship's commands will accordingly use any means available to them to keep the effects of rough seas and breaking-wave impact as small as possible. Cargo officers will stow cargoes which are particularly sensitive or require particularly extensive securing in locations which are subjected to less acceleration. In container trade, no consideration can be given to special requirements with regard to stowage space for particular containers. Moreover, the central stowage

planning offices, which prepare initial plans, and the ship's command have no knowledge as to what is loaded in the containers. Dangerous cargo containers are an exception. In this case, the contents are known and the containers receive special stowage spaces.



Breaking-wave impact means that "green water" has come onto the deck.

Damage caused by breaking-wave impact



Container ripped open by breaking-wave impact

Summary of mechanical stresses arising during maritime transport

In very general terms, it can be stated that cargo transport units may be exposed to very different stresses during maritime transport than they are in road, rail or inland waterway transport. Unless the voyage proceeds very calmly in good weather, the containers and their cargoes will be exposed to oscillation/vibration which is primarily caused by rolling and pitching. It is almost exclusively during rolling, due to the tilt/rolling angles which arise, that shipping packages are pressed against the container walls and are squashed against the walls or the surfaces of adjacent shipping packages. The same occurs in "open" containers if parts of the cargo are pressed against the lashings or bracing. The oscillations of rolling and pitching alternately increase and reduce stack pressure. These changes peak at the moment the motion is reversed. Assuming a vertical acceleration of 1 g, a package can thus alternate between "twice its weight" and "weightless". Appropriate deductions or additions may be made for other acceleration values. When containers are incorrectly packed or

the cargoes inadequately secured, the packages may shift, be dented, squashed, jumbled up etc.



Jumbled cartons in a container

2.3.4 Mechanical stresses in road transport

The short section 1.4 of the CTU packing guidelines is devoted to the stresses occurring on roads, specifically:

> *Road transport operations may generate short-term longitudinal forces upon the cargo and the CTU. They may also cause vibrations that may vary considerably due to different suspension systems, different road surface conditions and different driving habits.*

The guidelines also contain several explanatory sketches.

In a nutshell: anticipated stresses are determined by structural parameters of the goods and of the vehicle/vehicle combination, the position of the goods on the loading area, how fully laden the vehicle is, the condition of the roadway, the driver's habits etc. Special transport operations entail obtaining comprehensive information about the circumstances to be taken into account. Stowing and securing measures may then be tailored to the particular transport situation. If precise data are unobtainable, the values stated in the CTU packing guidelines, or the assumed loads specified by the relevant national organizations, should be taken into account.

Mode of transport: road	Forward acting forces	Backward acting forces	Sideways acting forces
VDI guidelines	0.8 g	0.5 g	0.5 g
CTU packing guidelines	1.0 g	0.5 g	0.5 g
Swiss road transport regulations	1.0 g	0.5 g	0.5 g
British regulations	1.2 g	0.5 g	0.8 g

In relation to the Table (see also comment on page 89), it is stated in point 1.7 of the CTU packing guidelines that examples of accelerations are given which could arise during transport operations:

... However, national legislation or recommendations may require the use of other values.
It is unsatisfactory that the tables generally state no values for vertical acceleration, although any road user will know just how much road vehicles can vibrate up and down. The Swiss road haulage association "Les Routiers Suisses" allows for upward vertical accelerations of 1 g.



Acceleration in longitudinal direction according to VDI guidelines



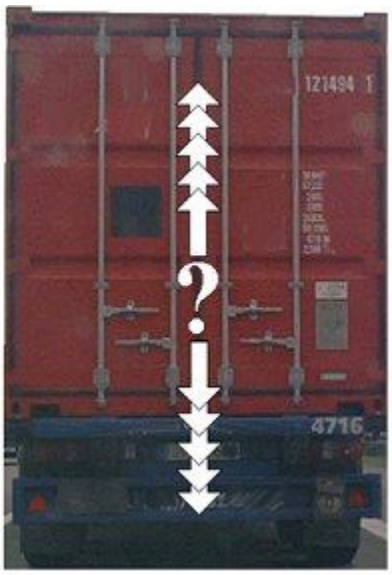
Acceleration in longitudinal direction according to CTU packing guidelines

The forward acceleration of 0.8 g according to the VDI guidelines or of 1.0 g according to the CTU packing guidelines means that forces of 80% or 100% respectively of the package weight will act on the packages in this direction. Both sets of guidelines assume backward acceleration of 0.5 g, i.e. forces of 50% of the package weight will act on the packages in this direction.



Acceleration in the sideways direction according to the CTU packing guidelines and VDI guidelines

Again, both sets of guidelines assume identical sideways acceleration values of 0.5 g. Forces amounting to 50% of the package weight will accordingly also apply sideways.

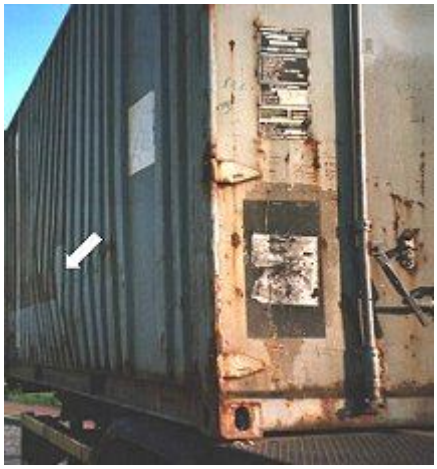


What value should be assumed for vertical acceleration?

The guidelines make no mention of vertical acceleration. Most road users will know from their own observation that loads can even lift off during road transport, i.e. values of just above 1 g vertically are quite readily achieved.

A brochure published by the former German federal railroad company, Deutsche Bundesbahn, states:

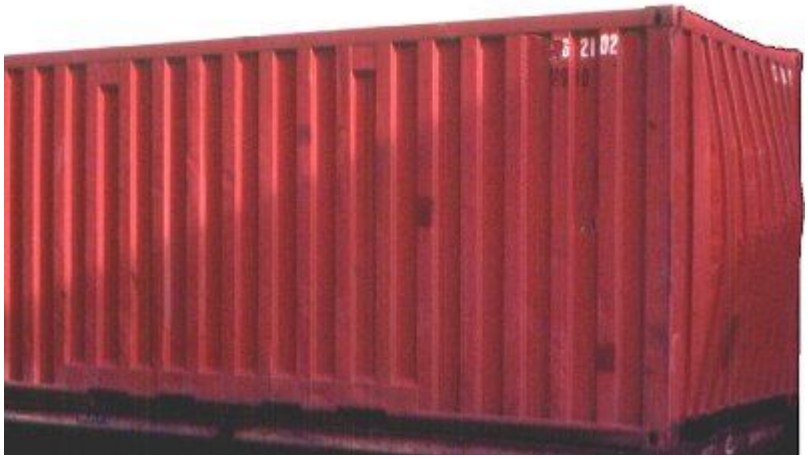
> *Considerable stresses .... in the vertical direction also occur during road delivery operations. (...) Forces of up to 0.85 times the weight-force of the load must be anticipated in the vertical direction. Measurements, filtered at 32 Hz, carried out by the Institute for automotive transport, Hanover University of Technology.*





Consequences of "home-grown" acceleration forces

As for every means of transport, the values stated in the guidelines only apply to loads which have been secured so that they cannot shift. If load items are able to move, considerably higher acceleration forces may come into play.



Consequences of "home-grown" acceleration forces in a container carried by road

An example: 8000 kg of goods in cartons had been loaded into the container in the photograph. The articulated truck carrying the container had to brake rather harder than usual at traffic lights. Although the braking deceleration was distinctly less than 0.8 g, this maximum value will be used for the purposes of the calculation. The coefficient of sliding friction of the cartons on the container floor and between the individual cartons will be assumed to be $\mu = 0.3$. The cartons would then have been able to exert a force of only 8000 kg x 0.5 g = 3924 daN against the front end wall of the container. As will be described in greater detail elsewhere, the loading capacity of the container end wall must amount to 0.6 times the payload. In the container shown, this would amount to 10,595 daN. The forces which actually occurred were accordingly at least 2.7 times higher. A very clear case of home-grown acceleration as a result of gaps in container packing.

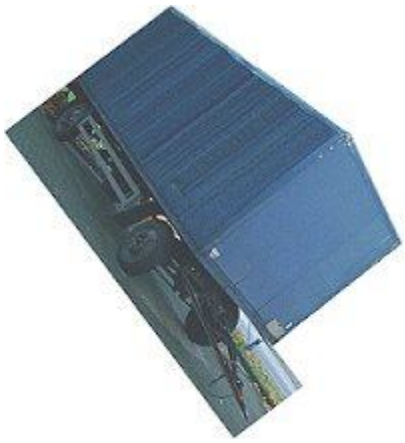


Consequences of "home-grown" acceleration forces on a small truck

An example: A 1000 kg package had been loaded into the vehicle shown in the photograph. The vehicle was going around a curve with a radius of 25 m at a moderate speed of 36 km/h. This generated a sideways acceleration of 4 m/s². A force of 392.4 daN was accordingly applied to the load. Assuming a coefficient of sliding friction of $\mu = 0.3$, this force was counteracted by passive friction forces of 294.3 daN. The difference of 98.1 daN would never have been enough to smash through the sideboards and cause such damage to the vehicle. However, because the package was lying unsecured in the middle of the loading area, it was able to get a "run-up" and develop its destructive force.

The provisions governing the loading of road vehicles and the relevant accident prevention regulations specifically state that the load must be packed and secured in such a manner that, under normal traffic conditions, nothing can fall over, drop or roll off the vehicle and that any risk to life must be excluded. Usual traffic conditions in road transport include evasive maneuvers, hard braking and unevenness of the roadway which may occur simultaneously not merely separately. It should accordingly be assumed, as the basis for proper load securing, that a vehicle on a poor section of road suddenly has to brake hard and additionally execute an evasive maneuver. If the load can pass through such a situation unscathed, it may be deemed secure.

It should be borne in mind that the acceleration values which must be assumed for road vehicles according to VDI guidelines and the BGF, the German road vehicle maintenance employers' liability insurance association, correspond to the following tilts in degrees.





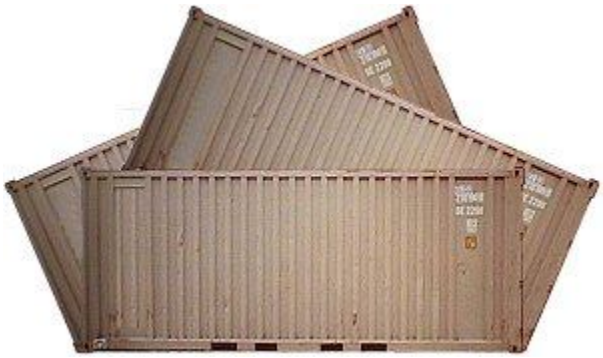
0.8 g forward acceleration in road transport corresponds to a tilt of 53°.

0.5 g backward acceleration in road transport corresponds to a tilt of 30°.



0.5 g sideways acceleration in road transport corresponds to a tilt of 30°.

The loading capacity of cargo transport units is specified in standards and the International Convention for Safe Containers. The relevant sections provide comprehensive information in this respect. However, the values will also be stated here by way of comparison with shipping stresses.



The loading capacity of the side walls of standard containers and of swap-bodies with a CSC plate corresponds to a tilt of 23.6°.

With a uniformly applied load, the front end walls of standard swap-bodies and containers must be able to withstand forces of 0.4 times the payload. This corresponds to an angle of 23.58°.



The loading capacity of the side walls of standard swap-bodies corresponds to a tilt of 17.5°.

With a uniformly applied load, the side walls of standard swap-bodies must be able to withstand forces of 0.3 times the payload. This corresponds to an angle of 17.46°.



The loading capacity of the side walls of standard containers and of swap-bodies with a CSC plate corresponds to a tilt of 36.9°.

With a uniformly applied load, the side walls of standard containers or of swap-bodies with a CSC plate which are used in maritime transport must be able to withstand forces of 0.6 times the payload. This corresponds to an angle of 36.87°.

2.3.5 Mechanical stresses in rail transport

The short section 1.5 of the CTU packing guidelines is devoted to the stresses occurring in rail transport, specifically:

> *Rail transport, in addition to subjecting cargo to vibrations (16 Hz), may also lead to shocks as a result of shunting [switching] operations. Many railways have organized their operations in such a way as to avoid shunting [switching] of railway wagons [rail cars] incurring high forces (e.g. by operating dedicated block trains) or by moving CTUs on wagons [cars] with high performance shock absorbers that are normally able to reduce shunting [switching] shock forces. It may be advisable to ensure that such operational features have been established for the rail journey.*

Several explanatory sketches are additionally included. The Definitions section of the CTU packing guidelines explains the terms shunting [switching] and block train:

Shunting [switching] *means the operation when single railway wagons [cars] or groups of railway wagons [cars] are pushed to run against each other and be coupled together.*



Switching engine with dangerous cargo container on a special rail car

Operationally, switching includes quite wide-ranging activities which will not be addressed in greater detail here. In modern switching yards, trains are divided up and reassembled by being pushed (for example with a switching engine) up and over a hump yard, so automating hump switching operations. The speed of the rail cars as they run down the hump is kept within the desired range by special braking or driving systems. Major switching impacts are a thing of the past. In a conventional system, the rail cars running down the hump are brought to a standstill with drag shoes. If the worker laying the drag shoes makes a mistake, switching impacts involving considerable deceleration may occur. If no hump yard is available, groups of rail cars are "kicked" by switching engines and the individual cars run into the appropriate sorting sidings, where they are again conventionally brought to a standstill with drag shoes. In this case too, high deceleration values may occur when the cars collide. Lower levels of deceleration occur when the cars are pushed to activate the couplings. The UIC specifies an acceleration value of 4 g for normal switching operations. Containers are not constructed for such stresses and should not be exposed to such acceleration forces.

Rail cars with high-performance buffers, as mentioned by the CTU packing guidelines, cut the "normal" switching impacts of 4 g in half to 2 g. In Germany, these rail cars with high-performance buffers have a lower case j in their name, for example Lgjs, Sgjs, Sgjkkms etc.

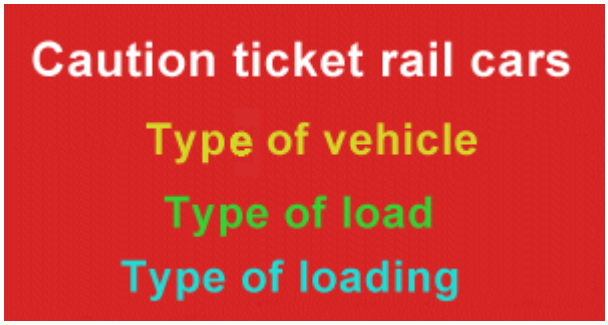


Rail car with high-performance shock absorbers



Rail cars with high-performance buffers

According to railroad operating procedures, a whole range of different rail cars must not be switched normally. This is determined by the type of rail vehicle, the type of loading or certain features.

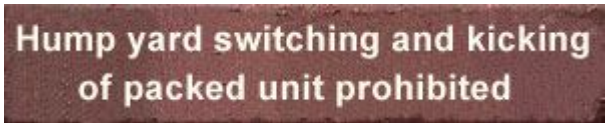


Reasons for operating under caution ticket scheme

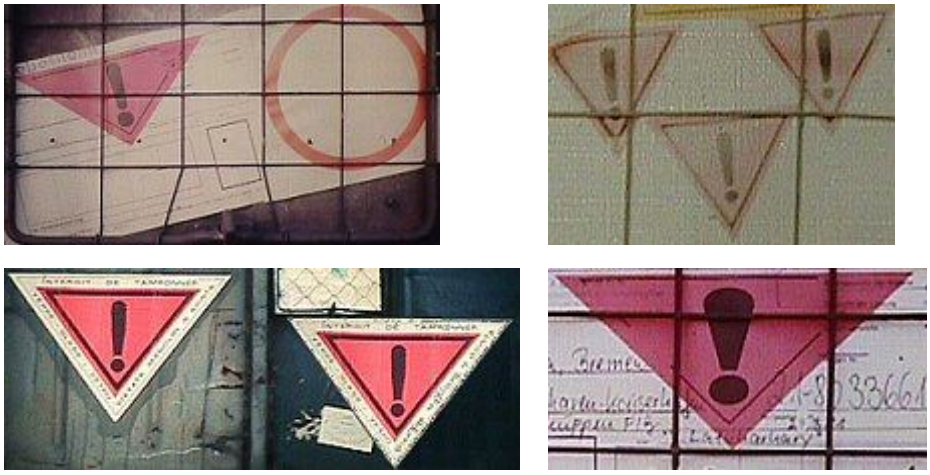
Rail cars operated under this scheme are either specially marked "from the outset", e.g. "Hump yard switching and kicking prohibited", "Switch carefully" etc., or they may be provided with special tickets bearing a yellow triangle standing on its apex, a red circle ticket or the standard caution tickets. Rail cars operating under the caution ticket scheme are divided into three classes.







Caution ticket marking, class 1



Caution ticket marking, classes 1, 2 and 3

The CTU packing guidelines also define block trains as follows:

> ***Block train*** *means a number of permanently coupled railway wagons [rail cars], normally running directly between two selected terminals or entities without shunting [switching].*

Such block trains are known as "point-to-point" services or "rail cars not switched in transit". A customer of the European UIC railroads can assume that any rail cars loaded with containers or other CTUs will be transported in block trains or handled under the caution ticket scheme. Accordingly, the only values which need be taken into account from the CTU packing guidelines Table stating the acceleration forces applying in railroad transport are those for combined transport in Europe:

Mode of transport: rail	**Forward acting forces**	**Backward acting forces**	**Sideways acting forces**
Rail cars subject to shunting [switching]*	4.0 g	4.0 g	0.5 g (a)
Combined transport**	1.0 g	1.0 g	0.5 g (a)
1 g = 9.81 m/s²			
The above values should be combined with static gravity force of 1.0 g acting downwards and a dynamic variation of: (a) = ± 0.3 g.			
* The use of specifically equipped rolling stock is advisable (e.g. high-performance shock absorbers, instructions for shunting [switching] restrictions).			
**"Combined transport" means "wagons [cars] with containers, swap-bodies, semitrailers and trucks, and also block trains (UIC and RIV)".			

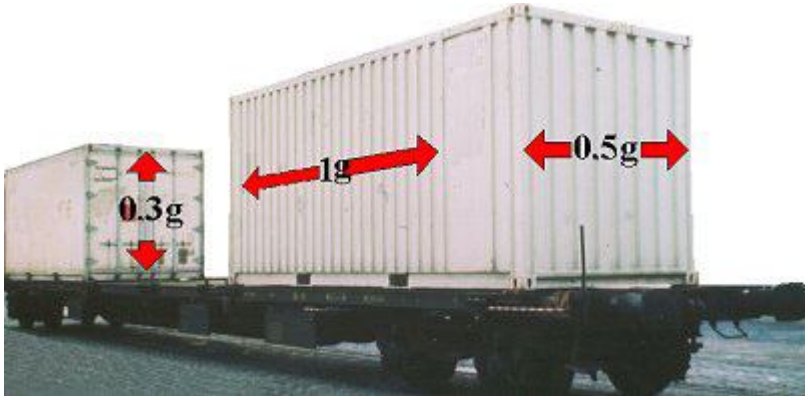
Table from the CTU packing guidelines

In relation to the Table, it is stated in point 1.7 of the CTU packing guidelines that examples of accelerations are given which could arise during transport operations:

> *... However, national legislation or recommendations may require the use of other values.*

The statement in the Table: "The above values should be combined with static gravity force of 1.0 g acting downwards and a dynamic variation of: (a) = ± 0.3 g" means that the CTU packing guidelines have adopted the UIC railroad values for acceleration. In accordance with these values vertical acceleration is calculated at 0.3 g.

The same values are also specified by the VDI guidelines for intermodal transport. In road-rail intermodal transport, the following values are thus obtained: 1 g in the longitudinal direction, 0.5 g sideways and 0.3 g vertically.



Acceleration values in intermodal transport

From the standpoint of the cargo, a longitudinal acceleration of 1 g is the same as if the container had been stood up vertically, first in one direction and then the other.



Longitudinal acceleration in intermodal transport is the same as if the CTU had been placed vertically.



Sideways acceleration of 0.5 g corresponds to a tilt angle of 30°.

Sideways acceleration values in road-rail intermodal transport are identical for both modes of transport. They correspond to a tilt of 30°.



Effect of vertical acceleration of ± 0.3 g in rail transport

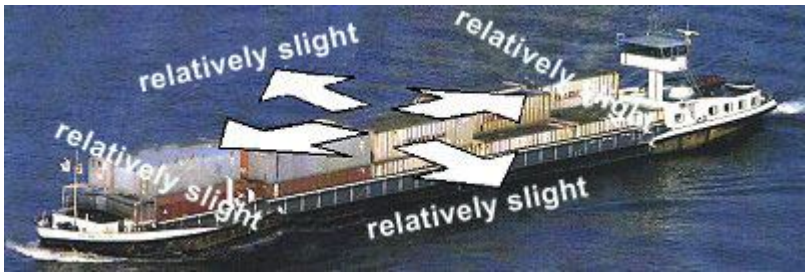
The effects of acceleration of ± 0.3 g are similar to each package in the container alternately becoming 30% heavier and then 30% lighter than its true weight.

Note: In the case of carriage by railroad companies in other continents or countries such as Africa, China, India, Canada, Russia, USA etc., information should be obtained about the prevailing conditions in each case. In some cases, stresses may be higher than in Europe. For example, in winter many containers destined for receivers close to the Great Lakes are unloaded in Halifax and carried by rail, for example to Detroit, because the sea route via the St. Lawrence Seaway is impassable due to ice.

2.3.6 Mechanical stresses in inland waterway transport

With regard to the acceleration forces encountered, an inland waterway vessel is regarded by the CTU packing guidelines as a very low risk means of transport, an opinion which is borne out in practice. Point 1.6 states:

> *Inland river and water transport is generally smooth. It will not normally exert any forces higher than those of road transport on the cargo and the CTU. Diesel engines of inland river and waterway vessels may create some low-frequency vibrations which under normal conditions should not give reason for any concern.*



Negligible acceleration forces in inland waterway transport

Higher frequency vibrations which could result in cargo damage are not a cargo securing but instead a packaging issue. Harmful vibration must be avoided in this case by means of appropriate cushioning materials. One error which is frequently encountered is providing excessive cushioning travel.

2.3.7 Mechanical stresses during cargo handling



View of a container terminal - Bremerhaven in this case

The definition stated in the CTU packing guidelines for handling reads:

> ***Handling*** *includes the operation of loading or unloading/discharging of a ship, railway wagon [rail car], vehicle or other means of transport (CTUs).*

The meaning of "ship" is common knowledge; the CTU packing guidelines definition reads:

> ***Ship*** *means a seagoing or non-seagoing watercraft, including those used on inland waters.*

The stresses occurring during cargo handling can be divided into two classes:

- stresses which act on an empty or packed cargo transport unit due to the use of suitable equipment when handling the whole CTU and those
- stresses which arise during packing and unpacking of the containers by manual methods and/or by using mechanical aids and equipment.



Handling a container with a reachstacker and top spreader



Transferring barrels into a container with a forklift truck and barrel lifter

The CTU packing guidelines define a forklift truck as follows:

> ***Forklift truck*** *means a truck equipped with devices such as arms, forks, clamps, hooks, etc. to handle any kind of cargo, including cargo that is unitized, overpacked or packed in CTUs.*

In addition to these general distinctions drawn between handling the cargo during loading and unloading a CTU and handling of the CTU itself, it is also possible to draw a distinction between

- avoidable stresses and
- unavoidable stresses



Avoidable cargo handling stresses during unpacking of a container

Packing and unpacking containers or other cargo transport units involves procedures which are no different from those previously used in conventional loading - the same risks are encountered and must be taken into account. Purely manual handling of packages generally entails exposure to more impact and dropping than in the case of mechanized handling using tried and tested industrial aids. Properly packaged and palletized goods are at little risk when forklift trucks and similar ground conveyors are used. The risk is distinctly greater for incorrectly packaged and palletized goods. However, if personnel are untrained, the risks associated with the use of mechanical aids are particularly high.



Avoidable handling stress
during container handling with a forklift truck

In this case, the attempt had been made to use a forklift truck to position a flatrack. In attempting to get the tines of a forklift truck under the flatrack and shift it, the fork slipped off, bending the side rail and puncturing the flatrack.



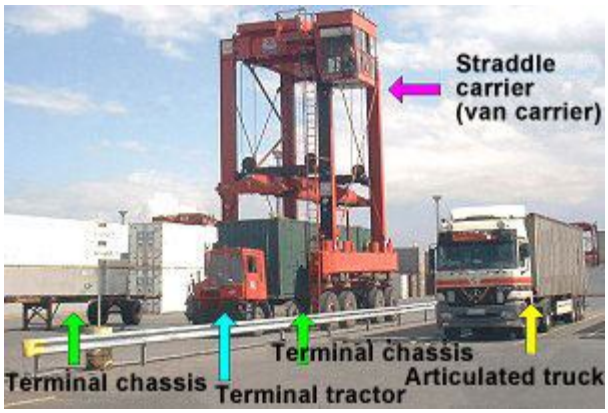


Avoidable handling stresses

If containers are handled with the equipment specially developed for this purpose, the impact stresses to which the various cargo transport units are exposed are comparatively uniform, irrespective of whether they are being transferred between road or rail vehicles or watercraft.

The CTU packing guidelines also provide some indications about cargo handling:

> *1.8 Container movements by terminal tractors may be subject to differing forces as terminal trailers are not equipped with suspension. Additionally, ramps can be very steep, causing badly stowed cargo inside CTUs to be thrown forward or backward.*



Cargo handling activities at a seaport terminal

Terminal tractors (Tugmaster units) and terminal chassis are normally only used for moving containers on the flat. Various methods are used in terminals for this purpose. With regard to ramps,

the guidelines relate to ro/ro tractors in conjunction with roll trailers. Both types of tractor require a hydraulically liftable fifth wheel coupling to allow access to the ramps. The normal chassis or semitrailers pulled by the tractors have suspension.

The stated effects on badly packed cargo have already been mentioned several times.



Ship/shore transfer with container gantry cranes and fully automatic spreaders



Intermodal cargo transfer with grapplers on a reachstacker and a gantry crane

The CTU packing guidelines also provide some information about the use of lifting gear and ground conveyors:

> *1.9 Considerable forces may also be exerted on CTUs and their cargoes during terminal transfer. Especially in seaports, containers are transferred by shore-side gantry cranes that lift and lower containers, applying considerable acceleration forces and creating pressure on the packages in containers. Lift trucks and straddle carriers may take containers, lift them, tip them and move them across the terrain of the terminal.*



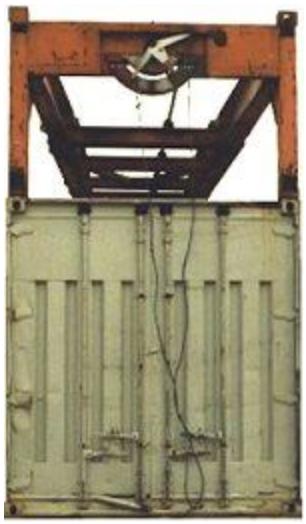
Deformed container floor due to the interplay of acceleration and incorrect packing methods

Even when equipment is expertly operated, stresses of approx. 1 g must generally be anticipated during cargo handling. Skilled operation assumes that the goods are lifted up and set down gently. Jerky lifting and setting down may generate very much higher g values.

Normal setting down impacts cannot always be avoided and additional crush pressures must thus always be expected. This applies both to setting down the receptacle and to setting down the spreader on the containers. If spreaders without flippers are used carelessly (the flippers center the spreader on the container), damage to container roofs must be expected. There is still a risk of damage even when manual spreaders or "overheight frames" are used.



Handling with manual spreader





Right and left:

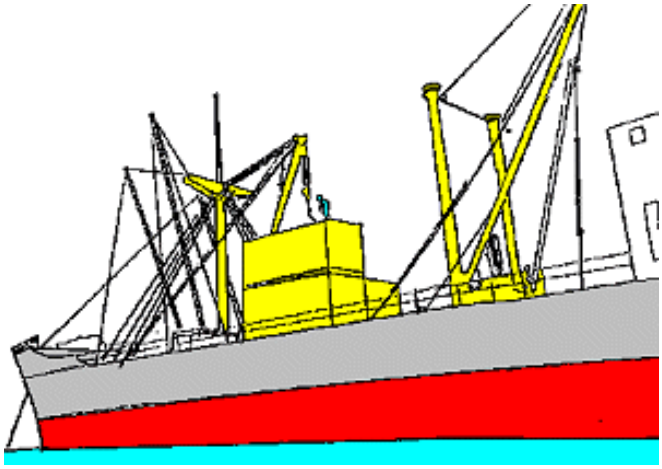
Overheight frame with manual locking
(in this case only set down on the container)

Especially in the case of onward carriage in countries with poor infrastructure, higher levels of stress must be anticipated during handling and unloading operations. So that no damage is caused during unpacking of the cargo transport units, packing must always be designed in such a way that the containers can be stripped as simply as possible.



Handling with on-shore container gantry cranes

It is also to be expected that containers will not always be handled as properly as they are here, but that during onward carriage they may possibly be unloaded under the most basic conditions from an old ship in the roads. "Bumping" against obstructions is not at all unusual under such circumstances. Packing and securing should be designed to withstand such occurrences.



Individual containers on an old design general cargo ship - in the roads

Handling stresses during packing and unpacking of containers are generally the result of carelessness. It is not unusual for:

- personnel to walk on cargo which cannot withstand such loads;
- packages to be dropped during manual working;
- poorly packed pallets to come apart during forklift truck operations and for individual packages to fall out;
- packages to be punctured with the forks;
- packages to be crushed or squashed with the forklift truck;
- damage to be caused by the use of tools and cargo securing materials etc.

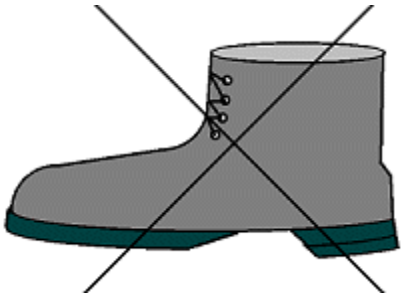
The best protection from these and the above-stated risks is good training and constant staff motivation.





The carton has already been crushed to 2/3 of its original dimensions.

Another case of human failure due to inadequate skills and insufficient supervision.



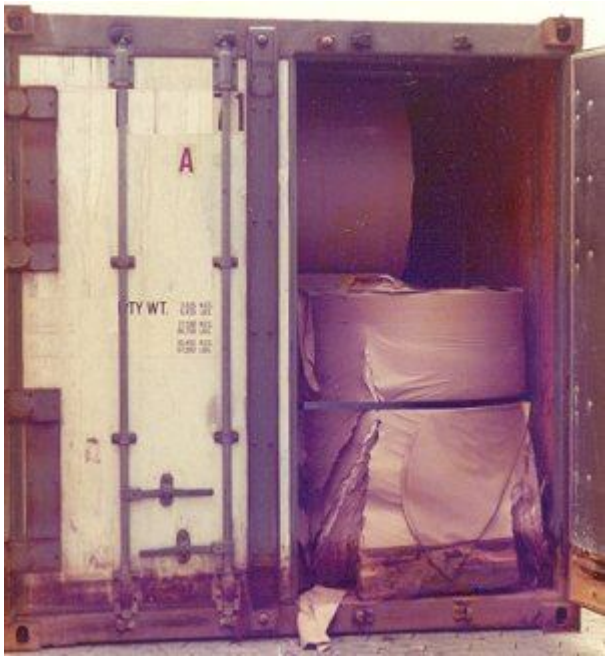
Stowing symbol:
Do not walk here!

The cargo could be marked with a stowing symbol like this.

2.3.8 Climatic stresses

Detailed information on this subject can be found in the Container Handbook section entitled "The product in the container" by Dr. Renate Scharnow, but the purpose of this section is merely to take a brief look at the subject.

An undamaged, tightly closed box container protects its contents from external influences such as ice, snow, rain, salt spray, dust, thermal radiation, ultraviolet light and other conceivable environmental influences.



Water damage in a container

However, box containers cannot provide protection from direct exposure to water because they are only spray-tight, not water-tight.

The CTU packing guidelines state that moisture damage must be avoided, point 3.2.7 reading:

> *In order to avoid cargo damage from moisture, wet cargoes, moisture-inherent cargoes or cargoes liable to leak should not be packed with cargoes susceptible to damage by moisture. Wet dunnage, pallets or packaging should not be used. In certain cases, damage to equipment and cargo can be prevented by the use of protective material such as plastic films.*

The section on dunnage indicates how the risks in the first sentence can be combated. The second sentence is very important - this principle is often ignored. Cargoes, wooden dunnage and other aids are often literally left outside in the rain before being placed in the container:



Rain-wettened cartons on wet pallets
- moreover inadequately palletized

If containers are packed in the open, there is always a risk in rainy weather that ground conveyors and personnel will bring moisture into the container with them.

Cargoes in a container in which air exchange is prevented may suffer spoilage or be damaged if temperatures and humidities during carriage reach a level which is incompatible with the goods or their packaging containers.

Point 1.3 of the CTU packing guidelines points out the negative effects of changes in temperature and humidity on container cargoes:

> *During longer voyages, climatic conditions (temperature, humidity etc.) are likely to vary considerably. These may affect the internal conditions in a CTU which may give rise to condensation (sweating) on cargo or internal surfaces.[1] Where cargo is liable to damage from condensation, expert advice should be sought.[1] (see Annex 1)*



Ice formation on a ship

If relatively warm air is cooled to below its dew point, the resultant condensation may result in cargo damage.



Wetting damage on bags of raw cocoa due to condensation

Additional information is provided in the stated Annex 1 "Condensation".

> *1. Cargoes in transit may be affected by the conditions to which they are subjected. These conditions may include changes in temperature and humidity and particularly cyclic changes that may be encountered). An understanding of condensation phenomena is desirable because condensation may lead to such damage as rust, discoloration, dislodging of labels, collapse of fiberboard packages or mold formation.*

2. Solar radiation can produce air temperatures under the inner surfaces of a CTU which are significantly higher than external air temperatures. The combination of these effects can result in a range of day and night cyclic temperature variations in the air adjacent to the inner surfaces of a CTU which is greater than the corresponding range of temperatures just outside.

3. Cargoes closest to the wall or roof will be more affected by external temperature variations than those in the center of a CTU. If the possible extent of temperature variations or their full significance is not known, advice should be obtained from specialists.

4. Under the circumstances described, condensation may occur either on the surface of the cargo (cargo sweat) or on the inside surfaces of a CTU (container sweat) either during transport or when the unit is opened for discharge.

5. The main factors leading to condensation inside a CTU are:

5.1 sources of moisture inside the unit which, depending upon ambient temperature conditions, will affect the moisture content of the atmosphere of the unit;

5.2 a difference between the temperature of the atmosphere within the unit and the surface temperature of either the cargo or the inner surfaces of the unit itself; and

5.3 changes in the temperature of the outer surface of the unit which affect the two factors above.

6. Warming the air in a CTU causes it to absorb moisture from packagings or any other source. Cooling the air below its dew point causes condensation.*

7. If, after high humidity has been established inside a CTU, the outside of the unit is cooled, then the temperature of the unit surface may fall below the dew point of the air inside it. Under these circumstances moisture will form on the inner surfaces of the unit. After forming under the roof, the moisture may drop onto the cargo. Cyclical repetition of cargo or container sweat phenomena can result in a greater degree of damage.

8. Condensation can also occur immediately after a CTU is opened if the air inside the unit is humid and the outside air is relatively cool. Such conditions can produce a fog and even precipitation but, because this phenomenon usually occurs only once, it seldom results in serious damage.

*9. The risk of damage and dangerous situations** can be minimized if the moisture content of the packaging and securing materials is kept low.*

**The dew point is the temperature at which air saturated with moisture at the prevailing atmospheric pressure will start to shed moisture by condensation.*

*** For example, when goods of class 4.3 (substances which evolve flammable gases on contact with water) are packed into a container.*

Where necessary, the information provided in Annex 1 "Condensation" may have to be supplemented by additional information from other sources.

2.3.9 Biotic stresses

Detailed information on this subject can be found in the Container Handbook section entitled "The product in the container" by Dr. Renate Scharnow, but the purpose of this section is merely to take a brief look at the subject.

Both biotic and chemical stresses are closely interrelated both with each other and with climatic stresses. It may accordingly be assumed to be generally known that biotic and chemical reactions proceed particularly well when exposed to certain temperature and moisture conditions.

Biotic stresses are deemed to be present if goods, packaging or parts thereof are damaged by living organisms of whatever kind. Chewing damage may, however, cause considerable losses as may, of course, damage caused by animal excreta.

The risk is relatively low in closed containers, provided that no animals have taken up residence before packing or "sneak in" during packing. Since many rodents are nocturnal creatures, CTUs which are being packed should be closed during work breaks or at the end of a shift especially during the hours of darkness. Prior inspection of cargo transport units for tightness is a basic requirement. Insects, for example, can nonetheless still get into such closed containers which, although classed as unventilated, still have openings of small cross-section.

It will be virtually impossible to avoid damage if goods and/or packaging are infested before packing and such infestation is not noticed. In the case of "open" cargo transport units, infestation can only be prevented by providing sufficiently tight packaging or suitable preservation.



Beetle chewing damage on a paper roll

Other frequently observed phenomena include infestation of the packed goods or packaging by fungi, especially molds, bacteria or other microorganisms. Heat and high relative humidity encourage the development of mold and the multiplication of e.g. bacteria. Slight air movement also encourages growth.

It is advisable to stack cargo securing lumber with spacing battens and store it under cover; in this way, air can pass between the layers of lumber and mold formation is prevented.

While the CTU packing guidelines do not mention biotic stresses, they do point out that certain countries, wishing to prevent the introduction of pests, place specific conditions on the lumber to be used for packaging and securing.

Point 3.3.2 of the CTU packing guidelines states:

> *If a CTU is destined for a country with wood treatment quarantine regulations, care should be taken that all wood in the unit, packaging and cargo complies with the regulations. It is a useful practice to place a copy of the wood treatment certificate in a conspicuous place inside and, where appropriate, outside the unit in a weatherproof pouch.*

This primarily relates to the mandatory and usual treatment against the Sirex wasp for voyages to Australia and New Zealand (and more recently also for China). Even if no lumber is packed into the container as cargo or packaging, lumber may nevertheless still be required for cargo securing or as dunnage. In such cases, it is worthwhile having the necessary lumber appropriately treated in advance. Treated lumber should be colored in order to differentiate it from untreated lumber:



Lumber treated against the Sirex wasp - colored for differentiation

2.3.10 Chemical stresses

Substances which react together and can cause damage to the cargo or its packaging are of relevance to cargo securing.

One of the most familiar chemical reactions is corrosion and goods must be provided with protection from it by a protective coating, sealed packaging or using the VCI method. However, this is not in principle the responsibility of packing or cargo securing personnel, but instead of the shipper or his packer. However, corrosion protection must not be impaired or eliminated as a result of packing or cargo securing operations. Appropriate steps should also be taken to prevent the introduction of corrosion-promoting substances into a cargo transport unit. It must not be forgotten that the salt aerosols present in sea air can have an effect on cargoes in closed containers. Unless special precautions are taken, the risk is very much greater in all open containers.

In general, this also applies to all other solid, liquid or gaseous substances which can impair the cargo in any way. To take one extreme example: even a few molecules of a chemical, e.g. a poison, could "migrate" through one physically completely tight package into another and harm the goods inside. Preventing chemical effects requires a considerable knowledge of chemistry and so is not a responsibility which can be left to loading personnel. Appropriate instructions are absolutely essential.

Simple but nevertheless very effective preventive measures against chemical stresses are:

- Only use cargo transport units which are fit for packing, i.e. which are clean and neutral in odor

- Do not ignore basic stowage rules, for example never stow odor-releasing goods with goods which can absorb odors, unless odor contamination can be prevented by special measures

- Protect any chemically sensitive cargo from extraneous substances which could cause damage.

The CTU guidelines provide advice on fitness for loading. Point 2.2.4 requires:

A CTU should be clean, dry and free of residue and persistent odors from previous cargo.

Point 3.1.4 additionally states:

Packing should be planned before it is started. (...) The possibility of cross-contamination by odor or dust, as well as physical or chemical compatibility, should be considered.

It is generally the case for hazardous materials that compliance with the relevant hazardous materials regulations will prevent impairment of other goods.

3 Containers - Explanation of terminology

This section deals with the technical aspects of CTUs and the cargo securing aspect of containers, but not the general use of containers; nor is it intended to address the economic viability of using containers.

Explanation of terminology

There is some ambiguity in English about the meaning of the word "container" (from the Latin: continere = to enclose), but for the purposes of this Handbook the word should be taken to mean a shipping container, whether large or small.

The American Heritage Dictionary of the English Language defines a container as a "large reusable receptacle that can accommodate smaller cartons or cases in a single shipment, designed for efficient handling of cargo". In common American parlance, this type of container is often called a "van", although a van is defined in most dictionaries as a motor vehicle or truck or wagon.

In the past, the term container, when used in the field of goods traffic, was taken to mean standardized transport units of different types, whose dimensions were so matched to one another that they could be combined together as "transport modules". This is still generally true today; however, usage of the term has moved more and more towards large or bulky containers, which are transported by road, rail, water and (in modified form) even by air.

This part of the Container Handbook deals in particular with the packing and securing of cargoes in freight containers. However, the packing and securing instructions are equally applicable to CTUs as defined in the CTU guidelines.

The "*Guidelines for the packing of cargo, other than bulk cargo, into or onto cargo transport units (CTUs) applicable to transport operations by all surface and water modes of transport*", in force since 17th February 1999, define the following terms:

> *For the purposes of these guidelines, the term "Cargo Transport Unit" ("CTU") has the same meaning as the expression "Intermodal Transport Unit" ("ITU") and the following definitions apply:*
> ***cargo transport unit (CTU)** means a freight container, swap-body, vehicle, railway wagon [railroad car] or any other similar unit.*



Freight container, in this case a partially ventilated 20' plywood box container



Swap-body

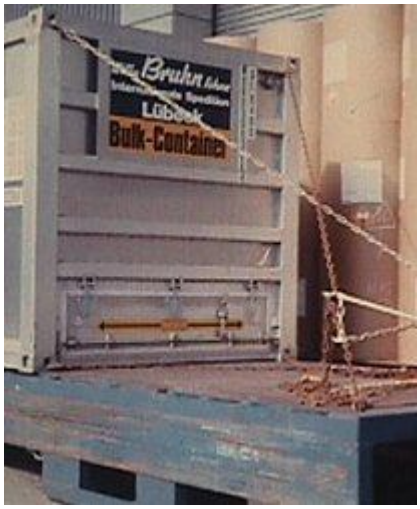


Vehicle



Railroad car, in this case a sliding wall bogie car





Other CTUs:

Roll trailers **Cassette**



Other CTU, in this case roll trailer:

Freight container/container *means an article of transport equipment that is of a permanent character and accordingly strong enough to be suitable for repeated use; it is designed to transport a number of receptacles, packages, unit loads and overpacks together from the packing point to its final destination by road, rail, inland waterway and/or sea without intermediate separate handling of each package, unit load or overpack. The term "container" is used throughout these guidelines.*



Freight container/container, in this case 40' high-cube steel corrugated container

... the "permanent character, sufficient strength and suitability for repeated use" are no use, however, if a container is incorrectly packed and secured.





Damage to containers due to packing and securing deficiencies

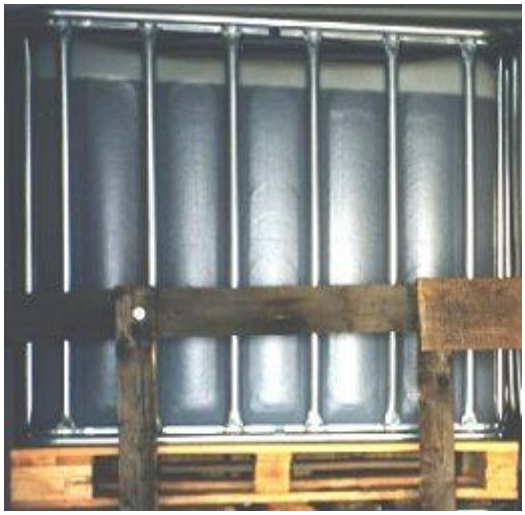
***I**ntermediate **B**ulk **C**ontainer, (IBC) means a rigid, semirigid or flexible portable packaging that:*

1. *has a capacity of not more than 3.0 m³ (3,000 liters) for solids and liquids;*
2. *is designed for mechanical handling; and*
3. *is resistant to the stresses produced in handling and transport, as determined by tests.*

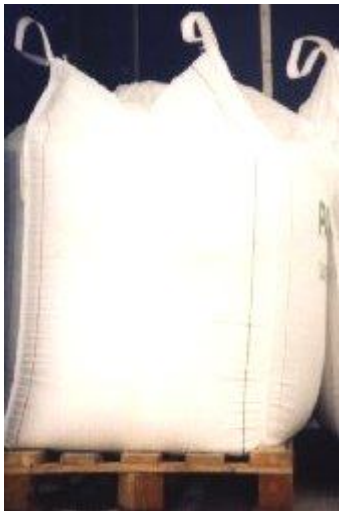




Rigid IBC



Semirigid IBC



Flexible IBC, in this case a Big Bag

***I**ntermodal **T**ransport **U**nit (ITU) means a container, swap-body or semitrailer suitable for intermodal transport.*



Freight container used for intermodal transport

Swap-body used for intermodal transport





Articulated truck consisting of truck tractor and trailer used for intermodal transport

Swap-body *means a CTU with at least four fittings for accommodating twist locks that take into account ISO standard 1161:1983 not permanently attached to an underframe and wheels or to a chassis and wheels. A swap-body need not be stackable but is usually equipped with support legs, designed especially for combined road/rail transport.*



Swap-body

The term swap-bodies has come to be used in modern German parlance.

Vehicle *means a road vehicle or railway freight wagon [railroad freight car], permanently attached to an underframe and wheels or to a chassis and wheels, which is loaded and unloaded as a unit. This term also includes a trailer, semitrailer or similar mobile unit except those used solely for the purposes of loading and unloading.*



Road vehicle



Railroad car

A distinction is drawn according to size between:

- Large containers
- Medium containers
- Small containers

This handbook deals in particular with cargo securing in large containers, with the main emphasis on those which spend at least part of their journey at sea. In principle, the cargo securing rules set out also apply to other containers. So-called pa containers are medium containers designed especially for rail transport. Small containers are used in groupage traffic and are carried by both road and rail vehicles. Neither of the above-mentioned groups will be dealt with here, however.

Depending on container design and the applicable standard, the following distinctions may be drawn:

- ISO container (also known as an overseas container or transcontainer)
- ASA container
- ISO inland container

An international standard is necessary for the standardization of transport and handling operations, e.g. to ensure uniform practice in the picking up and setting down of containers using lifting gear and ground conveyors or the marking of containers. In addition, a series of other national and international publications, some of which have legal force, cover the widest possible range of characteristics of these special containers for rationalized goods transport or give instructions for their use.

We shall not list the individual standards here, as they are of only limited relevance to packing and cargo securing. Should a particular standard be of relevance, the reader will be referred to it. Technical Committee 104 (TC 104) of the International Organization for Standardization (ISO) was involved in drawing up many of the ISO standards. German interests were represented with regard to some standards by the ISO Container sub-committee (SC). The international standards are applied in Germany as DIN ISO or these days for the most part as DIN EN ISO.

One important regulation which has legal force has been published in the German federal law gazette as the "Internationales Übereinkommen über sichere Container (CSC)" [International Convention for Safe Containers]. The Convention defines the term container as follows:

Article II
Definitions

For the purpose of the present Convention, unless expressly provided otherwise,

1. *"Container" means an article of transport equipment*
   a) of a permanent character and accordingly strong enough to be suitable for repeated use;
   b) specially designed to facilitate the transport of goods, by one or more modes of transport, without intermediate reloading;
   c) designed to be secured and/or readily handled, having corner castings for these purposes;
   d) of a size such that the area enclosed by the four outer bottom corners is either:
      I) at least 14 sq. m. (150 sq. ft.) or
      ii) at least 7 sq. m. (75 sq. ft.) if it is fitted with top corner castings.

   The term "container" includes neither vehicles nor packaging; however, containers when carried on chassis are included.

In both DIN ISO 668, entitled "Series 1 ISO containers - Classification, dimensions and ratings" and in DIN ISO 830 "Containers - Vocabulary", containers are defined as follows:

Container: a transport container which

- *is of a permanent character and accordingly is strong enough to be suitable for repeated use,*
- *is specially designed to facilitate the transport of goods, by one or more modes of transport, without intermediate reloading,*
- *is suitable for mechanical handling,*
- *is designed to be readily packed and unpacked,*
- *has a capacity of at least 1 m³.*

Vehicles and packaging are not containers.

In principle, the only difference between the "International Convention for Safe Containers (CSC)" and the DIN ISO standards is that the former provides for a container surface area of at least 14 m² or 7m², as a function of the corner castings, while the latter deem receptacles with volumes of 1 m³ or more to be containers.

We will not at this point go into the specific definitions of the term container given in hazardous materials legislation, but if the need arises, the relevant references will be cited at the appropriate point.

3.1 Container design

A container user should be aware of the most important structural differences between containers, so that he/she is in a position to make appropriate preparations for packing and cargo securing and correctly to assess container loading capacity.

Problem-free dispatch has been assisted by the standardization of transport units, such as containers, while the standardization of certain components and some dimensions permits the use of standard handling equipment and means of transport.

We will describe fundamental components and designs first of all with reference to standard box containers. More detailed information is given under the heading "Container types".



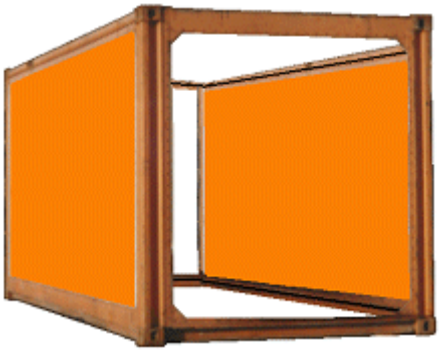
Basic container frame

The load-carrying element of all box containers is a steel framework, consisting of four corner posts and two bottom side rails, two top side rails, two bottom cross members, a front top end rail and a door header.

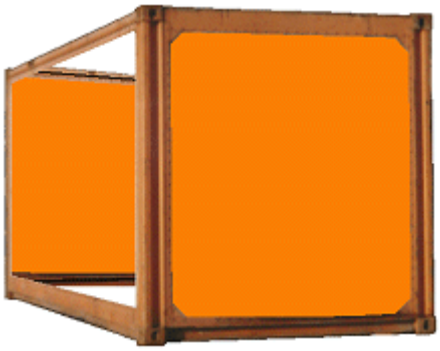


Bottom cross members serve as supports for the container floor.

Additional bottom cross members are fitted between the bottom side rails, to serve as supports for the floor covering.



Side walls



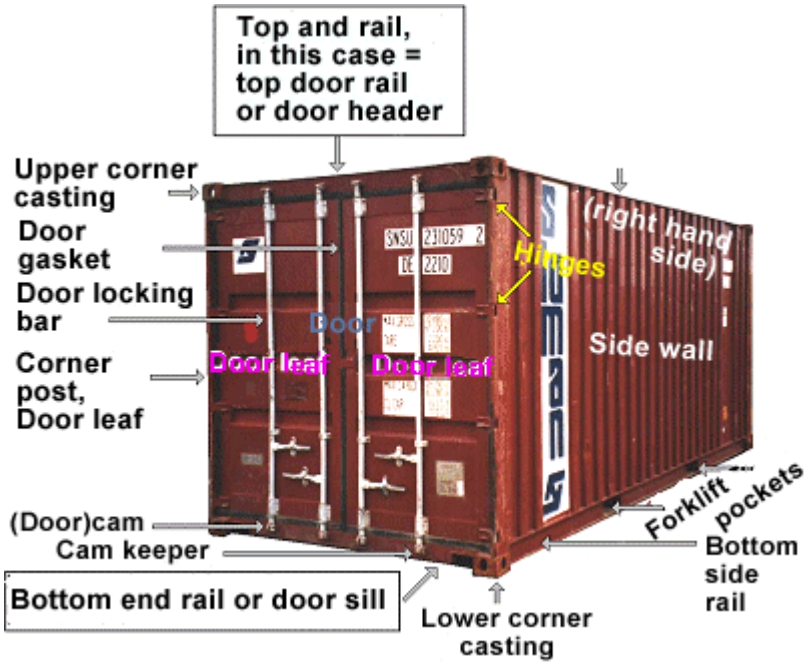
End walls



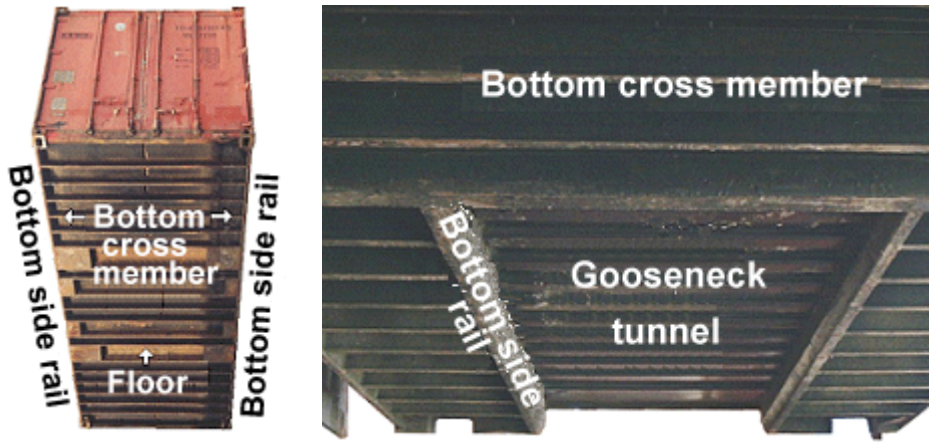
Roof panel

The side and end walls and the roof are the components of a standard box container which are capable of bearing the least load. To a certain degree, this naturally also depends on the construction materials used for them.

The following three Figures illustrate the essential components of standard box containers. Not included by name are, for example, the door bar handles, the locking components required for sealing, etc. Where necessary, descriptions of and comments about these components are provided at other points in the Handbook.



Essential components of a container



Part names in the area of the container floor

A comparison of German and English part names is given below:

German name	English name
Eckbeschlag	corner fitting; corner casting
Ecksäule	corner post
(unterer) Seitenlängsträger	bottom side rail
(oberer) Seitenlängsträger / Dachlängsträger	top side rail
unterer Querträger front also known as: Stirnschwelle	bottom end rail; door sill

rear also known as: Türschwelle / Türuntergurt	
oberer Querträger / Dachquerträger front also known as: Stirnträger rear also known as: Türträger / Türobergurt	front top end rail door header
Boden	floor
Stirnwand	front end wall
Bodenquerträger	bottom cross member
Dach	roof panel
Dachspriegel (e.g. in open-top containers)	roof bows
Seitenwände	side panel; side wall
Gabelstaplertasche	forklift pocket
Türverschlußstange	door locking bar
Scharnier	hinge
Nocke	cam
Nockenhalterung	cam keeper
Türdichtung	door gasket

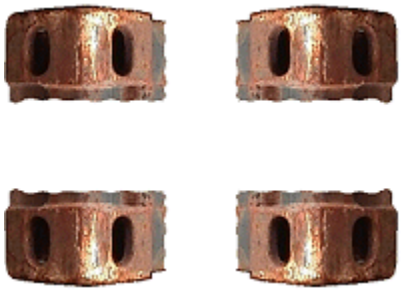
In the early days of container shipping, the majority of containers were constructed according to ASA standards, but now the containers used for maritime transport are almost without exception ISO containers.





ISO Corner Casting **ASA Corner Casting**

They differ both in dimension and in the shape of the corner fittings or "corner castings". Most ASA containers, i.e. containers like those used by Sealand constructed according to "American Standards Association" standards, have since been adapted to match ISO dimensions. To simplify handling, special universal spreaders were used, which could handle both types without difficulty.



ISO corner castings - horizontal and vertical mirror images

ISO standard 1161 specifies different shapes for top and bottom and mirror images for right and left.

The eight corner castings of a container or a corresponding CTU have to be particularly strong, since they work with the corner posts and the other basic components of the container frame to absorb the forces which lock units or lashings exert on containers when they are stacked on top of one another, during handling and during transport.



Securing on board



Cargo handling



Securing on a chassis





DIN/ISO standards specify certain minimum requirements for the loading capacity and **stackability** of containers; while higher levels of performance may be provided for individual properties, lower levels may not.

It must be possible to stack six ISO containers packed to the maximum weight vertically on top of one another. Maximum offset is set as follows: widthwise - 24.4 mm (1"), lengthwise - 38 mm (1½").



The actual values of modern containers are generally higher. Many are designed to be stacked eight or nine high. The maximum stacking load must be marked on the CSC plate. (More details are given in the relevant section of the Handbook).

According to safety regulations, stacked containers must where necessary be secured against toppling and shifting.

On larger container ships, the containers are stowed nine to twelve high in the hold. In such cases, the containers loaded must either be only partly full or designed to have greater stackability. The latter is generally the case with modern containers, but it is possible to use fold-out flaps in the cell guides, which subdivide the stacks.



Indicating stacking heights on a container

Inland containers are only designed to be stacked three high when fully loaded.



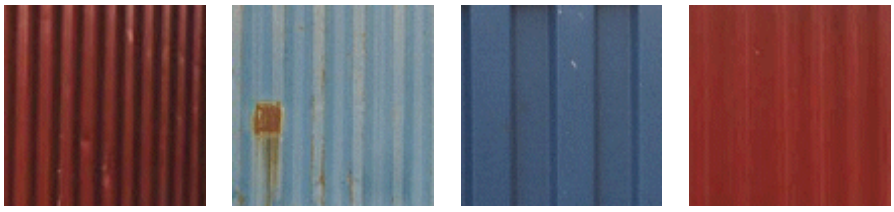
Irrespective of the material used to build a box container, it is essential for it to be **spray-tight**.

In standard box containers, the load-carrying parts are made of steel profiles, i.e. at least the entire frame including the bottom cross members and possibly also the elements serving as reinforcements, such as bottom side rails in the area of the gooseneck tunnel etc. Three main types of material are used for the walls and roof:

- steel sheet, corrugated
- aluminum sheet in conjunction with stiffening profiles
- plywood with glass fiber-reinforced plastic coating (plywood + GRP)

These are reflected in the conventional container names:

- steel container
- aluminum container
- plywood container



Variously corrugated steel sheet

In steel sheet containers, a wide range of differently profiled corrugated steel sheet may be used for the outer walls. It is protected against corrosion by painting or similar processes.





Indication of container wall material **Repair instructions on a steel container**

The cost advantages of this type of container have led to its current dominance. Of all the containers currently in use, a rough estimate would suggest that 85% are made of steel sheet.







Aluminum container skin

Aluminum containers are built either with a pure aluminum skin or with a plywood inner lining; they may also either be riveted or with a smooth or lightly riveted finish.

In plywood containers, the outer walls are made of plywood coated with glass fiber-reinforced plastic (GRP). Plywood is a popular material for "coffee containers".



Container doors are often also made of plymetal, which consists of a plywood core with sheet metal adhered to it on both sides.

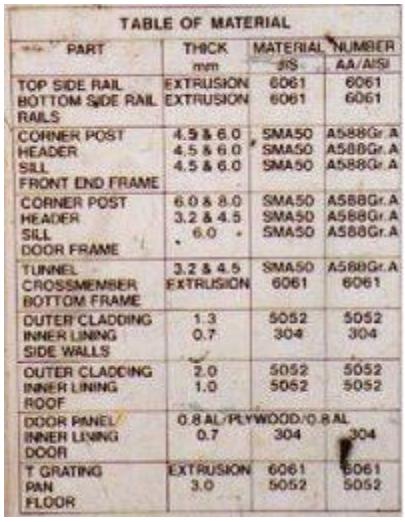


TABLE OF MATERIAL

PART	THICK mm	MATERIAL NUMBER JIS	AA/AISI
TOP SIDE RAIL BOTTOM SIDE RAIL RAILS	EXTRUSION EXTRUSION	6061 6061	6061 6061
CORNER POST HEADER SILL FRONT END FRAME	4.5 & 6.0 4.5 & 6.0 4.5 & 6.0	SMA50 SMA50 SMA50	A588Gr.A A588Gr.A A588Gr.A
CORNER POST HEADER SILL DOOR FRAME	6.0 & 8.0 3.2 & 4.5 6.0	SMA50 SMA50 SMA50	A588Gr.A A588Gr.A A588Gr.A
TUNNEL CROSSMEMBER BOTTOM FRAME	3.2 & 4.5 EXTRUSION	SMA50 6061	A588Gr.A 6061
OUTER CLADDING INNER LINING SIDE WALLS	1.3 0.7	5052 304	5052 304
OUTER CLADDING INNER LINING ROOF	2.0 1.0	5052 5052	5052 5052
DOOR PANEL INNER LINING DOOR	0.8 AL/PLYWOOD/0.8 AL 0.7	 304	 304
T GRATING PAN FLOOR	EXTRUSION 3.0	6061 5052	6061 5052



ATTENTION

A. THIS CONTAINER IS CERTIFIED FOR NINE HIGH STACKING.

B. CORTEN A STEEL PANELS.

C. PAINT SYSTEM

(1) PRIMER : HEMPADUR ZINC PRIMER 1535

(2) TOP COATING :

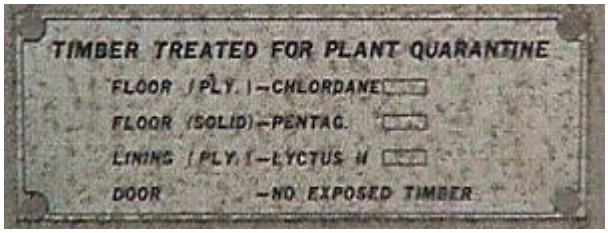
(A) HEMPATEX H.B. 4637-5063 FOR EXTERIOR

(B) HEMPATEX H.B. 4637-1217 FOR INTERIOR

MANUFACTURED BY
HEMPEL TORYO CO., LTD.

Materials information on containers

It is clear from these examples that containers are not generally made from a single material but various material combinations, here including steel, aluminum and plywood. The information even covers the type of preservatives used.



TIMBER TREATED FOR PLANT QUARANTINE

FLOOR (PLY.) —CHLORDANE

FLOOR (SOLID) —PENTAC.

LINING (PLY.) —LYCTUS H

DOOR —NO EXPOSED TIMBER

Wood treatment information

Special impregnation against insect or other pests is required for certain regions of service. Most container floors or wooden parts undergo preventive treatment.



TIMBER COMPONENT TREATMENT IM/BASILEUM SI-84/96



TIMBER COMPONENT TREATMENT

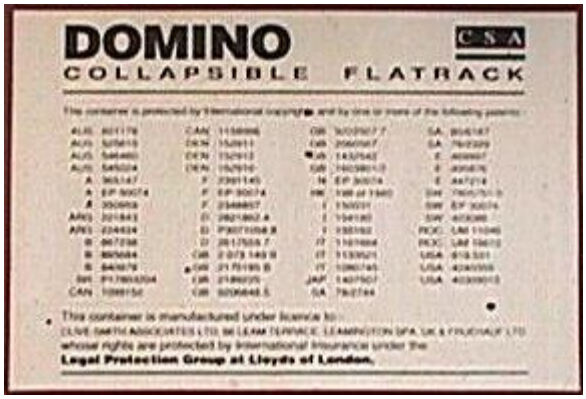
IM/BASILEUM SI-84/98

JINDO

GUANGZHOU, CHINA

Wood treatment information

Materials used for a [flatrack]





Plywood floor



Repair to floor

Box containers are predominantly provided with coverings of plywood or textured coated board mostly 25 mm thick, more rarely 30 mm thick. Although wood is relatively expensive, it has substantial advantages over other materials: it is strong and resilient, does not dent, may be easily replaced during repairs and, when appropriately finished, has an adequate coefficient of friction. The latter does not apply to the virtually new container in the left-hand Figure, which has a mirror-bright finish.



Cross-section through a seven-ply plywood board



Planking





Steel floor

Planking is preferred for flatracks and other similar platform containers. 20' platforms or half-height open-top containers often have a floor of steel, e.g. of "tear drop" or otherwise textured sheet.

The **floors** of ISO containers have to be capable of bearing the evenly distributed payload, the

emphasis being on "evenly distributed".

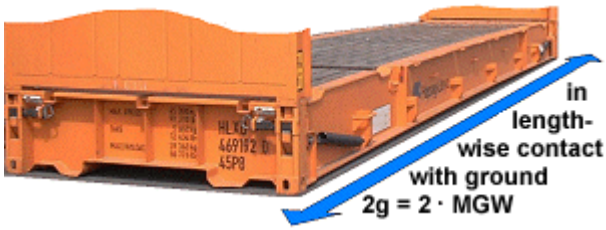
The following test criteria apply where **ground conveyors** have access to container floors.

Axle load	12,040	lbs / 5,460 kg
Wheel load	2,730	kg
Contact surface per wheel	142	cm²
Wheel width	180	mm
Wheel gage	760	mm

The wheel contact area of 142 cm² corresponds approximately to the size of a postcard. Forklift trucks with a load-carrying capacity of 2 metric tons have axle loads of just under 5 metric tons when loaded. Most 2.5 metric ton forklifts are within the admissible range. However, some electrically operated 2.5 metric ton forklift trucks reach front axle loads of over 6,000 kg when loaded. It is of course possible for even heavier forklift trucks to drive into containers, provided they are not fully loaded and the equipment and cargo dimensions allow it. It is essential to note that add-ons reduce the load-carrying capacity of forklifts, but increase the front axle load. Goods may only be stacked in box containers using equipment with a suitable telescopic mast. Using equipment with twin tires may reduce the wheel loads, but it doesn't completely resolve the issue of axle load. It shouldn't therefore be regarded as a license to use heavier equipment.

The **strength of ISO containers** is laid down in the relevant DIN standards and/or the International Convention for Safe Containers:

ISO containers must be capable of absorbing the **horizontal forces** arising during regular service at the level of the **end frames**.



Longitudinal loading capacity in the floor area

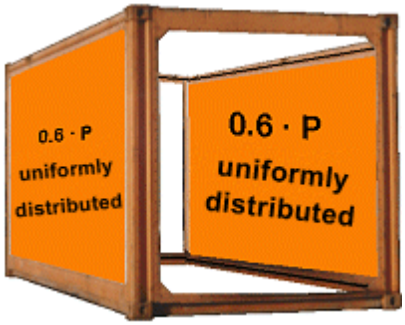
Containers must withstand loads in the lengthwise direction which correspond to external acceleration of 2 g acting horizontally on the floor fastening elements. This takes into account loads which are transmitted via twist locks and other vehicle locking elements to containers. Special railroad container cars with hydraulic shock absorption limit forces to 2 g; examples of these cars are Lgjs, Sgjs and Sgjkmmns cars and other cars with a j in their name, the j indicating high-performance (long-stroke) shock absorbers or buffers.



According to the CSC, **end walls** must be so constructed that forces of 0.4 times the uniformly applied payload may be absorbed, i.e. 40% of the container payload or 0.4 g. Higher or lower values should be marked on the containers.

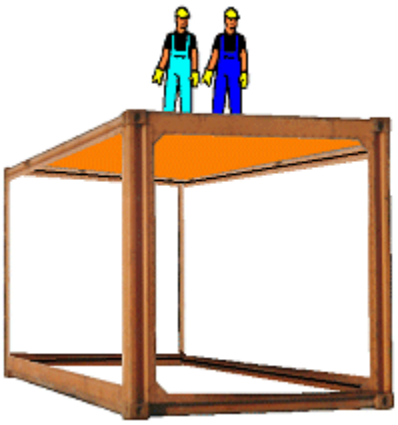
End wall loading capacity

The loading capacity of the **side walls** must correspond to 0.6 times the uniformly applied payload, i.e. 60% of the payload or 0.6 g. Higher or lower values should again be marked on the containers. More details are given in Section 3.1.2 CSC & structural and testing regulations".



Side wall loading capacity

Since the values for end and side walls are valid only for large-area loads, any point loading of the walls should be avoided. Because the weight-carrying capacity of many general purpose containers is not fully utilized, loading is kept below the maximum values in the case of compact and even packing. However, if the rate of utilization is high and/or uneven, countermeasures must be taken.



In the case of **container roof panels**, an evenly distributed 200 kg load may be applied to a surface area of 600 x 300 mm, so meaning that two people may stand next to one another on the container roof. Under no circumstances may container roof panels be covered with cargo.

Some containers are fitted with forklift pockets for handling with ground conveyors. Appropriate regulations relating to the required dimensions may be found in appendix C of ISO 1496/1. The pockets are cavities formed crosswise in the floor structure and allow insertion of the forks from the side; the forks must be pushed fully into the pockets. Forks which are too short must under no circumstances be used for lifting, since they may cause damage to the floor.



Unmarked forklift pockets on a box container.

The forklift pockets generally only allow handling of empty containers. Packed containers must not

be picked up in this way unless specifically permitted. This is not the case here; hence, the container may only be picked up with forks when empty.



Forklift pockets on a flatrack marked EMPTY



Forklift pockets on a flatrack not marked EMPTY





Both containers may only be picked up when empty.

For the most part, no marking is provided or no explicit instruction is given to pick up only empty containers, missing. To rule out errors, marking should be made a requirement.







Marking variant: the arrows bear the mark "Tare".

The containers shown here merely bear the marking "Tare" at the inner forklift pockets. The outer pairs of pockets lack markings or symbols. It is obvious here that the arrangement of these pockets also allows handling of the full container by forklift truck, but one can never be sure. This example shows that there is a need for marking to be mandatory.



Forklift pockets on a "tilt" container

With this container, it is even less certain how the forklift pockets are to be used. Standardized

regulations and compliance therewith in practice could help in the avoidance of many losses resulting from the incorrect use of these components.

Straddle carrier recess



Some containers have a recess along the longitudinal sides which allows the containers to be picked up using straddle carrier load suspension devices for transport within cargo handling facilities. Straddle carriers are specially built (low) van carriers with which loads may be lifted but not stacked.





Handling a swap-body with grappler in grappler pockets



Grappler pocket in a semitrailer



Grappler pocket in a swap-body

Grappler pockets are slots or recesses in the bottom side rails of containers or other CTUs, especially inland containers and swap-bodies. Grapplers slot into them during cargo handling. Such grapplers may also be used with gantry cranes, if no spreaders are used. Grappler pockets also allow direct pick-up of the containers with the tongs of a van carrier.



Detailed images of grapplers



Gooseneck tunnel

Many containers have recesses in the bottom of the front end This centrally located recess is known as a gooseneck tunnel. A large number of CTUs, especially flatracks have them at both ends. The tunnel does not have any effect on loading space, the inside of the container floor or the flatrack loading area being flat. This recess serves in centering the container on a gooseneck chassis.



Container with gooseneck tunnel on a normal container chassis



Container with gooseneck tunnel on a gooseneck chassis

Containers with goosenecks can be carried on both normal chassis and gooseneck chassis. Containers without goosenecks can only be carried on normal chassis. Depending on the construction of the chassis, a lower road vehicle overall height may be achieved with gooseneck chassis. In this way, many articulated trucks can see their height reduced by approx. 150 mm.



40' flatrack with gooseneck tunnel



20' flatracks without gooseneck tunnel

In accordance with the standards, gooseneck tunnels are only provided for 40' containers.

3.1.1.1 Container design and types, Part 1

Over 50 percent of the containers available internationally belong to shipping companies. Alongside these are a large number of leasing companies, which lease their containers both to shipowners and to direct customers. Containers belonging to forwarders tend to carry dry and liquid bulk goods, for which bulk and tank containers are mostly used. Specific details about the appearance of the containers, their external and internal dimensions, their weights and volumes, temperature control, cargo securing equipment and other special features may in general be found in the brochures published by the respective companies. Of necessity, the following can only deal with a few types of container.

According to DIN ISO 4346 of January 1996, a distinction may be drawn between the following types:

- General purpose containers
- Bulk container
- Named cargo containers
- Thermal containers
- Open-top containers
- Platform containers
- Tank containers
- Air/surface containers

Further distinctions are drawn within these groups depending on design and principal characteristics. Information relating to the respective code, the group and type code, is to be found in Section 3.4 "Size and type codes".

Over the years, expressions have become established which do not always correspond to the standards or which are used in addition to the standard expressions. Some of these need to be explained.

The term **standard container** was used for the first containers in their basic form. As these were closed and were primarily suitable for the loading of general cargo, they were/are also known as **general purpose containers**, **dry cargo containers** or **box containers**. The initial height of 8' has already very nearly been consigned to history. Most box containers have an external height of 8' 6".

Unventilated general purpose containers have openings on either one or both end(s).





Unventilated general purpose containers of sheet steel

The two steel containers of virtually identical construction can be designated standard containers. Both containers have an external height of 8'6" and no gooseneck tunnel. This is stated in coding 2210 on the one hand and 22G1 on the other. Both containers have forklift pockets and straddle carrier recesses.





Vents in a container

Containers equipped with such vents also count as unventilated general purpose containers, although they have small vents in the upper part of the cargo space.



20' plywood container with vents in the top side rail

This container too falls into the category of "unventilated general purpose container" although individual vents are provided all the way along the upper part of the cargo space.





Containers with end doors and side doors occupying the entire length

Another subgroup of unventilated general purpose containers specified in DIN EN ISO 4346, January 1996, has "openings at one or both end(s) plus full openings on one or both sides".



Container with end wall doors and partial openings at the side

Another subgroup consists of container with "openings at one or both end(s) plus partial openings on one or both sides".

The expression **high-cube container** originally covered all containers higher than 8' 6". The expression is now used in practice almost only ever for containers which have an external height of 9' 6". Particular attention needs to be given to possible height restrictions when these containers are carried by for road and rail. It may be necessary to use special chassis or carrying cars.



Comparison of a high-cube container (9' 6") with an 8' 6" container

The yellow and black marking on the top edges of the high-cube container serves as a warning

about its height. More details about operational markings are given in Section 3.5.





40' Container: left 8'6" high, right 9'6" high (high-cube)

40'-Containers have a larger volume-to-payload ratio than 20' containers, i.e. they are suitable for goods with a higher cargo stowage factor.

Open-sided containers (OS) have solid end walls and a solid roof panel. The sides may be closed at the bottom by folding down wooden, aluminum profile or steel sheet side walls, which may be divided into sections. Roof bow holders and roof bows are provided for the upper part, which may be covered with tarpaulins. The container is packed from the side. Open-sided containers also exist which are open only on one side. If bars are positioned over one open side, the containers can be used for transporting livestock. Another variant is the "folding side wall" container, a type of inland container.



Open-sided container, here in the form of a "tilt" container with end wall door



Open-sided container, here in the form of a "tilt" container with end wall door

As is clear from the pictures, open-sided containers are also available with doors at the rear of the container.

The statement found in many brochures to the effect that "lateral load securing consists of planks, which are suspended between the removable central support and the corner posts" is not to be trusted. It is essential to check what forces these structures can absorb.

Open-top open-sided containers (OTOS) combine the features of open-sided and open-top containers, i.e. the roofs and sides are open and need to be covered with tarpaulins.

Since it is American transport that gave rise to the 8' wide standard overseas container, these containers are not suitable for the interchangeable pool pallets used in Europe, which have dimensions of 800 mm x 1,200 mm. To counter this problem, pallet-compatible containers 2.50 m in width have been constructed, which must not, however, be confused with the pre-existing inland containers 2.50 m in width.





Pallet-compatible 40' containers

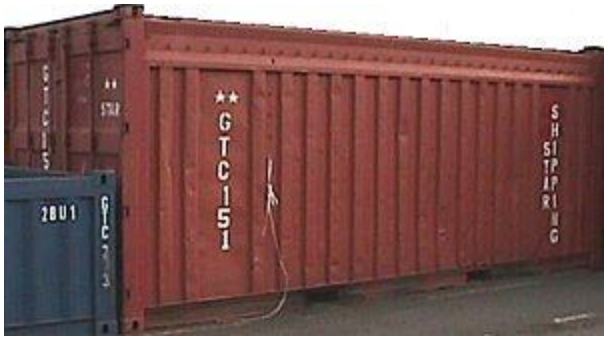


20' x 8' 6" container with side doors





2.50 m wide 20' inland containers provided by DB (German Railroads)



20' x 8'6" container with two end wall doors



General purpose container - special design with side doors



10' wide general purpose container

General purpose containers with special features are intended to make it possible to transport particular cargoes which could not otherwise be safely transported without damage. **Containers for hanging garments** belong to this group: they are equipped with clothes rails which are attached to

special supporting bars. Textiles, hanging on coat-hangers, can be carried in these containers.

Passively ventilated containers, also known as **ventilated containers**, hardly differ from standard containers in external appearance. They are used for the most part to transport organic cargoes with high moisture contents, such as coffee and cocoa beans. Special equipment is intended to ensure that, as far as possible, sweat is prevented from forming. In general parlance, the containers are also named after the type of cargo carried in them, hence the widespread use of the expression **coffee container**. There are two basic variants:

- Containers with natural ventilation use pressure differences between the internal and external air for air exchange purposes. Warm air rises in the container and exits at the top through the roof ventilation strips. Cooler external air then enters through the floor ventilation strips.

- Forced ventilation containers use fans and air ducts and/or ventilation flaps to achieve the necessary air exchange.

Container vent slots or air openings are often constructed as a labyrinth to prevent the penetration of spray or precipitation. Often, there are openings in the bottom and top side rails, which form regular air ducts. Sometimes, only relatively small, perforated areas are provided at regular intervals in the outer skin.

DIN EN ISO 6346, January 1996, lists ventilated general purpose containers under Code V, allocating to them either group code VH or type codes such V0, V2 or V4. A distinction is drawn between:

- Containers with non-mechanical ventilation at the lower and upper parts of the cargo space

- Containers with mechanical ventilation installed in the container and

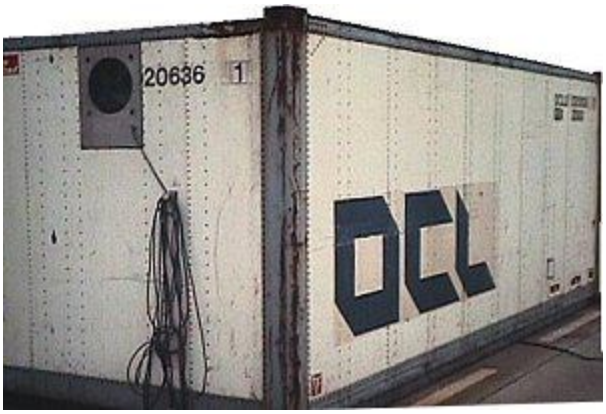
- Containers with mechanical ventilation located outside the container.



General purpose containers with non-mechanical ventilation



Non-mechanical ventilation at the upper and lower parts of the container



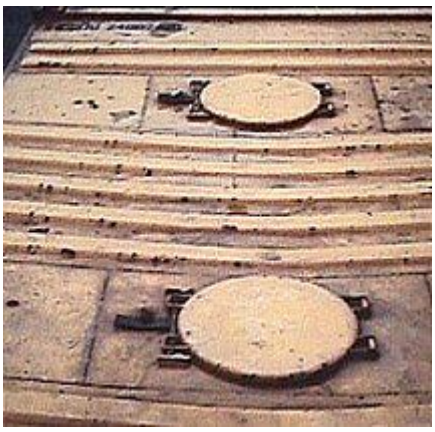
General purpose containers with mechanical ventilation installed in the container

There are plenty of other designs of general purpose container, in addition to those described above. A more unusual example is the container illustrated below.



General purpose container with flaps on the end and side walls

Dry bulk containers or **bulk containers** may be used to transport loose, free-flowing goods. DIN EN ISO 6346 of January 1996 distinguishes, under Code B, between the group codes BU and BK as well as various type codes for non-pressure-resistant dry bulk containers which are closed or air-tight and dry bulk containers with horizontal or tipping discharge pressure-resistant at test pressures respectively of 150 kPa and 265 kPa.





Above and right:

Loading hatches and discharge outlets in different bulk containers

Externally, normal bulk containers are of identical construction to standard containers except for the loading hatches and discharge outlets. The loading hatches or domes are arranged in the roof. To gain access to these, some containers are provided with swivelable ladders. To prevent contact between the cargo and the container walls, "inlets" or liner bags may be introduced into the containers and fixed in place. The unloading hatches are normally at one of the ends, generally incorporated into the doors. Sometimes, short hoses are also incorporated, so as to be able to direct the cargo as it is unloaded. Less frequently, the discharge outlets are arranged at the side. In all the above cases, unpacking is achieved by the force of gravity, generally assisted by tipping the containers.



Chassis with tipping equipment for emptying bulk containers

Some **special dry bulk containers** resemble tank containers. In addition to emptying by gravity, some containers are available which may be emptied by means of compressed air.

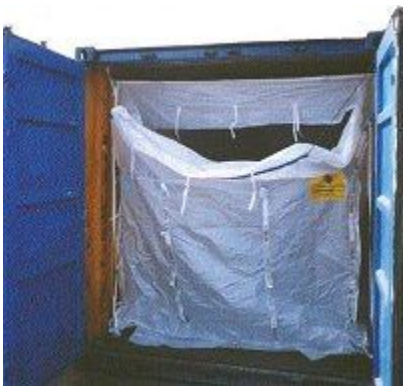


Bulk container with compressed air-assisted emptying



Bulk container

By fitting "inlets" or liner bags, normal general cargo containers may also be used as bulk containers:





"Inlets" in a general purpose container, for transporting bulk cargo

Reusable "inlets" are available, as well as single-use "inlets" or disposable liners.

DIN EN ISO of January 1996 specifies under Code S and group code SN "named cargo containers". Examples of these include containers for transporting livestock (type code S0), containers for transporting automobiles (type code S1) and containers for transporting live fish (type code S2).

3.1.1.2 Container design and types, Part 2

Thermal containers are divided into refrigerated, refrigerated/heated and merely insulated types. A distinction is also drawn between those with fixed and removable equipment. Refrigerated or heated containers allow goods to be transported irrespective of ambient temperature. The question of whether the container heats or refrigerates is relative. Nonetheless, the term **refrigerated container** or reefer has become established in common parlance. The correct term would be **temperature-controlled container**.



Thermal container with integral unit - rear



Thermal container - side and end with integral unit

Depending on container quality, the entire outer skin may be appropriately insulated, thereby reducing the internal dimensions of the container. According to ISO 1496/2, the internal width must amount to 2200 mm. The container (reefer) floor is generally made of T-shaped aluminum profiles and is also known as a T-grating. The floor is strong enough to allow access by forklift trucks. The type code distinguishes between thermal containers according to type of refrigeration unit and/or coefficients of heat transmission (k values). The temperature of **insulated containers** may be controlled by external refrigeration units.





Mobile refrigeration unit, in this case in stationary use




Mobile refrigeration unit, for stationary use

DIN EN ISO 6346, January 1996 lists thermal containers under Code R, namely:

- mechanically refrigerated under group code RE and type code R0
- mechanically refrigerated and heated under group code RT and type code R1
- self powered mechanically refrigerated under group code RS and type code R2 and
- self powered mechanically refrigerated and heated under group code RS and type code R3





20' x 8'6" thermal container, mechanically refrigerated/heated





40' x 9'6" thermal container, mechanically refrigerated/heated

Code H of the same standard covers refrigerated and/or heated thermal containers with removable equipment, with group code HR applying to:

- refrigerated and/or heated with removable equipment located externally, coefficient of heat transfer K = 0.4 W/(m² x K), type code H0
- refrigerated and/or heated with removable equipment located internally, type code H1
- refrigerated and/or heated with removable equipment located externally, coefficient of heat transfer K = 0.7 W/(m² x K), type code H2

Group code HI covers insulated containers, namely:

- Type code H5 = insulated, coefficient of heat transmission K = 0.4 W/(m²·K)
- Type code H6 = insulated, coefficient of heat transmission K = 0.7 W/(m²·K)

These containers also resemble standard containers externally, but inside they have a heat-insulating lining, generally of polyurethane foam-based insulating material. Their wall thickness of 50 - 100 mm reduces stowage space a little compared to normal containers. The insulation is intended to protect the cargo from over-rapid temperature variations. If lower temperatures or refrigeration are required, refrigerants may be added. Ice is seldom used nowadays, since it requires special ice boxes; instead, dry ice is often used. Another method is to vaporize liquefied gases. Such containers are used for the most part to carry heat-sensitive cargoes.

Insulated containers and refrigerated containers may also be used without refrigeration or heating. Since temperature variations in the container are delayed relative to the external temperature, using such containers can be entirely appropriate for certain goods.

Refrigeration and/or heating may be achieved by:

- compressors directly driven by electrical motors

- compressors directly driven by internal combustion engine
- externally generated cooling or heating air

The electrical power required for driving refrigerating/heating machines is supplied by on-shore or on-board power supply systems or by a separate generator driven by an internal combustion engine, diesel engines mostly being used for this purpose. A distinction is drawn between fixed generators and so-called clip-on generators, which are only fitted on a temporary basis.



Integral refrigerating/heating machine for connection to on-shore or on-board power supply system

Fixed refrigeration units (integral units) reduce the useful length and payload of containers.





Clip-on units for temporary fitting to thermal containers

Clip-on units increase the overall length of the containers. These heating/refrigerating machines are individual units which may be stored on shore or on board and temporarily attached to the end walls of containers. Each apparatus may be individually adjusted and does not affect the cargo space atmosphere for other containers. Supply air is input at the bottom and return air is extracted at the top.



Openings for supply and return air in an external unit

Such containers are also known as "porthole containers", the name arising from the similarity between these openings and the round ships' windows known as portholes.



Thermal container/insulated container with externally fitted supply device

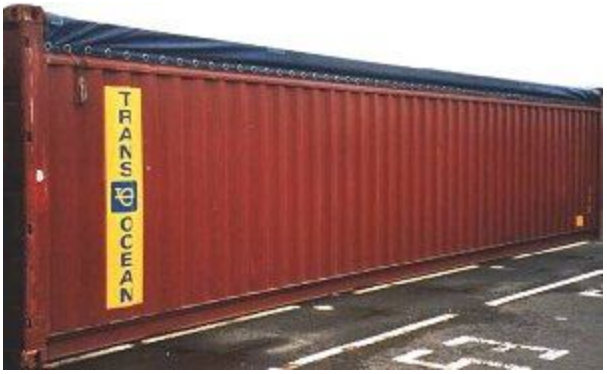


Supply device for a thermal container - detail

Externally generated cooling or heating air may be supplied via on-shore or on-board central refrigeration systems. Containers supplied by this system also have two openings in the end wall for the supply and removal of cargo space air subject to artificial temperature control.

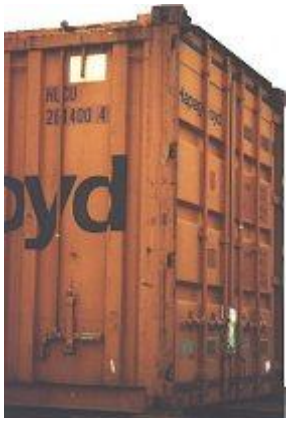
The term **Conair container** is a brand name often used for "insulated container".

Open-top containers are suitable in general for all types of general cargo but especially for heavy, overheight cargo. Since their roofs are openable, they may also be packed from above. They have doors at least at the rear and their roofs are openable or removable. The roof covering consists either of a tarpaulin supported by roof bows or a solid, fully removable hard-top. Containers with the latter type of roof covering are known as hard-top open-top containers.



Open-top container with tarpaulin and roof bows





Above and right:
Hard-top open-top containers



Cover removed from a 20' hard-top open-top container

So that it is possible not only to introduce cargoes from above but also to load overheight cargoes through the doors, some containers have removable or swing-out top members or top door rails. This also facilitates packing using lifting gear at floor level.



Open-top container with top member removed

The roof bows of an open-top container serve both to support the tarpaulin and to stabilize the whole container. Such containers are therefore also made wholly of steel, so that the structure is still sufficiently stiff despite the absence of a roof. If overheight cargoes are carried, the stabilizing effect of the roof bows is absent. In some cases, therefore, it would be sensible to investigate whether it would not be equally possible to use flatracks or indeed whether that would not be the better solution from the point of view of cargo securing.

Half-height open-top containers are open at the top, as their name suggests. There are two types in existence: either completely open or with a tarpaulin and roof bows. The rear door may often be folded down and used as a ramp.

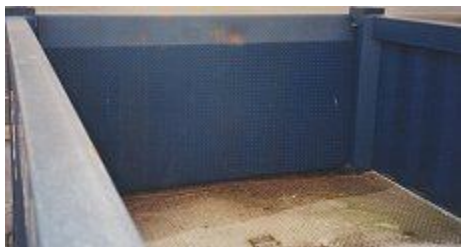


20' and 40' half-height open-top containers, with and without cover

DIN EN ISO 6346, January 1996 lists open-top containers, abbreviated as OT, under Code U. The group code for all such containers is UT. The following types are distinguished by the type codes indicated:

- U0 - Opening(s) at one or both end(s)
- U1 - Opening(s) at one or both end(s) plus removable roof in end frame
- U2 - Opening(s) at one or both end(s) plus opening(s) on one or both sides
- U3 - Opening(s) at one or both end(s) plus opening(s) on one or both sides plus removable top members
- U4 - Opening(s) at one or both end(s) plus opening(s) on one side plus full openings on the other side
- U5 - Full, solid side and end walls (no doors)





20' x 8' x 4'3" Half-height open-top - external and internal view

With this container, the rear end wall (at the front in the left-hand picture) can be folded out and used as an access ramp for forklift trucks. A warning is attached:



Warning about the "ramp" of a half-height open-top container

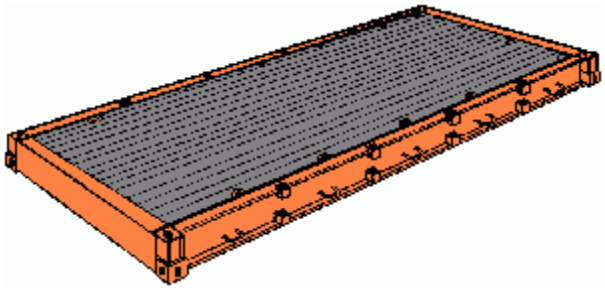
The old, but still valid, number combination 4351 would today be replaced by the code 42U3.





Two OTs: each with rear doors and removable top members

Platforms and flatracks are also known in common parlance as **open containers**. Although such containers may have special equipment, such stanchions, fold-down end walls, lashing equipment etc., they are often described in specialist literature as **containers without additional equipment**.



Platform: 20' long, 8' wide and 1'1¼" high

Platforms consist of reinforced container floors with sheet steel or planking. A large number of lashing points are provided for cargo securing; these may be welded-on or recessed lashing lugs or rings, or lashing bars attached to the outsides of the side rails.



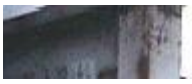
Two 20' platforms 1'1¼" high

If agreed with the shipping companies, several platforms may be combined to form larger loading areas for carrying oversize goods. Acceptance and delivery then require special attention and coordination of operations between the ship's command, shipping companies and terminal operator is recommended. When empty, platforms can be stacked into piles to save space during transport. Since loaded platforms are not stackable, they are loaded on board ship as the top layer of a hold or deck stack. If a ship's cell guides are equipped with flaps, any stowage space can be used. 20' platforms are generally 335 mm (1'1¼") high, while 40' platforms are generally 610 mm (2') high). There are 40' platforms with gooseneck tunnels at both ends.



Flatracks, also known as flats, consist of container floor and end walls. Flatracks with folding or collapsible end walls or end frames are commonly known as collapsible flats or collapsible flatracks.

20' flatrack with fixed end walls



Flatracks are also known as "open-top open-sided containers".

2.50 m wide 20' flatrack, one of the inland containers provided by DB (German Railroads)

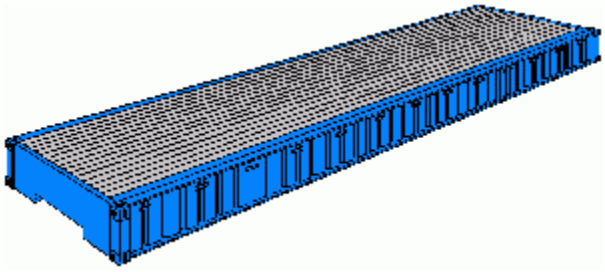


20' collapsible flatracks, erected and collapsed

The advantage of collapsible flatracks is that several unloaded flats can be stacked on top of one another to save space during transport. For cargo securing purposes, the flats are equipped with lashing bars, lugs or hooks of appropriate strength. Stanchion pockets and insertable stanchions are often provided. If agreed with the carriers, a number of flatracks may be combined together so as to be able to transport particularly large items of cargo.

3.1.1.3 Container design and types, Part 3

DIN EN ISO 6346, January 1996 allocates Code P to platform containers, with this edition of the standard combining both pure platforms and flatracks under this letter. Pure platforms bear group code PL or type code P0.



40' platform: 8' wide and 2' high with gooseneck tunnel at both ends



Group code PF covers type codes P1 and P2.

Half-height flats falling under P1, with lateral insertable stanchions

P1 platforms have two complete, fixed end walls, irrespective of how high they are.





Platform containers falling under P2 with corner posts and special load retainers

P2 platforms have fixed posts, either free-standing or with removable top members. The containers illustrated here are specially constructed to accommodate stacking boxes. The boxes are carrying cargo securing materials for securing the containers on board. They are naturally also ideal for transporting other heavy small parts.

Group code PC covers type codes P3 and P4. P3 platforms have folding complete end walls.



40' platform with completely folding end walls - collapsed



40' platform with completely folding end walls

P4 platforms have folding posts, either free-standing or with removable top members.



20' platform with folding free-standing corner posts - folded down in pairs



Group code PS covers type codes P5 to P9. P5 platforms are open at the top and ends (skeletal).

Frames for suspension of clip-on units

In the January 1996 edition, type codes P6 to P9 had not been assigned, but were kept as spares. Here is an example of how one of these codes has been assigned by Hapag-Lloyd:



40' x 8' x 9'6" P8 platform



Detail of P8 platform



40' collapsible flatrack with overheight, collapsible end

walls



Coil container with folding end walls

Coil containers are built like flats or flatracks, i.e. they consist of a container floor and flat or frame-like end walls. The container floor has cargo troughs for accommodating coils/rolls of steel sheet. Cargo securing costs are lower, since less complex lashing and blocking is required than on/in normal containers. However, when overall transport costs, including the return transport of empty coil containers, are taken into account, normal carriage without a special container may be more economical. Coil containers could be included amongst named cargo containers, but they are not covered by the standard.





20' flatracks, with fold-down end walls and coil wells (coil containers)

Tank containers are provided for carrying liquids and gases. The characteristics of the substances to be carried determine the material of which the tank is made, while the pressure under which the cargo has to be transported influences its construction. Tank containers almost always have as their basis a steel frame, into which tanks of various shapes may be inserted. Various fittings and accessories are incorporated, depending on type and method of filling and emptying. Temperature-controlled tank containers require special heating or cooling devices. They may be filled via domes or tubes and emptied downwards via floor drains or upwards via riser pipes and pressure generators or in any other suitable manner. The products to be carried may be any types of liquid, liquefied or gaseous substance, ranging from harmless to very dangerous.

Tank containers for non-dangerous liquids come under group code TN. Type codes T0, T1 and T2 distinguish between minimum pressures of 45 kPa, 150 kPa and 265 kPa.



Tank container for non-dangerous liquids

Tank containers intended for liquid foodstuffs must be clearly marked as being intended for this purpose:

Potable liquids only

Half-height tank containers or **half-height liquid containers** serve to carry high-density liquids which cannot be carried in normal tank containers because they cannot be filled to a high enough level and are therefore subject to surging.



Half-height liquid container

Tank containers for dangerous liquids come under group code TD. Type codes T3, T4, T5 and T6 distinguish between minimum pressures of 150 kPa, 265 kPa, 400 kPa and 600 kPa.



Tank containers for carrying dangerous liquids

Such containers are subject, among other things, to the regulations governing the carriage of hazardous materials and may also have to be tested for compliance with the regulations of the Department of Transportation (DOT) or the German Federal Institute for Materials Research and Testing (BAM).





20' x 8'6" tank container for hazardous materials with a test pressure of 600 kPa

Tank containers for gases are assigned to group code TG and type codes T7, T8 and T9. T7 and T8 cover minimum pressures of 910 kPa and 2,200 kPa, while T9 does not as yet have a pressure assigned to it.

Tank containers must be at least 80% full for safety reasons, so as to prevent dangerous surging of the liquids in transit. As a rule of thumb, they should not be filled more than 95% full, so as to allow for thermal expansion of the contents.

The CTU packing guidelines state under the heading "Scope":

> *... They do not cover the filling or emptying of tank containers, portable tanks, or road tank vehicles, or the transport of any bulky cargo in bulk packagings.*

For this reason, nothing more will be stated with regard to tank containers at this point in the Handbook.

Tank containers may be replaced by introducing "flexible tubes" into standard containers, so turning them into temporary tank containers. However, a major problem associated with this is surging of the liquids, which may result in damage to the container walls.

Frequently used terms and comments:

Closed containers include all non-ventilatable general purpose, dry bulk and tank containers. These containers allow no or only very slight air exchange. They are consequently gas-tight or at any rate virtually gas-tight. They are not suited to transporting goods which require an exchange of gases.

The phrase **design for ease of opening** is found in container literature in relation to the desire for rapid packing and unpacking. It is often used in relation to dry bulk containers with special openings.

Half-height containers are lower than standard containers. The size codes distinguish between those 1,295 mm (4'3") high and those of a height less than or equal to 1,219 mm (4'). The containers are specially designed for goods with low stowage factors and for high-density cargoes, such as heavy barrels, metal sheet etc.

The following needs to be said with regard to **special containers**: from a technical point of view, these meet the needs of many forwarders and are desirable with regard to cargo securing. Their special fittings simplify packing and cargo securing, reducing securing costs and shipping risks. However, since they are adapted to one product or group of products to be transported, it is more difficult to use them on all routes, resulting in higher freight rates than for standard containers due to more frequent carriage of empty containers. From the point of view of cargo safety, however, special containers developed for a particular product are preferable to conventional containers.

All wooden parts of containers traveling to Australia and New Zealand, including packaging and securing lumber, must be treated, and proof must be provided in the form of appropriate wood treatment certificates. The wooden parts of most containers are impregnated against insect infestation. Australia's and New Zealand's quarantine regulations require proof in the form of a plate:



This provides documentary evidence that the wooden parts have been treated against the Sirex wasp.

3.1.2 CSC & structural and testing regulations

The technical requirements placed on containers are enshrined in the respective standards and in the "International Convention for Safe Containers" or "CSC".

The aim of the Convention is to achieve the highest possible level of safety of human life in the handling, stacking and transporting of containers. The Convention applies to all containers used for international transport, except containers developed especially for air travel.

Article III, entitled "Application" states:

> *2. Each new container shall be approved either in accordance with the provisions for type-testing or for individual testing as contained in Annex I.*

The Convention specifies precise requirements which individual components must meet. Annex II of the CSC gives examples of structural safety requirements and tests. According to the CSC,

> *a container made from any suitable material which satisfactorily performs the following tests without sustaining any permanent deformation or abnormality which would render it incapable of being used for its designed purpose, shall be considered safe. ...*

Every contracting state must ensure that effective procedures are put in place to enforce the regulations in Annex I of the Convention. This Annex sets out regulations for the testing, inspection, approval and maintenance of containers. However, the text of the Convention does allow duly authorized organizations to be entrusted with all these tasks, other than maintenance. In

many countries, the national classification societies are entrusted with these tasks, e.g. Germanischer Lloyd in Germany.

A Safety Approval Plate must be permanently affixed to every container at a readily visible place, where it cannot be easily damaged.



CSC plate

The Plate shall contain the following information in at least the English or French language:

- "CSC SAFETY APPROVAL"
- Country of approval and approval reference
- Date (month and year) of manufacture
- Manufacturer's identification number of the container or, in the case of existing containers for which that number is unknown, the number allotted by the Administration
- Maximum gross weight (kilograms and lbs)
- Allowable stacking weight for 1.8 g (kilograms and lbs)
- Transverse racking test load value

The Safety Approval Plate (...) shall take the form of a permanent, non-corrosive, fire-proof rectangular plate measuring not less than 200 mm by 100 mm. The words "CSC Safety Approval" of a minimum letter height of 8 mm and all other words and numbers of a minimum height of 5 mm shall be stamped into, embossed on or indicated on its surface in any other permanent and legible way.

- Country of Approval and Approval Reference is in this case the USA, the certifier is AB, standing for the American Bureau of Shipping, the reference is 745.

Test plate from American Bureau of Shipping

- Date (month and year) of manufacture is year: 1998 and month: September (stated according to ISO standard as 98-9).

- Manufacturer's identification number of the container is JDK ...and so on.

- Maximum gross weight (kilograms and lbs is stated as 24,000 KGS and 52,910 LBS (i.e. pounds). According to the original DIN/ISO standards, the maximum total mass for a 20' container is 20,320 kg. In the example it is therefore higher. This is no longer the case. As can be seen in the picture to the right, containers with a markedly higher total weight are available.



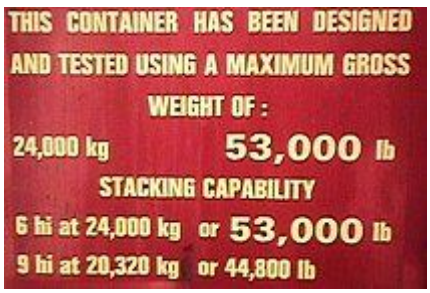
- Allowable stacking weight for 1.8 g (kilograms and lbs). According to ISO standards, fully loaded containers must be stackable six high. The container given by way of example may be stacked 192,000 high (192,000 kg ÷ 24,000 kg = 8).

These days, higher permissible loading capacities are practically the rule. On many containers, this is not only pointed out on the CSC plate but is also highlighted by the provision of special plates.









- Transverse racking test load value.In this instance, this value is 15,240 KGS or 33,600 LBS.



Transverse racking test

The values stated for the racking test are approximately in line with the standard; if the stated units of mass (kilograms) are converted into newtons, a slight difference remains.

The longitudinal racking test value is not stated on the CSC plate.



Longitudinal racking test

The test must be performed from both sides. The ISO standard requires loading of only 75 kN, Lloyd's Register requires 100 kN and Germanischer Lloyd applies 125 kN in its tests.



If important, legally prescribed data are no longer visible, a complaint should be lodged.

Damaged Safety Approval Plate



CSC plate

... The country of Approval should be indicated by means of the distinguishing sign used to indicate country of registration of motor vehicles in international road traffic. ...



The F in the above example stands for France. BV is the abbreviation for the classification society Bureau Veritas, which operates in France.

Test plate from Bureau Veritas

Paragraph 2 b) states):

A blank space should be reserved on the Plate for insertion of end and/or side-wall strength values (factors) in accordance with Regulation 1, paragraph 3 and Annex II, texts 6 and 7. A blank space should also be reserved on the Plate for first and subsequent maintenance examination dates (month and year) when used.

The CSC Safety Approval Plates illustrated above do not carry these details. With good reason, since the regulations subsequently state:

End Wall Strength to be indicated on plate only if end walls are designed to withstand a load of less or greater than 0.4 times the maximum permissible payload, i.e. 0.4 P.
Side Wall Strength to be indicated on plate only if the side walls are designed to withstand a load of less or greater than 0.6 times the maximum permissible payload, i.e. 0.6 P.

This is based on Paragraph 3 of Regulation 1, which states:

Where the Administration considers that a new container satisfies the requirements of the present Convention in respect of safety and if, for such container, the end and/or side-wall strength value (factor) are designed to be greater or less than that stipulated in Annex II such value shall be indicated on the Safety Approval Plate.



Positioning of data on the Safety Approval Plate

"A blank space should also be reserved on the CSC Plate for first and subsequent maintenance examination dates (month and year) when used."

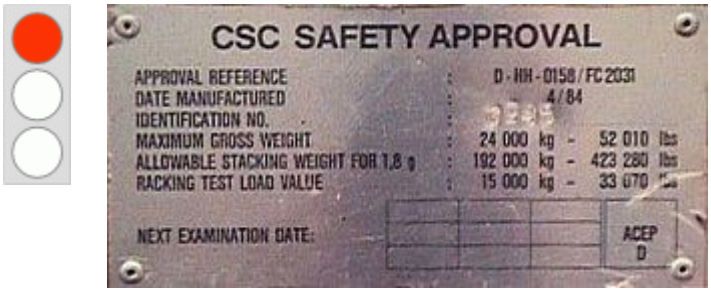
In the example illustrated, this blank space has been left not at the bottom but on the right of the other required data (see arrow). This is common practice.

In the "International Convention for Safe Containers", Regulation 2 of Annex I deals with maintenance, and reads as follows:

1. *The owner of the container shall be responsible for maintaining it in safe condition.*

2. *The owner of an approved container shall examine the container or have it examined in accordance with the procedure either prescribed or approved by the Contracting Party concerned, at intervals appropriate to operation conditions. The date (month and year) before which a new container shall undergo its first examination shall be marked on the Safety Approval Plate.*

3. *The date (month and year) before which the container shall be re-examined shall be clearly marked on the container on or as close as practicable to the Safety Approval Plate and in a manner acceptable to that Contracting Party which prescribed or approved the particular maintenance procedure involved.*



Next examination date not stated



Correct: Next examination date entered

4. *The interval from the date of manufacture to the date of the first examination shall not exceed five years. Subsequent examination of new containers and re-examination of existing containers shall be at intervals of not more than twenty-four months. All examinations shall determine whether the container has any defects which could place any person in danger.*



Correct: Interval between date of manufacture and first examination amounts to 5 years

The container was manufactured in 1998. On the CSC Plate, the first re-examination date is given as being month 09, i.e. September, 2003 (this is difficult to read on the Figure).

5. *For the purposes of this Regulation, "the Contracting Party concerned" is the Contracting Party of the territory in which the owner is domiciled or has his head office.*

For some years now, owners have in most cases been responsible for examining their own containers. Regulators have provided for this by establishing an "**A**pproved **C**ontinuous **E**xamination **P**rogram", in which owners participate. **ACEP** is a recognized repair and maintenance system providing for regular examinations and servicing. To participate actively in this program, it is necessary to register with the competent authorities. Registration is indicated on the container. The owner has then to take responsibility for the necessary inspections and the date for re-examination need no longer be indicated on the CSC plate.

A valid ACEP renders it unnecessary to indicate a next examination date.











"Approved Continuous Examination Program" registration data







Most container owners participate in the ACEP.

Chapter II of the "International Convention for Safe Containers" sets out regulations for approval of new containers by design type, as quoted in detail below:

Regulation 3 - Approval of new containers

To qualify for approval for safety purposes under the present Convention all new containers shall comply with the requirements set out in Annex II.

Regulation 4 - Design type approval

In the case of containers for which an application for approval has been submitted, the Administration will examine designs and witness testing of a prototype container to ensure that the containers will conform with the requirements set out in Annex II. When satisfied, the Administration shall notify the applicant in writing that the container meets the requirements of the present Convention and this notification shall entitle the manufacturer to affix the Safety Approval Plate to every container of the design type series.

Regulation 5 sets out the provisions for approval by design type:

1. *Where the containers are to be manufactured by design type series, application made to an Administration for approval by design type shall be accompanied by drawings, a design specification of the type of container to be approved, and such other data as may be required by the Administration.*
2. *The applicant shall state the identification symbols which will be assigned by the manufacturer to the type of container to which the application for approval relates.*
3. *The application shall also be accompanied by an assurance from the manufacturer that*

he shall:

a) produce to the Administration such containers of the design type concerned as the Administration may wish to examine;

b) advise the Administration of any change in the design or specification and await its approval before affixing the Safety Approval Plate to the container;

c) affix the Safety Approval Plate to each container in the design type series and to no others;

d) keep a record of containers manufactured to the approved design type. This record shall at least contain the manufacturer's identification numbers, dates of delivery and names and addresses of customers to whom the containers are delivered.

4. *Approval may be granted by the Administration to containers manufactured as modifications of an approved design type if the Administration is satisfied that the modifications do not affect the validity of tests conducted in the course of design type approval.*
5. *The Administration shall not confer on a manufacturer authority to affix Safety Approval Plates on the basis of design type approval unless satisfied that the manufacturer has instituted internal production-control features to ensure that the containers produced will conform to the approved prototype.*

Regulation 6 relates to "Examination during production":

In order to ensure that containers of the same design type series are manufactured to the approved design, the Administration shall examine or test as many units as it considers necessary, at any stage during production of the design type series concerned.

Regulation 7 covers "Notification of Administration":

The manufacturer shall notify the Administration prior to commencement of production of each new series of containers to be manufactured in accordance with an approved design type.

Chapter III of the CSC sets out "Regulations for approval of new containers by individual approval" and chapter IV sets out "Regulations for approval of existing containers".

In Germany, Germanischer Lloyd is the "administration" responsible for type testing of containers. Containers are certified if they fulfill the requirements of Annex II with regard to "Structural safety requirements and tests" and of course the other standards to be complied with.

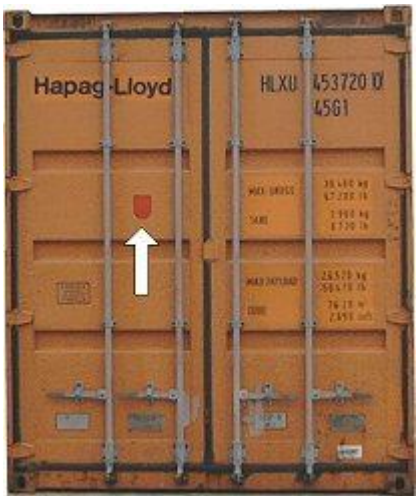






In the case of box containers, the test plate is generally affixed to the left door leaf.





Germanischer Lloyd test plates for approval by design type

The classification societies mentioned above are just a few examples of the many in existence. Other examples are the Belgian Bureau Veritas, Lloyd's Register in Great Britain, Nippon Kaiji Kyokai in Japan and Det Norske Veritas in Norway.

The Figures show additional plates affixed to the container and/or markings written thereon. In the "International Convention for Safe Containers", Regulation 1, Point 4 comments on this issue as follows:

> *4. The presence of the Safety Approval Plate does not remove the necessity of displaying such labels or other information as may be required by other regulations which may be in force.*





An international customs agreement ensures that empty containers do not count as imported merchandise in member states and are thus free of duty provided that the containers remain only temporarily in the customs territory. In addition, the container itself is deemed to be a bonded space.







Type test approval, Germanischer Lloyd

Although this container was manufactured in China for an owner in Bermuda, it was certified by Germanischer Lloyd. Of interest is the fact that Great Britain is the country of registration of participation in an "**A**pproved **C**ontainer **E**xamination **P**rogram" (ACEP) - a clear demonstration of the globalization of container traffic.



Container certified by Germanischer Lloyd (GL) with British ACEP



Container certified by Bureau Veritas (BV) with American ACEP

The various contracting states each recognize one another's national approving bodies. Although the states are bound by the CSC's structural safety requirements and tests, there is nothing to stop them enforcing additional safety requirements for their own containers.

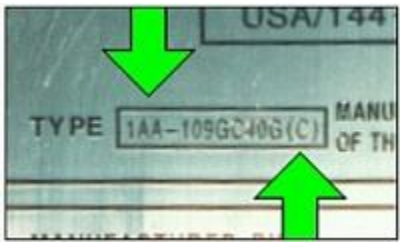
Type testing involves a wide range of test procedures, covering, for example, lifting from top corner castings, lifting from bottom corner castings, lifting using other additional devices on the container such as forklift pockets, grappler arm positions and other methods. The test procedures also extend to stacking and to concentrated loads on roof and floor. Transverse racking is another aspect which is subject to testing. Furthermore, containers must undergo permissible loading capacity tests with regard to longitudinal restraint, the end walls and the side walls.

The introduction to "Structural safety requirements and tests" reads as follows:

> *In setting the requirements of this Annex, it is implicit that in all phases of the operation of containers the forces as a result of motion, location, stacking and weight of the loaded container and external forces will not exceed the design strength of the container. In particular, the following assumptions have been made:*
>
> *a) the container will so be restrained that it is not subjected to forces in excess of those for which it has been designed;*
> *b) the container will have its cargo stowed in accordance with the recommended practices of the trade so that the cargo does not impose upon the container forces in excess of those for which it has been designed.*

This is significant in relation to the later Sections about packing of containers and cargo securing. Only if containers are selected in accordance with the cargo to be carried and properly packed are they in a position to justify the trust placed in them.

Testing and certification always relate to a particular type. A valid CSC plate affixed to a particular container tells the user what type of container he has before him. Nonetheless, some CSC plates give further details about this and about other supplementary standards:





Selective enlargement on the left

The character combination 1AA indicates a 40' long, 8'6" high standard container, while the letter C here stands for Closed.





Selective enlargement on the right

This container has also been type tested (yellow arrow). The character combination 1AA indicates a 40' long ISO container 8'6" high. The abbreviation OT stands for open-top (green arrow). The container is not subject to an "**A**pproved **C**ontainer **E**xamination **P**rogram" (ACEP) and the Plate therefore carries the date of its next examination (blue arrow), fully in accordance with regulations. Since the container was built in 1997, its first test falls due in 2002, with subsequent examinations

at two year intervals.

3.1.3 Cargo securing equipment

Owing to their cargo space being closed on all sides, box containers offer good possibilities for cargo securing by compact loading.

For securing individual items, a tight fit may be achieved using bracing, especially in corrugated steel containers. On the other hand, the possibilities for lashing are very limited. Relatively useful lashing lugs or rings are provided in all inland containers. Problems arise if lashing points are overstowed and are no longer available or reachable. Their strength also presents a problem: in general, their Maximum Securing Load (MSL) or Lashing Capacity (LC) is only 1,000 daN per lashing point.



Lashing points on the frame parts of a container

The lashing points for containers are not currently covered by standards and may therefore differ greatly. Not all lashing points may be loaded in all directions.





Lashing bars on the corner posts in the door area

Lashing points must be attached to the frame parts of a container, since only these components are adequately capable of absorbing forces.



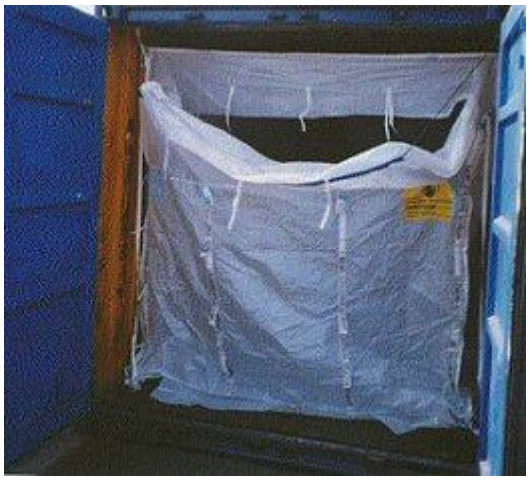
"Lugs" in the area of the top side rails/ top side rails

Lugs fitted in the area of the top side rails and sometimes also the front top end rails can only be used to a minimal degree for traditional cargo securing by lashing. Lugs are suitable, indeed almost too strong, for attaching "inlets" or special nonwoven fabric for catching sweat.



Nonwoven fabric providing protection against condensation water





Attaching nonwoven fabric

In any case, such measures serve to protect the cargo, and therefore to keep it safe: nonwoven fabrics provide protection against moisture or wetness dripping from the container ceiling and "inlets" protect against contact with the container walls. Some containers have lashing bars halfway up the container walls. In corrugated steel containers, they are welded in between the corrugations. The maximum securing load of these bars is not very high and they can only be used to secure relatively light individual items or small blocks of palletized cargo. The same applies to individual

lashing rails fitted into the wooden linings of aluminum containers.

Platform containers, i.e. the group comprising platforms and flatracks, have a relatively large number of reasonably strong securing elements.



Stanchion pocket
in a 40' collapsible flatrack

To achieve a tight fit by application of pressure, stanchions or stakes are very often provided, which may be inserted into corresponding stanchion (or stake) pockets.

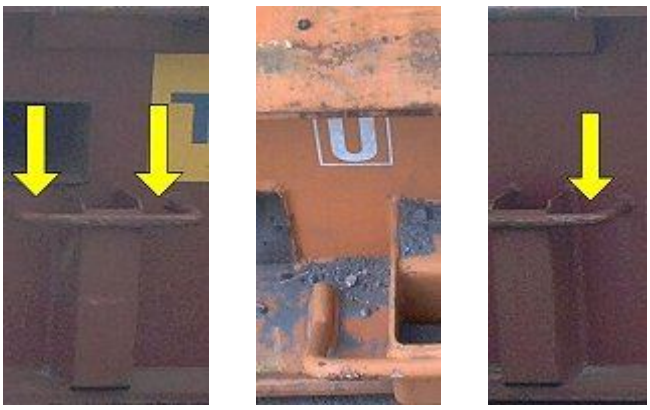


Right and left:

Do not attach lashings to stanchion (or stake) pocket components



Although the stanchion (or stake) pocket closing bar looks suitable for use as a lashing bar, this is expressly forbidden.



Lashing points
next to stanchion pockets on flatracks



Flatrack with lashing rings









Lashing point on the bottom rail of a flatrack



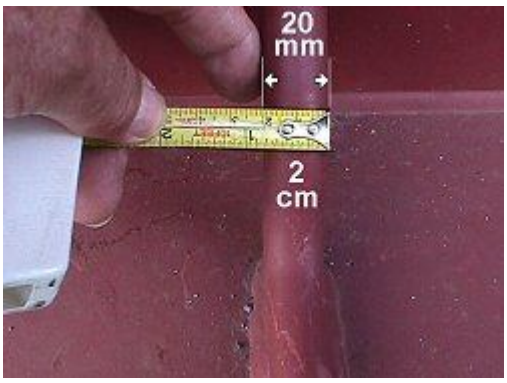
Safe Working Load



Maximum Pull Strength

It is regrettably often the case that no details are given about the strength of lashing points. Even if information is provided, it is mostly of no practical use because of the wording chosen. Further explanations relating to this problem are provided in the section headed Lashing materials, which states:

The maximum securing load (MSL) can be calculated using a rule of thumb, according to which the diameter of the lashing points is determined, squared and multiplied by 10; i.e. diameter x diameter x 10. The result of the calculation is in decanewtons (daN) if the diameter is stated in millimeters and kilonewtons (kN) if the diameter is stated in centimeters.



Determining the maximum securing load of lashing points using rule of thumb method

According to the above-stated rule of thumb, the maximum securing load of the lashing point is determined as follows:

In decanewtons: 20 · 20 · 10 = 4,000 daN

In kilonewtons: 2 · 2 · 10 = 40 kN

The rule of thumb can only be applied if the weld seams look good and the weld substrate appears sufficiently strong. If lashing points are welded to excessively thin metal sheet, the rule of thumb must not be used for calculation.





The rule cannot be applied, either, if the lashing points, e.g. rings, are held on with pop rivets, thin screws or the like, despite the rings "looking good".

Some platform containers have special securing systems:





Integral belt system in a 40' flatrack - one side ...





... and the other side

This flatrack has fixed belt reels, all on one side. The eyelets of the textile belts can be secured on hooks on the other side. Unfortunately, this securing system is virtually unusable, because the "tie-

down lashing/over-top lashing/friction loop" method has only a frictional effect, and this only with one-sided, uneven pretension. The belts do not allow a homogeneous tight fit to be achieved. If four of the total of eight lashing reels were fitted on each side, appropriate securing could be achieved for many types of goods.

The containers themselves are secured on ships and road and rail vehicles by means of the container corner castings. Appropriate securing systems, such as rods on board ship, twist locks or other lock units etc., may be attached in or to the corner castings, which are also responsible for load transfer if the containers are stacked in ship cell guides.



Securing of a container to a chassis

Occasionally, complaints arise during road-side cargo securing inspections because not all of the lock units have been firmly tightened, when of course they should be. The CTU packing guidelines provide advice on this matter. Section 6.4 states, on the subject of "CTUs on vehicles":

> *6.4.1 CTUs should be firmly secured on vehicles before the vehicle is moved. The most appropriate points for fixing containers and swap-bodies are the bottom corner castings of the unit. Before and during transport, it should be checked that the unit is properly secured on the vehicle.*
> *6.4.2 For transport on public roads or by rail, containers and swap-bodies should be secured to the road or rail vehicle by all bottom corner castings, in the absence of which, appropriate alternative measures should be taken. The main forces during the transport operation should be transferred to the unit through these bottom corner castings. Some additional forces may be transferred between the road vehicle chassis or rail-car surface and the unit bottom through load transfer areas in the unit bottom and in the vehicle surface. The securing devices on the vehicle may be twist locks, securing cones or securing guides. All such securing devices should be designed in such a way that the "open" or "locked" position of such securing devices is readily apparent.*

It is very common for problems to arise when containers, loaded in particular on road vehicles and attached firmly thereto, have to be carried by combined road/ship/road transport. Only occasionally do the vehicles have the legally prescribed lashing points, and even if they are present, they tend to be positioned extremely unfavorably or to be incorrectly or defectively designed. As at 2003, this is true of approx. 80% of all vehicles which have to be carried by sea.

On this matter, Point 2.1.6 of the CTU packing guidelines states:

> *A vehicle should be provided with points for securing it aboard ships (refer to European Standard EN 29367-I (ISO 9367-1): Lashing and securing arrangements on road vehicles for sea transportation on Ro/Ro ships - General requirements - Part 1: Commercial vehicles and combinations of vehicles, semitrailers excluded, and to EN 29367-2 (ISO 9367-2):*

Lashing and securing arrangements on road vehicles for sea transportation on Ro/Ro ships - General requirements - Part 2: Semitrailers".)



Strong, well-positioned lashing point on a semitrailer



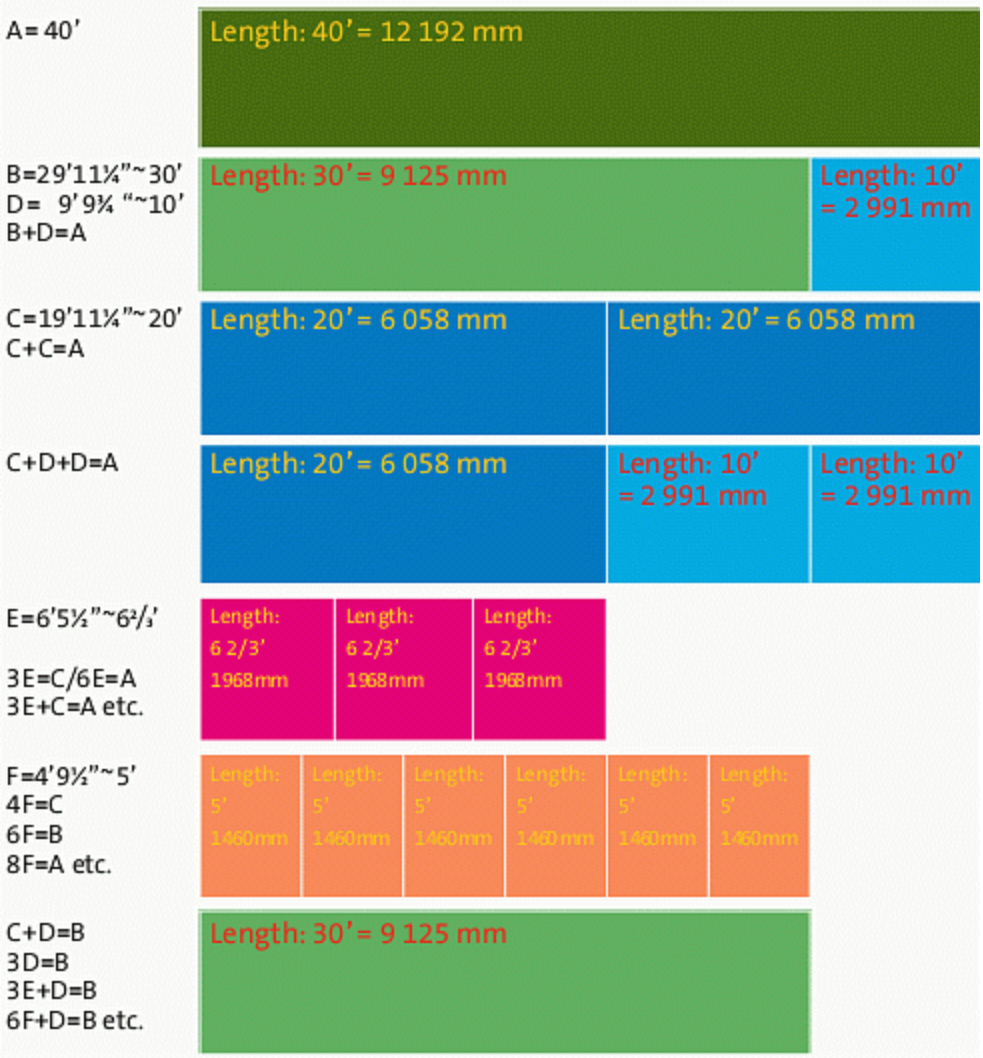
Will the screws withstand the stresses of maritime transport?



Unfavorably located lashing point - unusable

3.2 Container dimensions and weights

The lengths of freight receptacles as were and sometimes still are used for example in inland transport, and of conventional large containers are based on a modular system, for which the starting point was and indeed still is a 40' (12,192 mm) long container. The other nominal sizes have arisen by division, with 3 inches being taken off each time to allow the containers to be combined together in practice.



Example of module combination

Freight containers A, B, C, D etc. are 8' high. If the containers are 8'6" high, the letters are doubled to give AA, BB, CC, DD, for example.

Container dimensions as stipulated in DIN/ISO 668 or DIN 15190, Part 1

Desig-nation	Length			Height			Width			Maximum gross weight	
	mm	ft	in	mm	ft	in	mm	ft	in	kg	lb
1A	12,192	40		2,438	8		2,438	8		30,480	67,200
1AA	12,192	40		2,591	8	6	2,438	8		30,480	67,200
1B	9,125	29	11¼	2,438	8		2,438	8		25,400	56,000
1BB	9,125	29	11¼	2,591	8	6	2,438	8		25,400	56,000
1C	6,058	19	11¼	2,438	8		2,438	8		20,320	44,800
1CC	6,058	19	11¼	2,591	8	6	2,438	8		20,320	44,800
1D	2,991	9	9¾	2,438	8		2,438	8		10,160	22,400
1E	1,968	6	5½	2,438	8		2,438	8		7,110	15,700
1F	1,460	4	9½	2,438	8		2,438	8		5,080	11,200

At the moment, the following lengths are stated and defined in the metric and/or English customary systems. They relate not only to freight receptacles such as containers but also to swap-bodies:

Length code (character)	Container length		
	mm	Feet / ft / '	Inches / in / "
1	2,991	10	
2	6,058	20	
3	9,125	30	
4	12,192	40	
A	7,150		
B	7,315	24	
C	7,430		
D	7,450	24	6
E	7,820		
F	8,100		
G	12,500	41	
H	13,106	43	
K	13,600		
L	13,716	45	
M	14,630	48	
N	14,935	49	
P	16,154		
USA only		53	
Permitted in some states of the USA		57	

Current widths are:

Container width		
mm	Feet / ft / '	Inches / in / "
2,438	8'	
2,500		
2,550		
	8'	6"

Containers of the following heights are in use:

Height code [example of container type]	Container length		
	mm	Feet / ft / '	Inches / in / "
9 [20' Platform]	337	1	1 1/4
9 [40' Platform]	610	2	
9	1,219	4	
8 [Half-Height]	1,293	4	3
0	2,438	8	
2 [Most containers]	2,591	8	6
4	2,743	9	
5 [High Cube]	2,895	9	6
6	> 2,895	> 9	6

Length: 7.43 m
Width : 2.50 m
Height : 2.60 m

Containers 7.43 m long are in principle half-size 49' containers. With a width of 2.50 m and a height of 2.60 m, such containers fulfill the technical requirements and traffic laws of many countries.

Containers suitable for international use

Proposed size unacceptable in the majority of cases

Length: 7.45 m
> Width : 2.55 m
Height : 2.90 m

The above-mentioned container is virtually identical to the CEN standard C-type swap-body, which is 7.45 m long. However, attempts to introduce such a container with widths of over 2.55 m and heights of over 2.90 m may well meet with resistance.

Length = 49' = 14 935.2 mm (14.90 m)
Width = 8'6" = 2 590.8 mm (2.60 m)

Container used mainly in the USA

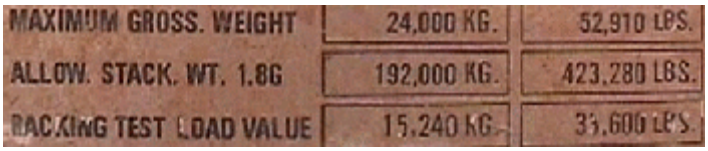
The appropriate specialist committees have devoted time to discussing the introduction of 49'/14.9 m long containers with a width of 8' 6"/2.60 m. However, such a container is unacceptable to most of the countries in Africa, Asia, Australasia and Europe. The same applies to a half-length container 24'4½"/7.43 m long, because of the 2.60 m width.

Container size	Maximum gross weight		Regulatory text
	Kilograms (kg)	Pounds (lb)	
20'	20,320	44,800	to old ISO standard
20'	24,000	52,910	to ISO 688
20'	30,480	67,200	optional
30'	25,400		
40'	30,480	67,200	
40'	32,000	70,550	optional



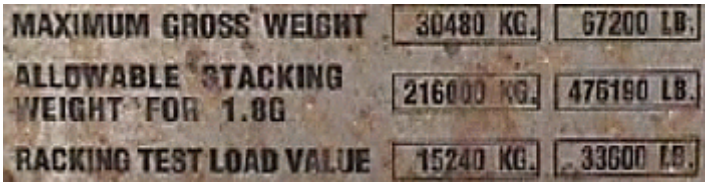
Maximum mass for a 20' container according to the old standard

The significant feature of this container is that the term used is the more correct "mass", the unit of mass being correctly stated as the kilogram.



Maximum mass for a 20' container according to DIN ISO 688

The term used in this example is weight, as is more usual, but the unit used is that of mass. The correct unit would be the newton. The correct unit would be the newton, with the decanewton or kilonewton [daN, kN] also being possible.



Maximum mass for a 40' container according to the old standard or optionally for a more recent 20'

The external dimensions of the containers are specified in ISO 668, with the maximum allowable dimensional tolerances being ± 10 mm. The internal dimensions are stated as minimum values. The current internal container dimensions are dependent on the structural material used and the container type selected.

Standard dimensions	Length		Width	Height	
	20'-Container	40'-Container			
External: mm	6,058	12,192	2,438	2,438	2,591
External: '/"	19' 10 1/2"	40'	8'	8'	8' 6"
Internal: mm	5,867	11,998	2,330	2,197	2,350
Internal: '/"	19' 3"	39' 4 3/8 "	7' 7 3/4"	7' 2 1/2"	7' 8 1/2"
Door opening: mm	Not applicable	Not applicable	2,286	2,134	2,261
Door opening: '/"	Not applicable	Not applicable	7' 6"	7'	

Many of the following statements fall equally within the scope of the operational markings covered in Section 3.5, where additional information may be found.

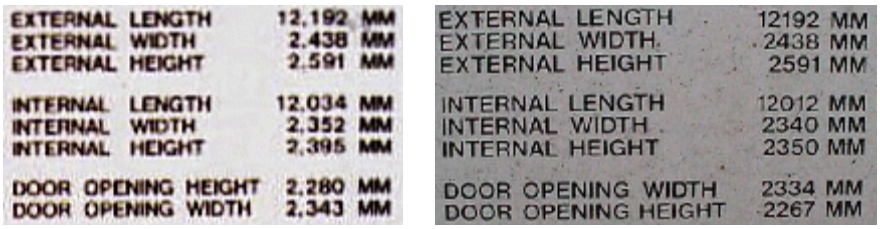
If real data relating to containers to be ordered and subsequently packed are required for the purpose of forward planning, it is best to refer to the brochures published by shipping companies or other container owners. When packing a container, it is important to cast an eye over the plates affixed to it.

Pallet-compatible containers are 2.50 m wide, for example, and usually carry an appropriate warning:

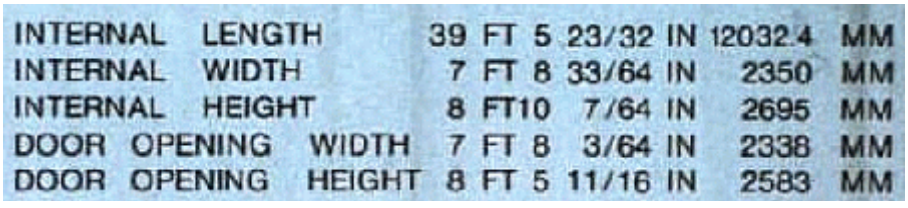


Warning affixed to a 2.5 m wide container

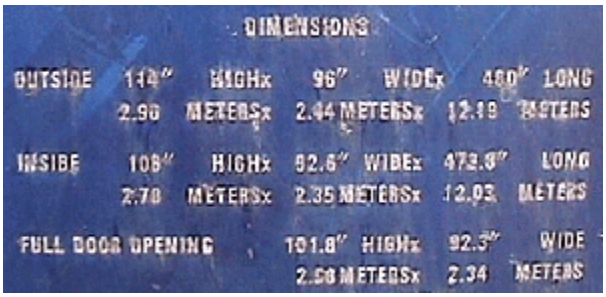
This warning also counts as an operational marking. More detailed information is also to be found in this section.



External, internal and door dimensions, metric system



Internal and door dimensions, in both feet and inches and millimeters
Millimeters



Dimensions, stated solely in inches and meters

The following two tables give the lengths and gross weights for 20', 30' and 40' ISO containers and 10' to 40' inland containers.

Container size in feet	Length		Maximum gross weight in kg
	External	Internal	
20'	6,058 mm	5,867 mm	20,320
30'	9,125 mm	8,931 mm	25,400
40'	12,192 mm	11,998 mm	30,480



20' container with maximum total weight of 30,480 kilograms

The ISO standard maximum gross weights for inland containers are specified as follows:

Length in feet	Length in millimeters	Width in millimeters	Gross weight [kg]
10'	2,991	2,500	10,000
20'	6,058	2,500	20,000
30'	9,125	2,500	25,000
40'	12,192	2,500	30,000

The minimum dimensions for the loading areas and volumes of ISO containers are specified as follows:

Container size	Designation	Loading area [m²]	Volume [m³]
40'	1 AA	28.0	65.7
40'	1 A	28.0	61.4
20'	1 CC	13.7	32.1
20'	1 C	13.7	30.0

Data relating to loading areas are very seldom found. Volumes, on the other hand, are almost always stated:







As a rough guide, values are approx. 30 m³ for 20' containers and approx. 67 m³ for 40' containers.

For tank containers, preferred practice is to state their volume in liters rather than in cubic meters:



Volume in liters on a French tank container

As already described in Section 3.1.2 CSC & structural and testing regulations, the International Convention for Safe Containers specifies that the maximum gross weight must be marked on the CSC plate. Other regulations require the maximum gross weight and the tare weight to be indicated. This constitutes the minimum information with which the user of the container must be provided by law.

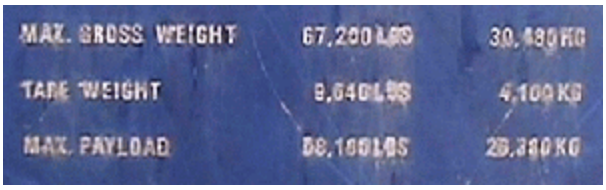


Minimum information on a half-height open-top

The maximum payload can be calculated as the difference between the maximum gross weight and the tare weight, but this information is already indicated on most containers.

Of interest in this context are the different terms selected by the various container owners. It would

be altogether desirable if these terms were to be standardized.



Maximum gross weight - tare weight = permissible payload

Tare weight + permissible payload = maximum gross weight



On platform containers, the data are located on the end walls or frame parts.



Markings on platform containers, including weights and other data



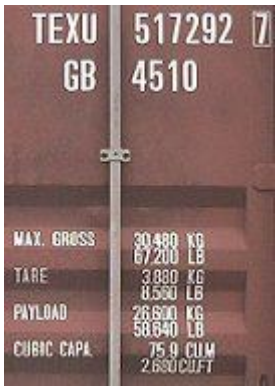


Max Gross 45,000 kg
or 99,210 lb
Tare 5,700 kg
or 12,570 lb

Markings on a collapsible flatrack with a 45,000 kg maximum weight

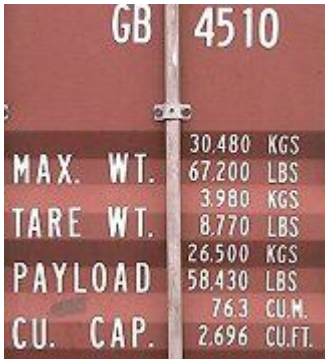
Volumes are almost always to be found together with the weight information. On box containers, all the above-mentioned values are usually marked large and clear on the right door leaf.





Weights and volumes on 20' reefers and 40' general purpose containers





Weights and volumes on high-cube reefers and general purpose containers

Nothing should be stuck over these important data on a container:



The text of the sticker refers limited quantities of hazardous materials and has nothing to do with the maximum gross weight. Loading area and loading capacity (volume) depend principally on wall thickness and structural height.

Unfavorably positioned sticker

In practice, the ISO standard minimum values for weights and volumes are generally exceeded. Depending on the intended goods transport operation, it may therefore be worth making a comparison and choosing the most favorable container. A comparison of the gross stowage factor with the stowage factor of the respective transport receptacles is always appropriate.

Containers often carry information about these aspects (picture to the right).

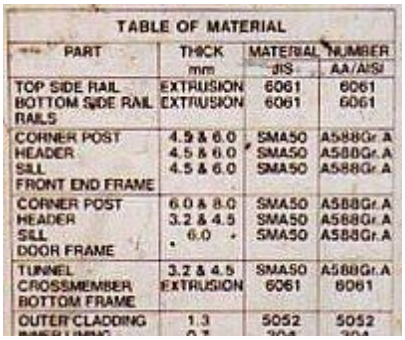
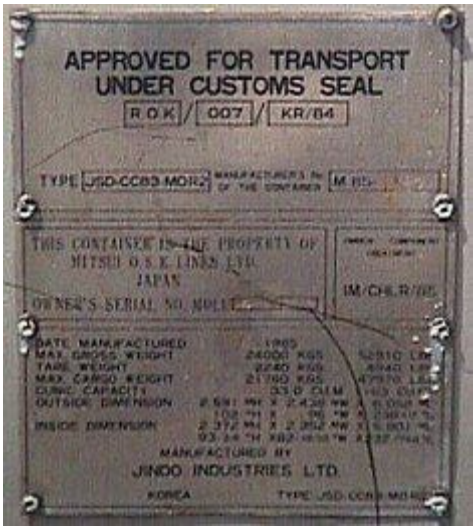


TABLE OF MATERIAL

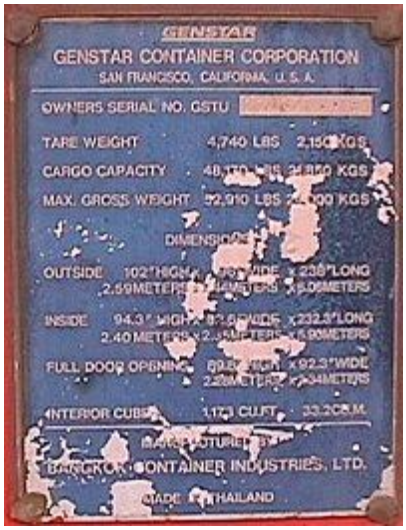
PART	THICK mm	MATERIAL JIS	NUMBER AA/ASI
TOP SIDE RAIL	EXTRUSION	6061	6061
BOTTOM SIDE RAIL	EXTRUSION	6061	6061
RAILS			
CORNER POST	4.5 & 6.0	SMA50	A588Gr.A
HEADER	4.5 & 6.0	SMA50	A588Gr.A
SILL	4.5 & 6.0	SMA50	A588Gr.A
FRONT END FRAME			
CORNER POST	6.0 & 8.0	SMA50	A588Gr.A
HEADER	3.2 & 4.5	SMA50	A588Gr.A
SILL	6.0	SMA50	A588Gr.A
DOOR FRAME			
TUNNEL	3.2 & 4.5	SMA50	A588Gr.A
CROSSMEMBER	EXTRUSION	6061	6061
BOTTOM FRAME			
OUTER CLADDING	1.3	5052	5052

Details of the materials used in a container

Sometimes, data about dimensions, weights, volumes etc. are also given on the CSC plates themselves or on separate plates:



CSC plate giving virtually full information



Separate plate giving virtually full information



Separate plate giving weights and dimensions

An English foot is divided into 12 inches and corresponds to 30.48 cm. An English inch corresponds to 25.4 mm. While inches are conventionally each subdivided into 12 "lines", it is usual to state fractions of an inch, such as ½", ¼", 1/8"or 1/16". An English pound (lb) corresponds to 453.6 g. A cubic foot (cu.ft.) corresponds to 28.35 liters.

Metric units may be roughly converted by rule of thumb into English customary units and vice versa, as follows:

- Meter x 10 ÷ 3 = foot
- Foot ÷ 10 x 3 = meter
- Kilogram x 2 + 10 % = pound

- Pound ÷ 2 - 10 % = kilogram
- Cubic meter x 35 = cubic foot
- Cubic foot ÷ 35 = cubic meter

3.3 Identification system

The current standard which deals with the coding, identification and marking of containers is DIN EN ISO 6346, dated January 1996. Among other things, this standard specifies that the previous standards with similar content have equal validity, since a number of older versions of containers with different markings naturally remain in service alongside the brand new ones. This Section will provide only certain essential explanations with regard to the systems used - for more detailed information, the reader should refer to the corresponding standards and more extensive specialist literature.

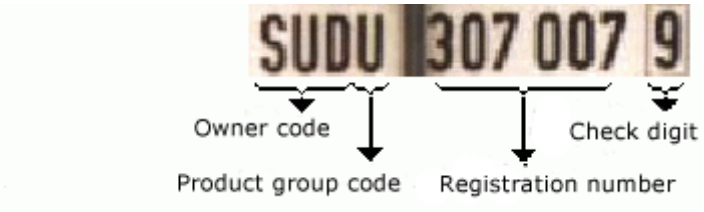
The foreword to the standard states, among other things, that it includes not only the statutory units but also corresponding sizes stated in Anglo-American units. Under the German Units of Measurement Act, 22nd February 1985, the use of such units nationally and commercially in Germany is proscribed. Such units may only be quoted to aid business relationships with countries which still use these units.



Marking on the door of a container

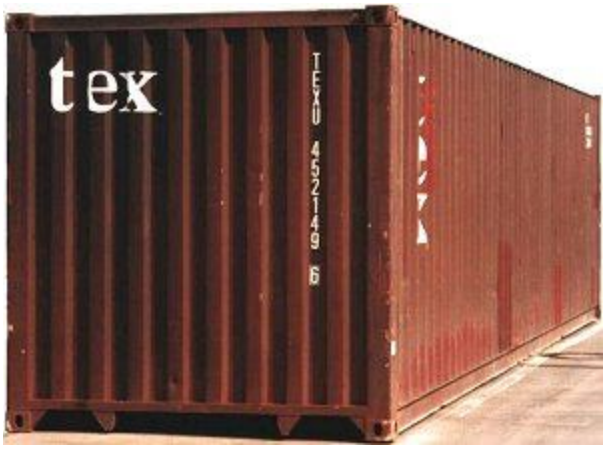
A distinction is drawn between compulsory and optional marking. Compulsory ISO marking must be used on all containers, while optional marking does not have to be: they are included in the standard to improve understanding and to promote uniform application of marking. However, if a particular style of representation is specified for an optional mark, it must be complied with. The terms "compulsory" and "optional" used in the standard do not apply to the requirements of any legislative bodies, however.

The following is a basic version of horizontal container marking.



Container identification marking

This Figure shows a version of vertical container marking.



Marking on the front end of a container

The container identification system specified in DIN EN ISO 6346 consists solely of the elements shown, which can only be used together:

- owner code, consisting of three capital letters
- product group code, consisting of one of capital letters U, J or Z
- six-digit registration number
- check digit

The owner code must be unique and registered with the International Container Bureau (BIC - Bureau International des Containers - 14, Rue Jean Rey, 75015 Paris), either directly or through a national registration organization. The German BIC representative is the Studiengesellschaft für den kombinierten Verkehr e.V., Börsenplatz 1, 60313 Frankfurt am Main (tel. +49 69 283571 or +49 172 6700597). The SGKV can provide information and handle applications for registration of an owner code. In the Figures shown, the owner code consists respectively of the letter combinations SUD and TEX.

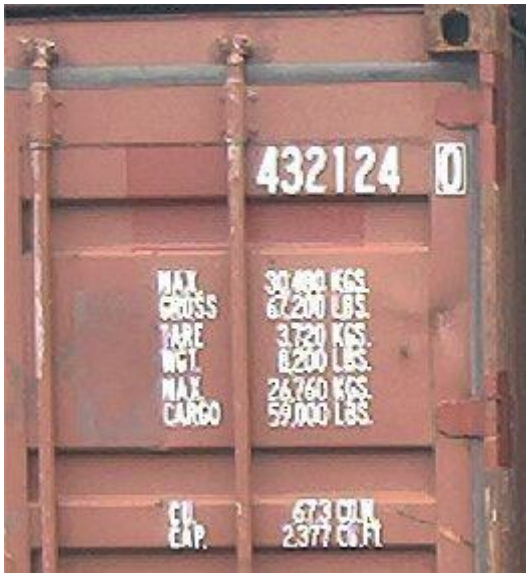
The product group code consists of one of the following three capital letters:

U - for all freight containers

J - for detachable freight container-related equipment

Z - for trailers and chassis

The term owner code may also apply to the combination of owner code and product group code, which is also known as an alpha prefix.



Alpha prefix absent

If the owner code is absent, the container cannot be identified.

The registration or serial number consists of six digits. In the examples shown, these numbers are 307007 and 452149. If the container number consists of fewer than six digits, it is preceded by enough zeros to make a six-digit number sequence.

The check digit, 9 and 6 respectively in the two examples shown, is always a single-digit number. It is usually in a box, to make it stand out from the registration number.

The check digit can be used to validate whether the owner code, product group code and registration number have been accurately transmitted. No freight information system (FIS), transport information system (TIS) or similar data processing system will accept a container number, if the result of the automatic checking procedure does not show agreement with the check digit. The procedure is deliberately designed to ensure that a number of transmission errors cannot cancel one another out, resulting in the acceptance of incorrect data. The checking procedure is as follows:

An equivalent numerical value is assigned to each letter of the alphabet, beginning with 10 for the letter A (11 and multiples thereof are omitted):

A	B	C	D	E	F	G	H	I	J	K	L	M
10	12	13	14	15	16	17	18	19	20	21	23	24

N	O	P	Q	R	S	T	U	V	W	X	Y	Z
25	26	27	28	29	30	31	32	34	35	36	37	38

The individual digits of the registration number keep their everyday value, i.e. 1 = 1, 2 = 2 etc.

The following numerical values are accordingly obtained for the two examples with the alpha prefixes "SUDU" and "TEXU":

S	U	D	U	3	0	7	0	0	7
30	32	14	32	3	0	7	0	0	7

T	E	X	U	4	5	2	1	4	9
31	15	36	32	4	5	2	1	4	9

Each of these numbers is multiplied computationally, as a function of its position, by numerical values of 2^0 to 2^9: the first number by 1, the second by 2, the third by 3 and the 10th by 512.

1st number/ digit	2nd number/ digit	3rd number/ digit	4th number/ digit	5th number/ digit	6th number/ digit	7th number/ digit	8th number/ digit	9th number/ digit	10th number/ digit
2^0	2^1	2^2	2^3	2^4	2^5	2^6	2^7	2^8	2^9
1	2	4	8	16	32	64	128	256	512

The following calculations are performed for the two examples:

S	U	D	U	3	0	7	0	0	7
30	32	14	32	3	0	7	0	0	7
×	×	×	×	×	×	×	×	×	×
1	2	4	8	16	32	64	128	256	512
=	=	=	=	=	=	=	=	=	=
30	64	56	256	48	0	448	0	0	3,584
The sum of these numbers equals				4,486	and is divided by 11, giving				407.8
The integer multiplied by 11 equals				4,477	The difference between the resultant values is the check digit				
				9					

T	E	X	U	4	5	2	1	4	9
31	15	36	32	4	5	2	1	4	9
×	×	×	×	×	×	×	×	×	×
1	2	4	8	16	32	64	128	256	512
=	=	=	=	=	=	=	=	=	=
31	30	144	256	64	160	128	128	1,024	4,608
The sum of these numbers equals				6,573	and is divided by 11, giving				
The integer multiplied by 11 equals				6,567	The difference between the resultant values is the check digit				
				6					

If the check digits 9 and 6 respectively are correctly input in each case during data entry, the system accepts the data.

If someone makes a mistake when transmitting a container number and inputs the alphanumeric sequence TEXU 4521**4**9 into a corresponding system instead of TEXU 4521**5**9, the program would perform the following calculation:

T	E	X	U	4	5	2	1	5	9
31	15	36	32	4	5	2	1	5	9
x	x	x	x	x	x	x	x	x	x
1	2	4	8	16	32	64	128	256	512
=	=	=	=	=	=	=	=	=	=
31	30	144	256	64	160	128	128	1280	4608
The sum of these numbers equals				6,829	and is divided by 11, giving				620.8
The integer multiplied by 11 equals				6,820	The difference between the resultant values is the check digit				
				9					

Since the correct check digit for this container is 6, the system would indicate an error.



Disadvantage of check digit 

The check digit 0 may occur twice, since it arises where the final difference is 0 and where it is 10. To ensure that this does not happen, the standard recommends that registration numbers should not be used which produce a final difference of 10. This is the case, however, with the registration number shown.

T	R	L	U		5	4	3	8	6	2	0
31	29	23	32		5	4	3	8	6	2	
1	2	4	8		16	32	64	128	256	512	
31	58	92	256		80	128	192	1,024	1,536	1,024	4,421
4,421	11	401.9	401	11	4,411	10					



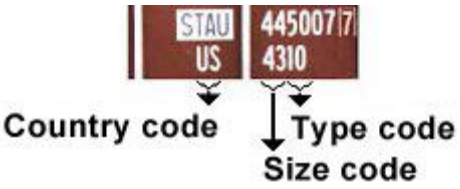
Correct identification using check digit 

H	L	X	U		4	6	9	1	9	2	0
18	23	36	32		4	6	9	1	9	2	
1	2	4	8		16	32	64	128	256	512	
18	46	144	256		64	192	576	128	2,304	1,024	4,752
4,752	11	432.0	432	11	4,752	0					

3.4 Size and type codes

The following photo shows a variant of horizontal marking which additionally includes country, size and type codes (in accordance with the 1985 version of DIN ISO 6346, use of which is still permitted):





Container identification including country, size and type codes

Appropriate abbreviations are used for the various countries, here US for United States of America, GB for Great Britain etc.

The first digit of the size code indicates the length of the container, with the number 4 standing for a 40' container. The second digit indicates height and whether or not a gooseneck tunnel is present. In our example, the number 3 stands for a height of 8 foot 6 inches (8'6") with gooseneck tunnel. The first digit of the type code indicates container type. Here, 1 means that the container is a closed container with ventilation openings. The second digit of the type code relates to special features. The 0 used here means opening at the end.

In the associated standard, columns are set out vertically:

Marking on Containers : Size and Type Code			ISO 6346
1	2	3	4
Length	Height	Type	Features

The corresponding data are laid out underneath. The abbreviation g.n.t. stands for gooseneck tunnel. A differently laid out size code summary is shown below:

1st digit	The digits have the following meanings...			
Length	1 = 10 '	2 = 20 '	3 = 30 '	4 = 40'

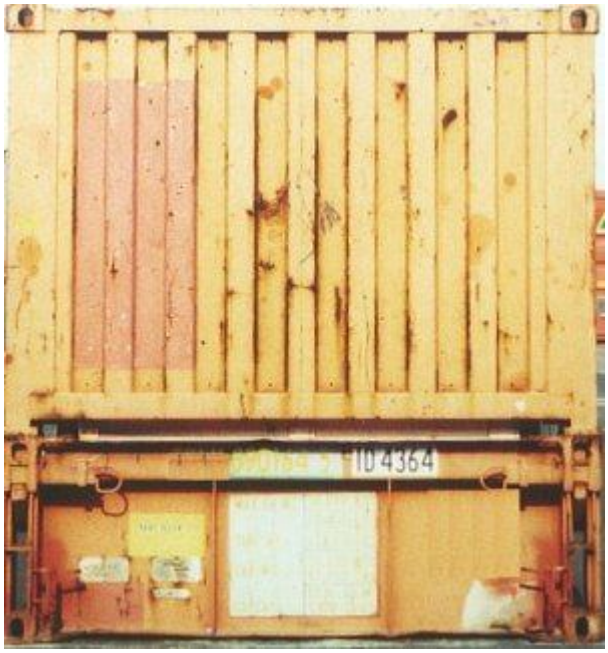
2nd digit	The digits have the following meanings...			
Height	0 = 8'	1 = 8' g.n.t	2 = 8' 6"	3 = 8' 6" g.n.t.
Height	4 = > 8'6"	5 = > 8' 6" g.n.t.	6 = > 4 ' 3 "	7 => 4' 3 "g.n.t.
Height	8 = > 4' 3 "< 8'	9 = < 4'		

In the type code, the first digit (i.e. the 3rd digit overall) indicates the container type and the second

(i.e. the 4th digit overall) indicates special features. However, there is a connection between the respective digits, which the following representation is intended to explain:

Marking on Containers : Size and Type code			**ISO 6346**
1	**2**	**3**	**4**
Length	**Height**	**Type**	**Features**

3. Ziffer = Type		4. Ziffer	
0	closed general purpose	0	end opening(s)
		1	end & full side opening(s)
		2	end & part side opening(s)
		3	end & roof opening
		4	end & roof & side openings
1	closed vented	0	smaller passive vents upper part
		1	bigger passive vents at upper part
		3, 4	passive vents at upper & lower part
		6	mechanical ventilation, located inside
		8	mechanical ventilation, located outside
2	thermal insulated heated named cargo	0	insulated
		1	insulated
		2	heated
		5	named cargo: livestock
		6	named cargo: cars
3	thermal refrigerated & heated	0	refrigerated, expendable refrigerant
		1	mechanically refrigerated
		2	refrigerated and heated
4	thermal refrigerated and/or heated removable equipment	0	refrigerated, expendable refrigerant
		1	mechanically refrigerated
		2	refrigerated and heated
5	open top	0	end opening(s)
		1	& removable top member in end frame
		2	& side opening(s)
		3	& removable top member in end frame
6	platform based	0	no endwalls
		1	complete fixed end walls
		2	fixed free-standing posts
		3	complete folding end walls
		4	folding free-standing posts
		5	with frame and roof
		6	with frame and open top
		7	skeletal, with open top and ends

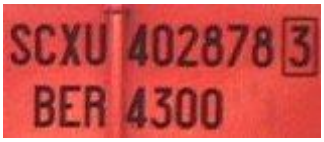


Incorrectly marked platform container

The digit sequence 4364 means: 40' long container 8'6" high with gooseneck tunnel and folding, free-standing posts. It should carry the digit sequence 4363, since the platform container has complete, folding end walls.

7	tank container	0	non-dangerous liquid, 0,45 bar
		1	non-dangerous liquid, 1.5 bar
		2	non-dangerous liquid, 2.65 bar
		3	dangerous liquid, 1.5 bar
		4	dangerous liquid, 2.65 bar
		5	dangerous liquid, 4.0 bar
		6	dangerous liquid, 6.0 bar
		7	dangerous liquid, 10.5 bar
		8	dangerous liquid, 22.0 bar
8	dry bulk	0-9	no specification
9	air/surface	0-9	no specification

Here are some examples of marking in accordance with this older standard:



This container is 40' long (4), 8'6" high and has a gooseneck tunnel (3). The type code 00 states that it is a general purpose container which has opening(s) at one or both end(s).



This container is 20' long (2) and 8' 6" high (2). It is a ventilated standard container (1), with narrow, passive vents in the upper part (0).



This container is 40' long (4), 8'6" high and has a gooseneck tunnel (3). It is a ventilated standard container (1), with narrow, passive vents in the upper part (0).

Both of these are 20' containers (2), 8'6" high and constructed as tank containers (7) suitable for transporting hazardous materials to a pressure of 6.0 bar.









According to the old Annex F "size code designations" annexed to DIN ISO 6346 of August 1985, the two containers are 40' long (number 4) and 8'6" high with a gooseneck tunnel (number 3). According to Annex G "type code designations", both containers are partially ventilated closed containers, which have passive vents in the upper part of the cargo space, the total cross-sectional area of the vents being less than 25 cm² per meter of container length (number combination 10).

However, the coding does not indicate that the green container is 2.50 m wide.



Below:
Warning due to
2.50 m width



The January 1996 edition of the standard bearing the same number includes another "size code", which has eradicated these inadequacies.



Like the above containers, this container is 40' long, 8½' high and has a gooseneck tunnel (number sequence 43). The type code 51 states that it is an open-top container, with openings at one or both end walls and a removable top member in the end frame.

The number sequence 43 stands for a length of 40' a height of 8'6" plus gooseneck tunnel. In each case the container is a flatrack, but



... the number sequence 63 is the code for a platform with complete folding end walls

... and the number sequence 64 is the code with a platform with folding, free-standing corner posts.





This flatrack allows verification of the coding, identification and marking according to old DIN EN ISO 6346 (1985), showing clearly that it is still valid, since the photo was taken in 2001. The marking beneath the container number reads RCX 4364.

According to the old country code, RCX stands for China (Taiwan). The size code 43 states that it is a 40' container 8'6" high and with a gooseneck tunnel. The number combination 64 states that it is a platform with folding, free-standing corner posts.

Similar flatracks exist which are 20' long and 8'6" high, of course, but they don't have goosenecks. This is clear from the number sequence 22. The type code 64 is the same as for the previous example: platform with folding, free-standing corner posts.







Both containers have a nominal length of 40', but are higher than 8'6" and each have a gooseneck tunnel (size code number sequence 45). According to type code 10, both containers are partially ventilated closed containers, which have passive vents in the upper part of the cargo space, the total cross-sectional area of the vents being less than 25 cm² per meter of container length.



According to the old 1984 standard:
4 = 40' Container
5 = > 8'6" high with gooseneck tunnel
3 = thermal
2 = refrigerated & heated





These photos show clearly that the container is a 40' long refrigerated container. According to the size code, the container height is > 8'6" - this is correct, as the container is 9½ feet high. The number combination 32, given as the type code, states that the container may be refrigerated or heated.

The following photo shows a variant of horizontal marking with size and type codes:





Size and type codes additionally stated in accordance with current standard

The container is 12,192 mm (40') long, 2,438 mm (8') wide and 2,591 mm (8'6") high. This is a general purpose container without ventilation, but which does have vents in the upper part of the cargo space.

The current standard, used for this marking, is not limited to numbers but also uses letters to make marking more precise. In addition, swap-bodies and the like are also covered by the coding. The superordinate term for both numbers and letters is character. The introductory country code has been discontinued.

The first character of the size code indicates the length of the receptacle:

Character	Container length			Character	Container length		
	mm	ft	in		mm	ft	in
1	2,991	10		D	7,450	24	6
2	6,058	20		E	7,820		
3	9,125	30		F	8,100		
4	12,192	40		G	12,500	41	
5	Spare			H	13,106	43	
6	Spare			K	13,600		
7	Spare			L	13,716	45	
8	Spare			M	14,630	48	
9	Spare			N	14,935	49	
A	7,150			P	16,154		
B	7,315	24		R	Spare		
C	7,430						

In the example, the 4 accordingly stands for a 40' container.

The second character is the code for the height and width of the container.

Container width	Charac-ter	Container height			Character for container width	
		mm	ft	in	> 2438mm und < 2500mm	> 2500mm
2,438/ 8'	0	2,438	8			
2,438/ 8'	2	2,591	8	6	C	L
2,438/ 8'	4	2,743	9		D	M
2,438/ 8'	5	2,895	9	6	E	N
2,438/ 8'	6	> 2,895	> 9	6	F	P
2,438/ 8'	8	1,295	4	3		
2,438/ 8'	9	< 1,219	< 4			

The standard type code allows identification of container type and other characteristics. Since this system is not yet complete, the standard recommends use of the group code if special characteristics of the container type have not yet been fixed or are unknown. The highest unassigned code character should be used as a provisional mark when it is necessary to represent significant characteristics which are not yet included in the Table.

Code	Group code	Type	Type code	Principal characteristics
G	GP	Unventilated general purpose container	G0	Openings at one or both end(s)
			G1	Vents in upper part of cargo space
			G2	Openings at one or both end(s), plus "full" openings at one or both sides
			G3	Openings at one or both end(s), plus "partial" openings at one or both sides
			G4	Spare
			G5	Spare
			G6	Spare
			G7	Spare
			G8	Spare
			G9	Spare

Code	Group code	Type	Type code	Principal characteristics
V	VH	General purpose containers with ventilation	V0	non-mechanical ventilation at the lower and upper parts of the cargo space
			V1	Spare
			V2	mechanical ventilation installed in the container
			V3	Spare
			V4	mechanical ventilation installed outside the container
			V5	Spare
			V6	Spare
			V7	Spare
			V8	Spare
			V9	Spare

Code	Group code	Type	Type code	Principal characteristics
B	BU	Dry bulk containers, non-pressure-resistant	B0	closed
			B1	airtight
			B2	Spare
		Dry bulk containers, pressure-resistant	B3	horizontal discharge, test pressure 150 kPa)[1]
			B4	horizontal discharge, test pressure 265 kPa
			B5	tipping discharge, test pressure 150 kPa
			B6	tipping discharge, test pressure 265 kPa
			B7	Spare
			B8	Spare
			B9	Spare

[1]) 100 kPa = 1 bar = 105 Pa = 105 N/m² = 14.5 lbf/in² (PSI)

Code	Group code	Type	Type code	Principal characteristics
S	SN	Named cargo containers	S0	Livestock container
			S1	Automobile container
			S2	Living fish container
			S3	Spare
			S4	Spare
			S5	Spare
			S6	Spare
			S7	Spare
			S8	Spare
			S9	Spare

Code	Group code	Type	Type code	Principal characteristics
R	RE	Thermal containers - refrigerated - refrigerated and heated - self powered refrigerated/ heated	R0	mechanically refrigerated
	RT		R1	mechanically refrigerated and heated
	RS		R2	mechanically refrigerated
			R3	mechanically refrigerated and heated
			R4	Spare
			R5	Spare
			R6	Spare
			R7	Spare
			R8	Spare
			R9	Spare

Code	Group code	Type	Type code	Principal characteristics
H	HR	Thermal containers - refrigerated and/or heated with removable equipment	H0	refrigerated and/or heated with removable equipment located externally, coefficient of heat transfer K = 0.4 W/(m² · K)
			H1	refrigerated and/or heated with removable equipment located internally
			H2	refrigerated and/or heated with removable equipment located externally, coefficient of heat transfer K = 0.7 W/(m² · K)
			H3	Spare
			H4	Spare
	HI		H5	insulated, coefficient of heat transfer K = 0.4 W/(m² · K)
			H6	insulated, coefficient of heat transfer K = 0.7 W/(m² · K)
			H7	Spare
			H8	Spare
			H9	Spare

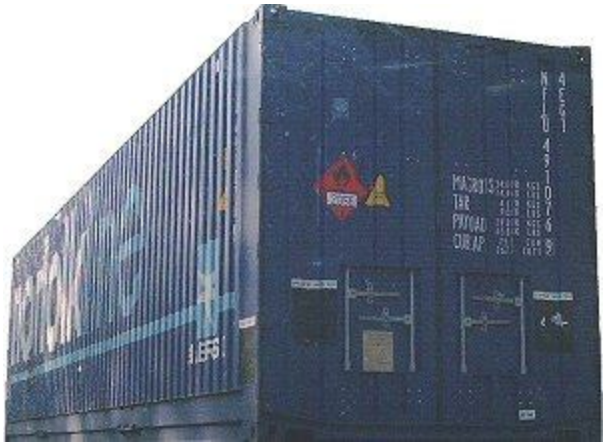
Code	Group code	Type	Type code	Principal characteristics
U	UT	Open-top containers	U0	Opening(s) at one or both end(s)
			U1	Opening(s) at one or both end(s) plus removable roof in end frame
			U2	Opening(s) at one or both end(s) plus opening(s) on one or both sides
			U3	Opening(s) at one or both end(s) plus opening(s) on one or both sides plus removable top members
			U4	Opening(s) at one or both end(s) plus opening(s) on one side plus full openings on the other side
			U5	Full, solid side and end walls (no doors)
			U6	Spare
			U7	Spare
			U8	Spare
			U9	Spare

Code	Group code	Type	Type code	Principal characteristics
P	PL	Platform (containers) - platform based containers with incomplete superstructure - fixed - folding - platform based containers with complete superstructure	P0	Platform
	PF		P1	Platform with two complete, fixed end walls
			P2	Platform with fixed posts, either free-standing or with removable top members
	PC		P3	Platform with folding complete end walls
			P4	Platform with folding posts, either free-standing or with removable top members
	PS		P5	Platform, open at the top and ends (skeletal)
			P6	Spare
			P7	Spare
			P8	Spare
			P9	Spare

Code	Group code	Type	Type code	Principal characteristics
T	TN	Tank container for non-dangerous liquids	T0	Minimum pressure 45 kPa [1])
			T1	Minimum pressure 150 kPa
			T2	Minimum pressure 265 kPa
	TD	Tank container for dangerous liquids	T3	Minimum pressure 150 kPa
			T4	Minimum pressure 265 kPa
			T5	Minimum pressure 400 kPa
			T6	Minimum pressure 600 kPa
	TG	Tank container for gases	T7	Minimum pressure 910 kPa
			T8	Minimum pressure 2 200 kPa
			T9	Minimum pressure (yet to be assigned)

[1]) 100 kPa = 1 bar = 105 Pa = 105 N/m² = 14.5 lbf/in² (PSI)

Code	Group code	Type	Type code	Principal characteristics
A	AS	Air/surface containers	A0	



This Figure shows a variant of vertical container marking, with size and type code (on the left):

The identifying details are more or less clearly visible.

Vertical container marking

Identifying mark plus size and type codes in horizontal arrangement



The container is 12,192 mm or 40' long (number 4 of first character of the size code). Its height is 2,895 mm or 9'6" and its width is greater than 2,438 mm or 8' and is less than or equal to 2,500 mm (letter E or second character of the size code). As regards type, the container is a general purpose container without ventilation, whose main characteristic is that it has vents in the upper part of the cargo space (characters G1 of the type code).

The owner code and product group code are also known as the alpha prefix. The check digit is often written in a box: .

There now follows a number of examples of marking according to DIN EN ISO 6346, January 1996:



According to the two characters 42 of the size code, the container is 12,192 mm or 40' long, 2,591 mm or 8'6" high and 2,438 mm or 8' wide. The type code characters G0 state that the container is a general purpose container without ventilation but with openings at one or both end(s).



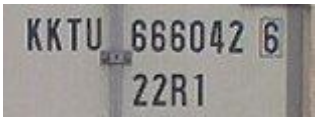




According to the two character combinations 22 and 42 of the size code, the container on the left is 6,058 mm or 20' long and the two containers on the right are 12,192 mm or 40' long. All the containers are 2,591 mm or 8'6" high and 2,438 mm or 8' wide. The type code characters G1 state that the container is a general purpose container without ventilation but with vents in the upper part of the cargo space.



According to the two characters 22 of the size code, the container is 6,058 mm or 20' long, 2,591 mm or 8' 6" high and 2,438 mm or 8' wide. The type code characters P3 state that the container is a platform based container with folding complete end walls.



According to the two characters 22 of the size code, the container is 6,058 mm or 20' long, 2,591 mm or 8' 6" high and 2,438 mm or 8' wide. The type code characters R1 state that the container is a thermal container which can be mechanically refrigerated and heated.

According to the two characters 28 of the size code, the container is 6,058 mm or 20' long, 1,295 mm or 4' 3" high and 2,438 mm or 8' wide. The type code characters P2 state that the container is a platform container with fixed posts, either free-standing (as here) or with removable top members.





According to the two characters 42 of the size code, the container is 12,192 mm or 40' long, 2,591 mm or 8'6" high and 2,438 mm or 8' wide. The type code characters U1 state that the container is an open-top container which may additionally be equipped with opening(s) at one or both end(s) plus removable top door rail in the end frame.



According to the two characters 45 of the size code, the container is 12,192 mm or 40' long, 2,895 mm or 9'6" high and 2,438 mm or 8' wide. The type code characters G1 state that the container is a general purpose container without ventilation but with vents in the upper part of the cargo space.



According to the two characters 45 of the size code, the container is 12,192 mm or 40' long, 2,895 mm or 9'6" high and 2,438 mm or 8' wide. The type code character P indicates that the container is a platform based container with complete end walls. The standard still gives type code P8 as being "spare".

Type code P8 has been used here for a "collapsible flat" (to the right), i.e. the end walls are collapsible for empty carriage.





According to the two characters 45 of the size code, the container is 12,192 mm or 40' long, 2,895 mm or 9'6" high and 2,438 mm or 8' wide. The type code characters R1 state that the container is a thermal container which can be mechanically refrigerated and heated.



According to the character 4 of the size code, the container is 12,192 mm or 40' long. The character C indicates that the container has a height of 2,591 mm or 8' 6" and a width ranging between > 2,438 mm and < 2,500 mm. According to type code G1, the container is a general purpose container without ventilation, which nonetheless has vents in the upper part of the cargo space.



The character 4 stands for the length 12,192 mm or 40'. E states that the container has a height of 2,895 mm or 9' 6" and a width ranging between > 2,438 mm and < 2,500 mm. The type code characters G1 state that the container is a general purpose container without ventilation but with vents in the upper part of the cargo space.

Given the large number of containers available today, it is impossible to tell how long the current codings will suffice and when more characters will need to be introduced.

3.5 Operational markings

The operational markings according to DIN EN ISO standard 6346, January 1996, are intended to simplify use of the container by providing additional information and warnings.

These markings also include both compulsory and optional markings. Examples of compulsory markings are those indicating gross weight and tare weight, which naturally have to agree with those on the CSC Approval Plate.

The standard prescribes the following form and sequence for marking of gross and tare weights:



Standard operational markings: gross and tare weights



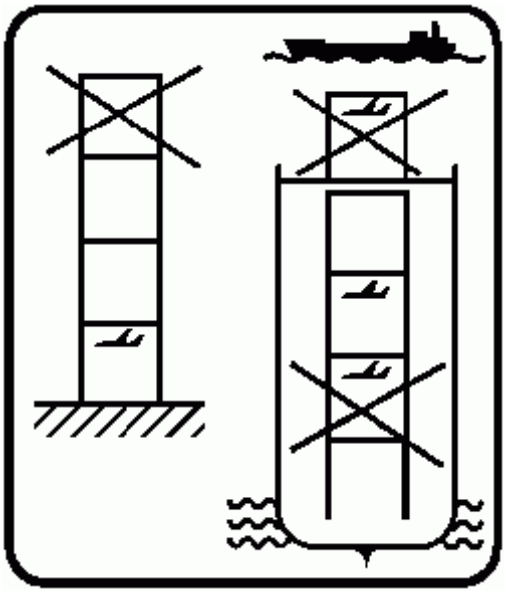
Non-standard operational markings: gross and tare weights

On this container, the minimum compulsory marking requirements are fulfilled as far as the data are concerned, but the sequence is wrong, the English customary values being given first.

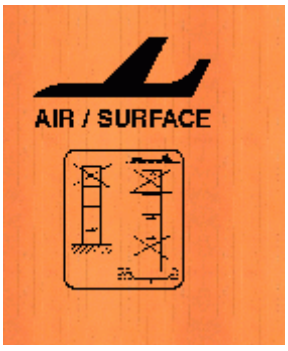
It is also compulsory to affix certain warning symbols. These include pictograms for air/surface containers, the danger posed by overhead power cables and height markings for containers which are higher than 2.6 m (8'6").

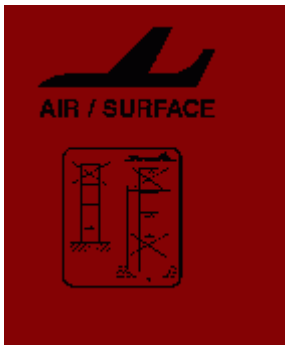
All air/surface containers should carry the following pictograms:





To indicate that these containers have limited stackability, the symbols should be affixed where possible in the upper left-hand corner of the end and side walls and the roof. The symbol is in black. If the color of the container makes it difficult to see the symbol clearly, it should be applied to a different background of a more suitable color, preferably white.







Distinguishability of labels against different background colors

According to the standard, the symbols should have the following dimensions: aircraft 130 mm (5"), stackability symbols 280 mm (11") high and 260 mm (10") high. The capital letters should be at least 80 mm (3") high.

All containers equipped with ladders must be provided with a warning symbol, which indicates the danger posed by overhead power cables.



The height of the lightning in the warning symbol must be at least 175 mm (6.875"). The size of the warning symbol, measured between the outer edges of the black border, must be no less than 230 mm (9"). The symbol must be affixed in the vicinity of the ladder.

Symbol warning against the danger posed by overhead power cables



(2) = Non-standard warning symbol

It is sensible to affix the lightning symbol (2) to the upper part of the ladder (1). It is not necessary, however, to affix signs (3) indicating that the container has a height of 2.6 m or 8'6".





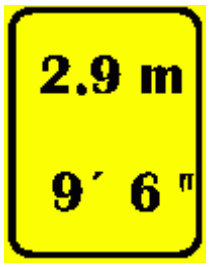
Different ways of writing 2.6 m and the English customary dimension

DIN EN ISO 6346 of January 1996 stipulates that all containers higher than 2.6 m (8'6") must carry the following compulsory markings:

- a height marking on each side
- yellow and black stripes, visible at the top and side, which must be affixed in the upper part of each side and end. These must start at the corner castings and extend at least 300 mm (12").



The height marking must be at least 155 mm high and 115 mm wide (6" x 4.5"). The characters should be as large as possible, so that they are clearly visible. The sign should be affixed at least on each side of the container, in each case in the vicinity of the right-hand edge no more than 1.2 m (4') from the top edge of the container and no more than 0.6 m (2') from the right-hand edge (beneath the identification number).



Height marking for containers > 2.6 m high

Yellow and black stripes constitute part of the height marking



Optional markings, such as mirror images of the height marking at every suitable point (e.g. end wall), may be affixed.



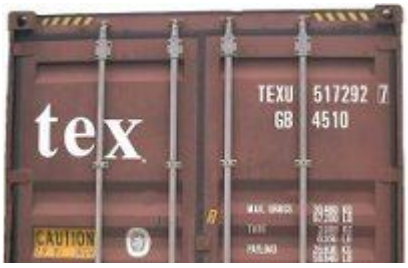


Mirror image of the height marking



In mirror image:
9'6" HIGH CAUTION













Optional height marking

It has always been usual to mark high-cube containers with optional markings of various designs.

The upper pair of images show a container marked according to the January 1996 edition of DIN EN ISO 6346, while the lower pair show a container marked according to the August 1985 edition of DIN ISO 6346.

It is always sensible to emphasize the height of individual containers, even if it doesn't always help.



Height markings do have to be observed.

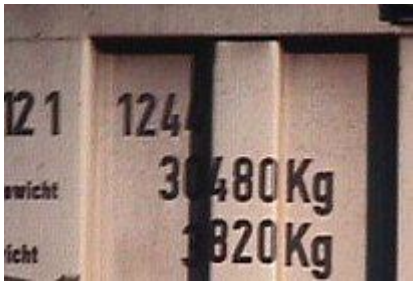
One possible optional operational marking which most operators do affix states maximum payload or net cargo weight, which is the difference between the maximum gross weight and the tare weight of a container. Although this marking is optional, the standard does stipulate that the weight labeled NET be given first in kilograms and then in pounds. In general, the various markings are so arranged that the weight data are followed by container volume data.





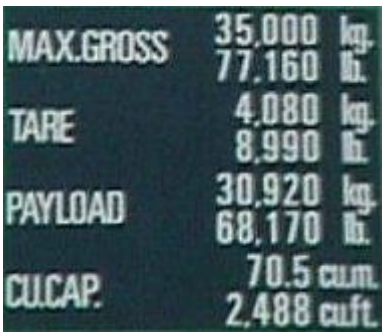


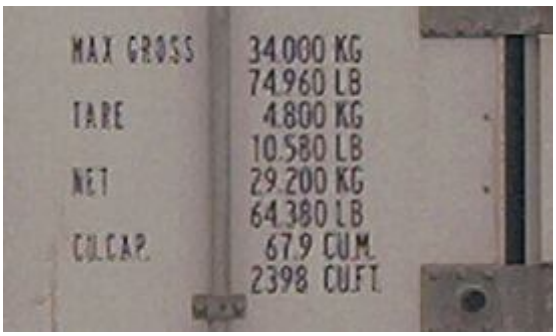
Weight and volume markings on 40' containers





Partially hidden or covered weight and volume data





The maximum gross weight may well deviate from the standard values.

M.G.W. = Maximum Gross Weight .... and in Chinese characters too





3.6 Other markings

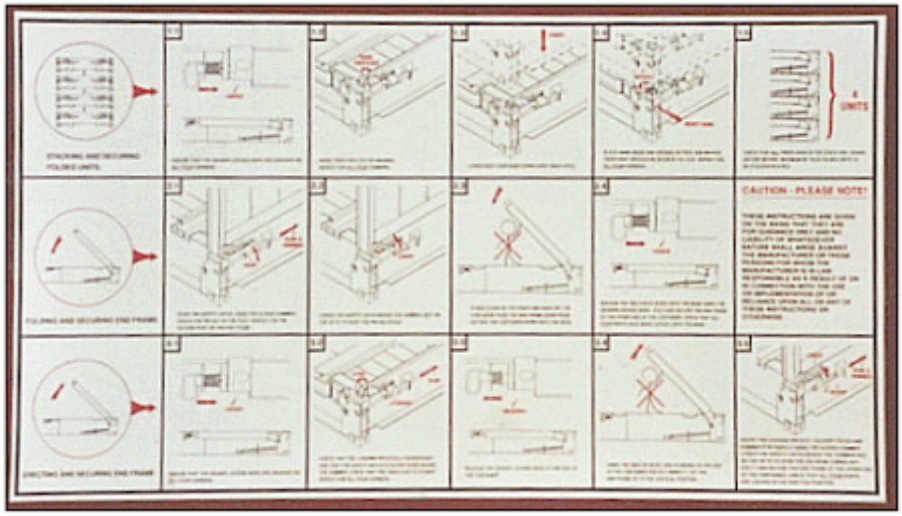
Many containers carry instructions about using particular structural elements, which are intended to serve as warnings.





How not to pick up a load

Apart from very few exceptions, containers may only be lifted vertically by the upper corner posts.



Safety instructions on a collapsible flatrack

It is not necessary to be able to read the instructions in the picture. The point is simply that there are such instructions describing how a collapsible flatrack is to be erected and collapsed and what points have to be observed.

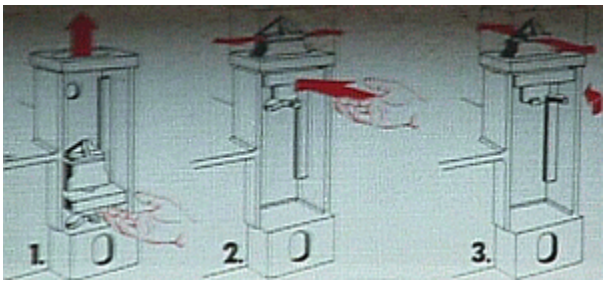
It should go without saying that inexperienced people should not be trusted with such activities. In any case, trained personnel also need to heed such instructions.





Safety instructions on a collapsible flatrack - details





Above and left:
Instructions for using the fitted twist lock



Safety instructions for empty transport

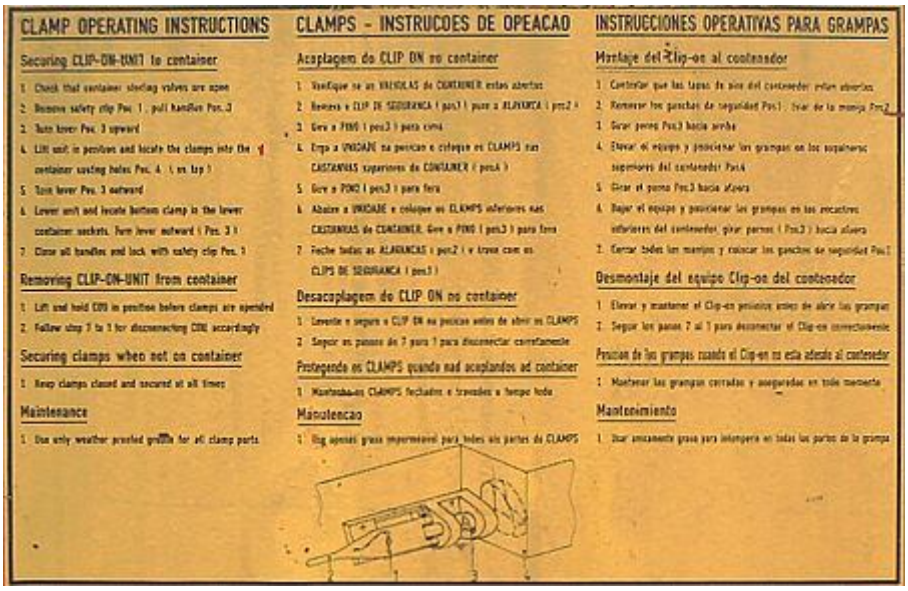


Label pointing out lubrication points





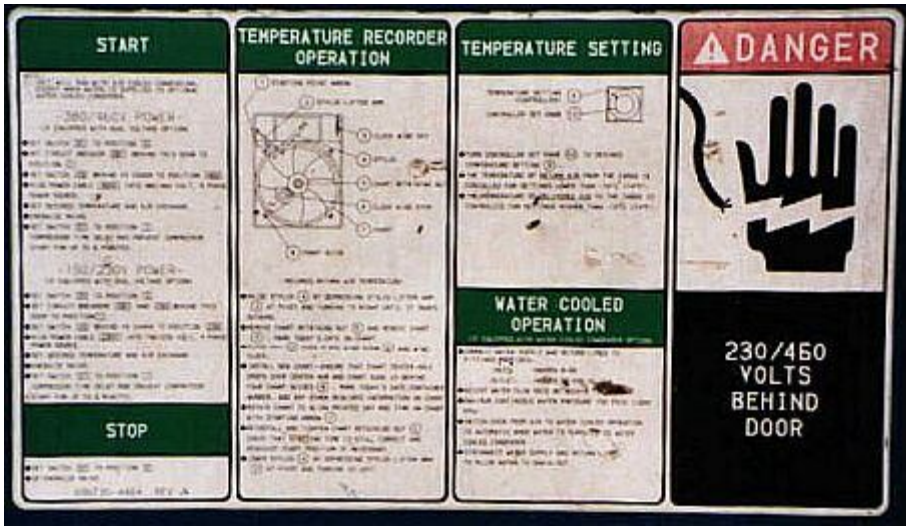
Warning about folding door on a half-height open-top container



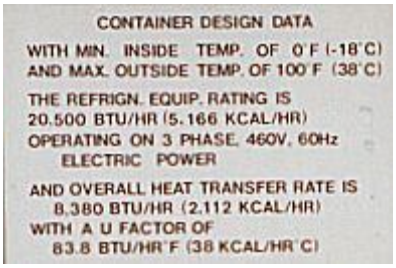
Instructions for securing a [clip-on unit]







Operating and safety instructions on a thermal container

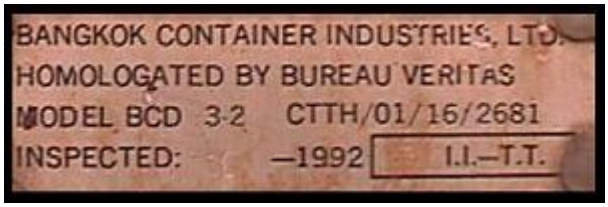




Above: Information about material used for walls

Left: Technical data on a thermal container

Statement of compliance with structural regulations from Bureau Veritas



Details of owner, manufacturer and treatment of plywood floor in accordance with Australian requirements









Above and left: Details of owner and manufacturer



The instructions in the right-hand Figure state:
CAUTION: Left-hand door must remain locked closed at all times if loaded boxes are stacked on top!



Right and left:
Safety instructions

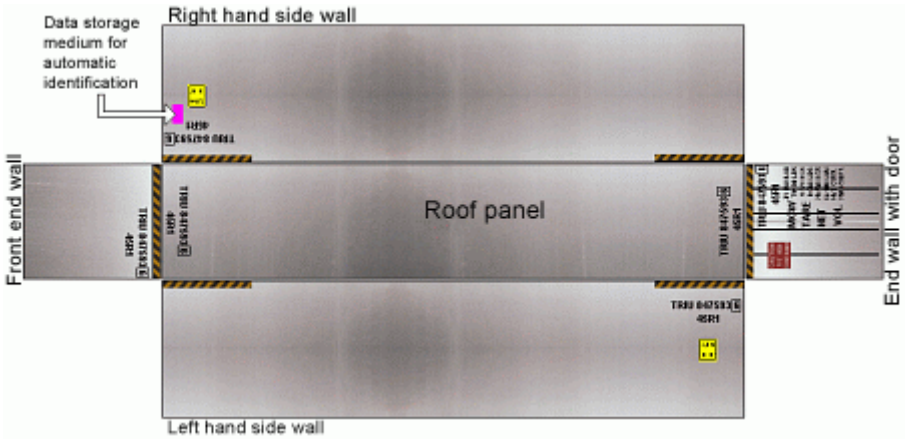


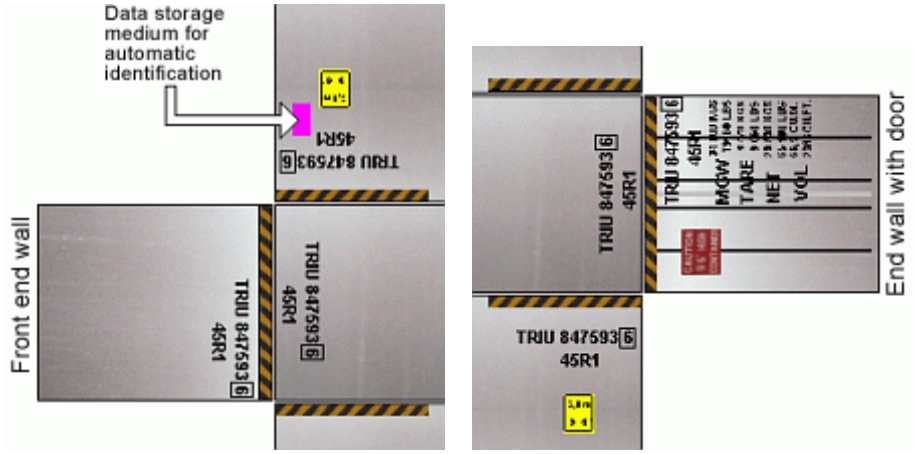


Above: this red line indicates the "max. load height" in order to ensure air circulation during cooling operation.

Warnings about extra-large width

3.7 Arrangement of obligatory and optional markings





Top and selective enlargements below:
Arrangement of obligatory and optional markings

The relevant standard allows for the areas of yellow and black stripes next to the corner castings to be reduced to a length of 300 mm (12").

It will be noted that the standard does not conform with the regulations in the German road traffic code and those of other countries, since in the standard the diagonal black and yellow stripes always run in the same direction.



Standard arrangement of black and yellow stripes



More sensible, mirror-image arrangement of black and yellow stripes



Marking error - the yellow and black stripes are absent at c





More sensible affixing of yellow and black stripes, which are present at c. Stripe b is mirrored relative to stripe a.



Non-standard but sensible Standard of black and yellow stripes



Red and white plates: correct



Red and white plates: incorrect



Correctly affixed red and white warning plates

Only this symmetrical arrangement of the warning plates, as provided for in the regulations, makes any sense.

This vehicle with correctly affixed warning is a particularly clear illustration.

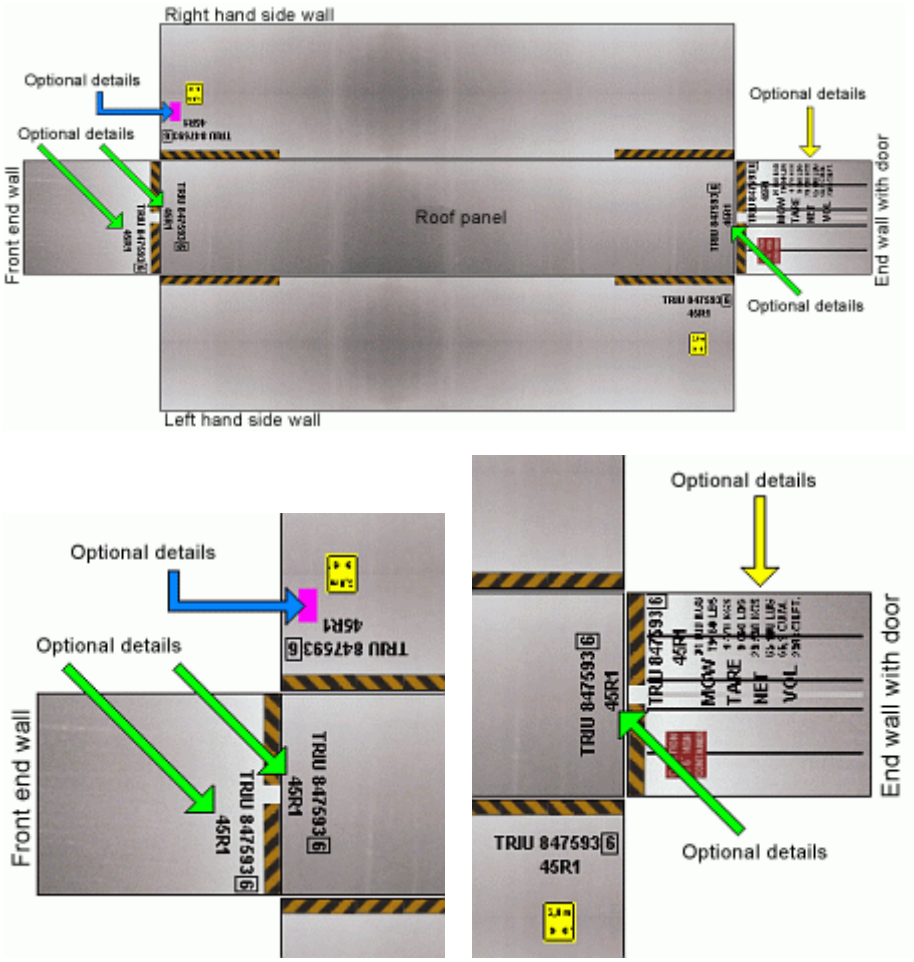


Correctly painted red and white warning



Desirable arrangement of black and yellow warning markings

It would be a good idea if this were taken into consideration when the standards are revised.



Top and selective enlargements below:
Optional details are indicated by colored arrows.

The standards allow for optional affixing of size and type codes to the roof and front end wall (green arrows). The same applies to affixing a data medium for automatic identification (blue arrow) and to marking of the net cargo weight (yellow arrow).

3.8 Marking of containers carrying dangerous cargoes

The CTU packing guidelines state in Section 4.4.1 in relation to placarding of containers carrying dangerous cargoes:

> *4.4.1.1 Placards (enlarged labels) (minimum size 250 mm x 250 mm) and, if applicable for maritime transport, "MARINE POLLUTANT" marks (minimum size of a side 250 mm) and other signs should be affixed to the exterior surfaces of a CTU or unit load or overpack to provide a warning that the contents of the unit are dangerous cargoes and present risks, unless the labels, marks or signs affixed to the packages are clearly visible from the exterior*

of the unit. This type of marking can be omitted on unit loads and overpacks if the hazard labels, markings or warning symbols are clearly visible from the outside.



Correct marking on a container side

The container is loaded with Class 4.1 flammable solids.



Correct marking on a container side

The container is loaded with Class 3 goods, i.e. flammable liquids, which are also marine pollutants.

The CTU packing guidelines give additional instructions for affixing placards, these being explained in more detail in the CTU packing guidelines Point 4.4.1.2: This paragraph reads:

(4.4.1.1 contd.) If possible, the placards, hazard labels, markings or warning symbols on the outsides of the CTU should not be obscured when the CTU is opened.



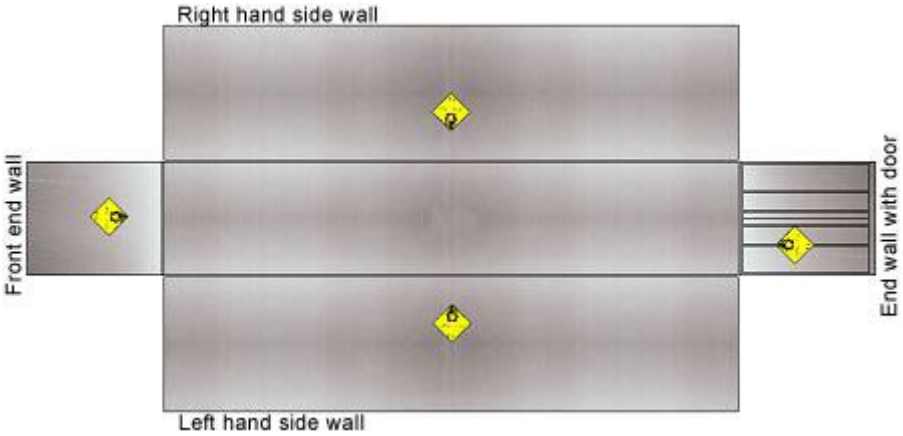
Non-regulation affixing of a placard

4.4.1.2 CTUs containing dangerous cargoes or residues of dangerous cargoes should clearly display placards and, if applicable for maritime transport, "MARINE POLLUTANT" marks or other signs as follows:

1. *a container, one on each side and, in the case of carriage by ocean-going vessel, also one on each of the ends of the unit;*

2. *a railway wagon [railroad car], at least one on each side;*

3. *any other CTU, at least one on both sides and on the back of the CTU and, in the case of a semitrailer, also one on the front of the CTU.*



Correct marking of a container for maritime transport according to the CTU packing guidelines

It has been proposed to mark the roof with a corresponding placard, in order to warn lifting gear or ground conveyor operators when picking up such a container. However, the regulations do not as yet contain any such obligation.

Point 4.4.1.2 of the CTU packing guidelines continues:

Placards on the sides of a CTU should be affixed in such a position that they are not obscured when the unit doors are opened.

The "if possible...not be obscured" of 4.4.1.1 has become an obligation: "should be affixed".

Point 4.4.1.3 deals with dangerous cargoes which present several risks:

Whenever dangerous cargoes present several risks, subsidiary risk placards should be displayed in addition to primary risk placards.

The regulations covering this area were amended in 2002. According to the old regulations, the primary risk placards had to carry the correct class number, while the subsidiary risk placard was not supposed to carry any class numbers.



Three old variants of primary and subsidiary risk placards

The way this requirement was fulfilled was open to choice and it was of no significance whether the class numbers were obscured by being painted or stuck over or cut off.

According to the regulations in force since 2002, both primary and subsidiary risk placards must carry the class numbers.



New regulations: Primary and subsidiary risk placards bear class number.

Point 4.4.1.3 of the CTU packing guidelines continues:

> *... CTUs containing cargoes of more than one class, however, need not bear a subsidiary risk placard if the hazard represented is already indicated by the primary risk placard.*



Dangerous cargo container carrying dangerous goods of various classes

For dangerous cargo containers carrying dangerous goods of only one class, the regulations in point 4.4.1.6 of the CTU packing guidelines apply:

> *Consignments of packaged dangerous cargoes of a single commodity, other than cargoes of class 1, which constitute a full load for the CTU should have the UN Number for the commodity displayed in black digits not less than 65 mm high either against a white background in the lower half of the class placard or on an orange rectangular panel not less than 120 mm high and 300 mm wide, with a 10 mm black border, to be placed immediately adjacent to the placard (see Annex 2). In those cases the UN Number should be displayed immediately adjacent to the Proper Shipping Name.*

According to the IMDG Code, the regulation applies from a mass of 4,000 kg.

The container contains only one dangerous cargo, i.e. Class 5.1 oxidizing substances (agents), which increase the risk and intensity of fire, and are also corrosive. The (yellow) primary risk placard correctly carries the number 5.1, but the subsidiary risk placard does not carry the number 8 (also correct according to the old regulations), which has been obscured. According to the currently applicable regulations, this placard would also have to carry the class number 8.



Primary and subsidiary risk placards plus UN Number.

The placards have been incorrectly positioned. They are obscured when the door is opened.





Correct: 4,000 kg consignment with hazardous materials, therefore UN number stated





Correct: < 4,000 kg consignment with hazardous materials, therefore UN number not stated





Incorrect: < 4,000 kg consignment with hazardous materials, no UN number stated





Correct: two classes, therefore no UN Number (the placard is obsolete and class 6.1 has since been replaced with a death's head and the word "Toxic").

Point 4.4.1.9 of the CTU states the following:

> *When solid carbon dioxide (CO_2 - dry ice) or other expendable refrigerant is used for cooling purposes, a warning sign should be affixed to the outside of the doors so that it is clearly visible to any person operating the doors. The sign should warn of the possibility of an asphyxiating atmosphere. ...*

The name of the gas used as refrigerant should be inserted beneath the word WARNING.



Warning sign for CTUs in which dry ice or other expendable refrigerants are used for refrigeration purposes

The IMDG Code recommends the following wording for the "Container Packing Certificate":

> *When solid carbon dioxide (CO_2 - dry ice) is used for cooling purposes, the container/vehicle is externally marked or labelled in a conspicuous place, such as, at the door end, with the words:*
> *"DANGEROUS CO_2 (DRY ICE) INSIDE.*
> *VENTILATE THOROUGHLY BEFORE ENTERING."*

The CTU packing guidelines contain a reminder that cargoes under fumigation may require special precautions:

> *4.4.1.10 As CTUs offered for shipment under fumigation may require special precautions, they should only be accepted with the agreement of the carrier and they should be identified to him prior to loading. CTUs under fumigation are now included in class 9 of the IMDG Code.*

The following is stated about the labeling of such CTUs:

> *4.4.1.11 When a closed CTU or its contents has been fumigated and is to be shipped under fumigation, a warning sign should be affixed to the outside of the doors so that it is clearly visible to any person operating the door. An example of such a warning sign is given in Annex 2. The sign should state the fumigant, the method of fumigation employed and the date and time when it took place. The sign should only be removed when the unit has been ventilated after fumigation, to ensure that no harmful concentration of gas remains.*

The intention of this Section was merely to provide some tips for marking dangerous cargo containers. In a real packing situation, obviously, the other regulations in the CTU packing guidelines should be consulted, especially the valid dangerous cargo regulations.



Picture of the warning sign "FUMIGATION WARNING"

4 Loading and load securing

Preface

Load securing cannot be defined as simply the physical securing of a consignment using friction and tight-fit methods. Instead, it should be taken to be the "Safety of loads and protection against potential damage by loads" and should cover:

- protection of the goods against all forms of damage and/or
- protection of the environment against potentially damaging effects of the cargo.

An all-inclusive approach such as this may encourage greater interdisciplinary thinking and consideration of the problems of load securing in context rather than as an isolated issue. Load securing, in its broadest sense, is dependent on a number of factors:

- the characteristics of the goods that are being transported
- the construction and/or manufacturing features
- the types packing and packaging used
- the cargo transport units chosen for transportation
- the aids and devices used during packing
- the packing methods
- the securing methods
- the materials used to secure the load
- the finish of the materials used to secure the load
- the transport methods and routes used etc.

As always, the people responsible for the overall process play a critical role. Only when these people have been trained properly and have the right experience is it possible to minimize damage. Only the use of the correct and appropriate forms of load securing is able to prevent damage being caused to the goods that are being transported as well as to equipment, public property and the environment.

Note regarding legal stipulations

Packing of containers and cargo securing in or on containers must be carried out in accordance with the "CTU packing guidelines" published by the "International Maritime Organization". The exact title of the document is "IMO/ILO/UN ECE Guidelines for Packing of Cargo Transport Units (CTUs)".

The "Scope" section of the CTU guidelines contains information about situations where these guidelines are not applicable. This states:

> *They do not cover the filling or emptying of tank containers, portable tanks, or road tank vehicles, or the transport of any bulky cargo in bulk packagings.*





CTU guidelines do not apply to tanks and bulk cargo

The "Definitions" section defines a number of terms:

> ***bulk cargoes*** *means cargoes which are intended to be transported without any intermediate form of containment in bulk packagings or portable tanks.*
> ***cargo*** *means any goods, wares, merchandise and articles of any kind which are intended to be transported.*
> ***dangerous cargoes*** *means packaged, dangerous, hazardous or harmful substances, materials or articles, including environmentally hazardous substances (marine pollutants) and wastes, covered by the International Maritime Dangerous Goods (IMDG) Code. The term "dangerous cargoes" includes any empty uncleaned packagings.*
>
> ***overpack*** *means an enclosure used by a single shipper (defined in section 8 of the German "Carriage of Dangerous Goods by Sea Ordinance", GGVSee, as the "producer or shipper") to contain one or more packages and to form one unit for convenience of handling and stowage during transport.*
>
> *Examples of overpacks are a number of packages either:*
>
> 1. *placed or stacked on to a load board such as a pallet and secured by strapping, shrink-wrapping, stretch-wrapping or other suitable means; or*
> 2. *placed in a protective outer packaging such as a case or crate;*
>
> ***packaging(s)*** *means receptacles and any other components or materials necessary for the receptacle to perform its containment function.*
> ***packages*** *means the complete product of the packing operation, consisting of the packaging and its contents as prepared for transport.*



Faulty packaging will affect the entire duration of the transport

> ***unit load*** *means a number of packages that are:*
>
> 1. *placed or stacked on and secured by strapping, shrink-wrapping or other suitable means*

to a load board such as a pallet;

2. *placed in a protective outer enclosure such as a pallet box;*
3. *permanently secured together in a sling.*





Failure to implement unitization correctly makes packing and securing more difficult

In the case of hazardous materials, the unitization shown on the left represents a failure to comply with the General Provisions of the IMDG code.

Unlike conventional methods of loading, closed containers offer better protection against robbery, theft and climate conditions. This is also a form of load securing or, to put it another way, protection of the load.



Loading containers in the rain

For all moisture-sensitive cargoes, namely the vast majority of all general cargo, measures must be taken to ensure that the goods to be loaded are not stored in the open whether it be for long or short term storage, and that they are only packed in roofed areas.

The basic requirements for preventing damage and thus protecting the load are:

1. container-suitable construction of loads, goods and/or packaging, including container-suitable palletization and unitization, as well as
2. the appropriate packing of the load into the container, and if this is not sufficient,
3. supplementing the packing measures by the use of suitable load securing mechanisms.

If these three rules are observed, the container is able to carry out the protective function it was designed for. Failure to comply with these basic rules, however, means that the containers are

endangered by their own cargo.



Damaged end wall, caused by a badly packed and unsecured cargo



Palletization in a form not suitable for containers



Palletization in a form suitable for containers

The only criticism that can be leveled at the pallets is the way the straps have been placed and the fact that this has been carried out using steel strapping. The use of plastic strapping and edge protectors would have been preferable. Top marks, however, must be awarded for the fact that the second layer has been placed on top of interlayer dunnage.

This section of the Container Handbook has been designed to show the basics required in order to transport cargo without damaging it or anyone/anything else.

The "Scope" section of the CTU packing guidelines states:

> *These Guidelines are not intended to conflict with, or replace or supersede, any existing regulations or recommendations which may concern the carriage of cargo in CTUs.*

This is intended to stress the fact that other regulations will still continue to be valid. For example, the German railroad regulations in which § 1 makes the following statement about the state of the cargo:

> *The cargo must be in a state that does not permit it to present a danger to the safety of the railroad.*

This paragraph affects, in the first instance, the manufacturers, shippers and packers of goods. Other areas of law also have similar regulations - including insurance law. Both the nature and the state of the packaged load and its packaging must meet all requirements for correct transportation. As we have already seen, and we will continue to see, this is very often not the case.

Load securing considerations are an issue as early as the design of products. The manufacturer intends selling their products. To do this, the goods are going to have to travel some distance - in particular goods designed for export. Since the manufacturer has a vested interest in getting their products to their customers in a undamaged state, it makes sense for the producer to enable or facilitate correct securing of the load by incorporating appropriate lashing points. Strictly speaking, the German Law on the Safety of Equipment, for instance, requires the manufacturer to do so.

Since once a load is passed on to the carriers, packing companies, cargo handlers, transport

companies etc. the load is no longer in the power of disposal of the shipper, these companies are thus responsible for checking to ensure that the consignment is in a condition suitable for transportation. If faults are detected, measures must be taken to ensure that the goods are made suitable for transport (again).

In the case of hazardous goods, damaged packages must not be loaded under any circumstances. Instructions to the contrary should not be observed.

4.1.1 Packaging receptacles and packaging aids

The influence of packaging receptacles and packaging aids on load securing

Choosing the right type of receptacle and packaging aids has a direct influence on the security of a load, the prevention of damage and the costs of storing, handling and transportation. The main tasks of transport packaging are:

- to protect the cargo from loss, damage or depreciation,
- to protect people, the environment and the transportation vehicle from potential damage caused by the cargo, and also
- to enable high levels of mechanization and rationalization of storage, handling and transportation processes.

These tasks can only be achieved by careful selection of packaging methods, packaging receptacles and aids as well as correct packing.

Modifications are relatively easy to implement for cartons, crates and cases. However, fiber, plastic and steel sheet packaging can only be modified gradually since many filling plants and packaging lines are designed specifically for use with special receptacles. Thus, solutions must be found that take account of the needs of all concerned. This can only be achieved in conjunction with manufacturers, industrial associations and standardization committees. This process also requires considerable investment.

The design of fiber drums, barrels, canisters, pails, corrugated barrels, quick lever-closure drums etc. must be revisited and modified in the long-term, both with regard to the fundamental design and the dimensions of the receptacles.

The risk of damage during transport is disproportionately large for some of the packaging receptacles commonly in use. Furthermore, transport using some of the existing packaging receptacles requires considerable outlay in terms of materials and personnel if the goods packed in these containers are to reach their destination without damage.



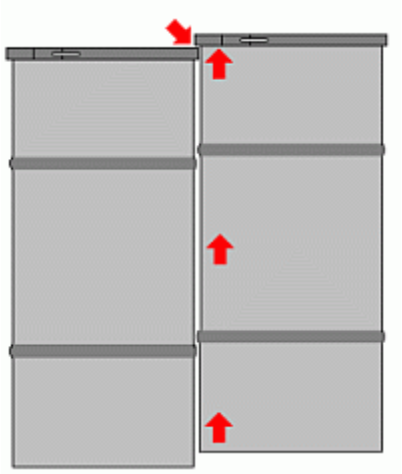




Risk of damage when using commonly available packaging receptacles

The closures on fiber drums, the handles on buckets, pails, canisters, and other similar containers can cause to damage to cargo stored on top of or next to them as a result of high point loading. Professional loading requires the use of additional dunnage, and increases the amount of stowage space lost during packing as well as increasing personnel costs.

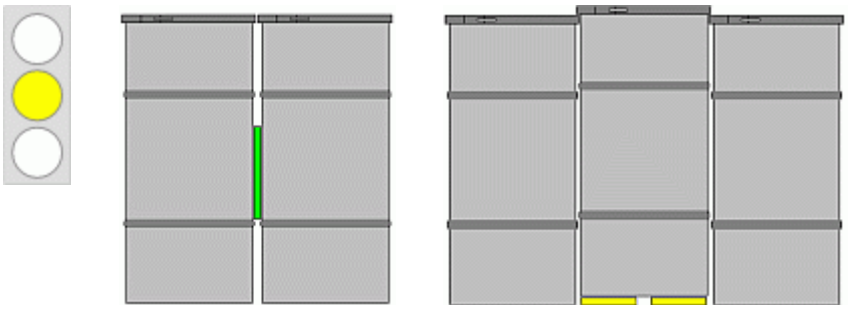




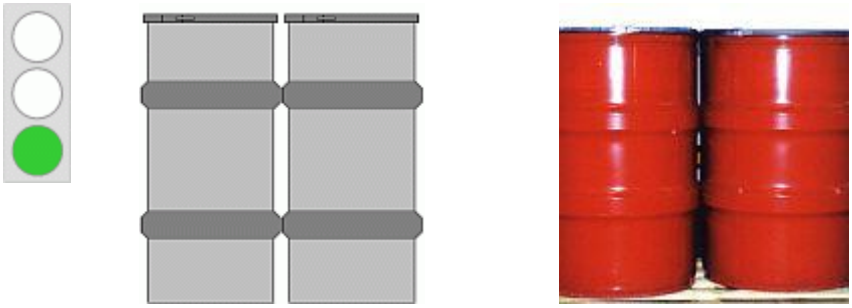


Disadvantages of commonly available drums/quick lever-closure drums

As a result of loads caused during transportation, drums of this type ride up over the corrugations of neighboring drums. This encourages the formation of transport gaps and the damage associated with these. If the levers of quick lever-closure drums extend beyond the edge of the drum, these may snag. The consequences of this include unintentional opening of the drums and/or damage to the drums.



Additional measures to avoid design-related gaps



Avoiding the formation of gaps by using a different drum design

Transport damage caused by gaps formed as a result of the design of the receptacles can only be prevented by employing further materials which leads to additional costs for materials and personnel, or by selecting a different type of drum with wider corrugations and recessed closures. It is obvious that, in the long-term, the selection of a better drum is the more cost-effective solution.

Careless packing is one of the main causes of accidents and damage. Fundamental errors are often made as early as design and production of the goods. This is because storage, handling and transport are rarely taken into consideration at this stage. The same applies to the production and use of various packaging receptacles and packaging aids: These simply do not meet the requirements.

In the majority of cases, however, it is the "packer" who makes the mistakes responsible for damage suffered during transportation. A package is only appropriate for carriage when it is able to withstand all the manipulation to be expected during storage, cargo handling and transportation, also in terms of keeping the environment protected from the goods. Not all packaging faults will cause damage, but the risk to the contents is increased considerably.



Machine component intended for packing into a container

Because the machine component itself has not been designed to be transported by forklift truck, it has been placed on a pallet (and not secured) for transportation within the company. Simply maneuvering the component into a container is already fraught with a number of difficulties. In

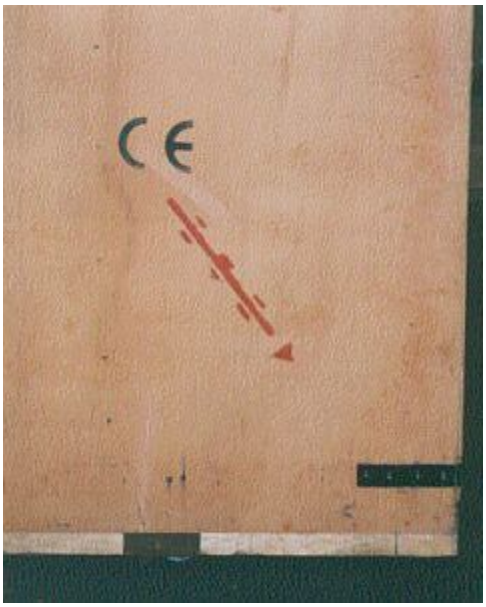
order to be able to secure it correctly, considerable outlay in terms of materials and staff hours will be required. If the packaging is designed to act as protection against climatic conditions or corrosion, then the damage to the plastic film that is likely to be caused by necessary securing measures is likely to have negative consequences for the cargo.

What is required is a skid which can be transported using forklift, similar to the floor of a case, and to which the machine component can be bolted. Securing would then be easy. The skid plus machine component could be secured in place in the container using vertical bracing.



Lack of securing in the container as a result of the method of packing

The packing staff often give up when attempting to properly secure objects that are not suitably packaged. The load is simply placed in the container and left to its own devices.



Packaging which is unsuitable for handling

This case does not have any lower skids. In order to be able to comply with the sling here hoisting instructions given by the symbol on the case, or for transportation using a forklift, the forklift operator must force the forks under the case to lift it.

Packaging that is not suitable for storage



The lower skids of this package are completely missing at the rear, and are breaking away at the front. Thus the package is no longer suitable for transportation.

In practice, people fail to assign as much importance to the issue of the suitability of packaging for transportation as they should. The issue affects all types of transportation and is thus not specific to maritime transport alone. It is, however, of particular importance when loading containers for maritime transportation.

The following basic principles may be used to assess the suitability of a load for transportation:

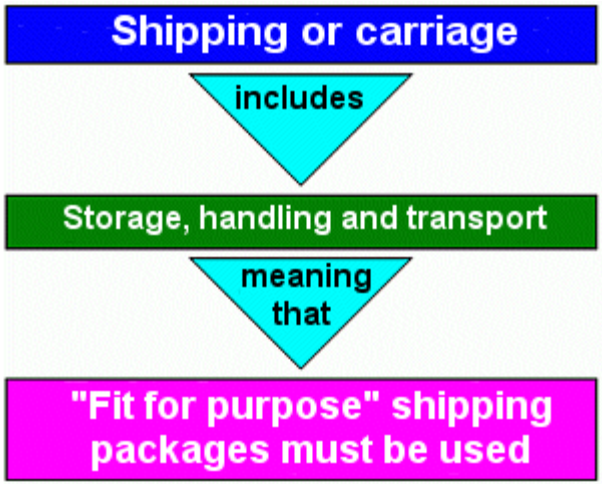
- Loads must be in a state which does not, in any way, affect safety during transport.

- A load is secured appropriately for carriage if, when loaded and handled in the proper manner, it is unable to cause damage to persons, to handling or transportation equipment or to other cargo.

The term "safe for carriage" must be defined in such a way that it is clear to all persons involved in the process. The average lay person can assume that manufacturers of goods and the people and companies entrusted with their transportation are specialists in their field. If the terms shipping and carriage are used, they also cover the storage, handling and transportation of the goods as well as all associated preparation and final work.

It must also be assumed that specialists are aware of the different demands made of small, large, display and sales packaging and are able to differentiate between these demands and the demands made of combination and transportation packaging and load units.

Transportation packaging must be constructed in such a way that it is suitable for carriage in order to ensure that it meets all the demands of handling, storage and transportation. This applies to all aspects: protection of the goods, protection of the environment from the goods, or issues relating to handling, packing, stowage, securing etc.



Unfortunately in some areas, concepts such as ordinary commercial packaging, overseas packaging and seaworthy packaging are still often used. Concepts such as packaging suitable for transport or fit-for-purpose packaging are preferable, since such concepts are used in transport insurance law.

The manufacturers and shippers of goods must, at the very least, inform themselves of the following issues and construct/select suitable packaging formats accordingly.



All measures for protecting the goods from damage must focus on the loads experienced during storage, handling and transportation. Goods should always be packed safely if they require protection from complete, or partial loss or from damage, or if the goods themselves represent a risk to the environment. If these basic principles are generally adhered to and the relevant ISO , EN or DIN standards and other technical regulations are also observed, the best conditions for damage-free transportation can be achieved.

In the area of hazardous goods, legislation has generally taken account of the above factors in the form of special packaging regulations. But what is the use of introducing packaging regulations for hazardous goods when they can (and must) be packed into a container with other goods which are less suitably packaged.

Not all packaging faults will cause damage. However, the risk is increased considerably. Poor packaging has an additional psychological effect: Bad packaging promotes carelessness and incorrect handling among handling staff.

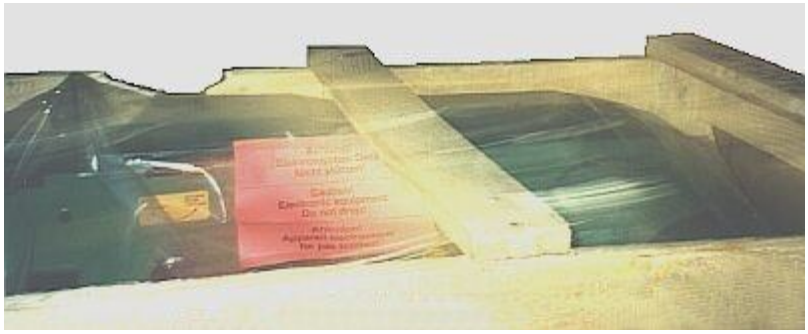






An example of bad packaging

It will be difficult to stow other items on top of this crate since part of the contents extend above the top of the wooden crate.





Incorrectly constructed wooden crate

Packing a CTU with packages of this type causes additional expense since so much interlayer dunnage must be employed in order to stack other objects on top of the crate while ensuring that the contents of the wooden crate do not suffer damage.

4.1.2 Unitization and palletization

4.1.2.1 Unitization and palletization

The influence of faulty unitization and palletization on load securing

Carelessness and poorly trained personnel are the main reasons for damage caused as a result of faulty palletization and unitization. The following applies: Once again, gaps are the main cause of all mechanical transport damage!

This carton really is in an exposed location. Would anyone actually load this pallet into a mixed consignment container? It is more likely that the steel straps will be cut away and the carton loaded as an individual item.



Palletization which actually increases freight costs

The combination of packaging receptacles, pallet and stretch wrap does not automatically result in a so-called "palletized load", as the example above shows. Only if the handling of pallets can be rationalized using ground conveyors can we really speak of palletized goods. These are handled by a number of companies at a cheaper rate.

Errors that occur frequently are demonstrated by these photographs:



Goods that are not safe for carriage

The quick lever-closure drums shown here are basically not suitable for transportation, since the lids are able to push each other open. This applies to both conventional methods of stowage and to palletization. If this does not happen when the goods are wrapped, as in this case, then it will occur at the very latest when the load is jolted during transport.

Pallets do not usually have diagonal bars which means that are very susceptible to asymmetric forces. In particular when used in containers, pallets can only really be used sensibly when they can

be packed flush and have level sides and surfaces. Gaps make it more difficult to pack and secure the load. Shrink and stretch wrap must firmly bond the goods to the pallets. This bond should be able to withstand the normal loads caused by handling. That is not the case here.

When loads arrive at a container packing station in such a pitiful state, the drums should be packed individually. It is obvious that drums or pails designed for use in containers can save on costs.

This picture demonstrates the potential danger that may arise when badly packed pallets are not rigorously unpacked, and instead an attempt is made to load them despite their obvious deficiencies:



An accident waiting to happen due to badly loaded pallets

Despite the fact that this is not permitted, a loader can be seen climbing onto the pallet lifted by the forklift truck in an attempt to stabilize the load. This attempt fails and the drums fall to the ground.

The package illustrated appears, at first glance, to be a perfectly good shrink-wrapped pallet containing boxed goods. The wider dimensions of the load toward the top, i.e. the fact that they extend beyond the bounds of the pallet, may mean that the goods are forced into a gap that is too small for them because they no longer have dimensions suitable for the means of transport. The cartons stacked on top restrict the options for packing other goods on top of this package. In the real world, many packers would slice open the shrink wrap and load these two cartons separately. This subsequently increases the probability of incorrect delivery. A possible reason for this type of unacceptable palletization is that producers tend to apply their pricing/discounting system to round numbers like, for example, 50 or 100 instead of matching it to the capacity of loading aids, transport aids or means of transport.



Two cartons too many!

The most frequently seen error is pallets that are not packed flush.

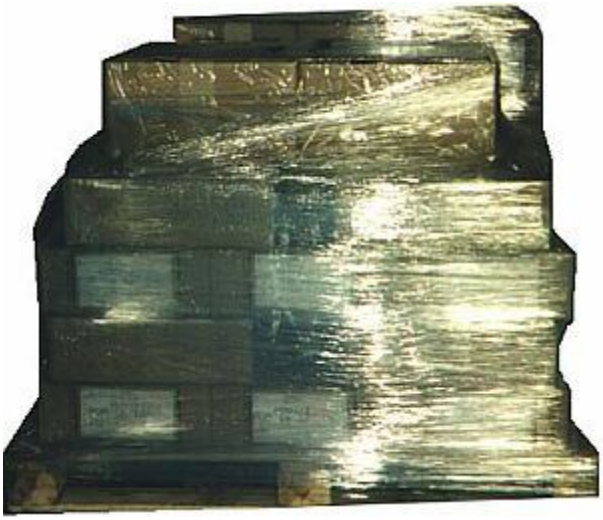




Incorrectly packed pallets containing boxed goods

Whether the goods are too small for their pallet, extend beyond the bounds of the pallet or are placed diagonally on the pallet, all these instances encourage careless loading into vehicles and containers, make load securing more difficult and can ultimately lead to the load being damaged.







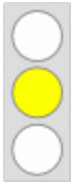
Faulty palletization

Bad palletization is not restricted just to boxed goods. When loading containers with hazardous goods you will often see badly shrink-wrapped or badly strapped pallets.



Load unit that is not suitable for transportation

These load units cannot be stacked. Under the slightest acceleration, the badly wrapped film will not be able to hold the plastic canisters and tin drums in place on the pallet.







These load units are generally well packed, the surfaces are level and they can be stacked. Unfortunately, however, the sides are not perfectly flush with the pallet base. There are still gaps that should be filled.





Deficiencies when forming load units





Note: Ignore palletization ...







... at your peril!

Goods that are palletized this badly cannot be stowed safely and without gaps, as the regulations require, without additional outlay in terms of work and materials.





Upper and lower images:
Load units that contravene the regulations





Upper and lower images:
Unacceptable packing of pallets with drums

In road and rail transportation, actions that contravene the general guidelines on palletization can be compensated for by additional outlay on stowage and securing. In maritime transportation and when dealing with hazardous goods, packages of this nature are clearly in breach of the law. The general provisions of the German GGVSee, a German translation of the IMDG code state that the unitization and labeling of items and unit loads to be transported must be carried out in accordance with the regulations. In section 10.18 of the IMDG code, unit loads are defined as a number of packages that are

1. *placed or stacked on and secured by strapping, shrink-wrapping or other suitable means to a load board such as a pallet;*

2. *placed in a protective outer enclosure such as a pallet box;*

3. *permanently secured together in a sling.*

In accordance with section 10.18.2, packages that contain hazardous goods, that are permitted to be transported in accordance with the code, may only be transported in unit loads if the following conditions are fulfilled:

1. *It may occur that the packages in a unit load will need to be separated. In this event, it must be ensured that the individual packages can be handled safely.*

2. *The unit loads should be compact, have as regular a form as possible, and for the most part, vertical sides. The top of the unit load should be level. It must be possible to stack the unit loads. They must be constructed and secured in such a way that it is unlikely that the individual packages can become damaged.*

3. *The unit loads must be sufficiently strong to withstand repeated loading and stowing operations and they must be able to bear unit loads with a similar specific mass which are stacked on them to a height commonly occuring during transportation.*

4. *The material used to bind a unit load together must be compatible with the substances contained in the unit load and must remain effective under the influence of moisture, extreme ambient temperatures and sunlight.*









Palletization of plastic canisters contrary to regulations

Without the additional use of appropriate corner rails or cover boards, the straps alone will not be able to hold the plastic receptacles in place for very long. It is only possible to stack further unit

loads on top of these with additional effort. When stowing the second or third layer, the goods stowed below must be protected from potentially damaging pressure by the use of additional measures.

Deficiencies can also be observed in the unit loads shown below:





Upper and lower images: Unit load with serious deficiencies

Changing proportions lead to increased freight costs since the outer dimensions are measured. If the pallet placed on top of these drums can be brought into the correct position, it will no longer be able to bind the load together securely. The tape wrapped around these cartons and the stretch wrap round the cases must be used correctly.

All in all, the only recommendation that can be made here is to separate the packages and load them individually.



Unit load with obvious deficiencies

If the lower pallet is intended to be part of the unit load then it should be firmly bonded to the rest of the load. That is obviously not the case here. Without the pallet, this "pack of three" cannot be handled by forklift truck and thus cannot be loaded rationally. The stretch wrap itself is unable to provide sufficient stability.



Less than perfect:
A unit load that is not flush

The benefits afforded by the efficient handling of unit loads are lost if gaps are left in the cargo. For the purposes of load securing, it would be more effective if each of the cases had been strapped separately.

Pallets should always be packed in such a way that the goods being transported, whether it be in cartons, sacks, pails, drums or canisters, are always flush with the pallet. Furthermore, only pallets should be used which are suitably dimensioned for the intended transportation method and the handling equipment that will be used.



Pallets that are appropriately dimensioned
for transportation by truck

The trays containing empty cans are designed for use with the pallets used here. The pallets themselves are compatible with the dimensions currently used for road and rail vehicles, swap bodies and inland containers in Europe. Thus, two pallets can be loaded next to each other

widthways or three pallets lengthways. For the purposes of overseas transportation, there are currently very few containers with an internal width greater than 2.4 m. Thus, these pallets are not suitable for transportation in overseas containers. The European transportation market now has a small number of CPCs or "Cellular Palletwide Containers".



Pallets that are not designed for the container

The packing receptacles are not designed for the pallet, and the pallets themselves are not designed for use with this container. This makes loading and unloading more difficult and increases the amount of securing that is required.
The risk of damage also increases.

It would have been more sensible to use pallets or pallet-like bases sized 116 cm x 116 cm for transport in the container. This would have allowed two units to be loaded into the container next to each other in normal steel corrugated containers. The goods themselves should be packed in modular unit load packaging such as cartons, canisters, drums etc. which would allow a clean block to be formed on the pallet.



Telescope cartons with pallet-like bases designed for use in the container

Here the requirement for harmonized dimensions has been implemented and not just in terms of width, but also in terms of height. The telescope cartons fit tightly into the container and need no additional securing.

The stability of the cartons is, however, a possible point of criticism. Whether these are likely to survive the rigors of transportation is a matter of doubt. Interlayer dunnage with a large surface area would improve the situation. It may even be possible to support this dunnage for the lower and middle layer. If the contents are heavy it may be necessary to find out whether the four lengthwise slats on the pallet-like bases would cause pressure damage on the bottom of the cartons.

The influence of faulty unitization and palletization on load securing



Load dimensioned to suit the internal measurements of the container

This example also shows that the dimensions of packaging receptacles can be designed to fit the internal dimensions of the containers themselves. Transportation modules of this type can help save costs.



Faulty unitization

The strapping as shown above is faulty. This method is unable to provide a stable unit load. The unpleasant tendency of corrugated drums to ride up over the corrugations can be prevented by appropriate unitization on pallets, but this will still not cure the tendency of pallets to ride up against each other.

Four drums with a maximum diameter of 585 mm can be stowed next to each other in standard containers. From the loading point of view, the most sensible option is to use drums with wide corrugations and a diameter of 580 mm, loaded onto pallets with dimensions of 1,160 mm x 1,160 mm.



Acceptable form of unitization

Formation of a unit load in the format shown above is acceptable, but its quality should not be overestimated. Since the strapping is vertical, it is unable to provide resistance to shifting. As a result, the top wooden board can easily shift. Diagonal strapping would be ideal but is extremely difficult to implement.

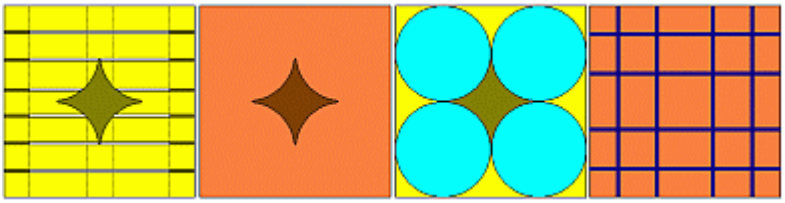
The picture below makes this problem clear.



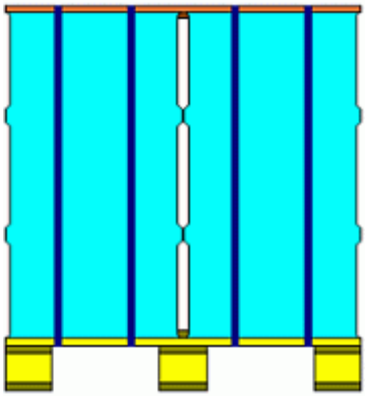
Diagonal shifting of the "lid" of a unit load

The "lid" used for this unit load is an inverted pallet. In this case, only two straps have been used for unitization but at least the drums were wrapped in shrink film first. Nevertheless: simply as a result of the transportation by road from the shipper to the container packing station, the "lid" has already shifted.

In series production it would make sense to affix a "lozenge" to both the pallet and the lid which would ensure a 100 % tight fit for the drums after strapping:



Pallet and lid with "lozenge" can guarantee a tight fit.



Side view of the strapped pallet

In order to reduce the risk of torn strapping, it would make sense to introduce pallets and lids which have grooves cut specifically to take straps.



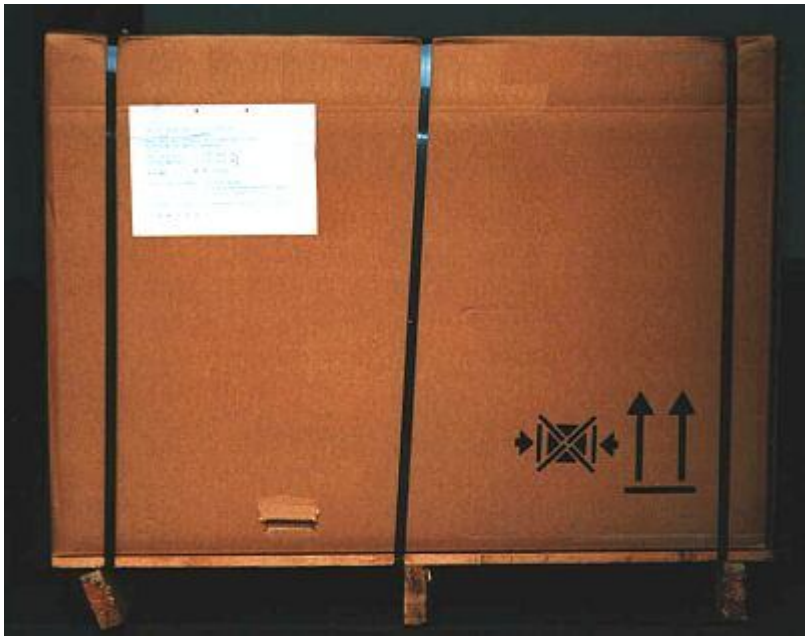
Catastrophic unit load

This example also requires additional effort in order to guarantee that the plastic canisters reach the recipient in an undamaged state.

The pictures below provide particularly vivid examples of poor packaging and unitization: Wooden feet that extend beyond the pallet/or are higher than they are wide always cause problems during loading, packing and securing. The loaded surface area is too small and results increased loads on the cargo stowed underneath. Even experienced stowage and loading personnel can only partially compensate for this by using additional dunnage.







Note: It's a well-known fact that small feet, narrow and tall, are likely to collapse.

The use of steel strapping to hold packages in place should be avoided. The use of steel strapping without any edge protectors is particularly critical.





Unsuitable "feet" on packaging receptacles
Note: Stability comes when the wide edge is facing down.

Even the slightest of lateral forces are enough to collapse the feet of this plywood case. This combination package shows an "ALTO" arrow which simply indicates the top of the item, and not "transport this way up".

This selection of frequently observed packaging faults is just the tip of the iceberg. There is also a whole range of other weaknesses that indicate that the transportation of goods in general, and the packing of containers in particular, are operations that do not always run as smoothly as they could.

The requirement laid down in virtually all national and international legislation, regulations and agreements, namely that goods should be "packed safely" is unfortunately all too frequently not put into practice.





Very poorly wrapped unit loads

These unit loads have fallen apart when being transported from the warehouse to the loading ramp on the company premises - despite being very carefully deposited by the forklift operator.



Insufficiently wrapped carton on a Europallet

Companies very rarely respond appropriately and immediately when confronted with badly packed goods, despite the fact that they have the opportunity to do so.

Generally the shipper is responsible for all consequences caused by a lack of packaging or by poor quality packaging. In particular, the shipper is responsible for compensating companies for damage caused as a result of such faulty packaging.



Consolidated package that is unsuitable for transportation

A company which accepts goods for carriage that already show obvious evidence of damage is entitled to demand that an entry is made in the consignment note by the shipper documenting the state of the goods explicitly.



Load that is only fit for writing off

Pallets that are not loaded flush require additional securing. The badly applied steel strapping requires particular care when handling these loads using a forklift truck since they are easily torn away when applied in this manner. It is very difficult to assess whether or not the damage to the carton has also resulted in damage to the goods inside it or will do so subsequently.

If the lack of packaging/faulty packaging is not entered in the shipping documents by the shipper or the party delivering the consignment, then the company responsible for the onward transportation is required to document these faults.



Fit for writing off: Crates without sufficient diagonal bracing

Every wooden crate that does not have sufficient diagonal bracing should be classed as faulty

packaging.



Fit for writing off: Crates without sufficient diagonal bracing

The lack of diagonal supports has already caused deformation of this wooden crate. Depending how sensitive the packed goods are, this deformation could cause damage. In addition, this example shows evidence of loading and securing errors.



Damaged chipboard pallet

As observations in many container packing stations have shown, pallets made of chipboard are not suitable for overseas transportation purposes. They are too weak and are very susceptible to damage. As a result of the very small surface areas of their feet, they also apply high loads to the objects they are standing on and can thus often only be used in conjunction with materials that are able to distribute this load.



The damaged feet of a chipboard pallet pose a risk to other goods.

Chipboard pallets are easily damaged even when subjected to very low loads. Both the sharp edges that remain and the reduction in surface area that results will further increase the loads on other cargo.



Insufficient wrapping of a chipboard pallet



Increased pressure as a result of small surface areas



Unsuitable solution to the problem

This pallet is too big for the carton. This causes gaps when packing the CTU. Since chipboard pallets are very sensitive to bending forces, the steel strapping may break off parts of the pallet. This means that the carton is no longer bonded securely to the pallet. In order to get around this problem, the carton and its pallet were loaded on their side. But this is not a particularly good solution because this can cause problems for handling staff and may even damage the contents.





Unit load that is not fit for transportation



Unacceptable unit load

Such badly packed pallets can only be loaded safely with a high outlay in terms of personnel and materials. The holes in the lower telescope carton indicate that an inexperienced forklift operator was entrusted with handling this pallet.

This unit load clearly shows the lack of understanding that has gone into unitizing the load. The consequence of this poor unitization will be that the packages will be split and loaded into the CTU individually.



In accordance with the IMDG code:
Load unit that contravenes the regulations

If a company is not prepared to load packages of this type individually, considerable effort must be put into correct load securing.



Unit load not suitable for transportation

With many packages, gaps remain when the packages are loaded next to each other. In other cases, the stretch wrap is too weak or does not form a firm bond with the pallets or other bases. Other unit loads cannot be stacked or have faulty strapping etc.







Above and left:
Faulty unitization hinders the correct packing of containers

Loads of this type make it impossible to pack the container tightly without additional work and materials.





Well packed unit loads are level and can be stacked. The ones shown here do not fall into this category.

The process of packing a container is made more complicated if unit loads are delivered which cannot be stacked. If unit loads are so heavy that they cannot be packed on the top layer or cannot be fitted into this space, then the packages must be split and loaded manually.



Faulty unit load

The faults are: No stable bond between the stretch wrap and the pallet base, the strapping cuts into the boxes, the surface is not level and thus does not allow anything to be stacked on top of it.



The sides of the unit load are not flush.

Since the sides of the unit load are not flush, additional work is required in order to fill the gaps.

According to the IMDG code, the unit loads should be compact, have as regular a form as possible, and for the most part, vertical sides. The top of the unit load should be level. It must be possible to stack the unit loads. They must be constructed and secured in such a way that it is unlikely that the individual packages can become damaged.





This unit load does not comply with the IMDG code

The requirements of the IMDG code have not been met. Nor have they been met by the following unit loads:



The main faults are:

No firm bond to the pallet, pallet is not loaded flush, unit cannot be stacked.



Load unit that does not comply with the regulations



Load unit that does not comply with the regulations

This pallet carrying hazardous goods is not packed flush. The bond to the pallet is not secure enough and there is a large gap in the top layer.



Irregularly shaped unit loads hinder packing work.

Unit loads that are as irregularly shaped as the one shown here make packing work more difficult. It may be necessary to split this unit and to load the packages individually.



The projection of the load beyond the edges of the pallet is a potential source of damage

One of the drums was already dented when the pallet was delivered by truck because the load extends beyond the edge of the pallet. Part of the strapping had become loose and the lid had shifted slightly.

It will only be possible to transport this load without damage by investing a considerable amount of

effort for load securing. Since this load comprises Class 8 hazardous goods for maritime transport, this marks a violation of the law.



Loading gaps and faulty strapping increase the risk of damage.

The violation of the law is even more obvious here:



Insufficient strapping - no bond to the pallet

This cannot be termed a unit load. The drums must be loaded individually.

There are no bounds to some people's imagination when it comes to dreaming up methods of forming unit loads. The few pictures below should serve to illustrate the problem.









Damage is inevitable if loads are packed into a container in this state. Unless, of course, a huge amount of work and materials are invested during handling to repack, improve the packaging and to secure the load in place safely.



Violation of the unitization regulations

In place of the outlay required to unpack the pallets, dispose of the wrapping film, and to then pack the items properly and secure them in the container etc. it would possibly be worthwhile to procure a (used) box pallet or case and load the pails in that. It should also be borne in mind that such a breach of regulations would incur a fine if the authorities were to carry out an inspection.



Above and right:
Faulty formation of unit loads -
Violation of loading guidelines



These plastic drums also are not firmly secured to their pallet by the wrap. The gaps between the unit loads are an obvious violation of the regulations for the transportation of hazardous goods.



Incomplete strapping

The strapping is missing on two sides and on the lower and middle sections of the load. The existing strapping is badly placed. The edge protectors used are only partially effective in this case and they are missing on the other two sides of the pallet. If the film that has been used is a shrink cover then the packers forgot to put the pallet in the shrink oven as well.



Unit that is unable to withstand a significant load

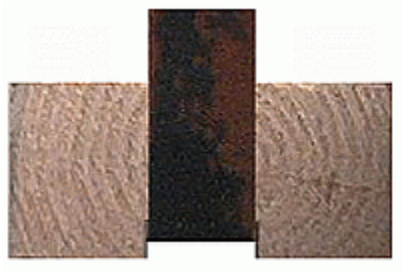
The use of weak packaging hinders the efficient packing of containers. Additional measures for damage prevention are required. Not only that, no edge protectors were used when strapping the load.



Rectangular dunnage placed on edge is liable to collapse.

This rectangular dunnage has been used incorrectly: Here a groove can been seen that has been cut specifically to take steel straps or plastic strapping in order to ensure that the strapping does not break or tear when it comes into contact with the floor. Used incorrectly as we can see here, the dunnage is likely to collapse. It is also increases the load on the surface it is standing on.





Correct use of dunnage





Incorrect use of dunnage





Risk of damage is increased when dunnage is used on edge.

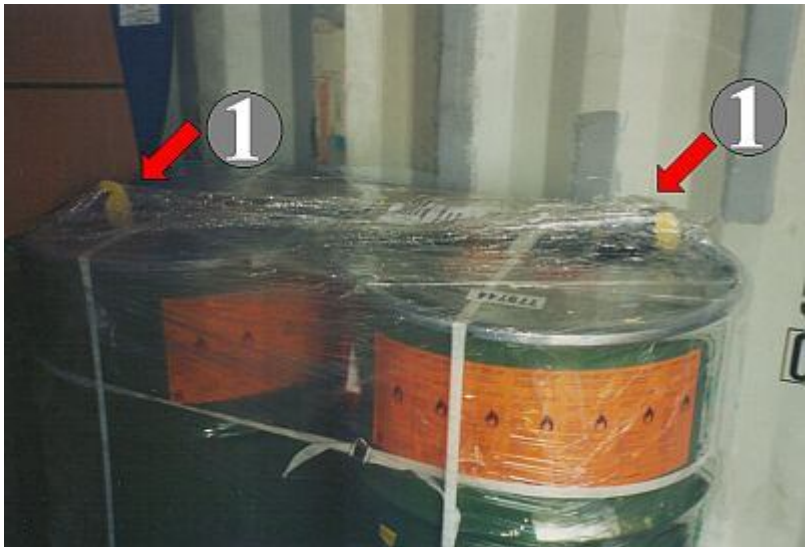
The example given below shows the effort that must be invested in order to counteract the problems of faulty packaging and how unsatisfactory the ultimate solution is:





Above and left:
Unit load that does not comply with the IMDG code

A number of mistakes have been made in packing this container: The pallet holding the drums has not been loaded hard up against the right-hand container wall. A wooden pallet has been placed vertically between the chipboard pallet and the drum pallet, but this does not fill the gap completely.



In violation of the regulations, this load surface is not even.

The drainage cocks for the drums (1) have been placed on top of the drums and stretch wrapped in place.

The only possible way of stacking other items on top of these drums would be to create a level surface using dunnage placed lengthways and then widthwise.



Risk of drainage cock being damaged by a packer standing on it

The gap behind the drum pallet must be filled in manually. Since the packer must ensure that he does not stand on the drainage cock, he is unable to handle the heavy carton (5) safely and it is distorted as a result of being accidentally placed on the edge of the drum.



The shrink-wrapped drainage cocks make packing work more difficult

The stowage gap above the drum pallet is only partially filled here. Behind package (3) there is a gap because the drainage cock of the second drum is located here.



Packing work is hindered by the shrink-wrapped drainage cocks

A gap has also been left for drainage cock (1) in front of package (3) and next to package (4). If the drainage cocks had been shrink-wrapped at the bottom of the drums, a wooden board could have been used as interlayer dunnage to allow the remainder of the stowage space in the container to be filled out more efficiently. It is correct and sensible to ensure that the hazardous goods drum pallet is packed in the vicinity of the container doors.

4.1.3 Securing goods in packaging receptacles



Badly constructed case

The basic idea, namely attaching a suitable base in order to stabilize a case that runs the risk of tipping, is in itself not a bad idea, but only if the package is to be transported on an open flatbed truck. It is unsuitable for use with a closed mode of transport. The case can only be secured with considerable effort, using wooden bracing or a considerable amount of material to fill in the gaps.

Lifting this object using a forklift truck from the side that can be seen in the photograph is only possible if the forks of the truck are very close together. Even a slightly uneven road surface could cause the case to topple from the forks. If the freight costs are calculated according to volume, money is being wasted since the dimensions used to calculate the volume are the extremities of the case.

It would have been more sensible to pack the contents into a stable case with a floor surface the same size as the special construction shown here. If the load is firmly bolted inside a case of this type, it can easily be packed into a closed CTU and secured. This method would not incur greater freight costs than the existing special construction.

Sometimes, the correct securing of the packed goods inside the packaging receptacle is overlooked.



Right and enlarged image below:
Insufficient securing of the load inside the receptacle



Even a sturdy box or case cannot ensure that the goods are not damaged in transit if the contents of the case are not securely packed. Here, the forces of inertia during road transport were sufficient to cause the load to penetrate the case.

Other notes about packing goods

For customs-related considerations, it is often advantageous to disassemble goods and transport them in cases or other receptacles.



Receptacle designed to accommodate two disassembled tractors

The practice is very often adopted when shipping cars. Terms like CKD and SKD meaning completely knocked-down cars and semi knocked-down cars, are used to describe vehicles that are packed in containers, crates and cases.



Wooden frame used for packing semi knocked-down sports cars into containers

4.1.4 Marking goods

Experts are generally in agreement that the marking of the goods is an essential part of the packaging. This opinion is reinforced by a series of court judgments. For example, in a judgment by the Duisburg Landgericht (regional court) a company's claim for damages was rejected because the markings (handling symbols) necessary for safe handling of a package were missing.

The various domestic traffic regulations are almost unanimous in requiring that the shipper of a package mark this package in such a way that the marking is permanent, clearly visible and cannot be confused. The markings must correspond to the specifications in the consignment note. All old addresses and labels must be removed or clearly negated. In some areas, it is also necessary to specify both the shipper and the recipient.

Part 1 of the current DIN standard 55 402 entitled "Shipping marks for packages" describes the pictorial markings for the handling of goods, and Part 2 provides a directive for export packaging. Adherence to such standards should ensure uniform marking of the packages to be shipped. The standard does not apply to advertising and required information that is regulated by the guidelines of various transport service providers, such as the postal services, the rail services or by individual countries. Further information can be found in ISO/DIN 780.

Markings should always be restricted to the necessary information. They should be applied without a border, and must be easily legible and permanent. They must be able to withstand the rigors of transportation.

Black should be used if possible. It must, however be ensured that the markings contrast with the color of the package. Where adhesive labels are used, the standard recommends black printed on a white background. The colors not permitted by the DIN standard are those that are reserved for hazardous goods, for example, orange and bright red.

The hazardous goods regulations previously demanded that a border was placed round the symbol. This is no longer the case.

If goods are relabeled, both the pictorial marks and the lettering of the old markings should be made illegible. This is intended to eliminate all risk of errors and misdirection.

The specifications in the shipping documents must match the specifications on the packages themselves. The problem for the practitioner here is that even if an incorrect or incomplete marking is applied, they are not permitted to correct the markings or add markings without authorization. Otherwise this could lead to problems with customs, foreign trade banks and similar interested parties.

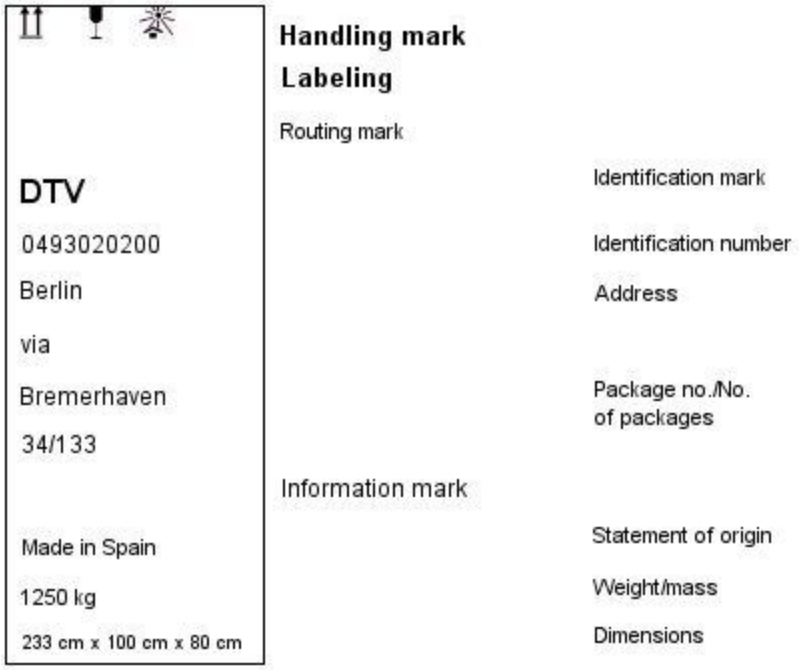
Those who are responsible for the packing and labeling of goods must be familiar with the various standards, or have them available for reference, and must act in accordance with them.

For those who "only" deal with the transportation of the packages, it is important that they are able to read and interpret the markings on the packages and not that they should be able to attach or modify these markings.

Labeling in accordance with the standards

According the various standards, the labeling is to be made up of the following items of information. The sequence should be adhered to unless special directives apply for particular circumstances.

Example of a marking that conforms to the standards:



The shipping mark and the statement of origin should be arranged one below the other. The weight and the dimensions should be applied to the bottom right of the package, and handling information preferably to the top left.

For cuboid packages, the handling information and the markings should not be separated. They should be applied to at least two adjoining sides. The only exceptions to this rule are pictorial markings that are tied to a specific location, for example, those showing the center of gravity. For cylindrical objects, it is sensible to apply the labeling to two opposite sides. It is sufficient to mark bagged cargo and bales on one side only.





Marking on a bale of tobacco from Indonesia



Incorrect marking:
Handling information and marking are separated



Incorrect marking and design

The pair of arrows should have been on the front of the crate. All marking should also have been duplicated on an adjacent side. A comment on the case: It is constructed in such a way that the lid boards can lift easily if slinging equipment with multiple cables and a single hoisting point is used. Here, either metal corners should be used or the lid boards should be recessed or rabbeted. The air vent protrudes by approximately 1.5 cm. This may be torn off or may damage other goods during packing.

Information that is not required for shipping should not detract from the effectiveness of the markings. They should thus not be applied to the same sides as the markings.

Unless otherwise specified in other regulations, all markings are to be effected using Arabic numerals and in capital letters. The size of the letters will depend on the amount of space available and is specified in the standards. Clarity and legibility must be ensured. The letters and numbers of the shipping mark should contrast with other markings. All letters and numbers should, however, be smaller than the specified handling instructions.



Markings that do not comply with the standards

Here, neither the size nor the location of the labeling meet the requirements of the standards.

Unfortunately the existing regulations are rarely applied in practice. In the event of doubt about the meaning of a marking, information should be obtained as soon as possible from experts or from the persons/institutes responsible. This is particularly important for hazardous goods markings as well as the sling here and center of gravity markings.

Shipping mark

The shipping mark of a package includes the identification mark, the identification number, the address and the total number of packages in the consignment, as well as the sequential number of the package within the consignment.

Identification mark

The identification mark may be the first few letters of the name of the shipper or recipient or the company name of the recipient.

Identification number

The identification number may be, for example, the order number, consignment note number or bill of lading number among other things.

Address

If the package is to be received at a port, the name of the port only should be specified. If the package is to be transported further once it has reached port, then the address should be specified as the destination via the destination port.

Total number of packages in the consignment, sequential number

The total number of items in the consignment must be specified plus the sequential number of the package within the consignment.

Information markings

Information markings include information about the country of origin, and the weight and dimensions of the package.

Statement of origin

The statement of the origin must be in accordance with the requirements of the relevant countries. The statement of the country of origin is often mandatory. In some cases, however, it is not desired.

Weight

As of a gross weight of 1,000 kg, packages must display weight information. With regard to ease of transport, handling and storage, however, the relevant standards also recommend indicating the weight in lighter packages.

Dimensions

The standards state that the dimensions of a package should be specified in centimeters.

Handling symbols

In order to guarantee the correct handling of packages and goods, pictorial symbols are used. The use of textual information to enhance the pictorial symbols should be avoided.

The pictorial symbols are to be applied without a border. In the past, the hazardous goods regulations required the use of pictorial symbols with a border to identify hazardous goods. This is no longer the case. The authorities will generally tolerate a border if there is one.

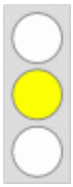
Meanings of the pictorial symbols according to DIN, ISO and IEC

The German meanings of the pictorial symbols in accordance with the German standards and the English meanings as defined by the International Organization for Standardization and IEC are described in the following section.

Symbol	Meaning according to DIN	Meaning according to ISO

	Keep dry	Keep dry

Since goods of this type should also be protected from high levels of humidity, they must be transported in closed vehicles or containers. If it is only possible to transport particularly heavy or bulky goods on platforms, flats or in open top containers these must be covered carefully using tarpaulins.





Tarpaulin-covered case with the umbrella symbol

Load securing issues will not be discussed here (although the securing could be improved). The important consideration is that the cover must be water-tight and that it is not possible for condensation to form below the tarpaulin. This can only be achieved with considerable effort. More information and hints about using tarpaulins can be found elsewhere. The cover must be as securely lashed as possible to make sure that it cannot be detached or destroyed by stormy conditions.

Symbol	Meaning according to DIN	Meaning according to ISO
	Protect from heat - But also: Protect from sunlight	Keep away from heat

In order to comply with the requirements of this symbol, goods traveling to certain climatic regions can be loaded into insulated containers or vehicles, or at the very least, an appropriate distance to the vehicle or container walls and roof should be maintained. Remember: Any gaps must be filled in.
When goods are imported from abroad, symbols are often used which are not ISO-compliant. In the vast majority of instances, these symbols can be understood by the storage and handling staff and leave little room for misinterpretation.



The Chinese symbol for "Keep away from heat"

Here, the sun as a source of heat is easy to recognize. Identifying the second symbol as a source of heat is somewhat more difficult.

Symbol	Meaning according to DIN	Meaning according to ISO
	Use no hooks	Use no hooks

Any other kind of point load should also be avoided with goods marked with this symbol. However, this symbol does not ban the so-called plate hooks that are sometimes used to manually move appropriately marked, robust, bags made of natural materials such as sisal, hemp, jute etc.

Symbol	Meaning according to DIN	Meaning according to ISO
	DIN does not recognize this symbol	ISO does not recognize this symbol
	Internationally understood meaning	
	Plate hooks may be used	

Symbol	Meaning according to DIN	Meaning according to ISO
	Center of gravity	Center of gravity

This symbol is intended to provide a clear indication of the position of the center of gravity. It only makes sense to use this symbol if the center of gravity is not in the middle of the object. If there are no symbols giving the location of the center of gravity, the warehouse and handling staff can safely assume that the center of gravity is in the middle of the load.



Unnecessary center of gravity marking

If a load with a center of gravity which is not the middle of the object is not marked up accordingly, the shipper/packer of the load can be held responsible in the event of accidents or damage.

The center of gravity is clearly identified if the symbol is applied to two adjacent sides (at right-angles). The DIN standard, however, recommends that it be applied to three surfaces, namely two adjacent sides and the top. This is particularly relevant for large and heavy packages as the operator of the lifting equipment is then also able to see that the center of gravity is not in the middle of the package.



Marking the center of gravity on three sides of a load, in accordance with the DIN standard

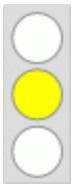
Exports destined for countries of the former Soviet Union should use the Russian symbol for the center of gravity. There, the cross is placed below the circle.



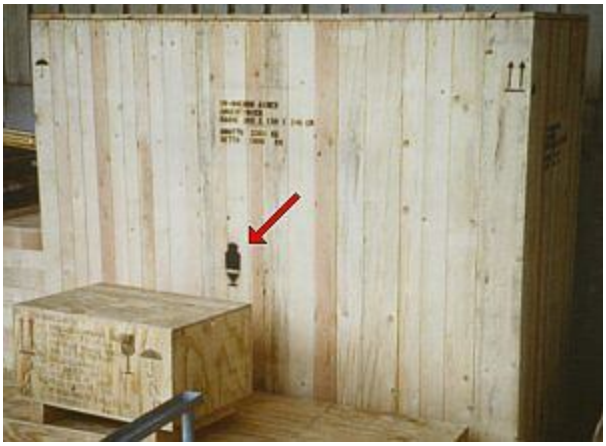
Russian symbol showing the center of gravity

Containers with a center of gravity that is outside the specified tolerance of ± 2' (≈ 60 cm) for 20' containers and ± 3' (≈ 90 cm) for 40' containers must always be marked with the center of gravity symbol. Permits must also be obtained from the transportation and handling companies with regard to the special location of center of gravity.

For some decades now, the DIN standard has not included the "top-heavy" symbol. This was symbolized by a weight balanced on an inverted triangle. It formerly had to be used for objects with a center of gravity above the middle of the object. As can be seen from this picture (taken recently) the information that this symbol should no longer be used has not yet reached all shippers.







Package showing the outdated "top-heavy" symbol

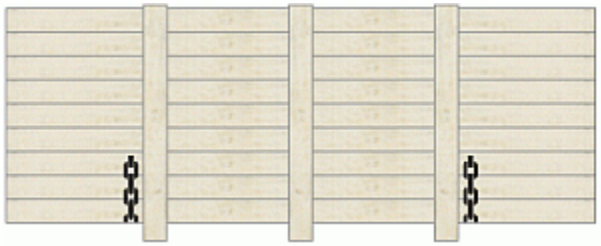
Symbol	Meaning according to DIN	Meaning according to ISO
	Clamp here	Clamp here

The statement that the package may be clamped at the indicated points is logically equivalent to prohibiting clamping anywhere else.

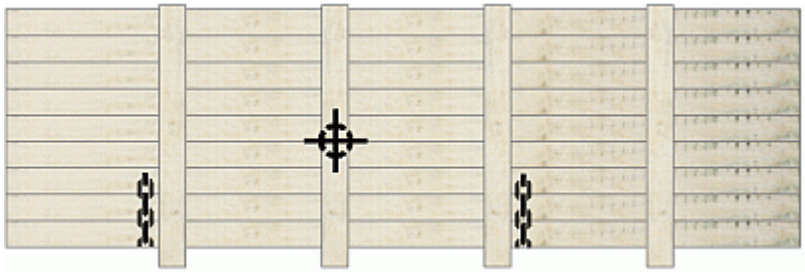
Symbol	Modified symbol as used in practice
	Only clamp with the specified pressure

This is a very useful piece of information in practice. The example gives the specified maximum pressure as 0.77 kPa (kilopascal) or 7.7 hPa (hectopascal) or 0.00077 MPa (megapascal). Expressed in the unofficial, yet still widely used units of pressure, this is 0.0077 Bar or 0.077 kg/cm² or kp/cm². For handling staff, the specification 0.077 t/m² may also be helpful.

Symbol	Meaning according to DIN	Meaning according to ISO
	Sling here	Sling here

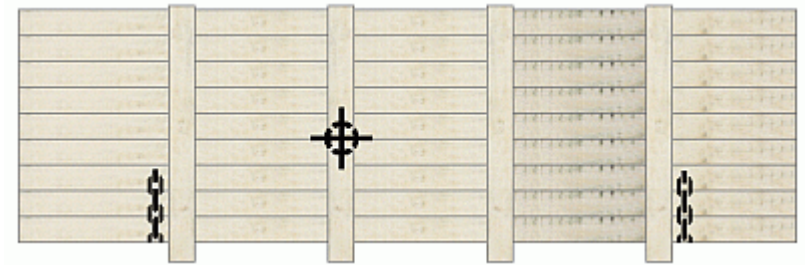


Case with a center of gravity in the middle of the load



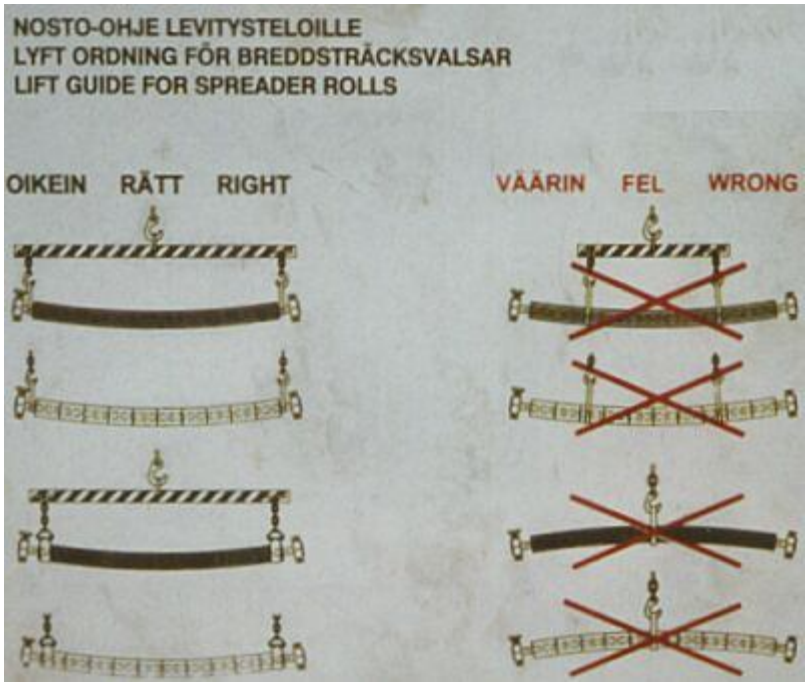
Case where the center of gravity is not central

If the "sling here" symbols for a load with a central center of gravity are equidistant from the middle or are equidistant from the center of gravity for an off-center load, then the package will be level when suspended if slinging equipment of the same length is used.



Case whose center of gravity is not central and with asymmetric slinging instructions

If this is not the case, the slinging equipment must be shortened appropriately where the distance to the center of gravity is shorter. If one were to attempt to use slinging equipment of the same length the case would not be level. Thus, in the example above, the case would tilt considerably to the left and may fall.



Additional slinging information using special markings

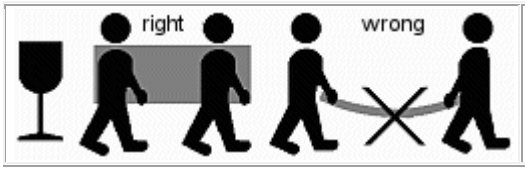
With certain goods that must be slung in a particular way, it makes sense to provide warehouse and handling staff with additional information to help them handle the object properly. The example shown here is easily understood.

It is may also be sensible to include information about restrictions on the maximum amount a load may be tilted or indications that the load is not to be tied.

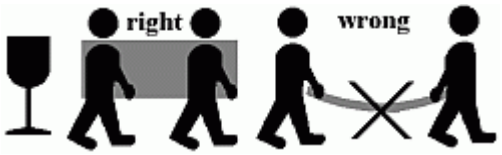
Symbol	Meaning according to DIN	Meaning according to ISO
	Fragile, Handle with care	Fragile, handle with care

This symbol is used for fragile goods. Goods marked with this symbol should be handled carefully and should never be rolled over or tied tightly. In the case of certain hazardous goods, packages of this nature should have anything stacked on top of them. More information about this can be found in the General Provisions of the relevant regulations or in the special notes for the various classes or special goods.

Symbol	Proprietary symbol developed by a German glass manufacturer

	Meaning: Object should only be carried on edge

This symbol can be clearly understood by anyone. When used abroad, the German "RICHTIG" and "FALSCH" can be replaced by English text, for example, "RIGHT" and "WRONG" or "DO" and "DO NOT", or colors and a clear X symbol could also be used to indicate the correct/incorrect method.







Symbol	Meaning according to DIN	Meaning according to ISO
	Top	This way up

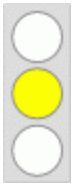
The package must be stored, handled and transported in such a way that the arrows always point upwards. Rolling, swinging, severe tipping or walking of goods marked in this way must be avoided. It has been suggested that the meaning of this symbol is changed to to "transport upright" or "keep upright" in the next edition of the DIN standard.



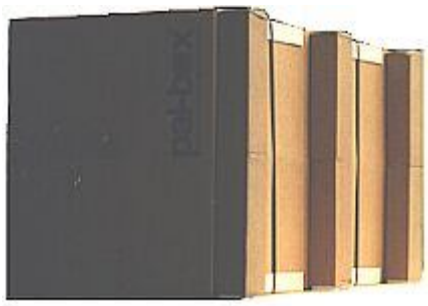


Pallet box and the appropriate handling symbols

The green traffic light indicates that the package is marked correctly. However, the red traffic light and the red arrow indicate that the marking has been applied at an inappropriate location and that the package has already been damaged by incorrect handling. The strapping used is not suitably placed for handling with a forklift truck.







Corrugated board carton standing and on its side

If a package does not have this pair of arrows, it may be handled or transported lying on its side or even upside down, which could damage the contents.

The pair of arrows does not mean that an object must be stowed on the top layer nor do they mean "open here". The latter of these two meanings is indicated by a single arrow or other similar symbol:



A package that is marked with an arrow like the ones shown does not have to be transported upright. The correct symbol should clearly indicate the intended meaning. However applying all sorts of nonsensical symbols is a practice that should be avoided. One can only really expect long-term observance of the handling symbols if they are used sparingly and sensibly.



Incorrect choice of handling symbol

The shipper of this case probably wants it to be transported upright. But this is not what the symbols mean. It is also better to apply the handling symbols next to each other and on two adjacent sides.

´

Symbol	Meaning according to DIN	Meaning according to ISO
	This is not yet incorporated in the standard	Do not roll

The package may not be rolled, swung, or tilted to any great degree during handling. The symbol should always be observed, despite the fact that it is not included in the German standard.

Symbol	Meaning according to DIN	Meaning according to ISO
	Tear off here	Tear off here

This marking is intended only for the receiver. Generally speaking, warehouse and handling staff should not open packages.

Symbol	Meaning according to DIN	Meaning according to ISO

	No hand truck here	No hand truck here

If this symbol is missing on one or more sides of a package it is assumed that the hand truck may be used on the unmarked sides of the package.

Although the "hand truck here" symbol does not officially exist, a symbol of this nature is often used.



Meaning: Hand truck here

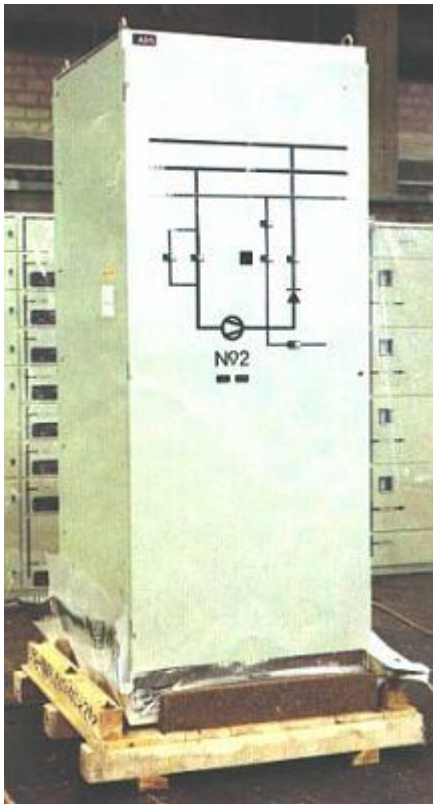
The use of this symbol to provide staff with clear information is to be welcomed. Thus, for example if a carton containing a refrigerator may be moved by hand truck from two sides, but not from the other two sides, then it would make sense to use both of these symbols and apply them to the relevant sides.

Left side of the refrigerator	Hand truck here
Door side of the refrigerator	No hand truck here
Right side of the refrigerator	Hand truck here
Rear of the refrigerator	No hand truck here

Symbol	Meaning according to DIN	Meaning according to ISO
	Do not destroy barrier	Do not destroy barrier

A barrier layer which is (virtually) impermeable to water vapor and contains desiccants for corrosion protection is located beneath the outer packaging. This protection is no longer afforded if the barrier layer is damaged. Since the corresponding symbol has not yet been approved by ISO, puncturing of the outer layer should also always be avoided for any packages bearing the words "Packed with desiccants".

For example, the handling symbol described should be applied to this package.





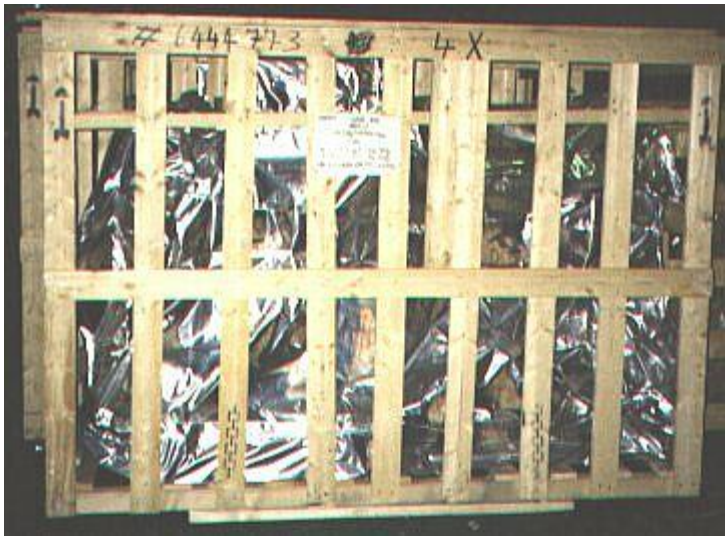


Above and left: Packaging for a control cabinet

Depending how sensitive the goods are, the length of the journey, the climatic conditions, the onward carriage and standing time of the goods, the appropriate form of conservation should be employed. Goods can be protected from corrosion using coatings, spraying, painting, dipping,

desiccants, volatile corrosion inhibitors (VCI method) and other effective measures. Attention should be paid to all critical issues before doing so. If in doubt, advice should be obtained from professional packers, or the job should be handed over to a reputable packing company.

Sealed packages, and in particular those in which desiccants have been included, should not contain hygroscopic materials. Packages of this nature should be carefully protected from damage.



Badly constructed and marked wooden crate

The lack of diagonal bracing can lead to the crate becoming deformed and thus causing damage to the contents. The symbols indicating a sealed package are missing. This can easily be damaged during handling. A case would have been a more suitable receptacle. The single arrows do not oblige the handling staff to keep the crate upright at all times.

Symbol	Meaning according to DIN	Meaning according to ISO
	Electrostatic sensitive device	Electrostatic sensitive device

Touching parts that are marked like this under relative humidity conditions of less than 70 % should be avoided if wearing electrically insulated shoes or when standing on a insulating surface. Low levels of relative humidity must in particular be expected on hot, dry summer days and very cold winter days.

Symbol	Meaning according to DIN	Meaning according to ISO
	Permitted temperature range	Temperature limitations

According to the regulations, the symbol should either have an additional °C for a single temperature or °C max. and °C min. to give the upper and lower temperature limits of a range. The relevant temperatures or temperature limits should also be noted in the shipping documents.

Transportation of goods that are marked like this is generally carried out using refrigerated containers or vehicles, or at the very least, insulated containers or well insulated vehicles.

Symbol	Meaning according to the hazardous goods regulations
	Temperature-controlled load

The symbol for temperature-controlled cargo has been included in the hazardous goods regulations for a number of years. The relevant hazardous goods regulations provide information about the necessary markings and their meanings.

Symbol	Meaning according to DIN	Meaning according to ISO
	Do not use forklift truck here	Do not use forklift truck here or: Use no forklift

This symbol should only be applied to the sides of a package where a forklift truck cannot be used. Absence of the symbol on other sides of the package amounts to permission to use forklift trucks on these sides.

The following symbol is not part of either the DIN or the ISO regulations, but is sensible and should be used as required.

Symbol	Unofficial meaning
	Use forklift truck here or: Forklift here

A sensible combination of these two symbols would be, for example, on a long case that as a result of its construction can be lifted with a forklift truck from its long sides but not from either of the ends. However, other combinations or variations are possible.

Symbol	Meaning according to DIN	Meaning according to ISO
	Stacking limitation	Stacking limitation

The stacking limitation should be specified in kg. Since a marking of this nature is only ever applied to packages that are able to take very little load, these are usually goods that are packed in the upper layer.

If the limit is specified as 0.00 kg it should be clear to both warehouse and handling staff that the goods may not have packages stacked on top of them.

Symbol	Recommended use with the following meaning
	Only transport in the upper layer or: Top layer or: Do not stack

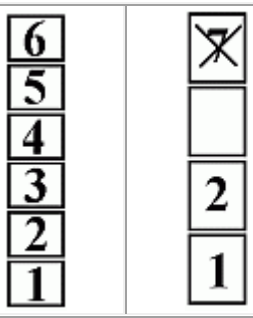
The recommended use of the symbol should be clearer than any proprietary labels:





The phrase "Bitte nicht belasten" will be clearly understood by German-speaking staff to mean that the package should not be subjected to loads. "Fragile" on its own is no guarantee that other items will not be stowed on top of this package. The marking "Please do not load" is more likely to cause confusion, as it is not clear what is meant.

For the carriage of homogenous loads, the industry has developed a number of its own symbols which are very clearly understood and refer to the number of layers or tiers that may be formed using certain packages.

Symbol	Meaning
	Only stack six layers high







Cargo is at risk if the handling symbols are missing.

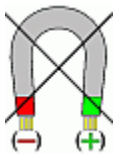
If this case should not be stacked, it would be better to use the appropriate symbols instead of writing "do not stack" by hand, in German on the case. The hazardous goods regulations state that the markings on a package should be applied in such a way that they are guaranteed to survive three months exposure to sea water.

The required hazardous goods markings and their meanings can be taken from the appropriate regulations. General notes can also be found in the appropriate sections of the CTU guidelines.

Symbol	Meaning according to DIN	Meaning according to ISO
	Protect from heat and radioactive sources	Protect from heat and radioactive sources

Since the term heat is not clearly defined here, the packages should be stowed in as cool a location as possible. In addition to this, sensitivity to the temperatures that can be expected should also be checked. The presence of radioactive sources should in theory be known as a result of adherence to the regulations or as a result of the correct labeling of packages and receptacles. If refrigerated containers or refrigerated vehicles are not to be used, it is recommended that at least insulated containers or vehicles are used. Under no circumstances should loads of this type be stacked close to the walls or roofs of normal containers or vehicles.

Certain packages such as computers and accessories, may not be exposed to magnetic fields. The industry in many countries has developed easily understood symbols to indicate this. Here is an example:

Symbol	German meaning	English meaning
	Do not expose to magnetic fields	Do not expose to magnetic fields

Further information

When transporting items such as steel bars and pipes, for instance, the labels are very often in the form of sheet metal tags that are hung on the cargo. When handling loads of this type, it must be ensured that these tags do not become detached, as this could lead to problems with customs authorities or incorrect delivery. If a tag of this type is detached or such a detached tag is found, it must be taken to the appropriate office or person.

German terms

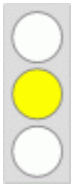
Markierung von Gütern	marking of shipping goods
Markierung von Gütern	kind of lettering
Bestimmungshafen	port of destination
Kollo, Packstück	package
Bestimmunsgort	port of destination
Ursprungsland	country of origin
Gewicht	weight
Abmessungen	dimensions
Marke; Märk	mark
Kollianzahl	number of pieces/packages
Kollonummer	package number
markieren	to mark
Leitmarke	guide mark
Kennmarke	identification mark
Kennmarke	registering mark
Volumen	volume

4.2 Packing and stowage methods

Unlike the transportation of general cargo on conventional ships, containers represent small, closed loading areas or loading platforms of a specific dimension. The first definition applies primarily to box containers, whereas the second applies to platform containers. The height and width dimensions may be exceeded to a certain degree.

"Stowage methods" is still a frequently used term in the industry. But the use of containers and other cargo transport units (CTUs) demands further distinctions in the use of terms, because not only do the CTUs themselves have to be loaded and unloaded but also, the containers have to be positioned on land or on various means of transport. It is therefore necessary, for regulations such as the CTU guidelines, to define terms to distinguish between the various activities. The "Definitions" sections includes the following:

Packing *means the packing of packaged and/or unitized or overpacked cargoes into CTUs.*





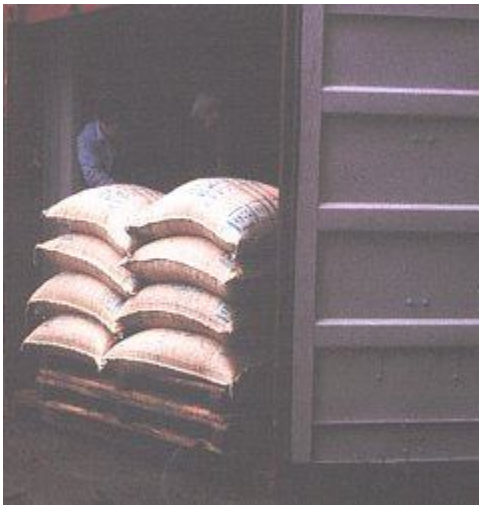


Packing/stuffing a container **Packing a semitrailer**

Terminal staff often refer to "stuffing" the containers in this context. It is often also carried out at "packing centers". It is essential that all dead space in containers is filled.

Unpacking *means the removal of cargo from CTUs.*





Unpacking/stripping an import container containing coffee bags

Terminal staff often refer to this activity as "stripping".

Stowage *means the positioning of packages, IBCs, containers, swap-bodies, tank containers, vehicles or other CTUs on board ships, in warehouses and sheds or in other areas such as terminals.*



Stowage on board a full container ship





Container stowage on land

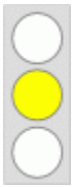
It should be obvious that every container load needs to be packed carefully. Where necessary, packing should be supplemented by appropriate load securing measures:





Unfortunately, not everybody thinks that the need for careful packing is obvious.

Here we see household effects which were not stowed properly.

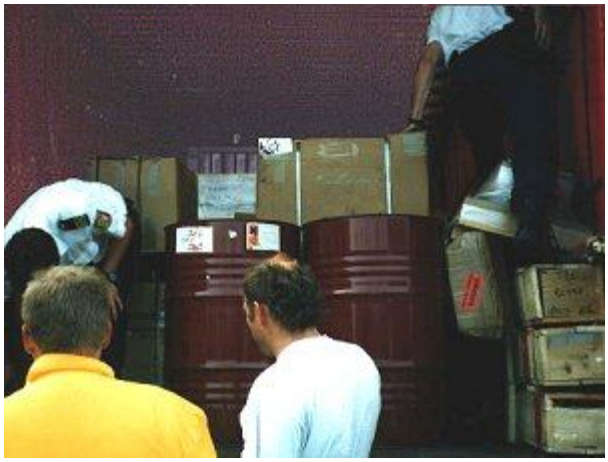




It is often difficult to pack carefully.

Here we can see commercial goods. Packages with different dimensions often present the packing staff with problems which are difficult to resolve. If the dimensions of the packages do not meet the

requirements of modularity, any gaps which remain must be filled in rigorously.



Inspecting an outgoing container

On arrival in port, random checks are occasionally performed to ensure that a load has been packed and secured correctly. However, these checks are mainly limited to a small number of containers carrying dangerous goods. They are arranged or performed by the harbor police or by the shipping company. It is unusual or even impossible for a load to be checked or corrected during a sea voyage. Loading and securing must therefore always be performed correctly. Stowage and securing errors made prior to acceptance of the container or which arise during the voyage can thus have more serious consequences than errors with a non-containerized load. Time is also a significant factor: On a long sea voyage, even minor initial deficiencies can develop into serious losses. The proportion of containers considered inadequate is alarmingly high. Around 70%!

There are a number of national and international regulations relating to shipping and transport which provide important guidelines on how to handle and package goods, as well as how to pack and secure them. These legal stipulations are supplemented by a number of civil-law regulations and contracts, in particular special conditions for individual means of transport. Further information can be found in the recommendations of special organizations or various companies. Loads can only be transported safely around the globe by observing some fundamental issues. The only way to prevent damage from arising is by packing and unpacking in a professional manner and by using appropriate packing and securing methods. All preparation and final work must be fully integrated in operational organization procedures. The remaining units in this section of the Container Handbook address and explain a number of important issues.

4.2.1 Preparatory work

When producers pack their own goods into cargo transport units, they should do so with trained staff and sufficient expertise.

If external companies are entrusted with the storage, handling or transport of goods, they must fulfill their duties as carefully as if they were dealing with their own goods. They must ensure that nothing is spoilt or damaged and that articles and materials entrusted to them cannot have a damaging effect on other goods or on the environment.

This obligation to exercise due care entails an important principle concerning the provision of suitable storage areas and handling and transport equipment:

> *Open or closed areas intended to receive goods must have facilities and characteristics suitable for transporting or storing these goods. They must be in a state or be brought into a state which allows correct and safe transportation.*



Port operation with all the facilities required for correct transportation

This results in a series of **obligations and activities** for all staff involved in the supervision, storage, handling and transport of goods to ensure smooth shipment of those goods. These include, most importantly, the accurate planning and sophisticated organization of all processes. Otherwise, errors can propagate to every area of goods handling.



"Trampling" on packages must be strictly forbidden.

Good organization involves not only clear procedural instructions but will also ensure that these instructions are observed and monitored and that the staff receive regular training.

This section provides a brief summary of important preparatory work. More detailed information on some of the specific issues outlined there will be found in separate sections. The actual work

procedures and final work is dealt with in separate sections.

Preparatory work for the orderly acceptance or handing over of a load includes particularly the following tasks:

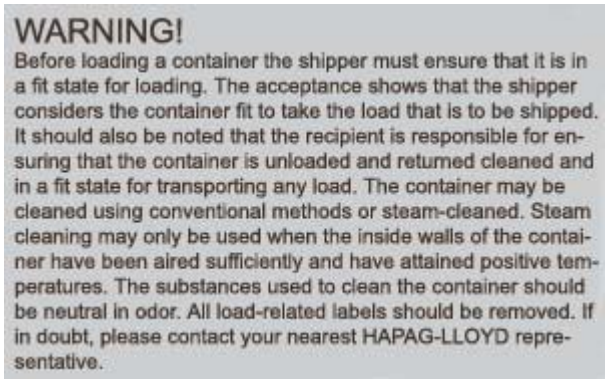
The **selection of suitable facilities for storage, handling and transport of goods and adequate stowage and storage space** is the particular task of all persons involved with the logistics for vehicles, containers or devices, and of shed or warehouse managers. They must ensure that suitable means of transport, ground conveyors and other equipment are available in the right place at the scheduled time. Outdoor short and long-term storage areas, covered hangars, sheds and warehouses should be marked out beforehand and dedicated to receiving specific goods. Staff under instructions have little influence in these considerations. Exceptions to this arise if staff are permitted to freely select from a series of empty containers. The loading staff in ports have no influence on the stowage locations for CTUs on board ships. These locations are specified by the stowage centers of the shipping companies or by the shipmasters.

Checking or establishing fitness for loading is an important prerequisite for being able to begin packing. Irrespective of the type of cargo transport unit used, fitness for loading must be established. The same also applies for short and long-term storage areas. They also must be in an adequate state to allow the goods to be stored safely and without damage. If this is not already the case, they must be brought into this state. Different properties of the different goods which constitute a load necessitate different requirements. Only a few general principles will be dealt with here. Although some concessions can be made under certain circumstances, they will also have to be supplemented by further measures under other circumstances. The term "fitness for loading" implies that work can be begun without delay. It may be necessary to line or pad out the floor of the area with boards, planks, squared lumber etc. It must be possible to handle the goods by lifting gear or ground conveyors without difficulty.



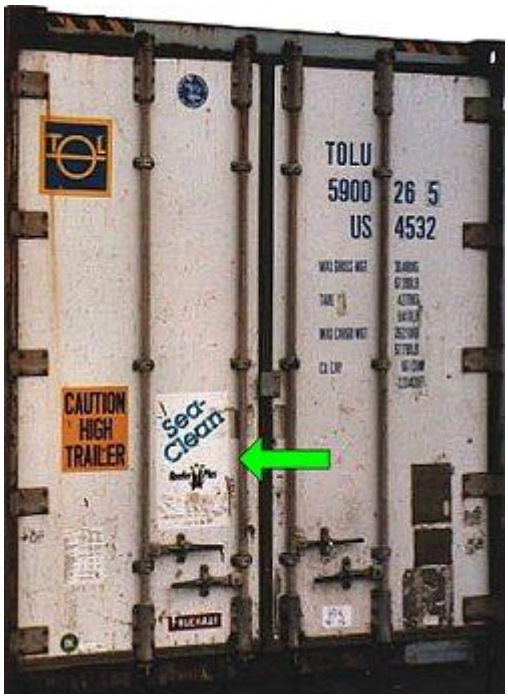
This step on the threshold presents a risk for staff, equipment and load

Fitness for loading also means that permitted stacking loads, wheel loads or axle loads are (can be) observed. Otherwise, the result could be damage to vehicles, stowage or storage areas or the goods that make up the load. Sometimes, the permissible load stated is clearly visible. Sometimes, it can easily be ascertained. In some cases, it must be taken from the relevant regulations.



Notice in a container

The degree to which a container must be **clean** must always be considered in relation to the particular goods to be stored or transported. The requirements for stowage space and holds will naturally differ for coffee, spices and other foods and foodstuffs compared with, for instance, granite blocks, steel, machine parts or hazardous materials.



Notice indicating that the container has been cleaned

The minimum requirement is that the stowage space is **swept out**:



Not swept out, and even traces of moisture

In this context, it is important not only that the floor is swept out, but also that any other dusty or contaminated parts, such as side and end walls, doors, roofs, covers, stanchions etc. are cleaned appropriately. Basic cleaning can prevent not just soiling or contamination but also chemical reactions. Sweeping out is also valuable on a physical level, since it generally improves the friction factor of the floor - dusty floors exhibit a lower coefficient of sliding friction.



Very smooth container floor

Absence or neutrality of odor is always required when odor-absorbing goods are stored or transported, otherwise their value could be adversely affected. Ensuring absence or neutrality of odor also means not using any odor-tainted or odor-emitting load securing equipment, dunnage or segregating materials in places where they could cause damage. Loads which can (could) negatively impact on each other must not be loaded together. Odor-neutrality is not required for the means of transport and accompanying load with most dangerous cargoes, but it can be important for certain chemicals. If odor-neutrality is required, appropriate information must be provided to the relevant offices. This is especially important if a molecular influence from other goods would have a damaging effect. In many cases, it is sufficient to remove residue from previous loads and to air thoroughly. Sometimes, it is useful to spray odor-binding chemicals, which should be environmentally friendly and in no way health-threatening or even toxic.

Special measures are required for storing, handling and transporting loads which are particularly odor-sensitive. The same applies if strong or badly smelling or dangerous loads have been shipped and the affected areas have to be prepared specially or restored before a load can be accepted. Extensive cleaning work, such as washing etc. can then be necessary. There are specialist companies on the transport market who offer these services.

Decontamination with special chemicals must be ordered specially and must be monitored. In certain cases, specialist companies with specially trained staff are to be called in.

Storage space and cargo transport units must be dry and offer protection from moisture, unless otherwise contractually agreed or this is not customary practice in a given trade. Generally, however, they must not show any defects which could lead to damage by moisture. Wet patches are to be removed by applying sawdust, dry sand or other absorbent materials and sweeping them up. Certain circumstances make it necessary to use special binders. In the simplest case, a thorough airing with "relatively" dry air is sufficient. To prevent moisture damage from occurring at a later date, the storage and stowage areas and means of transport must be inspected for leaks etc. This also means checking pipework, roofs, tarpaulins, doors, ventilation openings etc. and in particular checking the seals.



Moisture brought into a container by staff and forklifts



Danger of moisture being brought into a container

On rainy days such as this, no containers should be packed outside. It is another mark of good organization that either covered areas are provided or work is stopped under these conditions.

Long and short-term storage areas and cargo transport units must be free of any articles which could cause **mechanical damage**. They must therefore be inspected for materials which could damage the load, such as old load securing material, protruding mountings, incorrectly inserted roof bows or slats, sharp or pointed objects, etc. If there is a risk of damage, these items must be removed. This also includes removing old wires, wood splinters, nails, small stones etc. All protruding mountings, lashing rings, and sharp and pointed objects which cannot be removed, are to be covered. Carelessness during this work can not only cause significant damage to the goods themselves, but also consequential losses when the goods are further processed. An example of this is an instance of damage which occurred during the transport of newsprint in a container in which bags with plastic pellets had previously been transported. Due to inadequate cleaning, individual pellets became embedded in the paper rolls. When the rolls were subsequently processed, the granules brought a complete printing line to a standstill. The damage caused was enormous.

Inspections and protective measures are necessary before using cargo handling equipment, load-

bearing equipment, mechanical aids, tools etc. They must not cause tears, pinching, pressure points, scratches, soiling or a reduction of quality or safety standards which depreciate the value of the goods. Defective equipment must be repaired so that it is suitable for use or be rejected. This includes checking the loading capacity of ground conveyors and lifting gear, load-bearing equipment, etc. The materials used must be adequate to meet the requirements for correct segregation and correct use of dunnage. They must be available in a sufficient quantity and be of an adequate quality. Any missing stock must be made up in good time, to prevent any delays. Unusable materials must be rejected. Load securing means and transport protection equipment which have been installed or supplied are to be inspected to ensure they are ready to use, complete and in perfect condition. This includes stanchions, trailer rails, roof bow mountings or slats, partitions, permanently installed lashing systems, airbags, etc.

The **provision and selection of conventional load securing equipment** must be organized in good time. The most suitable materials are to be selected from those which are available or provided. Unusable parts must be rejected. Claims for incorrect or incomplete deliveries must be made in good time, to prevent time delays during purchasing or replacement delivery. Materials of this type could be: Steel wire, wire rope clamps, shackles, turnbuckles, steel strapping, lashing belts, lashing ropes, wood, etc. If individual items load securing equipment are passed on to third parties or used by third parties, this must be documented by appropriate receipts, etc.

Preparation of stowage, packing and storage areas or spaces must also include leveling any uneven surfaces. All surfaces, including container floors, must be prepared so as to enable work to be carried out without any delay. If goods are to be packed in several layers, it may be necessary to line, flatten or pad out the floor of the area with boards, planks, squared lumber etc. It must be possible to handle the goods by lifting gear or ground conveyors without difficulty.

The **load-carrying capacity and the permissible loading capacity of the underlying surface** must be checked. Permissible and required stacking loads, axle loads and wheel loads must be compared. Exceeding the permissible loading capacity or loads can result in damage to the operating equipment or cargo transport units. For some storage areas and CTUs, the permissible load or load-bearing capacity is clearly visible. It can sometimes be determined simply by dividing the load-bearing capacity or load limit by the loading area. The "General guidelines" of the UVV (a national German regulation) stipulate that permissible values must not be exceeded.

Necessary **protective clothing and equipment** must be requested and provided in good time. Basic safety clothing includes: Safety helmets, steel-capped safety boots with impervious soles and gloves. Gloves are indispensable for protection against "frayed edges" in wire ropes, splinters on rough wood, etc. When dealing with dangerous cargoes or working materials, it can be mandatory to use special protective clothing and equipment. Dust masks, filter masks or gas masks, acid-resistant footwear, antistatic footwear, rubber aprons, rubber boots, rubber gloves etc. must then be worn. It must be noted that even very traces of alcohol in the breath of the user can render certain filters ineffective. When using chainsaws, "saw-proof" clothing, ear protectors and face protection must be worn. Employers must provide the relevant safety equipment, employees must use it.

All necessary resources must be kept ready for **planning and documenting packing operations**. Computer lists, forms, marking pens and pencils, placards, rules, measuring tapes, etc. must be immediately accessible or available at all times, to prevent delays during handling.



An advantage:
Electronic support for packing with a forklift

Electronic support facilitates documentation and accelerates the handling process.

Supervisory authorities and specialists must be requested and informed in good time. These may be radiation protection experts, persons with appropriate qualifications for handling explosives or similar experts, who must be present during handling. Frequently, fire services, veterinary or plant protection officers, customs or similar authorities must also be brought in. In some cases, firefighting equipment must be to hand and the appropriate staff must be readily accessible. Provisions may need to be made for monitoring the handling process or the containers.

In some cases, it is required that extensive **information is provided to the staff**. When handling dangerous goods, all staff and other persons involved must be instructed before work begins about the special properties and risks associated with the load, and what protective measures need to be taken.

The names of all **supervisors** must be known to all persons involved in the monitoring process. A written record must be kept of the names of the appointed supervisors.

According to the CTU guidelines:

> *"responsible person" means a person appointed by a shore-side employer who is empowered to take all decisions relating to his/her specific task, having the necessary current knowledge and experience for that purpose, and who, where required, is suitably certificated or otherwise recognized by the regulatory authority.*

Hopefully he has not overlooked the fact that on one of the cartons, a label is only printed in black, and not permanently attached as a "colored label".



Responsible person?



It is essential that all safety instructions on the containers are observed. These instructions, for instance, stipulate that the refrigeration unit must be switched off, the doors must be opened wide and five minutes must elapse before entering the container:

Warning notice on a refrigerated container

To make **provision for emergencies**, staff should be informed about the location of fire alarms, emergency exits, the nearest stretcher and all relevant emergency numbers. In addition, every employee must be acquainted with the reporting procedures and general procedures in the event of faults and accidents occurring.



Trade association demands for safe workplaces must be met. These include adequately lit **traffic routes** and freely accessible **escape routes**. In Germany, for instance, one of the requirements is that:

> *The employer must ensure that only ramps which cover the entire width of the container are used when driving onto containers with ground conveyors.*





Ramp



Inspection plate for the ramp

It is obvious that safety-relevant aids of this kind must be checked regularly.



Ramp

(2) *Drivers of ground conveyors must only drive onto containers and vehicles once all necessary ramps and bridging have been set up and secured against unintentional movement.*

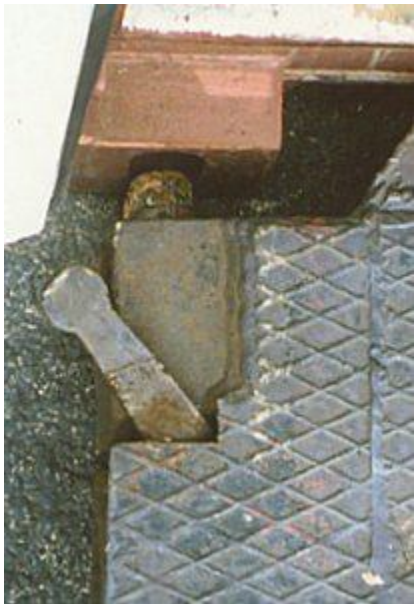


Ramp secured against unintentional movement

When driving onto containers, ramps are considered to be secured if they have been hooked into the containers or, for instance, lashed to the container with chains.



Not forbidden: Provisionally securing a ramp with chains



Even better:
Securing a ramp with bolts

Unsecured ramp





Accident hazard caused by unsecured ramp





Workers must use equipment to **protect against falling** when working more than 2 m above the ground or above the height of a single container.

Employee protected against falling

4.2.1.1 Selecting and checking CTUs

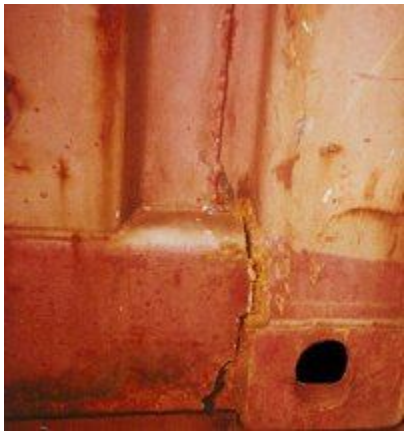
From an economic perspective, the most suitable type of cargo transport unit is the one which best harmonizes the volume-to-payload ratio of the container with the stowage factor of the cargo. This provides the best utilization of the space and weight constraints. Other aspects that must be considered when selecting a CTU include: Type of product, weight, center of gravity, substructure and load-bearing surfaces, type of packaging, permissible loading capacity and/or stackability, load securing options, and other similar aspects. The internal dimensions, door dimensions and other similar information can be obtained from the owners of the CTUs or the relevant leasing companies or can be taken from their prospectuses beforehand.

In all cases, the CTU should be inspected. Not only for reasons of cargo care, but also for reasons of liability and accident prevention. "EIR"s are usually used at the handover points. This abbreviation stands for **E**quipment **I**nterchange **R**eceipt. They are receipts for the handover of containers, trailers, chassis and similar cargo transport units and items of equipment. On the basis of a visual inspection, the EIR lists, or marks in the diagrams printed on the form, all defects found on a CTU, for instance. If an inspection reveals, for instance, that a container exhibits damage which has not previously been documented, the costs for restoring or repairing it must be borne by the person who was previously responsible for the container. Thorough inspection and true and accurate documentation must therefore be in the interests of all parties involved.

The CTU guidelines require a thorough inspection of the cargo transport units before they are packed. A number of issues are listed in the guidelines as a guide for visual inspection. For exterior inspection, the CTU guidelines prescribe the following:

> *2.1.1 The structural strength of a container depends to a great extent on the integrity of its main framework comprising the corner posts, corner fittings, main longitudinal and the top*

and bottom end transverse members which form the end frame. If there is evidence that the container is weakened, it should not be used.



Fractures on a container

2.1.2 The walls, the floor and roof of a CTU should be in good condition, and not significantly distorted.



These containers may not be packed.



Slightly deformed container side walls

This container can still be used. However, the distortion must be recorded in the EIR, the **E**quipment **I**nterchange **R**eceipt.





Doors in a technically sound state

2.1.3 The doors of a CTU should work properly and be capable of being securely locked and sealed in the closed position, and properly secured in the open position. Door gaskets and weather strips should be in good condition.

If containers are placed on an uneven surface, they become distorted. It is then only possible to open and close the doors with force. Fork-lift trucks are frequently misused in this way. "Dirty tricks" like this must be avoided. Unevenness of the ground or underlying surface must be leveled out before setting down the containers - possibly by using simple aids such as hardwood strips.





Top:
Plate as per UIC leaflet
on a swap-body

Left:
CSC plate

2.1.4 A container on international voyages should be affixed with a current International Convention for Safe Containers (CSC) Safety Approval Plate. A swap-body may be required to have a yellow code plate, fixed at its side wall (for details see UIC leaflet 596), which proves that it has been codified in conformity with the safety rules of European railways. Such swap-bodies need not be affixed with a CSC plate, but many of them will have one in addition to the yellow code plate.



Traces of removed placards

2.1.5 Irrelevant labels, placards, marks or signs should be removed or masked.



Placards which have not been completely removed can lead to mistakes! Are they still valid after all?



Lashing point on a semi-trailer

2.1.6 A vehicle should be provided with lashing points for securing it aboard ships (refer to ISO 9367-1: "Lashing and securing arrangements on road vehicles for sea transportation on Ro/Ro ships - General requirements - Part 1: Commercial vehicles and combinations of vehicles, semi-trailers excluded" and to ISO 9367-2: Lashing and securing arrangements on road vehicles for sea transportation on Ro/Ro ships - General requirements - Part 2: Semi-trailers".)



Canvas covers

2.1.7 When canvas covers are used, they should be checked as being in satisfactory condition and capable of being secured. Loops or eyes in such canvas which take the fastening ropes, as well as the ropes themselves, must be in good condition.



Loading a swap-body

2.1.8 When loading swap-bodies, it should be borne in mind that in most cases, the bottom and floor of swap-bodies are the main areas of their structural strength.

Checking vehicles includes checking the loading area, the side walls, the locking equipment, the support legs, the load securing devices, the supports used to guide the cover, the slats used to guide the cover, the canvas covers and the section where canvas cover is closed.

When performing an interior inspection, the CTU guidelines stipulate the following:





Scrape marks on the roof of an O.T. Has this already rusted through?

2.2.1 A CTU should be weatherproof unless it is so constructed that this is obviously not feasible. Previous patches or repairs should be carefully checked for possible leakage. Potential points of leakage may be detected by observing if any light enters a closed unit. In

carrying out this check, care should be taken to ensure that no person becomes locked inside a unit.

There was one case in which employees locked a colleague inside a container during a check before a work break as a practical joke. During the break, the container was then removed. The employee, who suffered from claustrophobia, then had a heart attack. Practical jokes of this kind must be severely sanctioned by the company.



Crack in a container



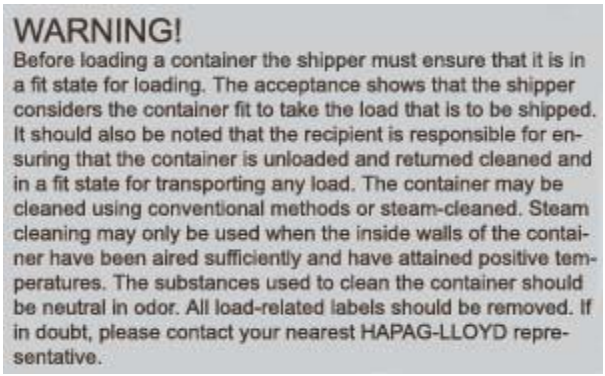
Hole in a plywood container

2.2.2 A CTU should be free from major damage, with no broken flooring or protrusions such as nails, bolts, special fittings, etc. which could cause injury to persons or damage to the cargo.



Lashing eye on a flatrack

2.2.3 Cargo tie-down cleats or rings, where provided, should be in good condition and well anchored. If heavy items of cargo are to be secured in a CTU, the forwarder or shipping agent should be contacted for information about the cleat strength and appropriate action taken.



Notice regarding the fitness for loading of a container

2.2.4 A CTU should be clean, dry and free of residue and persistent odors from previous cargo.

This point in the CTU guidelines relates to the fitness for loading of cargo transport units. For further information on this subject, see the section on "Preparatory work".

2.2.5 A folding CTU with movable or removable main components should be correctly assembled. Care should be taken to ensure that removable parts not in use are packed and secured inside the unit.

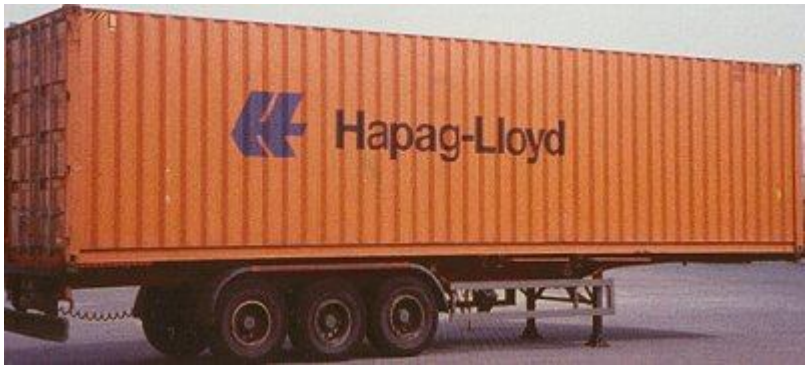
This is particularly important for flatracks. Notices describing how to set up and fold these CTUs safely are generally attached to these containers. For further information, see the section "Other markings".

4.2.1.2 Before packing

Section 3.1 of the CTU guidelines deals with actions required before packing. The following are some of the points defined in the guidelines:

> *3.1.1 Before packing a CTU, careful consideration should be given as to how the unit will be presented during the packing operation. The same applies for unpacking. The CTU may be presented for packing or unpacking as follows:*
>
> - *loaded on a semi-trailer chassis together with a truck;*
> - *loaded on a semi-trailer chassis, but without a truck;*
> - *loaded on a rigid truck or chassis;*
> - *standing on the ground;*
> - *standing on its supporting legs (in case of class C swap-bodies);*
> - *loaded on a rail-car;*
> - *loaded on an inland barge; or*
> - *loaded on a seagoing vessel.*
>
> *Any of these configurations is possible. The actual packing or unpacking situation often depends on site and facility considerations. However, whenever the CTU is presented on a chassis or on supporting legs, special care should be taken in planning the packing or unpacking operation.*
> *3.1.2 A CTU to be packed should rest on level and firm ground or on a trailer or a rail-car. If a CTU is on a trailer, care should be taken to ensure the trailer cannot tip while the container is being packed, especially if a lift truck is being used. If necessary, the trailer should be propped. Brakes should be securely applied and the wheels chocked.*

The CTU guidelines highlight particular hazards with illustrations and relevant comments.



40' high cube container loaded on a chassis

The support legs of the chassis are designed in such a way that they can carry the total permissible weight of the load or their own maximum payload. However, the support legs are unable to bear

additional forces which would arise e.g. by driving into a container of this kind with a fork-lift truck.



Risk of accident: Inadequate support

The CTU guidelines also provide a warning regarding inadequate support of semi-trailers.



Dangerously inadequate support of a chassis

There is a very great risk of the pallet collapsing at the slightest horizontal movement of the semi-trailer. During loading and unloading, the position of the loading area in relation to the horizontal plane changes, because the vehicle rides up and down on the suspension.



Correctly supported chassis



Correctly supported chassis - detail

Thanks to the wheels and the handles, the support can be moved without a vast amount of effort. The wheels are effectively deactivated when the support is loaded against the spring and reactivated when the load is relieved.



Adjustable-height support - detail view

Approved supports are inspected and bear an appropriate approval plate with the necessary data on their permissible loading capacity.



This is a genuine picture

For reasons already given, the height of the chassis changes with the container during handling. The supports must therefore be regularly checked and adjusted. Any continuation of work under these conditions would represent a breach of regulations.



A swap-body standing on its support legs

3.1.3 When a swap-body standing on its supporting legs is packed, particular care should be taken to ensure that the swap-body does not tip when a lift truck is used for packing. It should be checked that the supporting legs of the swap-body rest firmly on the ground and cannot shift, slump or move when forces are exerted on the swap-body during packing.

A swap-body can be shored provisionally by stacking hardwood pallets with a sufficient loading capacity horizontally on top of each other or by using cross-beams made of squared lumber of a sufficiently large cross-section. These aids would also have to be checked regularly and their height adjusted. As this is only possible in practice if work is interrupted, such provisional solutions are not recommended. As a precautionary measure, swap-bodies should be provided with additional support if fork-lift trucks are to be driven into them. The CTU guidelines only advise that fork-lift trucks do not drive onto the swap-bodies too quickly. The picture below illustrates the danger of the legs bending. It is better to never drive onto a swap-body with fork-lift trucks - or even to move loads horizontally in other ways with heavy equipment, if the containers are only standing on their legs - but unfortunately this is common practice.

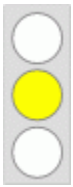
4.2.1.3 Stowage planning

Working and general stowage plans are prepared and used in normal maritime transport. The same practice should be adopted when packing other cargo transport units.

The CTU guidelines even make this an obligation: Section 3.1 of the CTU guidelines deals with actions required before packing. The following are some of the points defined in the guidelines:

3.1.4 Packing should be planned before it is started. This should make it possible to segregate incompatible cargoes and produce either a tight or secured stow, in which the compatibility of all items of cargo and the nature, i.e. type and strength, of any packages or packaging involved are taken into account. The possibility of cross-contamination by odor or dust, as well as physical or chemical compatibility, should be considered.

This point gives some fundamental guidelines as to basic stowage methods. Corresponding explanations and illustrations are provided in section 4.2.4 in this Container Handbook.





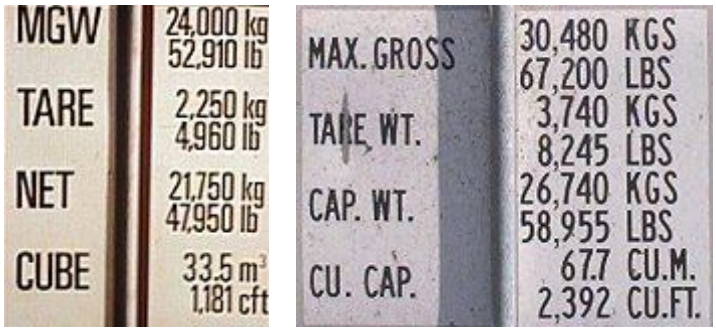
Not packed tightly and securely!





Packed tightly and securely

3.1.5 The planned cargo should not weigh more than the maximum payload of the CTU. In the case of containers, this ensures that the permitted maximum gross weight of the container (which includes the payload) marked on the CSC Safety Approval Plate will never be exceeded (see also Annex 3). For CTUs not marked with their maximum permissible gross weight, tare weight or any other features, any of these values should be known before packing starts. According to CEN standards, a swap-body of class C (7.15 m to 7.82 m) will have a maximum gross mass of 16,000 kg and a swap-body of class A (12.0 m to 13.6 m) will have a gross mass of up to 32,000 kg.



Information on a 20' and a 40' container

Annex 3, which is referred to under this point, deals with the consequences of overloading CTUs. Precise planning of packing is indispensable. Planning becomes even more important when the amount of the load to be packed is sufficiently large, in that it ensures that the containers are utilized to their maximum in terms of space and weight. This is the only way to minimize transport costs. A detailed packing plan is indispensable for this.

The volume-to-payload ratio of the containers can be determined from their volume and payload information, which can be obtained beforehand from prospectuses or documents provided by the container owners. The volume-to-payload ratios for the containers shown are calculated as follows:

20' container = 33.5 m^3 / 21.75 t = 1.54 m^3/t

40' container = 67.7 m^3 / 26.74 t = 2.53 m^3/t

This means that for every metric ton of payload on the 20' container, 1.54 m³ of packing space is available, and on the 40' container there is 2.53 m³ available per metric ton of cargo mass. The volume-to-payload ratio of a transport container therefore answers the question "How many cubic meters of stowage volume are available per metric ton of payload?"

The dimensions and masses of the items to be loaded can be used to determine the stowage factor of the load. Assuming that a consignment of 200 metric tons is to be loaded: The volume of the items is calculated to be 440 m³. The net stowage factor of the cargo is calculated by dividing the cargo volume by the cargo mass. Net stowage factor of the cargo = 440 m³ / 200 t = 2.2 m³/t. This means that, if the load is packed with no wasted space, a volume of 2.2 m³ would be required for every metric ton of cargo. Since most loads are not 100% suitable for modular packing, certain losses will result from stowage or packing. Experienced practitioners can estimate these losses well or know from their own records what values are to be taken for calculation purposes. This information can also be obtained from relevant specialist literature. For our example, let us assume stowage loss of 10 %. The gross stowage factor will then not be 2.2 m³/t but in fact 2.42 m³/t. Experts also say: "Cargo is stowed by a factor of 2.42". A comparison with the volume-to-payload ratios of the containers immediately reveals that economical transport can only be expected with the 40' containers.

If a consignment of 300 m³ volume and 230 t mass were waiting for loading and it were known that 15% stowage loss is to be expected, the net stowage factor of the cargo would be 300 m³/ 230 t = 1.30 m³/t and the gross stowage factor 1.5 m³/t. In this case, experts would say: "Cargo is stowed by one and a half times" or: "Cargo is stowed by a factor of 1.5". By comparing the numeric values, it can immediately be seen that only 20' containers can be considered for economical transportation.

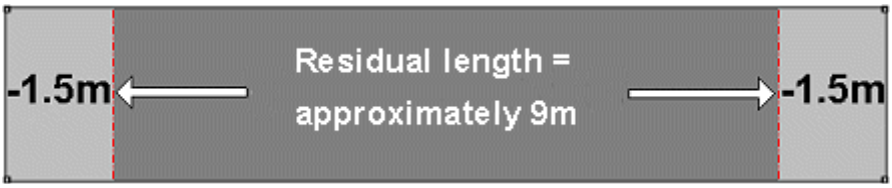
Other aspects must of course still be considered, such as factors relevant to a particular transport route or to the destination countries, etc. These points are dealt with in the following and other sections of this Handbook. Notes can also be found in the CTU guidelines:

> *3.1.6 Notwithstanding the foregoing, any height or weight limitation along the projected route that may be dictated by regulations or other circumstances (such as lifting gear, handling equipment, clearances and surface conditions) should be complied with. Such weight limits may be considerably less than the permitted gross weight already referred to.*
>
> *3.1.7 Stowage planning should take account of the fact that CTUs are generally designed and handled assuming the cargo to be evenly distributed over the entire floor area. Where substantial deviations from uniform packing occur, special advice for preferred packing should be sought.*

This applies indirectly to the line load of containers. This is determined by dividing the payload of the containers by a calculation length. For 20' containers, this calculation length is 2 m less than the container length, for 40' containers 3 m less. It can also be expressed as follows: In order to obtain the calculation length, 1 m is subtracted from each end for 20' containers and 1.5 m from each end for 40' containers.

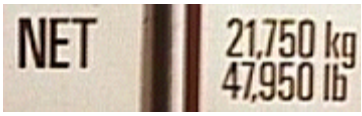


Determining the calculation length for the line load for 20' containers



Determining the calculation length for the line load for 40' containers

The payload, maximum gross weight (MGW), net, capacity weight (CAP WT) or whatever is specified on the container as the permissible payload, is divided by the relevant calculation length. The result is the permissible line load.





divided by

4 m **9 m**

equals

for the 20' container for the 40' container

a permissible line load of:

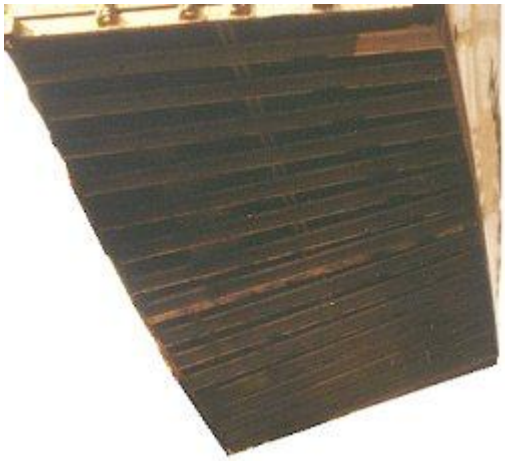
5,437.5 kg/m **2,971.1 kg/m**

It must be noted that the payload should actually be given in Newtons and the line load in Newtons per meter or daN/m or kN/m, if the line load is assumed to be a force. If the line load is regarded as a "line mass", the units kilogram per meter or metric tons per meter would be completely correct.

For older 20' containers with a payload of around 18,000 kg, the permissible line load is this around 4.5 t/m, while for older 40' containers with an average payload of 27,000 kg it is -3.0 t/m. On more modern containers, the values are considerably higher: On some 20’ containers, as much as 6.75 t/m. If necessary, the current values must be determined for every loading operation.

> *3.1.8 When a heavy, indivisible load is to be shipped in a CTU, due regard should be given to the localized weight-bearing capability of the unit. If necessary, the weight should be spread over a larger area than the actual bearing surface of the load, for example by use of properly secured baulks of timber. In such a case the method of securing the load should be planned before packing is started and any necessary preparations should be made.*

For instance, a machine part weighing 20 t and 3 m long could not simply be loaded into the 20' container described above without additional measures being taken. There would be a danger of it damaging the container floor.



Container floor seriously deformed due to overloading

The machine part used as an example (20 t weight, 3 m long), exerts a load of 6.666 metric tons per running meter. This is calculated by dividing 20 t by 3 m. Since forces are involved, a correct calculation would have meant dividing the normal force of 19,620 N by the length of 3 m. This would have produced the correct values of 65,400 N/running meter, 6,540 daN/running meter or 65.4 kN/running meter. Comparison with the permissible line load of the container of 5,437.5 kg/m (5,334.2 daN/m or 53.342 kN/m) immediately reveals that loading cannot be carried out unless additional measures are taken.



Bottom cross members of a container deformed due to overloading

In this example, this means that the weight of the case has to be distributed over a larger number of bottom cross members. This can be achieved by laying squared lumber longitudinally across them. The required length of the squared lumber is determined by dividing the weight of the case (or more correctly the "normal force") by the permissible line load of the container. In the example, this would be 20,000 kg divided by 5,437.5 kg/m = 3.68 m (19,620 daN / 5,334.1875 daN/m = 3.68 m).

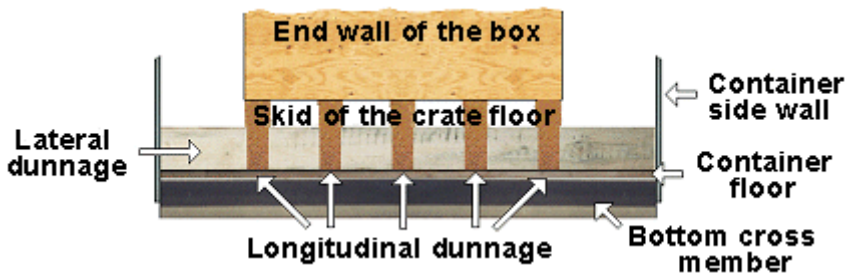


Non-permissible loading of 20 t machine box: Line load too great



Permissible loading with appropriate line load

An older model of container would not have been permitted to be used for transport, due to its low permissible payload of 18,000 kg. A more modern model of container with a payload of 24,000 kg has a line load of 6 t/m. The box could be loaded into a container of this kind without requiring any further measures. If the box is to be loaded with very very light but bulky items in the 40' container in the example, the following calculation would need to be made: 20,000 kg / 2,971.1 kg/m = 6.73 m. In the 40' container described, the box would have to be placed on squared lumber which was at least 6.73 m long. As far as practical considerations are concerned, it should be noted that where possible squared lumber with a large vertical edge length should be used, e.g. 8 cm x 16 cm or 10 cm x 20 cm etc. Half-sizes of this kind are generally less expensive. However, since there is a danger of them collapsing, they must be braced firmly laterally to prevent tilting. Preferably, this should result in a wooden lattice with a large height.



3.1.9 If the planned cargo of an "open topped" or "open sided" CTU will project beyond the overall dimensions of the unit, special arrangements should be made. It should be

borne in mind that road traffic regulations may not allow such overhangs. Furthermore, CTUs are often loaded door-to-door and side by side, thus not permitting any overhang.



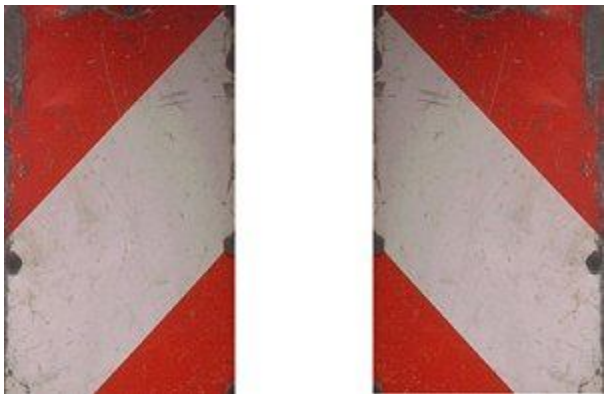
Photographic representation: Flatrack with overhang on both sides in the cellguides of a ship

It can clearly be seen from this photographic representation that three slot rates must be paid for transport, since the two adjacent slots on the ship must be kept free.



Photographic representation: Flatrack with overhang on one side in the cellguides of a ship

If the center of gravity of the flatrack makes it technically possible to load it with an overhang on one side and it is also possible to load it in this state on the ship - after agreeing this with the shipping company - , only two slot rates will have to be paid.



Marking for overwidth loads for road transport

Overwidth road vehicles must be marked with red and white, diagonally striped plates.

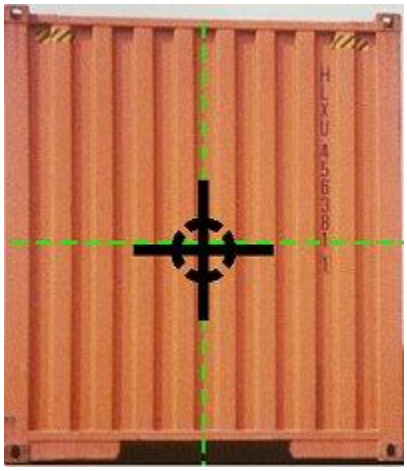
On board the ship, overheight flatracks can only be stowed as the uppermost container either in the hold or on deck. Ships with flaps can segregate individual stowage areas from others and could also store the flatrack in another position. As one



slot must be kept free above the flatrack, two slot rates must also always be paid.

Overheight flatrack

3.1.10 The center of gravity of the packed cargo should be at or near the longitudinal center-line of the CTU and below half the height of the cargo space of the unit. (see also 3.2.5 and other relevant sections.)

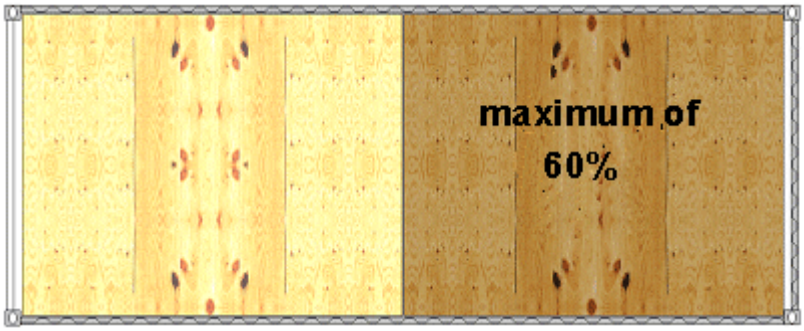


Prescribed center of gravity for loaded containers

3.2.5 The weight of the cargo should be evenly distributed over the floor of a container. Where cargo items of a varying weight are to be packed into a container or where a container will not be full (either because of insufficient cargo or because the maximum weight allowed will be reached before the container is full), the stow should be so arranged and secured that the approximate center of gravity of the cargo is close to the mid-length of the container. If it is not, then special handling of the container may be necessary. In no case should more than 60 % of the load be concentrated in less than half of the length of a container measured from one end. For vehicles, special attention should be paid to axle loads.



Ideal load distribution in a container with a payload of 18,000 kg



Maximum permissible weight shift for containers

If necessary, the real center of gravity of the container must be determined by calculating its moment.

3.1.11 When planning the packing of a CTU, consideration should be given to potential problems which may be created for those who unpack it, e.g. cargo falling when doors are opened.



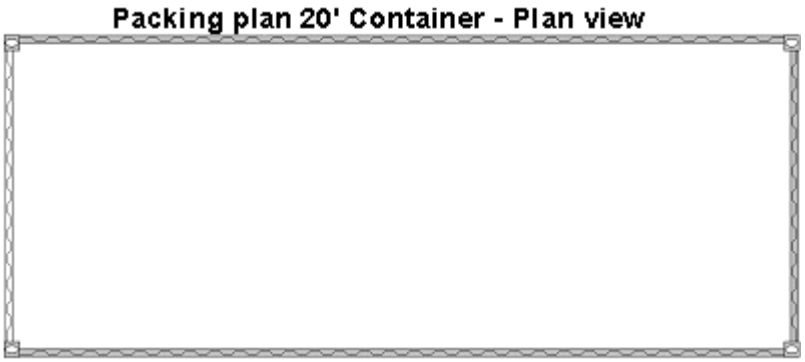
Danger to persons due to badly packed containers

This cartoon figure appear amusing, but in the real world, dreadful incidents have occurred. To cite only one accident here: Cotton bales weighing around 220 kg falling out onto a worker injured him so severely that he suffered serious fractures to his spine and hip in addition to internal injuries to vital organs. The young man only survived thanks to immediate medical attention and a number of operations. For the rest of his life, he is now confined to a wheelchair. And all this simply because the cotton bales in the container were badly packed and not secured.

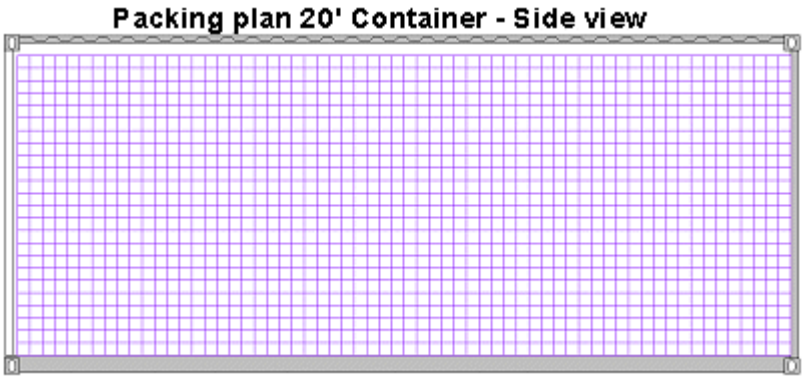
3.1.12 Before a CTU is packed, it should be ensured that the personnel responsible for the packing are fully informed about all the risks and dangers involved. As a minimum requirement some sketches showing the basic rules of CTU packing should be available. The present Guidelines should also be readily available. If necessary, the shipper and the packing personnel should consult each other regarding any special

feature of the cargo to be packed into the units. In particular, information on possible dangerous cargoes should be considered very carefully. Consideration should also be given to the provision of appropriate training for personnel involved in packing CTUs.

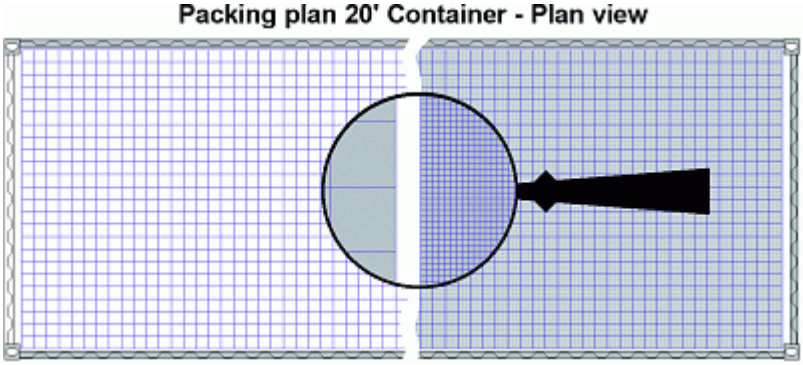
Data sheets with a plan view and/or side view of different containers, in which the items to be packed are drawn in to scale, should be provided for planning packing.



Blank form for a packing plan



Blank form for a packing plan with dm² grid



Blank form for a packing plan with dm² or cm² grid

The actual design of the packing plans is of little significance. What is crucial is that they contain all the most important information, e.g. the interior dimensions of the container, and that the

stowage plan can also provide important evidence in the event of any subsequent (legal) disputes.

When planning packing and illustrating it in the forms, the following points must be considered: How are an even load along the floor and an acceptable center of gravity to be achieved? What goods will have to be brought in using a fork-lift truck? Will any other ground conveyors need to be used? Is manual handling necessary - or even desired? Do all items have a sufficient loading capacity? Can they be stacked? Will items have to be packed on top? Can the necessary basic stowage rules be met for all items? Are dangerous cargoes also to be loaded? Has unloading also been considered? And so on.

It should be checked whether the stowage factor of the cargo has previously been determined using the weights and dimensions of the cargo and compared with the volume-to-payload ratio of the container. This is always good practice; moreover, this procedure gives all less experienced staff an insight into what is feasible. It goes without saying that the maximum payload of the container must not be exceeded.

3.1.13 When packing a CTU, the shipper and persons responsible for packing should bear in mind that any failure to pack and secure the cargo correctly may result in additional costs that they will have to bear. If, for example in railway transport, a unit is found not to be properly packed and secured, the rail-car may be marshalled out of the train into a siding and the transport can only be continued once the cargo has been properly secured. The shipper may have to pay for this work, especially for the repacking and resecuring operation, as well as for the additional time during which the rail-car has been used. In addition, he may be held responsible for any delay of the transport operation.

3.1.14 Not all handling equipment is suitable for container packing. Lift trucks used for container packing and unpacking should have a short lifting mast and a low driver's overhead guard. If the lift truck operates inside the container, equipment with electric power supply should be used. Container floors are built to withstand a maximum wheel pressure corresponding to an axle load of a lift truck of 5,480 kg or 2,730 kg per wheel. Such an axle load is usually found on lift trucks with a lifting capacity of 2.5 t.

The short lifting mast and low driver's overhead guard alone do not say anything about the usefulness of the fork-lift truck. If these values are less than the height of the door, the fork-lift truck container can de driven into the container, but it is not automatically clear whether load can be stacked. This is where free lift is crucial. The higher the forks can be lifted without changing the total height, the more suited the fork-lift truck is for stacking and working in the container.

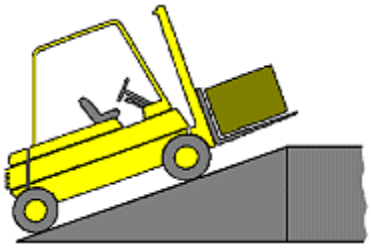
More information is provided on axle loads and working with fork-lift trucks in other sections of this Handbook.

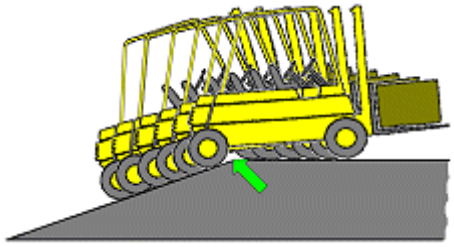




Fork-lift truck with a large free lift for loading box containers

3.1.15 If the CTU floor is at a different height level than the loading ramp, a bridging unit may need to be used. This may result in sharp bends between the loading ramp and the bridging unit as well as between the bridging unit and the CTU floor. In such cases the lift truck used should have sufficient ground clearance to ensure that the chassis does not touch the ramp when passing these bends.





Sufficient ground clearance for a fork-lift truck

4.2.2 Using segregating materials

The term "segregation" is used to describe the visible segregation of packages or batches of cargo.

It can be useful to segregate loads in a transport container which are of the same type type but destined for different recipients if the goods could otherwise be confused or subsequent sorting work might be required. Sorting involves considerable time outlay which can lead to additional costs. Segregating goods in good time is therefore critical for cost-effective delivery of goods to their final destination or to interim destinations.

It is thus of great economic significance for conventional maritime transport and for storage. Segregation plays a less important role in the transport of cargo with containers and other cargo transport units.

Segregation is unnecessary if there is no danger of goods being confused because they have different package dimensions, a different shape or color or other different characteristics.

Transport law stipulations require that the consignor, carrier or shipper of a cargo provide the goods for delivery in a suitable condition, meaning that the goods must be both complete and in an

undamaged condition. Such legislation may lead to an obligation to segregate the goods.

In principle, two different methods are used for segregation:

- spatial segregation and
- optical segregation using appropriate materials.

Spatial segregation of batches of cargo or individual packages is relatively easy to carry out on shore. On open spaces, and in sheds or warehouses, the storage spaces are indicated by appropriate location specifications, chalk marking or similar markings. For domestic transport, spatial segregation is achieved by delivering the different batches in separate vehicles or freight cars or by packing them separately in such vehicles or cars. Virtually the same principle applies for container cargoes.

The following requirements must be met when segregating cargo batches of the same kind or with the same appearance using segregation materials:

- The materials used must not cause any damage to the goods or their packaging, either by depreciation of their sales value or as a result of loss or shrinkage;
- Marking of the goods must not be rendered illegible by segregation;
- Segregation must be clearly recognizable.

With the exception of talcum, all materials described in the section "Dunnage" (see section 4.2.3) are used as segregation materials, e.g. wooden boards, wooden panels and walking boards, squared lumber, planks, boards and wooden dunnage, sailcloth, canvas and tarpaulins, reed, rattan or bamboo mats, films, cardboard and paper etc. The properties of these materials and their benefits and disadvantages are also described in the section "Dunnage" and will therefore not be discussed further here.

Materials which are only used for segregation are:

- Thin synthetic plastic nets or cargo nets
- Ropes, cloth strips or jute fabric strips
- Paints, marking pens, etc.

Thin synthetic plastic nets are relatively inexpensive. Segregation with these nets is easily recognized and does not cause any loss of stowage space. In addition, they are easy to transport and store, clean and reuse. Another benefit is that they do not hinder any necessary ventilation measures. A disadvantage is that they pose a hazard if anyone becomes entangled in them. To a certain extent, they are a trip hazard. They cannot be used to segregate bulk cargo.

Much the same applies to **cargo nets** as to thin nets. They are also expensive, more bulky and very difficult to free from odor infection. Under certain circumstances, they can cause pressure marks on the cargo.

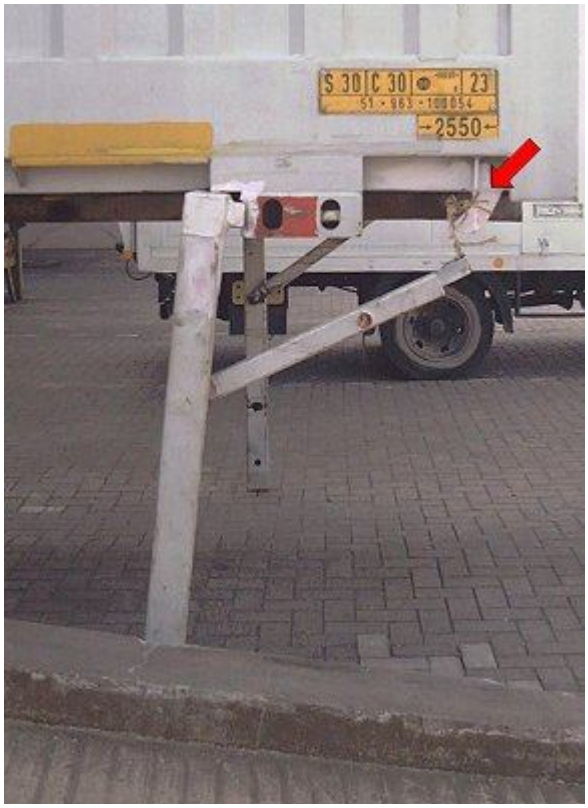
Ropes are suitable for segregating long cargo items, such as structural welded steel mesh, roundwood and cut lumber, TOR steel etc., provided there is no risk of pressure marks. Fiber ropes are preferable to wire ropes, since the latter can cause rust damage. Impregnated ropes could cause a

cargo to be infected by odors.

Strips made of various materials or **adhesive strips** are preferable to ropes, as they do not cause pressure marks and lead to smaller cavities and spaces. They are also generally cheaper. Cloth strips or jute fabric strips should never be used for fatty organic cargoes, as they could encourage or cause the cargo to ignite spontaneously.

Marking pens and paints can be used to indicate packages which belong together or the same batches, by means of clear signatures, color codes or stripes. They are only suitable for segregating goods if they do not restrict the further processing and actual marking of these, and if value of the goods does not depreciate as a result of any segregation indications. For instance, descaled metal sheets must not be marked with wax crayon, as otherwise it will subsequently be impossible to coat them without additional work. In the case of soft or absorbent woods, partial or total damage could be caused by using e.g. water-based paints.

Sufficiently heavy-duty and dense materials should be used to segregate bulk goods. Otherwise, parts of the various batches could become mixed if the segregation materials were to tear or develop leaks. Covers made of sailcloth, tarpaulin, canvas or strong plastic sheeting are suitable. The materials used to segregate grains and foodstuffs must be non-toxic and neutral in odor.



Potentially lethal negligence

Before driving onto a swap-body, it should always be checked that the supports are sound and are securely fastened. Here, not only is one "leg" deformed, but the diagonal support is even fastened with "ropes"!

The relevant German trade association also demands:

The employer may only use ground conveyors for driving onto containers and vehicles if no dangerous concentrations of health-threatening exhaust gas substances can be produced in the inhaled air.

Devices for reducing the quantity of dangerous substances in exhaust gas include, for instance, exhaust purification systems with catalytic converters. For guidelines on the use of vehicles driven by Diesel engines, see the German Technische Regeln für Gefahrstoffe TRGS 554 "Dieselmotoremissionen" (Technical Regulations for Hazardous Substances "Diesel engine emissions").

For information on securing the vehicle to be loaded or unloaded against unintentional movement, see Section 37 Para 2 of the German Accident Prevention Guidelines (UVV) for vehicles.

4.2.3 Dunnage

Dunnage materials or, more simply, dunnage, is the name used for all materials which are not firmly attached to the cargo transport unit, the cargo or its packaging, and are used to protect the load. This includes: Wooden dunnage, beams, planks, boards, wedges, plywood and hardboards, walking boards, mats, paper, sailcloth, canvas and tarpaulins; plastic and metal sheets, spray covers; cardboard and paperboard, packing paper, oiled paper and fabric paper, talcum powder etc.

Whether a material is to be classed as dunnage, segregation or load securing material does not depend on the material itself but on its application.

The main functions of dunnage are:

- Protection against sweat and condensation water
- Protection against moisture and liquids
- Protection against soiling and contamination
- Protection against mechanical damage

Sweat water can occur as container sweat or cargo sweat. It is primarily the roof surfaces that are susceptible to container sweat with the sides and the floor of the container only being a secondary source of problems. Top dunnage and side dunnage can absorb sweat dripping from the container roof until they reach saturation point. This can sometimes significantly delay, or even completely prevent, moisture damage. Dunnage cannot protect against cargo sweat, although this is rarer when goods are transported in containers.

To ensure **protection against moisture and liquids**, cargoes which are at risk and sensitive parts of the means of transport must be shielded. A check must be made for any possible leakage in the means of transport or other cargo items. Potential causes of this could be leaky walls, doors and roofs on the cargo transport units, or damaged drums, cans and other similar packaging receptacles for "wet cargoes". The effects of wet or very moist load securing materials must also be taken into account.

Protection against soiling and contamination must be ensured. This can be caused by the presence of contaminating goods or contaminated components on the cargo transport units. Contaminating goods must also be enclosed by dunnage to prevent them from damaging other goods or parts of the means of transport.

Preventive measures are always needed to **protect against mechanical damage**, if contact with components on the cargo transport unit itself or other loads or load items could cause mechanical damage. For instance, it can be necessary to adequately protect the load against contact with corrugations, corner posts, doors, lashing points, stanchions, edges and corners of other cargo items, load securing materials, protruding nails, screws etc. Appropriate dunnage must also be used to reduce the effects of harmful pressure forces.

The **nature of the materials used** must ensure that the packages or the cargo transport unit are adequately protected. The materials themselves must not be wet, moist, odor-tainted or contaminated. The quality of the material must determined for each individual case by assessing the value and susceptibility to damage of the load, the means of transport, the intended protection and other similar factors. The special properties of the particular type of dunnage used must be taken into account.

Wooden dunnage made of squared lumber, planks, boards, slats and battens, are very suitable for distributing pressure, bridging or lining cavities and gaps, creating air channels and enhancing friction. If wooden dunnage is laid too tightly, it impedes air circulation (this is a particular consideration for ventilated containers), causes a significant loss of stowage space and thus increases costs. Large spaces promote air circulation but can cause mechanical damage to the packages if the load-bearing area is too small. Wood easily absorbs moisture and releases it into the environment at a low vapor pressure. If it has a strong intrinsic odor or has taken up a foreign odor, it must not be used with odor-sensitive loads. Since wood can be infested by pests, only wood which has been impregnated against insects or fumigated may be used on certain trade routes. To distinguish such treated wood from normal wood, it must be appropriately stained or marked in some other way.

Wooden boards, wooden panels, walking boards, chipboard and hardboards are very suitable for distributing pressure and have a high loading capacity provided they are sufficiently thick. Since water-repellent, pest-proof or fire-retarding wood is odor-tainted as a result of such treatment or could have other harmful effects, it must virtually never be used with foodstuffs or similar items.

Mats made of rattan, bamboo, reed etc. only protect against surface dirt, not against dust. They absorb moisture and under certain circumstances release it back into the atmosphere. This can protect adjacent loads. Mats are easy to put in place and roll back up again, and do not cause any significant loss of stowage space. Provided a container is actively ventilated, mats can release back into the atmosphere any sweat or drops of water they have absorbed.

Canvas has a water-repellent impregnation and therefore not suitable for odor-sensitive goods. They are dust-tight. They impede air circulation.

Tarpaulins are watertight, dust-tight and airtight and very expensive. They must be handled with care if a long life is to be expected. It is very rare that tarpaulins will not be needed as a cover to protect against moisture and similar influences.

Jute coverings protect against surface dirt but not dust. They are breathable and allow a minimal amount of ventilation. They pass on absorbed moisture to the wrapped or surrounding cargo items. When used with fatty organic goods, jute coverings can spontaneously ignite or promote the spontaneous combustion of other goods.

Sailcloth has similar properties to canvas.

Plastic sheeting is available in a number of different thicknesses. It is neutral in odor, inexpensive and generally acid-proof and alkali-proof. It is watertight, dust-tight and airtight but only impervious to water vapor to a limited degree. It has a low loading capacity if it is not sufficiently thick. Composite sheeting is often very heavy-duty but comparatively expensive.

Paper, e.g. normal kraft paper, is inexpensive and dust-tight, but very sensitive to moisture. Fabric paper has a higher strength. Oiled paper is watertight. Tissue paper is acid-free.

Dispersible material such as talcum powder and similar materials can be used to prevent cargoes from caking together.

Depending on their **use and application**, a distinction is made between:

- Floor dunnage
- Interlayer dunnage
- Top dunnage
- Side dunnage

Floor dunnage is used for the following tasks:

- Dissipating and localizing sweat and moisture
- Protecting the load from moisture and dampness on moist or wet stowage surfaces or stowage spaces
- Dissipating or restraining moisture leaking out of the load, to protect other packages or the cargo transport unit
- Protecting the load from soiling, contamination or mechanical damage from the stowage surface or stowage spaces
- Protecting the cargo transport unit against negative influences from the goods

There are no generally binding regulations for laying dunnage. The condition, properties and intended protective action of the available materials and similar considerations must be taken into account. In many cases, only compromises can be considered, since some fundamental requirements can contradict each other; especially if materials are to assume a number of protective functions simultaneously.

The following guidelines are intended to help make practical decisions. Since not all variants can be shown, the action and decisions taken will need to reflect the given circumstances. How to lay dunnage most appropriately and what materials are to be used depends on the stowage space, the structural design of the cargo transport unit and the restrictions anticipated during transport. These include the climatic zones through which the cargo will travel, changes in weather, storage duration and voyage duration, anticipated mechanical, climatic and biotic shipping stresses etc.

Wooden dunnage is differentiated according to the quantity and thickness of the wood used and the method used to lay it:

- Simple wooden dunnage comprises boards laid out side by side.

- Double dunnage or criss-cross dunnage comprises boards laid at right angles to or obliquely over each other.
- Raised dunnage can comprise planks or squared lumber laid in single layers or a combination of boards, planks or beams laid at right angles to or obliquely over each other. Another good option is to use pallets as stowage surfaces.

The orientation of and space between the wood used depend on the intended protective effect and the nature of the means of transport or the stowage space:

If the main aim is to dissipate moisture or damp, the wood at the bottom must be laid in such a way that water and other fluids are conducted along the quickest route outside or to any available discharge outlets and do not produce any accumulation of damp. It is not practicable to dissipate liquid to the outside in standard containers which have not been structurally modified, since these containers are spray-tight and thus generally prevent water from flowing out freely. If actively or passively ventilated containers can be used, criss-cross dunnage can enhance the ventilation effect. When laying out dunnage, it should be remembered that ships are not constantly on an even keel. They can be trimmed by the stern or trimmed by the bow. Rolling and pitching cause the deck to slope. These slopes, as well as any special factors in the ship's construction, must be taken into consideration when laying out wooden dunnage. With open containers, dunnage can be laid out transversely. Liquids can immediately flow out when the ship rolls. If the ends of the wooden boards are taken right up to the side rails, load forces are distributed appropriately at the same time. It should be remembered that closed containers are spray-tight and that dissipation of moisture to the outside only happens to a limited degree and then only slowly.

If a good distribution of load forces is the primary consideration, the wood at the bottom must be laid out in such a way that as many load-bearing components of the cargo transport unit are covered as possible.

If good moisture dissipation is as important a consideration as a good distribution of load forces, the best possible compromise must be reached, for instance by laying out the base wood diagonally.

If the most important consideration is to protect against mechanical damage, it is essential that potential shifting or movement resulting from shipping stresses and typical for the particular means of transport are taken into account.

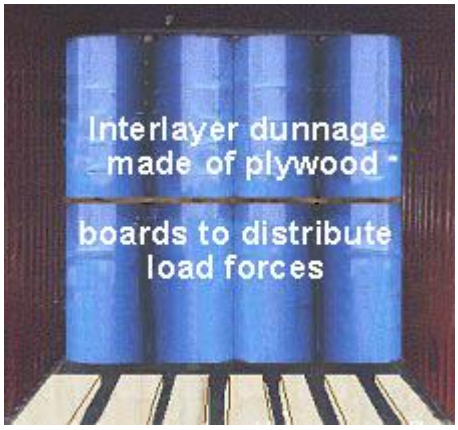
If goods which are sensitive to dirt, moisture or mechanical damage are loaded, additional materials such as mats, jute cloth, paper, sheeting etc. are to be used as required.

If there is a danger of dampness or contamination of the packaging spreading to the contents, dunnage must be laid with special care.

If plastic sheeting and similar materials are used to prevent dampness from penetrating the cargo, their orientation the way they are arranged play an important role. In these cases, consideration must be given to where damp could enter and where it can be dissipated. Under no circumstances must "water pockets" be allowed to form, which would enable collected damp to enter the cargo. Dunnage must first be laid out at the point where most water is able to penetrate.



Interlayer dunnage



Floor dunnage

Laying out floor dunnage to protect from damp in containers will always be necessary when "wet goods" are stowed together with moisture-sensitive goods. Occasionally, criss-cross dunnage and double dunnage will be necessary. Damp must be prevented from infiltrating sensitive cargoes by laying dunnage at appropriate heights and using additional material, e.g. plastic sheeting. In box containers, it is generally more appropriate to lay out wooden dunnage in a longitudinal direction, because of the distribution of load forces and the use of ground conveyors. On open containers, it should be laid out transversely. In both cases, the load-bearing components must be bridged for heavy packages so that the permissible line load is not exceeded.

On open chassis and trailers, wood must be laid out to distribute load forces in such a way that the load is taken by the vehicle's chassis. Walking boards made of glued-laminated plywood at a size of 1 m x 2.5 m, for instance, or wooden boards of a suitable length and adequate dimensions are very suitable for this. Floor dunnage made of wood or plastic sheeting is used to prevent contamination. Since it is possible that cargo transport units can be transported on deck, sufficient protection against damp must be ensured. When distributing load forces, the vehicle chassis and cross members must be covered.

Floor dunnage is very often not needed for freight cars with a wooden floor. If there is a risk of damp infiltration with moisture-sensitive cargoes, appropriate measures must be taken. On covered freight cars, the preferred orientation of the wood is longitudinal, in the door area it is transverse. On open freight cars and freight cars with sliding walls, wood is preferably to be laid out transversely for loading and unloading with ground conveyors. Exceptions to this must be made when end-loading platforms are used. The design of the chassis and of the side rails and cross members must be taken into account with regard to the distribution of load forces. Here, inexpensive materials such as paper, plastic sheeting etc. are sufficient for protection against contamination.

What has been said about freight cars applies in principle to cargo transport units for road transport. On box bodies, however, wood should always be laid longitudinally where possible, for handling reasons.

To be able to effectively protect cargo before packing and after unpacking cargo transport units, dunnage can also be required in stores, sheds, warehouses, hangars and open areas. This can be for leveling out storage areas, protecting against damp and dirt or for distributing load forces. The orientation should be suited to the transport paths and the equipment used. The materials used must

be able to provide the necessary protection. Especially on open areas, weather changes such as rain, snow, ice etc. must be taken into full account. Other factors to consider are bacteria on the ground and rot pathogens which could damage the cargo.

Side dunnage has similar functions to floor dunnage:

- Protection against damp or moisture penetrating from the side as a result of sweat or leakage from other cargo, but also protection of other cargo or of the means of transport against liquids escaping from the side of a load.
- Protection against soiling and contamination on the sides, both of a single load against other loads or from parts of the means of transport, or protecting the latter against a specific load.
- Protection against mechanical damage or other damage, such as chafing, tearing, chemical reactions etc. both with regard to a specific cargo and to other cargoes or parts of the means of transport.

The same materials are used for lateral dunnage as for floor dunnage. The use of wooden dunnage, however, is less significant.

To protect against damp or moisture or harmful dust penetrating from the sides, watertight and dust-tight materials such as plastic sheeting, oiled paper and tarpaulins are to be used. Under certain conditions, canvas and mats should also be used, but never wrappers or paper.

Sweat formation always occurs when temperature differences are too high, either with a positive temperature difference against the load or a negative temperature difference against components of the means of transport. For further information on this, see section 10.3.4 "Sources of sweat". The risk of sweat is higher on cargoes with a high water content. If there is a risk of cargo sweat (section 10.3.6.4) and the cargo is sensitive to moisture, it is urgent that a corrosion protection method is used (see http://www.tis-gdv.de/tis_e/verpack/inhalt1.htm). Wrapping cargo in plastic sheeting can have the opposite effect to that which is desired. Since hot air rises, water vapor can condense under the sheeting.

Practical experience shows that wooden dunnage boards, wooden boards, mats etc. provide good protection against mechanical damage. Whether or not it is necessary to use additional materials depends on the particular circumstances.

Top dunnage is laid to prevent the consequences of leakage, sweat formation, bad weather, vertical shipping loads etc., which could damage a particular cargo or the cargo transport unit and its components.

The main functions of top dunnage are:

- Protection against damp or moisture penetrating from the top or escaping upward
- Protection against dust or substances which threaten contamination or chemical reactions, either penetrating from the top or escaping upward
- Protection against mechanical damage anticipated to arise from above or acting in an upward direction

All previously described materials can be used as top dunnage materials.

To protect against damp or moisture penetrating from the top, or to prevent moisture from being allowed to permeate upward, plastic sheeting, oiled paper, tarpaulins and other watertight materials have proved themselves in practice.

If only small quantities of moisture are anticipated, the best materials to use are ones which can absorb small quantities of water.

The type of nonwoven fabric shown can absorb relatively large quantities of dripping water. Since the weight increases when these properties are used, it must be attached carefully.



Special absorbent, nonwoven fabric cover as top dunnage

When using watertight materials, it is essential that liquid which has collected in depressions (water pockets) is prevented from flowing into the cargo when the vehicle moves. For this reason, plastic sheets etc. must overlap each other properly or wood, cargo items or the stowage method must be used to create an appropriate slope. Respiring organic goods, such as tobacco, coffee, cocoa, fish meal etc., which are transported in passively ventilated containers, must not be covered with airtight materials or materials impervious to water vapor.

If top dunnage is used to protect against contamination or to prevent harmful chemical reactions, the same principles apply as for protecting against damp, but the materials must be dust-tight and chemically compatible. A certain degree of air circulation must also be ensured here occasionally.

Interlayer dunnage variously has the functions of floor dunnage, side dunnage or top dunnage, depending on how it is arranged. It is laid between two different batches or individual goods in a batch or load type.



Interlayer dunnage on a load of pails

In some cases, it simultaneously helps secure the load by increasing friction, improving the

distribution of load forces or improving the stability of the load.

All materials which have been described can be used. In addition, powdery substances such as talcum powder. They are introduced in the form of an intermediate layer or are sprinkled between layers, to prevent loads from sticking together, e.g. with bales of raw rubber.

Interlayer dunnage comprised of mats provides adequate firmness and protects against mechanical damage.

Here, wooden dunnage boards were used to create a level packing surface. But will the bottom left carton of the load be able to bear the load packed on top of it? This ought to be supported from beneath using vertical squared lumber.



Interlayer dunnage made of wooden dunnage used as a leveling aid



**Inadequate interlayer dunnage of wooden
dunnage boards**

Further measures should to be taken here as well. As in so many cases, inadequate unitization is responsible for additional work - which sadly is not very productive in this case.



Left and bottom:
Missing interlayer dunnage



In both examples, the use of interlayer dunnage is urgently recommended.

4.2.4 Basic stowage methods

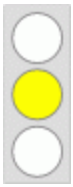
Stowage instructions and basic stowage methods

To be able to provide and follow appropriate instructions, it is necessary to be familiar with some of the fundamental concepts and principles which apply in this field. To ensure that they are well understood, some of them will be explained here.

"***Stowage for ready access***" or "**Packing for ready access**" means that a load must be immediately accessible. Ease of access may apply to a specific (intermediate) destination, i.e. that a given load must be readily accessible in for instance Bremen and can be unloaded without the need to move other loads.

Section 4.3.7 of the CTU guidelines state:

> *Dangerous cargoes consignments which form only part of the load of a CTU should, whenever possible, be packed adjacent to the doors with markings and labels visible. Particular attention is drawn to 3.3.1 concerning the securing of cargo by the doors of a unit.*





Cases with class 1.4G [airbags](): stowed for ready access

The amber light has been selected because the load has not yet been adequately secured.

CAP products in the European Community which are subject to customs checks should also be stowed for ready access, so that customs staff have immediate access to the goods. This avoids the need to restow:

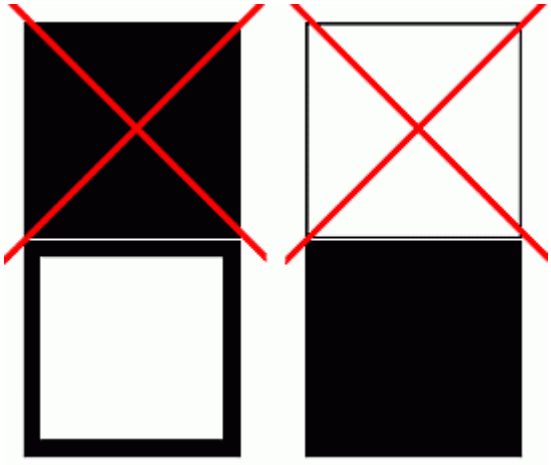




The container had to be restowed to make the container door accessible and the cargo had to be partially unloaded to allow access to the CAP products for a customs inspection.

"***Top stowage***" (occasionally "***on-top-stowage***") means no further items are stowed on top of the load. This instruction is not to ensure that a batch should be readily accessible, but is issued because packages are particularly sensitive or fragile. If stowage of this type is required, appropriate indications must be attached to the packages. Written instructions such as "Do not overstow", "Please load on top" etc. are not necessarily universally understood. Sensible, comprehensible markings can be more effective.





Symbol based on ISO **Alternative marking suggestions**

The original ISO symbol should be known universally. It must therefore be assumed that this symbol is the most likely to be understood.

"***Stowing or packing correctly for a fork-lift truck or a crane***" means that appropriate arrangements must be made to ensure that the goods can be lifted by a ground conveyor or lifting gear without requiring special preparation and without any time delay. The dimensions, strength and loading capacity of the aids used, such as squared lumber, wooden dunnage boards etc. must ensure that the goods do not suffer any damage during shipping. If necessary, stowage surfaces must be prepared with walking boards, boards, cargo items with a high loading capacity or other usable aids, so that work can be carried out safely and the batches that have already been loaded can be overstowed with other loads.



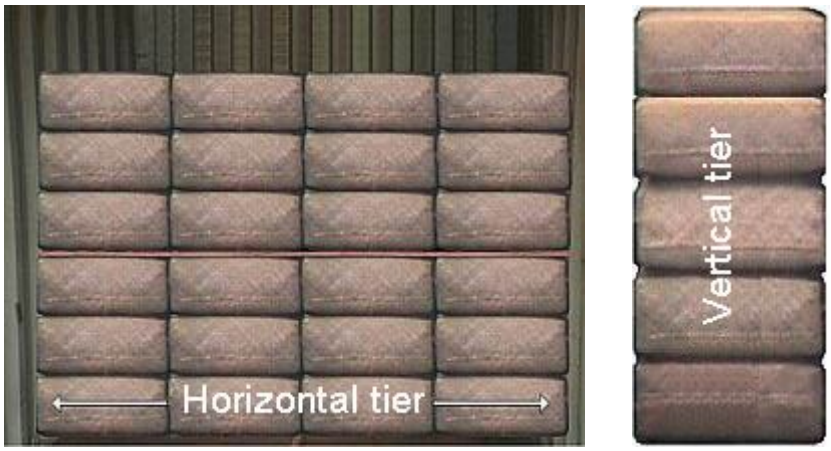
Correct stowage suitable for handling with fork lift trucks in a box container



Cargo stack suitable for handling with fork-lift trucks and cranes

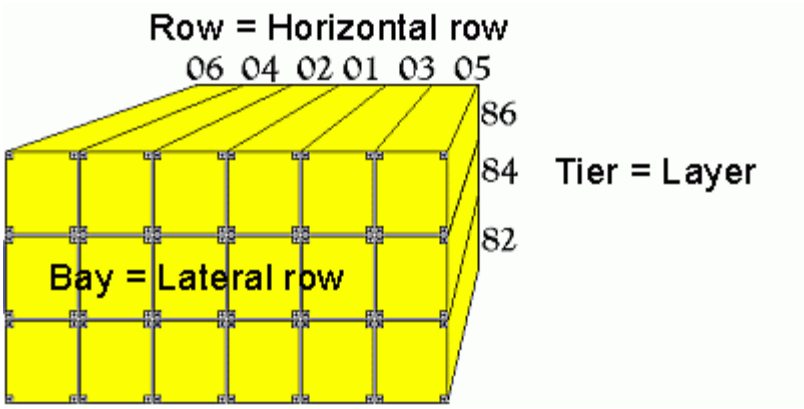
Bottom and intermediate dunnage must be arranged so that forks, strops, chains, claws and similar cargo handling equipment and slinging equipment can be used without any problems.

Tier means a layer or stack. It can mean either horizontal layers of cargo or cargo items stowed vertically one above the other. If circumstances do not make it clear from the outset what type of layer is meant, it makes sense to distinguish between a ***vertical tier*** and a ***horizontal tier***.



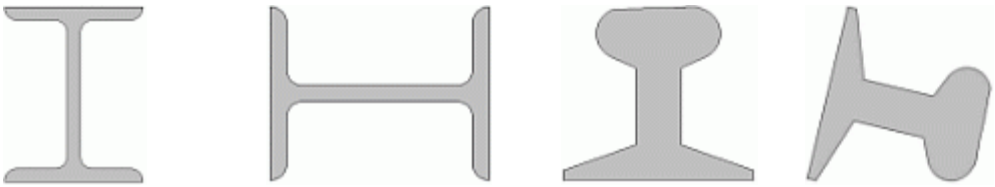
Horizontal and vertical tiers

The stowage position on board container ships is generally documented according to the bay-row-tier system or the bay-tier-row system. In this specific case, "tier" designates the horizontal layers of containers. Layers are counted from the bottom to the top.

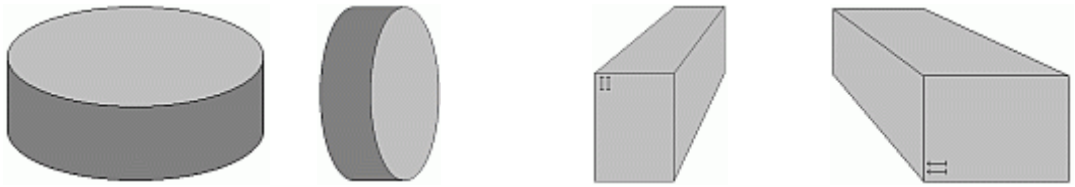


Extract from a [bay plan] showing the containers loaded on deck

Loaded upright or ***loaded on its side*** relates to the shape of the consignment items. In most cases, the meaning is clear.

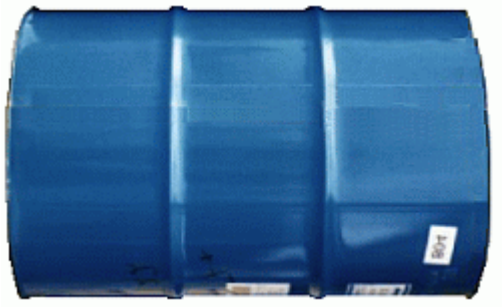


Beam is upright **Beam is on its side** **Rail is upright** **Rail is on its side**



Disk is upright **Disc is on its side** **Box is upright** **Box is on its side**





Drum is upright **Drum is on its side**

The same applies for wheel rims, pipes, steel bars, narrow wire rod coils and other loads. It is also rare for these to be confused.

With cylindrical, or roller-shaped goods, the expression "upright" should really be used uniformly. Such cargo items are generally understood to be "upright" if

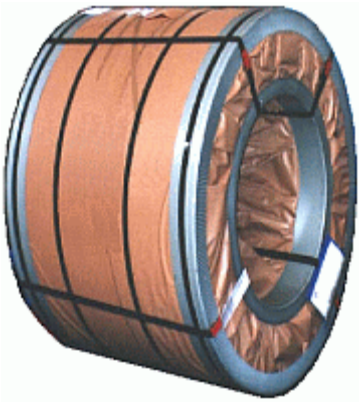
- the axis is vertical and the length of the axis is greater than the diameter or
- the axis is horizontal and the length of the axis is less than the diameter.







Paper roll is upright **Gas cylinder is upright** **Coil is upright**



Coil is upright



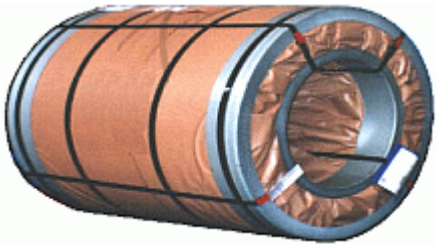
Tire is upright

The expression "on its side" also has a standard meaning for the same goods. By definition, cargo is "on its side" if

- the axis is horizontal and the length of the axis is greater than the diameter or
- the axis is vertical and the length of the axis is less than the diameter.



Paper roll is on its side



Coil is on its side



Gas cylinder is on its side





Coil is on its side **Tire is on its side**

Differences in understanding of these terms, sometimes regional, however, can lead to errors and misinterpretations and thus incorrect stowage.

Another problem arises if the length of the axis and the diameter are almost the same size. This can easily lead to misinterpretations of the terms in practice:



Is the coil upright or on its side?





Is the roll upright or on its side?



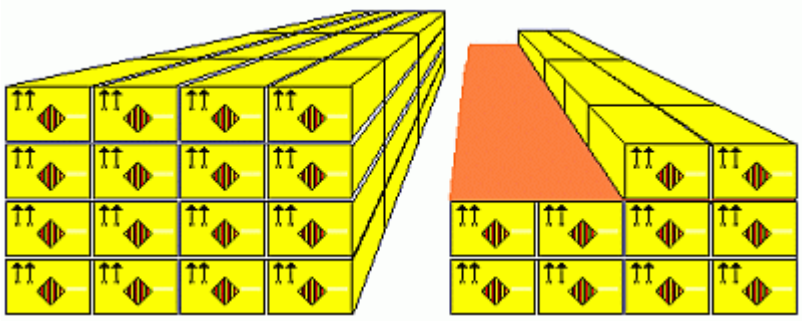
Incorrect expressions in the loading instructions or an incorrect interpretation of correct instructions frequently lead to damaged cargo. Such damage can be avoided if a reference is made in the stowage instructions to the orientation of the axis. Instead of the formulations "Load rolls upright" or "Load rolls on their sides", the expressions "Roll axis vertical" ("eye to the sky") or "Roll axis horizontal and transverse" or "Roll axis horizontal and longitudinal" should be used.

Misleading formulation	**Clear formulation**
... load so that	... load so that
Wire rod coils are upright	Ring axis/winding axis positioned vertically (English: "eye to the sky")
Wire rod coils are on their sides	Ring axis/winding axis horizontal (English: "eye to lie") or even better: ... Ring axis horizontal longitudinally...or horizontal transversely
Cylinders are upright	Cylinder axis is vertical
Cylinders are on their sides	Cylinder axis is horizontal, or even better: Cylinder axis is horizontal and longitudinal Cylinder axis is horizontal and transverse

As already mentioned, the terms "upright" and "on its side" are clear for most cargo items such as billets, pipes, profiles, bars etc., but it can be necessary in certain cases to provide or request more precise stowage instructions, such as "lying on its side" etc.

To prevent subsequent claims, always ask if anything is unclear. It is more cost-effective to obtain precise instructions from a superior or to make a telephone call to the customer than to lose one's reputation or to have to answer a claim for damages. In most cases, it is sufficient to use two arrows pointing upward to indicate that goods are to be transported a particular way up.

Stacking means loading, packing or stowing packages in layers so that the edges of the packages lie flush above each other.



Corrugated board cartons stacked with and without a hardboard anchor

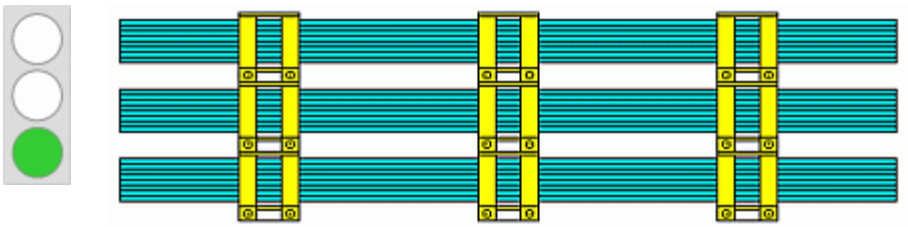
Pressure-sensitive cartons with homogeneous dimensions must always be stacked carefully ensuring that the sides and end faces lie flush. This ensures that only the load-carrying vertical sections are subjected to loads. When using cartons made of corrugated board, it is essential to check where possible that the flutes of the boards are vertical. If it could be disadvantageous that individual packages are not firmly connected to each other, anchors made of materials with a large surface area, such as hardboard, paperboard, plastic sheeting etc., are to be introduced during stowage.



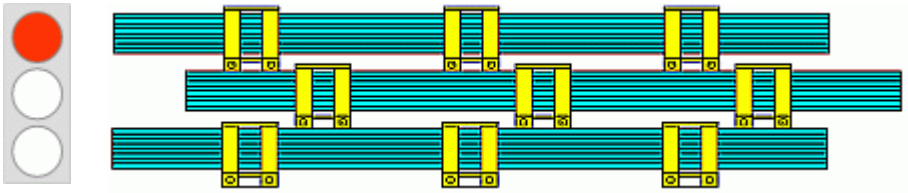


Stacked cartons, with and without plywood anchors

Wall boards and ceiling boards, plastic profiles and similar loads generally have single or double belt battens as "built-in packaging". To prevent any harmful loads from being applied to the boards themselves, the belt battens must be stacked flush on top of each other, and not for instance staggered to save on stowage space. Load securing material must also be attached to these points.

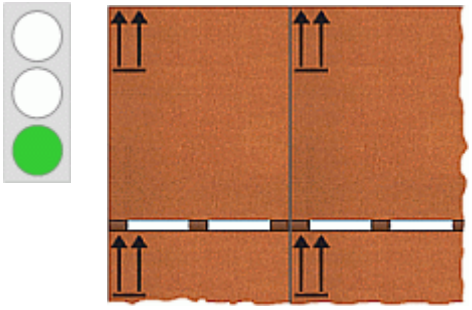


Ceiling boards - loaded correctly, packed one above the other

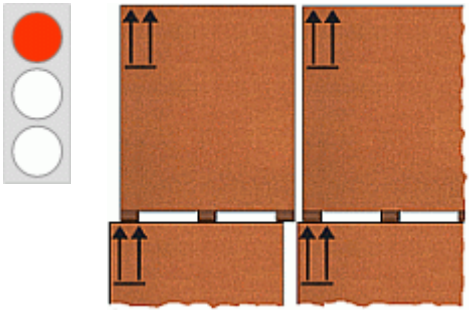


Ceiling boards - loaded in a staggered pattern and thus incorrectly

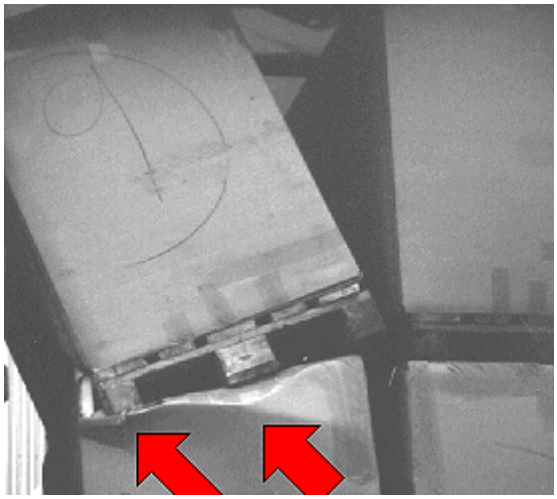
For particular loads, ***stacked stowage*** is an essential requirement, e.g. for pressure-sensitive cartons. In this case, any loads which arise must always be directed onto the load-bearing parts of a package. Even the smallest deviation from the vertical position can cause damage to the cargo.



Correct: Packed edge to edge



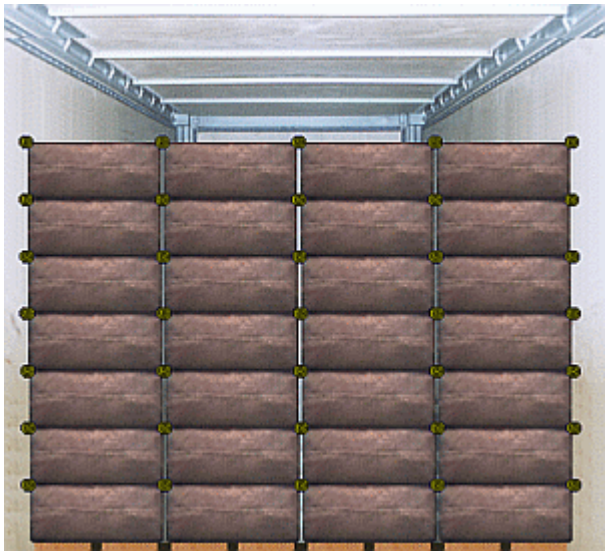
Incorrect: Untidy packing



Damage caused by incorrect stacking

The risk of packing errors can be avoided by using adequate interlayer dunnage.

Indonesian tobacco bales also demand correct "stacking". The only intermediate layers which are permitted are: plastic sheeting, kraft paper and other similar materials which can be used to "anchor" the layers to each other. Despite not being bound tightly, the stack as a whole is comparatively stable.



Possibility of ventilating Indonesian tobacco bales with rolled up mats. Floor dunnage made of wooden dunnage boards.

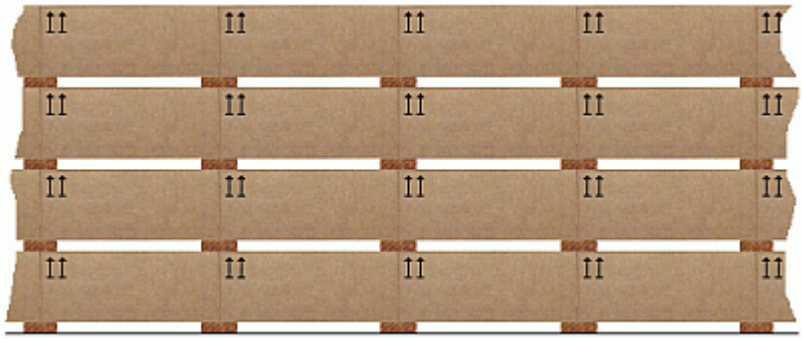
If gaps need to be left for reasons of ventilation or small gaps are required for stowage considerations, they can be achieved by using rolled up mats or equivalent materials.



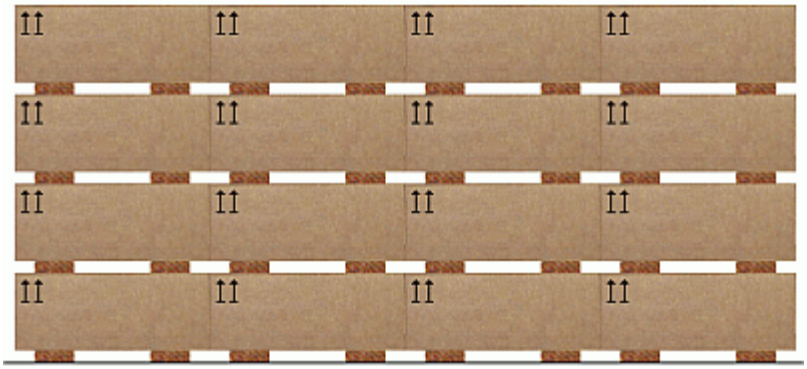
Narrow lattices and laths to ensure air circulation

If only narrow lattices, laths, boards or other strip-shaped materials can be used to ensure adequate air circulation, it must be ensured that they are placed on parts of the load which have sufficient load-bearing capacity.

With cardboard cartons, the load-bearing points are vertically below the side walls:



Correct: The wooden supports are placed on the load-bearing parts of the cartons, i.e. the sides



Incorrect: The wooden supports are placed on non-load-bearing parts

Tightly filled paper bags or sacks should be stacked in the same way. If the bags do not completely fill a hold or do not form a complete transverse tier, a sufficiently stable stack or interconnection of bags or layers can be achieved by inserting wooden dunnage or paper anchors or similar materials.

In most cases, it is sufficient to just insert the anchors in the top layers and/or on the sides; Generally, segregation material, dunnage and load securing material should be used sparingly, both for reasons of expense and to prevent stowage loss.

If dunnage has to be laid because "wet cargo" has to be packed together with dry cargo in a container, the dunnage must be laid without large gaps, otherwise, tightly filled paper bags and similar loads could burst or tear and could "bleed".



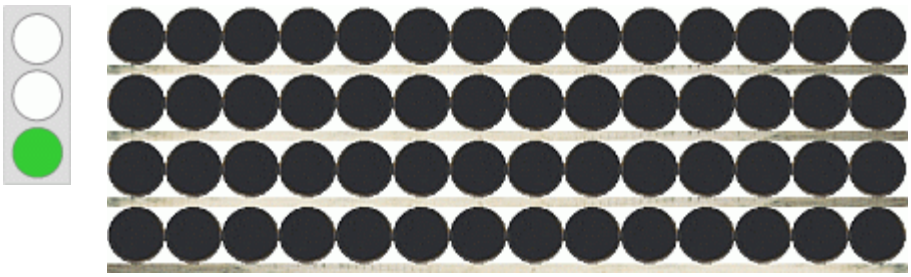
Sufficient floor dunnage prevents the bags from "bursting".



Insufficient floor dunnage makes it easy for the bags to "burst"

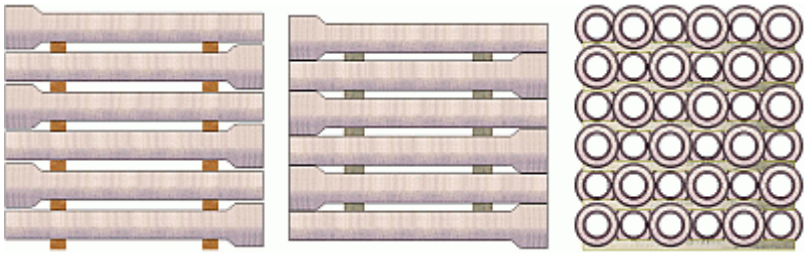
High load levels are produced when stowing cargoes in layers with intermediate layers made of squared lumber or wooden dunnage, since only linear bearing surfaces are produced in the area of the bottom and intermediate layers. Only cargoes insensitive to load forces may be stowed in this way. Harmful pressure can be reduced to an acceptable level by using relatively soft wood or by

using intermediate layers made of rubber.



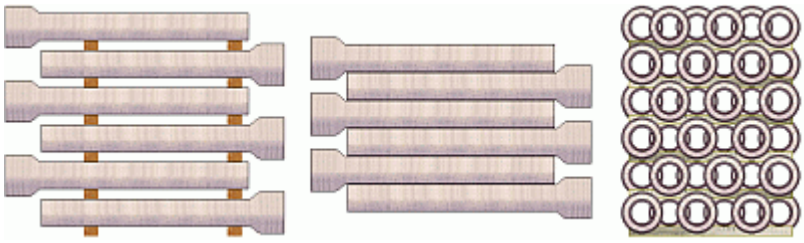
Stacking cargo with a sufficient loading capacity in layers

The pressure-sensitivity of fiber cement pipes or the susceptibility of ceramic pipes to breakage must be taken into consideration when selecting the type of dunnage:



Side view **View from the top** **Front view**

Stowage of socket pipes in layers and in alternate orientation



Side view **View from the top** **Front view**

Stowage of socket pipes in layers and in alternate orientation

All strong and resilient goods of various shapes or sizes can be packed in a

cross-tie stow. Remaining gaps must be filled. Wooden dunnage and similar intermediate layers should also be used as anchors. The need to bridge or pad out stowage gaps can result from a difference in the dimensions of cargo items.

In principle, this involves the cargo items ***interlocking*** with each other. It can generally be used to

minimize the effort required for securing cargo. Methods like this improve the stability of the cargo. But, as we have said: This method may only be used with resilient goods.

A ***complete transverse cross-tie*** refers to stowage in which goods fill the stowage space from side wall to side wall. Anchors do not need to be inserted if equivalent measures are taken. This stowage method is suitable for all means of transport having load-bearing side walls or with low lateral stresses, e.g. in rail transport. If the walls of a cargo container are not sufficiently strong, the cargo items must be stowed as a cross-tie, interconnected with anchors or secured using other special measures. It should always be considered that the speed of unloading can be increased by selecting the right anchor materials. The use of mechanical aids should be encouraged and not hindered in any way. Some examples of a complete transverse cross-tie have already been provided under the other stowage methods. The following warning must be taken seriously: "Complete transverse cross-tie stowage is only safe if the sides of the loading space can withstand the load forces!"



Special care is required when loading curtainsiders, trucks with tarpaulins and roof bows, open-sided containers etc. Vertical lateral tiers can be secured well on the "open" side, e.g. in the direction of a container door, by staggering the layers backward as the tier increases in height. The lateral tiers are then no longer vertical but at a slight angle to the vertical. A gradient of around 10° is recommended. At a stowage height of 2.5 m, the top layer is offset from the bottom layer by about 0.40 m.

Diagonal stowage can be practicable under certain circumstances, from the point of view of loading and unloading, on flatracks, trailers, container bolsters, trucks, certain types of freight car and similar vehicles, so that a number of teams can work at the same time. With this method, cargo of the same type or goods destined for the same recipient are loaded diagonally, to enable the cargo items to be accessed as quickly as possible. In contrast to conventional ship cargo, all goods must be destined for a single place of unloading. Onward transport with remaining diagonal load blocks is not possible.

The term ***bilge and cantline*** refers to a loading method in which packages are stowed or fitted into indentations produced by the round or rounded shape of other packages.

Genuine bilge and cantline stowage "on the quarter" is produced when stowing wooden barrels. This stowage method is only used very rarely nowadays.

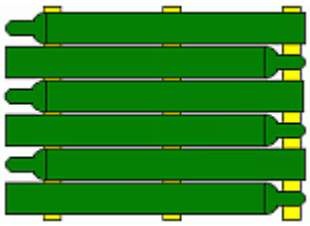


Wooden barrels stowed with the bilge and cantline method

There are some modified methods for stowing drum and barrel loads in containers, which are to be found in the section dealing with the loading and securing of drum loads. The term "bilge and cantline" is usually also used to mean "bilge and cantline on the quarter", although this is not strictly correct.



Gas cylinders stowed with the bilge and cantline method



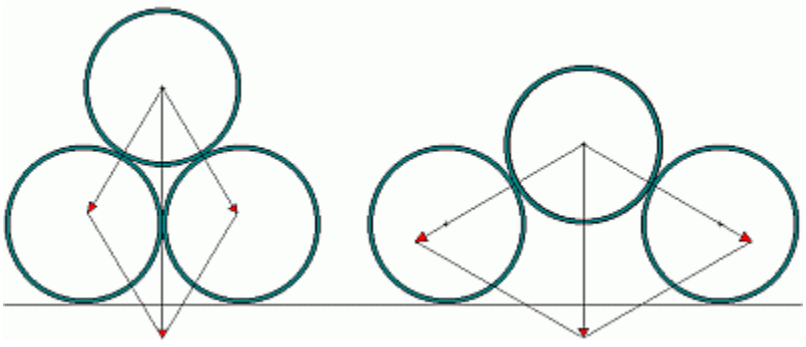
Even better: Stowed bilge and cantline and with alternate orientation

The figure on the left is a good example of how thin rubber nets are used to increase friction. The alternate orientation method makes it easier to load the cylinders with other goods and reduces the overall risk of damage.



Pipes stowed using the bilge and cantline method

If sensitive cylindrical cargo is stowed using the bilge and cantline method, the load forces are transferred over two load-bearing lines onto the cylinders stowed below. The cylinders in the bottom layer only rest on one load-bearing line. If wooden dunnage or squared lumber is laid as floor dunnage, only load-bearing "dashes" are present for each cylinder, which can cause harmful load forces. Items stowed using the bilge and cantline method exert considerable forces on the layers below them as a result of their opening angle. Only precise stowage can minimize these forces.

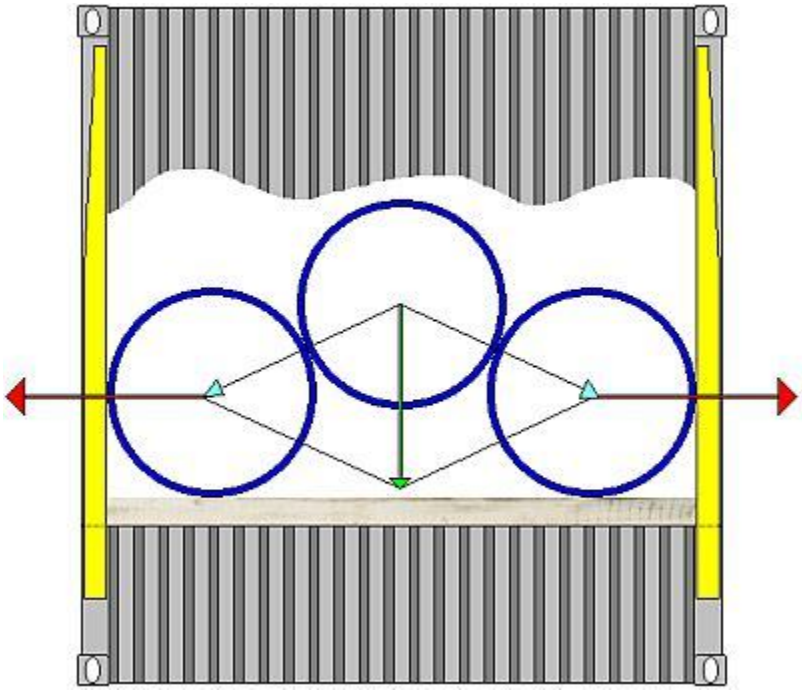


The lower a package lies in the gap, the greater the opening angle and therefore the greater the forces transmitted

It should be remembered that at an opening angle of 120°, a package already exerts a force of double its weight on the underlying packages and at 151°, this force is even four times its weight. If packages of this type are in turn bearing heavy loads, they will exert extreme downward forces. On welded pipes, the welded joints should not lie on the contact lines between the pipes. If cargo items do not fit exactly into the vehicles, improper stowage can result in gaps being left between the goods, which results in large opening angles and resultant forces. If gaps cannot be avoided, they must be left on the outer sides and padded out accordingly.

If cylindrical goods are loaded with stowage gaps and stowed with the bilge and cantline method, a

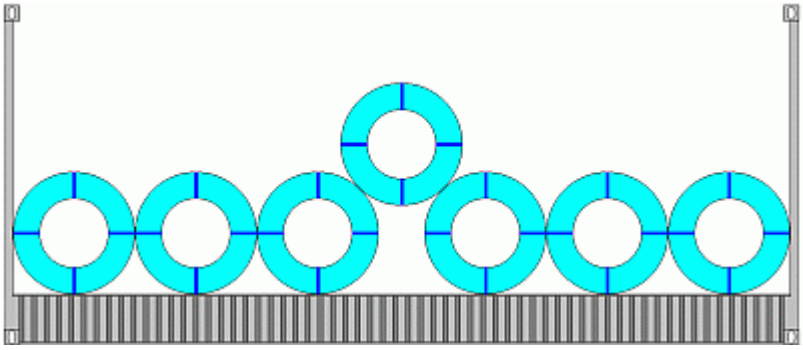
cargo item which protrudes low into the cantlines of the underlying layer could exert considerable lateral forces on the stanchions or other edges of the loading area. This would result in damage to the cargo and/or damage to the means of transport.



Load forces on other cargo and components of the means of transport caused by the opening angle

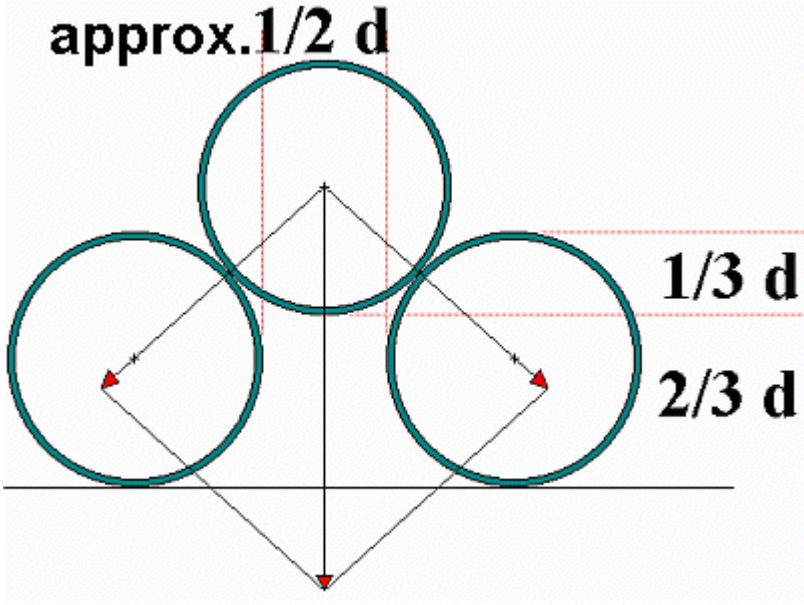
The middle pipe exerts lateral forces (red) as a result of its opening angle, which are greater than its own weight (green).

With resilient cargo items and load-bearing walls of the means of transport, the forces generated by the opening angles can be used to secure the cargo. The best-known example is the locking coil. This method can be used on any type of cylindrical cargo item. This is a good securing method, as long as other cargo items are prevented from riding up elsewhere. If necessary, additional lashing must be used.



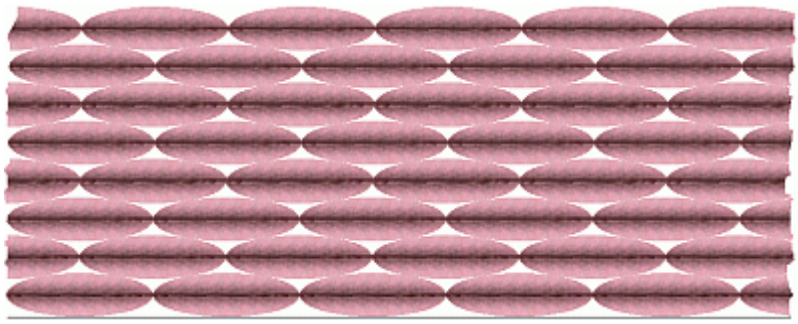
Principle of the locking coil

If the forces exerted by a cargo item are too great, they can damage other goods or components of the means of transport. The gaps should therefore be no greater than half the diameter of the cargo items. If all the items are of equal diameter, the locking element then protrudes by around a third of its diameter into the cantlines of the layer below.

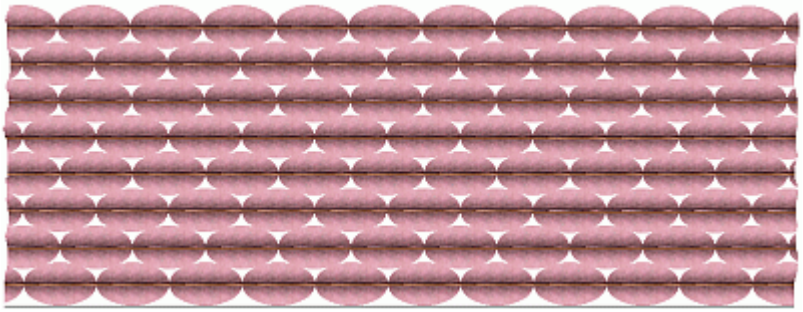


Maximum protrusion for goods stowed with the bilge and cantline method

Other goods can also be stowed using the ***bilge and cantline*** method, e.g. bagged cargo, more robust paperboard cartons etc. Using this stowage method, the seams or edges in all layers will lie in parallel. The packages of the vertical tiers are connected to each other, but not to the packages of adjacent tiers.



Bags stowed longitudinally with the bilge and cantline method

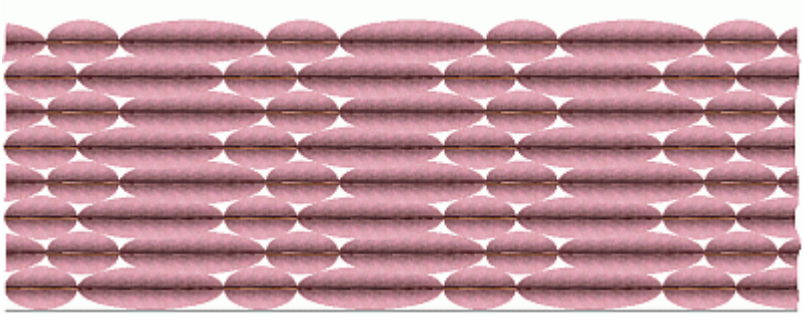


Bags stowed laterally with the bilge and cantline method



Cartons stowed with the bilge and cantline method

In a ***cross-tie stow***, packages are stowed alternately longitudinally and transversely. In this way, they are firmly interconnected:

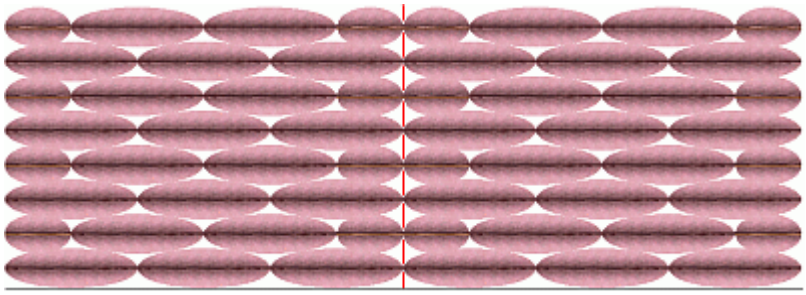


Example of cross-tie stowage of bags

Full cross-tie stowage enables goods to be completely connected to adjacent tiers: Cargo items in one tier extend half-way into the adjacent layer. Full cross-tie stowage can be recognized by the fact that no continuous lines can be seen either longitudinally or transversely. If cargo items have different dimensions, the stow must be arranged in such a way that cargo items which are as flat, long and stable as possible loaded in the outermost tier with the long side pointing into the stack.

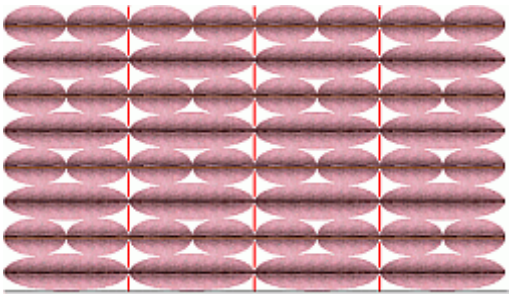
If bagged cargo is loaded in such a way that free-standing tiers remain at the edges, the seams or closures should point into the stacks, as they are weak points of the packaging. If this is not observed, bags can "bleed", which in turn endangers the stability of the stack.

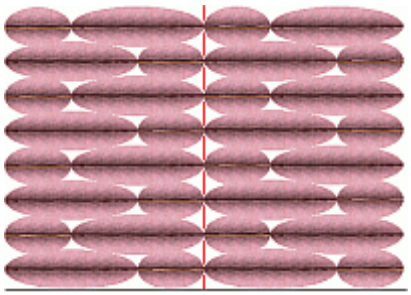
The following illustrations show partial cross-tie stowage, since continuous lines can be discerned in each case. Only the individual blocks are interconnected within themselves. By inserting anchors here, they can be connected to adjacent blocks.



Example of partial cross-tie stowage of bags

Example of partial cross-tie stowage of bags



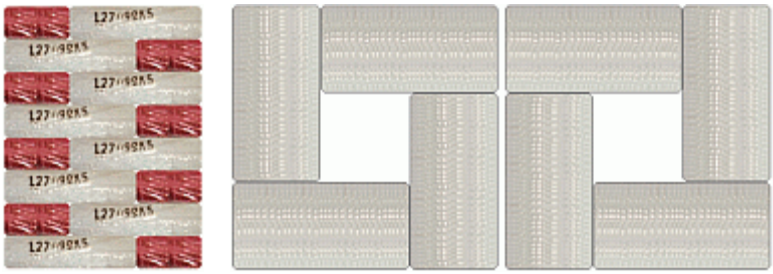


Example of partial cross-tie stowage of bags



Example of bags cross-tie stowed on a pallet and with shrink-wrap

Chimney-style stowage is extremely well suited for forming pre-slung cargo. With palletized bagged cargo, it is suitable for certain bag sizes. The bags are arranged layer by layer so that they overlap around a cavity. The bags are thus connected to each other. This produces a square footprint, which is very suitable for packing containers if it has the correct dimensions.

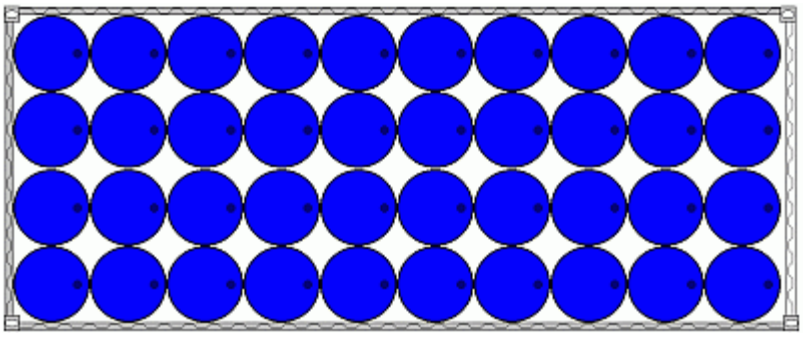


Front view **Layer 1, 3, 5, 7 ...** **Layer 2, 4, 6, 8 ...**

Principle of chimney-style stowage

Nearly all goods can be stacked using the ***bilge and cantline method*** or can be stacked and ***offset***, if sufficient interlayer dunnage is laid, allowing the load forces to evenly distributed, and thus preventing point loading.

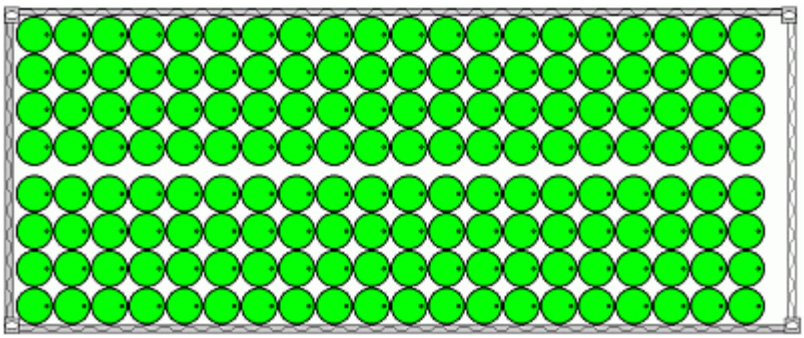
Soldier stow or ***soldier packing*** is used to describe the following arrangement of goods:



Soldier stowage of drums in a 20' box container

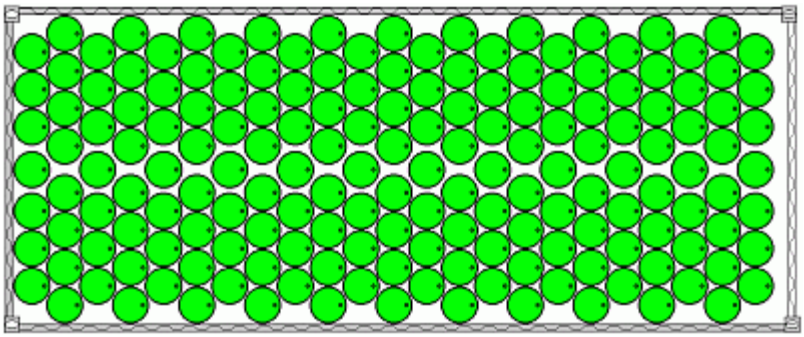
The 20 foot container used has an internal length of 5,895 mm and an internal width of 2,350 mm. The drums packed using soldier stow have an external diameter of 585 mm. Exactly 40 barrels fit into the container using this stowage method.

The same container will also accommodate a total of 160 pails with an external diameter of 290 mm using soldier stow:



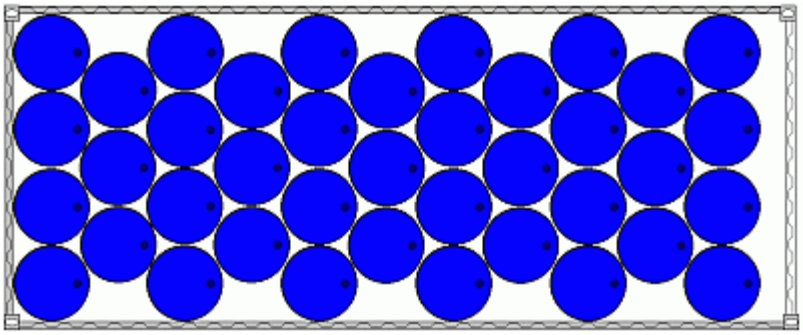
Soldier stowage of pails in a 20' box container

Offset stowage can minimize loss of stowage space, but not always. Offset stowage of the pails with an external diameter of 290 mm, for instance, will allow the container to accommodate a total of 172 pails:



Pails stowed using offset stow in a 20' box container

The same container will only however accommodate 39 barrels with an external diameter of 585 mm using offset stow - compared with 40 when using soldier stow:

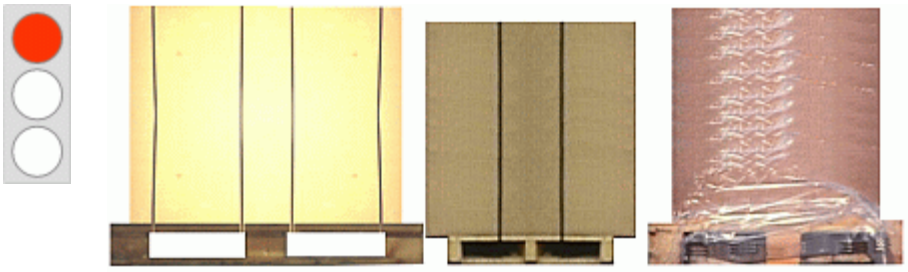


Offset stowage of drums in a 20' container

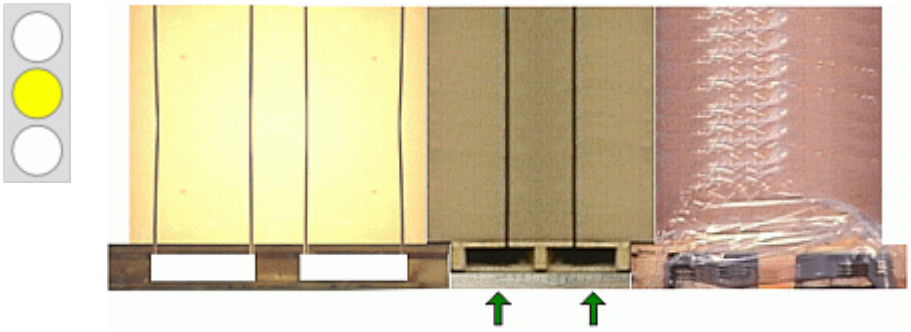
Vertical bilge and cantline stowage would also be a way of describing offset stowage, but it is not (yet) in use as a technical term. The term "vertical bilge and cantline stowage" of drums (or other cargoes) makes it very clear what is meant, however.

Whether stowage space can be saved depends on the dimensions of the goods and the dimensions of the means of transport. More goods can be stowed if the loading areas are large and/or the load diameters are fairly small. This is only sometimes the case for fairly small spaces and large load diameters.

Alternately raising loads can prevent damage, improve the usage of stowage space or save on load securing materials.



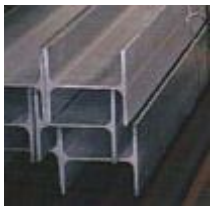
Incorrectly loaded pallets make load securing more difficult.



Alternately raising loads reduces the outlay for load securing.

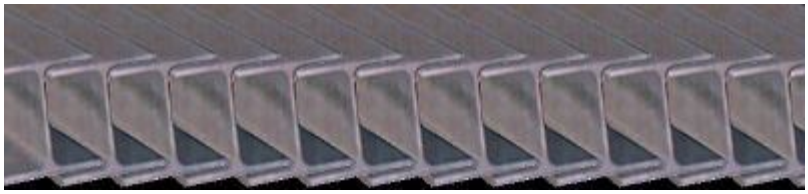
Drums, pails and similar cargo items have construction-related problems. Corrugated drums ride up on the corrugations as a result of transport forces. If closures protrude over the edge of quick lever-closure drums, the drums will snag on the closures. This results in unwanted opening of the drums and/or damage to the drums. Resulting gaps can also lead to further damage. The closures on fiber drums, the handles on drums, pails, cans and other similar containers can cause damage to cargo stored on top of or next to them as a result of high point loading. Alternately raising individual cargo items or groups can reduce the risk of damage. For further information, see the section on drum loads and mixed loads.

Manual ***interleaving*** of I beams and U profiles is rarely practiced. "Interleaved" loads are often delivered as a bundle, however, and then stacked using normal stowage anchors and squared lumber anchors.



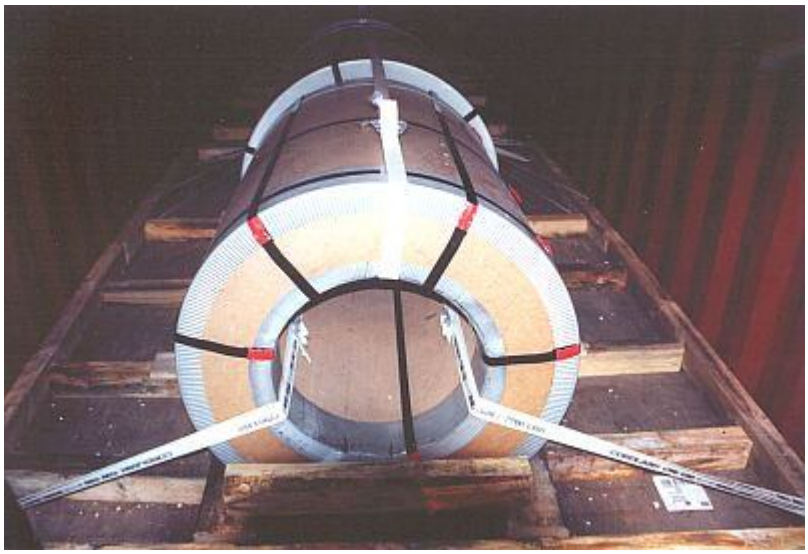


Nested stowage reduces loss of stowage space or can be used to create level cargo surfaces for access with fork-lift trucks. Some variants have their own names. Manually stowing on site is also becoming increasingly rare for this method, as it is growing much more common for cargo to be stowed in bundles beforehand at the factory.



Nested I beams

Face stow refers to the loading of coils, rolls etc., with their axis oriented parallel to the longitudinal axis of the skid or means of transport.



Face stow of coils in a container

Braiding involves placing ring-shaped loads, such as tires, wire rod coils with a short winding axis etc. in the core of other ring-shaped loads. Braiding has lost its importance through the use of special vehicles and the now common practice of transporting smaller batches in containers. The

method is still used, however, on complete loads or fairly large batches.



Braiding of car tires in a 20' containe

4.3 Load

A lot of material has been published about load securing in the last few years. The necessity for correct load securing has been unanimously confirmed by experts. However, the most effective methods are subject to fierce discussion. New regulations have been introduced and old regulations have been reworked. A range of recommendations and handbooks have appeared on the market designed to help the user, but these books do not always live up to expectations.

When selecting load securing methods and using load securing materials, economic considerations should obviously play a significant role, but safety should never be compromised as a result.

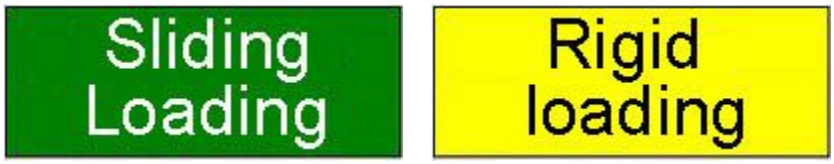
This part of the Handbook is designed to provide the user with information, particularly with regard to the practical techniques of load securing. But at the same time, as far as this is possible, the background and context will also be discussed from the theoretical point of view. It is impossible to do full justice to this topic given the limited number of pages available. However, the author hopes that this work will offer a suitable introduction to this topic.

4.3.1 General load securing methods

Because Cargo Transport Units (CTUs) are carried on all types of transport vehicle we shall here introduce some specific terms for loading and securing methods as used by each industry. Almost all fields of shipping refer to load securing in one way or another, yet each field has its own specialist terms. § 2 of the German rail traffic regulations (EVO) defines a general obligation to secure loads. This states:

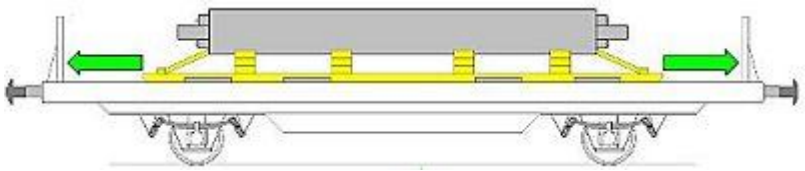
EVO - § 2 - Stowage
The objects to be loaded must be fundamentally safe and secure and should not be able to move as a result of jolts or vibrations that can be expected under normal operating conditions. The possibility of longitudinal movement is permitted insofar as the magnitude of this movement is limited by the use of appropriate means and there is no risk posed to safety.

This paragraph provides an important piece of information, namely that rail transport permits two fundamentally different securing methods:

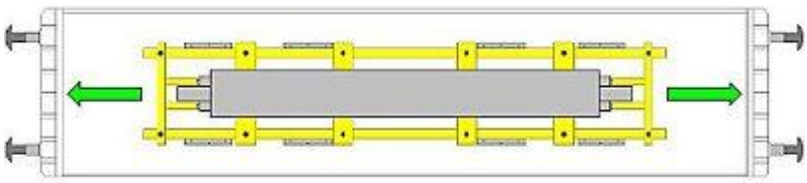


The **sliding loading method** allows cargo to move in the direction of impact as a result of the jolting forces that occur during rail transportation. With this method, jolting energy is absorbed by friction work. The magnitude of deceleration in g (1 g = 9.81 m/s²) corresponds to the size of the friction coefficient between the package and the loading surface. The lower the friction coefficient, the lower the forces acting on the cargo, but the greater the travel and vice versa. As a result of the limited travel which is possible, this method is geared toward the friction between wood and wood with travel of at least 1.5 m on each side of the object. If the possible travel is less than 1.5 m, then the use of non-slip materials placed between the load and the floor of the freight car is required.

The German railroad authorities recommend the use of this method for sensitive loads, for example, machines etc. if the properties of the load and the length of the loading area permits the method and if the goods are not in danger of tipping. The lower end edges of the load should be beveled in order to ensure that they do not snag on uneven areas of the freight car floor. If the bottom surface of the goods does not allow them to slide, they should be firmly attached wooden skids or sleds. The leading edges of the skids should be shaped like runners.



The sliding loading method - Side view



The sliding loading method - Plan view

The loads must be secured against sideways movement. Squared wooden guide rails attached next

to the loaded goods or sleds in such a way that the load not prevented from sliding have proved themselves in practice.

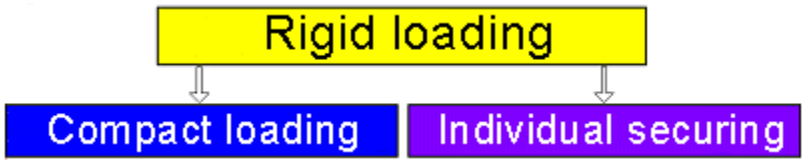
Any movement by the load must not cause permitted axle loads to be exceeded. Thus, the maximum permissible load of the freight car cannot be fully exploited. The axle load must not exceed the value that results when the sum of the tare weight plus the permitted maximum load is divided by the number of axles or bogies. The ratio of the axle loads of cars with two axles must not exceed 2:1, that of bogie cars must not exceed 3:1.

If the floor surface is of the same nature, goods will slide the same distance, regardless of their mass. Thus a number of partial loads or load groups consolidated as blocks can be loaded on a car using the sliding loading method. The loading guidelines require a gap of 50 cm between the individual goods/groups. When using this type of loading, several consecutive jolts during switching should not occur in the same direction. Cars loaded in this manner are specially checked at the switching yards.



Warning: The sliding load method may only be used in a Cargo Transport Unit if you can be absolutely sure that the unit will be transported exclusively by rail. The sliding load method should never be used with any other means of transport.

The term **rigid loading** comes from the loading guidelines published by the UIC (International Rail Union) and is used as a blanket term to cover both compact loading and individual securing.



The term "rigid loading" means exactly what it says: the load must be secured on or in a cargo transport unit in such a way that it is unable to move. If this demand is met, the load is unable to topple, fall down or become damaged/cause damage in any way. However, the term does not specify the method of securing that is to be used.



The term "compact loading" also clearly indicates the concept. A compact load is one which is stowed without gaps or, insofar as gaps remain, where these gaps have been filled by resilient material.

The term also immediately suggests that the CTUs must have borders of sufficient load bearing capacity around the loading area in order to allow a compact unit to be formed in which nothing is able to move. Even this simple description makes it clear that a CTU that does not have fixed side

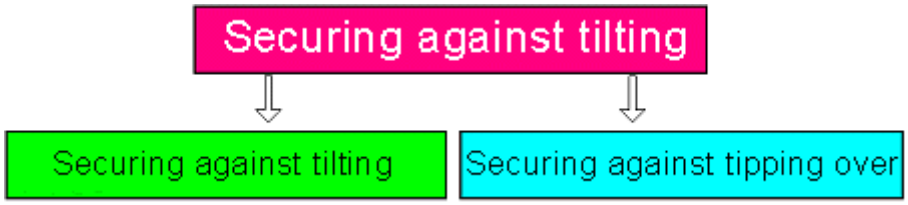
or end walls is not suitable/only partially suitable for securing loads in this way.

Individual securing

Individually secured loads are attached to the transport unit using special load securing aids. The term does not, however, indicate exactly how securing is to take place. It does however, imply that certain components must be available or certain requirements must be in met in order to allow loads to be secured individually: These components may be lashing points or other securing mechanisms on either the transport unit itself or the load.



If these load securing measures are carried out correctly, both of the important requirements of load securing will have been met: The load is unable to slide or tip. If we go into more detail, tipping can fall into two categories.

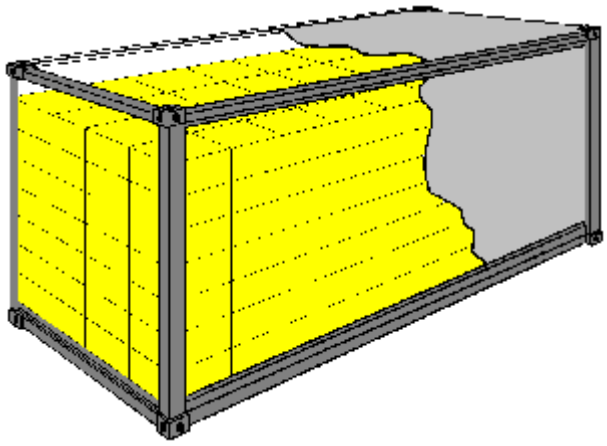




There's still time to ask for information.

4.3.2 Achieving a tight fit using container components and special components

This type of tight-fit is designed to transfer the forces from an item either directly to components of the transport unit, such as the walls or stanchions or directly via parts of the load which are capable of withstanding these forces. This cost-effective method of load securing has already been referred to as compact loading. If the packages have the right shape, size, strength and compatibility they can be packed together in tight contact. This forms a coherent loading block. If this block is unable to move in any direction, then no further securing measures will be required.



Compact loading in a box container

This method of packing may also be described as a complete longitudinal and transverse block. All the inertia forces acting on the load are transferred directly by the load to the components of the means of transport. The prerequisite is that the components of the transport unit are capable of withstanding such forces long-term.



A virtually complete compact load of cases in a container

Goods can often be packed successfully against the end walls and the sides. If the packages do not fill the entire length of the container, appropriate securing mechanisms should be used in the door area. If there is a risk of the packages working loose from the block as a result of the movement of the ship, then additional lumber bracing or other similar securing mechanisms should also be applied on top of the load.



Tight-fit for special receptacles traveling on a special flatrack



The half height open top containers in situ, as seen from the end

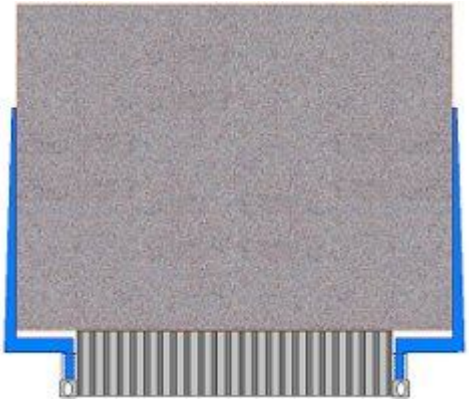
The flatracks shown here were specially designed to accommodate stacked receptacles. They are used to deliver securing elements such as stacking cones, twist locks, bridge fittings and other similar items used for securing containers on board ships. Solutions of this type are also suitable for transporting other small items. Taking into account the costs of packing and securing items, the use of a more expensive special container may, in the long run, actually pay for itself, particularly as the half-height saves on transport volume.

Platform containers of normal construction can usually be loaded in a compact/tight-fit fashion if the dimensions of the load are identical to the dimensions of the container loading area:



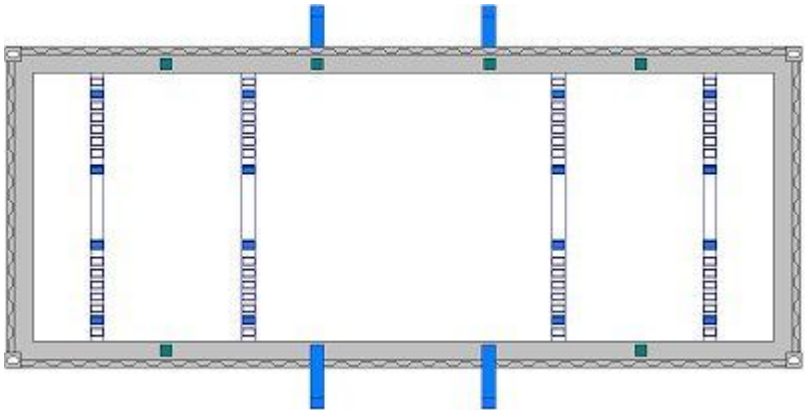
Compact stowage of a case on a flatrack with stanchions

This constellation is very rarely seen in practice. Shortcuts are not permitted in the field of load securing, but if the intended dimensions of a case are very close to those of the loading area of a real flatrack then it is possible to make the case fit the flatrack by building it slightly larger than originally planned. The additional costs invested in building the case are recouped by the costs saved on securing the case, and the risks of carriage are also lower.

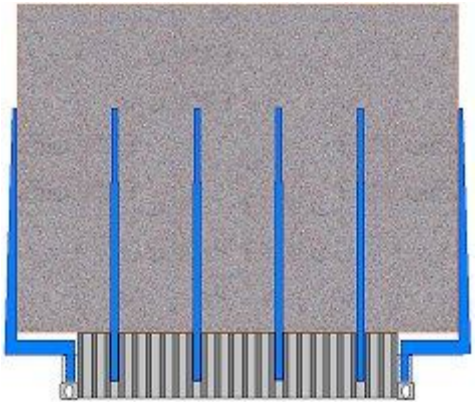


Compact tight-fit securing of a power substation using specially shaped stanchions crosswise on a flatrack

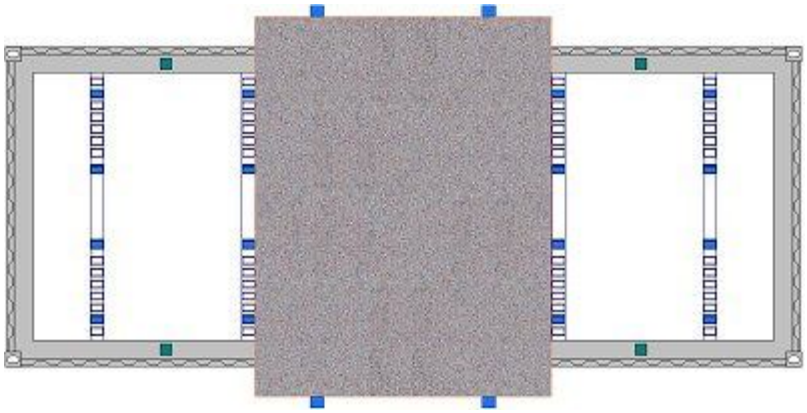
The load shown here is a substation. An overwidth such as this would normally require a considerable load securing outlay. The adjustable stanchions shown in blue (and which must be specially manufactured) can be used to ensure an excellent lateral tight fit. In reality, cargo items are not so large that they reach as far as the end walls. In this case, therefore, they would need to be braced with wooden beams or similar material. Securing by lashing would be even more work-intensive. Even if the items to be sent were the same length as the container, the overwidth would prevent the cargo from being loaded hard up against the end walls since the container would no longer fit into the slots of the ship. A possible solution would be to use a flatrack with special stanchion pockets that allow the load to be secured as a tight-fit.



Stanchion pockets on a specially designed flatrack



Power substation secured using removable stanchions and adjustable stanchions - Side view



Power substation secured using removable stanchions and adjustable stanchions - Top view

The means of transport are often only partially filled. Gaps may arise as a result of the characteristics of the load or for packing reasons. If so, then the load must be secured using the appropriate methods. Special securing measures may be required if there are edges on the means of transport or the edges available are not able to bear the load, as is the case when using partially open/open means of transport. In these cases, other methods will need to be used. These are described in the following sections.

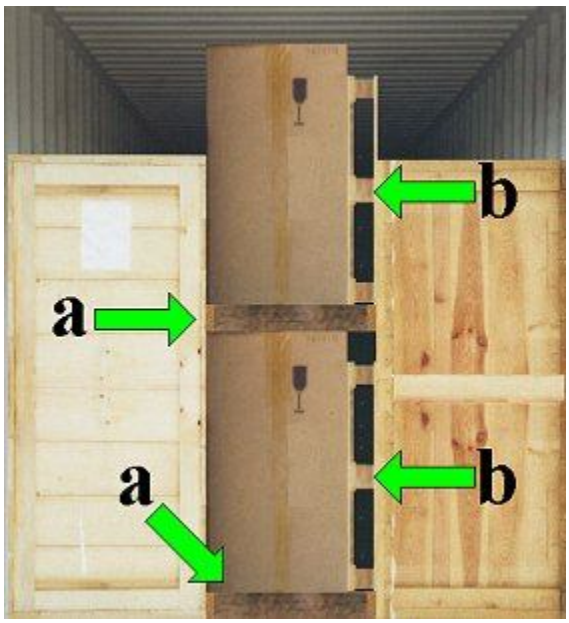
4.3.3 Achieving a tight fit by filling in gaps

This method of compact loading involves leaving gaps that must be filled in. When using box containers, these gaps may be longitudinal or transverse and should be filled in appropriately unless there is a better way of securing the cargo. Filling is usually the better and more economical method since lashing inside box containers requires considerable effort. The situation with platform containers is different; here lashing is often more suitable. Objects suitable for filling in gaps are wooden battens, which will be discussed in the next section, paperboard which can be used for very small gaps, boards and individual pieces of squared lumber for small gaps and pallets for larger gaps. If smooth surfaces are available or measures can be taken to eliminate sharp edges, then airbags may also be used.



Incorrect securing by filling

Compact packing and filling of gaps can only be implemented effectively if all parts of the load are sufficiently robust. Here, for example, the movement of the ship and the container while at sea would, sooner or later, destroy the cartons that are marked fragile. The gaps that occur as a result of this would then put the wooden cases at risk. The fact that the upper of the two cartons has been loaded upside down is not particularly good, but it is also not forbidden. If the shipper wishes to ensure that a packaged item is transported upright, it must be marked accordingly.



Correct filling of spaces

The gap has been left between the two strong wooden cases and filled in using boards and squared lumber (a). The cartons were loaded into this space. The remaining spaces were filled in using old pallets (b). The forces acting on the wooden cases are transferred from case to case by the squared lumber and onto the side walls of the container. The pallets are simply transferring the forces from the cartons to the case on the right.

An important note referring to the use of "old materials" is given in section 3.2.12 of the CTU guidelines.

> *When deciding on packaging and cargo-securing material, it should be borne in mind that some countries enforce a garbage- and litter-avoidance policy. This may lead to limitations on the use of certain materials and imply fees for the recovery of packaging at the reception point as well as similar problems for the shipper of the cargo. In such cases, reusable packaging and securing material should be used. Increasingly, countries are requiring timber dunnage and packaging materials to be debarked.*

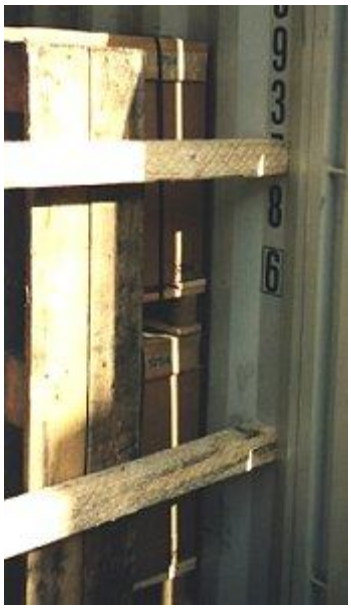
According to Section 8 of the GGVSee "shipper" is understood to mean the manufacturer or distributor.



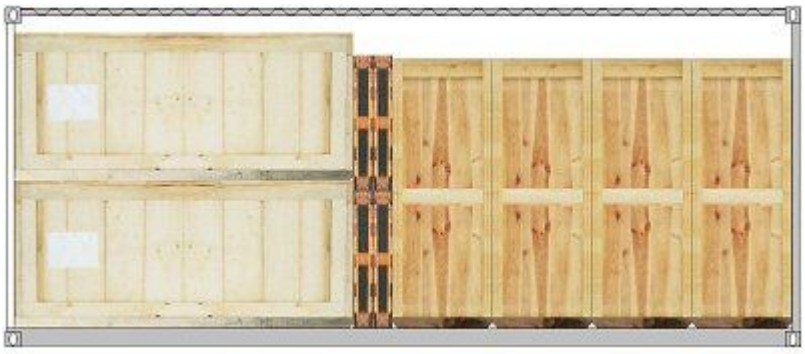
Filling a space in the vicinity of the door

The space remaining in the vicinity of the door is filled in using upended pallets placed across the space and squared lumber beams fitted into the corrugations of the container. Care must be taken if the overall mass of the load is large, since the use of this method could cause damage to the corrugations.

If possible, the load should be braced against the door posts in the vicinity of the doors. If this is not possible, the door area can be filled in, but in such a way that the load is spread over a sufficient area that no harmful pressure points arise.



Corrugations run the risk of being damaged



Filling in space left in the middle of a container

Leaving spaces in the middle of a container and filling them in requires the packer to calculate the required dimensions exactly. With good planning this is not a problem. There is an advantage to this, since it allows the distribution of weight to be better organized.



Using airbags to fill in a space left in the middle of a container

Since airbags should not be used in the vicinity of the door for safety reasons, the obvious option is to leave space in the middle of the container. The airbags can be affixed and partially inflated before loading the cases in the door area. Once the cases have been put into place, the left-hand door is closed and the airbags can be inflated fully.



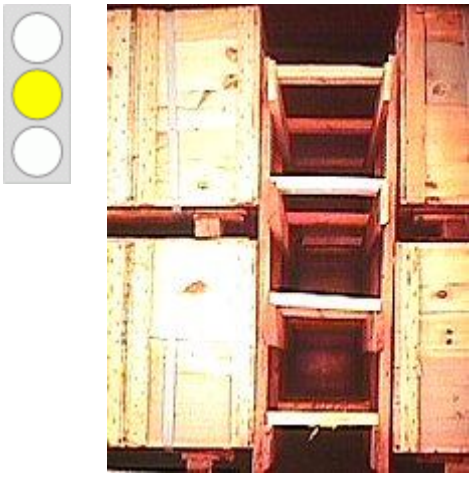
Impractical method of filling a gap in the middle of a container using airbags

Theoretically it is possible to determine the size of the gap and to fully inflate the airbags before loading the boxes. However, this runs the risk of the airbags being crushed without the packers being able to monitor this, since the height of the cases means that the airbags are no longer accessible. This method of securing is practical when used with containers which have side doors and with platform containers which can be accessed from the side.

4.3.4 Achieving a tight fit by bracing

Bracing elements made of wood are a tried and tested method of load securing when packing containers. Squared lumber, battens and other elements are fitted in in such a way that spaces within the load are bridged. Bracing between the cargo and the container, and between the items of cargo are both commonly used methods. The latter is the more cost-effective solution since the required securing forces are generally lower.

Wooden bracing elements used to fill in gaps or empty spaces can often be made quickly and simply. Occasionally, however, they are feats of craftsmanship that require a great deal of experience and ability.



Horizontally bracing, poorly placed in part

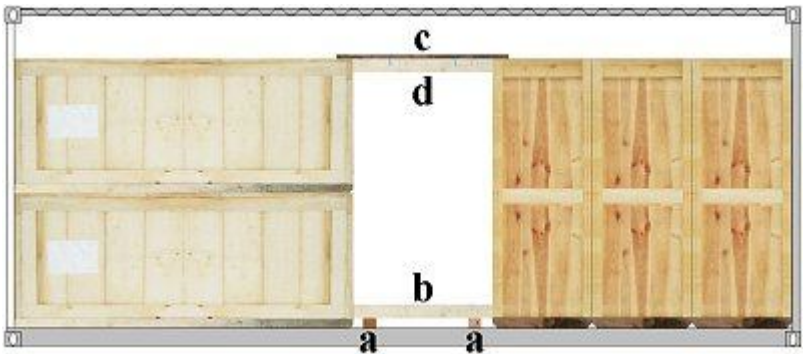


Well placed horizontal bracing elements

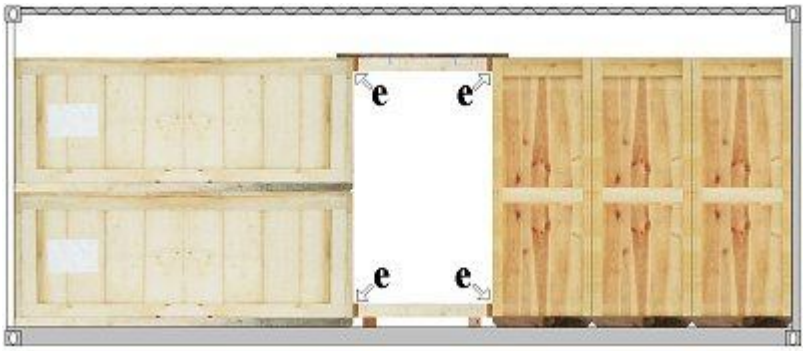
The important issue when bracing is that the forces must be transferred to the load-bearing components of the cargo transport unit or the packaged items that surround the gap. From a technical point of view, the bracing elements in both examples are equally well made. Horizontal elements are nailed onto vertical elements. The bracing elements are formed by the wooden beams that are cut to fit and placed transversely on top. The majority of this work can be done in advance outside the CTU. Only the bracing must be put in place inside the container. The advantage of the method shown on the right is that the bracing elements are placed level with the strongest parts of the cases, namely the top and the bottom.

This form of bracing (see the next figure) assumes that the packages either side of the gap are of almost identical height. Two transverse lengths of squared lumber are placed on the floor at the bottom of the space (a); depending on the forces that can be expected, at least two or more pieces of lumber are cut to fit and placed horizontally (b). Outside the transport unit, boards are prepared (c) which can then be nailed to the fitted lumber beams (d). This prepared bracing element is then

lowered into place from above. All elements are stapled in place to prevent them from moving or are cross-braced with wooden boards.



Tight-fit using a very simply made form of bracing



Using squared lumber fitted into a space in the way shown above is only possible if the packaged items are able to withstand such point loading. If the cases are not strong enough to allow the ends of the bracing beams to be placed against them directly, boards (e), planking or squared lumber can be additionally used to distribute the load forces. If this is not sufficient, vertical bracing elements or other methods of bracing should be used. The section on wood contains a number of other useful tips, as well as rules of thumb for calculating strength. Additional tips can also be found in the examples.



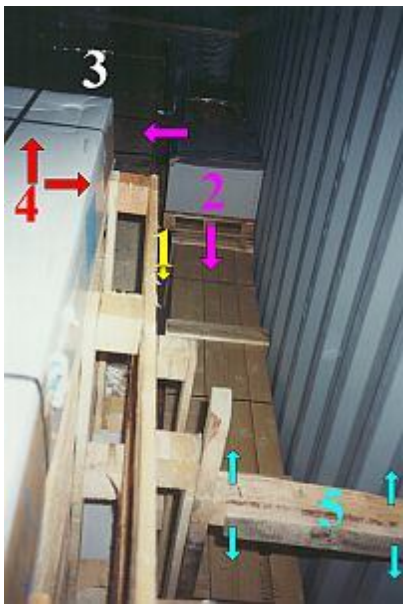
Bracing an overheight case on a 40' flatrack

The traffic lights here are on amber. There are a number of things to bear in mind with regard to the woodwork and the lashing that have been used here. This picture is only designed to indicate the wide range of bracing methods that can be used to create a tight fit.

It is often the case that insufficient attention is paid to the bracing of gaps and/or the work is carried out in an unprofessional manner:



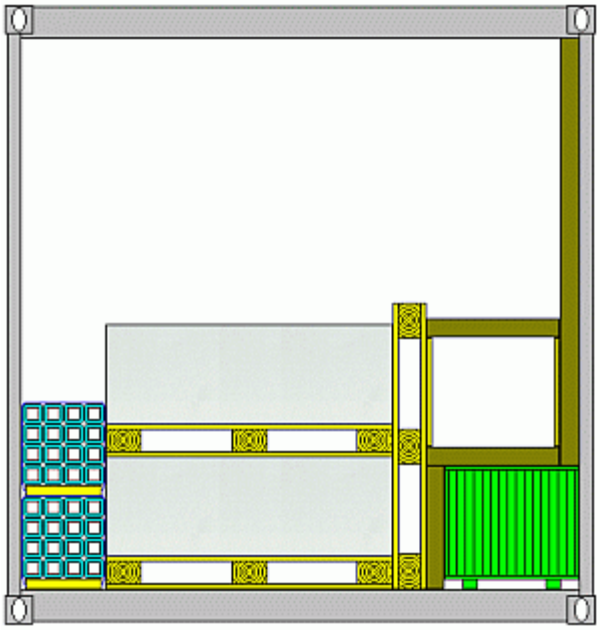




Badly braced spaces in a container

Space 1 allows the packaged items to slide around on the floor. Package 2 can slide both in the direction of the door and in the direction of the space. Package 4 can move forward into space 3 or escape to the side. Bracing element 5 is able to shift upward and downward on the right, and as a result of point loading may even damage the wall of the container. On the left, the bracing is able to move in all directions because it has not been fixed into place.

Neat packing and the professional use of beams and boards enables the remaining gaps to be braced without subjecting parts of the load or the container walls to point load forces.



An example of professional bracing

The picture shown here is of a stuffed container destined for an international voyage carrying, among other things, dangerous goods. In accordance with legal requirements a signed container packing certificate was available which testified that the container had been correctly packed and that the load had been secured adequately. It is difficult to believe that anyone could possibly issue this certificate for the load shown here.

The provisional bracing of the gap with a pallet (1) is not sufficient.



Goods are put at risk by provisional filling using a pallet

The red arrow (3) shows the foot of the pallet putting pressure on the wall of the drum. The cartons

are not strong enough to ensure that they will survive without damage. The green arrow (4) shows where forces can be transmitted via the corrugations of the drum.

In order to ensure an even distribution of forces, walking boards, chipboard or hardboard (2) are required in addition to the pallet (1).



Filling in a space using a pallet and plywood

Key: (1) = Pallet placed vertically;
(2) = Plywood board placed vertically;
(3) Transmission of forces to the drum;
(4) and (5) = Transmission of forces at the corrugations of the drum.

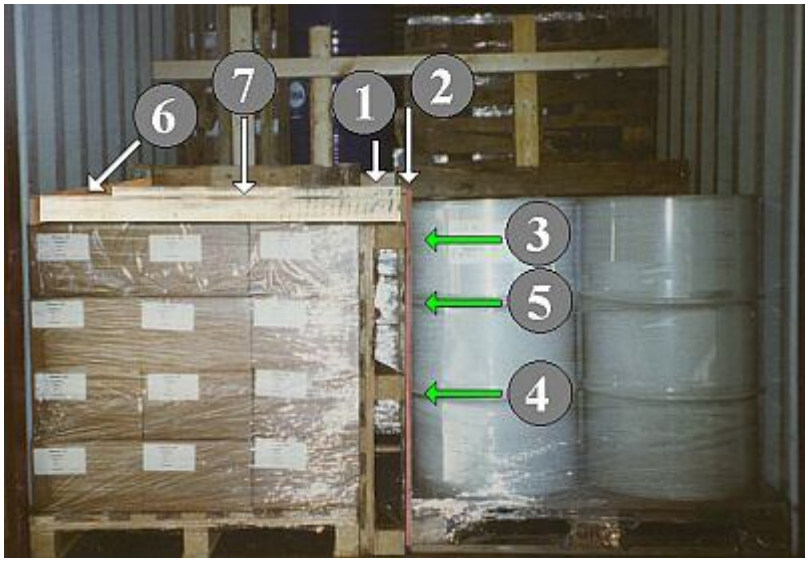
This alone is not sufficient to provide 100% protection from damage. An important factor is that the forces from the drums are absorbed at the top of the boxes.

This can be achieved by laying pallets on top of the cartons in conjunction with squared lumber or using a simple construction made of squared lumber and boards. The latter can be prepared outside the container and then put into place.



Different bracing elements

The option of boards (6) plus squared lumber (7) was used for the load shown here, which meant that the forces were transmitted to the top rims of the drums.



Absorbing the forces at the top of the goods in cartons

Every space in the load represents an increased risk of danger. Spaces should therefore always be filled in.



Badly wrapped pallets and spaces in the load



Filling in spaces in the load using two pallets

With goods that are liable to topple or palletized goods, as in (1) and (2), that are badly bonded to the pallet, it is not only the floor region which must be filled out, but a greater surface area as shown in the picture on the right where two pallets have been used for this purpose (3).

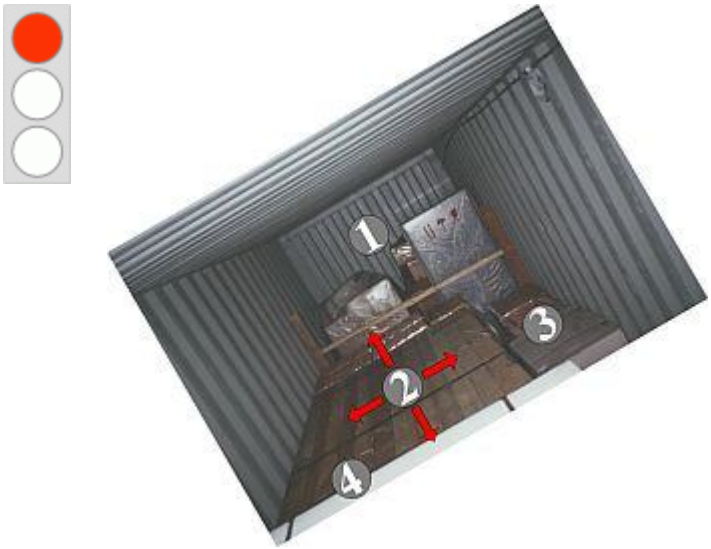
At a first glance, the container looks relatively well packed:

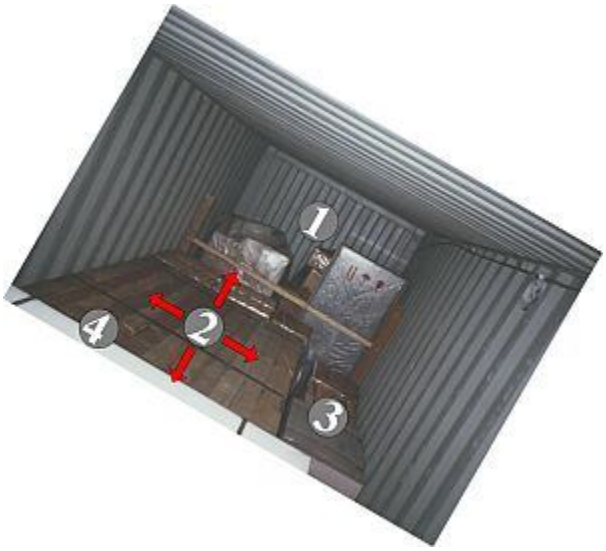


Faults in a container packed for export

The heavy case has not been braced at floor level. The forces from the case are able to work in all horizontal directions. Depending on the method of transportation and the forces that occur as a result, the cartons at the front (1), side (3) or rear (4) can be damaged by the case (2) or may even be

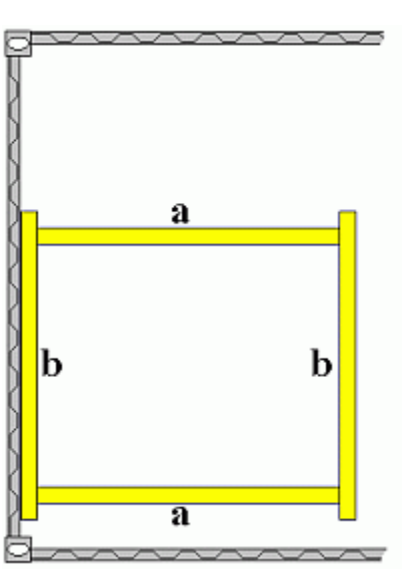
crushed completely.

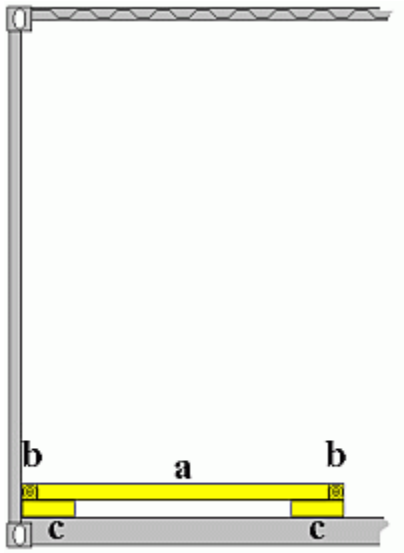




Here a roll angle of 30° is shown. Such transverse forces occur when a container is transported on a ship in the usual fashion, namely with fore and aft stowage. To put the risks in perspective, it can be assumed that on a long voyage a container will be subjected to several tens of thousands of these roll oscillations. During pre- and post-carriage by rail or by road, the objects in front of or behind the case are the ones most at risk. The same would apply if the container was to be stowed athwartships on the vessel.

The possibility of the packages being crushed could have been avoided by using squared lumber in the floor region between the case and the sides of the container.





View from the top **View from the side**

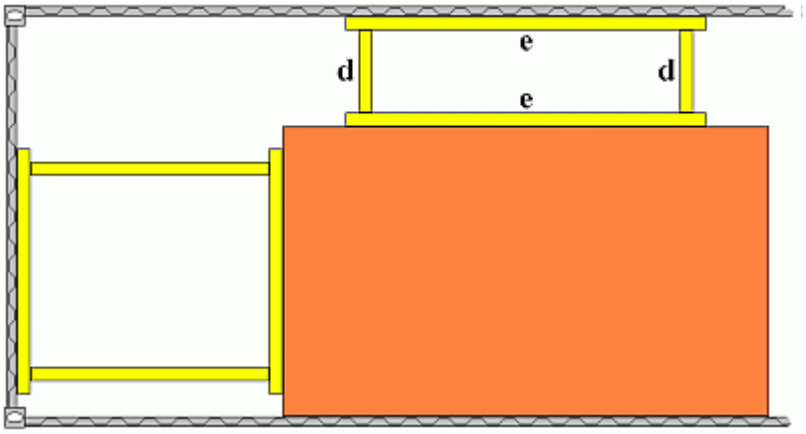
Frame used to brace a case against the end wall of the container

The squared lumber beams (a) lying lengthways are designed to brace the case which has yet to be loaded. They are raised (c) in such a way that the case is braced at the level of the bottom of the case. Squared lumber or boards are placed at the end wall of the container and the front end of the case; these serve to distribute the load forces (b).



The cartons and pallets of batch (1) are then loaded into this section of the container and secured appropriately above the height of the case that is still to be loaded.

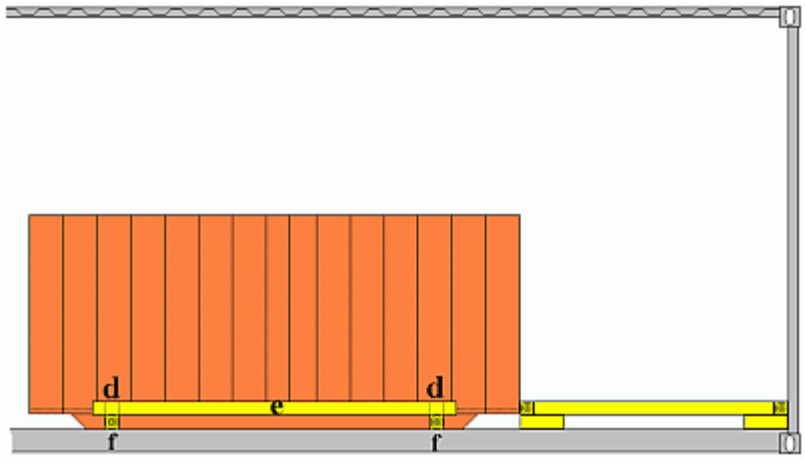
Once the case has been loaded, the space at the right of the container can then be braced:



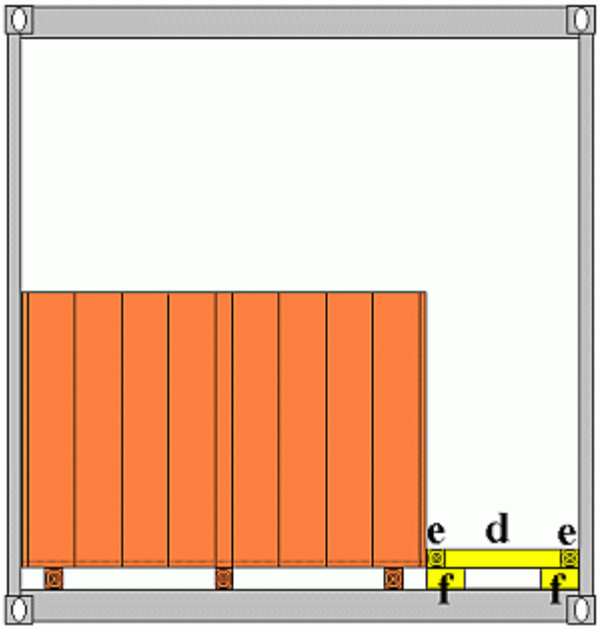
Bracing in the space at the right of the container - Plan view

The wooden bracing elements (d) and the wooden beams that are designed to distribute the load forces (e) are raised by beams placed below them to the extent that the frame is at the same level as the robust bottom of the case. The number of wooden elements used to form the bracing will depend on the weight of the case and can be calculated using a rule of thumb. For each square centimeter cross-section of a wooden element, a force of 30 daN can be absorbed.

The next two images illustrate more clearly how the frame is raised using wooden elements (f).



Bracing in the space at the right of the container - View from the right



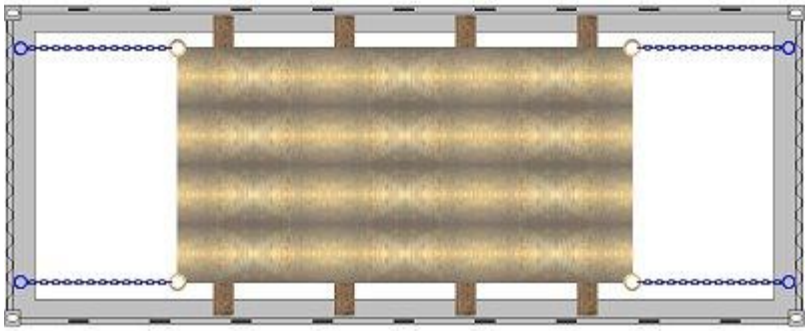
Bracing in the space at the right of the container - View from the door

If cases are at risk of tipping, they must also be braced close to the lid of the case. This is not necessary in this particular instance.

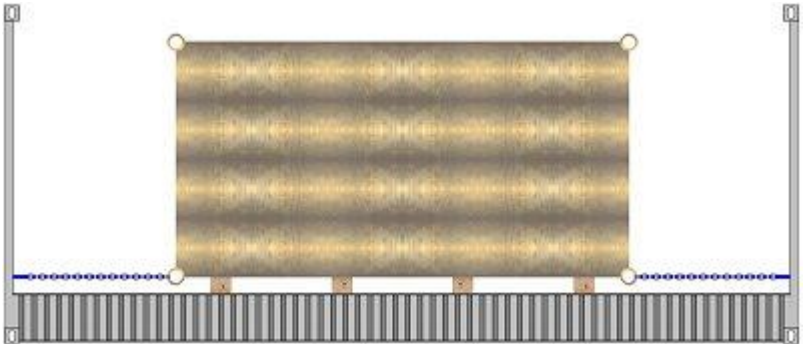
4.3.5 Achieving a tight fit by lashing

Lashing refers to the use of steel strapping, chains, steel wire, textile straps, ropes and other securing materials which are fixed, on the one hand, to the package and, on the other hand, to the CTU and then tensioned lightly. The important factors that determine the effectiveness of the lashings are the quality of the materials and the fixing points as well as the directions in which the lashings work. This means that lashing angles also play a critical role. Lashing a package is intended to prevent it from moving longitudinally or laterally and to stop it rising from the loading surface or tipping. A lashing is used to create a tight fit. The term direct lashing is also used.
The quantity and thickness of the required lashings will depend on the weight of the load that is to be secured, on the anticipated forces, on the maximum securing load of the lashings and the lashing angles. More information can be found in the relevant sections dealing with the materials and in the lashing examples.

Lashing has a less important role to play when securing packages in box containers. Since the lashing points in the container usually have a maximum securing load of 1,000 daN (corresponds to a mass of approximately 1 t), the use of lashing must be restricted to lighter packages. Another consideration is the fact that lashing points are often not accessible as a result of spatial restrictions and the space occupied by packages. When securing loads in open top containers a higher MSL can generally be assumed - often in the region of 2,000 daN (corresponds to a mass of approximately 2 t). Platform-style containers, on the other hand, offer good lashing facilities, which means that lashing is virtually indispensable on such cargo transport units.

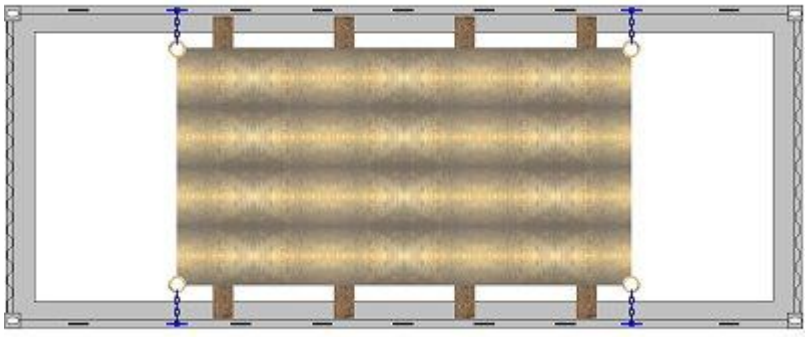


Horizontal lashings with longitudinal components - View from the top



Horizontal lashings with longitudinal components - View from the side

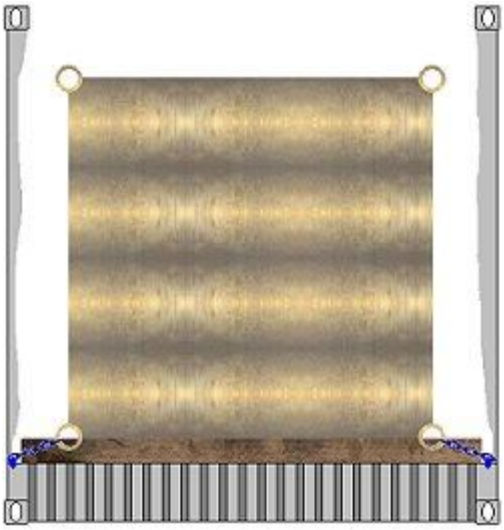
Horizontal lashings have no vertical component. Horizontal lashings attached longitudinally, as shown here, have no lateral components. The package is simply held in place longitudinally by this type of load securing.



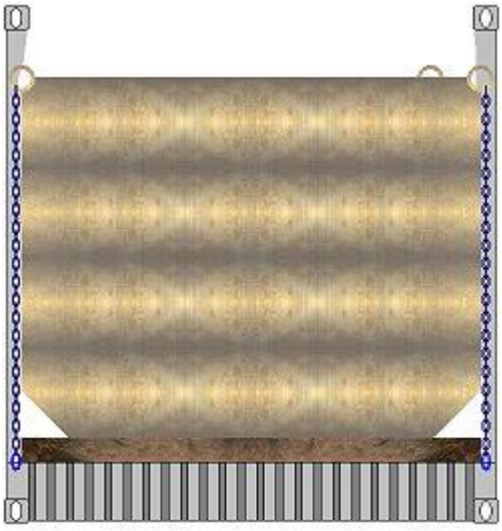
Horizontal lashings with horizontal components - View from the top

If the lashings are absolutely parallel to the horizontal transverse axis, they will have no longitudinal or vertical components. A package secured in this manner is thus exclusively secured in the transverse direction.

The lashing shown here, however, also has a slight vertical component as a result of the position of the lashing points.

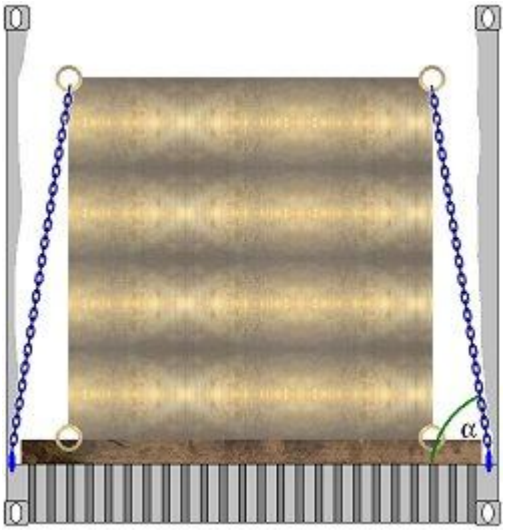


Horizontal lashing with transverse and vertical components - Lateral view



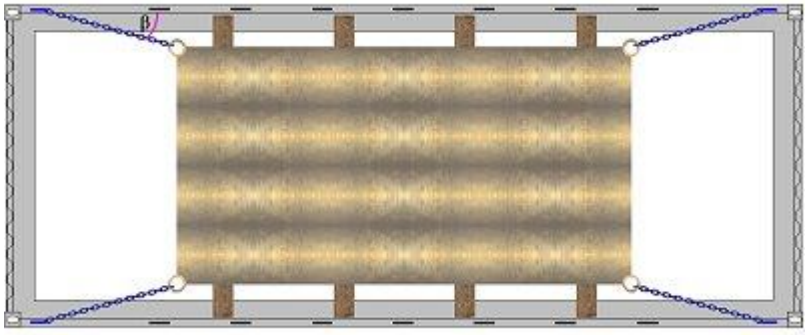
Vertical lashing without horizontal components - Lateral view

A purely vertical lashing has no horizontal component at all. These lashings are thus unable to exert either a longitudinal or a transverse securing effect. Longitudinal and transverse forces can cause the load to move. If this happens, the purely vertical lashings are displaced sideways and sometimes placed under considerable tension. The tension that is created as a result of the load moving exerts a force on the load pushing it down on the container floor. This increases the frictional forces on the floor. Frictional forces for each lashing are calculated using the product of the MSL and the friction coefficient.

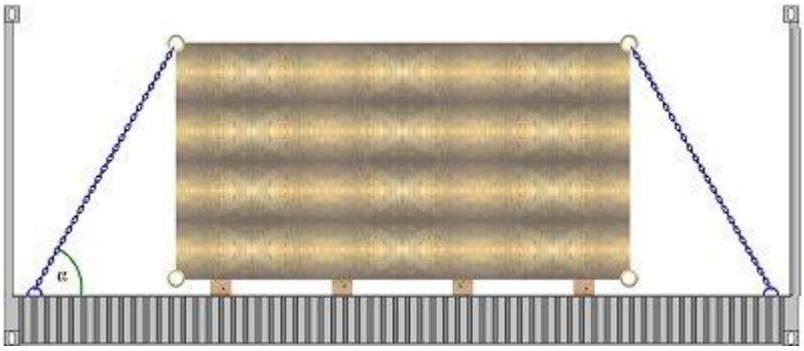


Vertical lashings with slight horizontal transverse components - Lateral view

The German VDI guidelines refer to lashings of this type as inclined lashings. Such lashings form a lashing angle with the horizontal plane, which is referred to as α.



Diagonal lashings with horizontal longitudinal and transverse components and vertical components - View from the top



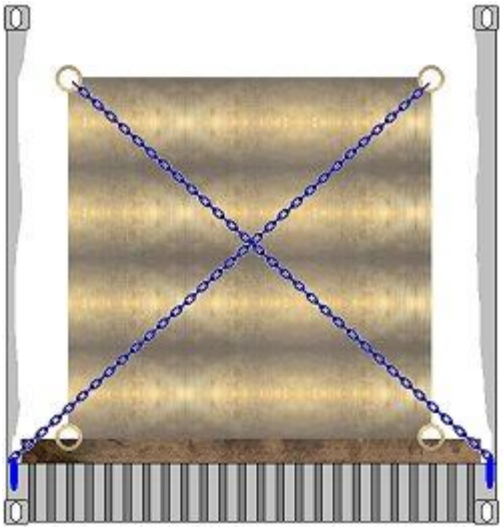
Diagonal lashings with horizontal longitudinal and transverse components and vertical components - View from the side

Diagonal lashings form a lashing angle α with the horizontal plane and a further lashing angle β

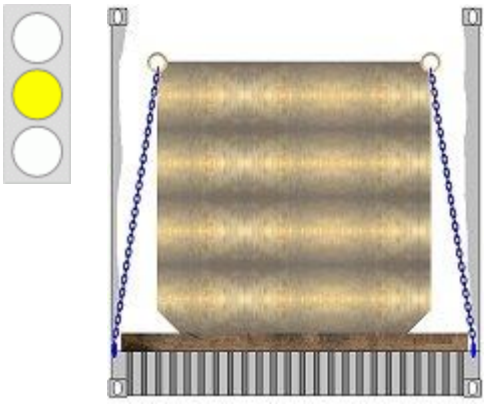
with the horizontal longitudinal direction of the transport unit. According to the terms defined by the VDI, lashings of this type are referred to as diagonal lashings.

With the diagonal lashings shown here, the vertical components are the greatest. The horizontal longitudinal components are considerably smaller, and the horizontal transverse components even smaller still.

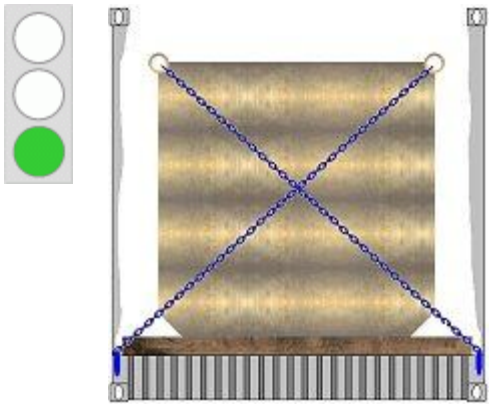
Cross lashings are simply a special form of diagonal lashing. These are advantageous if the lack of space requires greater horizontal components.



Cross lashings with horizontal and vertical components
- Lateral view

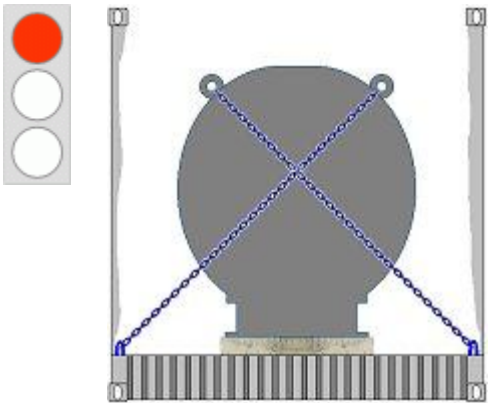


Diagonal lashings with small horizontal transverse components

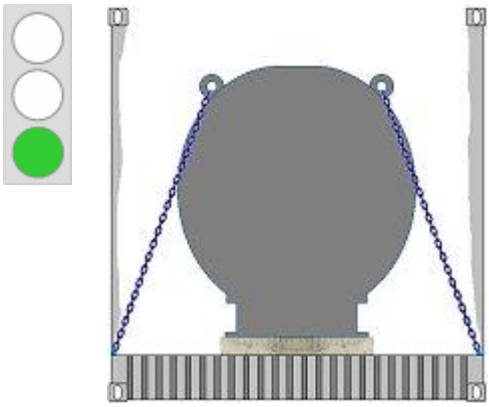


Cross lashings with better horizontal transverse components

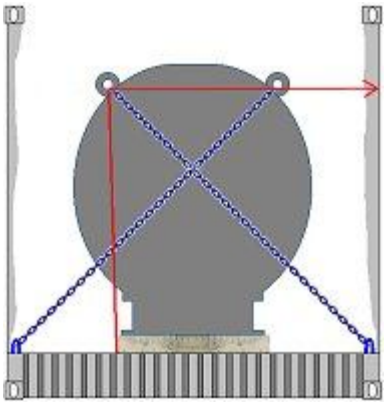
The package on the right is considerably better secured laterally than the one on the left. Under such conditions cross lashings are often suitable. But beware: This no longer applies if the package is to be secured against tipping.



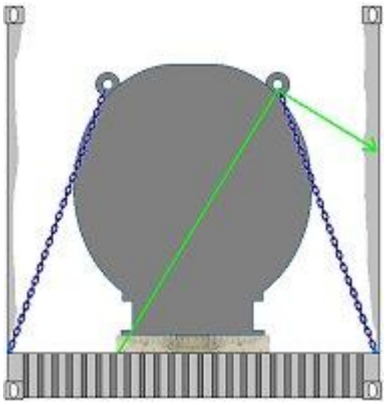
Ineffective components for securing against tipping



Effective components for securing against tipping



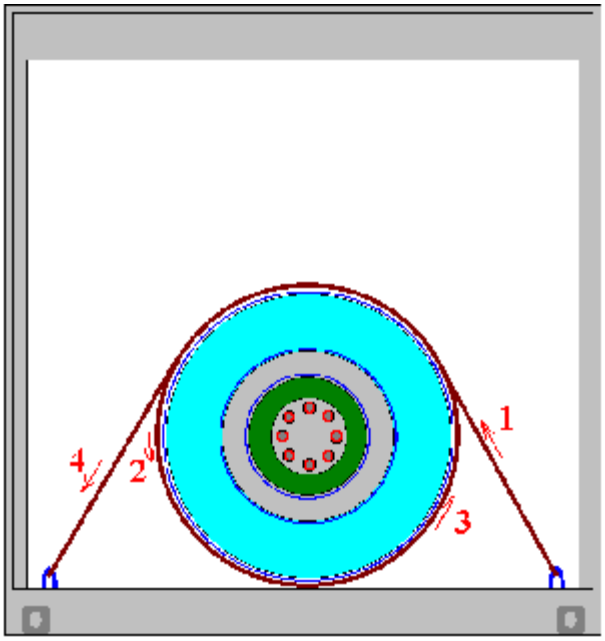
Optimum lashing angle to protect against tipping, but impossible to implement



The real lashing angle is close to the optimum to protect against tipping.

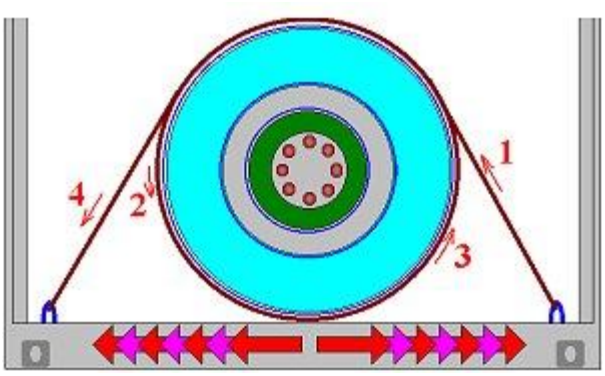
The optimum angle for securing against tipping is to imagine a line to the outside at right angles to the line connecting the lashing point and the tipping edge:.

A clear warning must be issued against the so-called round turn lashings where the lashing material is fixed at one side, wrapped around the object and then fixed at the other side:



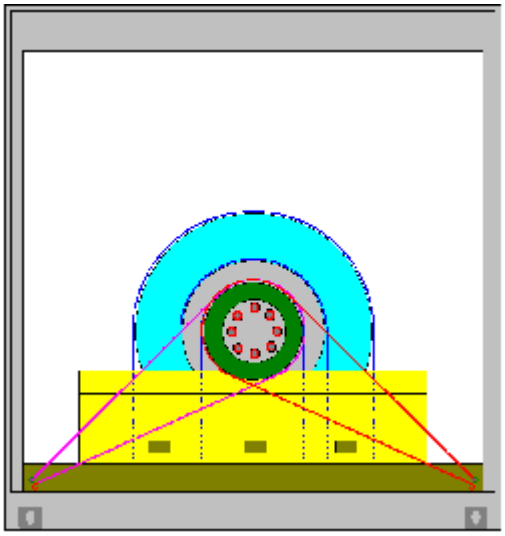
Round turn lashing

Round turn lashings allow the loads to move freely.

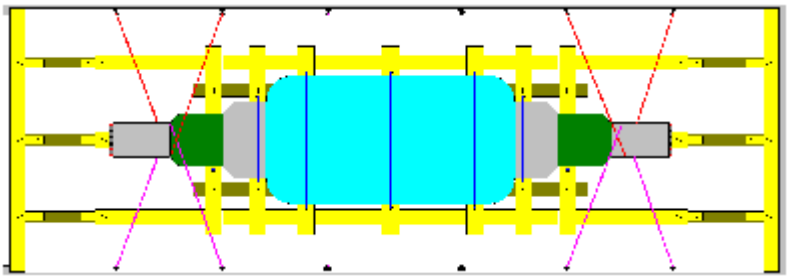


Round turn lashings are similar to the diabolo toy principle

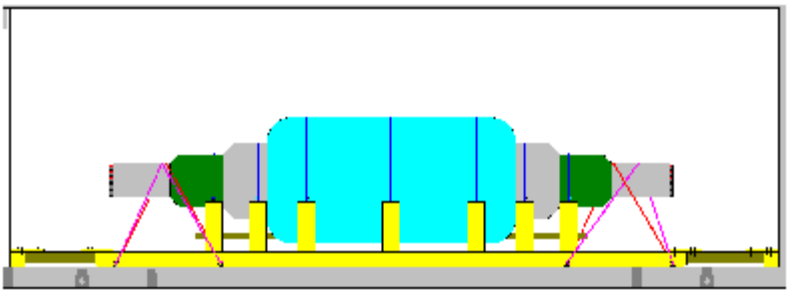
Loop lashings are unfortunately rarely used as a form of tight-fit securing although they are extremely effective. This method can be used very effectively with all long, cylindical loads.



Loop lashing used to secure a piece of machinery
- Lateral view

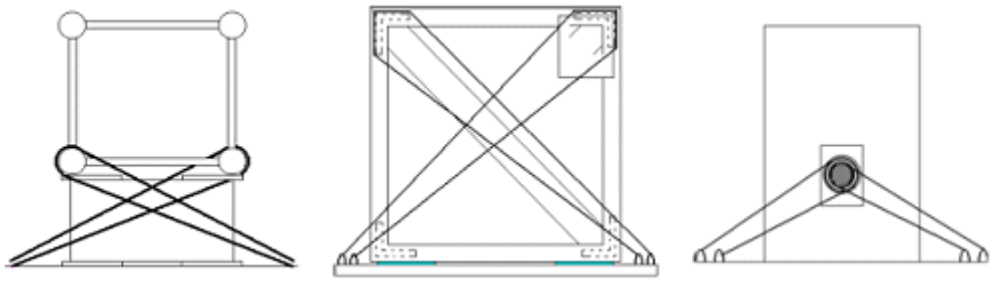


Loop lashing used to secure a piece of machinery
- View from the top



Loop lashing used to secure a piece of machinery
- Side view

Loop lashings can be used anywhere where the lashing can be wrapped around a component of the load. To create a loop lashing, the lashing material is fixed to a lashing point on the means of transport, wrapped around the load and back to the side it started from and, if possible, secured to a second lashing point.



When using separate lashing points, the permitted lashing force of a single strand of the lashing can be increased by a factor of up to two at best. With a lashing point with a permitted load of 2,000 daN (approximately 2 t) and a permitted lashing force of a single strand of lashing material of 2,000 daN (approximately 2t) as well, this will result in a maximum of 4,000 daN (approximately 4 t) securing force. The opening angle between the ends of the lashing material leads to a certain reduction: With a maximum possible angle of 90° in the three diagrams this is 30%. The pretensioning force in the lashing will also reduce the securing force. However, depending on the circumstances, the frictional forces may be increased.

There are numerous possible variations on the loop lashing principle. A little imagination and experience will show that this principle can be used to solve a multitude of load securing problems.

The weaknesses of the round turn lashing and the strengths of the loop lashing have been investigated by the Fortbildungszentrum Hafen Hamburg (the training center at the port in Hamburg) in a very effective test. Part of this series of photos is shown here:



The lashings have been applied - The tipping process begins.



An angle less than 30° has been reached - part of the friction forces are still effective.

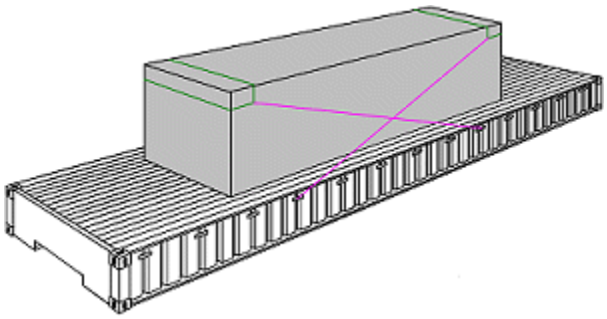


The round turn lashing fails, the loop lashing remains firm.

Impact: The round turn lashing fails even more, the loop lashing still remains firm!

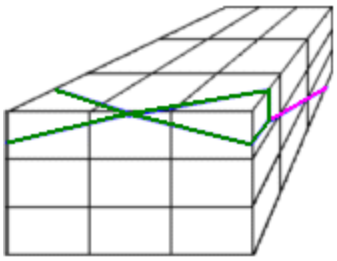


If there are no securing points, lashings can be attached with "head loops".



Head loops with spring lashings in the form of a cross lashing

Note that the lashing shown in this sketch is not sufficient for carriage. It is only shown to illustrate the principle of head loops (green) and lashings attached to them (magenta). Securing using head loops will usually require two members of staff. This method is much too time-intensive to implement alone. The term spring lashing is used to described lashings that run from the outside to the inside, regardless of whether they cross. Head loops can take a number of different forms. This Container Handbook and the GDV Cargo Securing Manual contain a number of samples in the various examples.



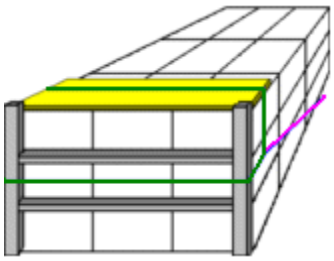


Figure of eight head loop **Head loop with padding**

If layered goods run the risk of the head loop cutting in between the individual packages, then a figure of eight head loop can be used to achieve the same result. The use of the head loop as shown above, requires the packages to be stable enough to take the full MSL of the lashing. If this is not the case, boards, lattices, walking boards, square lumber dunnage and other similar aids can be used to cushion them in order to meet the prerequisites for the head loops. This is usually needed when securing bundles, IBCs, units, bagged cargo pallets, or other similar packages.

The majority of securing errors are made when making and securing the lashings. This picture shows the use of a hook which has already been bent open, and which has also been inserted in the wrong direction. The chain tensioner shown has not been used correctly. It must be tightened down by at least 45° and must not protrude at right angles as shown here, otherwise there is a danger that the link of the chain could escape from the lug of the tensioner. The lashing angles are not suitable. High vertical components have been achieved, but the longitudinal and transverse components are too low.





Faulty fixing and errors

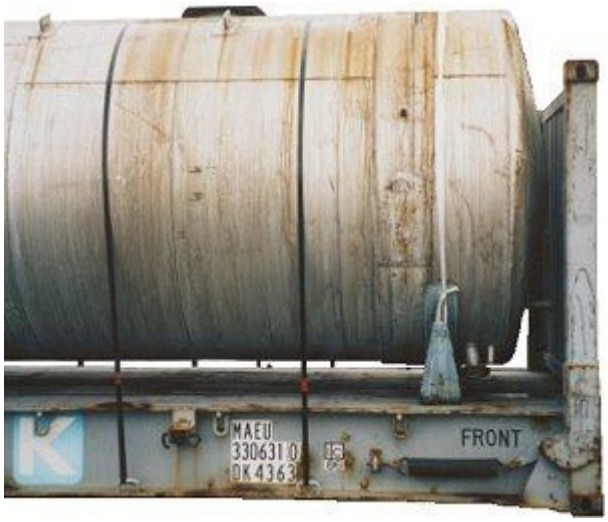


Tight-fit securing of rolls of paper using a WisaFix lashing cover

This example shows the use of a load securing tarpaulin with textile straps that have been secured to the ends of the roll trailer, thus ensuring a tight-fit. This type of securing is only suitable for ocean-going transport if the roll trailers are stowed in a "tight-fit" constellation next to each other and either along the length of the ship or athwartships. Since the load has simply been strapped down at the sides of the roll trailer, the securing is sufficient for terminal transport, but not for ocean-going transport.

4.3.6 Friction securing

Friction securing or friction loop securing means that the frictional forces between the packages and the intermediate layers or underlying surface are greater than the forces caused by transportation and which are working on the load. Only if this requirement is fulfilled when the load is packed and can be maintained during the entire transportation process, can the load be considered "secure". A simple example taken from everyday life is the passenger traveling on a bus who places their foot on top of their briefcase in order to prevent it sliding away from them in a corner or during acceleration and deceleration.

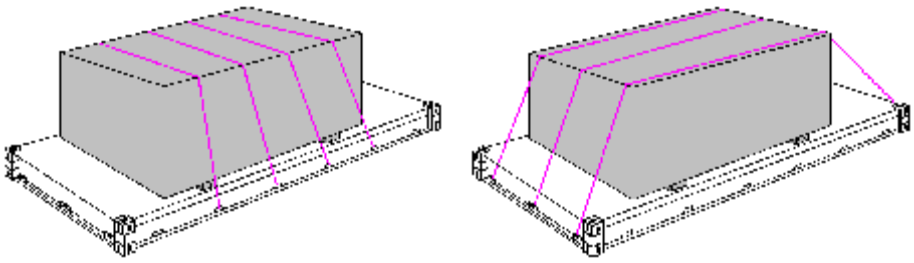


Friction loop made of steel strapping

The best-known and most frequently used form of friction securing is the round turn or friction loop. The VDI guidelines and other road traffic publications refer to this method as tying down, and to the lashing as a tie-down. The rail transport industry uses the term tie-down.

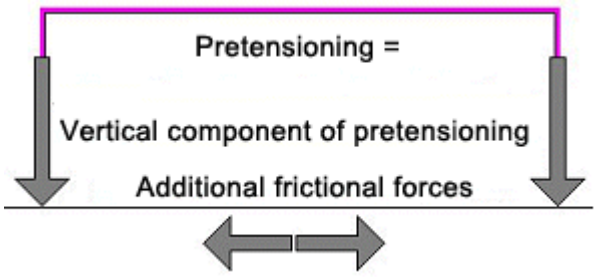
Whatever term is used, the guidelines are referring to the same method: With the aid of tensioning elements, a certain degree of pretensioning is introduced into the lashings which effectively puts additional artificial weighting on the secured package. This causes additional frictional forces on the bottom of the package. In conjunction with the "normal" frictional forces this will give the overall securing force of a given lashing. The effectiveness of this method of securing increases with the friction and the effective pretensioning.

If tie-down lashings can be referred to as "advantageous" at all, this is as a result of fact that the frictional forces act in all directions. Thus, it is not significant from which side of the object the tie-downs are applied.



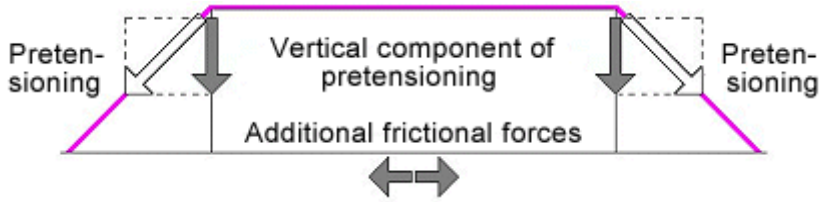
Frictional forces act in all directions.

The general securing principle is that the vertical components of the pretensioning force introduced to the lashing aid increase the downward pressure between the load and the surface it is resting on, thus generating additional frictional forces.



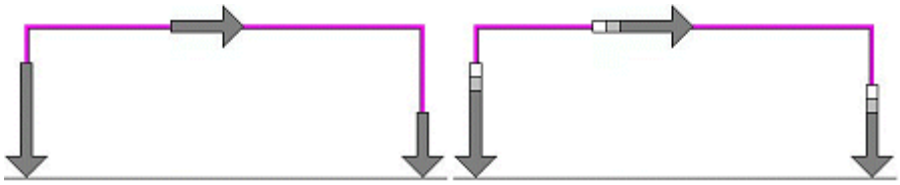
How tie-downs work

The smaller the vertical components and the frictional values, the lower the securing forces that can be achieved:



The relationship between pretensioning and the vertical component for lashing angles

Where tensioning aids are applied to just one side of an object, the pretensioning force decreases towards the opposite side. The rougher the contact surfaces over which the material passes, the lower the pretensioning force on the opposite side. The use of smooth edge protectors helps to ensure that as much of the pretensioning force created on the one side is distributed to the other as possible. Jolting may cause the pretensioning force on the tensioned side to decrease and to increase on the side that is not tensioned.



Migration of pretensioning force during transport

If it is not possible to use smooth edge protector corners with tensioners used on one side only, it is sensible to tension the lashings on alternate sides.



Incorrect installation of fixed lashing tensioners and steel strapping

The lashing capstans would have been more useful if three of them had been installed on each side of the flatrack. Here, it is not ideal that all the steel straps are tensioned on the same side.

What is important is that the pretensioning force always remains constant. Thus, it is only sensible to use tie-downs with elastic materials. Wire rope, chains and even steel straps are unsuitable for use as tie-downs unless they can be rendered elastic by the use of special padding materials.



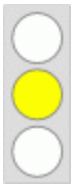




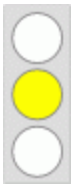


The securing forces only exist if the pretensioning force can be maintained.

This wooden case clearly shows that the steel strapping has left an impression in the wood of the case. Just a few more jolts and the pretensioning force will be reduced to nothing. The use of a piece of tire rubber, as shown in the picture on the right, can effectively help maintain the pretensioning force by making use of the elasticity of the rubber.









Steel wire and tire rubber **Decrease in the pretensioning force**

When transporting materials that give way easily, a padding with a high degree of recovery, like tire rubber, is not going to be very effective. As the picture shows, the loss of pretensioning force is dramatic. Here, a new 16 mm steel wire rope lost tension, dropping from approximately 2,700 daN to approximately 2,100 daN during a 20 minute coffee break. Unfortunately steel wire ropes tend to lose tension. In this example, however, the use of tire rubber is an ideal method of reducing damage to the tarpaulins and to the load.

The magnitude of the pretensioning forces that can be introduced into the lashing material is dependent on the tensioning forces used, the leverage on the tensioning element and the elasticity of

the lashing material. Experience shows that the following lashing materials are able to attain the following pre-tensioning forces in the lashing material when tensioned with normal physical effort:

- Normal ratchet tensioners approximately 300 daN per side
- Tensioner for single-use webbing approximately 500 daN
- Long-lever ratchet tensioners approximately 500 - 750 daN per side
- Commonly available spindle tensioners and capstans 500 - 1,000 daN
- Manual steel strap tensioners 1,000- 1,500 daN
- Lashing turnbuckles approximately 3,000 daN

These values are not definitive; they are based on practical experience gained in a sea port. Practitioners should calculate the appropriate values for their field depending on the materials used. The use of special tensioning aids may make it possible to apply greater pretensioning force. The use of pretension indicators is recommended. These allow both accurate measurement of the pretensioning force during lashing, as well as allowing the residual pretensioning force to be checked during transportation. However, it must be said that this is of little use if the containers cannot be checked during the transportation process.

For reasons that will not be explained here, the pretensioning force is only permitted to be, at the most, half of the MSL or the permitted lashing force of a single lashing.

The vertical component of the pretensioning forces decreases as the lashing angle of the tie-down decreases. From a mathematical point of view, the rate of decrease is by the sine of the lashing angle. The following values can be used as guidelines:

Lashing angle	Magnitude of the vertical component			Graphical representation
90°	1.00	or	100 %	
75°	0.97	or	97 %	

60°	**0.87**	**or**	**87 %**
45°	**0.71**	**or**	**71 %**
30°	**0.50**	**or**	**50%**
15°	**0.26**	**or**	**26%**
0°	**0.00**	**or**	**0%**

Influence of the lashing angle on the vertical component

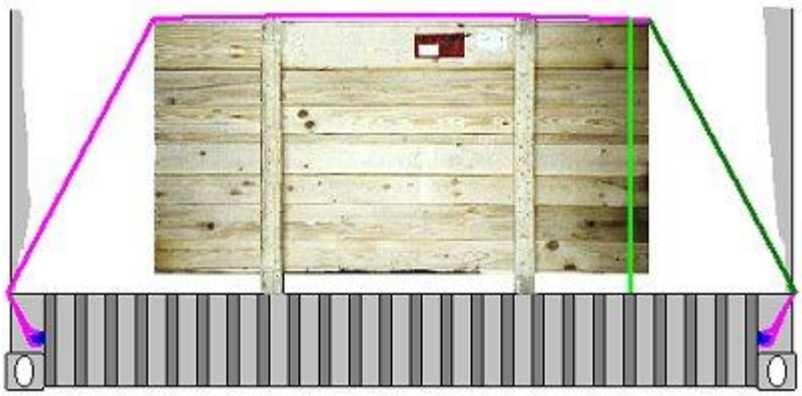
The table below shows examples of the magnitude of the overall securing forces of tie-downs with a total pretensioning force of 600 daN when used with various lashing angles and coefficients of friction.

Total pretensioning force in daN	**Lashing angle**	**Vertical component**	**Friction**						
			0.10	0.20	0.25	0.30	0.40	0.50	0.60
600	15°	0.26	16	31	39	47	62	78	94
	30°	0.50	30	60	75	90	120	150	180
	45°	0.71	43	85	107	128	170	213	256
	60°	0.87	52	104	131	157	209	261	313
	90°	1.00	60	120	150	180	240	300	360

Securing forces depending on pretensioning force, lashing angle and friction

The table shows that with a total pretensioning force of 600 daN, a lashing angle of 90° and a coefficient of friction of 30% it is possible to achieve a securing force of 180 daN per tie-down. Thus, in order to secure a load with a mass of 9 t, 50 (fifty !) tie-downs will be required. This shows that tie-downs have only limited use as securing aids. In addition to this, tie-downs require an equal distribution of the pretensioning force on both sides. This can be achieved by using tensioning elements in pairs, centrally or alternately.

The effective securing forces can be very accurately calculated on site with very little effort and some basic mathematics, as long as the pretensioning and frictional forces are known or can be estimated with some accuracy.



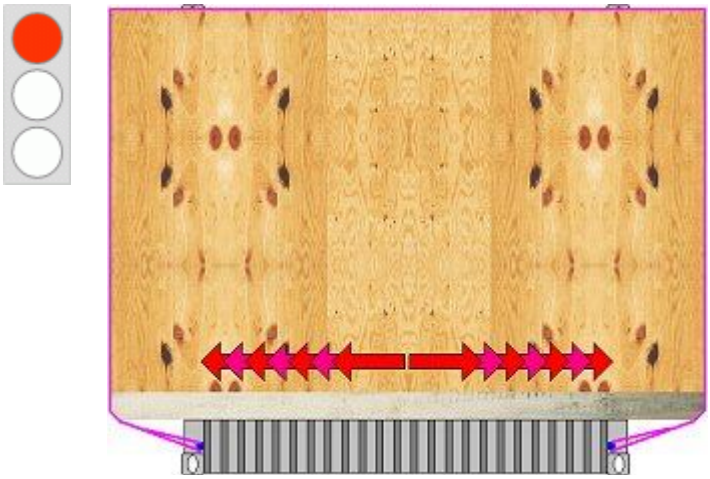
Determining the vertical component of the pretensioning force of a lashing

The effective length of the lashing aid in the example is measured at 1.00 m (dark-green line). The vertical component of the lashing in the example is 0.80 m (light-green line). The vertical component of the pretensioning force is thus 80% or 0.8 (always divide the smaller value by the larger value). Multiplying the value with the pretensioning force of the lashing aid and the coefficient of friction between the package and the surface will give the securing force. With a pretensioning force of 500 daN and coefficient of friction of $\mu = 0.3$, the lashing applies a securing force of 0.8 x 500 daN x 0.3 = 120 daN.

Using conventional materials it would be possible to use tensioners on both sides - but this is not practical. The central use of tensioning aids in container loads is a potential source of accidents since staff need to climb on top of the load. Prefabricated load securing materials usually only have tensioning elements that are not located in the middle and would thus require additional outlay in terms of material and work. Thus, it is recommended that tie-downs should be secured on alternate sides if they are used at all. Shifting of the load is more likely to occur if the tension is not distributed equally. Tie-down lashings can only be used in box containers under certain circumstances. They are easy to use with all forms of platform container, but are not to be recommended.

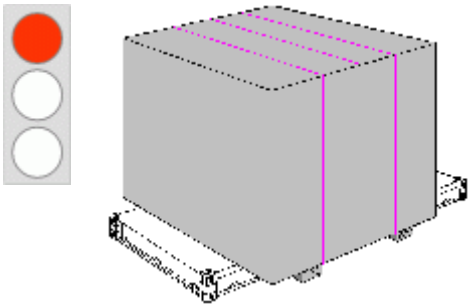
As has already been mentioned, in order to ensure adequate securing of the load, it is necessary to maintain the pretensioning during the entire transportation process. Even the slightest of gaps in the load, the settling of the load, yielding or compression of the load, or the cutting of lashing aids into the load as a result of a lack of edge protectors can all reduce the pretensioning force to zero.

Loads which have an overhang are unsuitable for tie-down lashings for another reason:

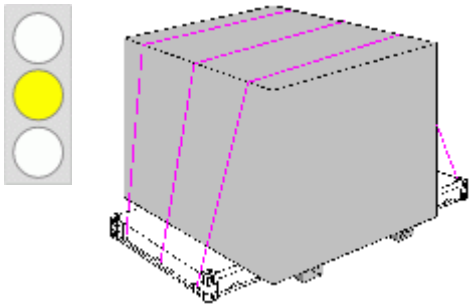


Potential movement of the load caused by too little securing force applied to a wide load

As a result of the unsuitable lashing angle in the lower area, it will be practically impossible to attain sufficient pretensioning force regardless of the type of lashing material used. Thus, the risk is particularly high that the package will shift during transport.



Poor



Not good, but better

To summarize, friction loops or tie-downs can only really be used as an effective form of securing if there are no gaps in the stow, or if any gaps are filled. With small gaps, the use of wedges or tapered blocks is recommended. Larger gaps in the load should be braced using wood or another equally strong material. It must also be possible to create sufficiently high pressure. If this is not possible, loads should be secured using other methods. Lashing materials without sufficient elasticity are not suitable for use as tie-downs. Those with a suitable degree of elasticity, for example lashing straps, will gradually lose their pretensioning force during use. This process will be accelerated if the load is exposed to vibrations.

Tie-downs must thus be checked and, if necessary, tightened at regular intervals. Since this is not possible when a load is stowed in a container, tie-downs are not suitable for securing loads inside containers. Again: If another method of load securing can be used, tie-downs should be avoided!

One thing tie-downs always do is to create a direct lashing acting against vertical movement.

Friction securing can also be achieved using wedges. Another variation is to to put pressure on the load forcing it down. In the event of an absence of available/accessible lashing points, this method of securing may be used in box containers. The prerequisite is the accessibility of components of

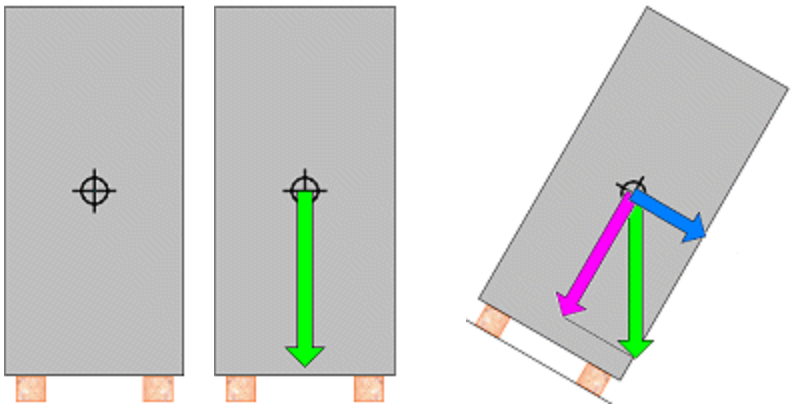
the means of transport that are able to withstand this load.



Principle of downward pressure - Example

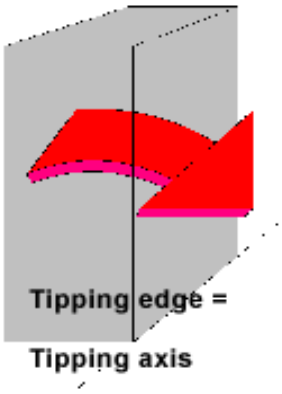
Depending on the magnitude of the securing forces to be created, the sensitivity of the packages and the resilience of the components of the means of transport, squared lumber, planking and boards can be used. Caution: At very sharp angles, driving the diagonal stays in laterally can create extreme vertical forces.

4.3.7 Securing against tipping and other hazards

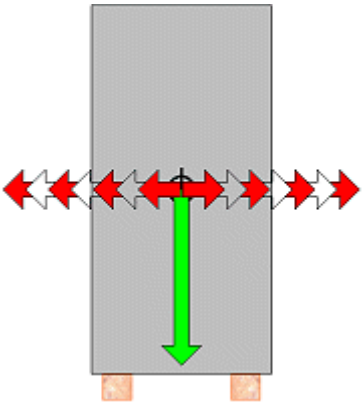


The stability of packages will depend on the position of the center of gravity and the load bearing area. Gravitational forces act on the center of gravity. These act vertically and downwards. On a steep incline, the gravitational force is divided into two components: one acting vertically to the plane and one in the direction of the slope, the shear force. Each of these forces acts on the center of gravity.

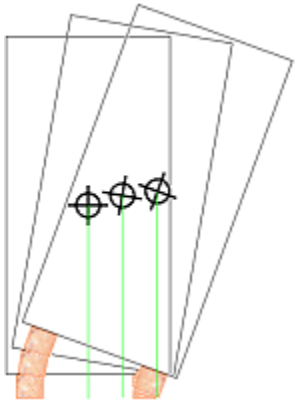




Inertia forces arising as a result of a change in speed or direction within a given time period will also act on the center of gravity. They may cause packages to slide or topple.

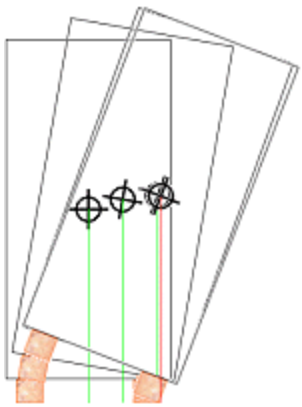


Horizontal forces and gravitation

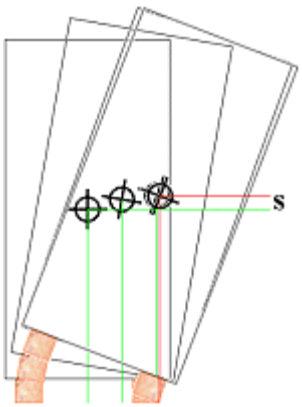


Tipping goods

When an object tips, the center of gravity is raised. If the center of gravity remains within the tilting edges, the package will return to its normal position, as soon as external forces cease to act on it.

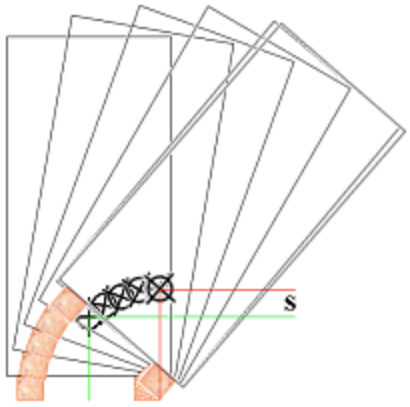


Unstable position

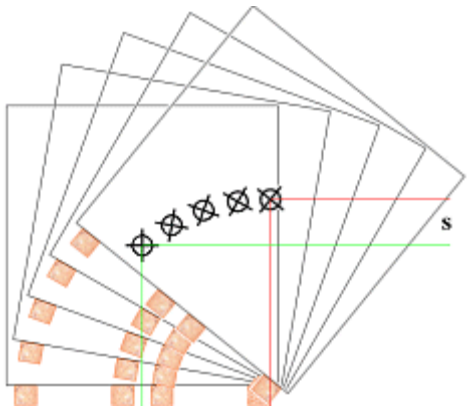


Lever arm of the stability moment

If the center of gravity of an object is located directly over the tilting edge, the package is unstable. The degree to which the center of gravity must be raised before it reaches that position is a measure of the stability of the object. The product of the weight of the object and this distance gives the stability moment.

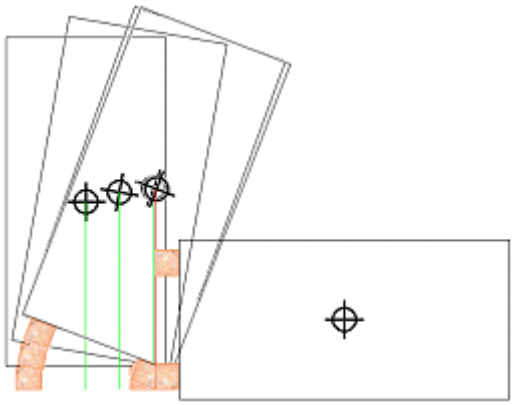


Large stability moment



Larger stability moment

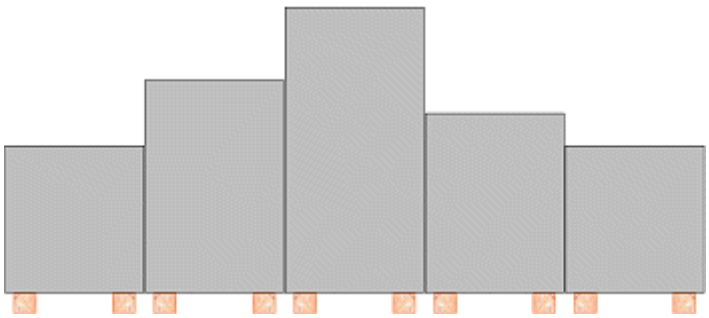
The lower the center of gravity, or the greater the lower surface area of the package, the greater the stability moment.



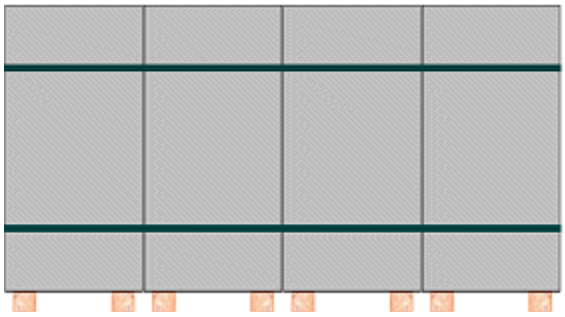
Toppling

If the center of gravity moves beyond the tilting edge then the package will topple.

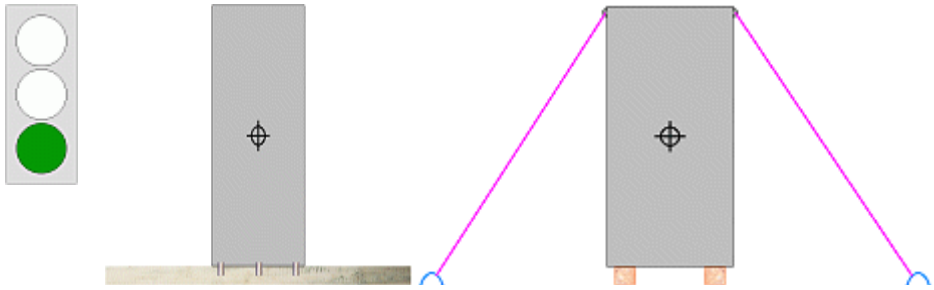
A number of different methods can be used to prevent tipping.



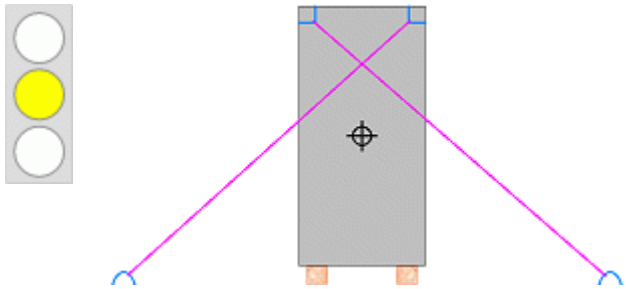
Combining a number of units that are liable to tip to form a single block



Bundling

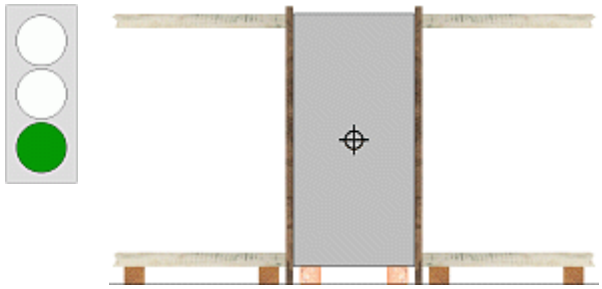


Increasing the lower surface area by using blocks or lashings

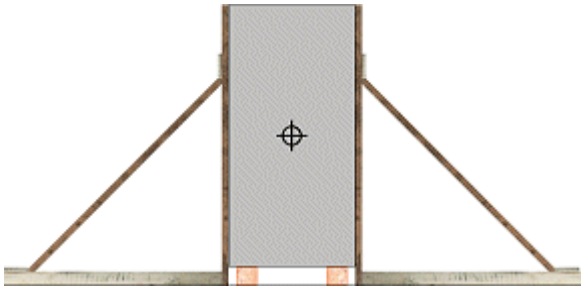


Lashing with head loops in the absence of lashing points

Caution: When using this method, the opposing forces created are not as high as those sketched previously.



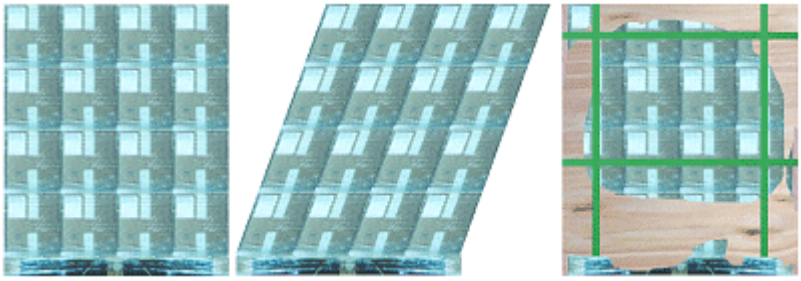
Using bracing elements to prevent tipping



Using diagonal stays to prevent tipping

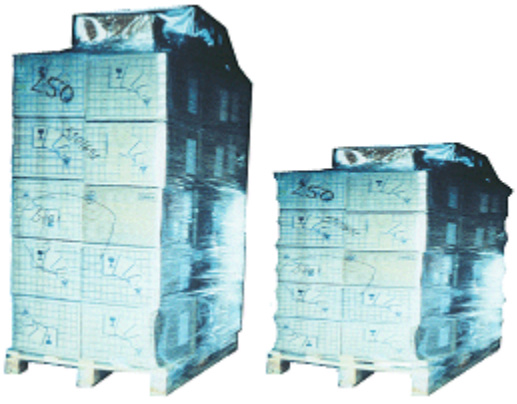
Caution! This method is recommended in a number of publications, including the CTU guidelines. Be warned. Our tests have shown that the uprights can be levered out of position. The steeper the angle, the greater the risk.

The packing and formation of load units is responsible for protecting against shifting or racking:



Shifting or racking

Improvements must be made if packages or unit loads are clearly too weak. This may be done using walking boards, wooden lattices etc. and additional strapping.

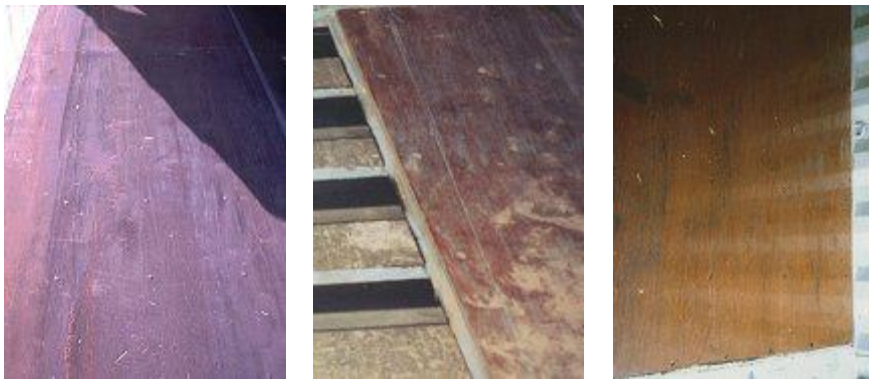


Before - After A collapsed unit load

The collapse of an entire unit load as a result of packaging that is not strong enough and/or excessive stack loads can be avoided by selecting out or rejecting packaging that is not strong enough, by improving the packaging, employing sufficient interlayer dunnage and by building "dummy decks".

4.3.8 Securing by nailing

A popular method of securing loads is to use wooden constructions that are fixed by nailing. Squared lumber and wooden wedges are generally used, but also planks and battens. These solid wooden constructions can only really be effective if the nails used are strong and long, and can penetrate deep into the wood and into a surface which will take nails.



Container floors

Container floors generally have a thickness of just 25 - 30 mm. Also, the majority of floor types will be damaged by the use of nails. Thus, these methods cannot really be recommended for securing in containers. They could be used on softwood planking, as is sometimes used on platform containers, but are not suitable as the only form of securing for heavy goods. Another variation is to create an additional, strong, specially-designed base made of planks or squared lumber beams and driving nails into this.



Wooden beam 5 cm x 12 cm

If the method is not used for light packages that are at risk of tipping, as it usually is, then it must be ensured that only top-quality wood is used, with a thickness of at least 50 mm. Top-quality in this case means, healthy, free from cracks and dry. Shear strength and extraction resistance are influenced by the diameter of the nails, the penetration through the wood, the penetration into the underlying surface, the angle at which the nail is driven in, and the properties of the nail surface. Nails with grooves or with coatings will have higher resistance than ordinary wire nails.

Experience suggests that a nail, 5 mm thick, that is driven in vertically and which penetrates through 50 mm of the grain side of a piece of wood, and is driven in to a depth of 40 mm can be expected to offer 400 daN of resistance. Our own testing suggests that this value can be halved for

wet wood. If the nail is driven in along the grain the values can also be halved. The resistance values are also influenced by the pattern of nails in the wood and the distance between the nails.



Securing using wooden beams



Nail strip for a nail gun

Nails should always be driven in vertically or at a slight angle to the direction of loading. They should not be too close to the edge of the piece of wood, and should not run in a line along the grain. Nails can be driven in efficiently using a compressed air nail gun. Magazines of nails, either rolled or in strips provide a source of nails that can be used with very little physical effort.

When using wedges to secure loads, badly cut wedges are often selected. Basically, wedges should be cut and positioned in such a way that the long side of the wood, i.e. the grain side, is the side that is nailed, and not into the grain.



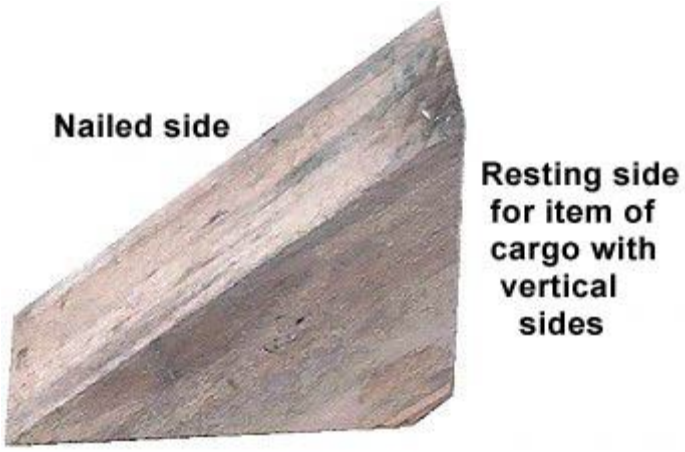
Correctly cut wedge for securing cylindrical objects

Wedges of this type are also called chocks, roll or pipe wedges. The critical factor is that the grain side of the wood is available to take the nails.



When used as a wedge for loads with vertical surfaces: Wrong

This is the same wedge, but now it is placed differently. If a packer were to use this to secure a case, they would need to drive a nail into the grain. The wedge would split either during nailing or on one of the first jolts during transportation. Tests have shown that when wedges are used incorrectly barely half of the resistance values are achieved than would be achieved if used correctly.



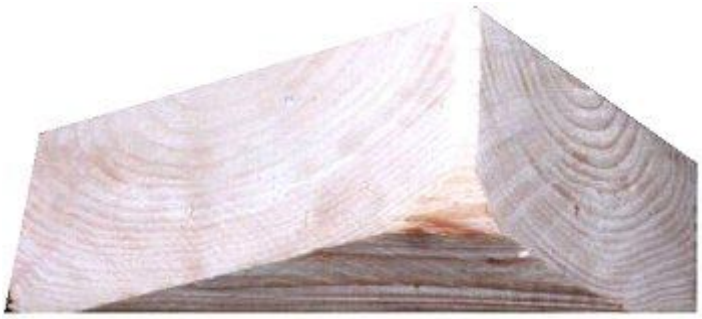
(Almost) correctly cut wedge for goods with vertical surfaces

A wedge of this nature can be referred to as a crate wedge. Here, it is obvious what is meant. The nail can be driven into the grain side - and rightly so. However the slope of the flank is too steep.



Correctly cut crate wedge

Here the slope of the flank is much better suited to the requirements of a crate wedge.



When used as a wedge for cylindrical objects: Wrong

If the crate wedge was to be turned the other way, it would make an incorrect pipe wedge.



Sawing patterns for pipe wedges

There is no waste material when cutting pipe wedges. Any flank angle is possible. The right angles are always at the outside edge of the piece of wood.



Sawing patterns for crate wedges

When cutting crate wedges, make one cut at the required flank angle and then continue at right angles. Any flank angle is possible. The steeper the starting angle, the slimmer the wedge. The right angles are always on the inside of the piece of wood.

If the packers are using wedges for both cylindrical and right-angled loads, a plentiful supply of both types should be made available.





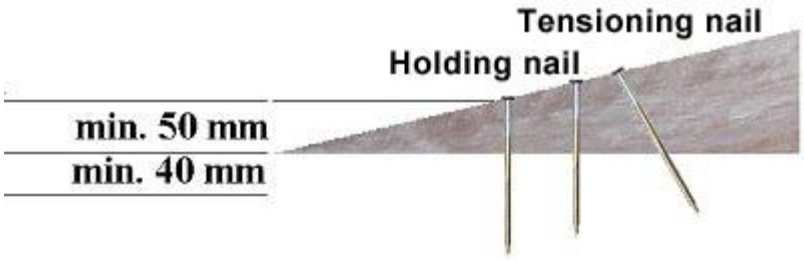
Pallet with pipe wedges **Pallet with crate wedges**

As a general rule, however, very little attention is paid to the instructions described here:



Incorrectly cut crate wedges, or pipe wedges used as crate wedges

It can be seen clearly that the wedges have already started to split. The function and effectiveness of the nails are to be doubted. They appear to be located too high up to fulfill the following requirements: For each wedge, at least three nails are necessary, one tension nail and two to hold the wedge in place.



Minimum conditions for nailing wedges and boards

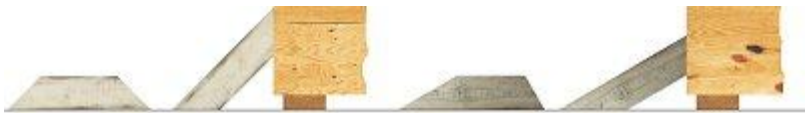
The tension nails have the task of pulling the boards and wedges close to the load in order to

eliminate any damaging gaps.



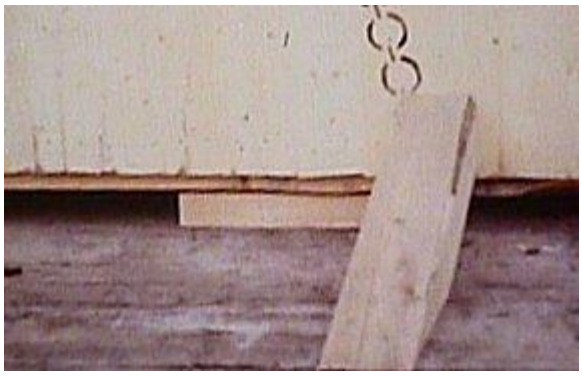
Nails in boards (left: holding nails, right: tension nails)

With boards, the nails can also be driven in against the direction of loading.



Wedge-shaped board cut to fit

This type of securing with wood is not usually capable of achieving the result expected of it.



Securing that has no effect

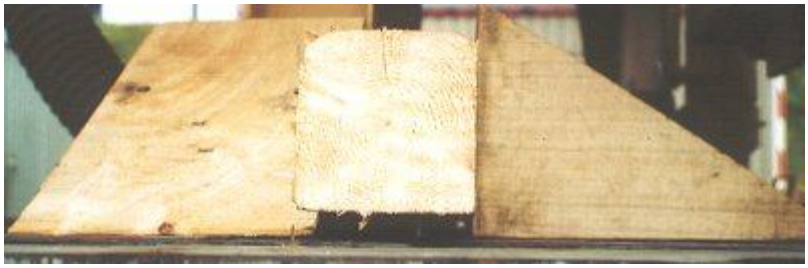
This form of board is not able to counteract the nail being lifted out of the floor.



Wrong type of wedge, in the wrong place

This wedge has been cut incorrectly. It has thus already split as a result of a hammer blow or a jolt

during transportation. The effective height is too small, the nails can easily be levered out.



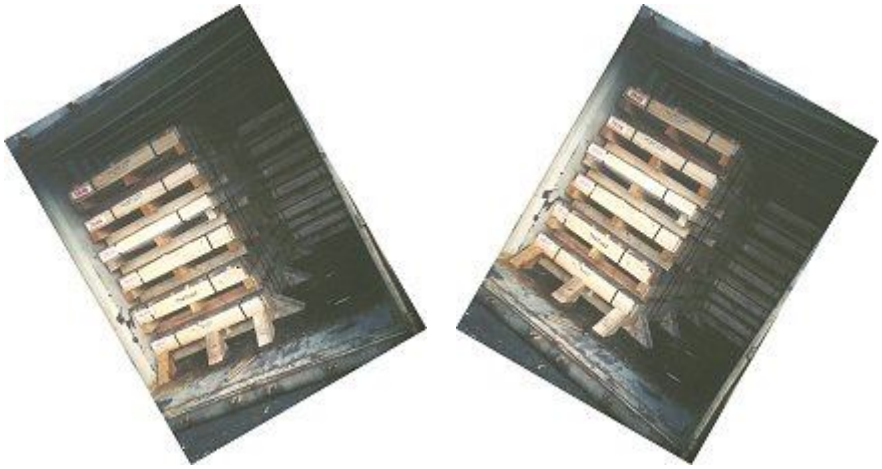
Incorrectly cut wedges



Incorrectly cut wedges



Correctly cut wedges - but insufficient securing



Simulation of a 30° roll angle of a vessel



Radial wedges



Tank wedge with a nose for the nail

Specially designed wedges of a variety of shapes can be used to secure special types of load. The securing effect is achieved by the shape of the wedge itself. The nails serve purely to hold the wedge in place.

4.4 Load securing equipment

This section of the Container Handbook deals with how to determine the maximum securing load of materials used for load securing using simple rules of thumb and explains some basic principles for practical work.



Steel wire rope



Lashing point



Steel strap





Inspecting and measuring lashing equipment

Note: Sections in italics have been reproduced from seminar material by kind courtesy of Captain Hermann Kaps, professor at the University of Applied Sciences in Bremen.

Fundamental terms

kilonewton (kN) is a unit of force useful for describing for instance the breaking strength or breaking load of load securing material. It has replaced the previously common metric ton which is the unit reserved for describing mass according to the SI standard. The conversion is easily learned: 1 kN ≡ 0.1 t or 100 kg.

Anyone who was used to calculating mass in kilograms can use the unit decanewton (daN) as a unit of force.

The following English terms are in common use in maritime transport across the world.

***Securing element** is an individual item of equipment on board ship which is used for load securing, e.g. a shackle, a deck ring, a turnbuckle, chain or wire rope.*

Securing device *is a suitable combination of elements which together form a means of load securing, e.g. lashing or bracing.*

Securing Arrangement *is a reasonable arrangement of load securing means with the aim of securing a cargo item or a cargo block.*

Breaking Load (BL) *is the nominal breaking load, generally specified by the manufacturer. However, it can also be estimated using rules of thumb.*

Maximum Securing Load (MSL) *in kN, is the greatest permissible force which can be applied to a load securing element or device.*

Calculation Strength (CS) *in kN, is an arithmetic force determined by reducing the MSL by the formula: CS = MSL / 1.5. CS values are only used to assess the efficiency of securing arrangements as per Annex 13 of the CSS code.*

The relation between Breaking Load and Maximum Securing Load is shown in Annex 13 by the following table:

Material	MSL
Shackles, rings, deck eyes, turnbuckles of mild steel	50% of breaking strength
Fiber ropes	33% of breaking strength
Web lashing	70% of breaking strength
Wire rope (single use)	80% of breaking strength
Wire rope (re-useable)	30% of breaking strength
Steel band (single use)	70% of breaking strength
Chains	50% of breaking strength
lumber	0.3 kN per cm^2 normal to the grain

Table: Determining the MSL from the breaking load

Lashing elements and lashing materials *There are no international standards on tie down lashings. It is to be expected, however, that manufacturers or dealers will provide information on or certification of the nominal breaking load on purchase. It is, however, generally unclear how this value was determined and under what conditions it is valid. No reference is made to any other properties, such as elasticity and fatigue strength.*

The table below provides a list of the most important materials and elements with the usual characteristic values. An accepted rule of thumb is used for the breaking load.

If millimeters are chosen instead of centimeters for the dimensions, the breaking load values will be in decanewtons [daN] instead of kilonewtons.

Material/element	***Breaking load [kN]***	***Notes***
Natural fiber ropes (manila, sisal, hemp)	*6 x d²*	*d = diameter of rope in cm. Natural fiber ropes are sensitive to decay, acids and alkalis. All fiber ropes are sensitive to chafing from sharp edges. Knots on synthetic fiber ropes can slip open. Heavers of sufficient thickness should be used to tighten them and these in turn should be secured to prevent them from unwinding.*
Polypropylene	*12 x d²*	
Polyester	*15 x d²*	
Polyamide	*20 x d²*	
Hercules (sisal)	*6 x d²*	
Hercules (polypropylene)	*12 x d²*	

Material/element	***Breaking load [kN]***	***Notes***
Wire rope 6 x 9 + 1 FC *Wire rope 6 x 19 + 1 FC* *Wire rope 6 x 37 + 1 FC*	*50 x d²*	*d = diameter of rope in cm. Producing conventional wire rope lashings with turnbuckles and rope clips is technically demanding and can give rise to a number of potential problems. More detailed notes are provided after this table.*
Wire rope 6 x 9 +7 FC *Wire rope 6 x 12 +7 FC* *Wire rope 6 x 15 +7 FC*	*25 x d²*	

Material/element	***Breaking load [kN]***	***Notes***
Shackles	*20 x d²*	*d = diameter of bolt in cm. The breaking load formula only applies to shackles made of standard strength steel.*
Turnbuckles	*20 x d²*	*d = diameter of thread in cm. The breaking load formula only applies to turnbuckles made of standard strength steel.*

Material/element	***Breaking load [kN]***	***Notes***
Untreated steel strap *Blued steel strap*	*70 x w x t* *85 x w x t*	*w = width of strap in cm* *t = thickness of strap in cm.*

Material/element	***Breaking load***	***Notes***

	[kN]	
Long- and short-link chains with different tensioners	*See manufacturer's specifications*	*Tie down lashing chains are always made of higher strength steel to save weight. Calculation of the breaking load is therefore dependent on the manufacturer's specifications.*

Material/element	Breaking load [kN]	Notes
Deck eyes and eye plates	*$20 \times d^2$*	*d = diameter of eye material in cm. The breaking load formula only applies to material made of standard strength steel.*

Material/element	Breaking load [kN]	Notes
Synthetic fiber lashing belts	*See manufacturer's specifications*	*Lashing belts are produced in a number of different grades. They are highly elastic but can become permanently deformed when subjected to threshold stresses greater than 50% of the breaking load and therefore quickly become loose. They must not be knotted. They are sensitive to external influences in the same way as synthetic fiber ropes.*

Material/element	Breaking load [kN]	Notes
Weld joints subjected to shear loads	*MSL = 4 kN per cm*	*Single-layer weld, 4 mm thick.*
	MSL = 10 kN per cm	*Three-layer weld, 10 mm thick.*

Material/element	Breaking load [kN]	Notes
Softwood used for bracing	*MSL = 0.3 kN per cm^2*	*Compressive load perpendicular to the grain*
Softwood used for bracing	*MSL = 1 kN per cm^2*	*Compressive load parallel to the grain*

Material/element	Breaking load [kN]	Notes
Special equipment for ro/ro ships	-	*Trailer horses, trailer jacks, wheel chocks; breaking loads usually unknown*

Special equipment for container ships	*See manufacturer's specifications*	*Lashing rods, turnbuckles, twist locks, D rings, sockets, bridge fittings, tie plates, etc. Strength and material properties as per the requirements of the relevant classification society*

For economic reasons, it is advisable to try to homogenize load securing equipment and load securing arrangements.

> ***Homogeneous load securing equipment*** *comprises elements which where possible have the same MSL values.*
>
> *A* ***homogeneous load securing arrangement*** *comprises load securing equipment which are arranged in such a way that, when subjected to extreme loads, they bear the part of the load appropriate to their strength.*

To summarize the problems of load securing, some examples are provided below as a sort of "recipe" how to calculate the number of securing devices required, what such a device can withstand and what can be expected of it.

Example: Tie-down lashing:



Use of tie down lashings

Let us assume that the wooden case on the flatrack has a weight of 12,000 daN. Without taking into account the risk of this overheight case tipping, the package must be secured for overseas shipment. Lateral acceleration forces of 0.8 g can be expected. This means that lateral forces of 12,000 daN x 0.8 or 120 kN x 0.8 i.e. 9,600 daN or 96 kN can be expected.

The single-use webbing belts used in the figure on the left have a breaking load of 3,433 daN. This equates to 2,403 daN at an MSL no greater than 70% of the breaking load. No more than half of this, i.e. around 1,200 daN, may be used as the pretensioning force. It should be noted that in practice this value can neither be achieved nor maintained throughout the entire voyage.

The effective length of the belt from its attachment to the lashing point to the edge of the case (red

line) is 3.0 m. The effective height (green line) is 2.93 m, a very high vertical component (97.6%). This component can be determined for any load by dividing the effective height by the effective length. Multiplying this by the pretensioning force gives the force with which the tensioned side of the load is pulled onto the flat. In the example, this is 97.6% of 1,200 daN, or 1,171 daN. If we assume ideal conditions and this force were completely transmitted to the other side, a total pretensioning force of 2,342 daN per lashing can be assumed. Assuming a friction coefficient of 0.3, a single tie-down lashing can achieve a securing force of around 703 daN. 13.65 belts are theoretically required to secure the case (9,600 daN/703 daN). In reality, the webbing belts used would be able to maintain a maximum pretensioning force of around 100 daN through 200 daN during the voyage. This means that a single belt is able to maintain a long-term securing force of 30 daN through 60 daN. To have really "secured" the case, somewhere between 160 and 320 belts would have to be provided!!!

Note: Tie down lashings only provide securing forces of the vertical component of the pretensioning force multiplied by the friction coefficient.

Note: The pretensioning force must never be greater than 50% of the MSL of the weakest securing element.

This recipe is simpler and more precise than a calculation which uses the lashing angle α, since in practice distances are easier to measure than angles. If the vertical component of a lashing is to be calculated using the lashing angle, the permissible lashing force must be multiplied by the sine of the lashing angle: vertical component = MSL x sin α.

The smaller the lashing angle, the smaller the vertical component will be. At a lashing angle of 90° it will be 100% (sin 90 ° = 1), at 75° 97% (sin 75 ° = 0.9659), at 60° 87 % (sin 60 ° = 0.866), at 45° 71% (sin 45 ° = 0.7071), at 30° 50% (sin 30 ° = 0.5), at 15° 26% (sin 15 ° = 0.2588) and at 0° 0% (sin 0° = 0).

Example: Direct lashing:

The main difference between direct lashings and tie-down lashings is that with direct lashings, the pretensioning force can and should be kept as low as possible.

Note: The pretensioning force should be as low as possible on direct lashings. However, slack must never be able to develop in lashings.

The pretensioning force must, however, be sufficiently high to prevent a lashing from becoming slack. The reason for this is that the lashing may be loaded up to its MSL under stress and the vertical components resulting from this produce additional frictional forces.



Direct lashing with chains

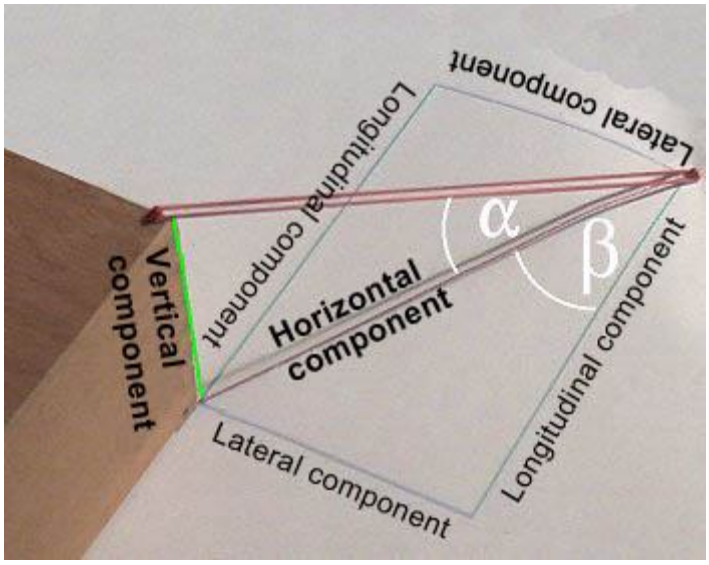
For those who enjoy mathematics, the relevant lashing forces can be calculated by first measuring the lashing angle α (47.5°) and then the sine and cosine of this angle to determine the vertical and horizontal components and using these in conjunction with the permissible lashing force of the chain.

Using another recipe, it is unnecessary to determine this angle or its sine and cosine. Basic arithmetic will suffice. The following lengths are determined by using a tape measure or meter rule: the effective length of the lashing chain (red line = 3.61 m), the effective vertical component (green line = 2.66 m) and the effective horizontal component (blue line = 2.44 m). Using rules of thumb or the manufacturer's specifications, the breaking load and the MSL of the 13 mm link material diameter high-tensile chain. This corresponds to 10,000 daN. Checking the size of the lashing point gives a steel diameter of 28.3 mm. This gives a breaking strength of 16,000 daN and an MSL of 8,000 daN. This value represents an upper threshold if the chain components have a higher MSL.

Vertical securing force: 2.66 m : 3.61 m x 10,000 daN = 7,368 daN. A lashing chain secures the package against vertical movement with a force of 7,368 daN. But this is not so important. This force becomes effective when the package is moved horizontally causing the chain to be tightened; the package is then pulled toward the floor with this force. Assuming a sliding friction coefficient of 30% (μ = 0.3), the package is secured by a lashing in all directions with a force of 7,368 daN x 0.3 = 2,210 daN.

Shortfall in securing force: 2.44 m / 3.61 m x 10,000 daN = 6,759 daN. A lashing chain directly secures the package laterally with 6,759 daN. To this are added the frictional securing forces of 2,210 daN as previously determined. The calculated chain lashing secures the machine component against movement laterally towards the right with a force of 8,969 daN.

Since no longitudinal components exist, a chain only secures the machine component longitudinally with the frictional forces produced by the vertical component of 2,210 daN.



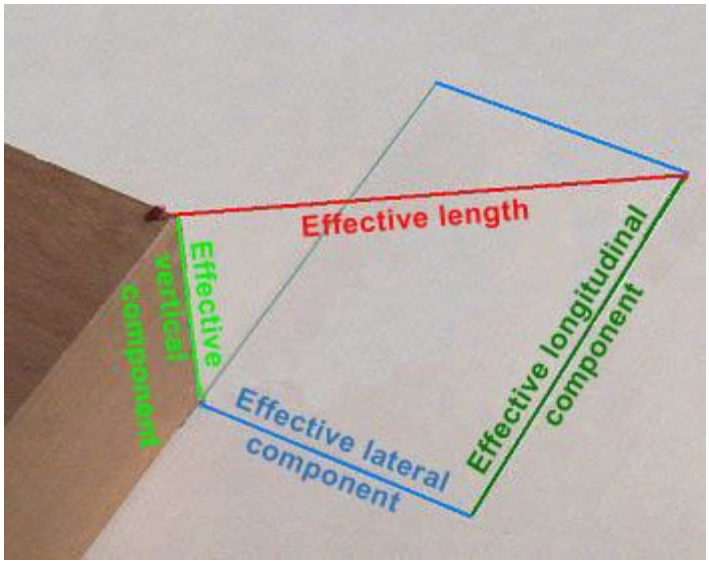
Different components on a diagonal lashing with lashing angles

To calculate the longitudinal, transverse and vertical securing forces using the lashing angles α and β, use the following method:

Component	Calculation
Vertical component	MSL x sin α
Horizontal component	MSL x cos α
Additional frictional forces	Vertical component x μ or MSL x sin α x μ
Pure lateral component	Horizontal component x sin β or MSL x cos α x sin β
Pure longitudinal component	Horizontal component x cos β or MSL x cos α x cos β

Since the additional frictional forces produced by the vertical component may be added to the forces produced by the lateral and longitudinal components, the securing forces produced are:

Securing forces	Calculation
Vertical securing	MSL x sin α
Lateral securing	MSL x cos α x sin β + MSL x sin α x μ
Longitudinal securing	MSL x cos α x cos β + MSL x sin α x μ



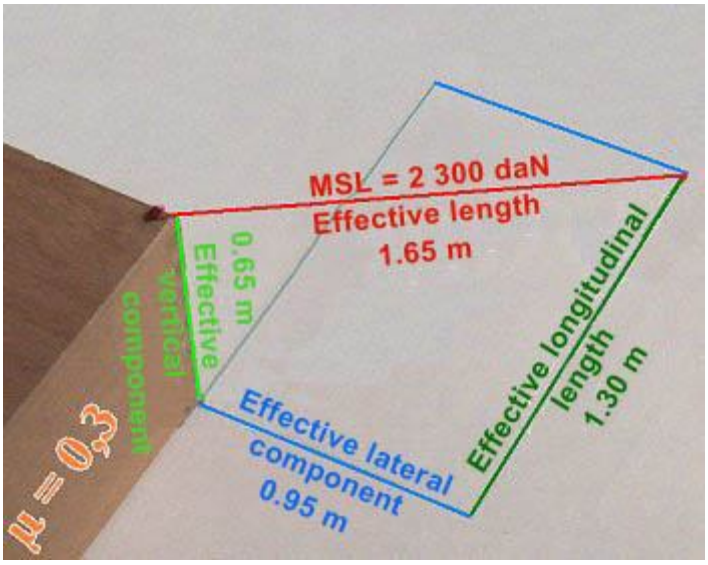
Determining the securing forces

Again, a recipe is quicker, simpler and more precise. Four distances must be measured and the MSL of the weakest load securing element must be determined. The friction coefficient must be determined or estimated.

Securing forces	Calculation
Vertical securing	Effective vertical component / effective length x MSL
Additional frictional forces	Effective vertical component / effective length x MSL x μ
Lateral securing including additional frictional forces	Effective lateral component / effective length x MSL + effective vertical component / effective length x MSL x μ
Longitudinal securing including additional frictional forces	Effective longitudinal component / effective length x MSL + effective vertical component / effective length x MSL x μ

Calculated example:

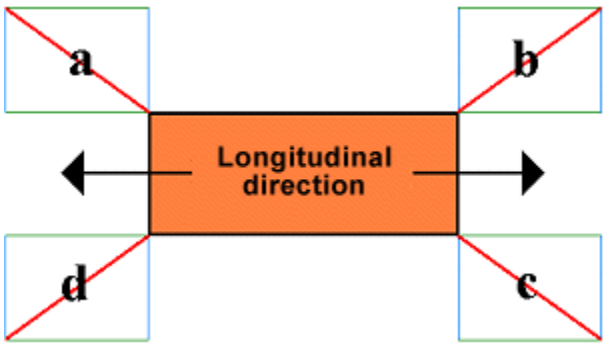
A doubled, single-use webbing belt is used for securing as previously. For reasons of caution, the MSL is not assumed to be 70% but only 30% of the breaking load. The sketch below shows all the data needed.



Calculated example: Determining the securing forces

Securing forces	Calculation
Vertical securing	0.65 m / 1.65 m x 2,300 daN = 906 daN.
Additional frictional forces	0.65 m / 1.65 m x 2,300 daN = 906 daN x 0.3 = 271.8 daN
Lateral securing including additional frictional forces	0.95 m / 1.65 m x 2,300 daN = 1,324 daN + 271.8 daN = 1,595.8 daN
Longitudinal securing including additional frictional forces	1.30 m / 1.65 m x 2,300 daN = 1,812 daN + 271.8 daN = 2,083.8 daN

As far as the overall securing is concerned, it should always be borne in mind what lashings are subjected to loads under what circumstances:

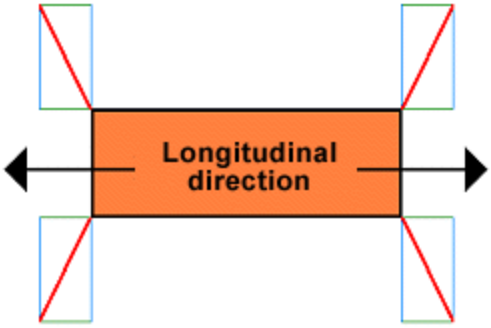


Package secured with four diagonal direct lashings

Upward	4 x vertical securing = 4 x 906 daN	3,624 daN

Longitudinally, to the left	The longitudinal components of b and c restrain	4,167.6 daN
Longitudinally, to the right	The longitudinal components of a and d restrain	4,167.6 daN
Laterally, upward	The lateral components of d and d restrain	3,191.6 daN
Laterally, downward	The lateral components of a and b restrain	3,191.6 daN

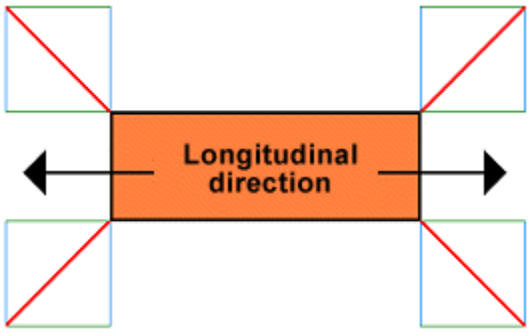
It can be concluded that the lashing arrangement would not be not homogeneous if the load in the example were loaded on a flatrack transported using fore and aft stowage on a container ship, where acceleration forces of 0.4 g occur longitudinally and acceleration forces of 0.8 g occur laterally. In this instance, the lashings would need to have been arranged so that the lateral component was twice the size of the longitudinal component:



Lateral components twice as large as longitudinal components

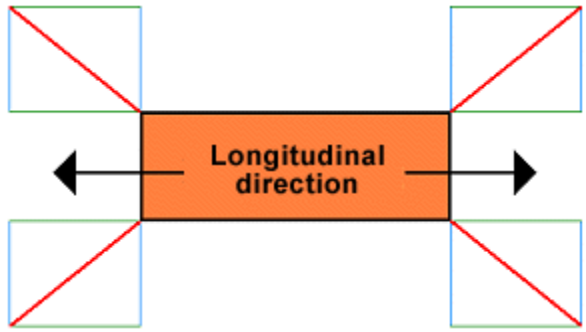
If it is assumed that the flatrack is transported using fore and aft stowage on a container ship and transported during precarriage and/or onward carriage on a road vehicle, longitudinal and transverse acceleration forces of 0.8 g should be assumed for the lashings.

The decision in this instance is simple: both components must be the same size.



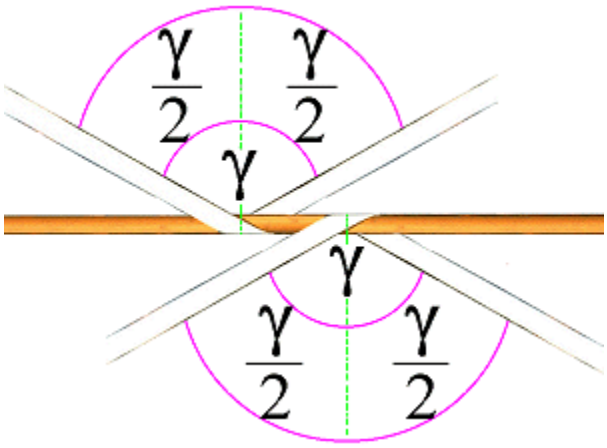
Transverse and longitudinal components same size

If the flatrack is transported during precarriage or onward transport on a freight car in multimodal operations, longitudinal acceleration forces of 1 g are assumed. If lateral acceleration forces of 0.8 g are assumed, the longitudinal components must be 25% larger than the lateral components or the lateral components can be 20% smaller than the longitudinal components:



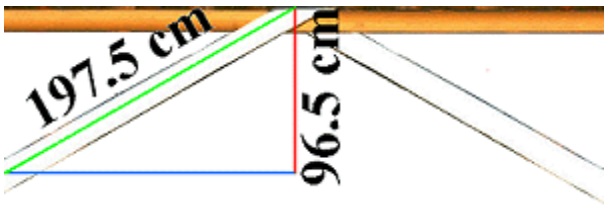
Longitudinal components 25% larger than lateral components

Using tie-down lashings also produces angles which cause a reduction in the MSL. The effects are not very dramatic because they are the cosine of half the opening angle between the ends of the lashing. It does not really matter whether angles are measured and forces are calculated or lengths are measured. It is easier for people familiar with mathematics to calculate using the trigonometric function than to measure distances - provided a pocket calculator with trigonometric functions or a relevant table is available. Both methods are feasible. Anyone who is familiar with a the shape of a cosine wave or has certain values in their head, can also make a good estimate.



Angle which is too large to be permitted

The angle γ is 121.552°, but who can ever determine an angle as precisely as this? Half this angle is 60.776°. The cosine of this angle is 0.488. This makes it obvious that this type of securing is ineffectual. The mathematically calculated part only generates securing forces which are less than half. It would have been better to have secured the cargo with a single-strand direct lashing. The cosine of 60° is 0.5. It is therefore clear that lashings are only worthwhile if their opening angle - i.e. the complete γ - is significantly less than 120° and γ/2, significantly less than 60°. The same could have been determined - possibly more quickly - by taking measurements:

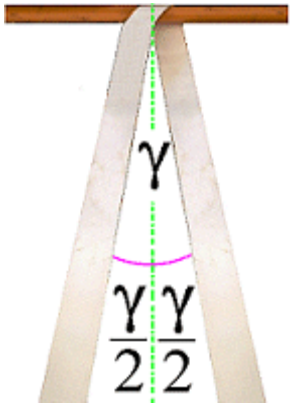


As previously: Angle which is too large to be permitted

The effective length of one end of the lashing is 197.5 cm, the effective lateral dimension is 96.5 cm. This is less than half. Both ends of the lashing together are thus less than 1. It can also be seen and proved from this that this lashing is not worthwhile.

This does not apply here:

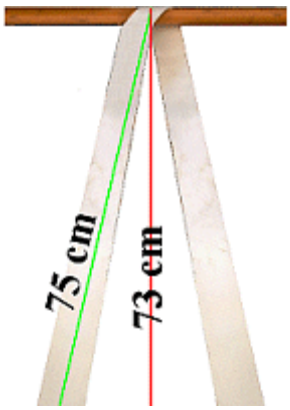
The opening angle here is γ 27° (γ/2 is thus 13.5°). The cosine of 13.5° is 0.973 - i.e. close to 1. This means that this securing aid achieves nearly double the MSL, or to be precise 1 times the MSL of a single strand.



Angle used for tie-down lashings in practice

Measuring would have produced approximately the same results:

If - using our recipe - the smaller measured value is divided by the larger measured value, the result is 0.973. That means, the lashing secures 2 x 0.973 times, i.e. 1.946 times the MSL of a single strand.



As previously: Angle used for tie-down lashings in practice

To be precise, the angle between the ends must be measured in 3D space, since lashings which are attached to separate lashing points form an "oblique" angle to each other. These problems should not occur during measuring, even if one end comes from the top and the other end comes from the bottom.

Here are the rough guideline values for the MSL at different estimated angles:

Estimated angle	MSL of the lashing
120°	2 x MSL of a single strand x 0.50 = 1.0 x MSL of a single strand
90°	2 x MSL of a single strand x 0.70 = 1.4 x MSL of a single strand
60°	2 x MSL of a single strand x 0.87 = 1.7 x MSL of a single strand
40°	2 x MSL of a single strand x 0.92 = 1.8 x MSL of a single strand
30°	2 x MSL of a single strand x 0.97 = 1.9 x MSL of a single strand
< 30°	2 x MSL of a single strand x 1.00 = 2.0 x MSL of a single strand

4.4.1 Lashing materials

The term "ropes" covers a wide range of manufactured ropes made of different materials for different purposes. In the field packing and load securing, a distinction is made between:

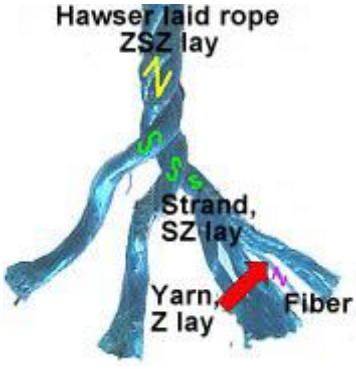
- Fiber ropes
- Wire ropes and
- Composite or mixed ropes

Fiber ropes are divided into:

- Natural fiber ropes and
- Synthetic or man-made fiber ropes



Natural fiber rope



Split fiber rope made of polypropylene

Ropes are made in a number of different ways. Generally, a distinction is made between laid rope and braided rope. In many cases, the way a rope is manufactured determines how it is treated and used. The basic process used to manufacture laid fiber ropes is as follows: When they have been obtained from the raw materials, the fibers are combed to separate them. These are then twisted to produce yarns. In the trade, this is known as laying. If the direction of lay is to the right, it is known as Z-laid, or if it is to the left, it is known as S-laid. In the next stages of the process, the directions of lay are alternated. This is referred to as a 'cross lay' or 'conventional lay'. A cable lay is only used

for very strong fiber ropes - but this is not relevant for load securing purposes: In the normal direction of lay, three Z-laid ropes are laid to the left to produce a cable; in the opposite direction of lay, three S-laid ropes are laid to the right to produce the finished cable. The normal direction of lay is also known as Z-lay or ZSZS-lay in and the opposite direction of lay is known as S-lay or SZSZ-lay.



Natural and synthetic fiber ropes - all hawser-laid and Z-laid

Laid (twisted) ropes are generally used for load securing purposes.

They are generally type A hawser-laid, i.e. a 3-strand rope is used. There are both Z-laid and S-laid versions of this type. The normal direction of lay, however, is to the right.

Natural fiber ropes are no longer used for load securing in most industrialized countries. In some countries, however, natural fiber ropes may be used for securing loads in or on specific cargo transport units. This includes in particular ropes of the following materials:

- Hemp (Ha)
- Manila (Ma)
- Sisal (Si)
- Manila mixed (Ma/Si)

Natural fiber ropes are very sensitive to acids, alkalis and solvents. Mold and other microorganisms attack the fibers. Manila and sisal are comparatively resistant to natural weathering, but hemp loses its strength very quickly unless it is impregnated. As impregnated ropes usually have a strong odor, they must not be used for odor-absorbent or odor-sensitive cargoes. Natural fibers swell when they absorb moisture and shrink on drying. Fluctuations in moisture content result in considerable changes in the length of ropes:

- The ropes become shorter when wet;
- The ropes become longer when dry.

For the above reasons, it is very difficult to maintain uniform tension in the ropes. Their range of application is therefore limited to use in closed cargo transport units where no great fluctuations in humidity are to be feared. Natural fiber ropes are also combustible and can lead to spontaneous combustion in connection with certain chemicals. One advantage is thst natural fiber ropes are "environmentally friendly". Since they decay quickly, they can be disposed of without any problems.

The main raw materials for synthetic fiber ropes are:

- Polyester (PES)
- Polyamide (PA)

- Polypropylene (PP)
- Polyethylene (PE)
- Hempex

Polyester exhibits exceptionally good behavior with acids, alkalis and solvents and also only loses very little strength due to natural weathering; it is therefore very UV-stable. Polyester ropes are not purchased for load securing purposes, however, as they are relatively expensive.

Polyamide (generally known under its trade names nylon, perlon etc.) exhibits good behavior with alkalis and solvents but is sensitive to acids. It loses around 20% of its strength per year from natural weathering, especially UV radiation. Because of its price, polyamide is rarely used for load securing purposes.

Polyethylene has no place in load securing on account of its poor mechanical properties. It is even banned for use as slinging ropes.

Hempex is a modified polypropylene material which looks so similar to the natural fiber hemp that it is often confused with it. It is UV-resistant but in terms of its strength not much better than natural fiber ropes. As it is particularly soft, it is sometimes used to fasten tarpaulins etc.

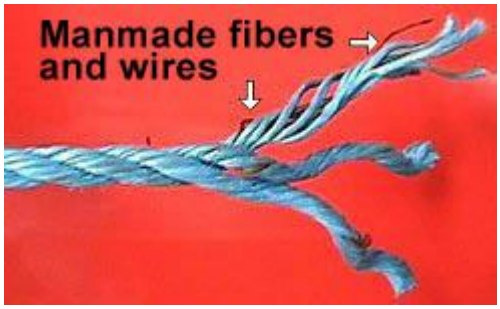
Polypropylene exhibits very good resistance against acids, alkalis and solvents. If it is not stabilized, however, it is very sensitive to natural weathering. For this reason, polypropylene ropes should always be light and heat stabilized. Black dyed ropes are best suited for this. Their strength only decreases at around 5% per year from natural weathering.

There are two main groups of polypropylene ropes:

- monofilament ropes and
- multifilament fiber ropes.

Monofilament ropes behave exceptionally well under dynamic strain, but because of their material properties are difficult to knot. Knots tend to come undone. Monofilament ropes are thus almost exclusively used as slinging ropes. They are stronger than a steel-reinforced "Hercules", but it is not to be recommended that they be purchased as load securing material.

Multifilament ropes exhibit very negative properties when they are dynamically stressed. Movement causes the fibers to separate further, which quickly produces a rupture. This type of stress rarely occurs with load securing. For this reason, composite ropes are produced for load securing purposes generally use multifilament materials.

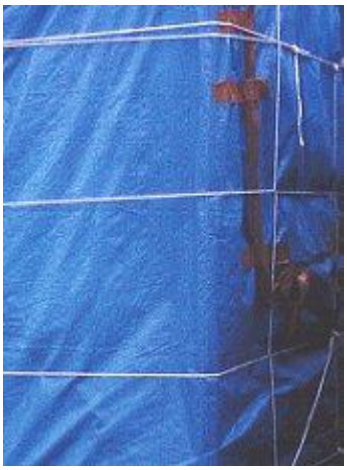




Steel-reinforced "Hercules" lashing rope

The type of composite rope generally used for lashing purposes is known as "Hercules". This is a rope made of steel wire and natural or synthetic yarns.

Predominantly, "Hercules" made of interwoven polypropylene and wires is sold as lashing material. Ropes of interwoven wire and sisal are no longer commonly used in most industrial countries. "Hercules" has the same strength for lashing purposes as ropes made of sisal or polypropylene with the same diameter, because the wire in Hercules does not have a load-bearing function. The individual wrapped wires have a very low strength and are only intended to increase the rigidity of the material and improve its twisting properties, e.g. when tightening it with a Spanish windlass. The main advantage of "Hercules" over fiber ropes is not its strength but improved handling. In terms of its pure material properties, the same applies as for sisal or polypropylene. It must be stressed again that it exhibits good properties in terms of resistance to aggressive substances.



Thin ropes for securing tarpaulins



Car secured with "Hercules" lashing

Fiber ropes are suitable for securing tarpaulins and relatively light loads, e.g.

- Automobiles in or on containers
- Drum cargoes, fiber drums and similar loads in small batches and light receptacles
- Fairly light cases, small batches of boxed goods, individual pallets etc.





5 mm thick polypropylene rope for securing

tarpaulins etc.

The MSL (Maximum Securing Load) of fiber ropes is 33% of the breaking load. Since the breaking load of polypropylene can be calculated with a rule of thumb using the formula 12 x d², the MSL for the rope shown is 1 kN or 100 daN, depending whether the diameter was specified in centimeters or millimeters.



Calculating the diameter of a polypropylene strap: 5 mm

Breaking load	MSL factor	MSL	
0.5 x 0.5 x 12 = 3 kN	x 0.33 =	1 kN	(diameter in cm)
5 x 5 x 12 = 300 daN	x 0.33 =	100 daN	(diameter in mm)

Since a factor of 33% is corresponds to virtually one third, the MSL can also be calculated directly with an easily remembered formula:

MSL of polypropylene ropes = d x d x 4

If a strap or rope is doubled, the values can also be doubled; if it is used four-fold, the values can be quadrupled. It is not possible to increase the values any further, since there is no guarantee that all the runs of rope would be evenly loaded.



Determining the diameter of polypropylene-covered "Hercules": 12 mm

Breaking load	MSL factor	MSL	
1.2 x 1.2 x 12 = 17.28 kN	x 0.33 =	5.76 kN	(diameter in cm)

12 x 12 x 12 = 1,728 daN	x 0.33 =	576 daN	(diameter in mm)

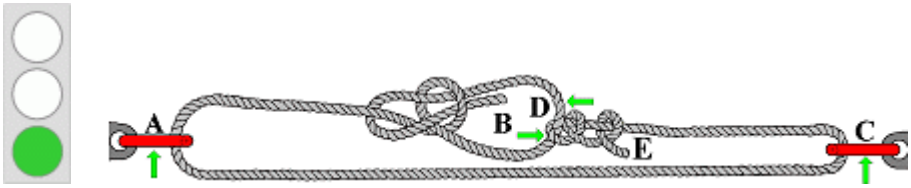
It would be rather quicker to calculate this using the direct rule of thumb for the MSL:

MSL PP "Hercules" 1.2 cm thick = 1.2 x 1.2 x 4 = 5.76 kN

MSL PP "Hercules" 12 mm thick = 12 x 12 x 4 = 576 daN

In this case as well, the values can be doubled or quadrupled respectively for double or (at the most) four-fold use.

Safety note: Fiber ropes must never be tightened over sharp edges!



To fabricate a direct lashing with a "Hercules" rope of this type, the necessary rope length is estimated and cut off. The end is threaded through one of the lashing points (A). A loop (B) is knotted into one of the ends using a bowline. The other end is threaded through the second lashing point at (C). The loose end is threaded through the loop of the bowline at (D) and pretensioned by hand. The end is knotted at (E) with at least two half hitches. If greater pretensioning forces are required than those which can be achieved manually, this can be achieved using a Spanish windlass - i.e. using heavers.

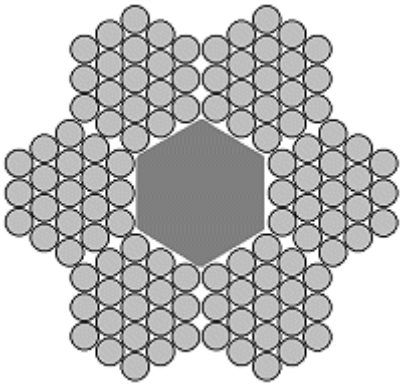
If a strap or rope is doubled, the values can also be doubled; if it is used four-fold, the values can be quadrupled. It is not possible to increase the values any further, since there is no guarantee that all the runs of rope would be evenly loaded.



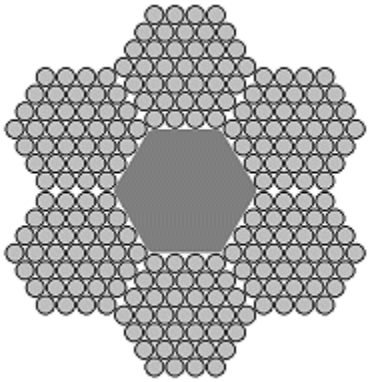
Different rope structures - cross-sections and plan views

The type of steel wire ropes mainly used for lashing are cross-laid stranded ropes laid to the right.

Occasionally, left-handed cross-lay used.

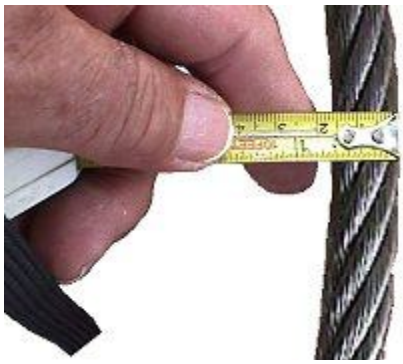


6 x 19 + 1 FC



6 x 37 + 1 FC

Stranded rope is the designation for a wire rope construction where the individual wires are laid into strands and these are in turn laid into the finished product. The number of individual wires and strands significantly influences the pliability of the wire and its price. The more individual wires there are in a wire rope, the more flexible but also the more expensive it is. A frequently used construction consists of 6 strands each with 19 individual wires per strand, with a fiber core to fill the cavity remaining in the center. The fill factor for rope constructions of this kind is around 0.455, i.e. the cross-sectional area occupied by metal accounts for around 45.5% of the total cross-section. Wire ropes with the construction 6 x 37 + 1 FC are also favored. These have the same fill factor.



Determining the diameter of a steel wire rope: 16 mm

Using a rule of thumb, the breaking load and MSL of single-use wire ropes can be calculated as follows:

Breaking load	MSL factor	MSL	
1.6 x 1.6 x 50 = 128 kN	x 0.80 =	102.4 kN	(diameter in cm)
16 x 16 x 50 = 12,800 daN	x 0.80 =	10,240 daN	(diameter in mm)

Since the of 80% of 50 equates to a value of 40, the MSL can also be calculated directly with an easily remembered formula:

MSL single-use steel wire ropes of the above type = d x d x 40

It would be a little quicker to calculate the MSL using the direct rule of thumb:

MSL for steel wire rope, 1.6 cm thick = 1.6 x 1.6 x 40 = 102.4 kN

MSL for steel wire, 16 mm thick = 16 x 16 x 40 = 10,240 daN



Use of a 16 mm-thick steel wire rope on a platform container

Using steel ropes of this kind is a waste of materials, since the high MSL value is out of proportion to that of the lashing points on the containers. The strongest lashing rings have an MSL value of 8,000 daN, many are around 5,000 daN and most are around 3,000 - 4,000 daN. To for homogeneous lashings, it is usually perfectly sufficient to use wire ropes of a smaller diameter. For instance, 12 mm wires:

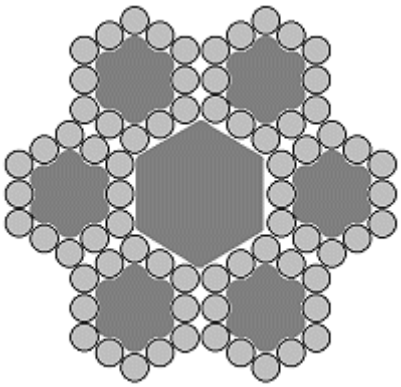
MSL for steel wire rope, 1.2 cm thick = 1.2 x 1.2 x 40 = 5.76 kN

MSL for steel wire, 12 mm thick = 12 x 12 x 40 = 5,760 daN

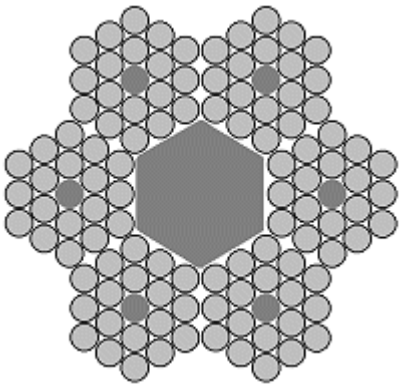
Different MSL values must be applied for reusable wire ropes. Wires of this kind must only be calculated with 30% of the breaking load for the MSL:

Breaking load	**MSL factor**	**MSL**	
1.6 x 1.6 x 50 = 128 kN	x 0.30 =	38.4 kN	(diameter in cm)

16 x 16 x 50 = 12,800 daN	x 0.30 =	3,840 daN	(diameter in mm)



6 x 12 +7 FC



6 x 18 +7 FC

Significantly lower fill factors are exhibited by wire ropes with constructions such as 6 x 9 + 7 FC, 6 x 12 + 7 FC, 6 x 15 + 7 FC, 6 x 18 + 7 FC or similar, where, as the designation already indicates, a fiber filler has been incorporated in the center of each strand. Ropes of this kind are frequently used by Dutch and Belgian companies as lashing wires.

The breaking loads and MSLs of wires of this kind are only half as high, because a factor of 25 rather than a factor of 50 has to be used for calculation.

Breaking load	**MSL factor**	**MSL**	
d x d x 25	x 0.80 =	kN	(diameter in cm)
d x d x 25	x 0.80 =	daN	(diameter in mm)

The same applies for re-usable wire ropes of this type:

Breaking load	**MSL factor**	**MSL**	
d x d x 25	x 0.30 =	kN	(diameter in cm)
d x d x 25	x 0.30 =	daN	(diameter in mm)



Steel wire rope coil

When ordering wire ropes, the following details should be stipulated to ensure that the correct rope type will be received:

-	Diameter in mm or inches	e.g. 16 mm or 5/8"
-	Quantity and length	e.g. 20 x 200 m
-	Rope construction	e.g. 6 x 19 + 1 FE
-	Type and direction of lay	e.g. cross lay, to the right
-	Special features (plain, galvanized etc.)	e.g. plain
-	Nominal strength	e.g. 1570 N/mm²
-	Greasing	e.g. normal
-	Termination: swaged / sharpened	e.g. swaged
-	Packaging	e.g. coils









Cutting wire ropes with shears

Incorrect -
small lever arm

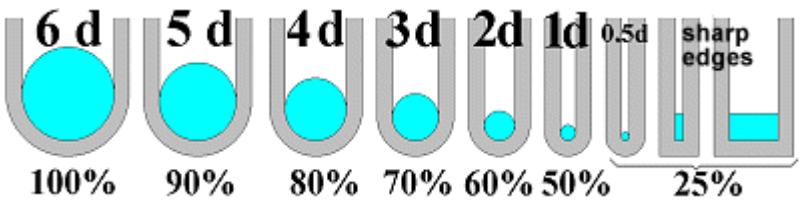
Correct -
large lever arm

Wire ropes can be cut to length with hydraulic shears or other special tools if larger quantities need to be processed. Handshears are sufficient on site and with small quantities.



Wires can be damaged by sharp edges.

Running wires around sharp edges will lower their MSL. There are precise values, but a number of additional factors should be taken into account. Rough but nonetheless usable values are provided in this easily remembered table:



MSL of a single run at various bending angles

You will find an example showing exact values in Volume II.



Wire ropes with spliced or pressed eyes are rarely used for lashing. Generally, wire cable clamps (clips) are used to connect to other lashing elements, such as turnbuckles, shackles, lashing rings etc. There are suitable clips available for every thickness of rope, in both metric and Imperial sizes. For a 12 mm wire, 12 mm or ½" clips are required. For 16 mm wires, 16 mm or 5/8" clips must be provided.

When the nuts are correctly tightened as described further below, the following figures can be seen

as guideline values for the strength of wire cable clips with common rope diameters.



At a sufficient tightening torque:
1 clip = 25% MSL

Up to 25% of the MSL can be achieved with one clip. If - as in this case - there is no tightening torque, the value approaches 0.



At a sufficient tightening torque: 2 clips = 50% MSL

50% of the MSL of the wire rope is achieved using two wire cable clips. The indentations in the wire indicate a good tightening torque. The following rule of thumb applies: if the free end on which the U-bolts of the wire cable clips should be placed is crushed to half the thickness of the wire, the clips have been tightened to a sufficient torque.



Only with a sufficient tightening torque and correctly attached clips:
3 clips = 75% MSL

The wire cable clips have been attached incorrectly and the tightening torques are too low. The MSL of lashings of this kind is usually overestimated. An maximum MSL of approximately 75% can be achieved with three wire cable clips.





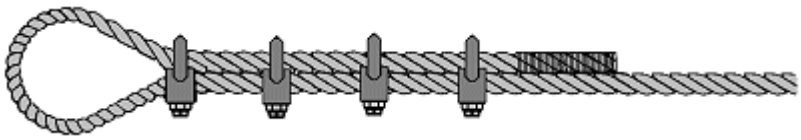
Incorrectly attached wire cable clips in insufficient quantity

All too often in practice, too few wire cable clips are used or they are attached incorrectly. Often, the nuts are not tightened sufficiently. The wires slip through the wire cable clips under load.



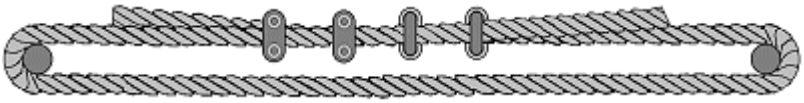
Wires which have slipped through where only two wire cable clips were attached

If a wire rope lashing is to be homogeneous, four wire cable clips must be placed with the U-bolt on the free end.:



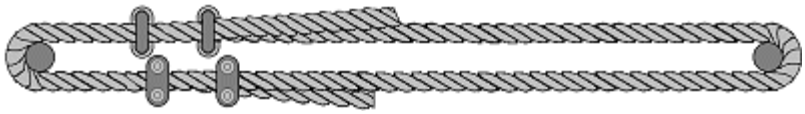
Single cable with eye

This type of attachment is advisable if relatively long lashings have to be made. They are usually not necessary for container loads.



Sling or double run - unsuitable construction

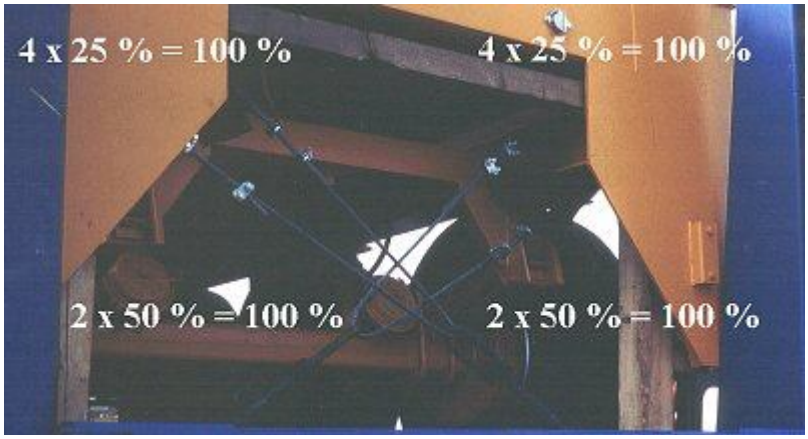
This construction is often used for shorter lashings. But it should not be made like this.



Sling or double run - ideal construction

This format should always be used for relatively short lashings because it is the most resilient. Inadequacies such as the presence of sharp edges can also be counteracted with this method.

Where possible, work should be carried out as demonstrated here.



Positive example - wire rope arranged correctly, wire cable clips attached correctly and sufficiently high tightening torque on the nuts



Lashing is a technically demanding task which has to be learnt. Otherwise, errors creep in even with the best will in the world.

Lashing which is not homogeneous



Anchor shackle



Chain shackle

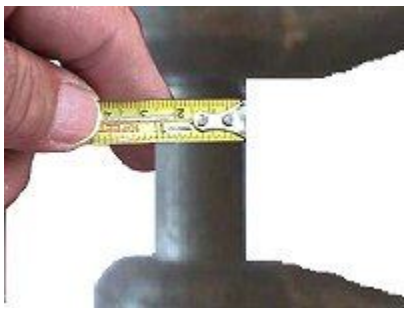
Anchor shackles should be preferred for use as lashing shackles. They can adapt better to the directions in which forces arise.

Using a rule of thumb, the breaking load and MSL of lashing shackles can be calculated as follows:

Breaking load	MSL factor	MSL	
d x d x 20	x 0.50 =	kN	(diameter in cm)
d x d x 20	x 0.50 =	daN	(diameter in mm)

Since the factor 50% of 20 is equivalent to 10, the MSL can also be calculated directly with an easy-to-remember formula:

MSL for lashing shackle = d x d x 10



Determining the diameter of a bolt on a lashing shackle: 26 mm

The diameter of the bolt is first measured in centimeters or millimeters. The breaking load formula only applies to shackles made of standard strength steel. The value for this shackle is quickly calculated using the direct rule of thumb for the MSL.

MSL for lashing shackle bolt of diameter 2.6 cm = 2.6 x 2.6 x 10 = 67.6 kN

MSL for lashing shackle bolt of diameter 26 mm = 26 x 26 x 10 = 6,760 daN



Lashing turnbuckle with very well worked weld seams

The same values apply to turnbuckles as to lashing shackles. The diameter of the thread is first measured in centimeters or millimeters. The breaking load formula only applies to turnbuckles made of standard strength steel. The value for this turnbuckle is quickly calculated using the direct rule of thumb for the MSL, if the thread was measured at 1 1/8 inch = 28.575 mm.

MSL for lashing turnbuckle of thread diameter 2.86 cm = 2.86 x 2.86 x 10 = 81.796 kN

MSL for lashing turnbuckle of thread diameter 28.6 mm = 2.86 x 2.86 x 10 = 8,179.6 daN

When purchasing turnbuckles, it is important that only turnbuckles with sufficiently wide nuts and weld seams are purchased. Spot welded turnbuckles are available on the market. These should not be used.

The turnbuckle shown above is generally available in three sizes: 1 1/8 " , 1¼" and 1½" thread diameter. 1 inch is equivalent to 25.4 mm.



Turnbuckle made of higher strength steel for round steel chains with short links

The manufacturer's specifications must be observed for turnbuckles made of higher strength steel. 50% of the specified breaking load is assumed as the MSL. Unless, as with this turnbuckle, a WLL (Working Load Limit) has already been specified. This then corresponds to the MSL.



Tag on a lashing turnbuckle



Lashing point on a 40' flat

The same rules of thumb apply for lashing points made of normal strength steel as for lashing shackles and lashing turnbuckles. The diameter of the ring material or the bars is critical.

	Breaking load	**MSL factor**	**MSL**	
d x d x 20		x 0.50 =	kN	(diameter in cm)
d x d x 20		x 0.50 =	daN	(diameter in mm)



Determining the diameter of a lashing point: 20 mm

MSL lashing point material diameter 2.0 cm = 2.0 x 2.0 x 10 = 40.0 kN

MSL lashing point material diameter 20 mm = 20 x 20 x 10 = 4,000 daN



Notice indicating the strength of a lashing point

Even if it is not entirely clear what is meant by a strength specification, the MSL should still be calculated using the rule of thumb.







Load on lashing points

Loads may only be applied to lashing points in a permissible manner. If a number of lashings are attached to a single lashing point, the total load must be taken into account. If lashings attached to the same lashing point are alternately subjected to load and relieved of load, every lashing can have the full MSL. If the lashings subject the lashing point to load simultaneously, the MSLs of the lashings must be distributed accordingly.





Steel strapping, untreated **Steel strapping, blued**

Steel strapping can be applied quickly and easily and is therefore suitable for securing purposes on many loads.

The following values can be used for calculations for untreated steel strapping:

Breaking load		**MSL factor**	**MSL**	
Strap width w x strap thickness t	w x t x 70	x 0.70 =	kN	(measurements in cm)
Strap width w x strap thickness t	t x w x 70	x 0.70 =	daN	(measurements in mm)

Blued straps have a higher strength. It can be calculated using these values:

Breaking load		**MSL factor**	**MSL**	
Strap width w x strap thickness t	w x t x 85	x 0.70 =	kN	(measurements in cm)
Strap width w x strap thickness t	t x w x 85	x 0.70 =	daN	(measurements in mm)

A blued steel strap 32 mm wide and 1.6 mm thick would produce the following value for the MSL:

MSL for blued steel strap 36 mm wide, 1.6 mm thick = 3.2 x 0.16 x 85 x 0.7 = 30.464 kN

MSL for blued steel strap 36 mm wide, 1.6 mm thick = 32 x 1.6 x 85 x 0.7 = 3,046.4 kN

The dimensions of steel straps are often coded without specifying the dimension units. It is usual practice to encode the width in mm and the thickness in 0.1 mm. The strap referred to above would

have the designation 32/16 steel strap.



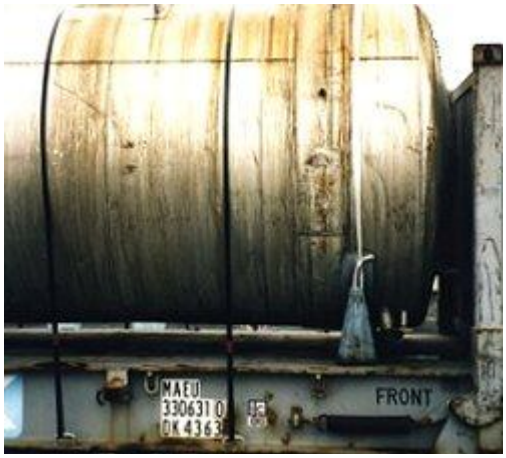
Lashing point for steel strap as it is rounded

Strength values calculated by rule of thumb must not be used if the steel strap is used incorrectly.

Another important requirement is that the strapping seals are applied correctly.



Steel straps have a very high breaking strength and this is a common selling point. The disadvantage of steel straps, however, is their low elasticity. This ranges from around 0.25% to a maximum of 0.5%. Steel straps are therefore not really suitable for use as tie-down lashings.





Steel straps are utterly unsuitable as tie-down lashings.

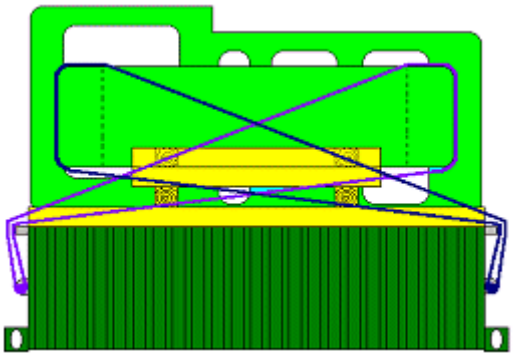
For instance, if a lashing is 7 m long, an ordinary commercial steel strap would have an elasticity of 7 m x 0.0025 = 0.0175 m or 17.5 mm. About half of this is exhausted for pretensioning, which means that just 8-9 mm remains. If the circumference of the lashing is reduced by this amount due to the strap cutting into the wood of cases, shifting of goods etc., the steel strapping will become loose and no longer able to fulfill its function as a securing aid. Further jolts during transportation then produce greater forces on account of the resulting acceleration forces which can cause the steel strapping to tear.



Compensating for the low elasticity of steel straps

The low elasticity of steel straps can be compensated for by padding with materials with a high degree of elasticity and recovery. It is generally more convenient to use steel straps for direct lashings. They are extremely suitable for this:





Loads ideally suited for securing with steel straps



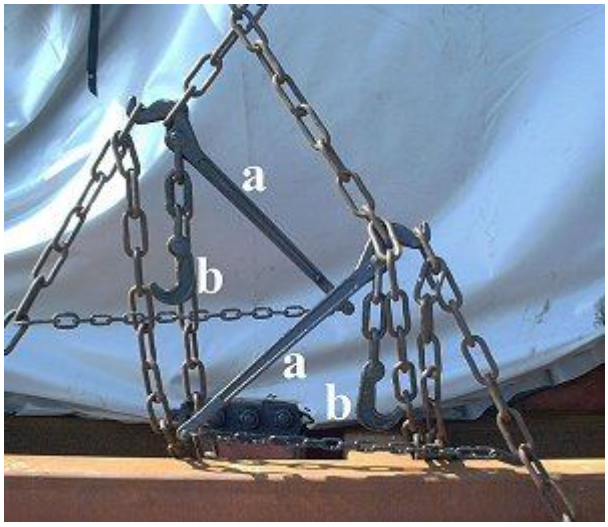
Lashing chain with long links



Lashing chain with short links

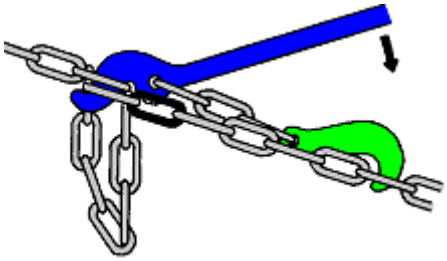
Lashing chains are generally only used to secure container cargoes if the chains will be returned. On very valuable cargoes, however, it may also be worthwhile to use them as a "lost load securing aid", because of the benefits offered by their high strength and speed with which they can be deployed.

Since lashing chains are made of high strength steel, there are no rules of thumb for calculating the breaking loads. The manufacturer's specifications should be observed. The MSL may be assumed to be 50% of the breaking load. A range of different tensioning mechanisms are used with chains. Errors are frequently made when using these aids.

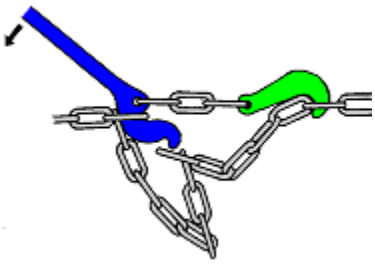


Error made using a lashing chain with tensioning lever (a) and hook (b)

Tightening the chain using the hooks:

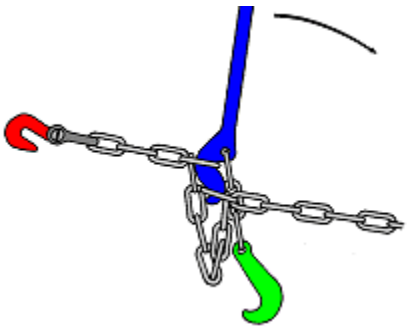


Inserting the hook

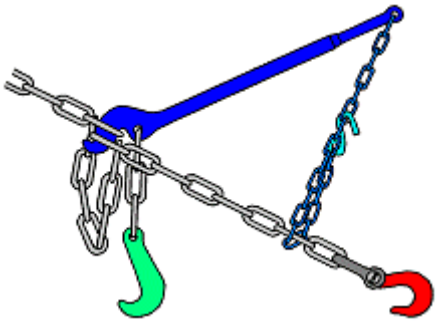


Shortening the chain

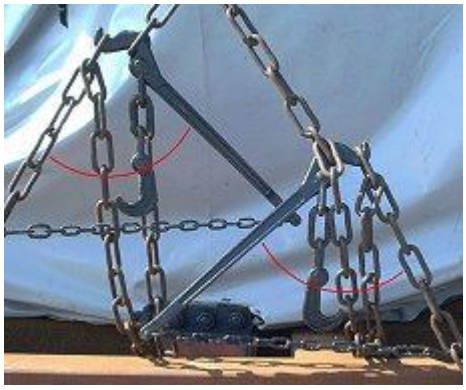
Tightening the chain with the tension lever:



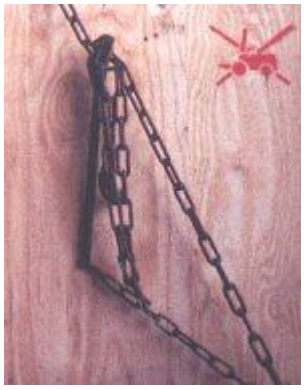
Inserting the tensioning lever



Tightening and securing the lever



Incorrect



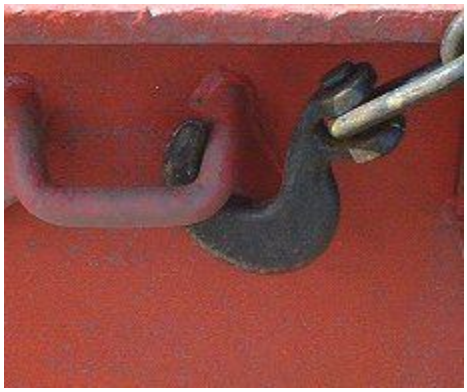
Correct

The tension levers must not remain at an angle of 90°. They must be adjusted to an angle of at least 45°. Otherwise, the tongues could buckle or shear off.

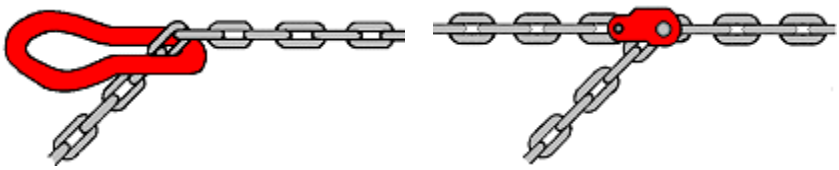




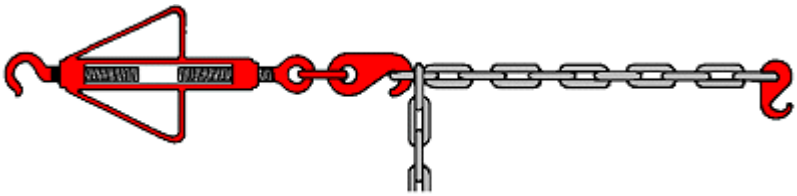
Lashed with hook



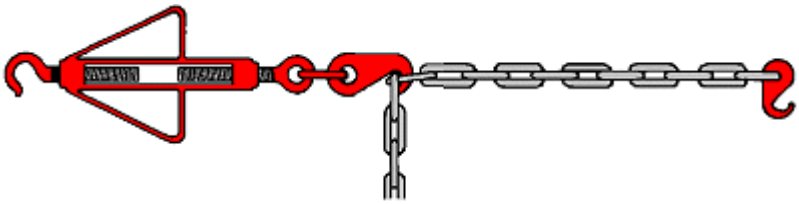
Hook incorrectly inserted



Permissible shortening of chains



Correct shortening of a chain - no chain link is trapped



Incorrect shortening of a chain - a chain link is trapped







Shortening a chain with special claw hooks and securing lever



Chain tensioner (load binder)



Shortening hook on tensioner

No rules of thumb are provided in the CSS code for high strength chains, because the diversity of the products is very high. There are chains made to all kinds of different standards on the market. If the stamp on the chain and its accessories clearly identify it as quality class 8, the rule of thumb d^2 x 120 can be used to calculate the breaking load. The MSL is to be assumed to be 50% of the breaking load. This produces the following figures for the following diameters of chain steel:

Diameter of steel	Breaking load	MSL factor	MSL
0.6 cm 6 mm	43.2 kN 4,320 daN	0.5 0.5	21.6 kN 2,160 daN
0.8cm 8 mm	76.8 kN 7,680 daN	0.5 0.5	38.4 kN 3,840 daN
1 cm 10 mm	120 kN 12,000 daN	0.5 0.5	60 kN 6,000 daN
1.3 cm 13 mm	202.8 kN 20,280 daN	0.5 0.5	101.4 kN 10,140 daN





Textile lashing belts

Pre-fabricated lashing belts have already been described in detail in the GDV Cargo Securing Manual. It is assumed that staff will be familiar with how to use systems of this kind and that no more than an occasional note is needed. There is no need to calculate with rules of thumb, since pre-

fabricated lashing belts usually carry a label indicating the Lashing Capacity (LC). This is the permissible lashing force (F_{max}) which can be used to secure cargoes.



Polyester lashing belt

The values given on the label can therefore be accepted as the MSL. The breaking load of a belt of this kind is double this value and the standard therefore sets the LC at 50% of the breaking strength (The CSS also names "50% of breaking strength" as the permitted value).

In relation to all lashings used, the proportion of pre-fabricated lashing belts is small, since the belt systems can only be returned with specific shipping companies and cargo types. Flexibility suffers in day-to-day lashing operations as a result of fixed lengths and sewn-in end fittings. Due to the speed with which they can be applied, however, the proportion of these lashings being used is constantly growing. If lashing of this kind is used, however, it should be applied out correctly and professionally.

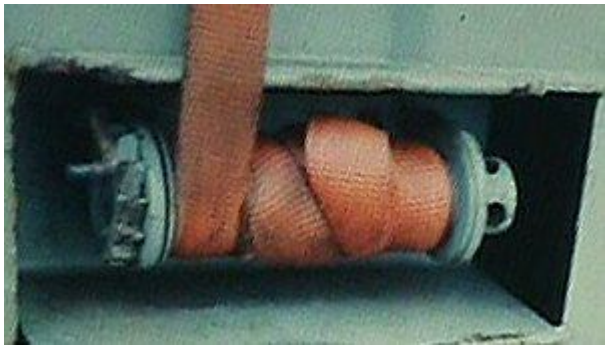


Use of unsuitable end fittings




Chafing points due to incorrect usage of the belt

Belt systems permanently installed in containers must also be included among the pre-fabricated systems.



Lashing winch with incorrectly wound belt

The lashings below used to secure automobiles must also be classed as pre-fabricated goods.







Various automobile lashings









The CSS do not provide any rules of thumb for the breaking load of single-use webbing belts, but refer to the manufacturer's specifications. 70% is given as a factor for the MSL.

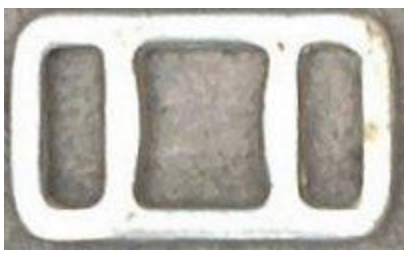
MSL for synthetic fiber lashing belts = breaking load as per manufacturer's specification x 0.7



Marking on a single-use textile belt

The breaking strength is specified as 3,500 kg on the label, i.e. 3,433.5 daN. The MSL would then be 70% of this, or 2,403 daN.

In the opinion of the author, this is far too high. It is well-known that in defining this factor the national interests of some IMO members played a greater role than the known problems associated with single-use lashing belts, where the quality of production differs. They are often very elastic. Some materials exhibit permanent deformation at threshold loads above 50% of the breaking load. This means that the lashings made from them will then become slack. Since they are also identical in many other ways to synthetic fiber ropes, the author recommends that at least the 50% factor of the European and German standards is assumed for pre-fabricated lashing belts. For the material discussed above, this would be a value of 1,717 daN. If the author were personally responsible for lashing work, he would only assume the value for synthetic fiber ropes, i.e. 33% of the breaking load. For a belt with a breaking load of 3,433 daN (3,600 kg), this would be 1,133 daN. Since belts are nearly always used doubled, the value would double accordingly.









Various locking devices for use with single-use textile lashing belts

It is useful and practical to have operating instructions stamped onto the locking devices.



Packaging straps



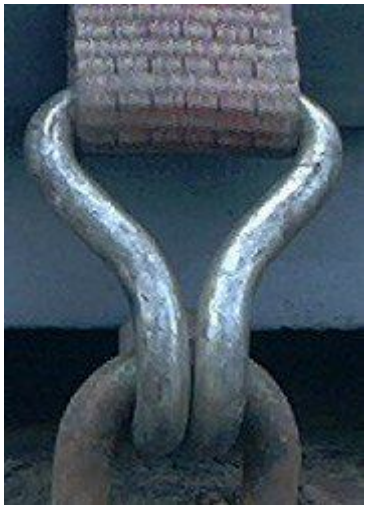
Packaging straps of this kind are only suitable for securing individual, relatively light packages on pallets and similar supports as well as for unitization.





Two different types of end fittings

There are a huge variety of end fittings and other connecting elements available. It is important to select the one which best suits the lashing points on the particular cargo transport unit.



Incorrectly inserted hook

Hooks must where possible be hooked in from the bottom to the top or from the inside to the outside, so that they cannot loosen if jolted during transport, should the lashing become slack.

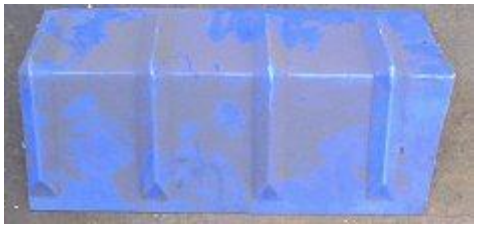


Belt protectors

It is essential that belts are protected against sharp edges whether this be by means of belt protectors or special sleeves. If this is not possible or items like this are not available, edge protectors are to be used:










Various edge protectors

There are a number of different devices available for tensioning textile lashing belts.



Belt tensioner



Knotted textile belts

Belts and straps must not be knotted and twisted. They must rest on a wide surface and must not be tightened over sharp edges. Damaged belt material must be removed from stock.



Knotted textile belts -
locking devices or buckles too weak

Single-use textile belts are unsuitable for use as tie-down lashing





Tight-fit friction securing with a WisaFix lashing cover

Using tarpaulins of this kind results in a combination of tight-fit and friction securing.

4.4.2 Wood

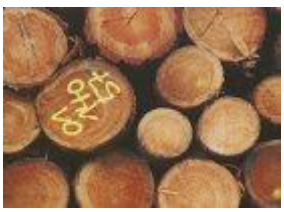
A great deal of information is provided on the use of wood and its application in load securing in the relevant sections of the examples. This section, therefore, will only provide information on basic properties of wood, the various formats, technical terms, designations and methods of cutting. Rules of thumb for calculating the strength of are also provided.



Logs

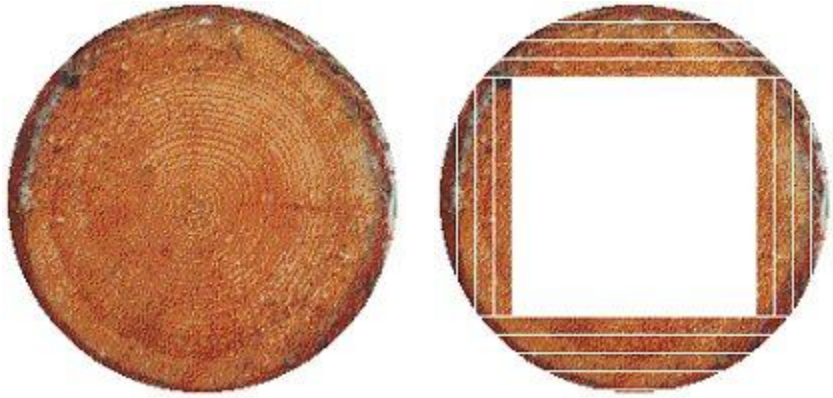


Long edge/with the grain



End grain/ across the grain

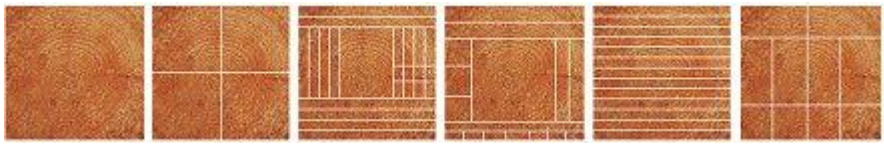
Wood is indispensable as a load securing material. A distinction is always made between the long and the short side of the wood (across the grain and with the grain). Wood is less able to withstand loads on its long edge, i.e. when the load is perpendicular to the grain. The extraction resistance of nails and screws, however, is higher when they are nailed or screwed perpendicular to the grain. In contrast, wood is far better able to withstand loads applied on the end grain, i.e. parallel to the direction of the grain.



Untrimmed edge boards or waney edge lumber are often cut from the outer sections of a log for use as wooden dunnage.



Wooden dunnage board



Depending on the thickness of the trunk, balks, squared lumber, battens, laths, planks and boards are cut from the trunks.



Balks



cross-stacking of balks (with errors, in this case: no overhang, dogs attached incorrectly)

Balks have very large cross-sections, with edges usually over 15 cm long, squared lumber starts as of about 8 cm x 8 cm.



Solid wood



Halved lumber



Quartered balk



1:2 format

On solid wood, the heart, medulla or pith is located in the center, on halved lumber on the side and on quartered lumber on one corner. 1:2 can be a size such as 16 cm x 8 cm. Dimension stock could, for instance be 6.3 cm x 7.5 cm (2 1/2" x 3"). Thicker battens might be 3.2 cm x 5 cm (1 1/4" x 2") or 3.8 cm x 6.3 cm (1 1/2 x 2 1/2").



Sticked squared lumber packages



Mold on lumber which has not been sticked

Thin laths are used as an intermediate layer between lumber so ensure that it does not develop mold or rot.



Very knotty waney edge lumber

Wood with a very high frequency of knots should not be used for bracing. It must be rejected beforehand.

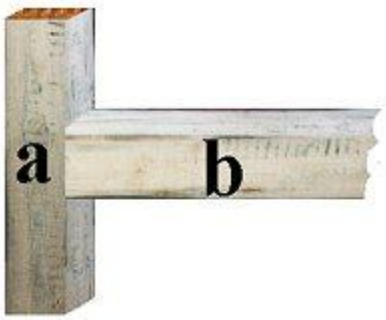


Squared lumber, battens and wedges - Wood which has been stained indicates that it has been treated to protect it against the sirex wasp .

The following rules of thumb can be applied to sound lumber to calculate the maximum securing load:

Softwood used for bracing, compression strength perpendicular to the grain, MSL = 0.3 kN per cm²

Softwood used for bracing, compression strength perpendicular to the grain, MSL = 30 kN per cm²



Applying the rule of thumb to compressive strength parallel to the grain of the wood

Assuming that the contact surface between a and b is 10 cm x 10 cm = 100 cm², a securing force of 3,000 daN (30 kN) can be introduced via a and transmitted to b.

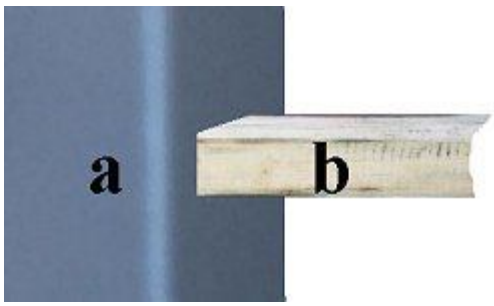
The following rule of thumb applies for the maximum securing load parallel to the grain:

Softwood used for bracing, compression strength parallel to the grain, MSL = 1 kN per cm²

Softwood used for bracing, compression strength parallel to the grain, MSL = 100 daN per cm²

Note: For road and rail transportation only, 200 daN/cm² can be assumed for the load parallel to the

grain, since it is assumed that only isolated or few load events occur during each transport operation. For maritime transport, the IMO halve these values to 100 daN/cm² due to the constantly changing stresses in rough seas.
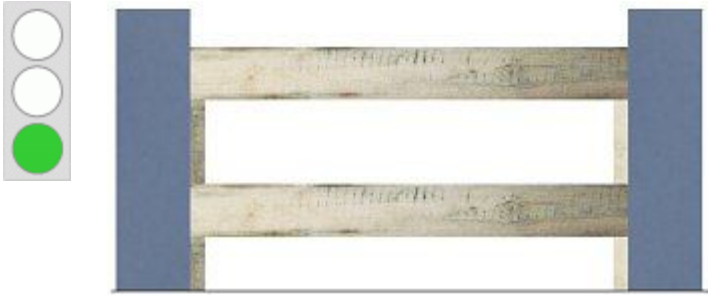


Applying the rule of thumb to compressive strength parallel to the grain

Assuming that the contact surface between the steel component a and the wood b is 10 cm x 10 cm = 100 cm², a securing force of 10,000 daN (100 kN) can be transmitted between a and b.



High outlay - low strength



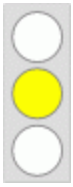
Little material - high strength

Since the grain side is crucial for the bracing shown in the left-hand illustration, four horizontal bracing elements measuring 10 cm x 10 cm will achieve an MSL of 12,000 daN. The values for the load on the end grain can be used for the bracing shown in the right-hand illustration. An MSL of 40,000 daN is achieved with significantly less outlay in terms of work and materials.





Even less material - high strength with four horizontal bracing elements used in pairs





It may be that one pair of bracing elements may be sufficient.

The traffic light really ought to be "double-green" for the figure at the top, since 40,000 daN is achieved with even less material. Probably, even the variant with only two bracing elements would suffice as shown in the bottom figure (the second bracing element is hidden by the first). Even this achieves 20,000 daN. The wood should be placed at the top for goods that are likely to topple. It can be placed at the bottom for flat goods which are not likely to topple. The bracing elements must be cross-braced against shifting so that they do not become detached.





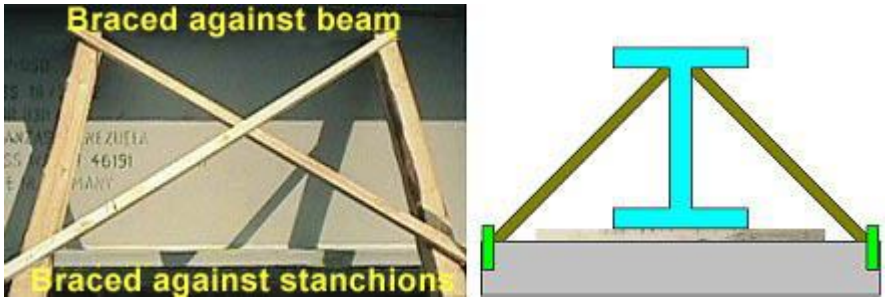
Unprofessional bracing which has become detached due to lack of cross-bracing





Heavy drive shaft on trestles

If the circular segment on which the wooden-clad drive shaft is placed is 50 cm wide and the wood on the trestle is 20 cm wide, there will be a projected area of 1,000 cm², which means a total bearing surface on the trestle of 2,000 cm². Since the compression load is perpendicular to the grain, the trestle can absorb 2,000 cm² x 30 daN/cm² at this point, i.e. 60,000 daN. Since the shaft has been placed on several trestles, they have obviously been over dimensioned here. The workmanship also leaves something to be desired. There is still some potential for rationalization here.



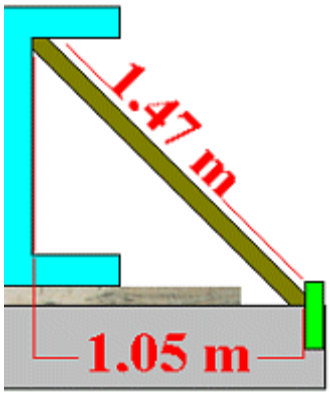
Securing with diagonal stays

Lumber measuring 10 cm x 12 cm has been used here. This would produce an area of 120 cm² at the contact points. Since two pieces of wood were used as bracing on each side, the total area is 240 cm² per side. The stays would therefore theoretically absorb 240 cm² x 100 daN/cm², i.e. thus 24,000 daN. There is however a slight problem here: The stanchions are not as wide as the lumber.



Always take note of to the smallest contact surfaces!

Since the stanchions are only 8 cm wide, only an area of 8 cm x 12 cm = 96 cm² per wooden element can be used for calculation, i.e. 192 cm² per pair of stays. In reality, therefore, the stays can only be loaded with 19,200 daN per pair.



Only the lateral component is effective against tilting.

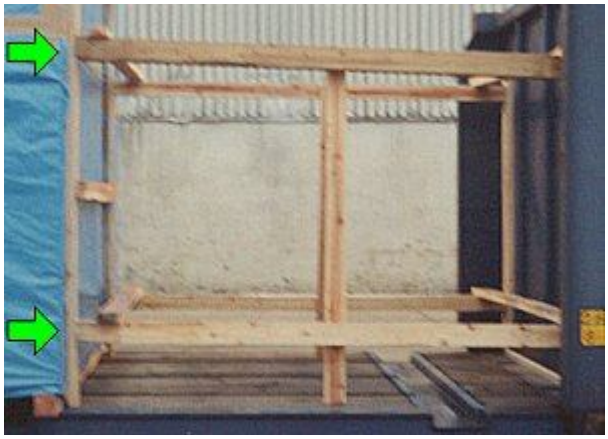
Since the total length of the stay is 1.47 m and the transverse component is calculated as 1.05 m, a pair of stays secures the beam against tilting with 1.05 m / 1,47 m x 19,200 daN = 13,714 daN.

Generally, the following rules apply:

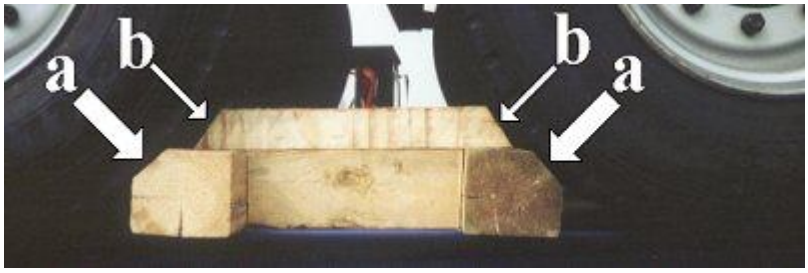
- If it is feasible, always brace horizontally;

- If it is feasible, brace so that the end grain loading capacity is used;

- Always brace against the parts with the greatest load-bearing capacity, e.g. on cases, use the plate effect provided by the base and lid or guide the forces into the vertical sides.



Transferring forces onto the ends of the side walls of the box



Chamfered wood (a) - wood cut to a bevel (b)

Securing measures of this kind can only be created using wooden aids and driving wedges, which are removed again after securing has been completed.



Driving wedges - tapered blocks - slim wedges

Driving wedges can be used individually or in pairs. They should be made of hardwood. The very shallow angle here produces large leverage effects which can be used to achieve extremely high forces. Caution is therefore demanded. Only drive wedges in gently and then fix them into place.



Simple stays for filling gaps which can be prepared outside the container

Sometimes only very simple structures are required to fill in a gap in the container. But one last note: The less material has to be used for load securing the better. The best and most cost-effective load securing measure is a compact stow using well-protected and sufficiently strong packages

4.4.3 Filling material



Expanded synthetic plastics have very poor recovery properties and nearly no elasticity. They deform very quickly under load, i.e. they become thinner under compression leads. They can therefore only be used for filling gaps with relatively light loads. In all other cases, they should not be used as a filling material. The same applies for cardboard and corrugated board.



Used tires may to a certain extent be suitable for filling in gaps, but not as has been done here: Ring-shaped point loads may occur. To enable them to fill in a large area, they could be arranged so that they are pressed between two walking boards which each cover a large surface area of the cargo.

Again, we quote the CTU guidelines:

> *3.2.12 When deciding on packaging and cargo-securing material, it should be borne in mind that some countries enforce a garbage- and litter-avoidance policy. This may lead to limitations on the use of certain materials and imply fees for the recovery of packaging at the reception point as well as similar problems for the shipper of the cargo. In such cases, reusable packaging and securing material should be used. Increasingly, countries are requiring timber dunnage and packaging materials to be debarked.*



Airbags

3.2.4 If airbags are used, the manufacturer's instructions on filling pressure should be scrupulously observed. Allowance should be made for the possibility of a considerable rise in the internal temperature of the CTU above the temperature at the time of packing. This may cause the bags to expand and burst, thereby making them ineffectual as a means of securing the cargo. Airbags should not be used as a means of filling space at the doorway unless precautions are taken to ensure that they cannot cause the door to open violently when the locking bars are released.

The most commonly used form of airbag comprises a multilayer paper bag available in a wide variety of different sizes. This type should only be used if the areas to the left and right of the gap are as smooth as possible and have a high load-bearing capacity. If necessary, walking boards are to be provided to ensure correct distribution of pressure. Special measures are required for working with airbags, in particular with white and brown goods, since the parts of the cartons which are not padded would be pushed in. The minimum inflation pressure should be 200 hPa. For many airbags, this is around 300 hPa. This can still achieve a securing force of 3,000 daN per m². Airbags are inflated using compressors. Special inflation fittings with pressure reducers are required. Special fittings enable the air to be evacuated. This is an advantage if a bag is not seated correctly, as it can quickly be deflated and then inflated again. This fitting facilitates deflation of reusable bags. Since it is time-consuming to have to unscrew valves to let out the air, the recipient will generally deflate single-use bags by puncturing them. When closing gaps, airbags which have already been partially inflated should be placed in the stowage gap and then completely inflated. Suitably large and smooth surfaces are required on the cargo transport units when using them. Only airbags which are capable to a certain extent of withstanding point loadings should be used. One important factor with regard to usability is that their side faces should be as near as possible to parallel. Air bags with a pronounced bulge must not be used.

4.4.4 "Artificial tight fit"



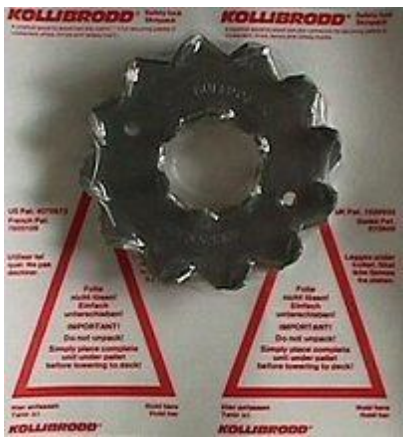
Gangnails - without and with nail holes

Gangnails of this kind, sometimes known as dowels, can be used to provide a tight fit. They are available in a wide variety of different shapes and sizes. The specialist literature also refers to these as "shear transfer plates". They are punched pieces of steel sheet with triangular teeth bent upward and downward.



Different shapes and sizes of shear transfer plates

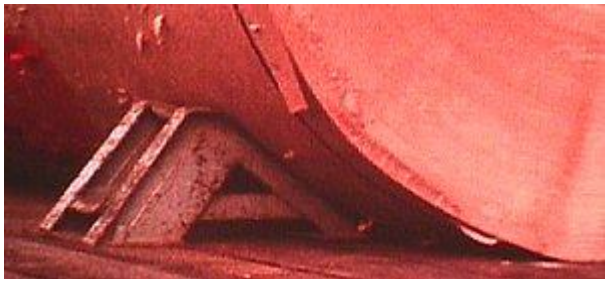
To facilitate handling, these devices are also available in "display packaging". Then they are shrink-wrapped ready-to-use and can be inserted simply.



Aids like this make sense when unitizing packages with robust softwood surfaces, e.g. single-use pallets, softwood pipe clamps, cases with suitable skids or belt battens etc. If gangnails are laid between loads of this kind and then the loads are strapped or bound together in some other way,

they will increase cohesion. If it is possible to lay them on platform containers with softwood floors, they can contribute to improving load securing or to reducing the remaining securing work. On their own, they are not sufficient as a means of securing. Under stress, the teeth bend and flatten and consequently become virtually ineffective. This has been confirmed by testing carried out on unsecured loads.

In box containers it is conceivable to use them between individual package layers, but not practical, since accessibility is difficult in most cases. Unless special aids are used to lay them. Because of the risk they pose, they should not be used on container floors made of plywood or textured coated board.



Spike-based chock on a roll of liner boards

It makes sense to use spike-based chocks on cargo transport units with soft floors which allow this. A further requirement is that cylindrical goods can be placed against the chocks. When securing cylindrical goods with for instance four spike-based chocks, the load would have to be set down, the chocks put in place, the load raised, the chocks secured and the load then set down again. If the positions of the chocks are measured accurately and they are placed beforehand, the first steps can be omitted, but the product must be put in place from above. The applications for spike-based chocks of this kind are generally very limited. In the field of container traffic, they could only be used on platform containers.

4.4.5 Friction and friction-enhancing mats

A fundamental distinction is made between two types of friction, internal and external.

External friction is used to refer to the resistance that is created as a result of the relative movement as the contact surfaces of two objects rub against each other. External friction is caused, in particular, by forces of adhesion and unevenness on the surfaces of the objects. Friction is virtually independent of the size of the contact surfaces. Friction is often also explained as the meshing of two materials in contact with each other at a microscopic level.



The structure of softwood on the grain edge

This can be seen clearly, if for example, the structure of softwood is examined on the grain edge. It is not difficult to imaging that two surfaces of this nature will become 'meshed' if they are in contact with each other.

The frictional force F_F is always counter to the current movement of an object. The magnitude of the frictional force is dependent on the magnitude of the normal force F_N with which the contact surfaces press against each other and on the friction coefficient μ. Thus, the basic formula for Coulomb's law of friction is:

$$F_F = \mu \cdot F_N$$

In this formula μ stands for the friction coefficient or friction factor. It is dependent on the material, the state of the surfaces (roughness and whether it is lubricated) as well as the sliding speed of the bodies rubbing against each other. The symbol used in the formula is μ, the lowercase Greek letter "m" = "mu". Different types of friction are distinguished, depending on whether or not there is relative movement between the bodies, whether the bodies are already moving and if so whether they are sliding or rolling:

- **Static friction**
- **Sliding friction**
- **Rolling friction**

If the conditions are otherwise identical, the static friction coefficient is always larger than the sliding friction coefficient and the rolling friction coefficient is usually much lower than the sliding friction coefficient. During frictional processes, mechanical energy is converted into heat, frictional heat.

Internal friction is due to molecular forces. It occurs when individual components of a liquid or a gas, or the various layers that make up a substance, rub against each other. The technical term is viscosity. There are two types of viscosity, dynamic and kinematic.

Contact surfaces between liquids and gases, on the one hand, and the walls of a pipe both exhibit

resistance which is referred to as **pipe friction**.

Friction in the service of mankind. Without friction - our lives would be impossible. All forms of locomotion are ultimately reliant on friction. When transferring forces, for example, when starting or braking a vehicle or securing a load, high levels of frictional resistance are desired. All movement in gearboxes, when moving loads etc. the objective is to keep frictional resistance as low possible in order to reduce the loss of energy to a minimum.

Friction testing. In order to determine the level of frictional resistance, very simple tests can be used. The resistance to movement can be determined using measurements of force or comparisons of mass, or, measurements can be carried out to show the gradient at which an object on a slope remains in position, starts to move or remains in motion.

Test configuration used to determine frictional resistance by measuring forces:



Static friction is measured when a measuring instrument, for example, a spring balance, is pulled until the frictional force F_F is almost sufficient to move the object being pressed onto the surface by the normal force F_N. The force that is required to keep the object in motion and pull it across the surface corresponds to the sliding friction. When applied to a vehicle, this principle can be used to determine the rolling friction. A more detailed test can distinguish between static rolling friction and sliding rolling friction. In the field of load securing, the values for sliding friction are of most interest.

The simple method described here is not admissible for determining friction in genuine scientific studies. There are special standards which detail how friction coefficients should be determined.

Example: A block of wood with a normal force or weight-F_N of 90 N is dragged over a cardboard floor. The friction coefficient F_F is measured at 27 N. After transformation of the basic formula $F_F = \mu \times F_N$ this results in:

$$\mu = \frac{F_F}{F_N} = \frac{27\,\cancel{N}}{90\,\cancel{N}} = \underline{\underline{0.3}}$$

For this example, the friction coefficient of wood on cardboard is calculated as 0.3. This value can also be expressed as 30% or three tenths. If the test block is doubled by the addition of an additional block, and increased to 180 N, then the frictional force is increased to 54 N. The frictional coefficient of 0.3 does not actually change, because 180 N divided by 54 N = 0.3. The friction coefficient remains constant for any given pair of materials.

If the normal force of an object and the friction coefficient are known, then the frictional force can be calculated mathematically. Thus, the calculation for the above example is as follows:

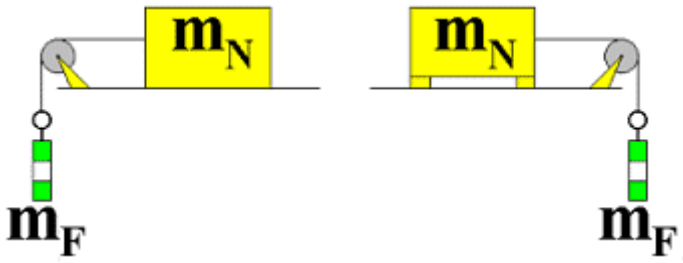
$$F_F = \mu \cdot F_N = 0.3 \cdot 90\,N = \underline{\underline{27\,N}}$$

$$F_F = \mu \cdot F_N = 0.3 \cdot 180\,N = \underline{\underline{54\,N}}$$

If the friction coefficient remains the same, the frictional force is always proportional to the normal force or weight. Thus if the normal force is doubled, the frictional force is doubled. Likewise, if the normal force is halved then the frictional force is also halved. If the friction coefficient and the frictional force are known, the basic formula $F_F = \mu \times F_N$ can be transformed and used to calculate the normal force or weight:

$$F_N = \frac{F_F}{\mu} = \frac{27\,N}{0.3} = \underline{\underline{90\,N}} \qquad F_N = \frac{F_F}{\mu} = \frac{54\,N}{0.3} = \underline{\underline{180\,N}}$$

A test configuration used to calculate the frictional resistance by comparing mass may be as follows:



Sufficient weight m_F is added until the mass m_N only just remains motionless. When the masses start to move, weights can be removed. The formula that is used to calculate the friction coefficient and the transformed formulas based on it are:

$$\mu = \frac{m_F}{m_N} \qquad m_F = \mu \cdot m_N \qquad m_N = \frac{m_F}{\mu}$$

Strictly speaking, friction is still being determined using forces, since all masses are forced onto surfaces by the gravitational pull of the earth.

Example: A block of concrete with a mass m_N of 200 kg is pulled over a wooden surface. The mass m_F required to overcome the friction is determined to be 80 kg. In accordance with the formula $\mu = m_F / m_N$ this gives a friction coefficient of $\mu = 80\ kg / 200\ kg = 0.4$.

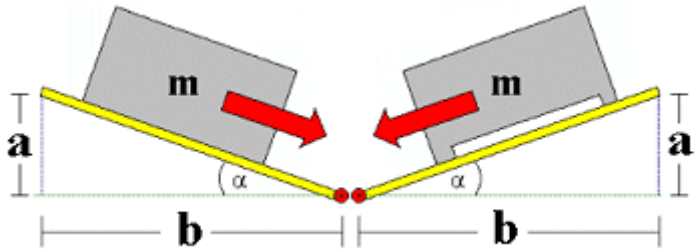
If the friction coefficient and the mass of an object are known, then the required frictional force can be calculated mathematically. Thus, for the example:

$m_F = \mu \times m_N = 0.4 \times 200\ kg = \underline{80\ kg}$

If the friction resistance and the friction coefficient are known, then the mass can be calculated:

$m_N = m_F / \mu = 80\ kg / 0.4 = \underline{200\ kg}$

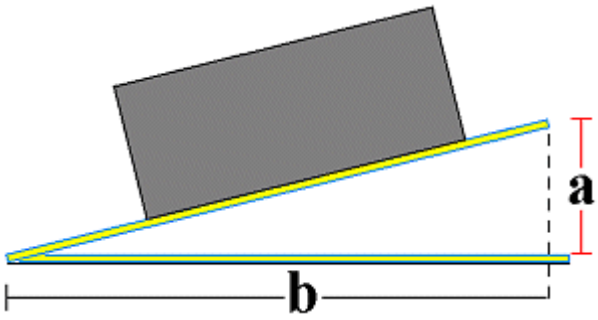
Possible test configuration used to determine the friction resistance on an inclined surface:



If no dynamometers or calibrated weights are available to determine the friction coefficient, the values can also be determined using an inclined surface. The surface is raised until the mass just starts to slide or roll. Once it has started to move, a lower angle of slope is sufficient to keep the object in motion.

There are two methods of determining the friction coefficient μ using a gradient or a sloped surface. One option is to divide the height of the sloped surface by the length of its base.

$$\mu = \frac{a}{b}$$

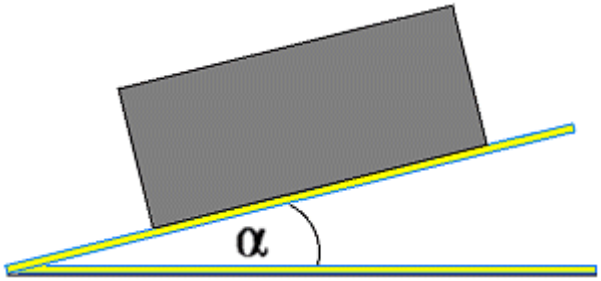


Example: An aluminum block is placed on a rusty steel plate which is raised at one edge. The height at a is measured at 96 cm. The length b is measured at 3.84 m. Using the formula μ = a / b, this gives a friction coefficient of μ = 0.96 m / 3.84 m = 0.25.

The friction coefficients determined using the sloped surface always correspond to the gradient of the slope expressed as a percentage. A μ value of 0.25 determined by a test such as this means that the slope has a gradient of 25%. Thus, if the friction coefficient of car tires on an icy surface is calculated at 0.1 this means that the car is able to drive on a maximum gradient of 10% on black ice.

If a pocket calculator with trigonometrical functions is available, or a table showing the values of the trigonometrical functions, then μ can be calculated using the angle of the incline. In this case the formula is:

$$\mu = \tan\alpha$$

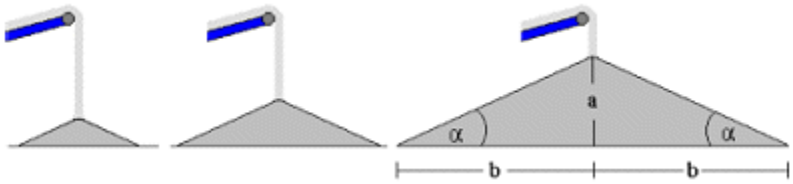


Example: Going back to the aluminum block on the rusty steel surface, the angle necessary for the block to begin to slide is 14°. The tangent of this angle is 0.25 and corresponds to the friction coefficient μ.

By transforming the formula, two known values can always be used to calculate a third unknown value:

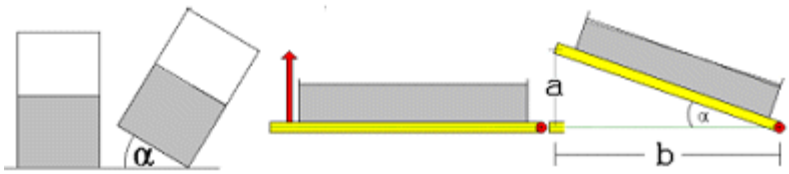
$$\tan\alpha = \frac{a}{b} \qquad a = b \cdot \tan\alpha \qquad b = \frac{a}{\tan\alpha}$$

Calculating the friction coefficient μ for bulk cargo. When using a conveyor or grab to move bulk cargo, when shoveling, tipping or pouring bulk cargo, the natural slope angle or angle of repose is formed naturally.



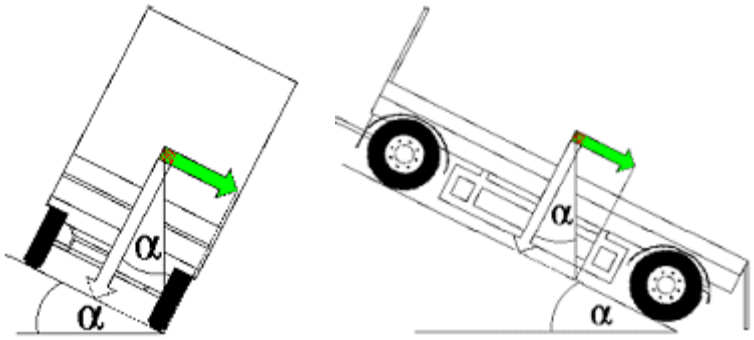
Formation of a cargo mound with a slope angle or angle of repose of α

Using the formulas for inclined surfaces, the friction coefficients (μ values) can be calculated. The value of the friction coefficient results when the height of the heap (a) is divided by the base length of one of the flanks (b) or the tangent of the angle of repose or slope angle (α) between the slope of the heap and the horizontal plane is calculated. During testing, values are determined by leveling the surface of the contents of a receptacle and then either tipping the receptacle or placing it on a surface which is then raised at one edge until the contents start to slide/flow.

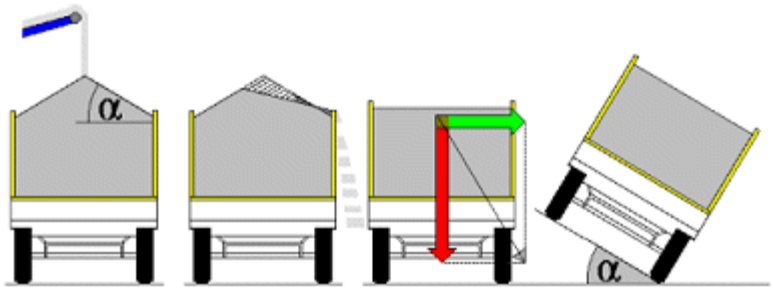


Examples: A glass of salt with a level surface is tipped until the first grains of salt break from the surface. A tipping angle α of 31° is determined. The tangent of 31° can be used to determine the friction coefficient of this type of salt as μ = 0.6. A receptacle containing leveled peas is standing on a surface which is subsequently raised until the individual peas start to roll/slide. The height a = 1.36 m and the base length of the inclined surface b = 4.00 m are used to calculate a friction coefficient for peas of μ = 0.34. Checking using the measured tipping angle of 18.8° confirms the friction coefficient: tan 18.8° = 0.34.

To completely empty bulk containers on vehicles at tipping points, the loading platforms must be raised so that the "tipping angle" α is reached or exceeded:



With respect to the safe transportation of bulk cargoes, particular attention should be paid to the fact that loads are leveled off before the vehicle is driven off:



If this rule is not followed, the load may begin to slide and overflow at very low acceleration. The picture on the far left shows a bulk load heap left in its natural state. The next picture shows that lateral acceleration of just 0.2 g would cause the shaded portion of load to slide from the vehicle. The next picture shows a vehicle where the heap has just been leveled. With the cargo loaded in this manner, it requires a lateral acceleration force of 0.6 g to make the cargo slide. The gradient which corresponds to 0.6 g is shown in the picture on the far right. The angle α is identical to the slope angle α of 31°.

The **angle of repose, slope angle or discharge angle** as well as the **friction coefficients of bulk cargo** are all affected to a great degree by the moisture content of the cargo, the size of the grains and other similar factors.

Test observations. Running tests and noting the measured data for different materials and masses or objects with varying weights will allow the following conclusions:

Bearing area. Insofar as the objects do not press into the surface, the dimensions of the bearing area have no influence on the magnitude of the friction resistance.

Weight/mass. Under otherwise identical circumstances, the friction resistance of objects is proportional to their mass/weight. Thus, doubling the mass will double the friction resistance, and halving the mass will halve the friction resistance, etc.

Material. The materials which are in contact are what determine the values observed. The magnitude of the friction coefficient depends solely on which materials are making contact.

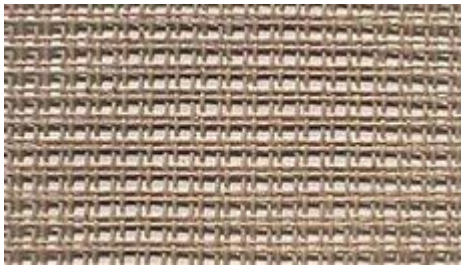
Units of measurement when using the basic formulas. For all calculations using the basic formulas $\mu = F_F / F_N$, $\mu = m_F / m_N$ and $\mu = a / b$ it is not relevant which unit of measurement is used to measure force, mass or distance. The important thing is that they are used consistently. Since the calculation dimensions in the formula cancel each other out, μ is a dimensionless numerical value.

Units of measurement when using the transformed formulas. With these calculations, care must be taken to ensure that the same mathematical dimensions are used, otherwise the results will not be suitable for comparison or will need to be converted. Writing down the mathematical dimensions guarantees the correct results, because errors can be spotted immediately.

Sliding friction coefficients. For load securing, the sliding friction coefficients are of particular importance. The following table contains sliding friction coefficients for selected general and bulk cargoes as well as a number of materials that are used on a regular basis. The values are taken from our own tests. The abbreviation FE mat stands for friction-enhancing mat.

Table 1a - Sliding friction coefficients for selected materials

Material pairs	Friction coefficient μ as			Discharge angle
Surfaces in contact or bulk cargo	Decimal	Fraction	Gradient	
Stones/loose soil, certain varieties of ore and coal	1	1/1	100%	45°
Friction-enhancing mats or car tires/very rough concrete, FE mat on FE mat (gum)	0.9	9/10	90%	42°
FE mat/rough concrete, rough wood or rough chipboard; tire rubber/macadam; certain types of paper/FE mats	0.8	4/5	80%	38.7°
FE mat/rusty steel or matt varnished wood, tire rubber on rough materials	0.75	3/4	75%	36.9°



Material with a µ value of approximately 0.8



Material with a µ value of approximately 0.7

Materials of this type are ideal for use as interlayer dunnage when layering goods that are unitized with suitable strapping.

They are less suitable for use as underlay or interlayer dunnage for unsecured loads or partial loads. As vibrations occur, the friction coefficient drops dramatically and the items will start to move. These relatively thin materials tend to wear easily. At times, particularly if they are heated, these materials can even have an adhesive effect which can depreciate the value of sensitive goods.

Table 1b - Sliding friction coefficients for selected materials

Material pairs	Friction coefficient µ as			Discharge angle
Surfaces in contact or bulk cargo	Decimal	Fraction	Gradient	
Rough galvanized sheets, rough ekki (Azobé) or softwood/FE mat; very rough concrete or stone/very rough concrete, FE mat (gum)/wood or PE	0.7	7/10	70%	35°
FE mats or rough stones or concrete/rough wood, planed oak or smooth plywood/FE mat; very rusty steel/very rough wood; car tires/wet road; various cereals as bulk cargo	0.6	3/5	60%	31°
FE mat/PA; rough concrete or rough stones/rough wood, very rough concrete/rough concrete, various materials/FE mats	0.5	1/2	50%	26.6°





Materials with a µ value of approximately 0.6

These materials can be used to maintain friction coefficients of approximately 60%. The material on the left is available in a number of different thicknesses, but usually 6 mm and 10 mm thick. The thicker version is preferable for use with heavier goods because it doesn't wear quite so quickly.

Materials of this sort are usually composite materials from rubber scrap and recycled rubber etc. The material on the right is just 2 mm thick and has a ridged surface. This is more suitable for forming unit loads.

In some cases, friction-enhancing materials cannot be brought into the containers, because they would hinder the normal work. This method can only really be implemented if the goods can be placed cleanly on prepared pads or strips. This method can also be used when loading open top containers or platform containers where the intended positions are easily accessible to staff and equipment. The use of non-slip materials is impossible if the length or any other characteristic of the load requires it to be pushed into the container.

Table 1c - Sliding friction coefficients for selected materials				
Material pairs	Friction coefficient μ as			Discharge angle
Surfaces in contact or bulk cargo	Decimal	Fraction	Gradient	
Aluminum profiles/FE mats;	0.45	9/20	45%	24.2°
Rough wood/matt varnished wood; aluminum/FE mat; rusty steel/very rough softwood or oak; certain types of paper/PE; very rusty steel/very rusty steel; concrete/wood; concrete/concrete; minimum value for FE mats	0.4	2/5	40%	21.8°
Rough wood/wood; rough wood/PE; aluminum/softwood or PE; rusty steel/rough wood; rough galvanized steel plate/softwood; certain types of paper/cardboard or wood; concrete/wood; wood/wood; wood/special plastic films; car tires on snow	0.3	3/10	30%	16.7°
Matt varnished wood/PE; rough chipboard/softwood; rough chipboard/PE; planed ekki (Azobé)/softwood; plywood/softwood; paper/wood; steel/aluminum	0.25	1/4	25%	14°



Softwood

In practice, dry softwood should not be calculated with a friction coefficient greater than 30%.

Table 1d - Sliding friction coefficients for selected materials				
Material pairs	Friction coefficient μ as			Discharge angle
Surfaces in contact or bulk cargo	Decimal	Fraction	Gradient	
Planed oak, PA/softwood, PE; Bongossi, plywood/PE; FE mat/sanded wooden loading platform; rusty steel/PE, PA; rough galvanized steel/PA; contaminated steel/aluminum; dusted steel/ rough wood; wood, cardboard on textured	0.2	1/5	20%	11.3°

coated board, PVC, plastic coated wooden floors etc.				
PA/PE, rough galvanized steel/PE; rough wood/sanded wooden loading platform	0.15	3/20	15%	8.5°
Aluminum, PA, PE, steel, wood and various other materials on heavily sanded or contaminated FE mats; smooth steel on smooth steel; tires on ice	0.1	1/10	10%	5.7°
Water, oil and other liquids	0.0	0/∞	0%	0°



Normal container floor

With normal container floors made of plywood or textured coated board, a maximum friction coefficient of 20% can be reckoned with. Even if the floor has been steam cleaned and dried thoroughly, when packers walk/drive across the floor, dust and other contamination is usually deposited thus lowering the friction.

Factors which alter the friction coefficients. The values given are just guidelines. Strictly speaking, each shipper should themselves determine the values that should be used in their situation. But beware: The values obtained under laboratory conditions are rarely the same as those that occur in practice. External influences, such as humidity, dust and grease can affect the figures considerably. Dirty loading areas with the remains of granular materials, such as sand, etc. reduce the friction coefficient considerably. Some of these values are given in table 1. The friction coefficient can, in particular, be reduced considerably by vibration, and in a worst case scenario it may even be reduced to values approaching zero.



Ultra-smooth container floors

When using containers with very smooth floors, it is recommended not to rely on friction, but instead to pack and secure the load in such a way that it cannot move, even without friction.

VDI 2702. Guideline VDI 2702, published by the Verein Deutscher Ingenieure, and entitled "Ladungssicherung auf Straßenfahrzeugen - Zurrkräfte" (Load securing on road vehicles - Lashing forces) gives the following sliding friction coefficients:

Table 2a - Sliding friction coefficients in accordance with the VDI Guidelines

Material	Dry	Wet	Greasy
Wood on wood	0.20 - 0.50	0.20 - 0.25	0.15 - 0.05

Metal on wood	0.20 - 0.50	0.20 - 0.25	0.10 - 0.02
Metal on metal	0.10 - 0.25	0.10 - 0.20	0.10 - 0.01

The VDI Guidelines recommend using the lowest value for the sliding friction coefficient μ if in any doubt. In addition, attention is drawn to the fact that additional material pairs and environmental influences, such as dirt and ice, require that the friction coefficients should be estimated or should be determined specifically by testing.

The following table gives sliding friction coefficients from the VDI guideline expressed as fractions, as gradients in% and as angles:

Table 2b - Sliding friction coefficients in accordance with the VDI Guidelines

Material	Dry			Wet			Greasy		
Wood on wood	1/5 through 1/2	20% through 50%	11.3° through 26.6°	1/5 through 1/4	20% through 25%	11.3° through 14°	3/10 through 1/20	15% through 5%	8.5° through 2.86°
Metal on wood	1/5 through 1/2	20% through 50%	11.3° through 26.6°	1/5 through 1/4	20% through 25%	11.3° through 14°	1/10 through 1/50	10% through 2%	5.7° through 1.15°
Metal on metal	1/10 through 1/4	10% through 25%	5.7° through 14°	1/10 through 1/5	10% through 20%	5.7° through 11.3°	1/10 through 1/100	10% through 1%	5.7° through 0.57°

Here it should be noted that the issue of friction is under review by the Verein Deutscher Ingenieure and the figures given above are now obsolete (information as at the beginning of 2002).

Rolling friction coefficients are much lower than static or sliding friction coefficients. Values for common materials are shown in the following table:

Table 3 - Rolling friction coefficients of selected materials

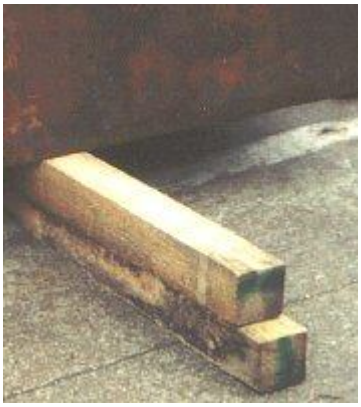
Material pairs	Friction coefficient μ as			Overflow angle
Surfaces in contact or bulk cargo	Decimal	Fraction	Gradient	
Roundwood, rollers and wheels on an unmade surface	0.5	1/2	50%	26.6°
Roundwood on rough surface	0.2	1/5	20%	11.3°
Roundwood on asphalt, steel or other firm surface	0.1	1/10	10%	5.7°
Wheels with air-filled tires on a firm surface	0.02	1/50	2%	1.15°
Steel wheels traveling on rails with flanged wheel grooves, starting and pushing on free tracks	0.01	1/100	1%	0.57°
Railroad wheels on free tracks, or clean flanged wheel grooves	0.0025	1/400	0.25% 2.5‰	0.14°

Squared lumber with a square cross-section can act like rollers. This risk is particularly high when using waney edge squared lumber since this often behaves in a similar way to roundwood.

Never stand rectangular beams on edge. Rectangular formats or, better, planks should be used flat. The thickness should be calculated in order to ensure that lifting gear or ground conveyors are able to handle the goods. A better format is the so-called "sandwich" which combines wood with top-quality friction-enhancing mats glued or screwed to each side. The gluing or screwing can be made more durable if the lumber is shaped to accommodate the mats. The depth should be measured in such a way that even when a heavy load is placed on the mat, the FE material is not crushed to such an extent that the goods are resting on the wood.

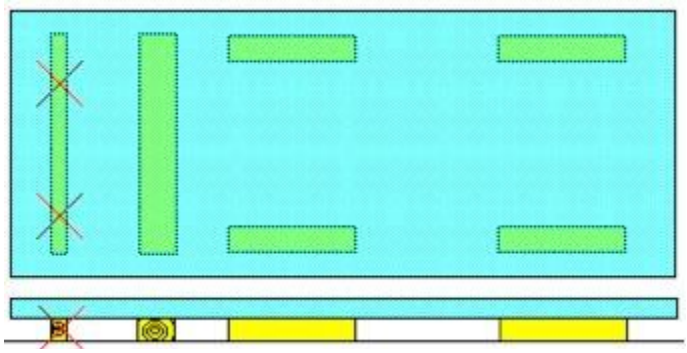






Incorrect, and incorrectly used lumber dunnage

If transport jolts are to be expected transversely to the orientation in which they are laid, rectangular formats such as planks are to be used. It would be better to set out the beams parallel to the expected direction of the jolts, but for handling reasons, this is only rarely possible.



Risk of rolling with incorrect and correct use of wooden dunnage

As has already been mentioned, frictional forces can be reduced to zero as a result of vibration. A certain minimum amount of load securing should always be implemented to counteract the effects of vibrations. Goods should never be transported unsecured just because the calculated or assumed friction coefficients are greater than the horizontal acceleration that is to be expected. With very few exceptions, for example, when materials are not compatible or the selected handling methods do not

permit the use of friction enhancing mats, friction should always be enhanced as much as possible by selecting the appropriate materials. Since the use of tensioning or lashing aids or vertical bracing creates additional frictional forces, the load securing outlay may be reduced considerably if high friction coefficients can be achieved.

5 Examples of packing and securing

This part of the container handbook is divided into three main sections:

5.1 This section deals with modularized cargoes, which require a minimum of securing effort, but may very well consist of a variety of types of cargo.

5.2 This section contains instructions relating to the packing of individual cargoes and homogeneous container cargoes, i.e. those which consist of the same types of shipped goods or cargo units.

5.3 This section deals with the packing and securing of heterogeneous, i.e. different or dissimilar, shipped goods or cargo units. This variant occurs most frequently with grouped loads.

Each individual shipped item, or each cargo group makes specific demands on the type of cargo transport unit used and the manner of packing or securing. Differences arise due to the characteristics of the goods carried and the shipping presentation or packaging used, which determine, or at least influence, compatibility, shape, strength, packing and securing options.

5.1 Containerized and modularized loads

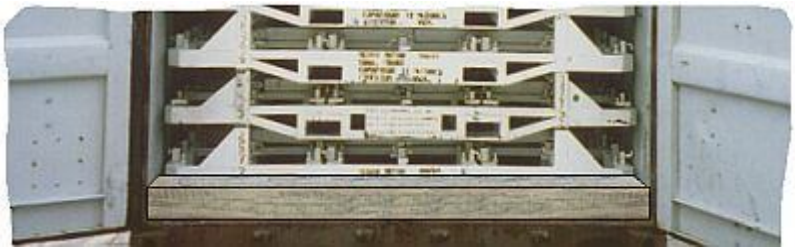
Section 3.2 of the CTU packing guidelines, entitled "Packing and securing", states that the cargo in a CTU must be made secure to prevent cargo movement inside the unit. In addition, it is pointed out that the method of securing the cargo should not itself cause damage or deterioration to the cargo or the unit. A tight stow from wall to wall should also be sought where possible, if cargo of regular shape and size is loaded. Since void spaces cannot always be avoided, it is pointed out that the cargo should be appropriately secured by using dunnage, folded cardboard, airbags or other suitable means.

The best and most economical way of carrying cargoes is in box containers, if the cargo dimensions allow easy, tight packing of the containers with transit trays for motor vehicle components in a 20' box container.



Transit trays for motor vehicle components in a 20' box container

In the stuffing example illustrated, the cargo is slightly narrower than the door opening. The door opening itself virtually matches the internal dimensions of the container . The trays for transporting motor vehicle components therefore fill the container almost completely. Since the trays interconnect, all that is needed for longitudinal securing in the door area is squared lumber or empty pallets.



Securing the container cargo in the door area

If such cargoes are loaded loosely stacked, gaps in the door area may be braced with wooden lattices, pallets or equivalent materials or simple structures. Any small gaps that may remain against the container side walls can be filled with boards, laths or the like.



Detail of the transit trays in the area of the container side walls

If package dimensions are not adapted closely enough to container dimensions, deficiencies regularly arise, which lead to cargo losses or greater labor costs and use of materials.



Unfavorable package dimensions can cause packing errors.

The telescope cartons should have been a few centimeters wider. Other aspects which merit criticism are the strapping with steel straps and the lack of edge protection. The bases of this combined packaging are only suitable for stacking if the tare weights are relatively low or the overstowed cargoes have adequate loading capacities.



Gaps in the cargo may result in damage.

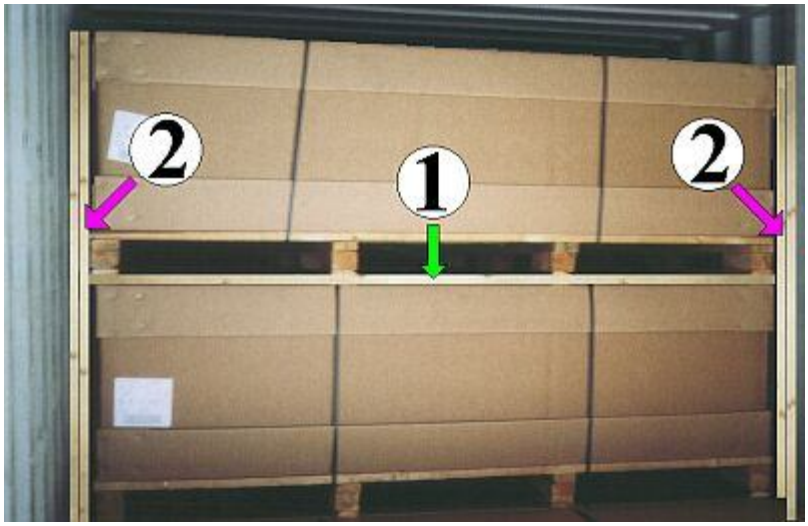
In transit, the small amount of play between the cargo and the container walls could result in damage to the packaging and possibly also to the contents.

Lateral dunnage consisting of boards or similar materials can reduce possible play during carriage sufficiently to reduce the risk of damage.



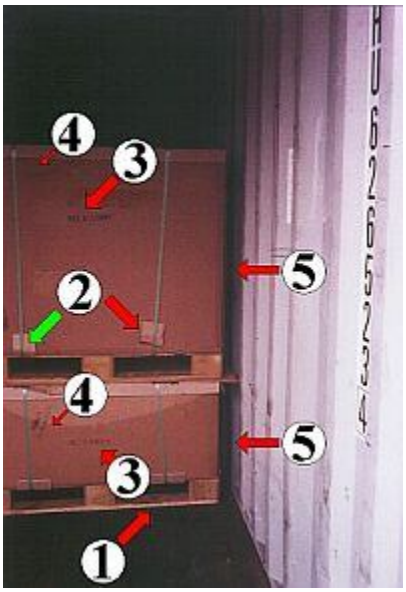
Even provisional filling of the gaps reduces the risk of damage.

However, it is better to use interlayer dunnage to stop packages in the upper tiers from exerting any damaging pressure on cargo below them (1) and to rule out completely any sideways movement by using appropriately securely and firmly fitted materials (2).



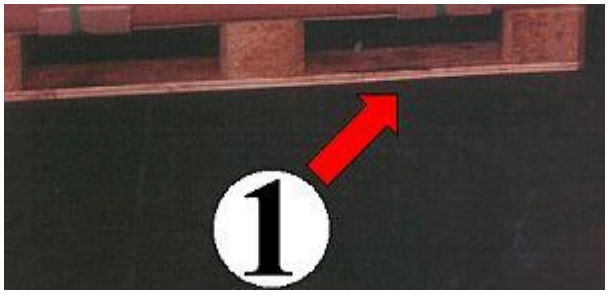
Compact stowage by filling all the voids

The packing example illustrated below is also deficient in certain respects:



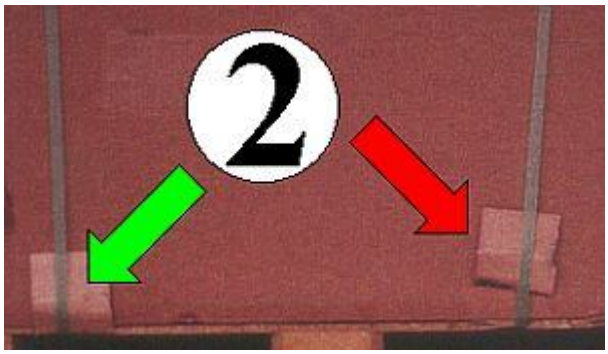
Inadequate packing in a 20' box container

The pallet base used here is certainly an improvement on the previous example with the telescope cartons, since the different arrangement of the boards makes the contact area larger:



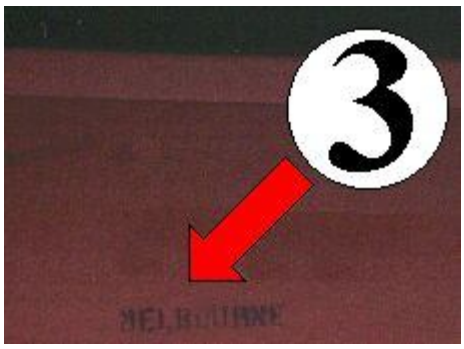
Sufficiently wide boards at the base of the pallet increase the contact area.

Steel straps are unsuitable for strapping cartons. The provisional edge protection is inadequate. It would be better to use wide plastic strapping with appropriate elasticity and sufficiently strong edge protectors:



Steel strapping and inadequate edge protection constitute a packaging risk.

The label on the package states that the container is bound for Melbourne. For voyages to Australia and New Zealand, it is essential to comply with regulations on the infestation of lumber by the Sirex wasp.

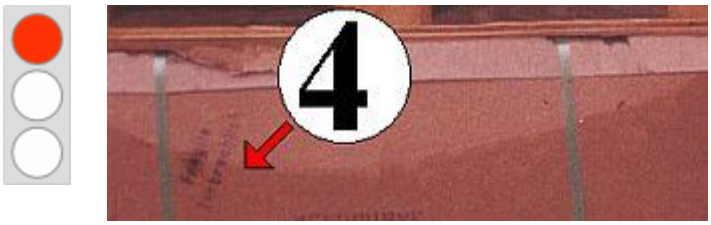


The CTU packing guidelines give the following general instructions:

3.3.2 If a CTU is destined for a country with wood treatment quarantine regulations, care should be taken that all wood in the unit, packaging and cargo complies with the regulations. It is a useful practice to place a copy of the wood treatment certificate in a conspicuous place inside and, where appropriate, outside the unit in a weatherproof pouch.

It must be taken into account that any wooden components of the container and also introduced lumber must be treated or the entire container must be treated after packing. Included in this requirement are the container floor, any wooden liners, cargo securing lumber, pallets or pallet-like bases and also the lumber used inside combined packaging.

Marking often constitutes the only communication between the cargo shipper and the warehouse, packing and handling personnel. Labels on shipping packages should therefore be conspicuous and clear. The small characters used here for the marking "fragile" cannot be deemed adequate. Such markings generally relate to the package contents. The condition of the package gives the impression, however, that it is the packaging that is fragile here.



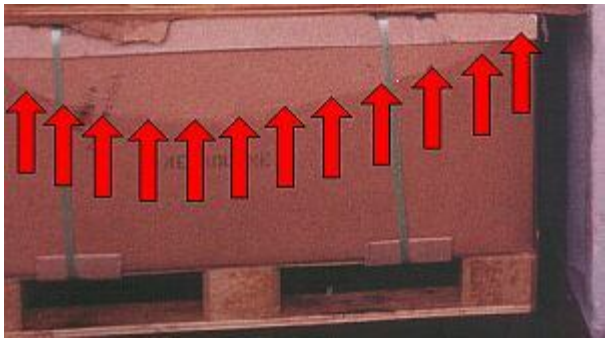
Inadequate marking of shipping packages

Where contents are fragile, clear labeling with an appropriate DIN or ISO symbol, i.e. an upright glass, is absolutely essential:



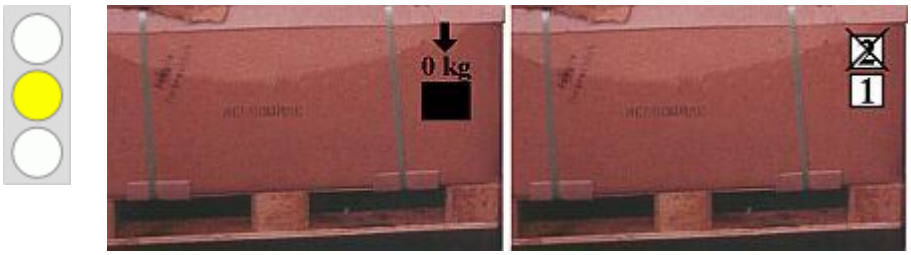
Symbol indicating fragile package contents

However, it is clear from the picture that the shipping package has already been bent, because the packaging was too weak, despite the provision of hardboard to distribute pressure and the fact that the package stowed over it was not excessively heavy.



Clear indication of weak and thus inadequate packaging

Although it would theoretically be possible to mark packages as weak using symbols forbidding overstowage, this is not really a practical suggestion as so much stowage space would be lost.



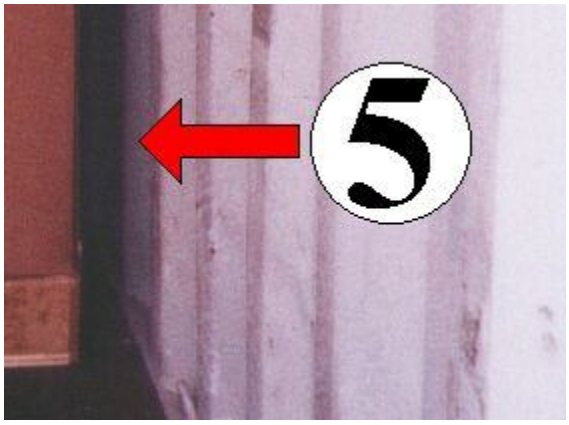
Theoretically possible symbols for "Do not overstow" or "Single-tier loading"

Packages should also be so constructed that they are able to withstand normal stacking loads in the means of transport used for carriage.

If the intention is to provide goods with particularly high levels of protection, it is best to use tested packaging or to have packaging which has been developed in-house tested by independent institutes.

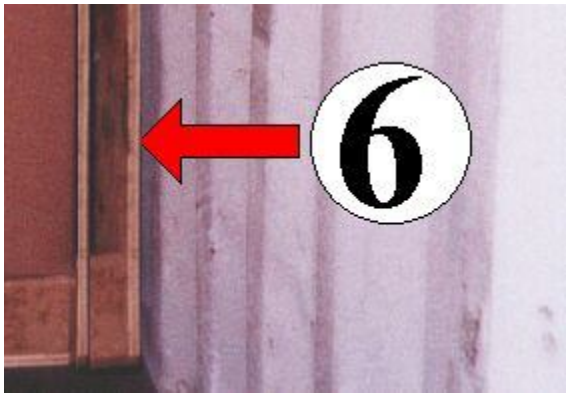
It is also possible to package normal goods in packaging whose strength or loading capacity is in line with the law on hazardous materials. The Annex to the IMDG Code contains regulations relating to stack pressure testing, which state that test packages which contain goods comparable to the original cargo should be stacked at least 3 m high. At the end of the test period, the packaging must neither lose its cargo nor deform or become unstable.. The minimum test period is generally twenty-four hours, though twenty-eight days is prescribed for certain packages. With the exception of bags, this stack pressure test is prescribed for all types of packaging.

Under no circumstances should gaps be left in the cargo during stowage, as they are the main cause of cargo damage.



Stowage gaps are the main cause of cargo damage.

The gaps must be filled. It is important to fill gaps with boards, squared lumber, pallets or similar materials using large bearing areas. If sensitive cargoes are being carried, large areas around the goods or packaging must be lined. With relatively heavy cargoes, large areas of lining are also necessary at the container walls. In the example illustrated, there was just room for a particularly thin pallet (6):



Filled gaps virtually guarantee transport without damage

Airbags are not suitable for such small gaps and load-securing foam is only suitable for rail and road transport due to its low "recovery".

5.2 Individual or homogeneous cargoes

5.2.1 Castings, plant and machine parts

Plant in box containers

Very severe cargo damage, right up to total loss, is inevitable here:



On a ship, heel angles of 30° are not unusual during rolling. These heeling angles are also commensurate with the lateral acceleration forces of 0.5 g in road and rail transport.

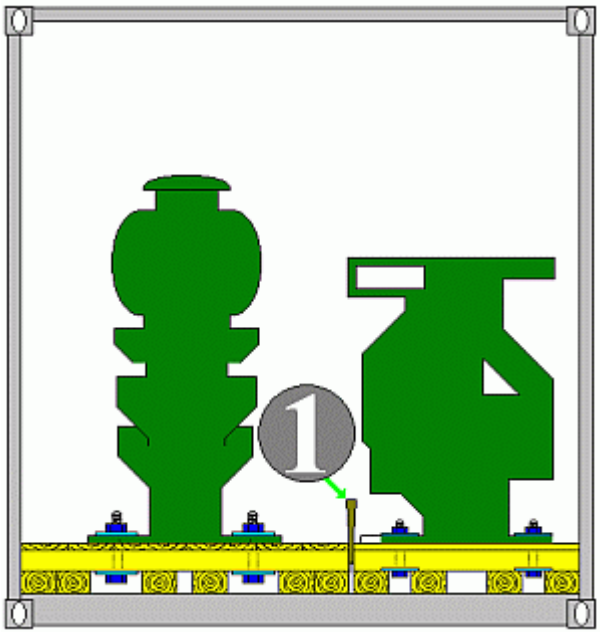




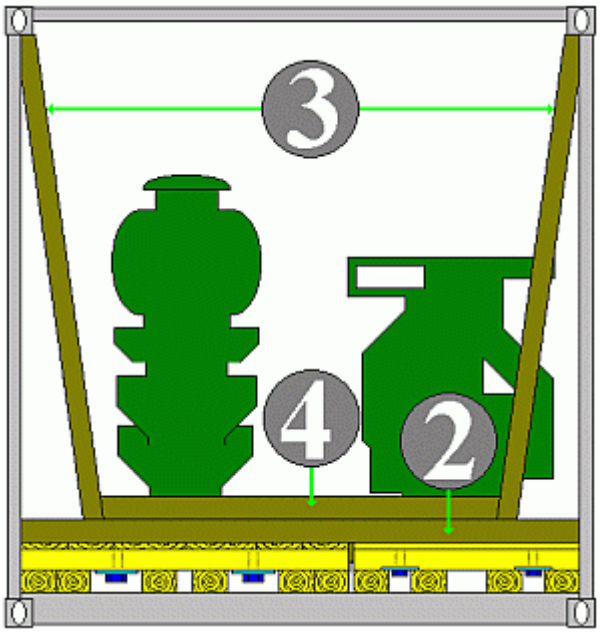
Although attempts have been made to restrain the cargo at floor level using squared lumber, no thought was given to the fact that the cargo is at risk of tipping over and toppling out of these restraints during transit under the above-mentioned conditions.



Provided that machines or plant parts that are unpackaged or are wrapped only in a sealed package for corrosion protection are attached to a base or frame of sufficient loading capacity, securing of such cargoes is relatively simple and cost-effective.

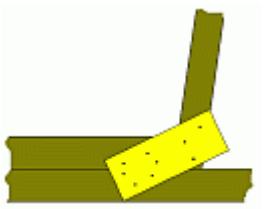


The shipping packages are introduced into the container and any gaps are filled with wedges (1) or fixed in the base area with squared lumber. Securing against tipping and also against shifting in all directions can be achieved by shoring.

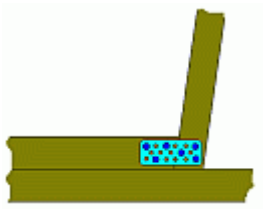


When producing the package bases, care must be taken to ensure that the bottom joists run lengthwise, so that the cargo weight can be transmitted uniformly to the container bottom cross members. Appropriately cut squared lumber is laid across the package bases or frames at several points (2). "Shoring" (3) is fitted between this lumber and the container's top side rails and knocked outwards slightly in the bottom area in order to exert sufficient pressure on the "wooden pressure members" (2). Finally, "wooden securing members" (4) are nailed on, with the purpose of holding the shoring in place throughout the journey.

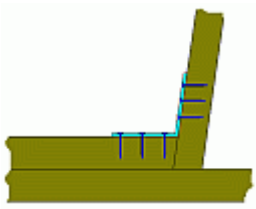
If there is concern that shoring may shift in the longitudinal direction, it may be stopped from doing this by nailing wooden bars on to it. Better results can be achieved with wood connectors. However, using wood connectors is more expensive with regard to nailing, since thought has also to be given to removal of the cargo from the container - detaching wood connectors is more difficult than detaching boards.



Securing with board ends



Securing with flat wood connectors

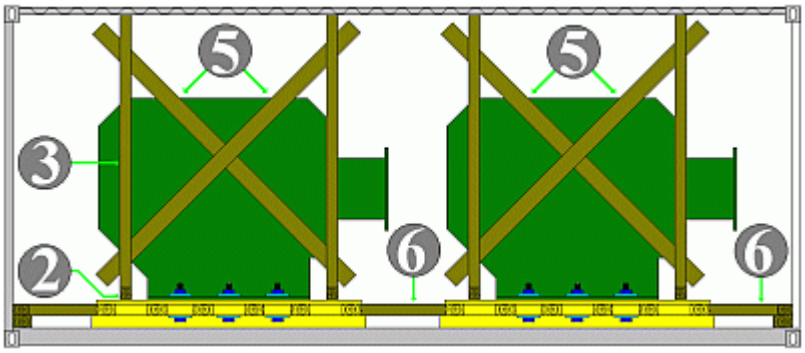


Securing with angular wood connectors

The risk of damage to the cargo and the costs are reduced if wood connectors are screwed on by machine, so avoiding powerful hammer blows to detach the nailed-down lumber.

In the case of containers with corrugated walls, slippage of the shoring in the upper area may be ruled out by arranging it in the corrugations. The same applies to the wooden pressure members, which may also fit into the corrugations. In the case of smooth or inadequately profiled container

walls, however, the lumber must be made more secure by "X-bracing".



2 = wooden pressure members, 3 = shoring, 5 = X-bracing boards,
6 = wooden bracing

Plant parts and accessories in a container

The entire container is lined with a film, to protect the contents from moisture and thus from corrosion. The film shown cannot achieve this.



Container packed with plant parts

The film has been damaged by introduction of the cargo, through being walked over by the loading personnel and by nailing of the joists and securing lumber to the container floor and it therefore no longer functions as a barrier. Even if the barrier were still intact, the lumber introduced in large quantities is such a source of moisture that the water vapor released by it could only be absorbed if enormous quantities of desiccants were introduced.

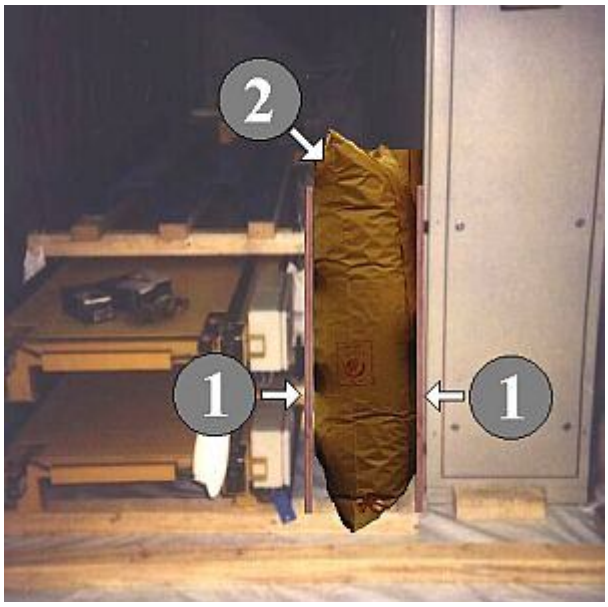
Only if kiln dry lumber is used and it can be guaranteed that the barrier remains undamaged can

reliable corrosion protection be achieved in this manner.

The following details relate only to mechanical cargo securing, irrespective of the efficacy of any attempts to achieve corrosion protection.

Lining of the container with film makes all the lashing points inaccessible. The remaining cargo securing options are therefore primarily only compact loading and gap filling. As a secondary option, lashings can be attached to the fixed lumber or wooden frames.

The switch cabinet is not yet secured. The gap can be filled with cargo, braced or closed up with airbags.



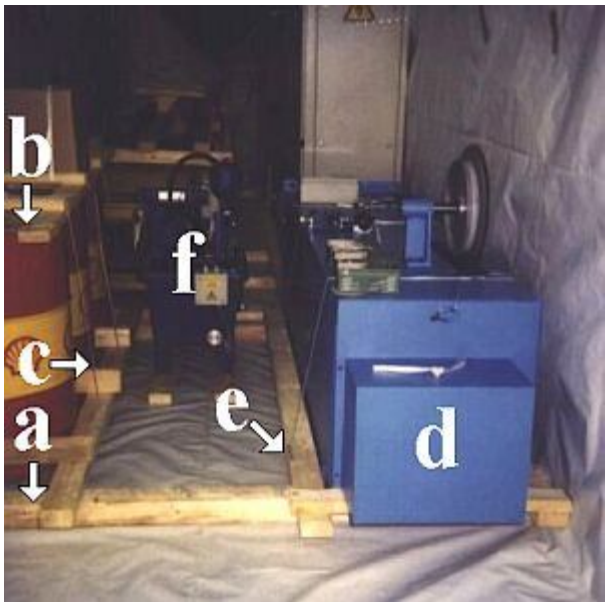
Gap closed with airbag

To prevent harmful deformation of the sheet metal switch cabinet body and the other items of cargo and to protect the airbag from damage, two plywood boards or the like (1) are positioned to the left and right in the gap. The airbag (2) is positioned in between them and inflated.

A wooden frame was prepared for securing lubricant barrels.



Wooden frame for lubricant barrels



Securing cargo to wooden frames

The lubricant barrels were positioned on the base frame (a) introduced into the container and fixed in the base frame by planks nailed crosswise in front of them. A further frame (b) was positioned on the barrels, over which straps (c) were tightened to secure the barrels vertically and against tipping. The plant parts (d) were also fixed in a wooden frame with straps (e) and the same was done for part (f). In principle, such securing is possible if the frames themselves cannot be levered out by the lashings or tip over together with their attachments. It is therefore essential to secure the frames against upward movement. Since container roofs have only a low loading capacity, shoring against the top side rails is again an option. Without these additional measures, the cargo will be damaged.

5.2.1.1 Cylindrical plant parts in wooden cradles

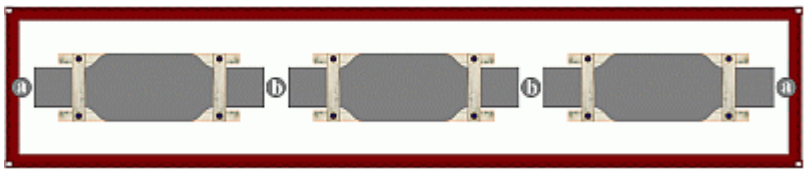
Example 1: Three plant parts on a 40' flatrack



A considerable amount of material was wasted securing the cargo lengthwise with wooden bracing. Although it looks expertly done, there are a number of deficiencies.



The gross weight of each of the three parts is stated as 7,366 kg. Thus, the total weight loaded on the flatrack is 22,098 kilograms, corresponding to normal forces of 7,226 daN per item or 21,678 daN for the whole cargo.



Basic diagram of the cargo

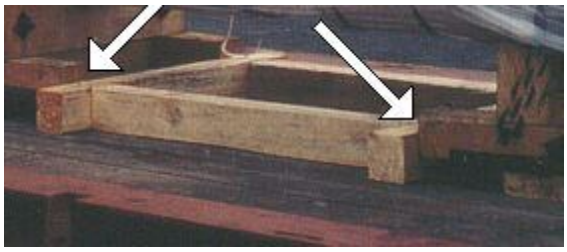
Taking the maximum possible lengthwise acceleration of shipment of 1 g as the basis for

calculation and leaving possible frictional forces out of the consideration, the following securing forces must be produced in the lengthwise direction:

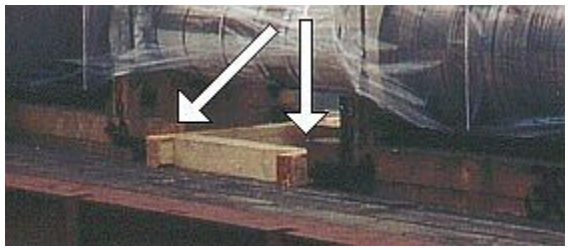
- at the end walls at (a) 3 x 7,226 daN = 21,678 daN;
- between the items of cargo (b) 2 x 7,226 daN = 14,452 daN.

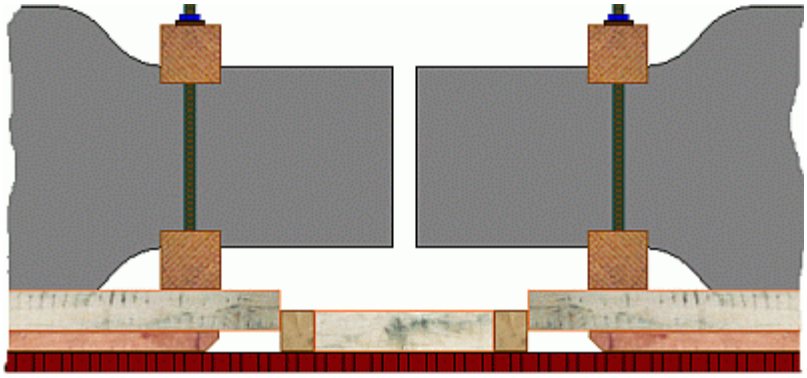
If the load bears on bracing lumber against the end grain, i.e. if the lumber is used end on to the grain, 100 daN per square centimeter of lumber cross-section may be expected. 217 cm² of effective lumber cross-sectional area would thus be required at points (a), and only 145 cm² at points (b).

If the load bears on bracing lumber against the face grain, i.e. if the lumber is used perpendicularly to the grain, 30 daN per square centimeter of lumber cross-section may be applied. The lumber cross-sectional area would accordingly have to be 723 cm² at points (a), and 482 cm² at points (b).



Above and right: incorrectly applied bracing means material wastage

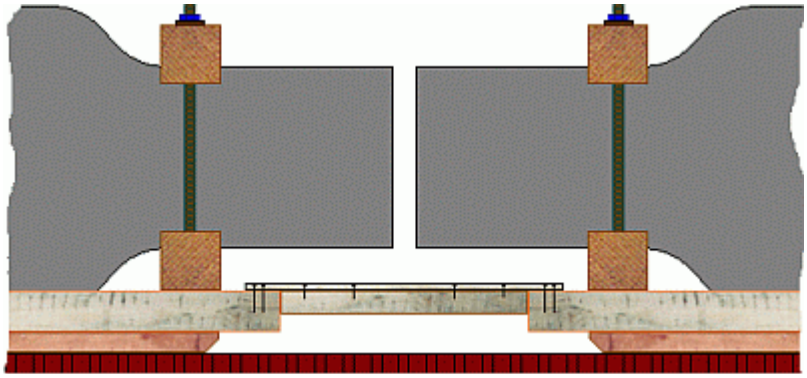




Basic diagram of the chosen bracing method

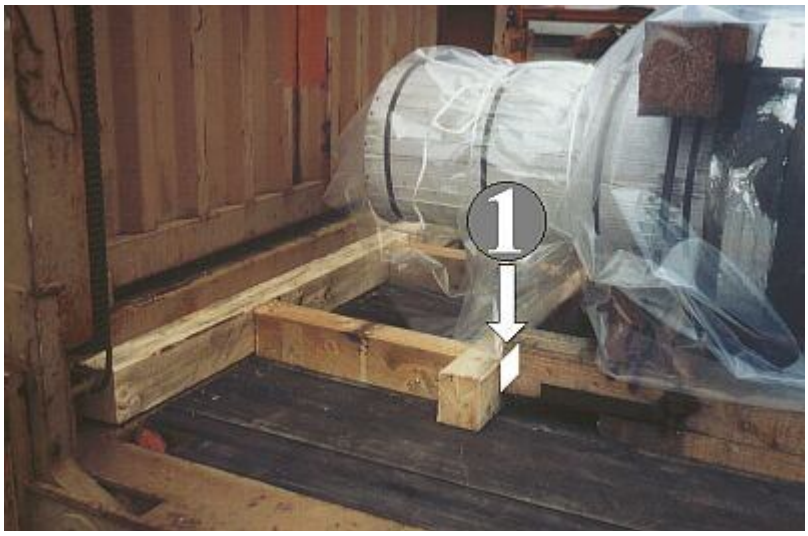
With the chosen method of bracing, wooden lengthwise members and crosspieces have been fitted on the flatrack floor between the plant parts' "wooden sled members" without taking account of their height.

Using 14 x 14 cm lumber on the flatrack floor and the same size lumber for the higher "wooden sled members" of the plant parts results in a contact surface of only approx. 2 x 14 cm x 7 cm = 196 cm², so meaning that the cargo is inadequately secured. It is also unfavorable that crosspieces have been used which are stressed perpendicularly to the grain, despite the fact that the sled lumber is capable of bearing loads against the end grain. Appropriate securing could have been achieved with a quarter of the volume of lumber used.



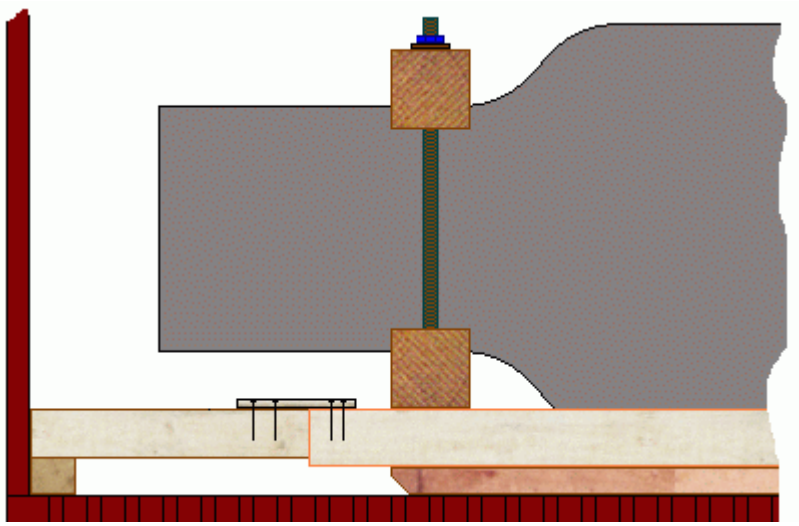
Cost-effective bracing

Since, when the lumber is exposed to stress against the end grain, an effective lumber cross-section of only 145 cm² is required to absorb 14,452 daN of longitudinal forces, two squared lumber members 8 cm x 10 cm nailed under a board and suspended from above and nailed to the wooden sled members would have sufficed.



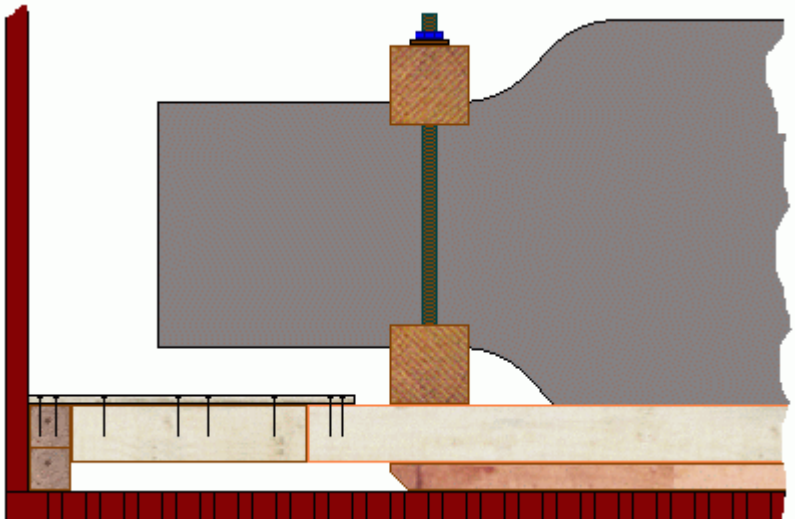
Incorrect use of bracing lumber at the end of the flatrack

Some of the possible lumber loading capacity has also been wasted at the end, because the bracing has not be applied at the level of the wooden sled members, so making the effective lumber cross-sectional area smaller than was possible.



Possible bracing, provided that the front end wall has sufficient loading capacity

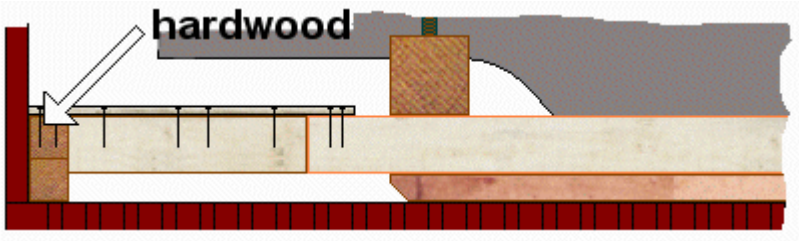
In order to be able to introduce forces of 21,678 daN into the front end wall, the wall must be capable of withstanding point loads at the appropriate places. If it is, the method illustrated may be used for cost-effective securing, since a lumber cross-sectional area of only 217 cm² is required and consequently of only 109 cm² per bracing member. Sufficient securing is achieved with only two 10 cm x 12 cm wooden members.



Bracing with pressure-distributing measures

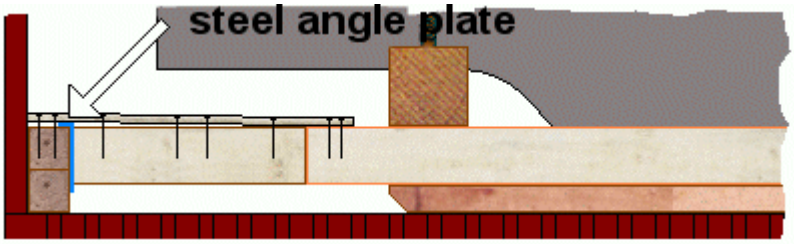
If the front end wall is not able to withstand point loads, crosspieces must be fitted. Since the bracing members bear on the face grain of the crosspieces for pressure distribution, strength values of only 30 daN/ cm² must be assumed. Consequently, at 21,678 daN, a surface area of 723 cm² is required, or a cross-sectional area per member of 362 cm² if two members are used. Lumber 18 cm x 20 cm or with a similar cross-section would be necessary. In the packing example selected,

this is impossible, since the sled lumber has a smaller cross-sectional area due its smaller size. As no changes can be made to the sled under the plant parts, there are three possible options:



Changing the strength of the lumber by using hardwood

The strength of the crosspieces may be increased by using hardwood beams. In the example described, it is sufficient for just the upper beam to be replaced by beech or oak.



Enlargement of the area by steel angle plates

Load transfer from the wooden bracing members loaded against the end grain and with a strength of 100 daN/ cm² to the 30 daN/ cm² crosspieces loaded against the face grain may be improved by fitting steel angle plates to increase the area for load transfer.

The third option is to transmit only a proportion of the longitudinal forces via wooden bracing and to absorb the remaining forces by means of lashing. This option has always to be considered when the front end wall of the container is insufficiently strong to absorb the necessary securing forces.



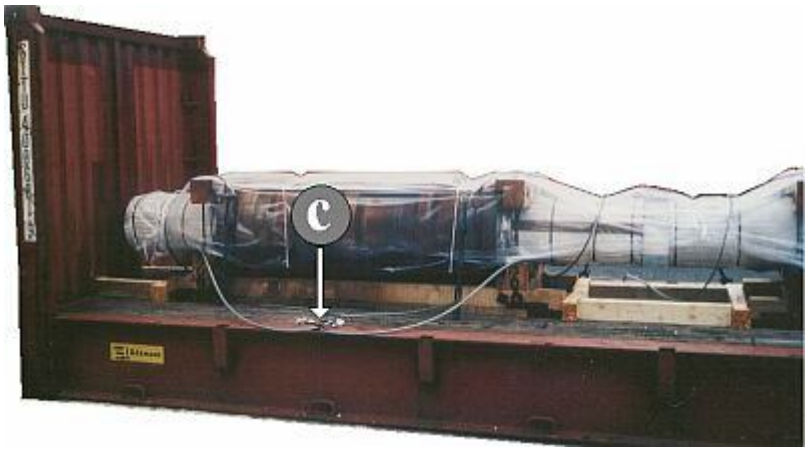
An "over-the-top" approach to securing

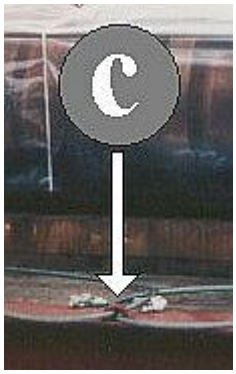
Here, much energy is being expended to secure the plant parts appropriately. Chain saws, steel wire ropes, wire clips, turnbuckles etc. have all been used, despite being unnecessary.



Preparation for cargo securing

The following pictures show that, despite all this effort, the objective has not been achieved:

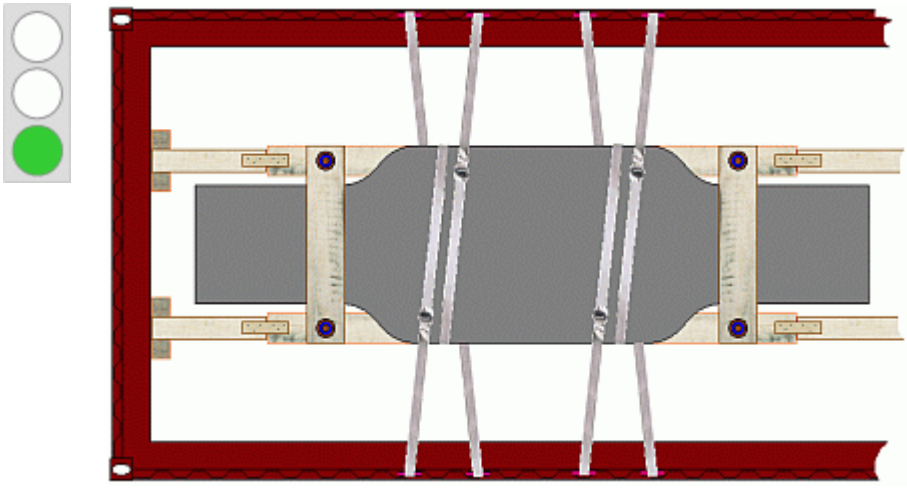




Top Above and selective enlargement to the left: Nonuniformity of lashings

Two steel ropes 16 mm in diameter, with which a maximum securing load per rope of 10,240 daN can be achieved in expert hands, are attached to lashing point (c), which can take a maximum securing load of approx. 3,000 daN. The intention was apparently to assist the obviously too small wooden bracing members by attaching the wires. They are intended to be effective in 3 directions: lengthwise, crosswise and vertically. The greatest attention is paid to the lengthwise component.

If sufficient wooden bracing is provided in the lengthwise direction, as already explained, sensible crosswise and vertical securing is lacking, a problem which can be readily solved with laterally acting loop lashings around the plant components. For this to be feasible, however, the nature of the cargo does have to allow the use of loop lashings.



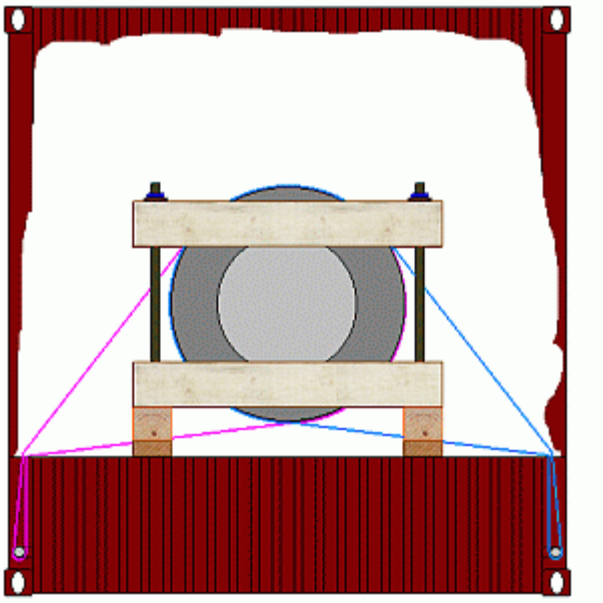
Crosswise and vertical securing by loop lashings, applied to separate lashing points.

In the case of a normal force of 7,226 daN per item, in the least favorable case transverse acceleration of 0.8 g and forces in the region of 5,780 daN have to be expected. The cargo dimensions result in average vertical lashing angles α of approx. 30°. The vertical component of a lashing thus amounts to approx. 50% and the horizontal component amounts to approx. 85% of the maximum securing load.

If single-use webbing belts with a maximum securing load of 2,000 daN are used, horizontal forces of 2 x 2 x 2,000 daN x 0.85 = 6,800 daN can consequently be achieved with the two loop lashings

on each side. The vertical component of the four loop lashings then amounts to 8,000 daN, calculated from 4 x loop lashings each having two working parts x 0.5 for the lashing angle α x 2,000 daN maximum securing load.

In the example, the ends of the loop lashings are applied separately to different lashing points. It is assumed that the lashing points have a maximum securing load of at least 2,000 daN. The horizontal lashing angle β of approx. 12° should be disregarded, since a value of 0.995 is obtained for the cosine of 6° in accordance with the formula cos β/2. This reduction of 5 thousandths understandably does not need to be taken into account.

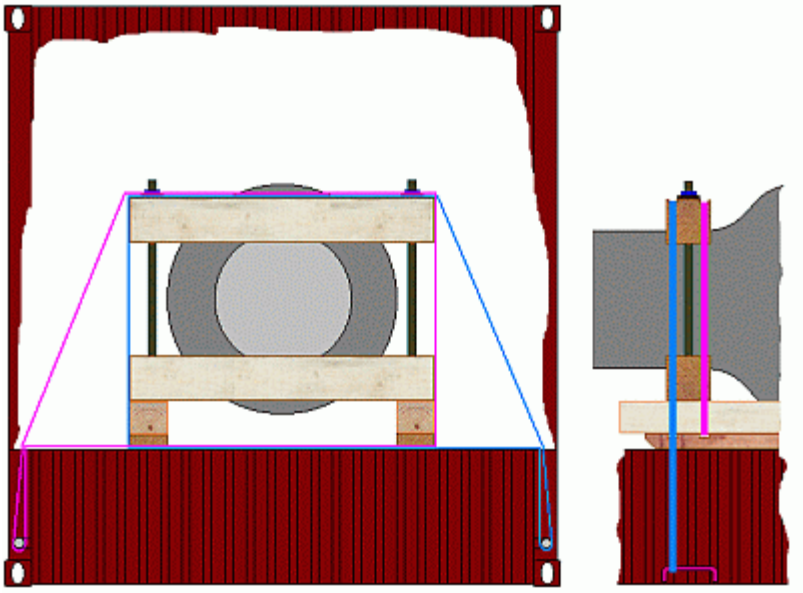


Crosswise and vertical securing by loop lashings, applied to a single lashing point

If the maximum securing loads of the available lashing points are at least twice that of the lashing materials used, the two ends of each loop lashing may be attached to one lashing point or guided around it.

Materials other than the above-mentioned single-use webbing belts can also be used for securing. However, any equipment used must be as economic as possible to use and not cause any damage to the shipping packages.

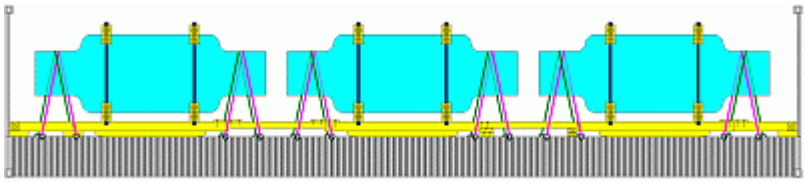
If the nature or sensitivity of a cargo forbids fastening to or around the cargo itself, securing may achieved by including the cradles, if they are as sufficiently strong as the components described above. This requires the cradles to be specially constructed, with routed grooves, recesses in the lumber or the like, but, if planned in good time, such measures do not involve excessive effort.



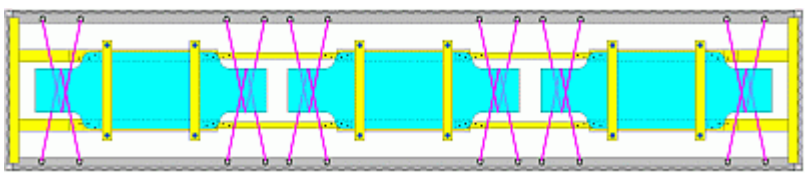
Crosswise and vertical securing by loop lashings passed around the cradles.

Since the above-described securing measures may damage the film applied to the packages, it is essential for cargo items which need to be kept dry to be provided subsequently with sufficiently tear-resistant protection against the weather, which must be applied in such a way that it cannot be damaged by wind forces during a voyage.

If the ends of the plant parts are capable of bearing a load, they may be secured with loop lashings. The advantage of this is that the smaller diameters result in more favorable transverse components:

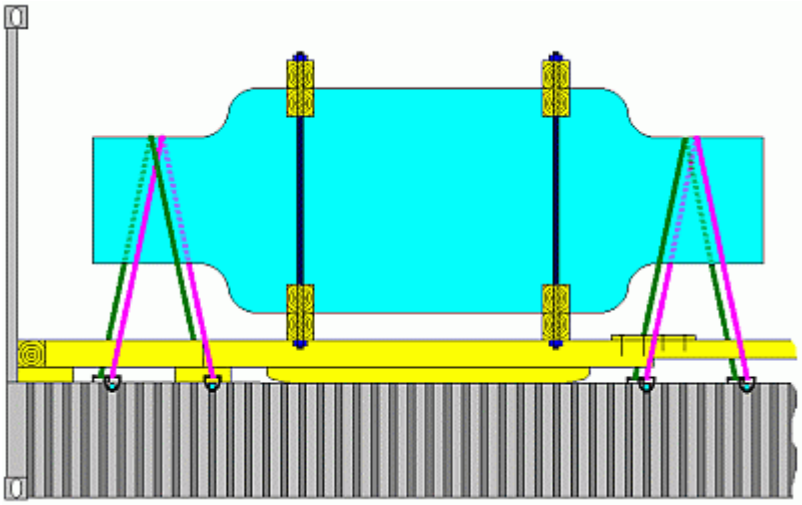


Securing at the ends of plant parts - side view

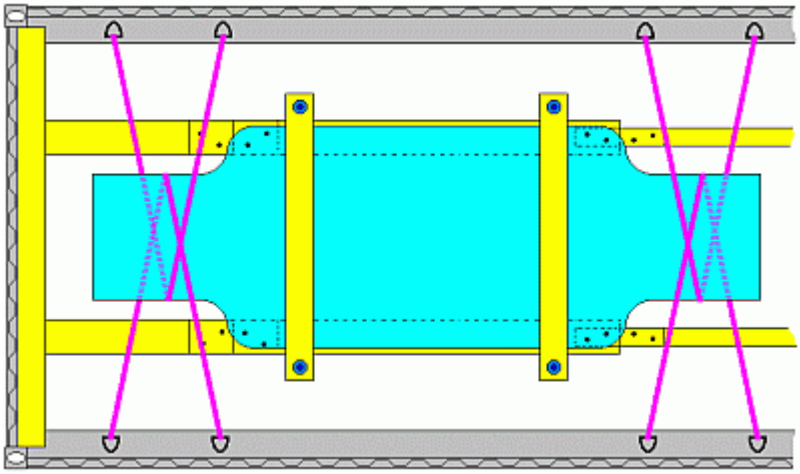


Securing at the ends of plant parts - plan view

The path taken by the loop lashings is more clearly visible in the following Figures:



Securing at the ends of plant parts - detailed side view



Securing at the ends of plant parts - detailed plan view

5.2.1.2 Cylindrical plant parts in wooden frames

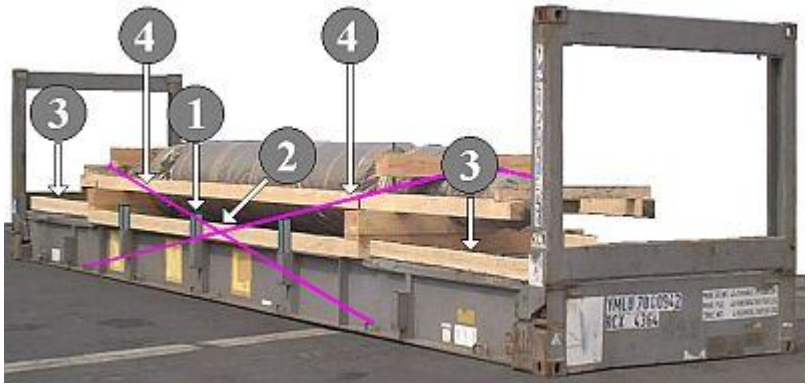
Example: Plant part in a wooden cradle on a 40' collapsible flatrack



Plant part in a wooden cradle - not yet secured

The roll-like plant part lies in a cradle attached to the forwardly and rearwardly tapering ends by threaded rods in the form of "pipe clamps". Interconnection is effected only by the two lengthwise wooden members, which are fitted laterally at the bottom. The upper frame consists of two lengthwise wooden members and two wooden crosspieces, which are simply nailed. This alone is not adequate to hold the part secure in the cradle.

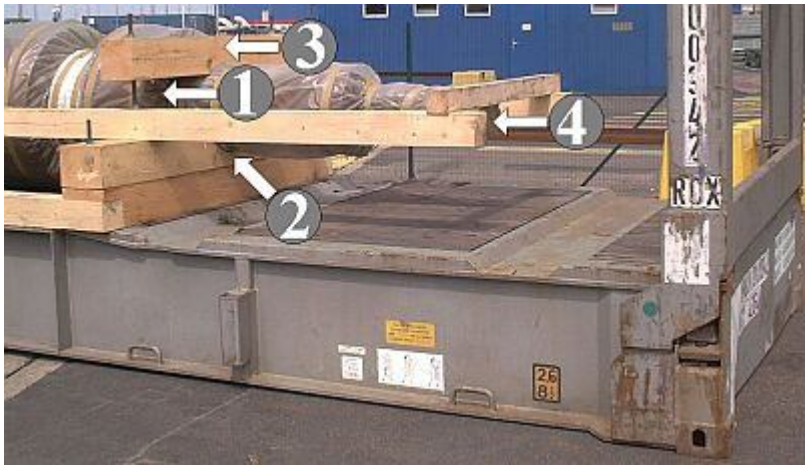
This picture shows how satisfactory securing can be achieved:



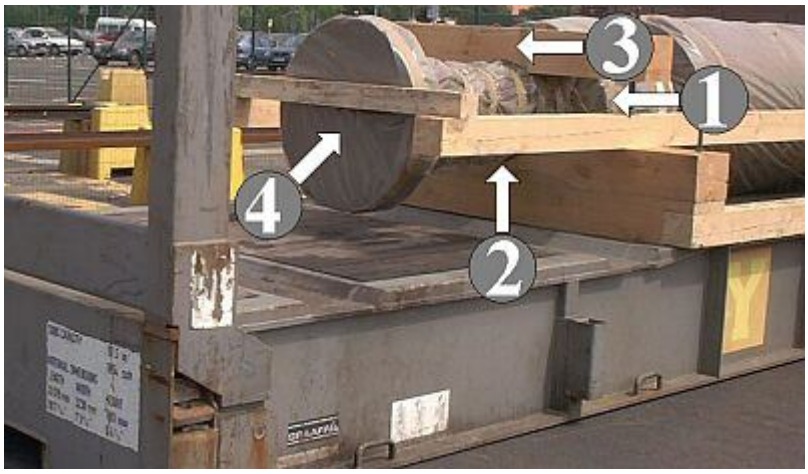
Plant part in a wooden cradle - secured

The flatrack used being one with stanchion pockets, three stanchions (1) should be inserted on each longitudinal side (merely indicated in the picture). If no stanchions are available, appropriate steel profiles or steel girders should be used. It is absolutely necessary for three squared lumber members to be fitted in the base frame transversely relative to the stanchion positions (2), so that the cradle is stabilized in the base area and held secure in the crosswise direction by the stanchions or steel profiles . Corresponding lengthwise securing of the cradles in the base area should be achieved by using longitudinally positioned squared lumber members (3). The wooden members illustrated need to be conformed to the weight of the package and possibly X-braced with boards. The top crosspieces of the "pipe clamps" need to be fixed lengthwise with loop lashings (4) in such a way that the plant part is secured in its cradle.

If the factory-fitted cradle is studied carefully, it will become apparent that other options for lengthwise securing might be possible, provided that information about the loading capacity of the plant parts is provided by or can be obtained from the manufacturer.



Cradle of the package at one end



Package cradle viewed from other end

If the bearing (1) is loadable in the lengthwise direction, the crosspieces (2) and (3) could be reinforced by means of horizontally fitted oblique bracing against the corner posts of the flatrack. If the shaft and shaft flange (4) were loadable in the lengthwise direction, oblique bracing could be positioned from that point horizontally against the corner posts of the flatrack.

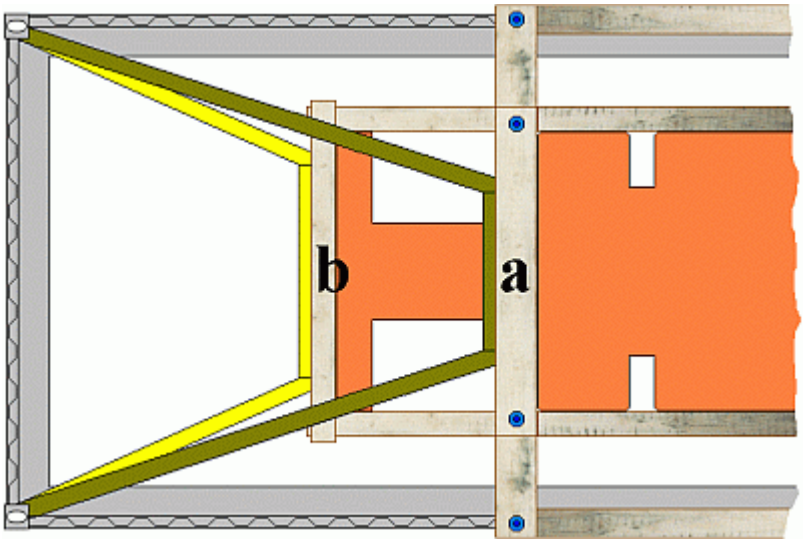
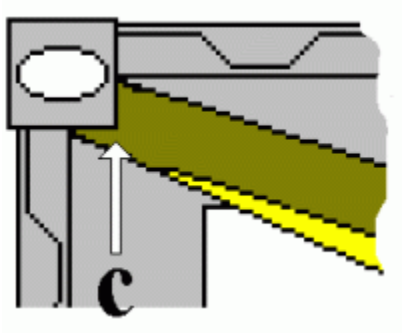


**Diagram showing the principle of oblique bracing between the bearing struts (a) or the end flange (b) and the corner posts
in flatracks without a fixed end wall**



"Bird's mouth" in the wooden members for the corner posts

So as to be able to transmit the force to the corner posts, so-called "birds' mouths" have to be cut into the squared lumber members which bear on the corner posts.

When using flatracks with fixed end walls, horizontal bracing could be fitted against the end walls of the flatrack, using wooden members for pressure distribution.

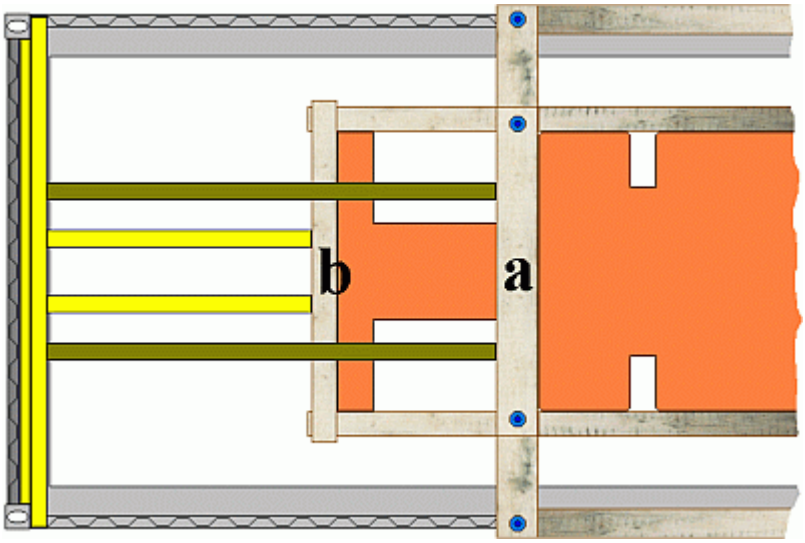
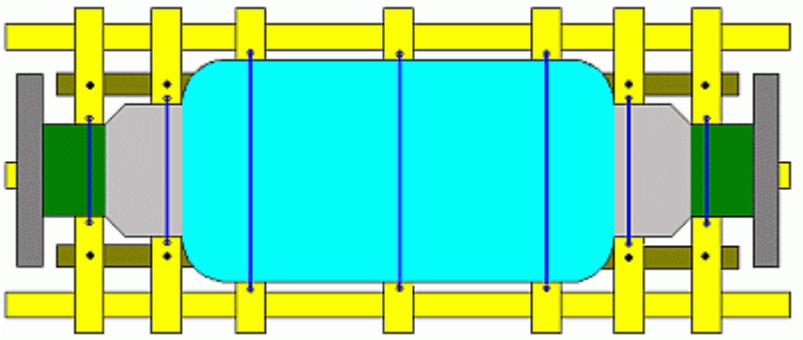


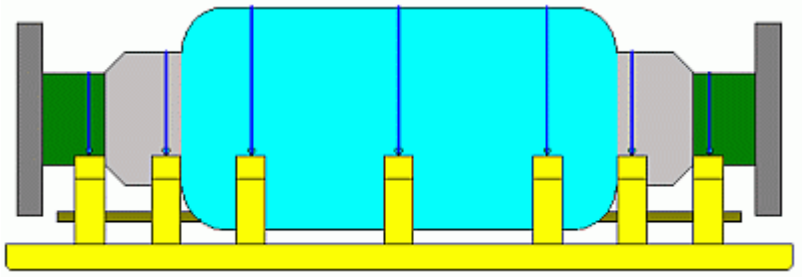
Diagram showing the principle of horizontal bracing between the bearing struts (a) or the end flange (b) and the flatrack end wall

It should be possible to prevent damage by simultaneously securing both static and rotating parts of the plant. Individuals involved in providing cargo securing who are not well versed in mechanical engineering are not in a position to assess technical features accurately. It is therefore essential that the manufacturers provide information about the loading capacities of plant components beforehand or at the very latest on delivery to the container packing company, so that only admissible securing measures are used and inadmissible measures are not carried out.

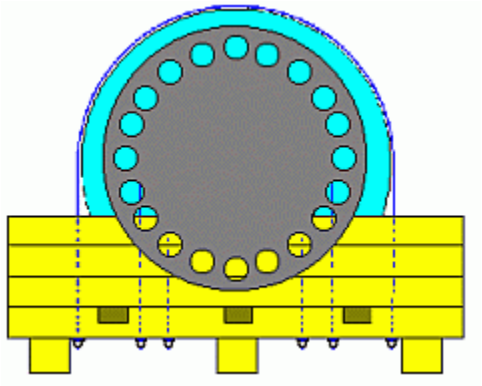
The following drawings are just suggestions; for instance cradles and securing for roller-, shaft- or turbine-like parts could look like this:



Cradle for a plant part - plan view

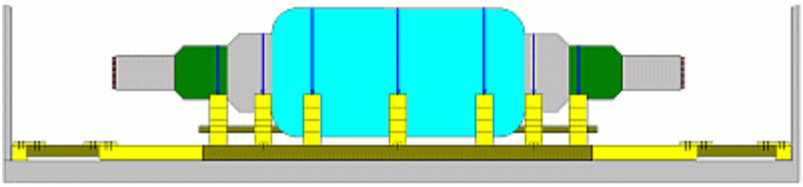


Cradle for a plant part - side view



Cradle for a plant part - end-on view

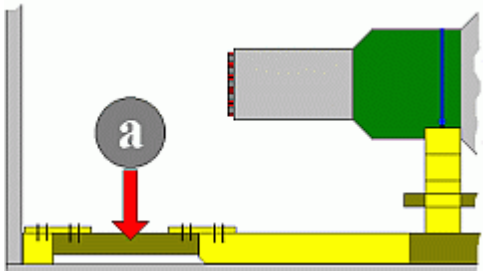
Such a part could be secured like this on a flatrack or in a container or similar transport receptacle:



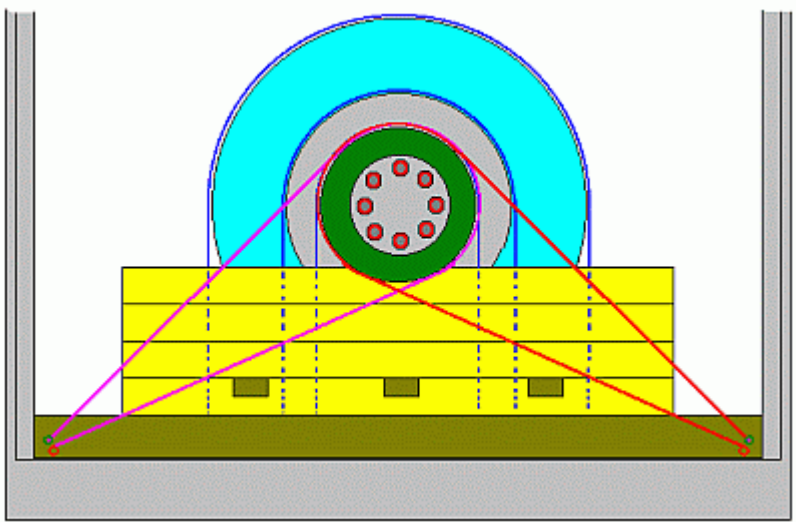
Lengthwise securing using wooden bracing

To distribute pressure, crosspieces are fitted to the end walls of the container or CTU. The remaining gap between them and the lengthwise members of the cradle is secured with "suspended" squared lumber (a):

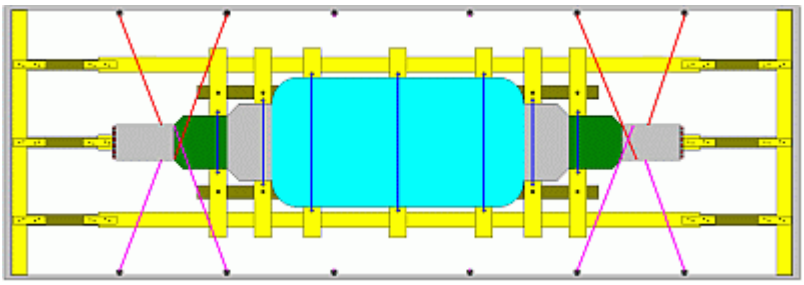
"Suspended" squared lumber for lengthwise securing

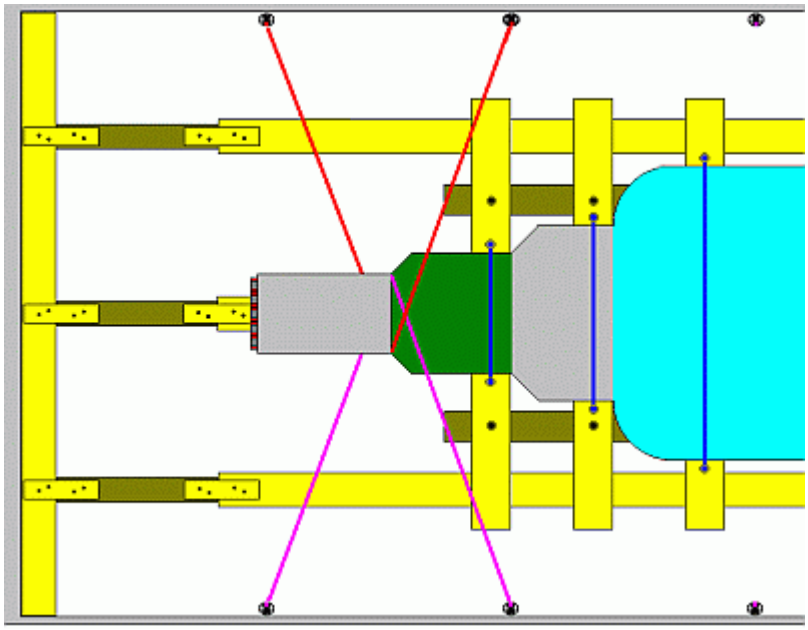


Lateral securing may be achieved with loop lashings over areas of the plant part with an adequate loading capacity, the loop lashings having favorably dimensioned horizontal transverse components and also sufficiently large vertical components. The vertical components are not intended here to act as tie-down lashing but rather to hold the plant part in the cradle even in the event of extreme heel angles.

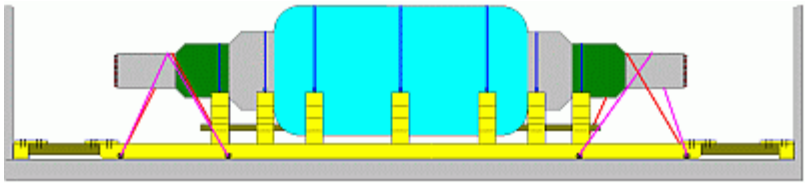


Lateral securing using loop lashings - end-on view





Top and selective enlargement below:
Lateral securing using loop lashings - plan view



Lateral securing using loop lashings - side view

Example: Unknown plant part on a 40' flatrack



Plant part on 40' flatrack





Securing with tie-down lashings

The type of cargo and its weight are not known. It can definitely be assumed that the six fitted tie-down lashings made from webbing cannot constitute adequate cargo securing. They have been only very slightly pretensioned and could not therefore produce frictional forces of sufficient magnitude. The single-use webbing belts have been pretensioned with a special tool. Subsequent re-tensioning is not possible, or only with considerable effort. All the buckle closures were on one side, i.e. it was unilaterally pretensioned. In addition, the shipping package is slightly overwidth, which rules out securing with tie-down lashing from the outset .
Woven tarpaulins with a net stretched over them are provided for protection against the weather; they are satisfactory but should have been secured more carefully, especially in the end wall area of the plant part.

5.2.1.3 Heavy plant part on 40' flatrack

Example: Plant part on a 40' flatrack



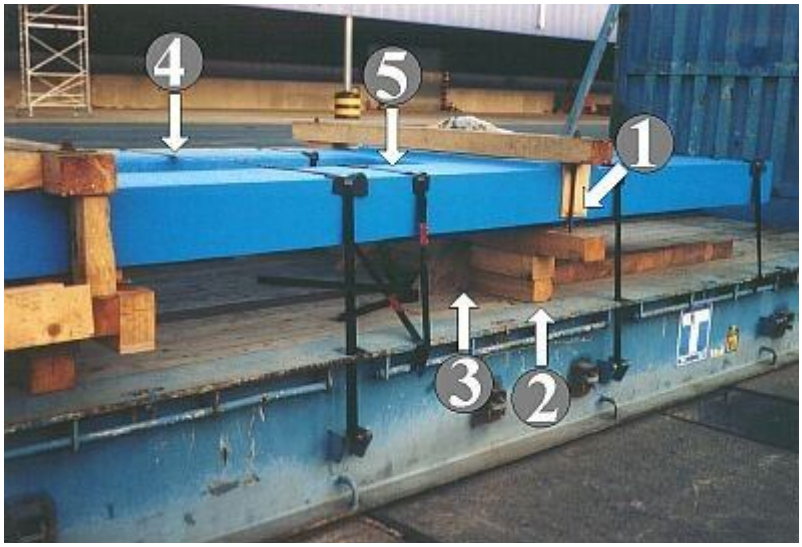
Inadequately secured plant part

In this instance, a lot of work and material have gone into securing which will not withstand the shipping stresses which may arise. The transverse securing consists of steel strapping, mostly fitted in the form of tie-down lashings. The nailed-down wedges which are intended to effect lengthwise securing are a waste, since they are incapable of performing their task.



The wedges cannot withstand the longitudinal forces which are to be expected.

Although the item of cargo is not excessively heavy, it does nonetheless weigh 8,750 kg. A positive feature is that the wedges have been correctly cut. Nailing into the face grain is possible.



The item of cargo is supported under the struts (1) by crosspieces (2) which are (should be) secured by wedges (3) against tipping in the lengthwise direction. As has already been mentioned, the use of steel strapping as tie-down lashing (4) is problematic. The use of steel strapping as direct lashing (5) is better, although it was applied here in a somewhat unfavorable manner.

If it is assumed that the cargo will be exposed to the highest possible transport stresses in combined road/rail/sea transport operations, the following horizontal stresses should be expected, without taking account of frictional forces:

- lengthwise: 8,584 daN normal force at 1.0 g = 8,584 daN
- crosswise: 8,584 daN normal force at 0.8 g = 6,867 daN

When bracing with squared lumber in the lengthwise direction, 86 cm² of lumber cross-sectional area are necessary if the lumber is loaded against the end grain or 286 cm² if the load is against the face grain. The same lumber cross-sectional area is necessary for an appropriate base structure.

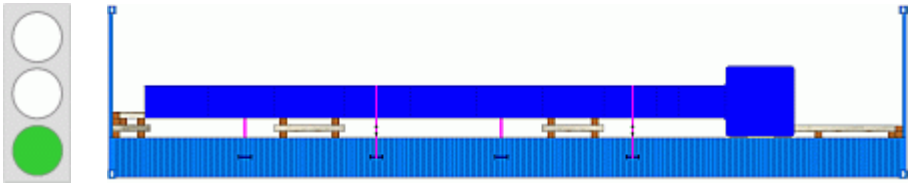


Diagram showing the principle of appropriate securing - side view

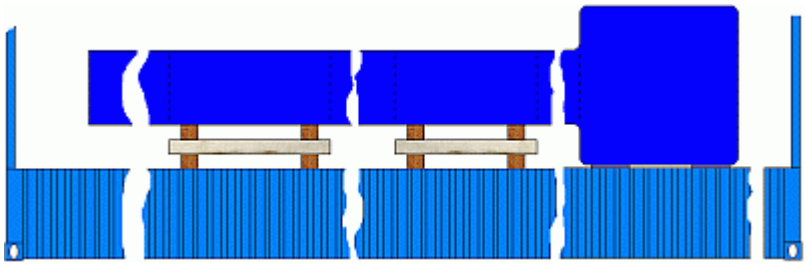
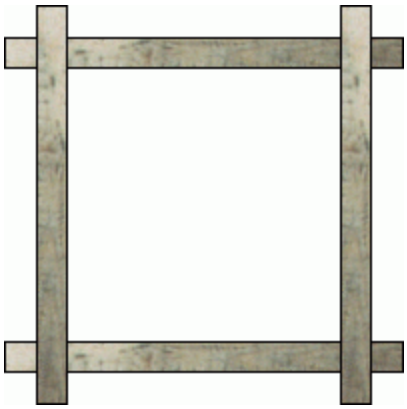
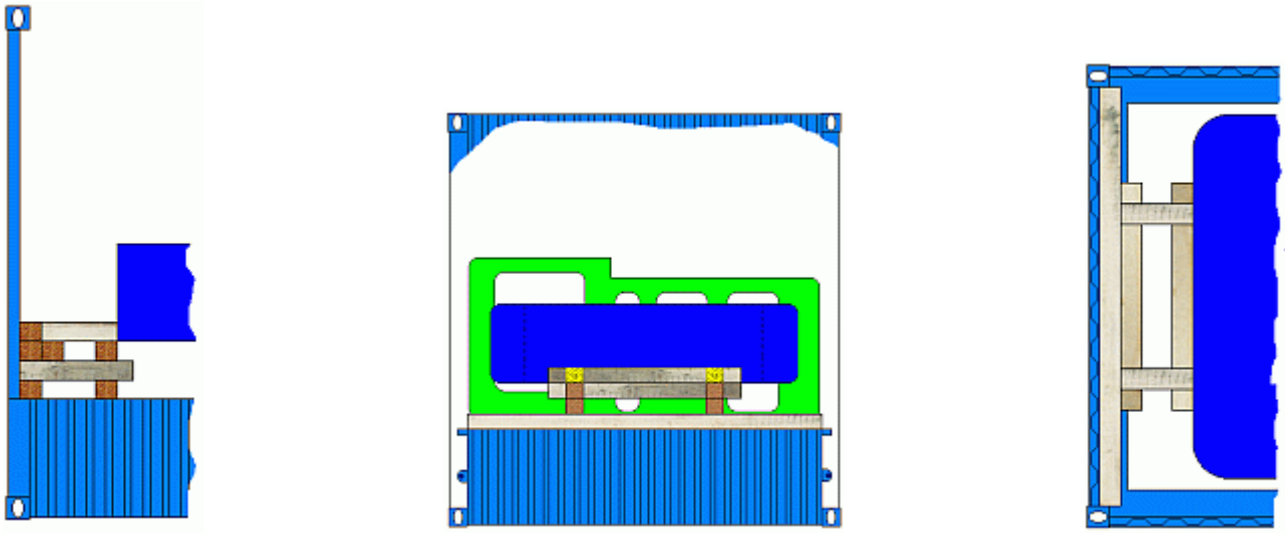


Diagram showing the principle of using cross-over beds as a base structure - side view

Since two cross-over beds provide a total of eight cross-over points, simple wooden beams with an edge length of 6 cm would suffice for supporting the steel part from below.

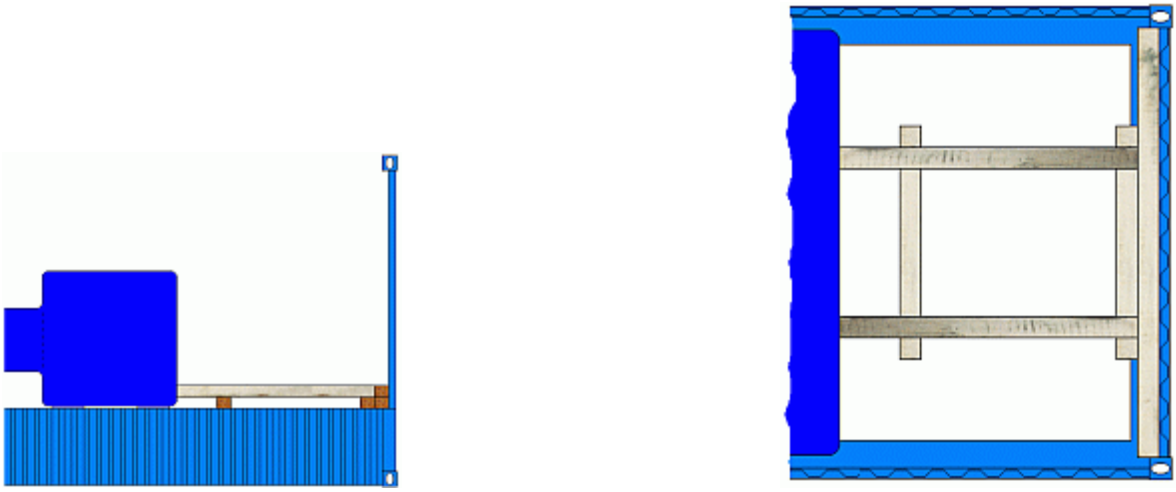


Cross-over bed in plan view

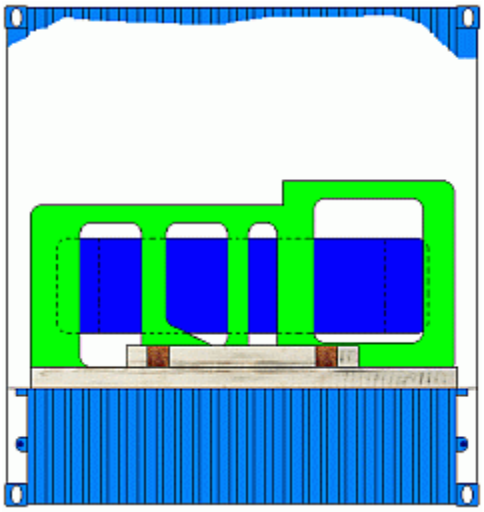


Bracing of the narrow side of the part in side, end and plan view

The variant shown is only a suggestion. Raising of the active squared lumber in the top layer can also be achieved by nailing planks to one another in steps, or by other similar methods. The other examples relating to wooden bracing contain a range of suggestions. When using two wooden members as longitudinal struts, they need to be at least 12 cm x 12 cm in size. If 10 cm x 10 cm wooden members are used, three are needed . The same minimum lumber thicknesses apply for bracing the other side.

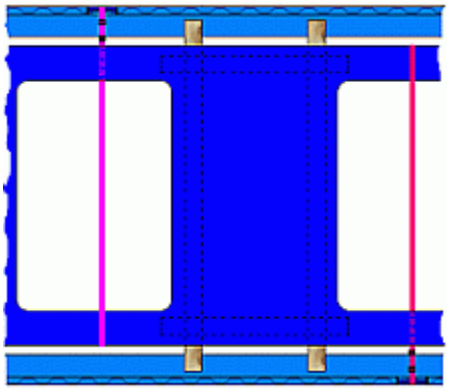


Bracing of the broad side of the plant part in side and plan view

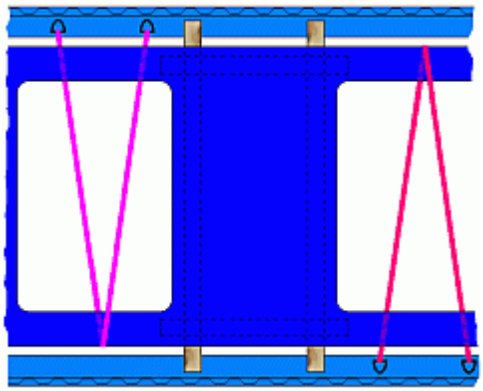


Bracing of the broad side of the plant part in end-on view

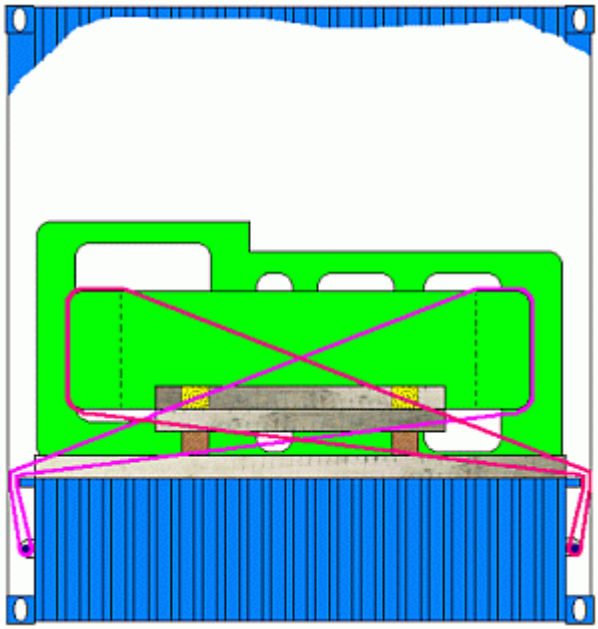
Appropriate transverse securing can be readily achieved using loop lashings, which are arranged around the opposite beam of the plant part from the lashing point(s), the question of whether the ends of the loop lashings are applied to one lashing point or two being dependent on the maximum securing loads of the lashing materials and points used.



One lashing point per loop lashing

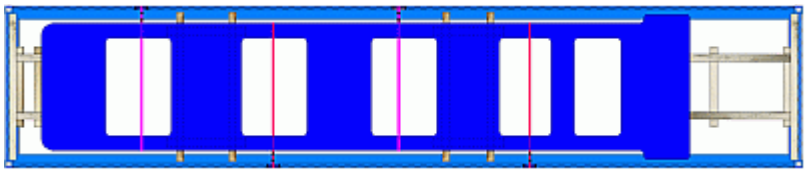


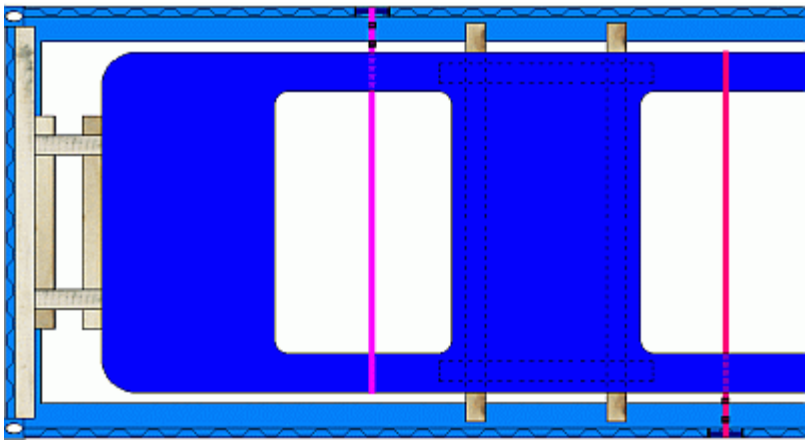
Two lashing points per loop lashing



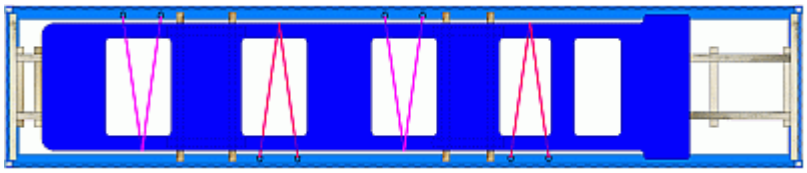
Arrangement of loop lashings in end-on view

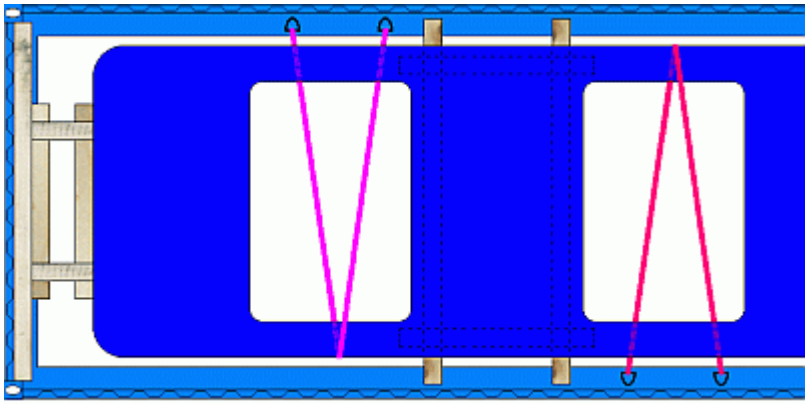
If the various methods are selected, the securing looks like this overall:





Top and selective enlargement below:
Securing with wooden bracing in the lengthwise direction and two loop lashings to the sides.
Loop lashing ends applied to one lashing point.





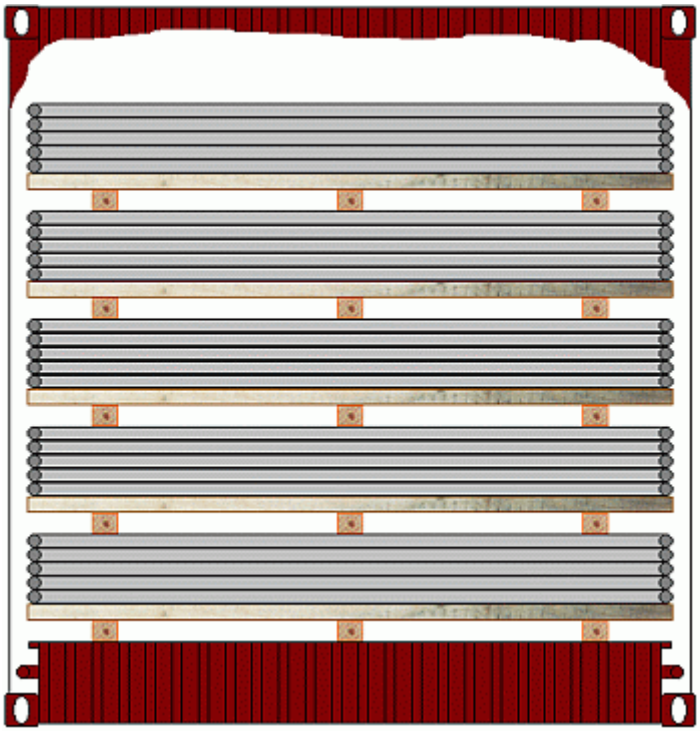
Top and selective enlargement below:
Securing with wooden bracing in the lengthwise direction and two loop lashings to the sides.
Loop lashing ends applied to two separate lashing points.

5.2.1.4 Pipe frame on 20' flatrack

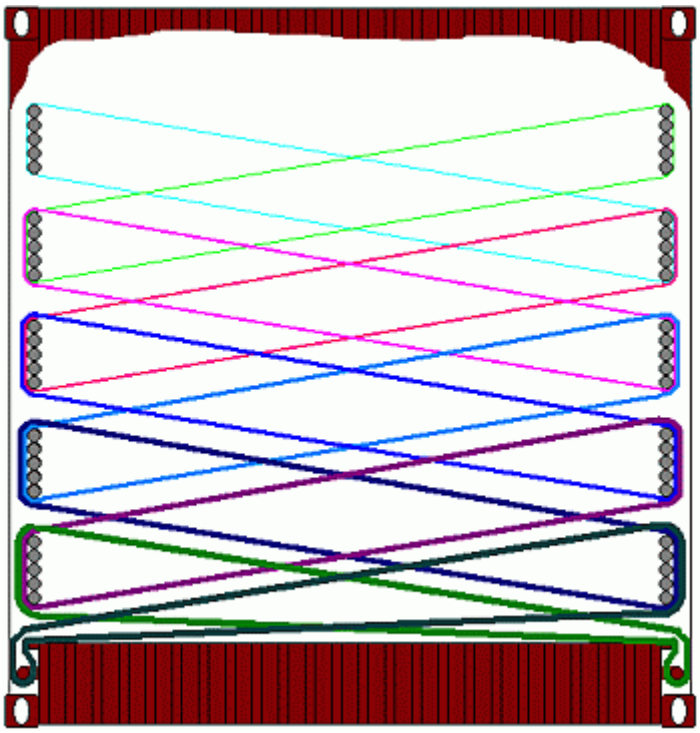
Steel pipe structures on a 20' flatrack



Pipe or lattice structures can virtually always be secured from the opposite side using loop lashings. Since the angle becomes less favorable as the height of the cargo increases, the cargo can be secured directly to the cargo stowed below it and ultimately to the flatrack itself.

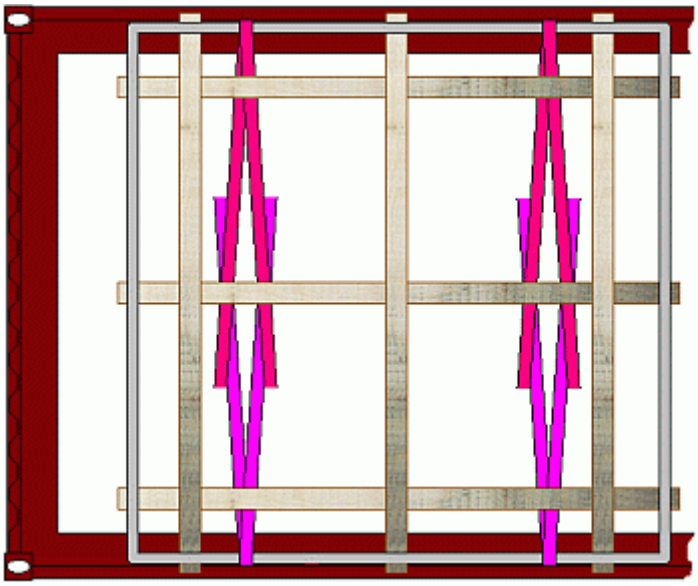


Principle of stowage - end-on view

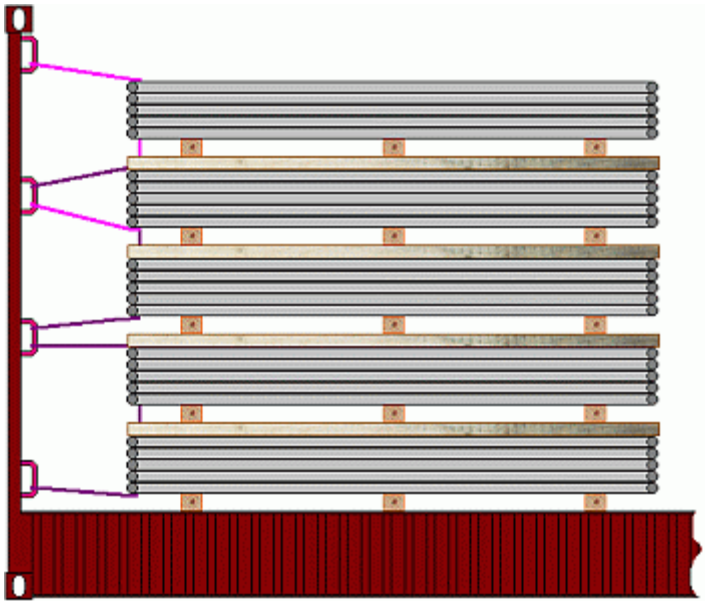


Principle of securing in end-on view

To make the illustration a little clearer, only the outer pipe frames have been shown. Lower down, the strength or number of securing means increases in relation to the increasing cargo mass. The principle could also be described as piggy-back securing, as each part of the cargo takes the next on its back.

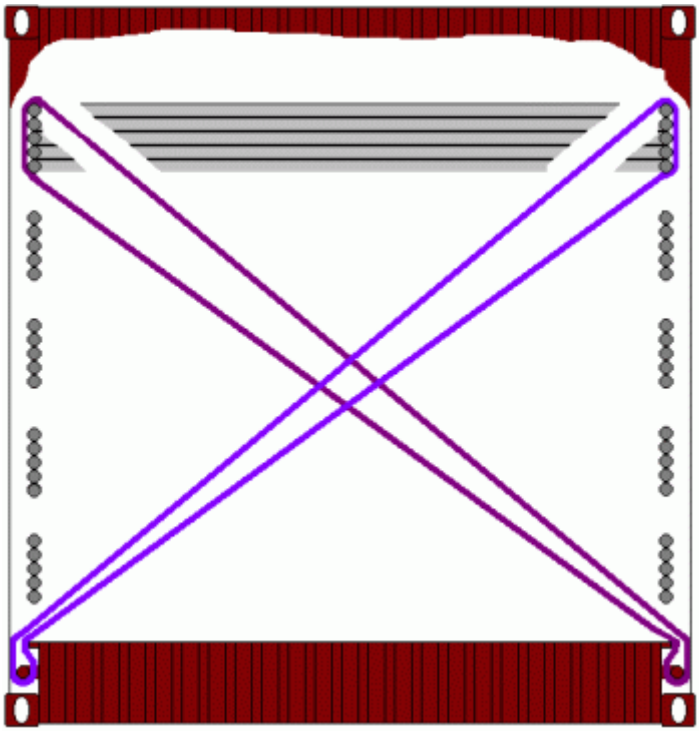


Principle of securing one layer in plan view



Principle of securing at front

Whether the entire cargo block or only individual parts are lashed to the end walls (or the next stack) depends on the maximum securing load of the lashing points, the securing materials available and the mass of the cargo. It goes without saying that blocking may also be used in the lengthwise direction. Lateral blocking is also an option in the case of flatracks with stanchions. Depending on the mass of the cargo, additional cross lashing may be incorporated.



Additional cross lashing for stabilization

To clarify the securing principle, only the outer edges of the "pipe bundles" and part of the top stack have been shown.

5.2.1.5 Overheight, overwidth plant

Plant part on 20' flatrack



Inadequately secured plant part on a 20' flatrack

Such plant parts can only be adequately secured when they are so firmly bolted to the wooden bed that only the wooden bed itself needs to be secured. The weather protection fitted would be inadequate for carriage on a normal container ship, but this flatrack is intended for carriage below

deck on a ro/ro ship.



Inadequate lengthwise securing at one end

Three nailed wedges are not up to preventing the plant part from moving in a lengthwise direction.



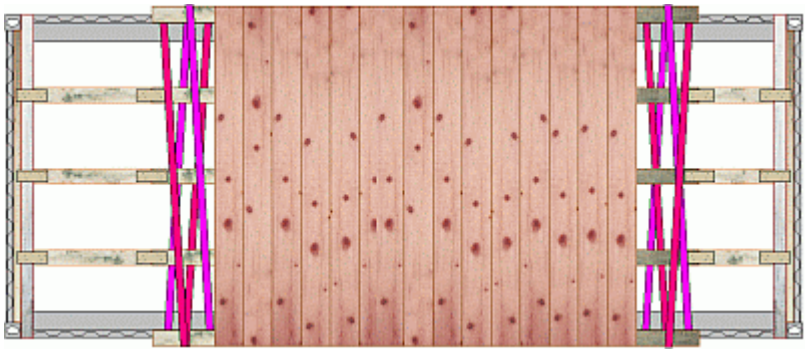
Inadequate lengthwise securing at the other end

It is more than optimistic to hope to prevent leftward movement of the heavy plant part with a relatively weak plywood case, and the lashing belt used to secure the plywood case (which has already deformed the case) deserves no further comment.

Wooden bracing covering the area of the bed to which the plant part is bolted would provide appropriate lengthwise securing. The appearance of such wooden bracing has already been sufficiently described. As the bed is overwidth, and the lengthwise members of the bed are completely covered with transverse planks, transverse securing using lashing means is not feasible or can only be achieved with corresponding additional effort.

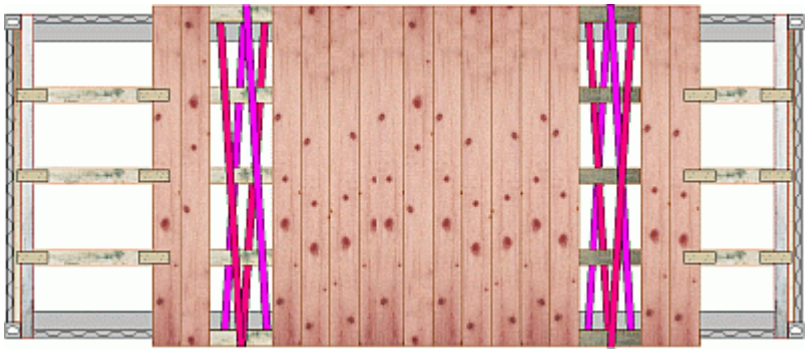
Since the flatrack has stanchion pockets, the bed could be secured laterally using specially shaped stanchions, or appropriately sized case restraint shoes could be set in place before loading to achieve a tight fit between flatrack floor and plant part bed.

Leaving out two transverse planks at the bed ends would have made securing by loop lashings possible.



Lengthwise securing using wooden bracing
Transverse securing using loop lashings passed around the bed at the ends, around the lengthwise bed members

Greater flexural strength could be achieved in the bed for securing purposes if the structure of the plant part allows planks to be omitted not absolutely at the ends but within the surface of the bed.



Lengthwise securing using wooden bracing
Transverse securing using loop lashings passed around the lengthwise bed members within the bed

To achieve either variant, the lengthwise members of the bed must be firred to such a degree that the lashing means can be passed through without difficulty.



Firring of the lengthwise bed members, so that

the lashing means can be passed through

If the plant part itself had load-carrying fastening points, lateral securing could be achieved using direct lashings attached to them. However, care should be always be taken in the case of overwidth cargoes, as is the case here.

In this case, tie-down lashings, here constituting direct lashings, are suitable for vertical securing of the plant part.

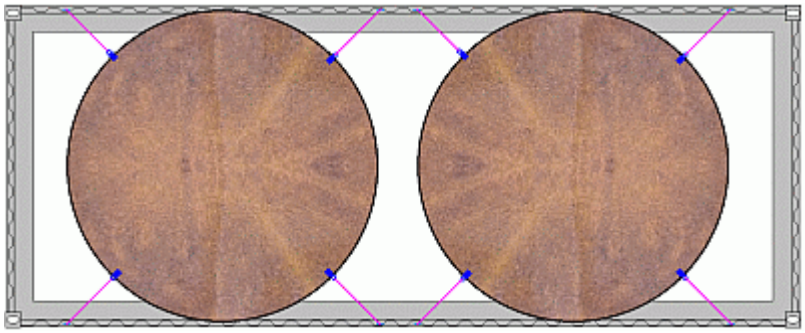
5.2.1.6 Half-shells

Half-shells on a 20' flatrack



Inadequate securing of half-shells on a 20' flatrack

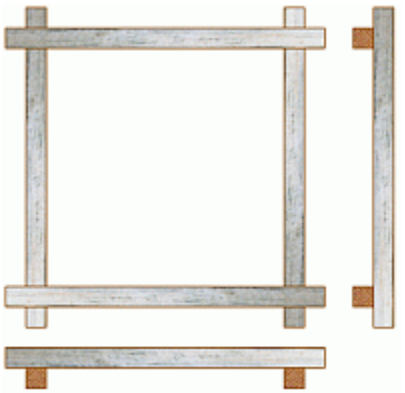
The half-shells lie relatively neatly on cradles but cannot be held securely in position by the steel strap lashing spanning them crosswise. The wooden bracing between the two stacks of half-shells was no doubt put in place with good intentions, but will not hold under likely shipping stresses.



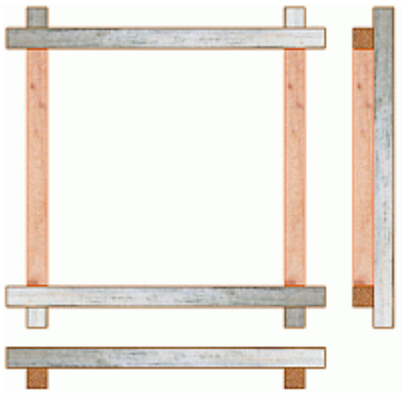
Adequate securing of the half-shells on the flatrack

The easiest securing option is to fit symmetrical direct lashing using claws which engage in the shell stack from above.

The cradle takes the form of a simple cross-bed, the top layer of which consists of squared lumber providing an edge of uniform height which allows the half-shells to be positioned in form-fitting manner thereon.



Simple cross-bed



Simple cross-bed, lined

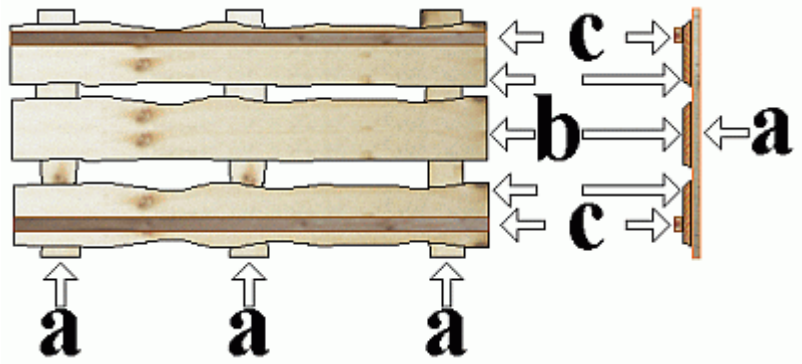
(in each case in plan view and with corresponding side views)

If dimensions allow, half-height open-top containers are suitable for transporting such goods:



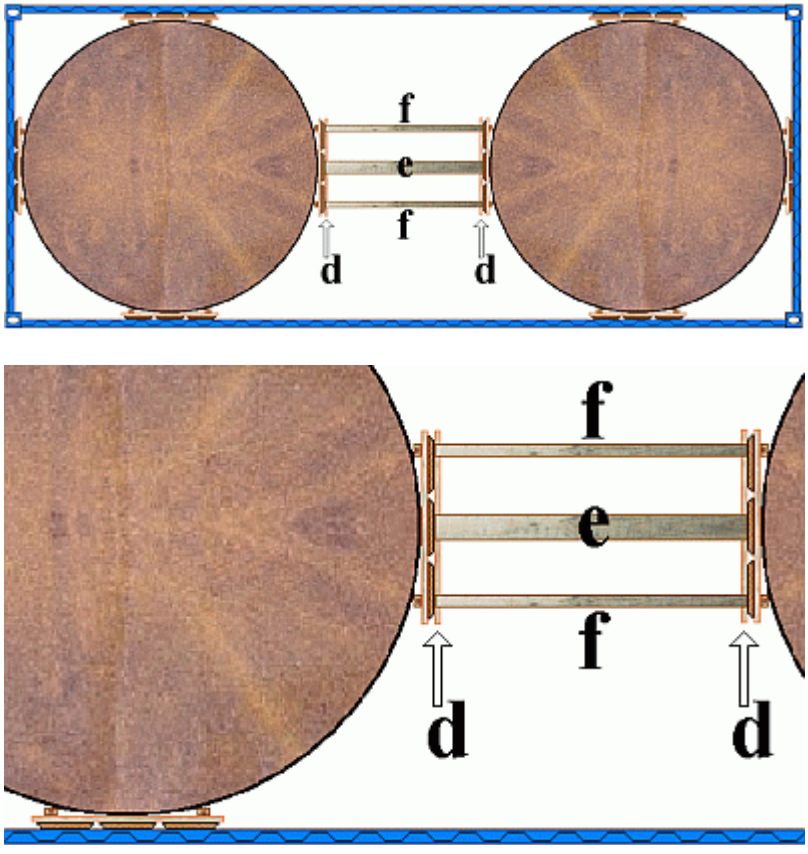
Partial view of a half-height open-top container

The effort involved in securing is kept within limits, since compact stowage can be achieved using simple wooden lattices and bracing. Reasonably priced, unsquared wooden dunnage and laths can be used to secure the cargo to the solid sides of the container.



Preparation of reasonably priced securing lumber

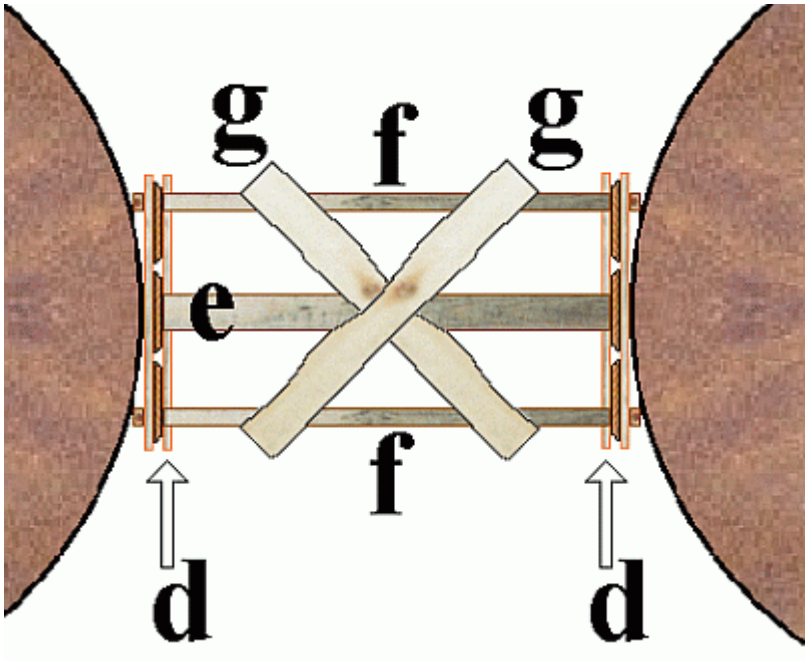
The boards (a) and (b) are nailed to one another crosswise. The laths (c) are attached parallel to the outer boards (b). The overall thickness of the boards must match the size of the gaps between half-shells and container side. If the gaps are relatively large, planks may be used instead of the boards or the boards can be adjusted to fit the gaps with additional squared lumber.



Top and selective enlargement below:
Securing of half-shells in a "half-height open-top container"

Bracing is placed in the gap between the stacks of half-shells. Lengthwise wooden members (e) are used on crosswise nailed boards or laths (d) as bracing. These members cannot become laterally dislodged; however, if it is felt that there is a risk of their doing so, additional laths (f) or boards

should be fitted, which are arranged as X-bracing, as shown in the detailed view below.



Detailed view of wooden bracing and X-bracing (g)

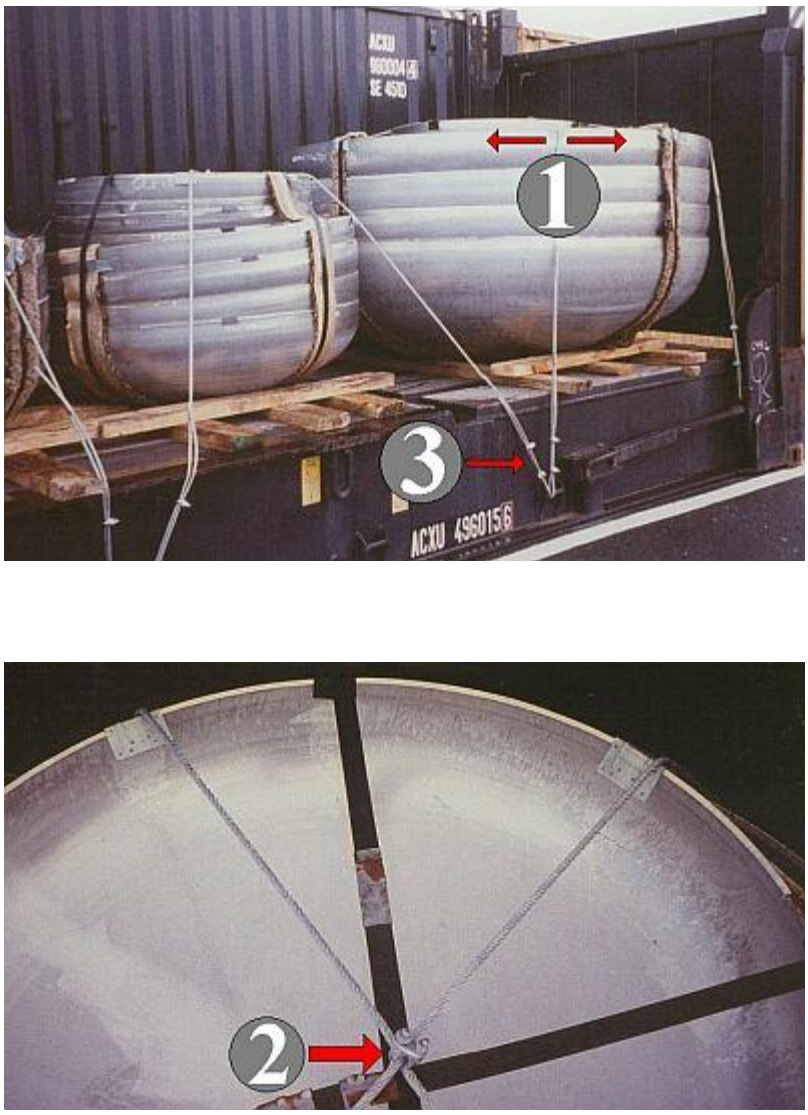
Half-shells on a 40' flatrack

The following example is a good illustration of the errors which can be made when loading such goods.



Inadequately secured half-shells on a 40' flatrack

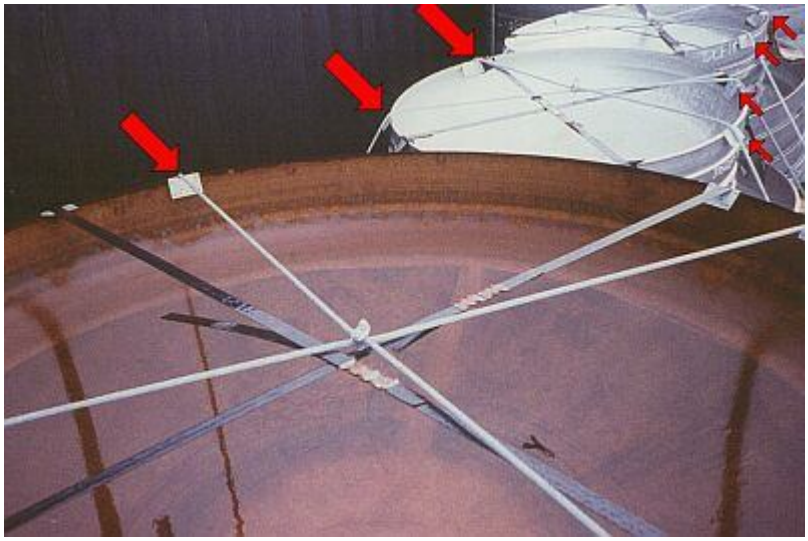
These half-shells are secured nonuniformly with 16 mm diameter steel wire ropes. They are fitted in such a way that a lasting securing action cannot be guaranteed.



Inadequately fixed half-shells

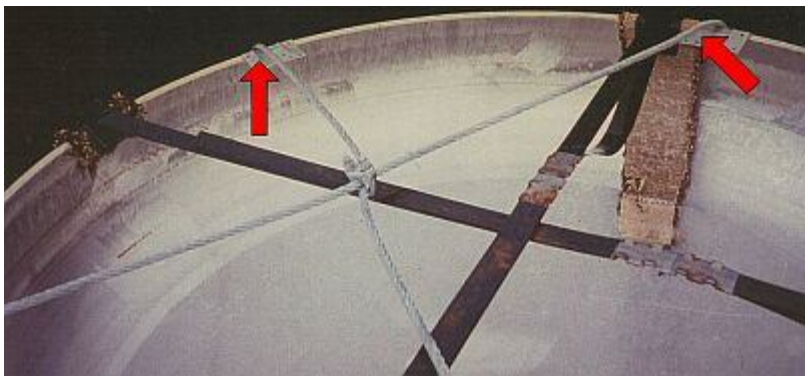
Even slight lateral shifting of the steel wire ropes (1) can slacken the securing means. Fastening the ropes with only two wire clips (3) represents considerable wastage of material, due to the nonuniformity of the maximum securing loads. Moreover, most of the wire clips throughout the flatrack cargo are incorrectly positioned or inadequately tightened.

Displacement of the wire rope cannot be prevented by the wire clip (2) positioned at the point of intersection.



Reduction in strength due to sharp edges

The nonuniformity of the lashing is also caused by using inadequate edge protection. The sharpness of the half-shell edges weakens the steel wire ropes at the deflection points.



The "gentle curves" in the cables
are evidence of inadequate pretension

In addition, the steel wire ropes are inadequately pretensioned. The gentle rounding at the deflection points is clearly visible. Sufficient pretensioning is particularly essential with the selected method of tie-down lashing.

The particular properties of steel wire ropes would in any case lead one to expect that the lashings will slacken in transit;
the reader is referred to the specific comments made in the section headed Lashing materials.



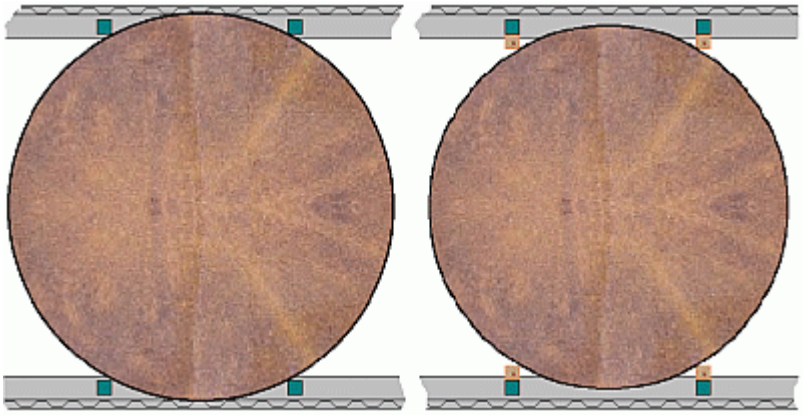
Possible securing with claws

Adequate securing of these half-shells on this flatrack could also be achieved by using claws, which are used as direct lashings and with which a completely tight fit is achieved.

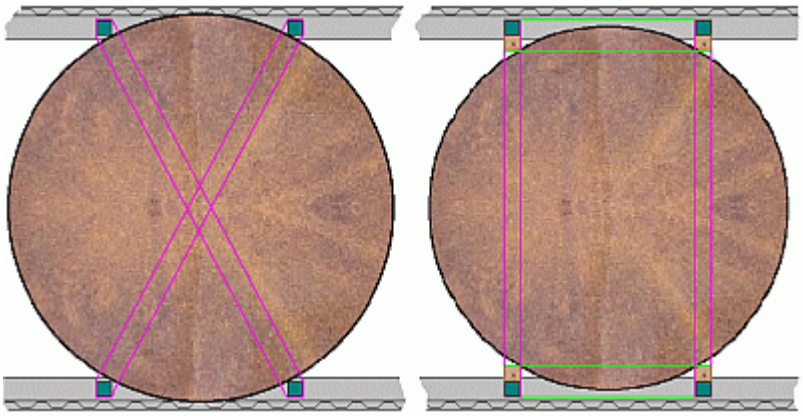
The most cost-effective cargo securing option is to provide containers suitable for transporting half-shells. In the above case, recourse should have been made to flatracks with insertable stanchions.

Simple, quick, reasonably priced securing options are available, depending on the diameter of the half-shells: either the half-shells are positioned directly between two pairs of stanchions inserted parallel to the sides or the stanchions are modified beforehand by squared lumber fixed to the insides thereof in such a way that the half-shells can be fitted precisely between the four stanchions. Small stowage gaps can additionally be filled with board ends or the like.

To increase the strength of the stanchions and at the same time to provide the half-shells with a really tight-fitting "stanchion corset", crosswise lashing is provided between the "plain" stanchions and rectangular lashing is provided between the stanchions lined on the inside.

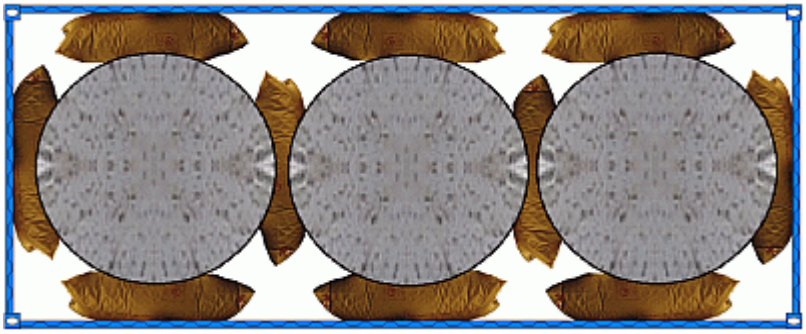


Ideal securing conditions using flatracks with insertable stanchions



Crosswise and rectangular lashing of stanchions

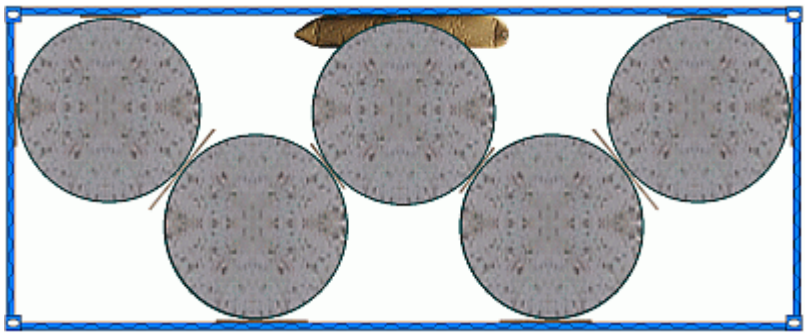
It would be worth checking whether it is possible to stow certain half-shells in half-height open-top containers and secure them with airbags. The following Figure is just a suggestion. The airbags must fit firmly. No sharp edges should be present; if the edges are sharp, they must be appropriately padded so that the airbags are not damaged.

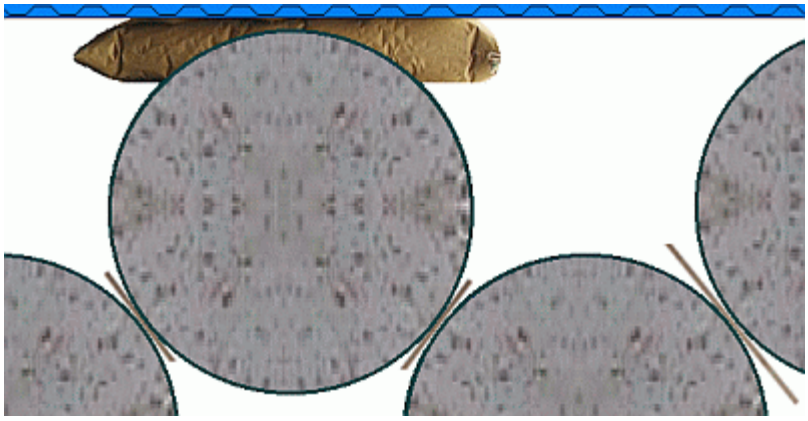


Possible use of airbags for securing

Consideration should also be given to whether a combination of plywood sheets, boards and the like

with airbags can provide adequate securing. This method would certainly be cheap.

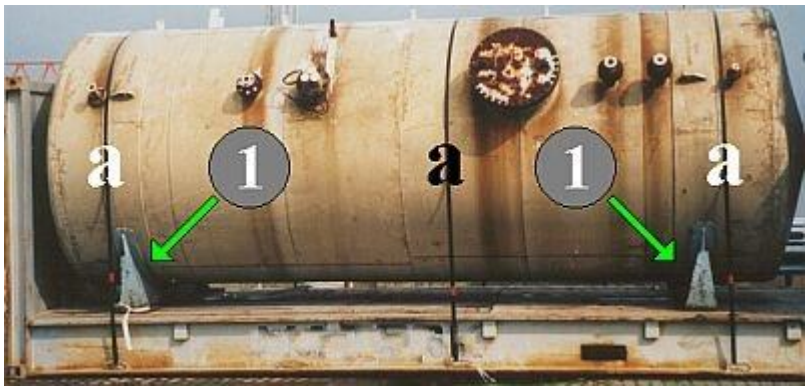




Top and selective enlargement below:
Combination of plywood sheets and airbags for securing

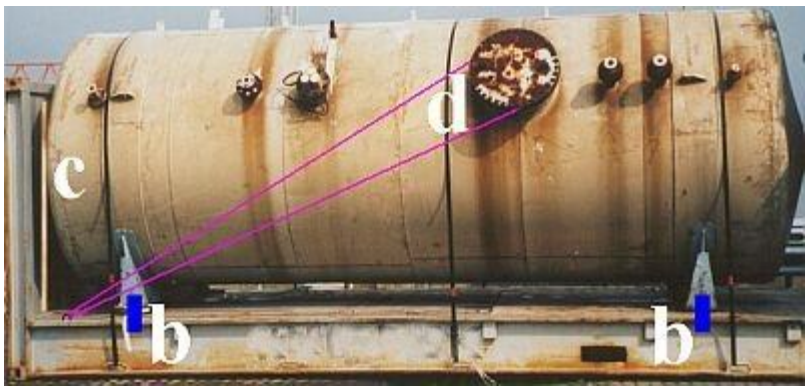
5.2.1.7 Boilers and tanks on flatracks

Used plant part on a 40' flatrack



Inadequately secured boiler on a 40' flatrack

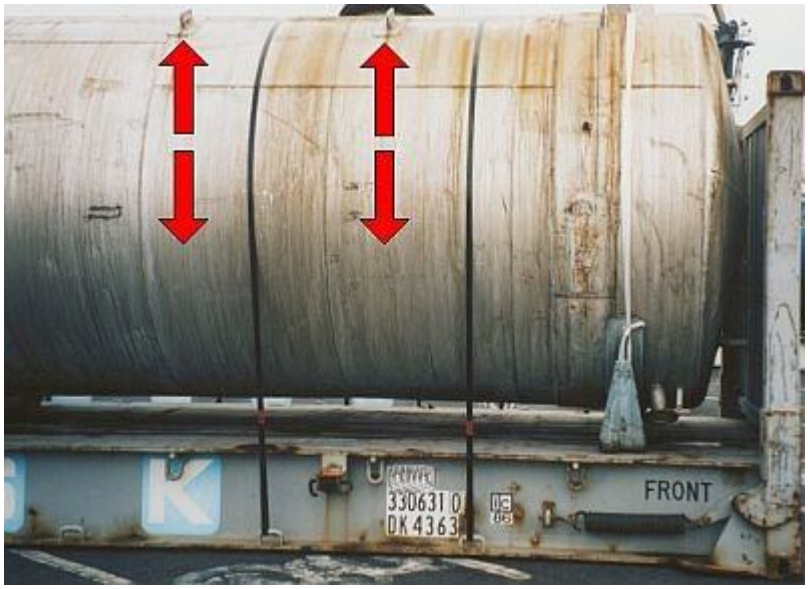
The steel cradles (1) have enormous potential for providing safe securing. However, they do not provide adequate cargo securing when used in combination with these three steel strapping tie-down lashings.



Adequately secured boiler

Full lateral securing can be achieved by welding to the cradles angles and/or guide plates (b) which engage over the edge of the flatrack.

For lengthwise securing in the one direction, the boiler is packed tight against the front end wall and/or any small gaps are filled with lumber (c).
To prevent movement to the other end wall, a lashing is guided obliquely relative to the direction of movement on each side (d). The tie-down lashings then assume the function of direct securing in the vertical direction. If a material with good recovery were positioned between the steel strapping tie-down lashings and the boiler, the tie-down lashings could produce additional securing forces in all horizontal directions due to their pretension. The numerical value of these securing forces would be even greater if friction-enhancing material were laid or had been laid between the steel cradle and the flatrack floor.



Alternative securing options

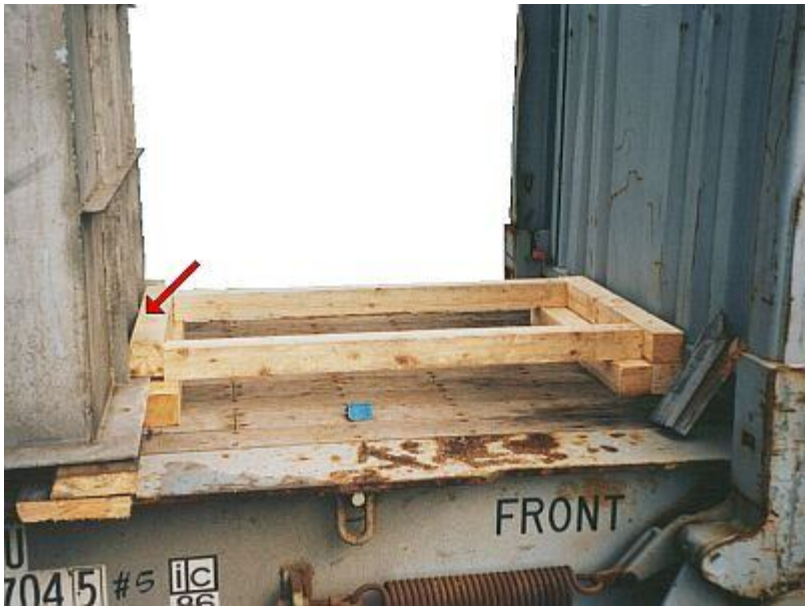
It should have been checked whether direct lashings would have met the securing objectives better than the tie-down lashings.

Used plant parts on a 40' flatrack



Inadequately secured plant parts on a 40' flatrack

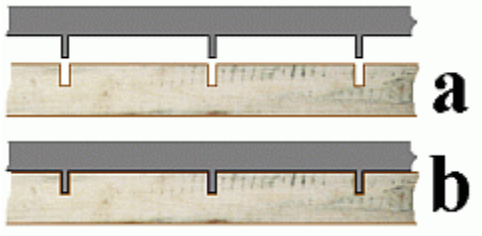
Neither the left-hand, boiler-like plant part nor the right-hand receptacle is properly secured:



Deficiencies in the wooden bracing against the front end wall

The crosspiece lying against the item of cargo is too short and has an effective cross-sectional area of only a few square centimeters. The gaps between the item of cargo and the crosspiece need to be filled.

However, it is better and quicker to cut slits in an additional crosspiece with a saw (a), so that the metal webs on the receptacle can lie flush against the lumber (b).



Options for eliminating deficiencies



Deficiencies in the wooden bracing between the items of cargo

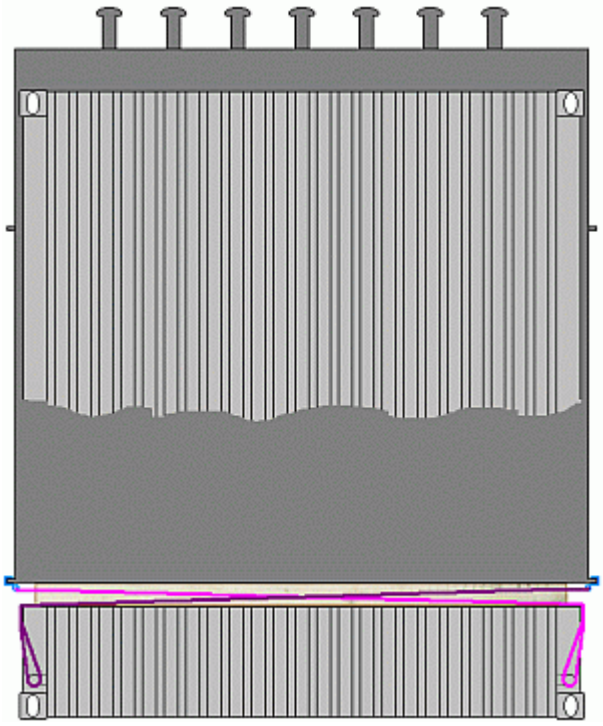
The wooden bracing between the items of cargo exhibits the same shortcomings as that against the front end wall.

The bracing lying against the right-hand receptacle can be modified as described above. Against the left-hand receptacle, the upper crosspiece must be long enough to cover the boiler edge.

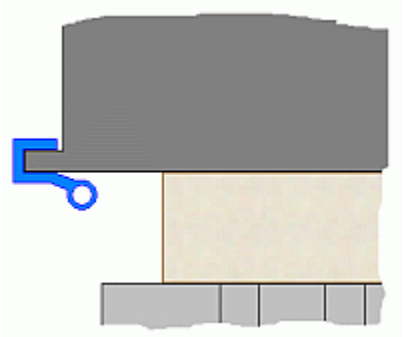


Inadequate securing of the receptacle

The lateral securing of the receptacle itself is inadequate, consisting as it does of only three tie-down lashings.



Lateral securing by direct lashings using claws

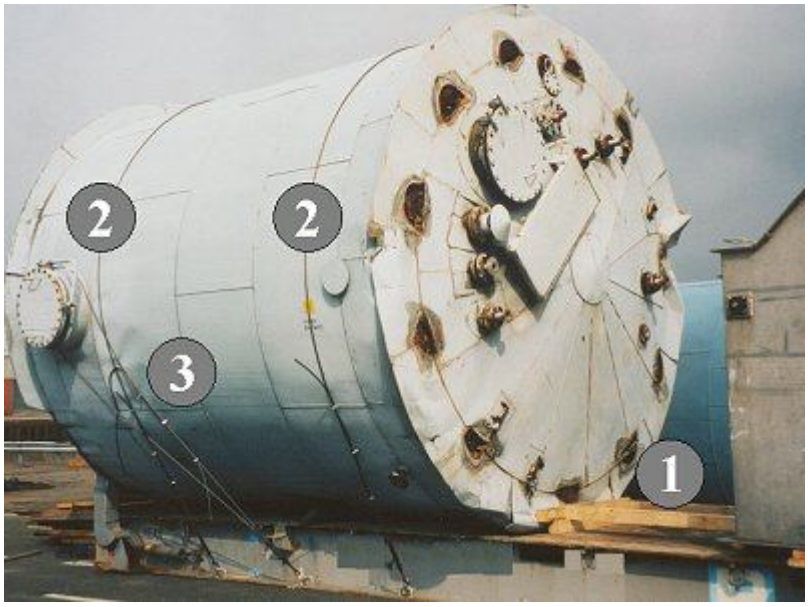




Use of claws for lateral securing - detail

A good way of providing lateral securing is to use claws, which can be applied to the base profiles of the receptacle.

The tie-down lashings are retained to provide vertical securing and to secure against tipping.



Inadequate securing of a used plant part

The wooden bracing (1) between the two items of cargo has already been criticized. The lashings (2) act solely as tie-down lashings due to friction forces and as direct lashing against upwards motion. They cannot provide additional lateral securing because of the overwidth. Although the direct lashing (3) could hold the boiler to a degree in the lateral direction, a longitudinal component also acts in the direction of the bracing. The wire lashings do not comply with the instructions given above, being nonuniform.



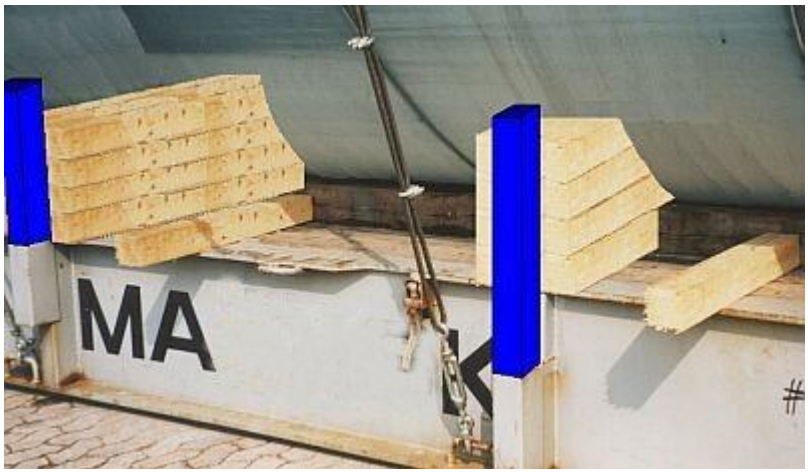
Inadequate lateral securing in the base area

On this side, only one beam is positioned lengthwise in the base area and attached with nails.



Inadequate lateral securing with wooden fixings

On the other side, two wooden fixings (5) are positioned crosswise in addition to the laterally fitted squared lumber (4) and are fixed with a few nails.



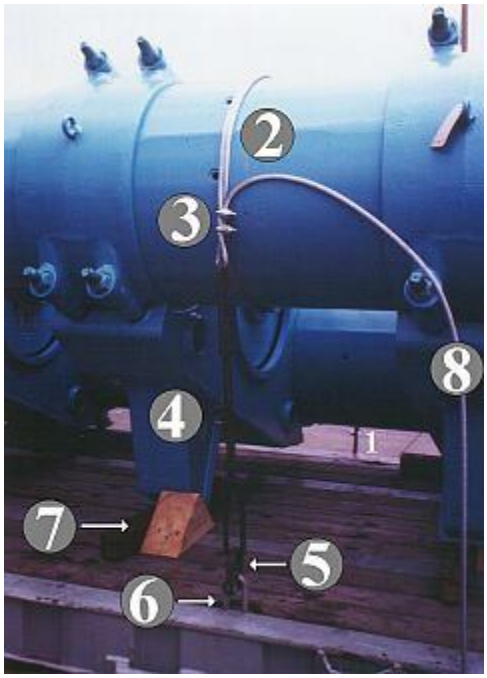
Improvements to lateral securing

The stanchion pockets provided allow adequate lateral securing of the boiler with wooden members and relatively short case profiles or steel beam ends. For this to be feasible, however, the boiler walls have to be able to withstand this load. If they can, then the tie-down lashings once again seem sensible and no space is left for the direct lashing (3) to the flange shown in the third last picture - under these new conditions, it may be dispensed with.

Plant part on 40' flatrack



Above and right: inadequately secured plant part on a 40' flatrack



In the arrangement shown, the plant part was secured by three lashings. A 16 mm diameter steel cable was attached to a lashing bar (1) on the one side of the flatrack with one correctly applied (a) and one incorrectly applied wire clip (b). From there, the cable was passed round the component (2) with a round turn, i.e. an additional winding, and attached to one end of a turnbuckle (4) with two incorrectly applied wire clips (3). The other end of the turnbuckle was attached by a shackle (5) to the lashing point (6) recessed into the floor of the flatrack. In addition, the shipping package was fixed in the floor area of the flatrack by three nailed-down wedges (7) on each side. The wedges

were all incorrectly cut.

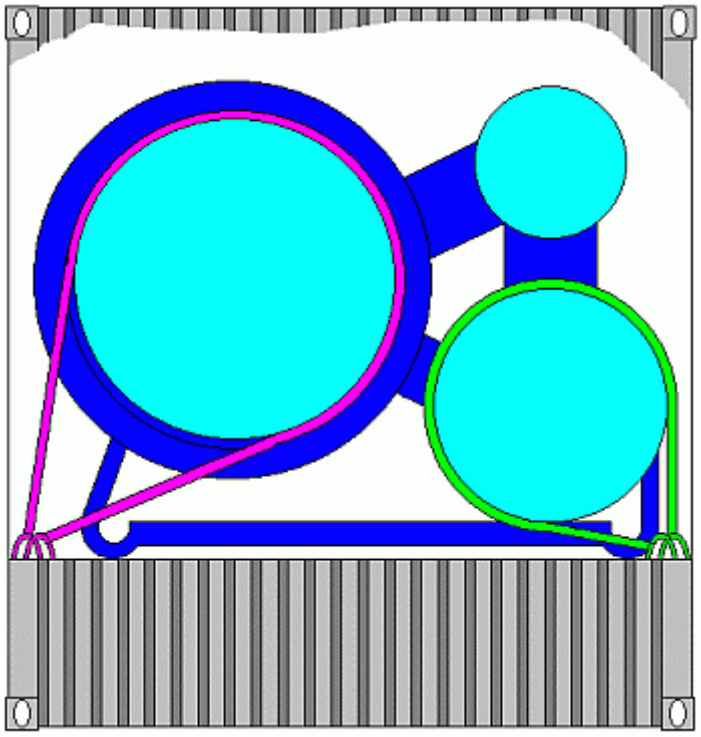
The wire lashings were nonuniform for various reasons. The lashing point at (1) has a maximum securing load of approx. 7,500 daN, while that of the lashing point at (3) recessed into the flatrack floor is only approx. 4,000 daN. The steel cable itself has a maximum securing load of something over 10,000 daN, but only 5,000 daN at most are utilizable if, as is the case here, only two wire clips are applied in each case. The perceptible pretension at the turnbuckle (4) was very high. However, because of the round turn, not very much of this was applied to the lashing point (1), which is clear from the round shape of the wire loop at (c). Added to this waste of resources due to nonuniformity is the loose end of the wire (8), which was more than 2 meters long and signifies additional waste of material.

It must be pointed out that this flatrack had six integral lashing belts each with maximum securing loads of 2,000 daN guided over lashing reels, albeit on one side.



Incorrectly cut wedge

Since the wedge has been incorrectly cut or used, the nails have been knocked into the end grain. Even here at the point of departure it is clear that the wedge is splitting and the same could be said for all the other wedges.



Effective lateral and vertical securing by loop lashings

Loop lashings, with their ends applied to separate lashing points, would have allowed adequate transverse and vertical securing. Full lengthwise securing would have been readily possible if the end feet had been braced against the end walls of the flatrack. The most sensible option economically would be to use the lashing belts of the integral lashing reels on the one side as loop lashing and to secure the other side with prefabricated lashing belts, which must have an identical maximum securing load.

5.2.1.8 Concrete pump on a flatrack



Inadequately secured concrete pump

Considerable effort has been made to secure this concrete pump. However, the securing action achieved thereby is minimal because of the nonuniformity of the wire rope lashings used. It is incomprehensible why the lashing reels incorporated into the flatrack have not been used.



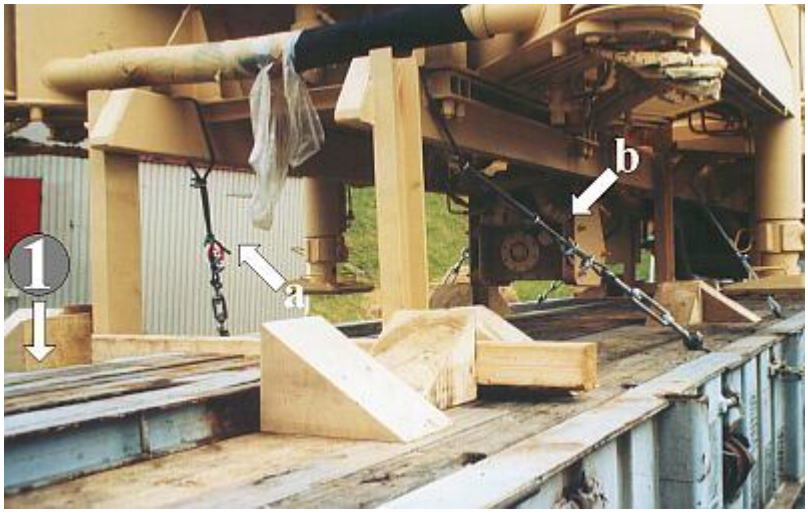
Securing material wastage

The wedges used have been incorrectly cut and their efficacy is minimal. They weren't basically even necessary. The wire rope lashings are nonuniform and only some of the possible maximum securing load has been achieved.

The use of tie-down lashings is particularly ridiculous, since the frame of the concrete pump can move freely sideways in them:

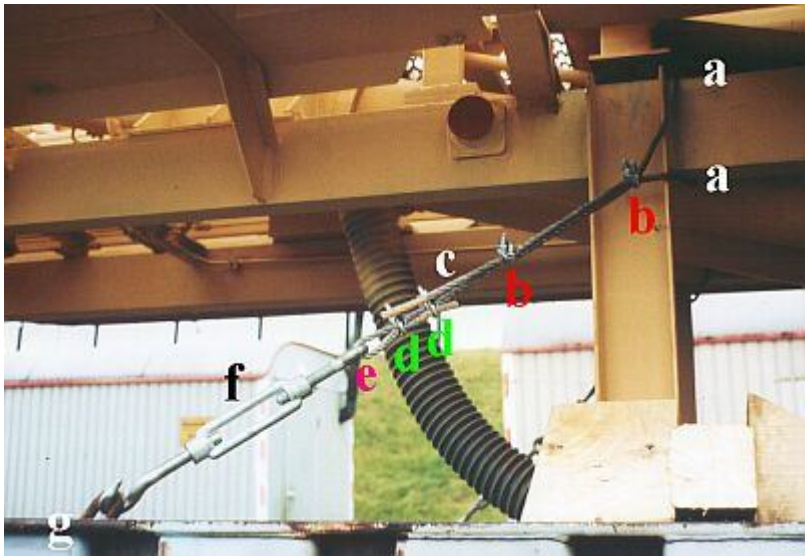


Tie-down lashing over the frame parts of the concrete pump



Material wastage due to pointless, nonuniform securing

Securing of the stanchions of the flatrack is unnecessary, since the flat has stanchion pockets at the side in which the stanchions can be inserted when not in use. None of the wire rope lashings applied are uniform. This will be explained with reference to the two lashings (a) and (b).



Nonuniform wire rope lashing

A 12 mm diameter steel wire rope was used with a maximum securing load of 5,760 daN per single run. The following are the values for the maximum securing load of the individual components of the lashing or at the various points of the lashing:

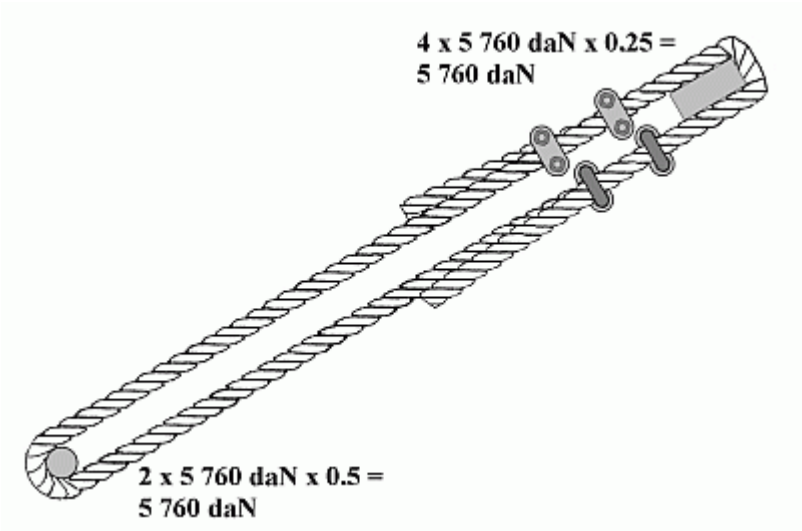
a	As a result of deflection around sharp edges, load can be calculated as 2 times working parts each of 5,760 daN x 0.25 =	~ 2,880 daN
b	Two wire clips have been positioned with the bow on the working part. In addition,	< 2,880 daN

	they have clearly not been tightened enough, meaning that the strength of the connection cannot be calculated. At any event, it is less than 2,880 daN.	
c	Loose or non-working part. This is where the shackles should have been placed.	
d	These two wire clips have been correctly positioned and tightened more firmly. If the correct tightening moment has been achieved, a strength is obtained in conjunction with the curvature of e of 2 parts each of 5,760 daN x 0.5 =	~ 5,760 N
e	Diameter of curvature corresponds to cable diameter	
f	Maximum securing load of turnbuckle approx.	~ 4,000 daN
g	Maximum securing load lashing point approx.	~ 4,000 daN

With virtually the same length of wire and the same number of wire clips, but a different way of proceeding, the following values could have been achieved:



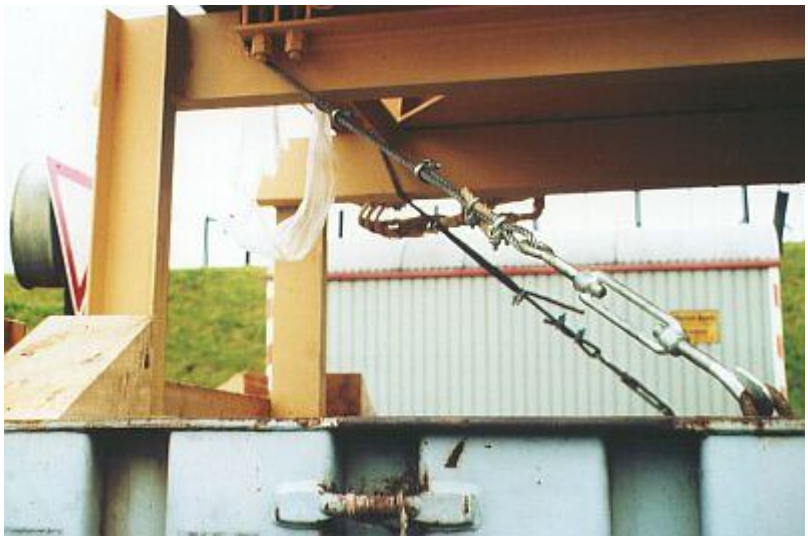
At point of connection
to frame:
5,760 daN



At point of connection
to turnbuckle:
5,760 daN

The weak points in this variant are the lashing ring recessed into the flatrack floor and the turnbuckle with a maximum securing load in each case of 4,000 daN.

If the lashing bars fitted to the side of the flatrack with a maximum securing load of approx. 6,000 daN are used, the maximum securing load of a lashing may be increased. Compared with the maximum securing load of less than 2,880 daN which was originally achieved...



The maximum securing load of this lashing amounts to less than approx. 2,880 daN.

.... 5,760 daN maximum securing load may then be achieved per lashing.



The maximum securing load of this lashing amounts to 5,760 daN

Since the forces are distributed to the working parts, even a turnbuckle of only approx. 3,000 daN could be used.

The concrete pump could easily have been secured to the flatrack with a total of four lashings, see below:

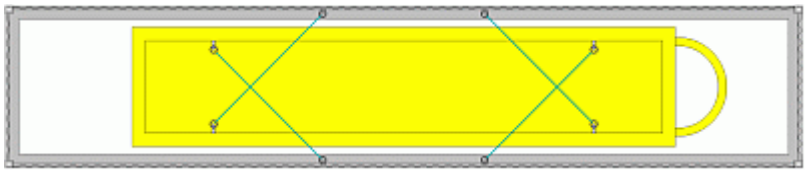


Diagram showing the principle of adequate securing with four direct lashings

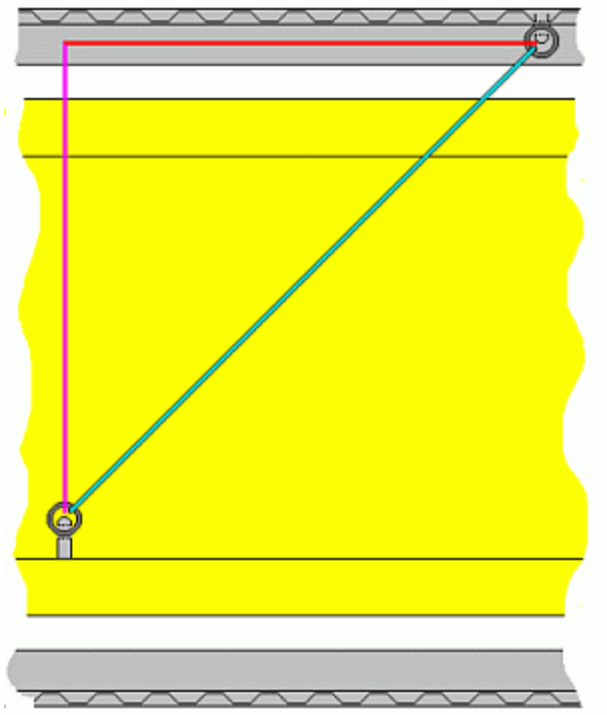


Diagram showing the principle of lashing and the horizontal components

The longitudinal and transverse components are identical. The vertical components are somewhat smaller per lashing. However, since all the lashings have this vertical component, wholly satisfactory securing is achieved.

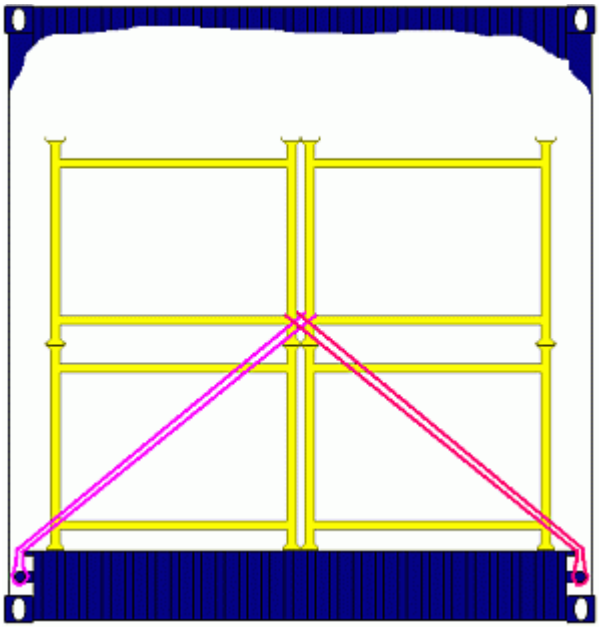
5.2.1.9 Axles on flatracks

Example: Truck axles on a 40' flatrack

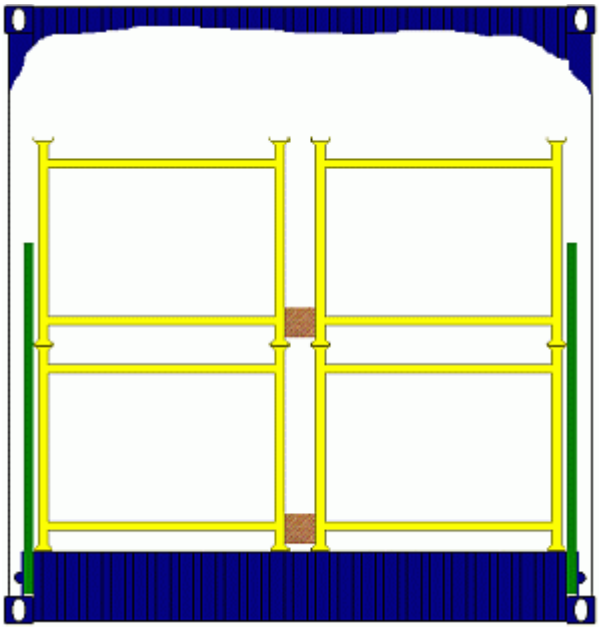


Unsuitable securing of truck axles on a 40' flatrack

Producer and trader have designed special stands for transporting axles and had them manufactured. The axles are packed into the stands with a tight fit. It is incomprehensible why the stands have been secured on the flatrack with tie-down lashings. The cargo can move freely under the tie-down lashings.. Only with a tight fit can the forces arising during transport be absorbed. To this end, the flatrack stanchions should be used and/or securing with oblique lashings to the sides.



Tight-fit securing of the stands using oblique lashings



Tight-fit securing using stanchions and centrally positioned squared lumber

It goes without saying that combined methods and other types of securing are also feasible.

5.2.2 Bales in box containers

As a homogeneous cargo, bales are relatively easy to pack and secure. In each individual case, how the bales should be packed depends on the dimensions and proportions of the bales. Also of importance for operating procedures is whether forklift trucks without add-ons or with bale clamps can be used, since this determines whether, for example, floor and interlayer dunnage of wooden boards or thick battens must be laid so that the bales can be handled with normal forks.

The strength of the bales and the way in which they are strapped or wrapped is also relevant to handling. Some bales, e.g. those consisting of combed top, are very sensitive and require particularly careful operating procedures.

Purely manual stowage is impossible because the individual bales are so heavy. An exception could be made if hard-top open-top containers are used, since these allow the bales to be directly set down using lifting gear with wool hooks or similar load suspension devices, individual bales then having merely to be straightened. Manual stacking is out of the question.

As a rule, standard box containers are used. The stowage factors mean that really only 20' containers can be used - 40' containers could only be used for relatively loosely compressed bales of

light materials.

Bales requiring stowage consist in particular of sheep's wool, cotton and tobacco of widely varying origin, combed top, textiles, cellulose, paper, aluminum residues, waste paper etc. Many natural fibers, such as sisal etc, which used to be transported (carried) in bales, are now more and more frequently shipped in further-processed forms, such as "hanks", reels etc. Natural rubber, empty bags (gunnies) and similar products are still transported in bales, however.



Bales, standing lengthwise, without dunnage



Bales, standing lengthwise, with dunnage

The bales are packed standing, with their narrow, rounded sides in the lengthwise direction. Wooden dunnage is not required if the bales are handled with bale clamps. The advantage is that no additional moisture is introduced into the container and sensitive bales do not suffer pressure damage.

If wooden dunnage is laid, it should be kiln dry or at least dry. If the moisture content is not known, the lumber should be covered with strips of material which can neither damage the bales nor allow moisture to pass through. In the example, the lumber is laid in such a way that the bales can be picked up in pairs by the forklift truck. To simplify packing and stripping operations, the bales can be tied together in pairs with binder twine. If there is a risk of pressure damage, wooden dunnage must not be laid or it must be laid sufficient densely to prevent pressure damage while still leaving sufficient gaps for forks to pass between it.





Bales, standing crosswise, without dunnage

Bales, standing crosswise, with dunnage

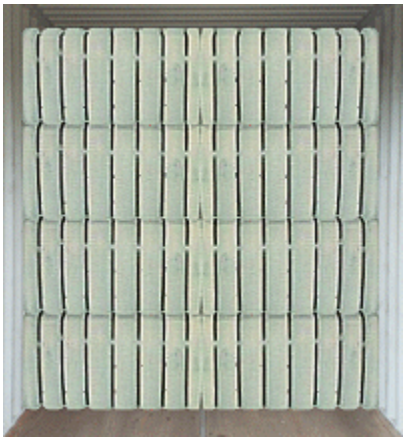
Here the bales were packed standing, but with their rounded sides in the transverse direction. The wooden dunnage was laid in such a way that the bales can be picked up individually and the forks can be positioned close to the bale edges.



3 layers of bales lying horizontally, without dunnage



3 layers of bales lying horizontally, with dunnage



4 layers of bales lying horizontally, without dunnage



4 layers of bales lying horizontally, with dunnage

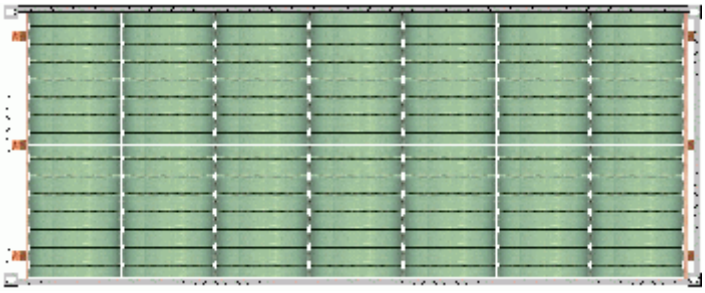


Large tobacco bales, without dunnage



Small tobacco bales with interlayer dunnage

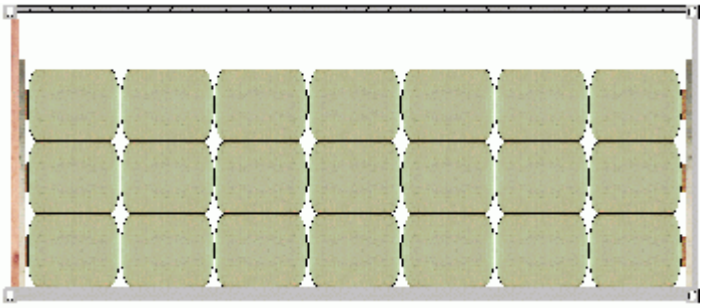
Tobacco bales are very sensitive to pressure damage and must be stowed flat. Special measures with regard to air circulation etc. are described under Basic stowage methods.



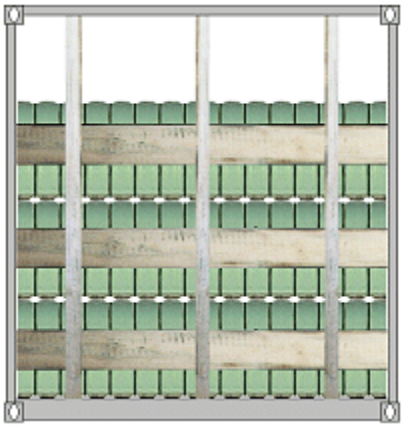
Bales in a 20' container (plan view)

Because the bales are so dimensioned that they occupy the full width of the container, the gap at the front end wall of the container is filled with a wooden lattice. A lattice of similar construction, but with additional squared lumber, is positioned on the door side.

Bales in a 20' container (side view from right)



The smooth tops of the bales point towards the outer walls of the container. If contact with the container walls was likely to cause degradation in quality, appropriate measures would have to be taken.



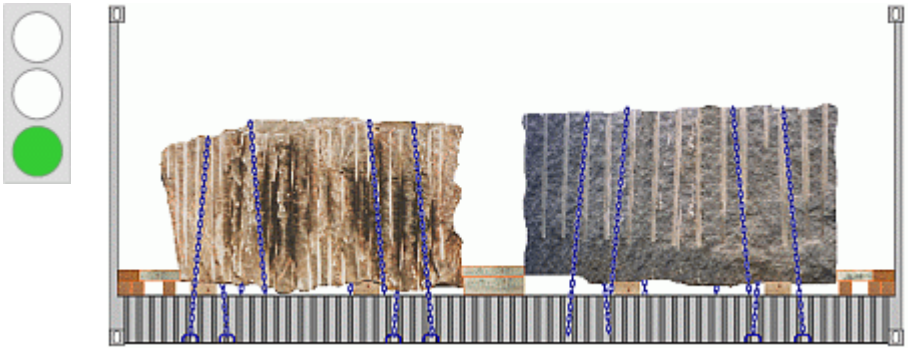
The horizontal boards of the lattice should be positioned in such a way that the bales are held exactly centrally, and their width should be such that on the one hand there is no risk of pressure damage and on the other hand they retain sufficient strength. The squared lumber uprights may be braced against the door frame. This may be achieved by gentle bracing or by using tapered blocks.

Bales in a 20' container
(view from door end)

5.2.3 Blocks, slabs etc.

5.2.3.1 Granite blocks on flatracks

It is very easy to stow and secure granite blocks on flatracks Since chains are best for "heavyweights", chains and loop lashings should be used for lateral securing. Squared lumber bracing is suitable for lengthwise securing.



Securing of granite blocks on flatracks

The number and size of the wooden bracing members may be readily determined using the rules of thumb already given..

5.2.3.2 Granite curbstones in box containers

When packed in box containers, granite counts as a "heavy" cargo, since its stowage factor is such that the container's volume cannot be fully utilized. Depending on volume and payload, the volume-to-payload ratio of 20' containers ranges from approx. 1.2 - 1.8 m³/t. The stowage factor of granite is around 0.36 m³/t, i.e. a container can only be filled with such cargoes to between a fifth and a third of its volumetric capacity. Depending on the unitization of the granite articles, their shape and any wooden props or wooden interlayers used, this value may increase to approximately half the container volume.



Compactly stowed granite bundles

The granite is bundled on squared lumber underlays using high-strength steel wire. The wires themselves are guided through holes drilled in the ends of the squared lumber. The bundling and packing method used favors the use of forklift trucks and load transfer to the container floor. Since the tied-on wooden underlays lie lengthwise, the admissible line load cannot be exceeded. The load is thus well distributed over the bottom cross members of the container. Small stowage gaps can be filled with lumber.

Granite bundles - gaps filled with airbags and lumber



If the ends are sharp, boards or wooden sheets should be inserted between the container wall and the granite. The same applies if airbags are inserted at sharp-edged ends, but is unnecessary in the case of straight hewn granite.
Gaps to be braced with airbags should not be much larger than approx. 20 cm. To achieve uniform weight distribution, the stone packages should be packed alternately in groups. A group should correspond approximately to the length of an airbag. It must be ensured that the airbags cannot slip out in an upwards direction,

a problem which can be prevented by using boards and/or wooden sheets to produce inverted "funnels" which are open wider at the bottom:



Granite bundles - gaps filled with airbags and lumber

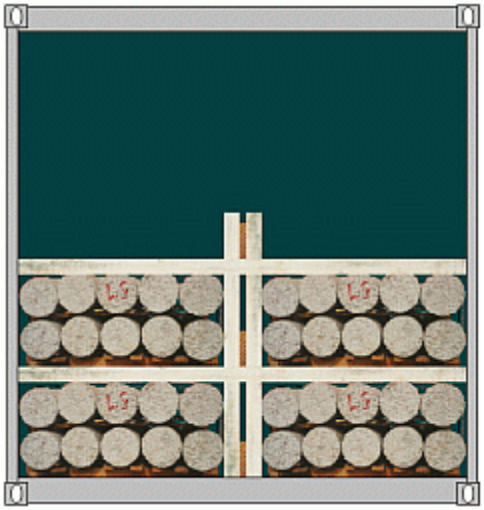


Unfavorable packing method

Such a packing method is not advisable. The container floor is loaded unfavorably, since the tied on wooden underlays extend parallel to the bottom cross members of the container. Forklift trucks can only be used at right angles to the underlaid lumber. Since the bundling was not intended for this, however, considerable damage may occur during packing and unpacking. Damage to the bundles is inevitable. Such packing would theoretically be possible if additional wooden supports and interlayers were used. However, if the container is carried lengthwise (fore and aft stowage), even the smallest of gaps would be sufficient for the rolling motion of the ship to deform the bundles.

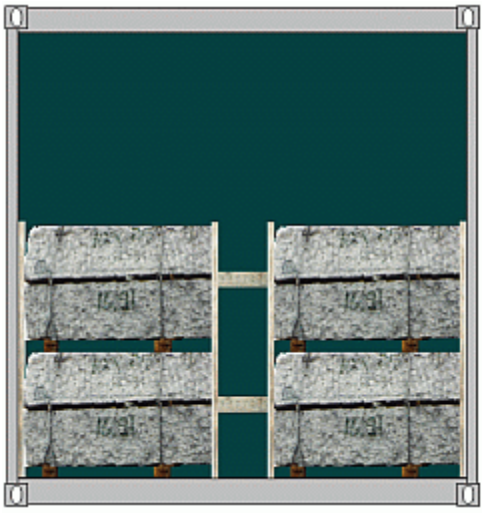
The curbstones shown are around a meter in length, making the following packing pattern easily achievable:

5.2.3.3 Granite columns in box containers



Granite column bundles: gaps braced with squared lumber

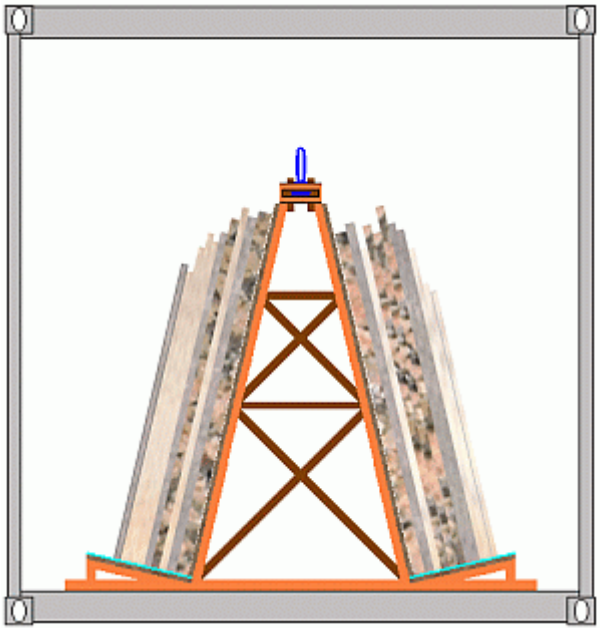
Intermediate and top wooden members positioned crosswise simplify bracing of the central gap. The vertical upright blocking is attached to them. Final strength is achieved by boards or beams inserted longitudinally, which guarantee overall compact stowage.



Granite curbstone bundles: gaps braced with boards and squared lumber

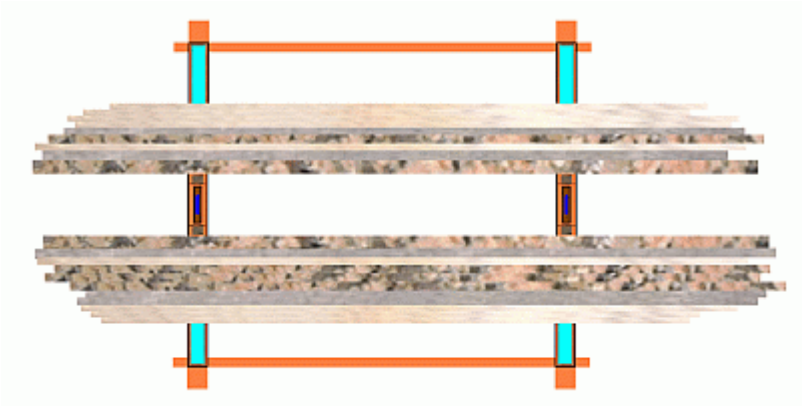
The bundles are packed to the left and right against the side walls using upright wooden dunnage. The "aisle" left in the middle is secured with wooden bracing consisting of boards and squared lumber. The squared lumber is positioned at the level of the respective "seams".

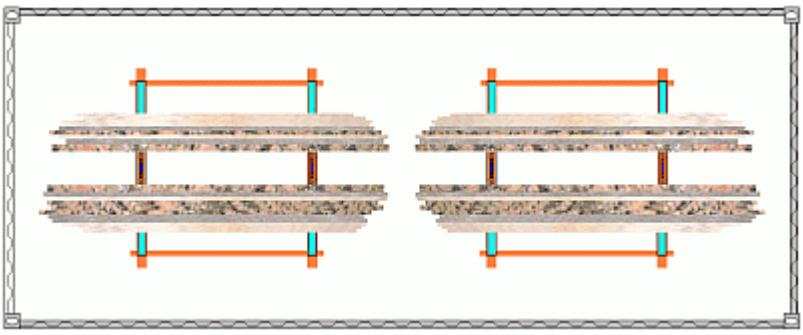
5.2.3.4 Granite and marble slabs on A-frames



Granite slabs on a steel A-frame suitable for use with lifting gear and forklifts

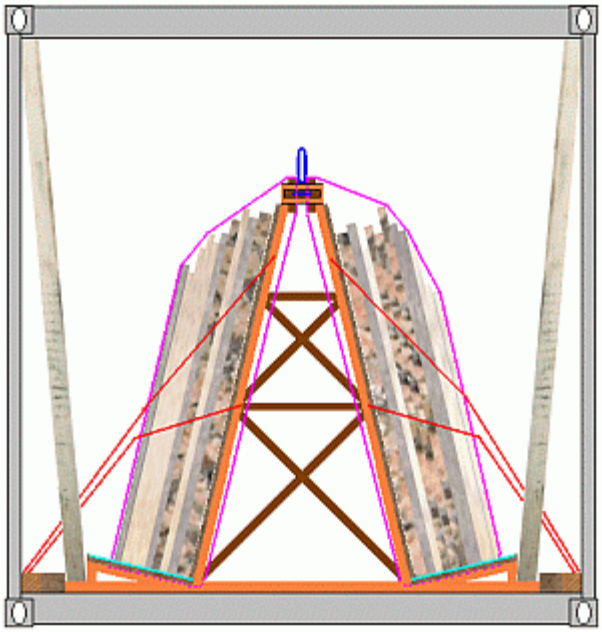
In the event of regular outward-and-return transport, it is worth building permanent frames for transporting granite, marble and slate slabs and other similar slab-like material which are suitable for use with lifting gear and forklift trucks.





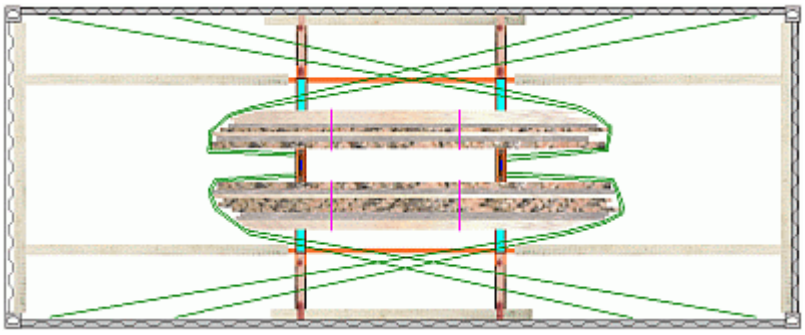
Granite slabs on steel A-frames - plan view

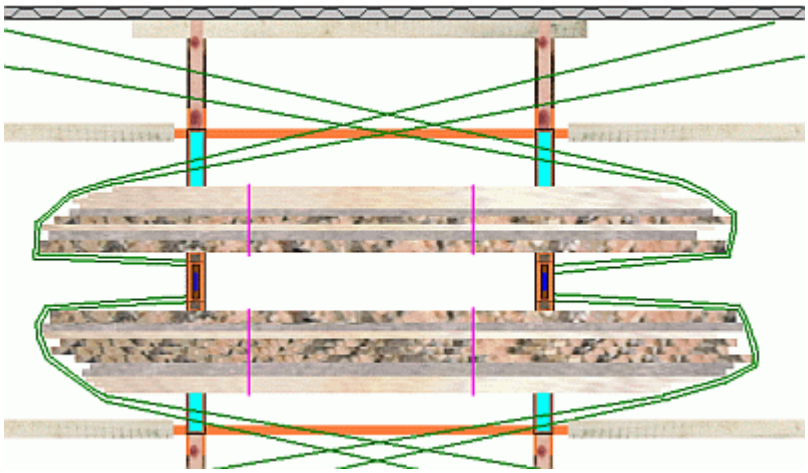
Whether 1 or 2 frames are loaded per container depends on the mass of the cargo. The nature of the frames allows stowage in both standard box containers and open-top containers.



Secured A-frame

The slabs may be secured transversely and vertically to the frames prior to loading. To this end, strapping is tensioned around each slab and frame half. In the container, the frames are secured against lateral and longitudinal shifting with squared lumber. Shoring prevents the frames from moving vertically and tipping. Direct lashing is used to prevent any lengthwise movement of the slabs.





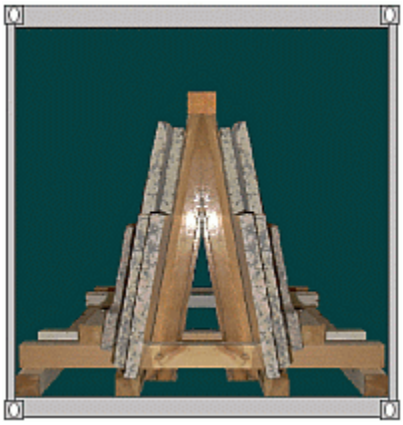
Top and selective enlargement below: Lengthwise securing using direct lashing - plan view

The direct lashings are attached to lashing points at the tops of the A-frames, pass forward round the protruding sections of the slabs and are tightened on the opposite side. Since the slabs are very fragile, the lashings must be only slightly pretensioned. The cross beams of the A-frames which slope obliquely upwards and outwards are covered with friction-enhancing material, so that the majority of the longitudinal forces are eliminated by friction with the floor.

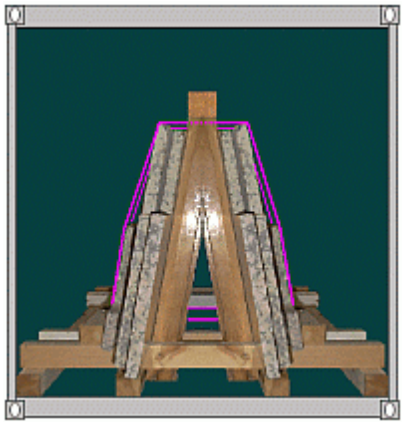


Laterally arranged half frames

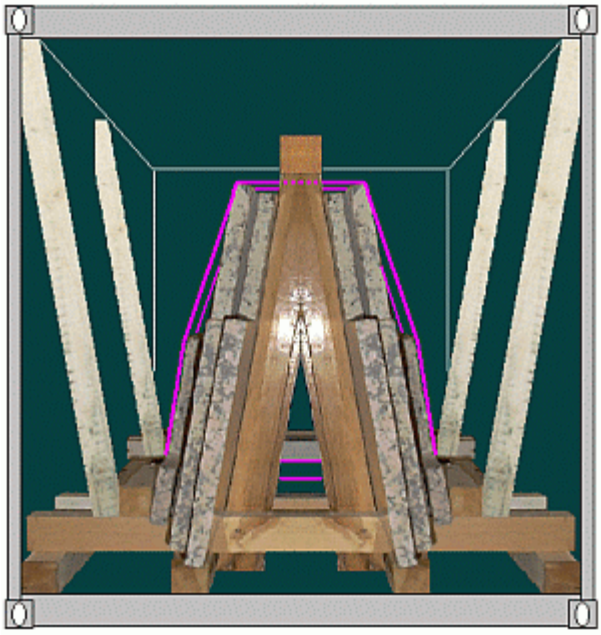
The cost of securing is considerable if such slabs have to be secured using single-use material. For packing in open-top containers it is expedient to build "half frames" on each side, load on the slabs and shore them crosswise. The crosswise squared lumber members are held in each case by two vertical or oblique squared lumber members. Loop lashings are suitable for longitudinal securing and are passed around the tops of the slab sections and pulled taut at the other container end.



Granite slabs on A-frame



Transverse securing with strapping



Securing against vertical and tipping movement using shoring

A-frames made from squared lumber are, of course, also feasible for one-off transport. The arrangement of the wooden members is intended only as a suggestion and must always be tailored to the mass of the cargo, the transport routes etc.

5.2.4 Vehicles and construction machinery

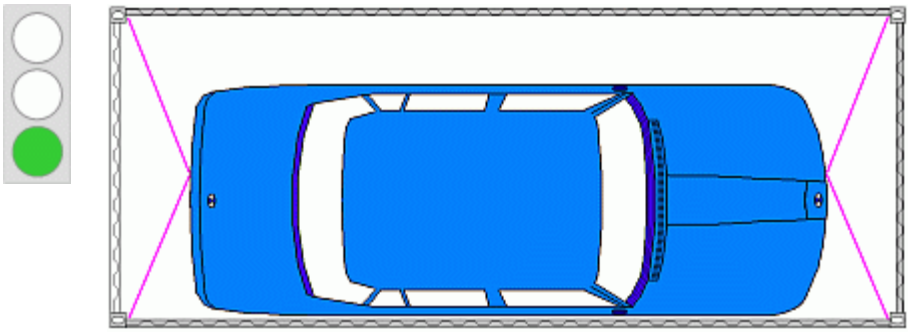
5.2.4.1 Automobiles in standard containers

Compared with other cargoes, automobiles are considered a very light container cargo. The mass of an automobile constitutes only a fraction of the payload of the container. The rubber tires are a great advantage with regard to cargo securing, with coefficients of sliding friction ranging from at least $\mu = 0.4$ to $\mu = 0.8$ as a function of the container floor. Even with assumed accelerations of 1 g in the longitudinal and transverse directions, securing forces of only 200 - 600 daN would be necessary per metric ton of cargo mass.

As far as the "fitness for loading of the container" is concerned, particular care needs to be taken to ensure that no sharp-edged or pointed objects have been left in or on the floor which could damage the tires. No materials with a relatively high moisture content, such as lumber etc., should be in the container with the automobile. Condensation could cause mold to appear on upholstery etc. or other damage.

When opening containers packed with road vehicles, it should be ensured that no sparks are produced and that there are no naked flames in the vicinity, as leaking fuel could have created an explosive mixture in the container. Access to such containers should therefore only be permitted after thorough ventilation.

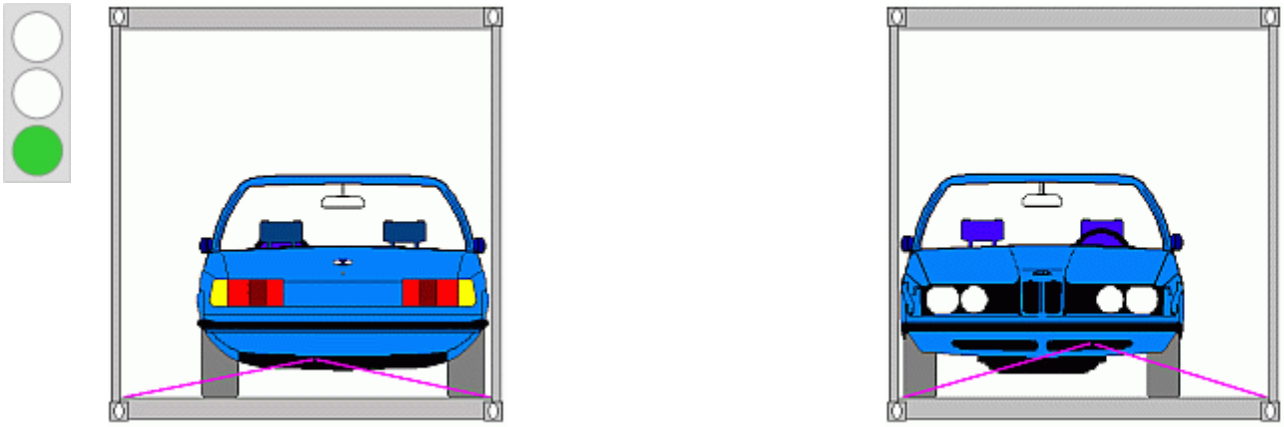
If vehicles are driven directly into containers, space must be left for getting in and out. The vehicles have therefore to be driven up relatively closely against one of the container walls (the right-hand container wall in the case of left-hand drive vehicles). However, enough space must be left to rule out the chance of contact with the container walls even if the vehicle structure sways.



Lashed automobile in a 20' box container - plan view

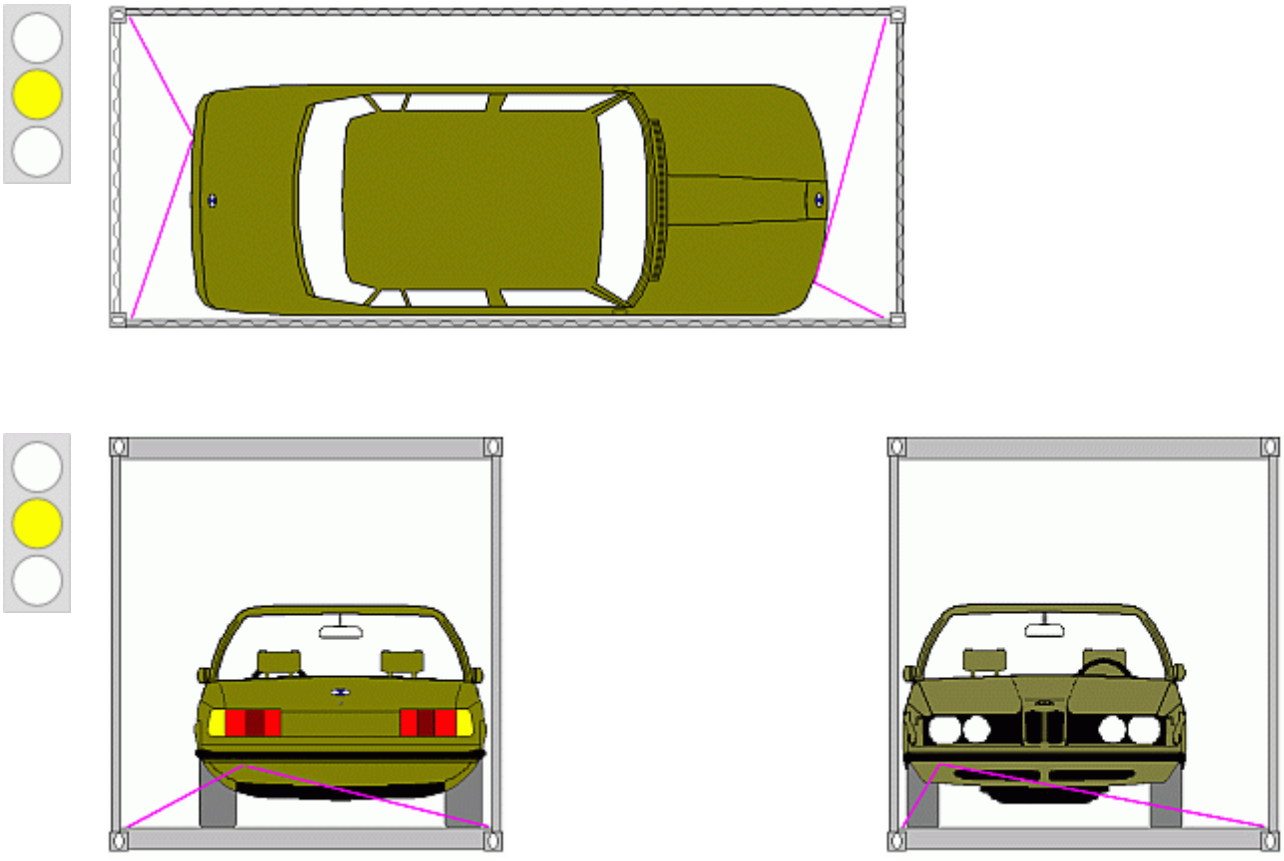
The ideal positions for lashing points on a vehicle are shown in the Figure. In practice they are not generally in these positions.

To achieve a uniform lashing angle, the fastening points on left-hand drive vehicles would have to be fitted symmetrically at front and back but somewhat eccentrically relative to the left-hand side of the vehicle. On right-hand drive vehicles, which would have to be driven up close to the left-hand container wall, the lashing points would have to be arranged somewhat to the right of center.



Lashed automobile in a 20' box container
viewed from the door end and the front end wall

Very often, vehicles only have inappropriately fitted tow eyes as lashing points, for example back right and front right, back left and front right and similar combinations. If this is the case, the lashing angles with which an automobile is secured in a container are inevitably different.



Asymmetrical lashing angles resulting from inappropriate arrangement of tow eyes or lashing points

However, damage is most frequently caused to automobiles in containers not as a result of inadequate securing but as a result of carelessness during driving in and out and during working in the cramped conditions inside the container.

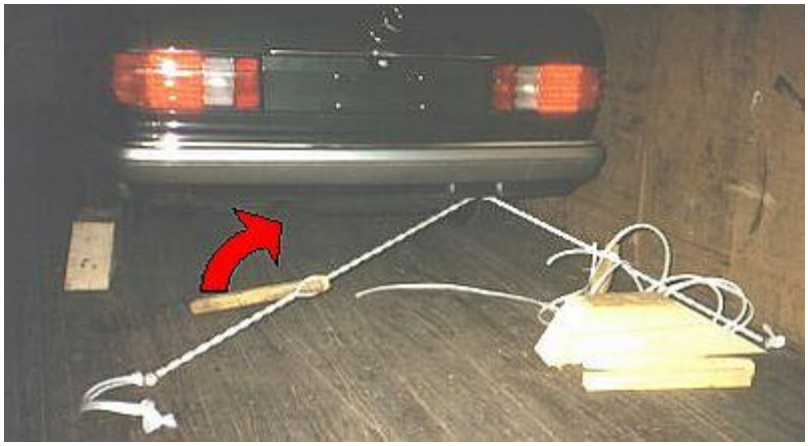
For various reasons, sufficiently stable and/or easily accessible lashing points are often not present on vehicles. Moreover, the preparatory work carried out on vehicles, such as covering the driver's seat with protective film, does not in practice meet current requirements. Here is an example:



Automobile securing with unfavorable angles

The lashing points on the vehicle would have ensured uniform angles, if the vehicle had been driven forward into the container. However, the vehicle was intended for South America, where vehicles are often damaged during reversing out of the container. The shipowner thus specified that the vehicles were to be reversed into the container in Germany. Since it is also a requirement that the driver get in and out through the driver's door only, and only the driver's side was protected by a film covering, it was only possible to drive the vehicle so its right-hand side was against the left-hand container wall. If the lashing points had been fitted symmetrically and at the same time the passenger side had been covered with film, such vehicles could be parked against the right-hand container side: symmetrical lashing angles would be the positive result.

"Hercules" rope interwoven with polypropylene was used for securing by means of a "Spanish windlass", which is an extremely reliable and quick method. However, it is extremely important for the tightening spar to be secured against coming undone.



Incorrect use of a tightening spar

The left-hand tightening spar is positioned centrally. The rope turns are evenly distributed on both sides, as they should be, but the winding could come undone. The tightening spar should therefore have been longer. The wooden members or wedges have no business to be in the container. Blocking wheels with wedges or lumber nailed laterally against the wheels does not constitute sensible cargo securing, since there is too great a risk that the tires will be damaged when the material is inserted or that the tools used will damage the paintwork or make small dents.



Unfavorable angles
- tightening spar not secured against coming undone -
use of wheel wedges

The wooden wedge, which has moreover been incorrectly cut, has no doubt been used because the lashings have a very small longitudinal component.



More favorable transverse components due to the existence of two lashing points on the automobile

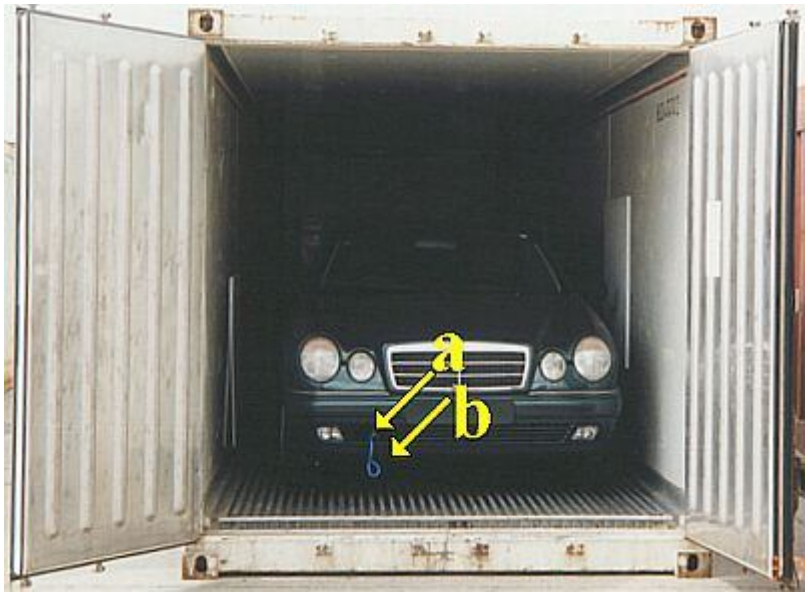
If the automobile had two lashing points at front and back, it could be far better secured than when only one lashing point is available at each end.

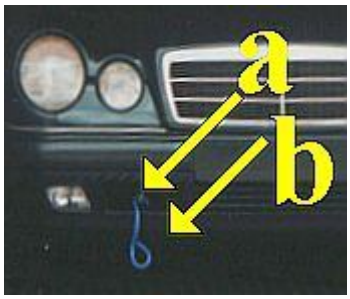


Longitudinal components improved by different positioning of tow eyes

Two lashing points at front and back allow greater flexibility in the fixing of lashings.

N.B. With all of the above methods, there is a risk of the tightening spar coming undone. If this risk cannot be combatted, the use of prefabricated rapid-tightening systems is recommended. However, using them is more cost-intensive.



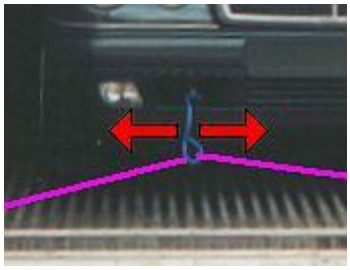


Above and selective enlargement to the left:

Automobile in a refrigerated container: "modern" securing hooks

Many lashing lugs (a) are hidden behind removable flaps. Lashing hooks (b) have to be hung in these hidden lashing lugs (a) for lashing the vehicles.





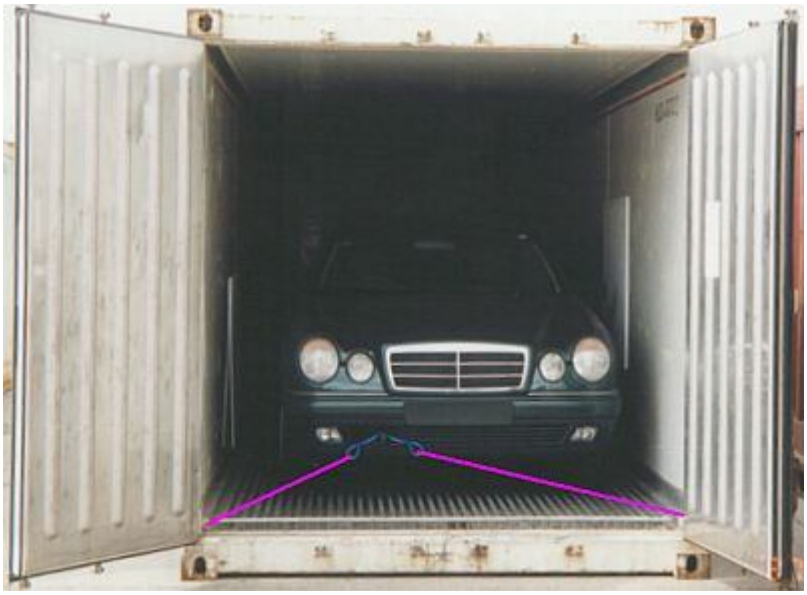
Above and selective enlargement to the left:

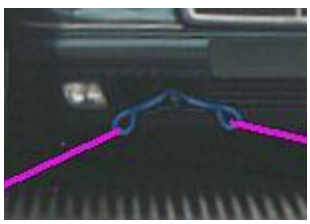
Risk of damage due to "modern" lashing hooks

Because of these hooks, in which two lashings have to be hooked and fastened, the vehicle has a degree of "play" to the left and right (see red arrows) and can move to and fro.

It should be pointed out that such impractical methods are used by a very large number of automobile manufacturers, many being very much less suitable than those described here. Many automobiles do not have any lashing points and have to be lashed by the wheel rims.

If two hooks could be fixed to the lashing lugs, vehicles would be fixed appropriately by the lashing means used, provided that the angles and resultant force components conform to shipping stresses.





Above and selective enlargement to the left:

possible method of fixing a vehicle using two lashing hooks in the lashing lug





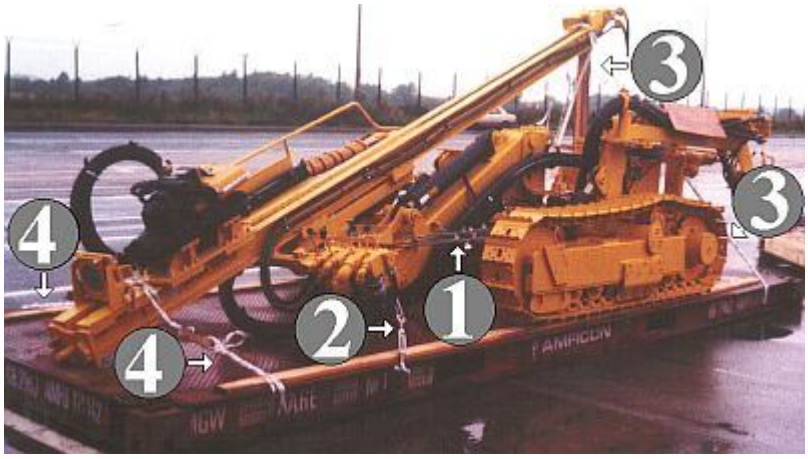
Above and selective enlargement to the left:

sensibly fitted lashing lugs and hooks

With two lashing lugs and hooks at back and front, the vehicles would be appropriately equipped for securing.

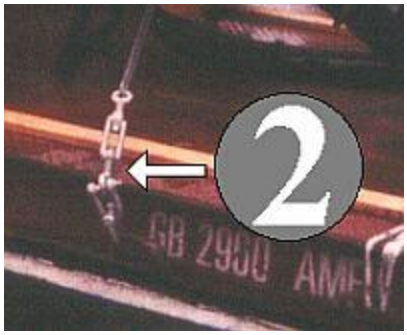
5.2.4.2 Earth borer on 20' platform

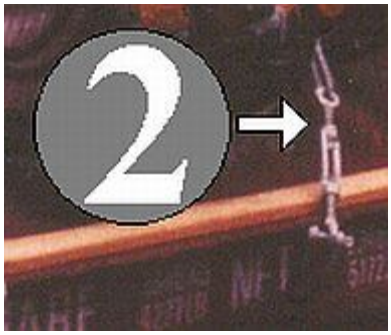
The earth borer is adequately secured on the platform. A couple of generally positive features are that wooden planks have been laid under the vehicle's tracks, to increase the friction between platform floor and machine, and that only direct lashings were used.



Earth borer on platform

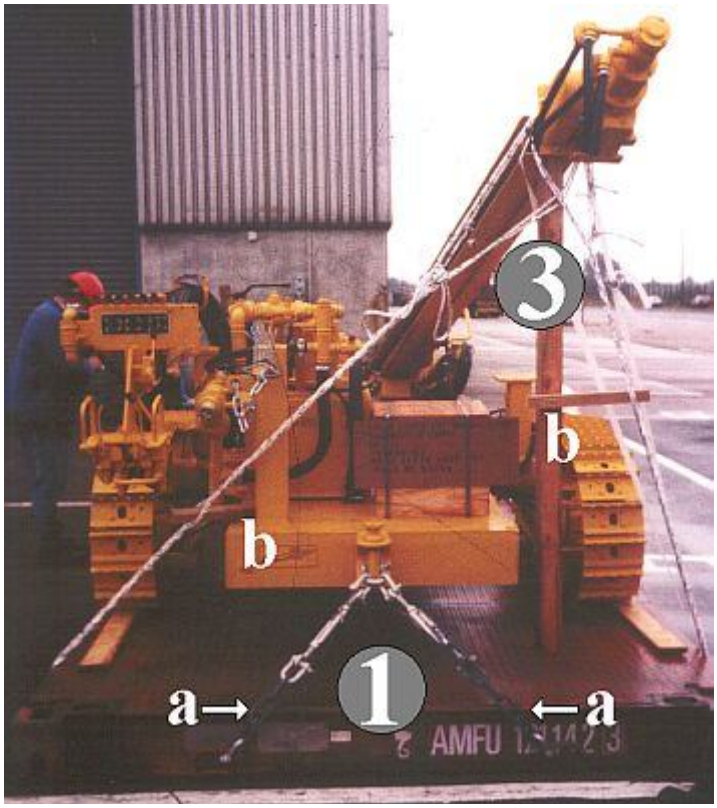
The running gear was secured at the rear (see next Figure) with turnbuckles used as diagonal lashings and (see Figure above) to the tracks by means of oblique and diagonal lashings consisting of steel wire rope (1). The lower part of the boring mechanism was secured with diagonal lashings consisting of shackles, turnbuckles and steel wire ropes (2). The boring arm was fixed at the rear (3) and front (4) by applying Spanish windlasses to oblique lashings consisting of "Hercules" rope interwoven with polypropylene.





Inappropriately fitted lashings (2)

The lashings (2) are inappropriately fitted. It is clear that the turnbuckles are stressed to the point of slight bending. Although, in this case, this does not impair safety, it may prevent the turnbuckles from being reused subsequently. It would have been better if, as in the next picture at (1), the turnbuckles had been attached to the lateral frame of the platform using chain links, i.e. in this instance small pieces of high-strength, long link chains (a). If deflections around sharp edges are necessary, short link chains would be more appropriate, because they would not then be stressed by bending. However, they can only be used as high-strength chains in conjunction with special end links, since no suitably strong shackle can be screwed into short link chains.



View of the back part of the secured earth borer

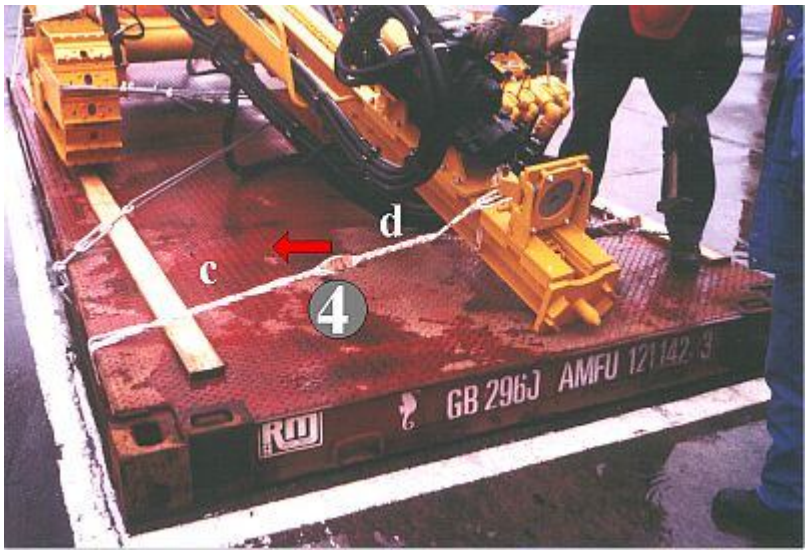
The selected lashing angles of the lashings (1) are very well balanced. They provide markedly uniform transverse, longitudinal and vertical components. The lashing angles of the lashings (3) of the boring arm, on the other hand, have an uneven effect. Different positioning of the boring arm was not possible, however.

In this case, securing is only insignificantly impaired thereby, since the lashings (4) produce adequate transverse components for lateral securing of the boring arm. Positive features of the previous Figure are the positioning and fastening of the tightening spars (b): they are prevented from coming undone.



Earth borer on platform - view from the other longitudinal side

Things are different on the side of the lashing (4) facing the direction of view. Here the tightening spar should have been positioned a little further to the left.

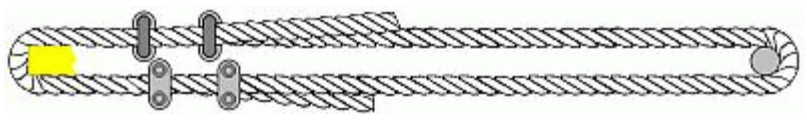


Tightening spar position at (4) in need of improvement

At (c), the number of turns is distributed over a greater length than at (d). Moving the tightening spar a little to the left would have produced more even turns and firmer positioning of the tightening spar.



Wire rope lashings attached to the tracks



Correct wire rope shear

The type of shear ensures that the full maximum securing load of the wire rope is retained at the sharp edge because four working parts are produced which each provide 25% of the full strength.

However, a possible criticism is the thickness of the wire ropes used. Since the maximum securing loads of the lashing points present ranged from 3,000 daN to 4,000 daN, material is wasted by using wire ropes with a diameter of 16 mm, since maximum securing loads of 10,240 daN can be achieved with such wire ropes.

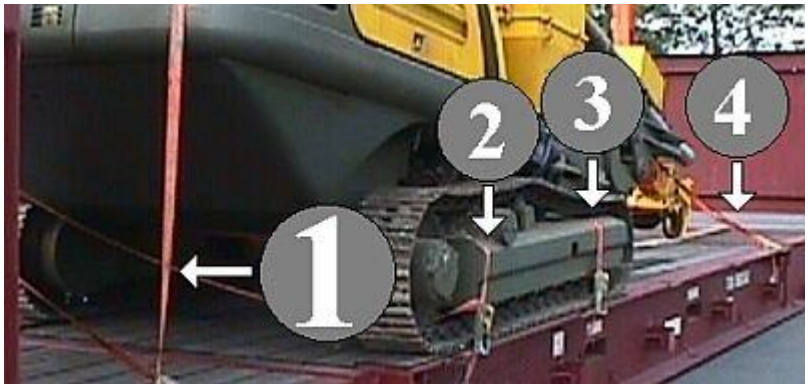
5.2.4.3 Earth borer on 40' flatrack



Inadequately secured earth borer on a 40' flatrack

It is obvious, even at first glance, that the earth borer is inadequately secured and its center of gravity is eccentrically positioned. The apparatus will slip during road or terminal transport and, unless improvements are made, there will be an acute risk of damage during a voyage.





Top and selective enlargement below:
Loosened, slipped lashing belts

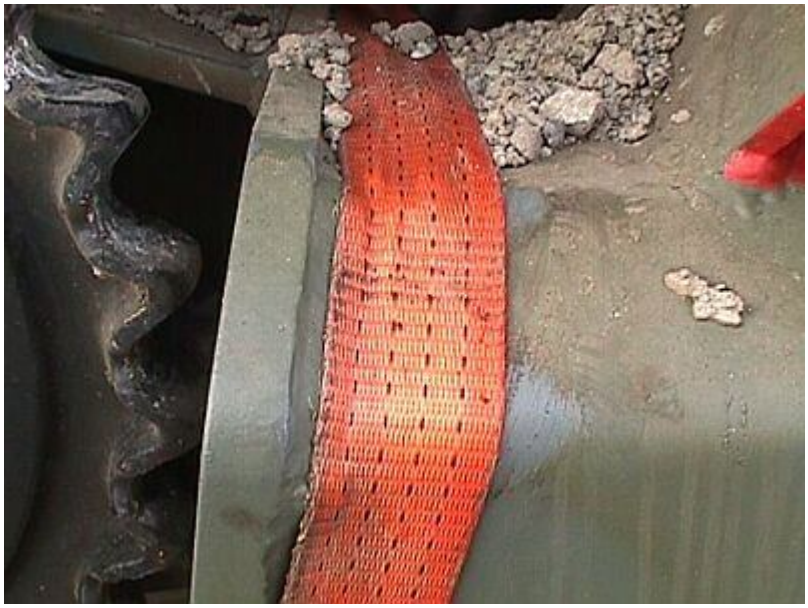
The lashing belts (1) and (4) have clearly slackened. The lashing belts (2) and (3) have tightened up due to displacement of the machine.





Ineffective, incorrectly applied lashing belt

The way the belts have been applied, they are capable of absorbing virtually only vertical securing forces and act only against upwards movement. It is incorrect to pass belts through the louvers in the engine compartment cover serving as a counterweight in such a way that they are constricted and thereby weakened. The fittings on the belt are not entirely suitable for attachment to the steel stirrups visible on the flatrack.



Lashing belt weakened by sintering

The lashing belt (2) has been stretched by the movement of the earth borer on the flatrack. Slippage produced so much energy that paint was rubbed off and the belt material was damaged by frictional heat. Allowing stones to get under the belt is sloppy practice and could weaken the belt. The fact that the appliance has already slipped during precarriage shows that the tie-down lashings used for cargo securing were unsuitable.



Lashing belt weakened by slippage

Lashing belt (3) also shows slight damage due to shifting of the earth borer caused by inadequate securing.



Inadequate securing of the boring arm by a round-turn lashing

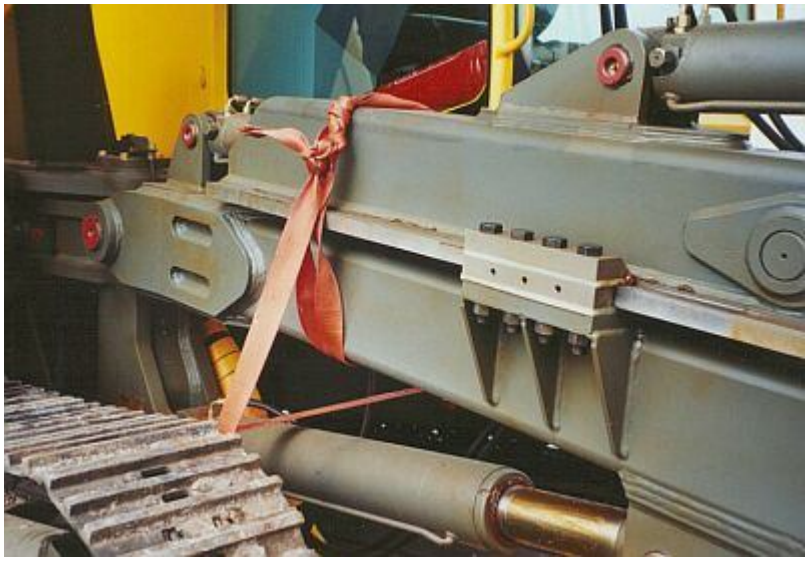
A part can move relatively freely in a round turn. In this case, the boring arm can consequently move easily to the left and right, if it is not prevented from doing so by a bolt in the turning gear. This deficiency could be remedied by two loop lashings.





Above and selective enlargement to the left:

Incorrect use of lashing belt (5)



It is forbidden to knot lashing belts.

If lashing belts are knotted, up to 70% of the admissible lashing force F_{adm} or the lashing capacity LC stated on the belt label is lost. Even specialists don't know what strength is actually left.



Misused and appropriately used lashing hooks

The lashing hook of lashing belt (5) has also been incorrectly used. It is not intended to be used in the manner illustrated on the left. If the opening in the hook is big enough, the hook can be used as illustrated on the right. The load borne by the hook must be applied to its base.

The manufacturer of the earth borer has not taken any precautions with regard to cargo securing, despite being well aware that the machine does not travel to its purchaser or place of use on its own tracks. Cargo securing is therefore particularly difficult and risky. Cargo securing personnel seldom know which parts of the machine can be loaded to what degree and in what manner and such information can often be difficult to obtain. The following recommendations for appropriate securing are therefore made with reservations and without any guarantee that they are correct:



Basic principles of securing the earth borer

Appropriate longitudinal securing means (purple), transverse securing means (blue) and vertical or anti-tip securing means (green) must be provided, in addition to appropriate load distribution. The following more detailed options are feasible:

1. The earth borer is positioned on the flatrack in such a way that the overall center of gravity of the machine lies as far as possible within the central longitudinal and central transverse line of the flatrack.

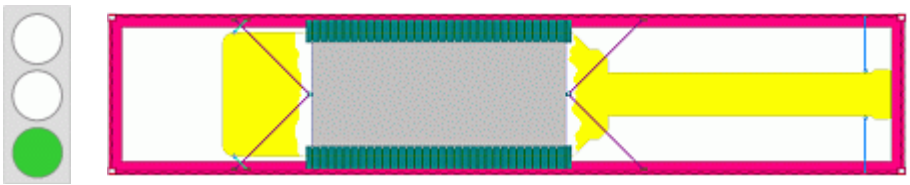
2. Sufficient longitudinal components need to be produced for cargo securing. To this end, as indicated by purple lines, lashings are attached to the inside of the tracks with sufficiently broad fastening elements and tightened in the longitudinal direction of the flatrack with as flat as possible lashing angles. As an alternative, bracing could be provided between the earth borer and the ends of the flatrack. Given the large distances to the end walls, this method is only economic if no lashings have to be attached to the tracks.

3. Sufficient transverse components need to produced for cargo securing. To this end, as indicated by blue lines, lashings are attached to the inside of the tracks with sufficiently broad fastening elements and tightened in the transverse direction of the flatrack with as flat as possible lashing angles. Before the tracks are used for load securing, it should be clarified in each individual case with the manufacturer of the construction machinery whether they can withstand the loads applied by load securing. To secure the boring arm, appropriate loop lashings need to be selected which are passed in each case from right to right and left to left to separate lashing points. As an alternative, lateral securing is possible by inserting the stanchions of the flatrack in the area of the tracks and bracing small gaps between tracks and stanchions with boards.

4. To secure against tipping, appropriately shaped fittings can be hooked into the solid metal louvers of the engine housing. Direct lashings are hooked into these fittings to secure against tipping and vertical movement.

Similar provision is made at the front of the earth borer. However, electric or hydraulic lines must not be impaired in any way.

If the manufacturer of the earth borer had provided adequately sized lashing points on the running gear, the counterweight with engine housing and the boring arm, appropriate securing could easily have been achieved.



Problem-free securing of an earth borer suitably designed for transport

5.2.4.4 Concrete breaker on 40' flatrack



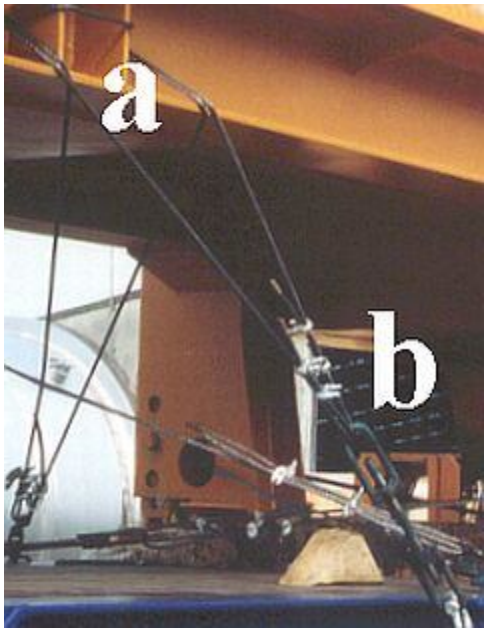
Adequately secured concrete breaker on a 40' flatrack

Once again, the manufacturer had not taken any precautions with regard to transport and cargo securing, resulting in particularly high material and labor costs when it came to securing the concrete breaker. Some areas of the vehicle could not be used for cargo securing, because they had hydraulic and electric lines running along them. Some correctly placed, appropriately dimensioned lashing points would have simplified cargo securing operations tremendously.



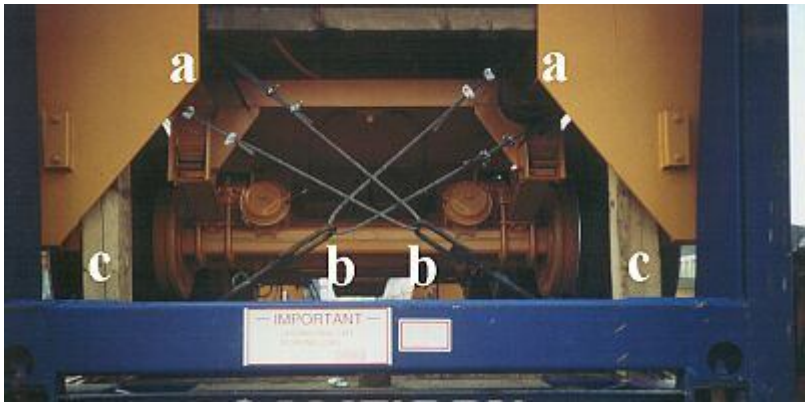
Oblique view of some securing measures

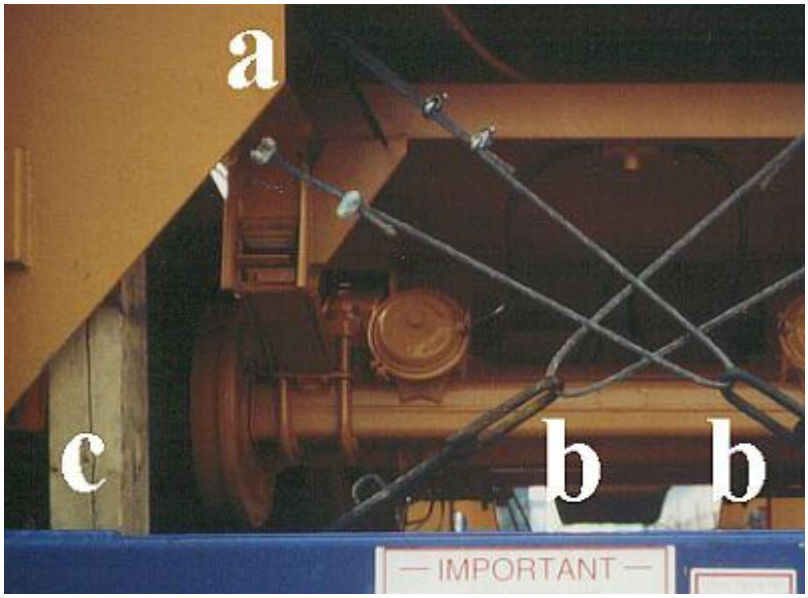
At the sharp edges of the breaker components, the maximum securing load of the wire ropes was reduced by approx. 50%, but no other fastening arrangement was possible due to the design of the breaker.



Lashing problems caused by the breaker design

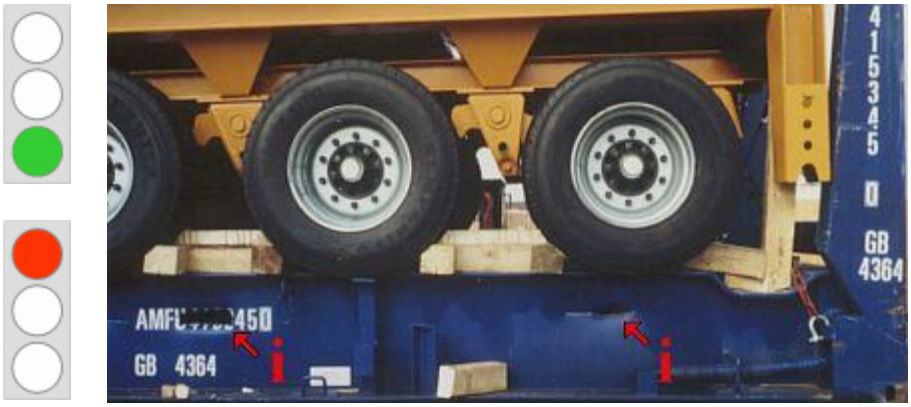
In order to achieve uniform lashing, quadruple cable shear should have been provided at (a) and double shear at (b). However, this was impossible because of the very narrow openings provided by the design. The length of the wires hindered manual pretensioning. As a result, a very large number of turns had already been used when it came to actual pretensioning by means of the turnbuckles.





Top and selective enlargement below:
Correct arrangement of wire ropes

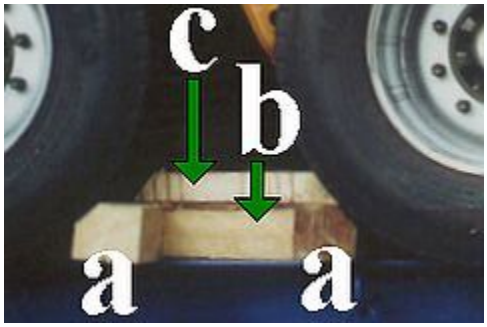
At the rear part of the vehicle, it was possible to fit the wire ropes correctly. Quadruple shear is produced by the sharp edges at a, and double shear at the turnbuckle stirrups b. A positive feature in the Figure is the blocking up of the vehicle off its suspension by means of the squared lumber c, so preventing unnecessary vibrations of the vehicle and abrupt loading of the lashing wire ropes.



Lengthwise securing using wedge members

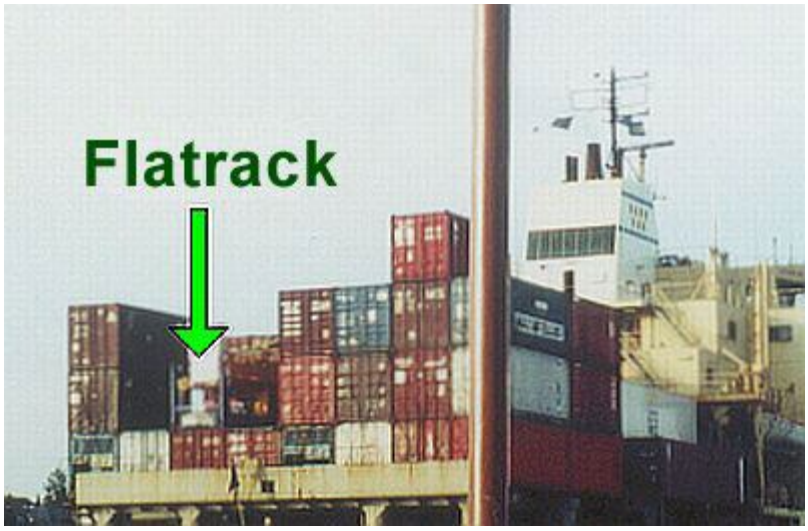
The wedge members, among other things, contribute to lengthwise securing of the vehicle. This effort could have been spared, if the breaker had had appropriate lashing points: adequate securing could have been quickly and cheaply achieved with oblique lashings. The misshandling of the flatrack with the tines of a forklift truck at (I) was far from "gentlemanly".

There is a knack to producing tight fitting wooden assemblies.



Wedge member bracing between the tires

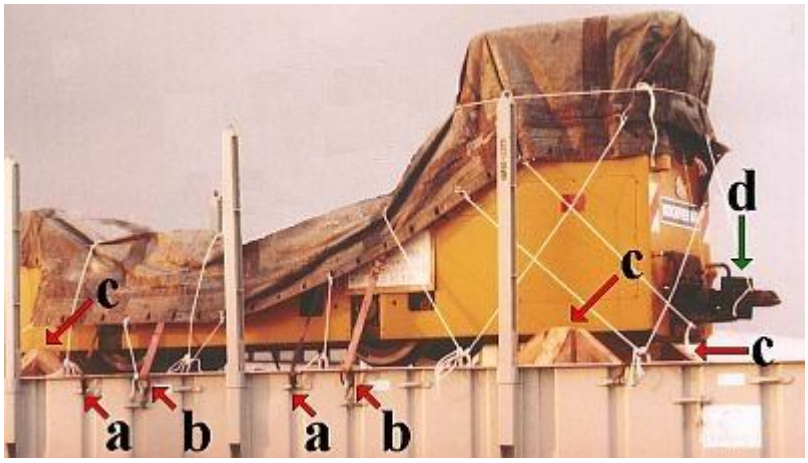
First of all, the two wedge members a are inserted crosswise between the tires on the axle. An auxiliary member, not shown here but whose length matches the gap between the members a, is cut to size, inserted between the wooden members and driven apart towards the tires with driving wedges. The then somewhat enlarged gap is measured and the wooden member b is cut to this size and fitted. Once the dimensions for the securing member c have been determined, this member is cut to size and likewise fitted. Finally, the driving wedges are knocked free and the auxiliary member is removed. The wooden bracing is held firmly in place due to the elasticity of the tires, without any nailed joints.

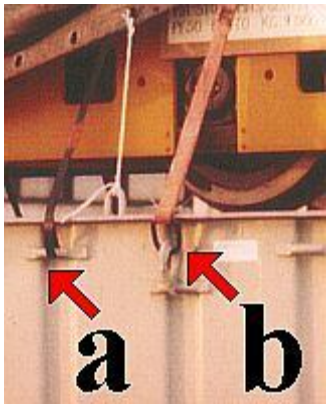


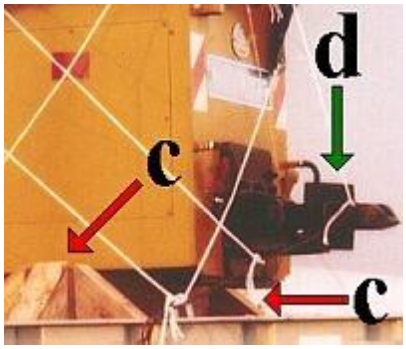
Slot for the flatrack on board ship

This picture illustrates just how important it is to secure each cargo appropriately, even in the vertical direction. The flatrack is positioned in the last bay of the ship and will experience the greatest vertical accelerations during pitching at sea, as well as the other movements of the ship.

5.2.4.5 Rail vehicle on 40' flatrack







Top and selective enlargements below:
Inadequate securing of a rail vehicle

The vehicle cannot be held securely by the four tie-down lashings applied. Two consist of steel strapping (a) and two of textile belts (b) from the lashing reels fixed to this flatrack. The wooden wedges (c) do not have any great securing effect.

This example gives cause for much criticism:

1. Although the manufacturer of the flatrack has installed lashing reels, they are all on one side and can only be tensioned in the transverse direction. If the lashing reels had been installed evenly or alternately on both sides, the vehicle could have been secured against transverse acceleration with two loop lashings on each side. If the structure of the reels allowed the lashing means to be tensioned in the longitudinal direction or obliquely as well, securing against forces in this direction would have been possible.

2. The manufacturer of the vehicle omitted to install appropriate lashing points on the vehicle. The apparatus cannot be deemed fit for transport without them. Their provision would result in a marked reduction in the risk of damage during transport.

3. It is clear from the securing provided that the packing company used untrained personnel.

Despite the lack of other lashing points, the vehicle could have been appropriately secured with loop lashings and direct lashings at the coupling, which requires blocking, and/or with wooden bracing against the stanchions.

5.2.5 Cargoes in barrels

Section 3.2.3 of the CTU packing guidelines provides a useful introduction to this topic:

> *Where cargo of regular shape and size is loaded, a tight stow from wall to wall should be sought. However, in many instances some void spaces will occur. If the spaces between the packages are too large, then the stow should be secured by using dunnage, folded cardboard, airbags or other suitable means.*

Some information has already been provided about barrels in the "Basic stowage methods" section. This section uses individual examples to point out securing options and covers particular points which have not been dealt with sufficiently clearly previously.



Packing a container with barrels on pallets

The wording "packing a container with barrels on pallets" has been chosen deliberately, as the barrels have not been palletized, for which they would have had to have been firmly connected to the pallet. Here, the pallets serve on the one hand to rationalize handling and on the other hand as floor and interlayer dunnage. Care is recommended if the dimensions of the barrels do not exactly match those of the container, since stowage gaps are then left which absolutely must be adequately filled.



Packing progresses

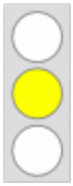


Dented barrels should be checked to ensure that

the dents do not occupy so much of the volume of the barrels that they may burst as a result of expansion due to heating.

Wooden lattice for securing in the door area

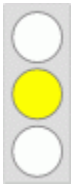
If the dimensions of the barrels are such that they fill the container to the extent that it can be packed right up to the door, a lattice consisting of vertical boards (a) and horizontal squared lumber (b) is prepared outside the container and positioned in front of the batch. The vertical boards should be positioned precisely centrally against the barrels, so that they assume the task of load transfer precisely at the strongest points of the barrels, namely the upper and lower barrel rims and corrugations.





It is distinctly less advantageous to construct the lattice from horizontal boards (a) and vertical squared lumber (b), because fewer contact points are available overall.

Less favorably constructed wooden lattice





To achieve the same number of contact points as with the first lattice, considerably more material would have to be used.

Wooden lattice using too much material



Shoring in door area - fitting of oblique bracing (c)

If a gap is left because of the cargo dimensions, the lattice has to be braced towards the door. This may be achieved on the one hand with horizontally/obliquely fitted squared lumber, which is positioned against the corner posts or, as here, with shoring. To this end, squared lumber members (c) are placed against the feet of the vertical lattice members and positioned obliquely against the top door rail.



Shoring in door area - fitting of horizontal members (d)

Wooden members are fitted at each layer in the longitudinal direction between the oblique shoring and the horizontal members of the lattice.



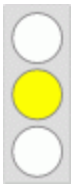
Inadequate securing of barrels in door area

A "lattice" fitted like this cannot prevent the barrels in the top layer from shifting. The vertical boards are only there to hold the horizontal squared lumber in position. The barrels rest with their body, the most sensitive part of a barrel, against the squared lumber.





Closing a container packed with poorly secured barrels



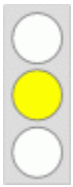


Packing a container with pails or small drums

Interlayer dunnage made of hardboard or thin chipboard is positioned at (a). The main purpose of the boards is pressure distribution. Instead of tiny contact points between individual drums, the weights are distributed over circular strips of the drum rims. Further details about this problem may be found in the section on Static mechanical stresses.

Point 4.3.6 of the CTU packing guidelines is highly relevant to the next packing example:

> *Drums containing dangerous cargoes should always be stowed in an upright position unless otherwise authorized by the competent authority.*





Slight shortcomings





Shortcomings eliminated

Point 4.2.7 of the CTU packing guidelines states, among other things:

> *Packages of dangerous cargoes should be examined and any found to be damaged, leaking or sifting should not be packed into a CTU.*

The drum or barrel indicated in red is dented. To what extent that already constitutes damage cannot be settled conclusively here. The frame is at risk from the top layer of barrels, for which reason the frame has been reinforced (a) and the barrel replaced (B).





Unsecured barrels





Secured with shoring

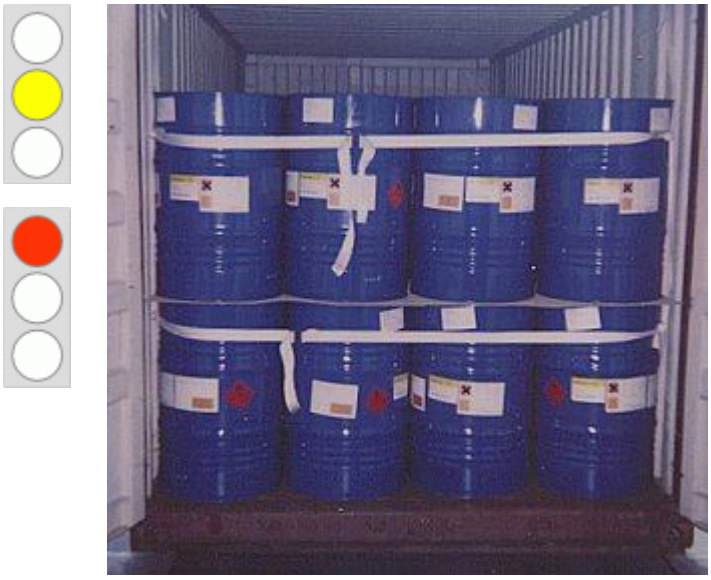
Barrels containing hazardous materials must not be packed in the manner shown and even for barrels with normal contents it goes against "standard stowage practice". At any rate, they cannot remain unsecured. Safety can be ensured with shoring.

In the section headed "On completion of packing", point 3.3.1 of the CTU packing guidelines reads as follows:

> *During the final stages of packing a CTU, care should be taken, so far as is practicable, to build a secure face of the cargo so as to prevent "fall out" when the doors are opened. Where there is any doubt as to the security of the cargo, further steps should be taken to ensure security, e.g. by weaving strapping between securing points or placing timber [lumber] between the rear posts.*
> *Two factors should be borne in mind:*

- *that a container on a trailer usually inclines towards the doors; and*
- *that cargo may move against the doors due to jolts, etc., during transport.*

The main reason for this requirement is to ensure that, when a CTU is opened, in particular when a container is inclined towards the doors, no one is endangered by items of cargo falling out. This objective can be achieved only to a very limited degree by the cargo securing illustrated.



Incorrectly arranged securing material

Since the single-use textile belts have only been fitted in the upper area of the barrels, the barrels, can slip out at the bottom. Given that this form of securing has been selected, the strapping should have been attached at least around the upper and lower thirds of the barrels. The amber traffic light is thus intended to signify "Caution".

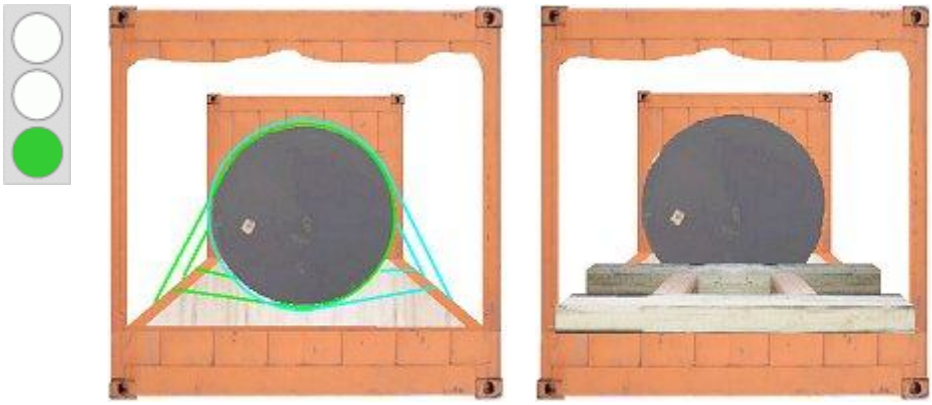
The actual implementation and working method in themselves are given a red light. The belts are tightened only across the cargo end face, so generating angles of spread of virtually 180°. This means that the slightest shift in the longitudinal direction may exert extremely large forces on the belt material. This is particularly true of the middle barrels, against which the belts lie completely straight. The angle of spread amounts to 180°, the tangent to 180° is infinite, meaning that the securing force provided by the belts is virtually zero. If such securing means are to be provided, care must be taken to ensure that the fastening belts extend as far as possible into the interior of the container. In this way, the angle of spread (at the outer edges) is avoided and direct securing is produced. However, this does not solve the problem for the middle barrels and should therefore not be used to secure barreled cargoes unless additional aids are provided such as wooden members attached transversely in front of the barrels.

In addition, the straps are knotted, which contravenes the relevant technical rules and German accident prevention regulations.

5.2.6 Lumber cargoes

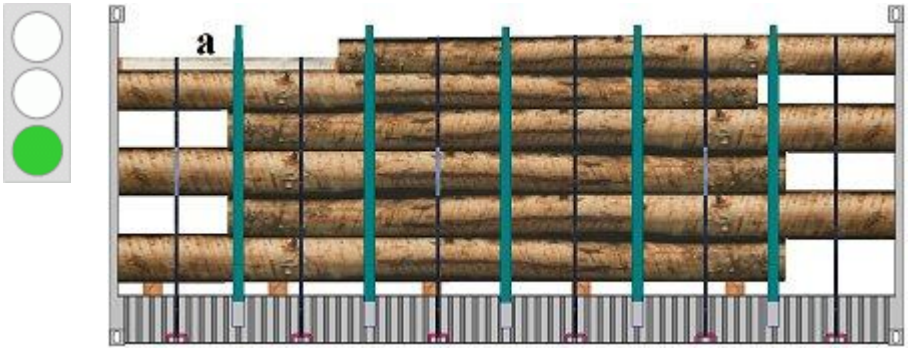
5.2.6.1 Roundwood or logs

Roundwood can be very easily stowed on flatracks equipped with stanchions. It is better if other open containers or platforms are not used. The fewest problems are caused by individual, heavy tropical logs or blocks. These can be positioned centrally on the transport supports and secured laterally with loop lashings. Longitudinal securing depends on the type of container. Bracing is one option, or lengthwise loop lashings, overhead loops plus oblique lashings or similar methods.



Transverse securing **Lengthwise securing**

If lashing rings with an MSL of 6,000 daN are available and chains of a similar grade are used as loop lashings, a 24,000 kg block could be secured with two loop lashings against acceleration of approximately 1 g. Wooden bracing can be used in the lengthwise direction.

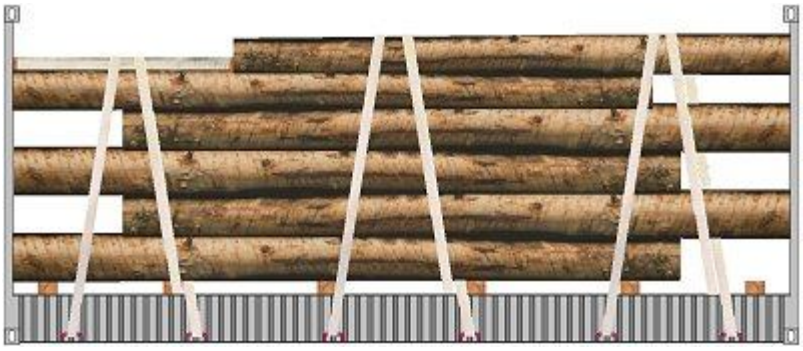


Staggered - wedged together - top gap blocked

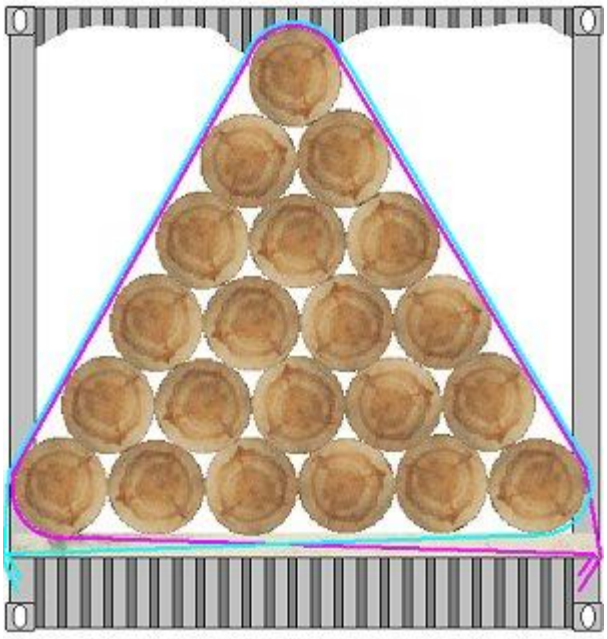
The logs were positioned alternately with their thick ends against the end walls, resulting in wedging together of the lower layers. Of course, this only works if the end walls are sufficiently strong. The gap in the top layer is braced (a). In the case of flatracks with stanchions, lashings can be used. Securing with steel strapping is acceptable, if the stanchions are lashed together transversely. However, it is to be expected that the steel strapping will slacken. A resilient material would be better. If tie-down lashings are used, the logs can even be loaded without any transverse underlays. These cannot be omitted if loop lashings have to be used for securing due to a lack of

flatracks with stanchions.

This works if the logs are loaded in the cantline.



Lateral securing using loop lashings



Logs packed in the cantline in pyramid stow and secured with loop lashings



Roundwood cargo on a 40' flatrack with stanchions

Although this roundwood cargo is properly secured, too much effort has been put into lengthwise cargo securing, since the wooden bracing at the ends requires a lot of work and material. The securing used at the ends consists of vertical squared lumber, to which boards have been nailed crosswise in the form of a lattice. Squared lumber braced lengthwise between the vertical squared

lumber lies on each of these boards. The logs have been packed in such a way that they rest with their largest diameter on one another and against the stanchions, so meaning that they are not positioned in the cantline directly against the stanchions. The maximum securing load of the blued 1.6 mm x 32 mm steel strapping matches that of the lashing points.

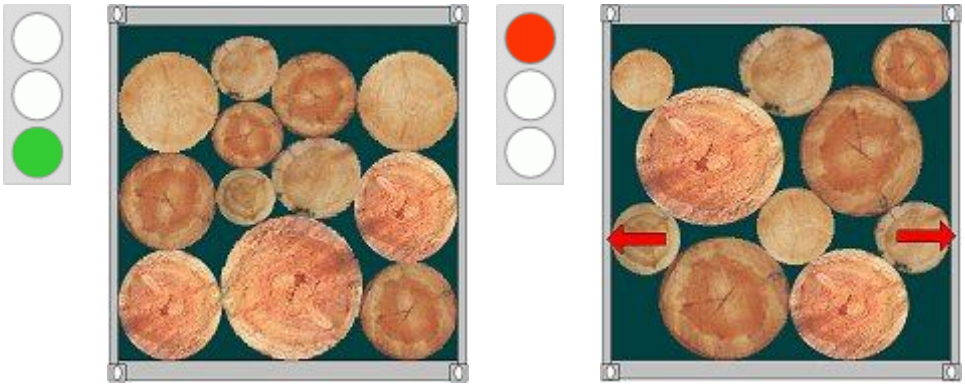
The stanchions, which are bound together in the transverse direction, effect transverse securing. Steel strapping effects vertical securing. Slack is to be expected in the steel strapping. Load distribution still falls within legally admissible limits, despite the fact that the thick ends of all the logs point in the same direction.

The following variant is somewhat cheaper but still very complex. Load distribution is definitely within regulatory limits.



Load distribution good - cargo securing effort high

Prior to packing, a lattice of squared lumber and boards is prepared and so dimensioned that the logs on the flatrack are still caught by the stanchion furthest to the left. The lattice is placed against the right-hand end wall and the logs are stowed tightly against it. The gap to the left is braced by two lattices plus squared lumber. As before, steel strapping is used for securing.



Correct stowage **Incorrect stowage**

When stowing logs in box containers, it must be noted that the logs directly or indirectly load the container walls due to the angles of spread or rest. The logs must be packed tightly against the end walls and so as not to overload the side walls. Gaps at the door end must be braced.

5.2.6.2 Examples - cut and packaged lumber

The most important objective when bundling cut and packaged lumber is to ensure that the materials used for bundling, generally steel strapping, cannot be damaged by handling with forklift trucks and lifting gear.

Therefore, only lumber with a routed-out groove should be used as a support.



Expertly fashioned supports

Steel strapping has very little elasticity. This shortcoming may be compensated, for example, by using edge protectors of a material with good recovery. Otherwise, the strapping regularly slackens, since the steel strapping presses into the wood and becomes loose as a result of the reduction in circumference. Steel strapping can only be recommended if it is used in conjunction with such materials. Otherwise, materials should be used which have good, but not excessive, elasticity.



Normally arranged strapped packages

If packages with the usual transverse strapping are moved lengthwise, they should additionally have skids, so that the straps are not torn off during handling.



Well organized package base

Here, the lengthwise members have been recessed and the transverse members let into the recesses. In addition, further transverse members have been fitted and the ends of the lengthwise members cut in the manner of skids. All the wooden members have been positioned in such a way that there was no risk of the strapping being damaged by forklift trucks, and also in such a way that lifting

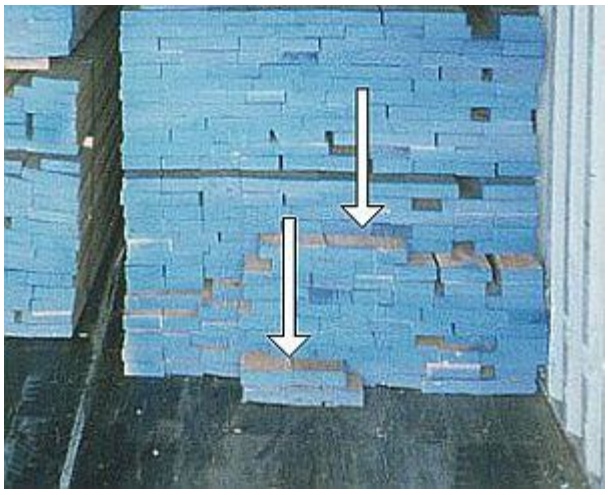
gear can be used for lift-on/lift-off operation.



Risk of damage due to inappropriate strapping

Strapping is not suitable for the handling method shown here. The strapping could tear during packing and unpacking, resulting in delays and extra costs.





Cut lumber packages in a box container, enlarged section

It should be noted that the strapping did not withstand the stresses of handling even during loading.



Stowage gaps filled with squared lumber

For trouble-free transport it is important for all gaps to be filled.

If stowage gaps are not filled, the goods will be displaced during transport, possibly resulting in damage to the container and/or goods.



As may be seen from this import container, financial losses are the ultimate result of impeded handling, storage after shipment and onward transportation.

Losses result
if gaps are left.

Strapping deficiencies and unfilled gaps regularly lead to deformation of packages.



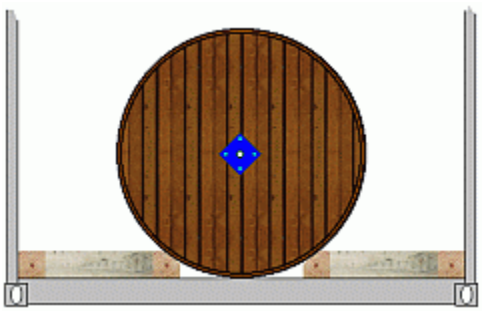
Cargo slippage due to weak strapping and unfilled gaps

5.2.7 Cable reels

5.2.7.1 Cable reels in standard containers, winding axis horizontal and lengthwise

Stowage of six larger cable reels in a box container

Smallish cable reels can be secured relatively simply with a tight fit in box containers, provided the containers have an appropriate number of lashing points.

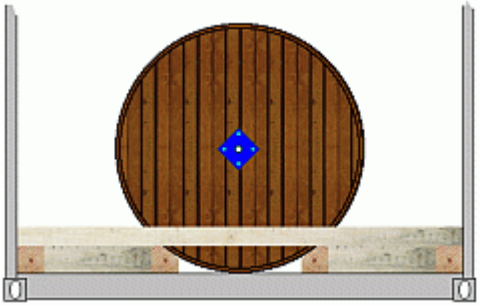


Bed for lateral securing of cable reels

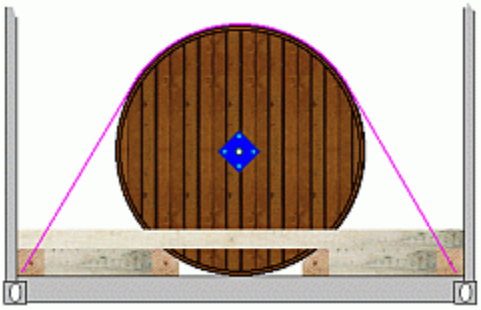
The cable reels are stowed with their axis lying lengthwise. Wedge members are positioned to the left and right, with flank angles which should correspond to the adjacent tangent. Unlike with steel sheet coil stowage, the cable reels lie centrally. For pressure distribution, squared lumber or planks are positioned against the container side walls. It is advisable for the appropriate lashing means to be attached before the wooden members are set in place. Special measures are not generally necessary where the lashing points are fitted between the container corrugations. If the lashing points are recessed into the container floor, the wooden members have to be recessed at these points. Between these wooden members and the wedge members, transverse members are fitted for securing purposes.

Depending on the reel packing pattern, transverse members for subsequent lengthwise securing of the

reels are fitted either in front of and behind a cargo block or in front of and behind each cable reel:

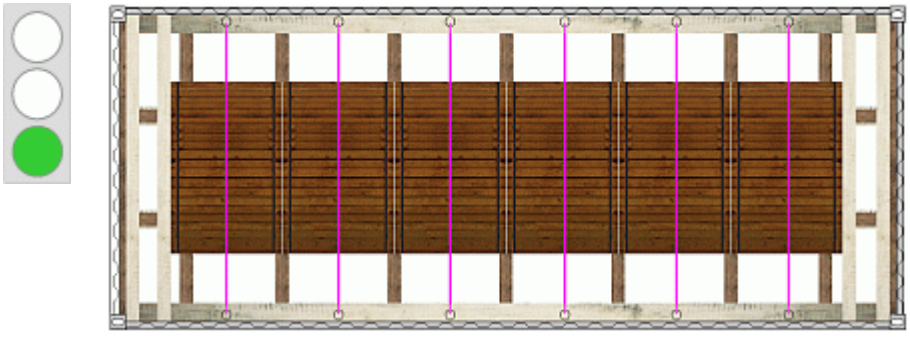


Transverse members for subsequent lengthwise securing of the cable reels



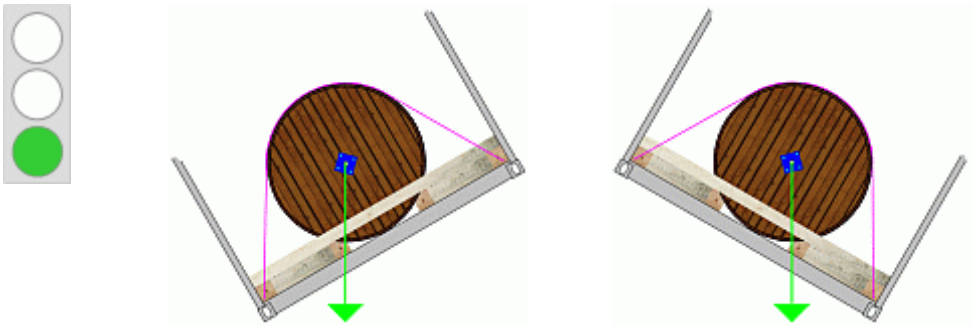
Overlashings preventing the reel from "popping out" of the bed under dynamic loads

Because of the number of cable reels and lashing points, in this example the cable reels are each secured with overlashing to prevent them from "popping out" of the bed under dynamic loads. Given their function, these are not tie-down lashings but direct lashings, so that only moderate pretension may be applied.



Cable reels secured in all directions

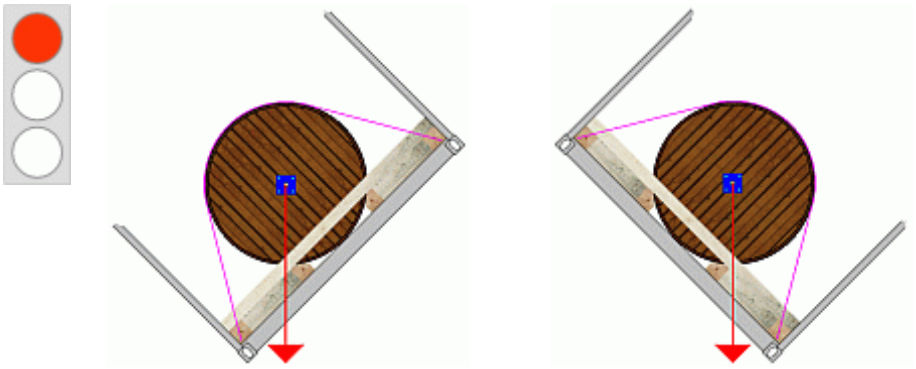
It was only possible to use one overlashing per cable reel but, nonetheless, the reels are adequately secured in the longitudinal and transverse directions, if the rolling angle remains within the usual limits for containers stowed lengthwise (fore and aft stowage).



Weight-force vector at 30° rolling angle

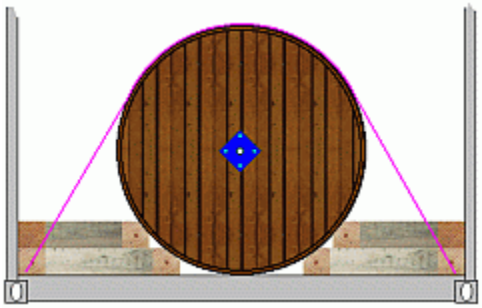
At a tilt of 30°, the weight-force vector corresponds to the line of contact with the wedge members. In this way, adequate lateral securing of the cable reels is achieved.

The picture is different if rolling angles of 45° are assumed.



Weight-force vector at 45° rolling angle

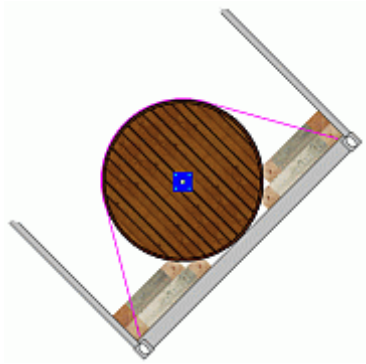
At an inclination of 45°, the weight-force vector is outside the line of contact with the wooden wedges. In this way, adequate lateral securing of the cable reels is not achieved. They could roll out of the cradle and, to prevent this, additional lateral wooden members are required:

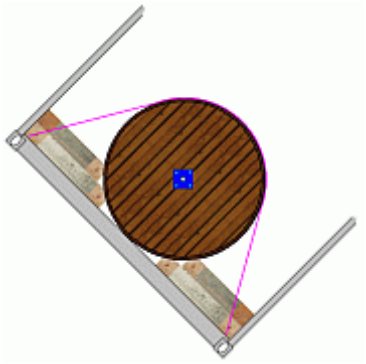


Additional wedge members and transverse braces for lateral securing

These measures allow the cable reels to be supported further up, so eliminating the risk of cargo shifting:







Adequate securing of cable reels
even in the case of a 45° rolling angle

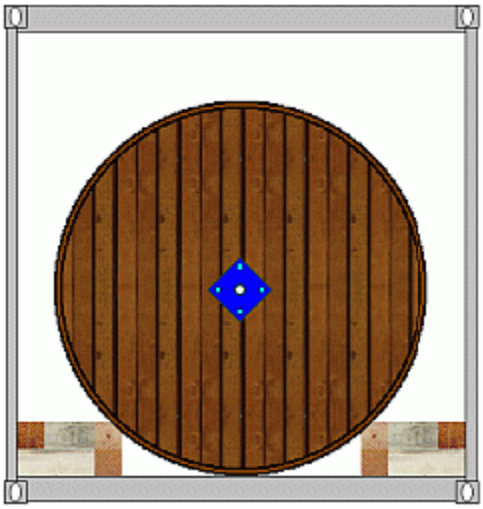
Even with a rolling angle of 45°, the weight-force vector is still within the line of contact with the upper wedge members.

Stowage of three larger cable reels in a box container



Load distribution and lateral securing of the cable reels

The cable reels are loaded uniformly in such a way that two lashing points are available on each side for each cable reel.



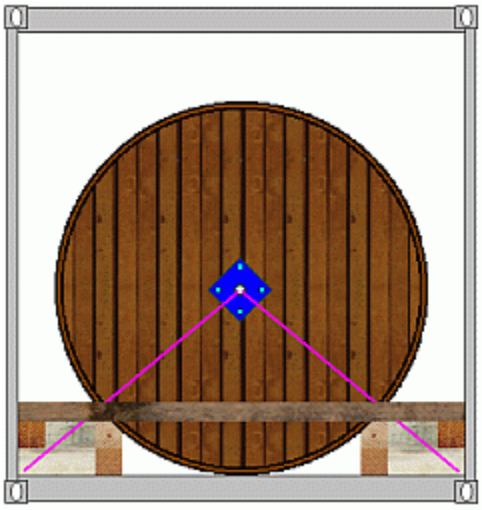
Lateral securing using wedge members and bracing

To achieve better lateral securing, the wedge members were raised by placing them on other lengthwise squared lumber. In the Figure, transverse securing is effected at the level of the wedge members. It is also the intention here to secure the cable reels additionally by loop lashings through the eye loop lashings through the eye. In the case of lashing points recessed into the floor, the outer crosspieces in the bottom layer must be so positioned that the lashing points remain accessible.



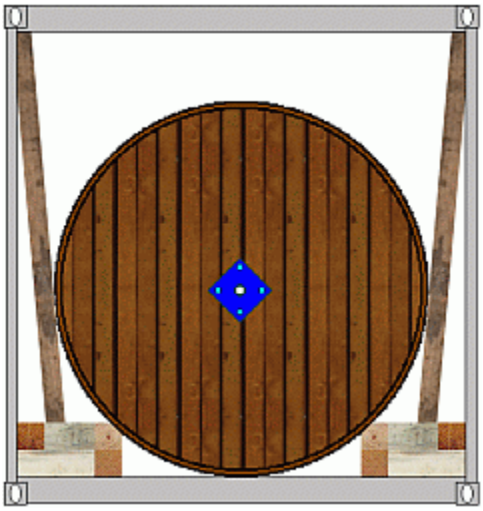
Lengthwise securing using bracing, crosswise and vertical securing by bracing and loop lashings through the eye

One loop lashing is positioned to the left and right through the eye of each cable reel. Together with the transversely acting wooden members, they secure the cable reels laterally and prevent them from popping out of the beds under dynamic loads. The cable reels are blocked in the lengthwise direction. At the same time, the loop lashings through the eye secure the cable reels against lengthwise tipping.



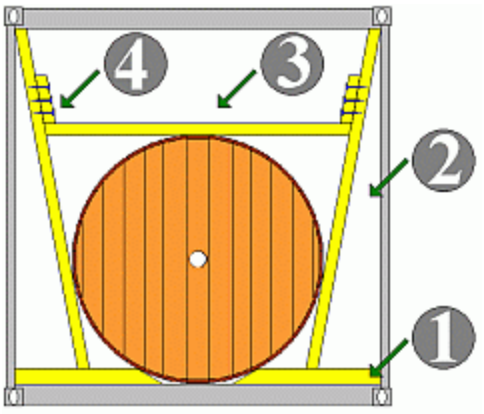
Securing by loop lashings and wooden bracing, in cross-section

If lashing points are absent, additional lateral securing may be achieved by simple shoring, which is fitted between the bed lumber and the top side rail in such a way that they are retained by the container corrugations.



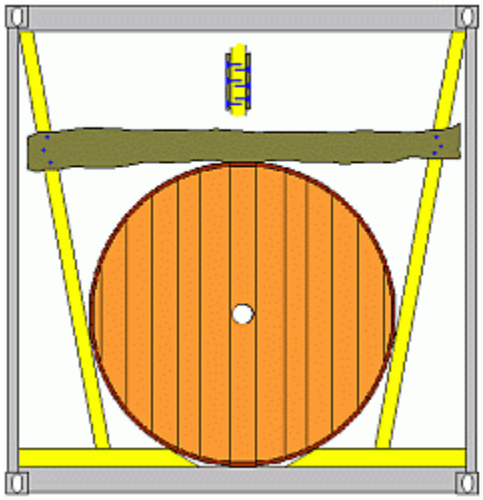
Additional lateral securing by shoring

If no suitable lashing points are available in a container, lateral securing may be achieved solely by shoring. To what extent the use of wedge members or even raised wedge members is necessary depends on the particular circumstances. A simple variant is presented below, in which all that is used in the floor area is beveled crosspieces.



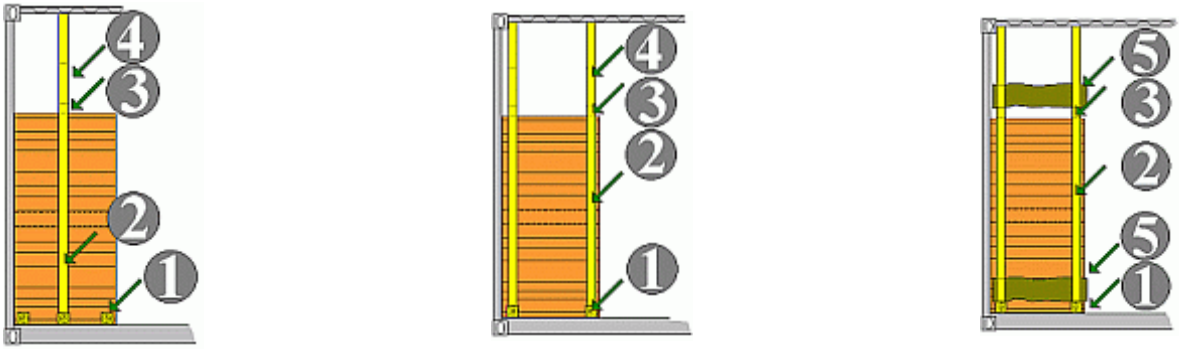
Lateral securing by shoring - cross-section

Each cable reel is secured in the floor area with the beveled squared lumber (1). The shoring (2) is fitted between bottom cross members and top side rails in such a way that it is stabilized by the container corrugations. Crosspieces (3) are fitted between the shoring and secured with cleats (4) in such a way that they rest on the reels.



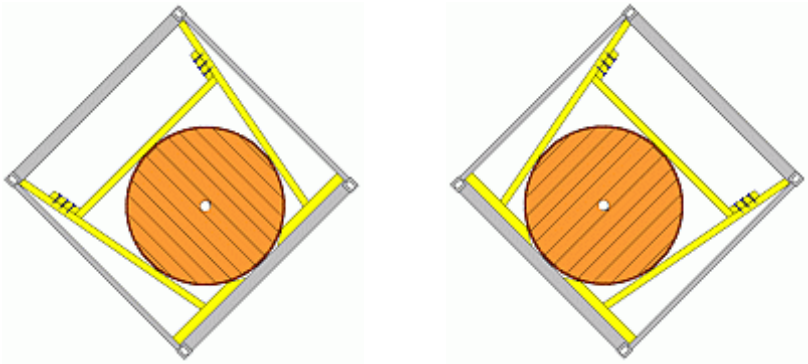
Vertical securing using boards - cross-section

Instead of squared lumber, vertical securing may also be provided by wooden dunnage boards nailed or screwed against the shoring from both sides.



Shoring variants - side view

It depends on the dimensions and weights of the cable reels whether one shoring structure or two is provided on each side per cable reel. Sometimes additional bracing with horizontal boards (5) or even boards nailed on diagonally is necessary, to provide the shoring with a secure hold.

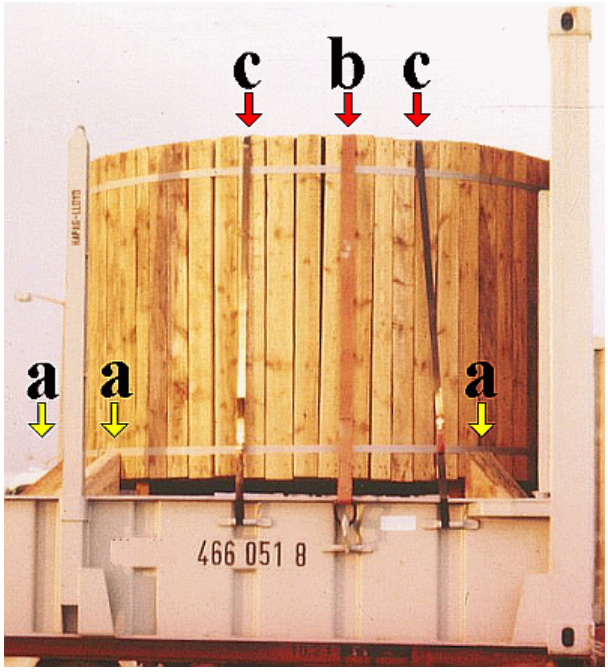


Cable reels at a tilt of 45°

However, the Figures shows clearly that it is more favorable to raise the wooden members in the floor area, since the weight-force vector is clearly outside the line of contact with the bottom cross members.

5.2.7.2 Cable reels on a flatrack, winding axis vertical

Inadequately secured cable reel

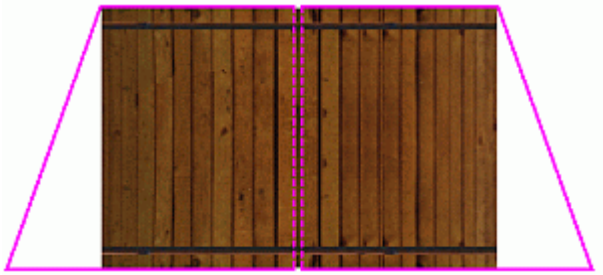


The wedges (a) have been correctly cut, namely in such a way that nails can be driven into the face grain. All in all, the small number of nails cannot apply sufficient shearing force to secure the cable reel with the wedges in the floor area. Additional measures would have been necessary.

The webbing belt (b) comes from a lashing reel fixed to the flatrack - it is tensioned on one side and is

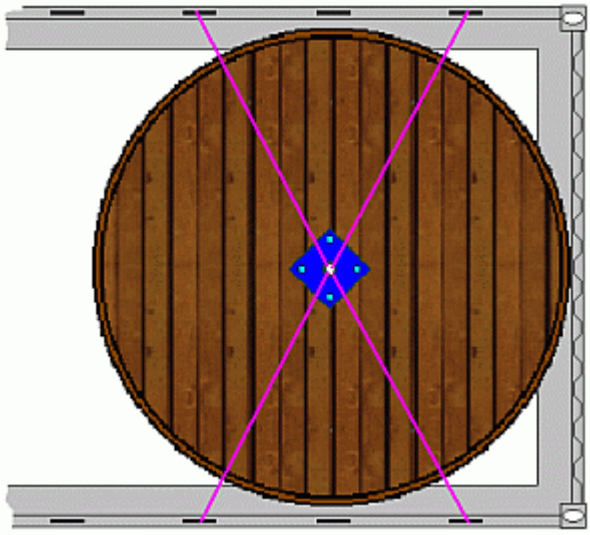
passed directly over the rough, sharp sawn edges of the reel boards without using edge protectors. There is a risk of fraying.

The two steel straps (c) have very low elasticity, roughly half of which has already been used up for pretensioning. Approx. 7.5 mm residual elasticity remains. The slightest jolt during transport would cause the steel strapping to cut into the wood and slacken. Since it is used as tie-down lashing, it can then no longer exert any securing force.



Loop lashings through the eye - diagonal section

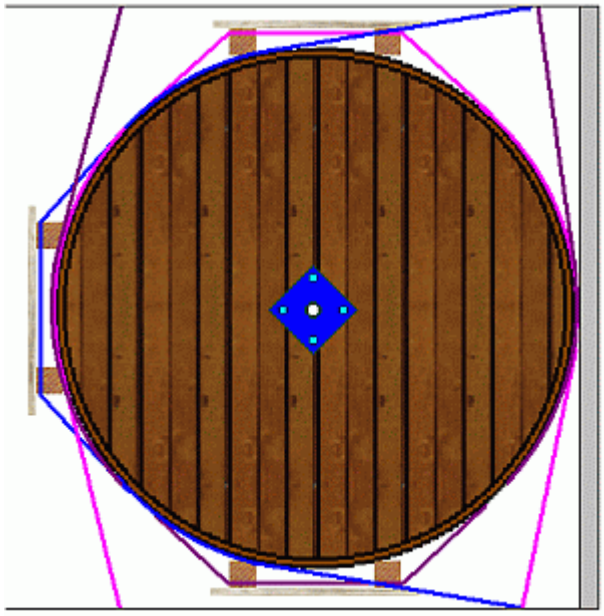
The simplest option is to position the cable reel in such a way on squared lumber underlays that the eye and the path to the most favorable lashing points remain accessible, and then to secure it with four loop lashings through the eye.



Loop lashings through the eye - plan view

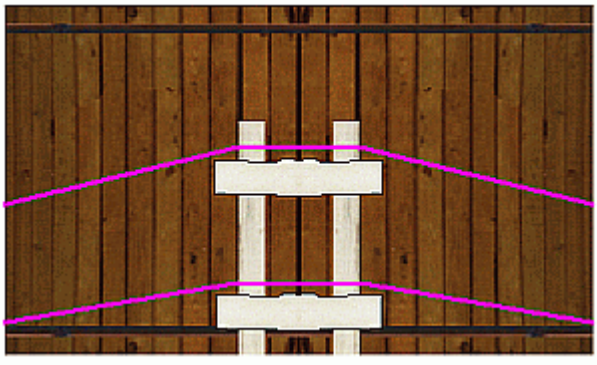
If the eye is inaccessible or it is too difficult to pass lashing means through the eye, securing using obliquely

applied loop lashings at the end wall and the two sides is possible.



Securing by loop lashings

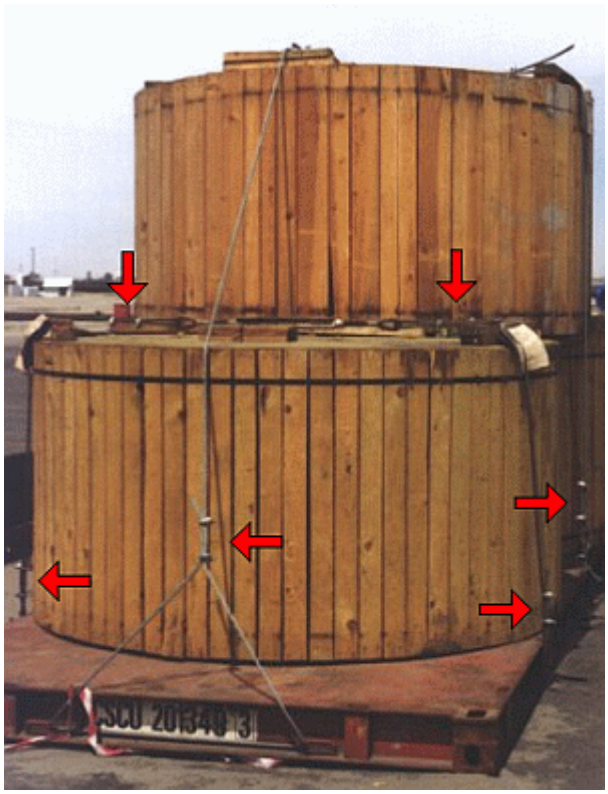
The blue loop lashings hold the reel firmly against the end wall and at the same time secure it on the left. The pink loop lashings secure it against movement to one side (upwards in the Figure) and the purple loop lashings secure it against movement to the other side (downwards in the Figure).

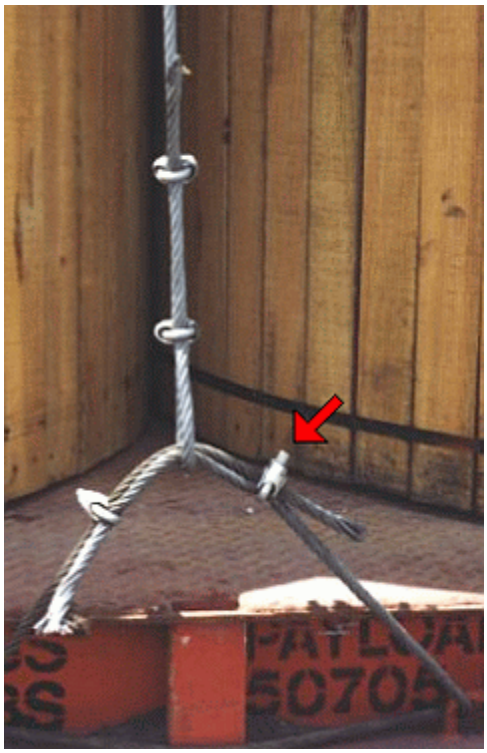


Notched squared lumber holds the loop lashings firm against slippage

The loop lashings may be held firm by notched squared lumber, which is made into a lattice using board ends and positioned in front of the reel. Whether additional securing against tipping has to be applied depends on the diameter:height ratio of the cable reel.

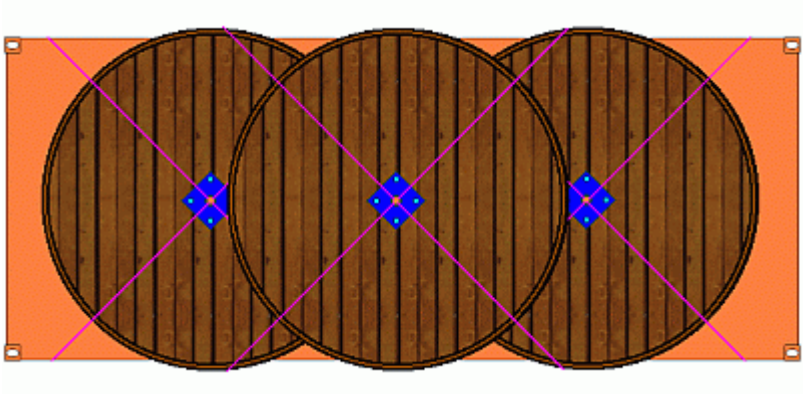
Three cable reels on a 20' platform





Inadequately secured cable reels on a platform

The cable reels cannot be held secure by the longitudinally and transversely tensioned tie-down lashings. Moreover, the wire rope lashings have been applied in nonuniform manner. Too few wire clips have been used and some of them have been applied contrary to the rules of application.



Cable reels each secured with four loop lashings through the eye

The cable reels can easily be secured with four loop lashings through the eye per reel. The number and orientation of the lumber members laid beneath and between the reels should be such that the cable reels are not subject to any harmful pressures and at the same time application of the lashing means is not prevented.

5.2.7.3 Overheight cable reels on a flatrack, winding axis horizontal and crosswise

Particularly heavy cable reels on 20' flatracks

NET WEIGHT:	KGS 21721,926
GROSS WEIGHT:	KGS 24480,926
DIMENSIONS:	376x234x385 CM
LENGTH:	2287 M

Some reel labeling details

For a voyage to Indonesia, these reels need particularly careful securing, since the probability that the ship will meet with bad weather increases with the length of the voyage.



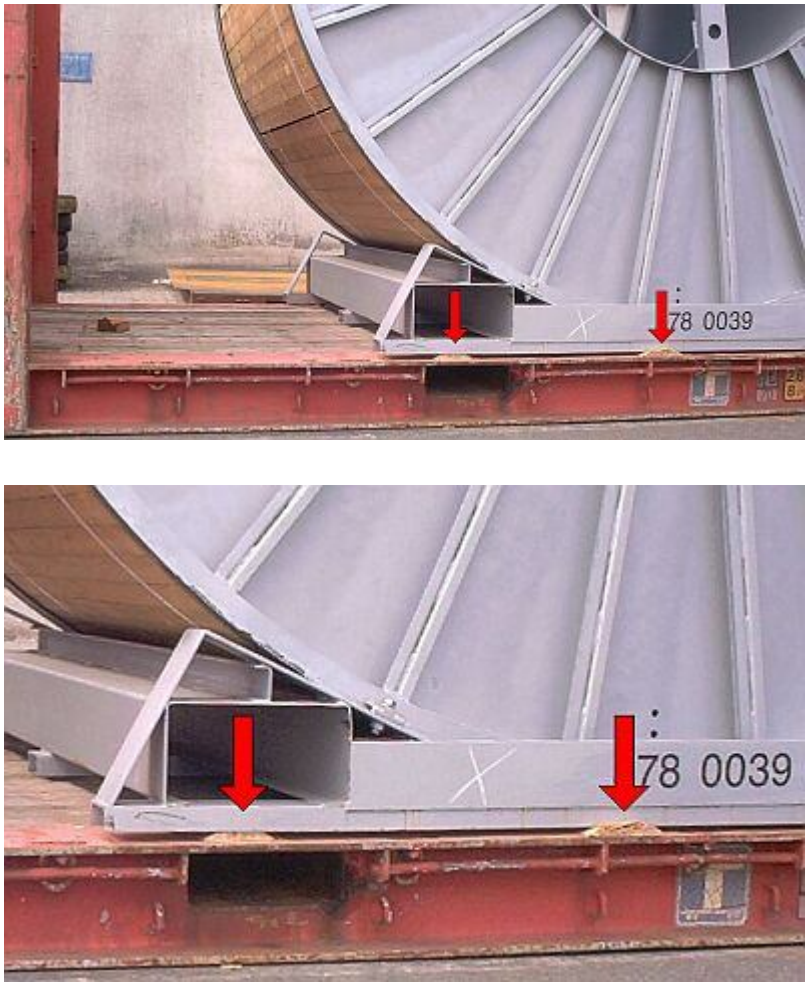
Heavy, bulky cable reels on 20' flatracks



Poorly constructed floor assembly made from U-profiles

It was foolish of the manufacturer to choose a floor structure of three U-profiles extending perpendicularly

to the reel axis. Its six steel strips provide so little surface area that laying friction-enhancing underlays is pointless.



Squashing of the boards laid underneath due to excessively small bearing areas (selective enlargement below)



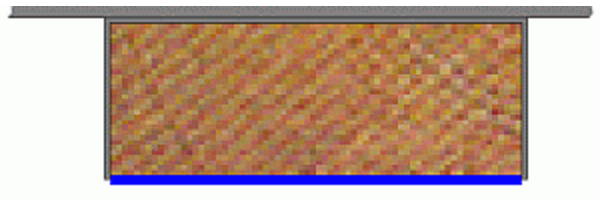
Floor structure and underlays cause extremely high pressures.

The boards laid underneath are squashed by the extremely high pressures. If four approx. 200 mm wide boards are laid underneath and the steel thickness of the 3 U-profiles is 8 mm, the bearing area is 24 x 200 mm x 8 mm = 38,400 mm² or 0.0384 m². With a cable reel gross weight of 24,481 kg or a normal force of 240,159 N, the pressures are 6,254,141 pascals, i.e. approx. 6.3 MPa. This would previously have been written as 637 metric tons/m².



Per transverse board, the load is distributed over six tiny strips.

It would have been better to omit the boards and to have laid the cable reel directly on the flatrack. However, friction is reduced markedly thereby, since at the outside steel is resting on steel. The use of strips of friction-enhancing mats is out of the question, since they would be cut and chafed in transit by the heavy load.



Floor structure with integral friction-enhancing material

The manufacturer of the cable reels or floor assemblies for them may assist in subsequent cargo securing by incorporating squared lumber and friction-enhancing material into the U-profiles.



Preparation of inadequate "securing means" from single-use webbing belts

The initial securing stages illustrated here are wholly inadequate. On the one hand, webbing belts must be applied over a large area, which is impossible here; on the other hand, the chosen securing methods are not capable of holding the approx. 25 metric ton mass on the flatrack over an extended period.



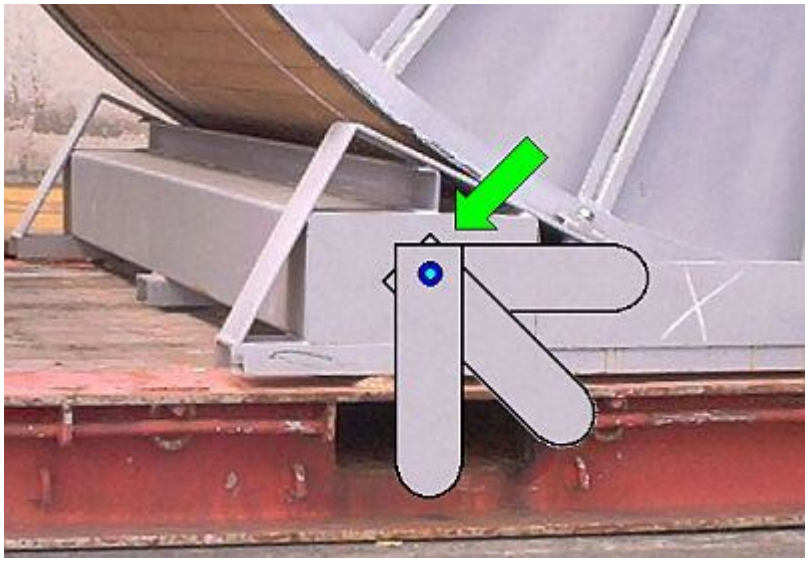
Inadequate "securing" with single-use webbing belts

Even if it is assumed, incorrectly, that 3,000 daN of lashing force could be produced with a textile strap, the horizontal lengthwise securing force would amount to 1,500 daN in the longitudinal direction because of the lashing angle. The vertical component amounts to 2,100 daN. The method of application means that the cable reels are virtually unsecured in the transverse direction.



Lateral securing using steel edge provided at the design stage

The cable reel could be held absolutely securely on the flatrack if the manufacturer had given some thought to cargo securing from the outset. A steel edge which is welded on or can be bolted on ensures 100% secure lateral securing.



Lateral securing option using steel lugs

Steel lugs provided at the design stage, which may even be adjustable in the transverse direction, would be another possible way of ensuring transverse securing. A large number of other options is feasible - it is not unreasonable to expect the manufacturer's engineers and technicians to display a little imagination.



Lengthwise securing using squared lumber

Appropriate lengthwise cargo securing can be readily achieved by using squared lumber bracing.



Lengthwise and transverse securing using chains



Lengthwise and transverse securing using chains - plan view

The use of chains allows securing to be achieved in both the transverse and lengthwise directions. Because of the package dimensions and the lashing points provided, the transverse components turn out to be greater than the lengthwise components. To achieve adequate securing, several chains should be used or the longitudinal components should be supplemented by additional squared lumber bracing.



Vertical securing and securing against tipping using vertical and oblique lashings

Provided that the cable reel is secured adequately in the floor area against lengthwise and sideways shifting, vertically and obliquely applied lashing are sufficient to secure the cable reel against tipping and other vertical forces.

Cable reels on 40' flatracks



Inadequately secured cable reels on a 40' flatrack

The two outer reels are not stowed with a tight fit against the end walls of the flatrack. Lengthwise securing is achieved by the lashing belts passed through the eye. The effective horizontal component amounts to approx. 40% of the maximum securing load. In the case of lashing belts of 2,000 daN maximum securing load, each cable reel would be secured with 2 x 2,000 daN x 0.4 = 1,600 daN in each longitudinal direction. However, this theoretical value is not achieved, since the webbing belts are not used properly. The useful maximum securing loads cannot therefore be determined.

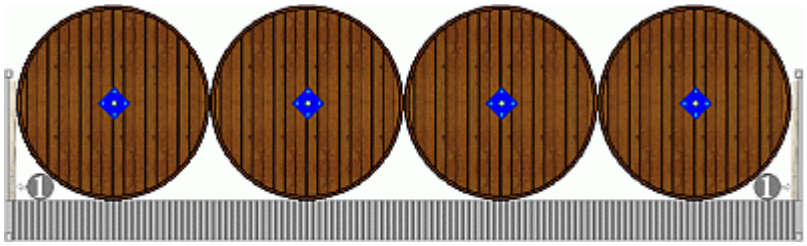


Detail of the floor area of a cable reel

The squared lumber (a) laid crosswise can only contribute to a small degree to lengthwise securing due to the incorrectly cut wedges (b. The wooden members (a) are only held together minimally by the nailed-on board (c). In addition, board (c) constitutes the only transverse securing, since the webbing belts only hold the cable reel by means of the vertical pretension component together with friction. The resultant values are minimal.

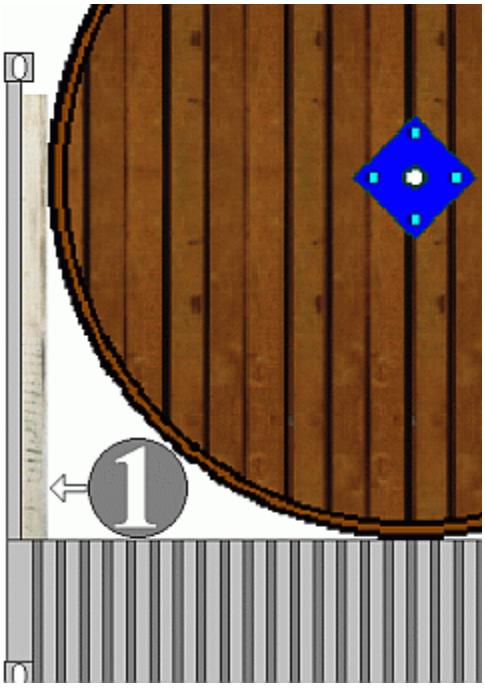
To sum up: cable reels cannot possibly be sent on a voyage like this. With the exception of ships with flaps, in which stowage is also possible in the bottom of the ship, flatracks will most probably be stowed in the top tier below deck or on deck.

In general, the following procedure can be followed for such cargoes:

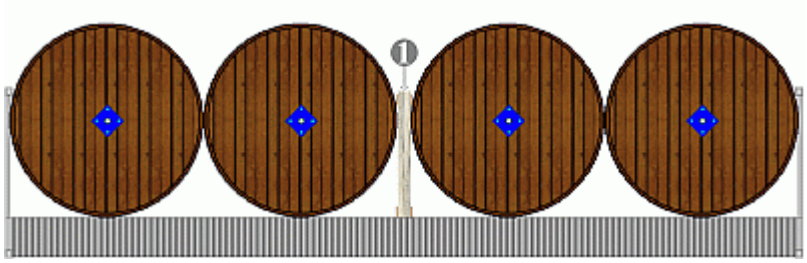


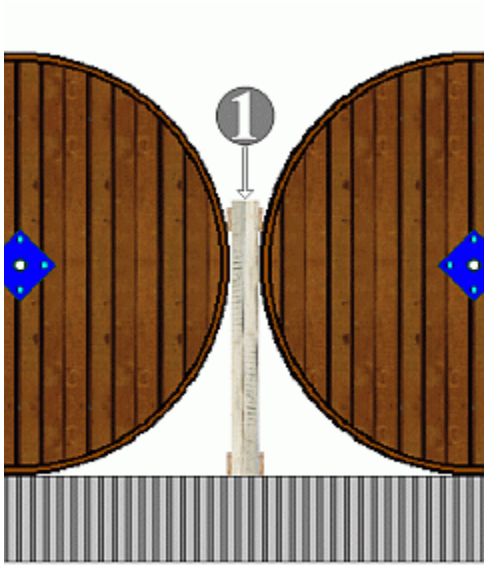
Above and selective enlargement to the right:

Compact stowage of relatively light cable reels:
gaps filled at the end



The reels are loaded onto the flatrack. To prevent accidents, each reel should provisionally be prevented from rolling by wedges, beams or the like. If gaps are left at the front end wall, they should be filled with squared lumber, planks or boards (1). The bracing should be directed inwards from the external edge of the reels, so that the high strength of the outer panels of the reels is utilized.



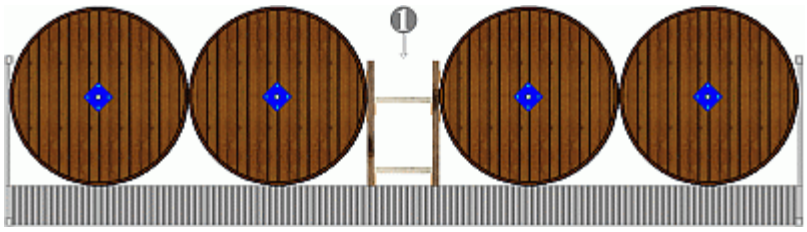


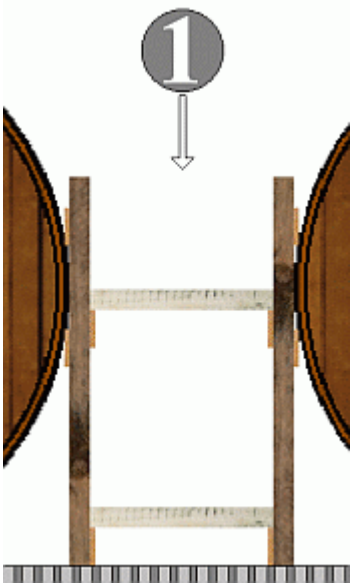
Above and selective enlargement to the left:

Compact stowage of relatively light cable reels: gaps in the middle

Loading from the ends to the middle is easier. To brace the gap remaining in the middle, only half the lumber cross-section is required, because only half the load is applied to the lumber (1). Care is required if, in the case of reels of the size shown in the end area, container handling could be obstructed.

In the case of a mass per cable reel of only 3,000 kg, i.e. 12,000 kg altogether, the end walls of the flatrack can still withstand forces which would result from acceleration of 1 g.



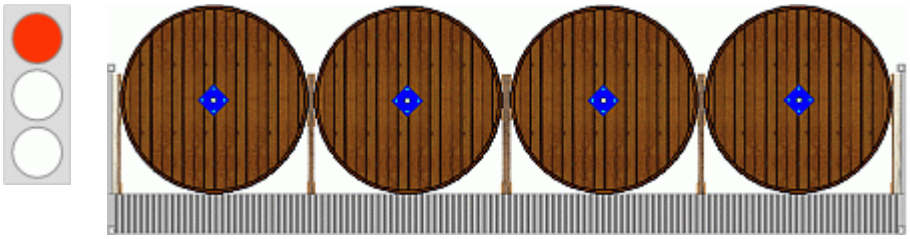


Above and selective enlargement to the left:

Packing variant - larger gaps in the middle

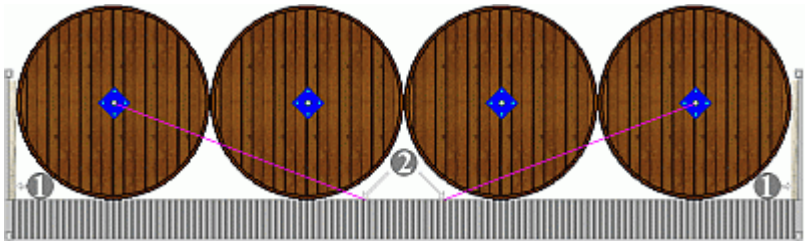
If larger gaps (1) remain, it is always better to leave these in the middle and brace them.

So that the wooden members are held secure, they should be connected together transversely by wooden boards. Attachment to the boarding of the cable reels requires the greatest of care, in order not to damage the cables.



Impractical: Leaving several gaps and bracing them

Since the end walls of the flatrack can be loaded with 0.4 times the payload, all that is needed to achieve adequate securing of a cargo of a total mass of up to 40% of the payload is compact stowage or filling of the gaps.



Relieving the load on the end walls by lashings

If the mass of the cable reels to be stowed exceeds this value, the load on the end walls of the flatrack must be relieved by inwardly tensioned lashings (2). Loop lashings passed through the eye and pulled towards the middle of the flatrack are best suited to this task. Number and type and thickness of material depend on the maximum securing loads of the lashing points on the flatrack and the values of the acceleration to be taken as basis for the particular transport. When calculating corresponding numerical values, coefficients of sliding friction must not be taken into consideration, since the cable reels can roll when stowed in the ways shown so far.

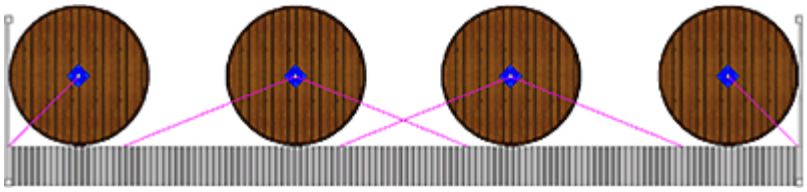
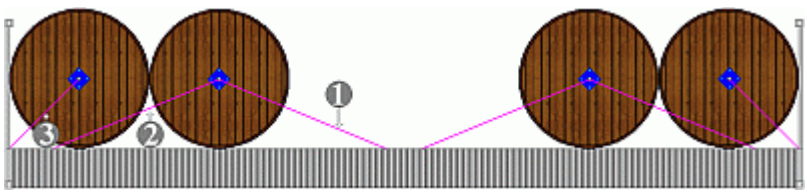


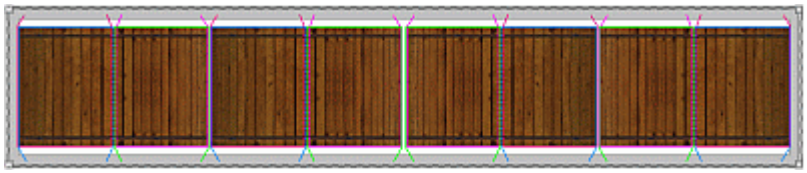
Diagram showing the principle of individual lengthwise cable reel securing

If the total mass of the cable reels reaches the payload of a flatrack, load distribution could look like this in the case of uniform stowage. However, the disadvantage is that only some of the end wall strength is utilized. If each reel exhibits 25% of the payload mass, while the end walls can be loaded with 40% of the payload, 15% of the strength is wasted. If, as is shown here deliberately, the lashing angles differ, the maximum securing loads of the lashings would likewise have to be different.



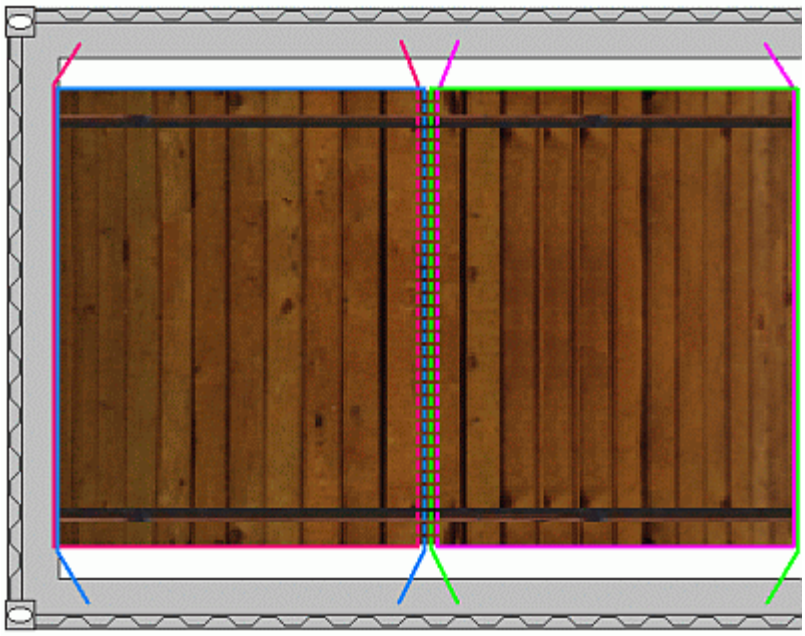
Variant of individual lengthwise securing

If the mass of the cable reels reaches the payload of the flatrack, and longitudinal accelerations of 1 g are assumed, the stowage method illustrated is particularly favorable from the point of view of cargo securing. Since 50% of the payload has been packed against each end wall, but the end wall themselves can only bear 40%, the lashings (1) have only to take up forces produced by 10% of the cargo mass and the 1 g acceleration. However, the lashings (2) and (3) have to be so strong that their effective force components correspond to the forces resulting if the mass of a cable reel is multiplied by the assumed acceleration.



Lateral securing using loop lashings through the eye

Provided that stanchions are not provided for bracing purposes, lateral securing of cable reels may be ensured by loop lashings through the eye.



Loop lashings through the eye of a cable reel

The red and purple loop lashings secure each cable reel against movement to one side while the green and blue secure against movement to the other side. To calculate the necessary maximum securing loads, the

corresponding coefficients of sliding friction can here be taken into consideration. Using friction-enhancing materials under the reels can have a considerable effect on the material thicknesses required.

It should be noted that loop lashings through the eye produce almost no lengthwise securing forces.

N.B. In the case of cable reels which are stowed with their axis lying horizontally, it is essential to check that the container's admissible line loads are not exceeded and that no excessive point loads arise.

5.2.8 Cases and crates

5.2.8.1 Overwidth boxes and crates, example 1

Three flat cases on a 20' flatrack

It is impossible to secure laterally overhanging cases with tie-down lashings, since the cases can move freely to and fro in the tie-down lashings (1). Lengthwise securing with nailed-down lumber (2) is worse than useless and cannot prevent shifting in the longitudinal direction; indeed, not only that, but nails hammered into the outside of the cases may damage the goods. The nailed-down wedges (3) are not capable of providing adequate securing against shifting, either. To sum up: Labor and material have been wasted, to no avail.



Inadequately secured cases on a 20' flatrack



Tie-down lashings cannot prevent shifting in the case of overwidth cases

The following procedure could have been followed, to achieve optimum stowage and securing:

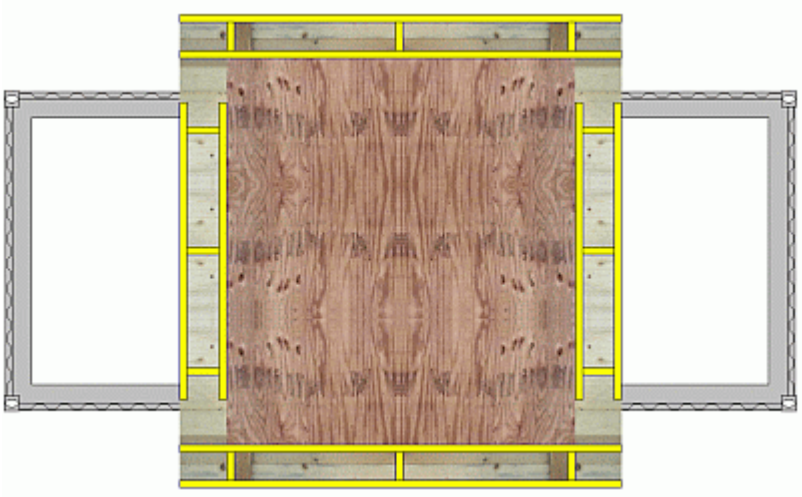


Step 1: Central loading of large overwidth box



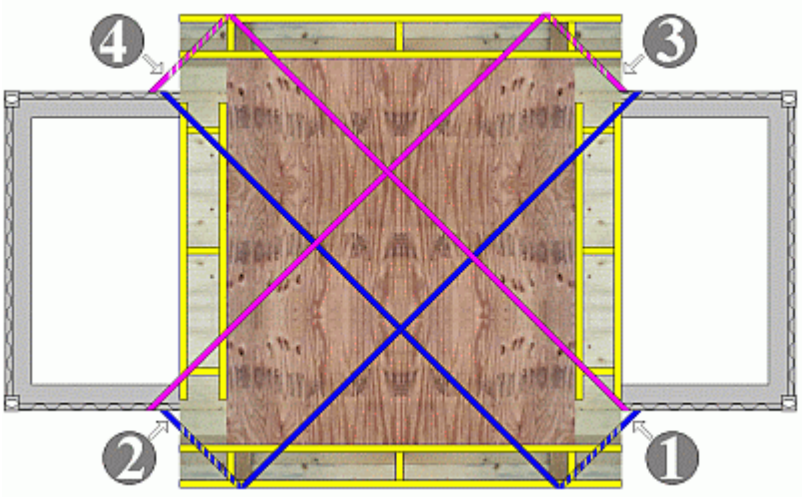
Step 2: Central loading of flat, shorter overwidth case

The shorter, flat overwidth case is loaded as second package. So that it is not damaged by the case to be loaded thereafter, on the one hand, but can be secured jointly with the case loaded first, on the other hand, a wooden frame is built around the case, the height of which matches that of the flat case.



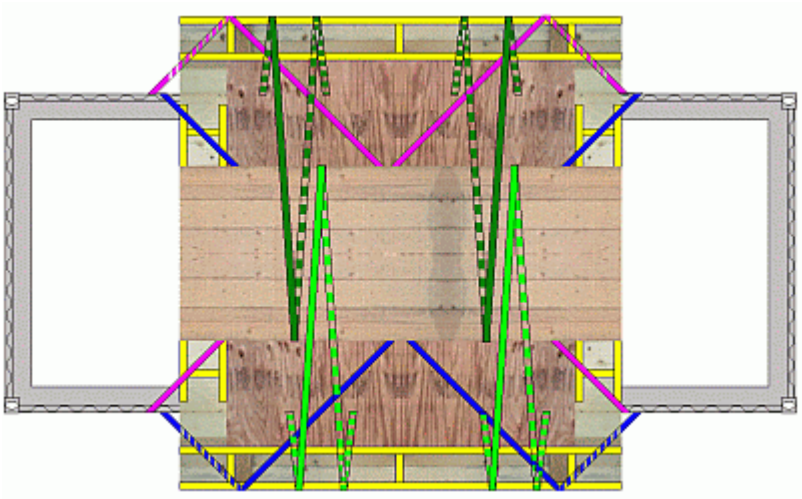
Step 3: Building a wooden frame round the flat case

Before loading can continue, these two cases are secured against sideways shifting with "true loop lashings" (half loops). The blue loop lashings (1) and (2) secure the cases on one side, the purple loop lashings (3) and (4) on the other.



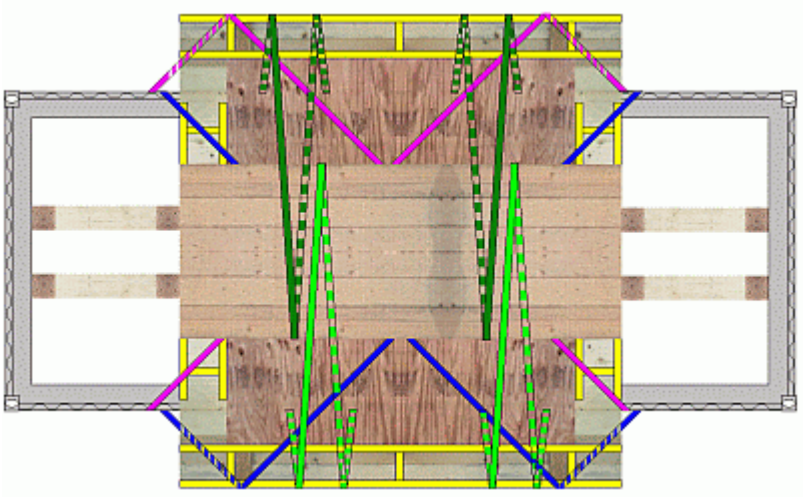
Step 4: Lateral securing of the overwidth cases using loop lashings

The narrow case is placed centrally on the two laterally secured overwidth cases and secured against lateral shifting by two loop lashings on each side. These "half loops" are light green and dark green in the Figure.

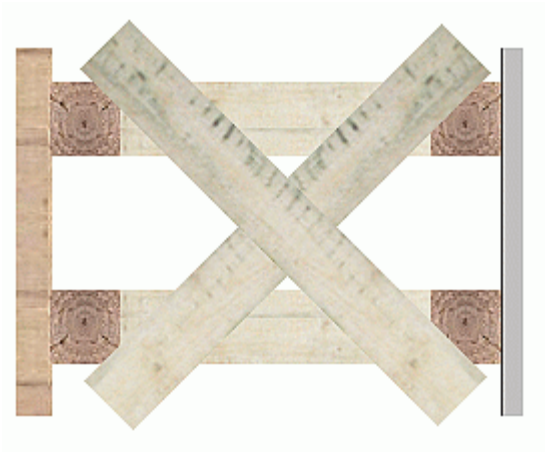


Step 5: Loading and subsequent lateral securing of the large, narrow case by two loop lashings on each side

The cases are secured jointly against the end walls of the flatrack using wooden bracing, which consists in each case of two "uprights" at the case sides and end walls with bracing fitted in between.



Step 6: Lengthwise securing of the cases using squared lumber bracing

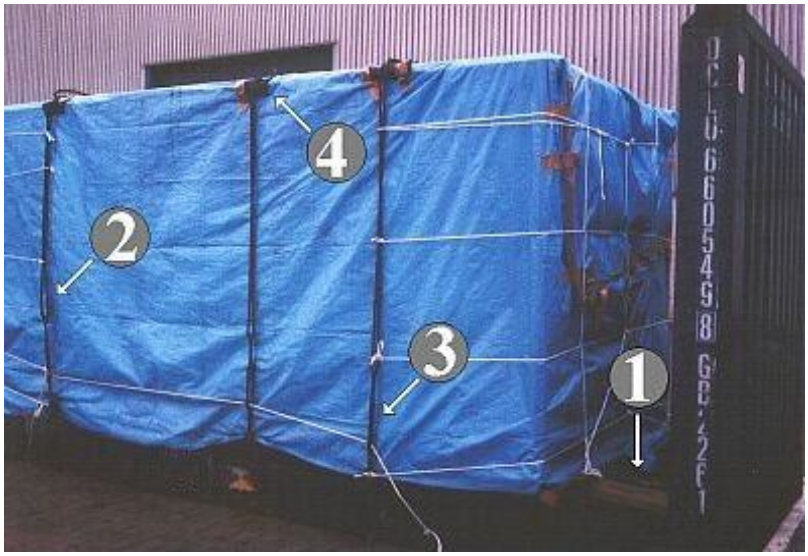


Step 7: Securing of the squared lumber bracing with wooden X-bracing, if there is concern that the wooden bracing members may become dislodged

N.B. So as to be able to work as quickly and efficiently as possible, the loop lashings are each attached at one end to the corresponding lashing points before loading.

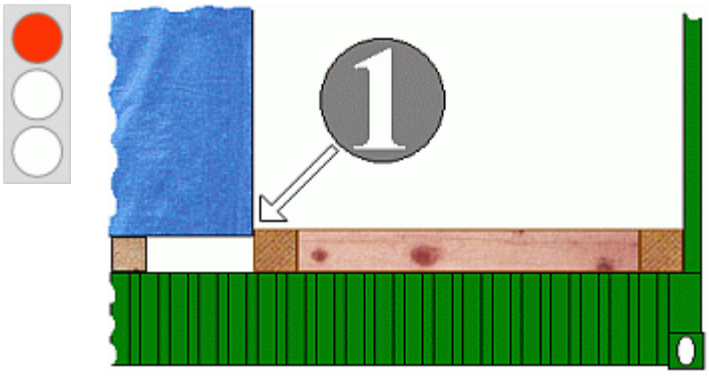
5.2.8.2 Overwidth boxes and crates, example 2

Case on a 20' flatrack



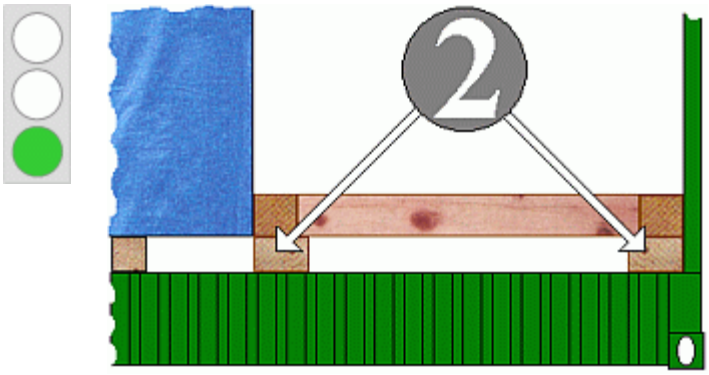
The wooden bracing at (1) consists of two lengthwise and crosswise beams, attached directly to the floor of the flatrack. Since the case itself is standing on transverse skids, the effective height of the bracing lumber is too small at the case end wall. It is uneconomic to secure the case by means of tie-down lashings of 16 mm diameter steel wire ropes and turnbuckles (2) and (3). It is a good idea to use edge protectors made from hard-wearing segments of automobile tires (4) and the weather protection with which the case is provided is definitely a positive feature. However, a few more meters of binder twine would not have done any harm. The adhesive strips used are water-resistant.

The small effective height of the squared lumber is shown here.

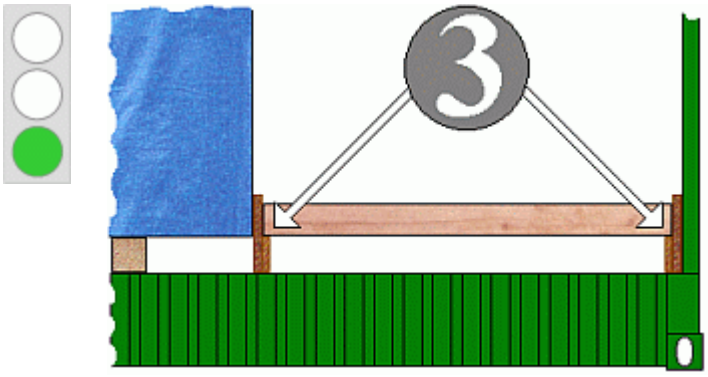


Inadequate effective bracing height

The problem could have been eliminated by using two more crosspieces (2).

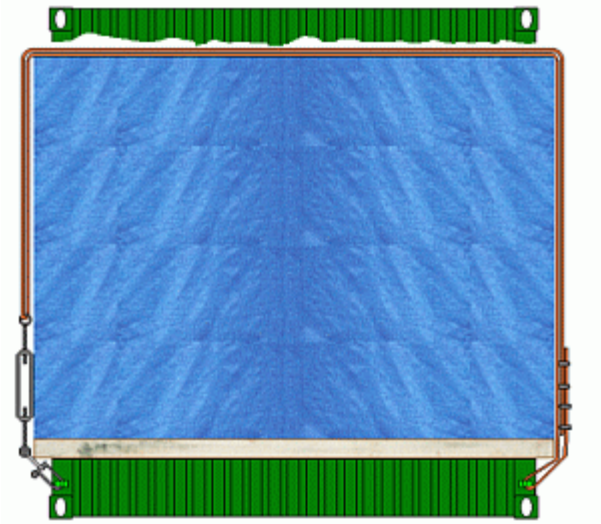


It would have been somewhat cheaper to use two boards (3) nailed together to form steps, between which the two lengthwise pieces are inserted.



It is a waste of material to use tie-down lashings made from steel wire ropes with a diameter of 16 mm together with turnbuckles, since, on the one hand, the maximum securing load of these materials is higher than that of the lashing points and on the other hand the method of arranging them requires an unnecessarily large amount of wire.

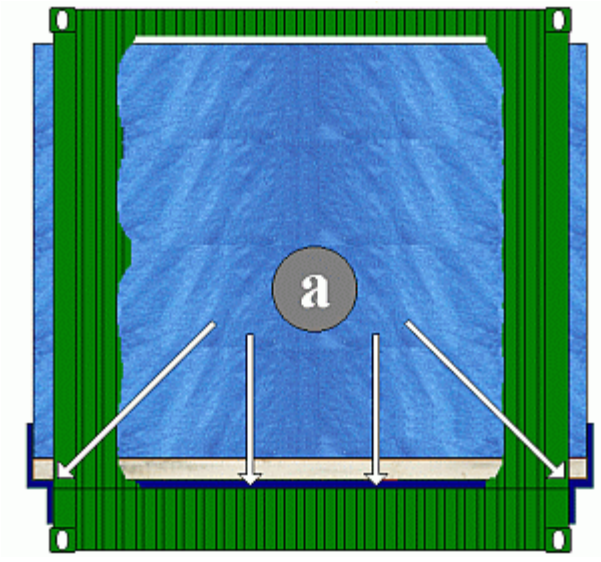
With normal deflection radii, 16 mm diameter steel wire ropes could be used to produce lashings with a maximum securing load of 10,240 daN. However, the lashing points on the flatrack have a maximum securing load of only 3,000 daN. Approx. 12 m of steel wire rope, two shackles, one turnbuckle and four wire clips are used per tie-down lashing.



Basic diagram showing wasteful tie-down lashing

Another disadvantage is that, when the case is secured, all the tensioning elements are located on one side and the pretension is thus considerably higher on that side than on the opposite side.

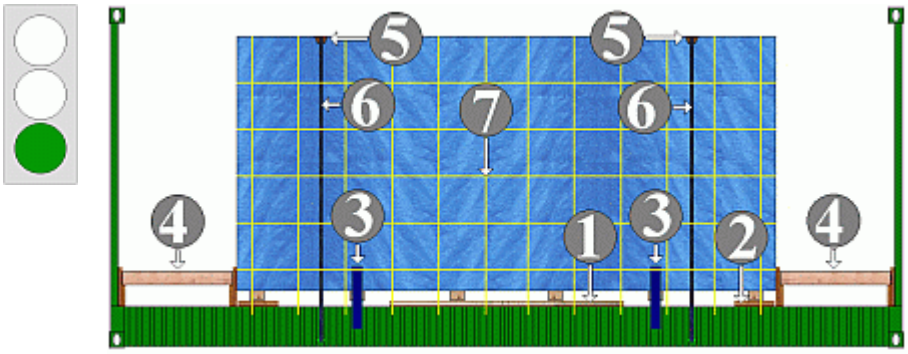
Since the flatrack does not have stanchion pockets, it is out of the question to use specially shaped stanchions for transverse securing. From the point of view of labor and materials, it would have paid off to prepare "case restraint shoes" for transverse securing purposes.



Lateral securing using case restraint shoes

With two such case restraint shoes (a), a 100% tight fit could have been produced for lateral securing.

Efficient securing could have been produced in this way:



Securing the overwidth case on a 20' flatrack

Boards of the same thickness as the case restraint shoes are positioned lengthwise (1) or crosswise (2) beneath the transverse members of the case bottom in such a way that the case cannot sag at the bottom. Two case restraint shoes (3) are positioned in such a way that the case can be placed on them with two of the transverse skids. The gaps remaining relative to the front end wall of the flatrack are braced with boards or planks and squared lumber (4). Edge protectors of a material with good recovery (5) are put in place and two steel strapping tie-down lashings (6) are fitted. The tarpaulin provided to protect the case from the weather is fixed securely with tightened and knotted close-meshed binder twine or the like, such as 4 mm thick PE or PP tape.

5.2.8.3 Overheight cases on flatracks, example 1

1,600 kg wooden case on a 20' flatrack

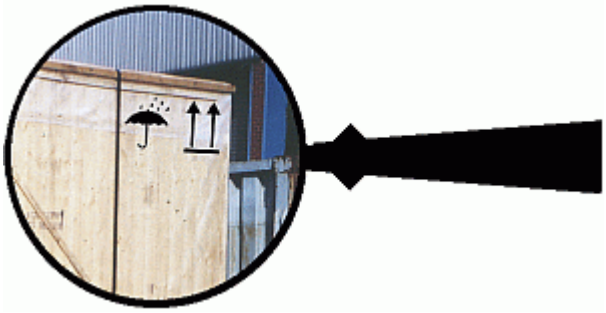


Overheight moisture-sensitive case on a 20' flatrack

The features of this stowed case which are immediately noticeable are the "Top" marking and the umbrella symbol. It would be desirable for this case to have been provided with the standard "Keep upright" symbol, in other words two upright arrows which are positioned at the top right and on an adjacent surface of the case, together with the umbrella symbol for "Keep dry".

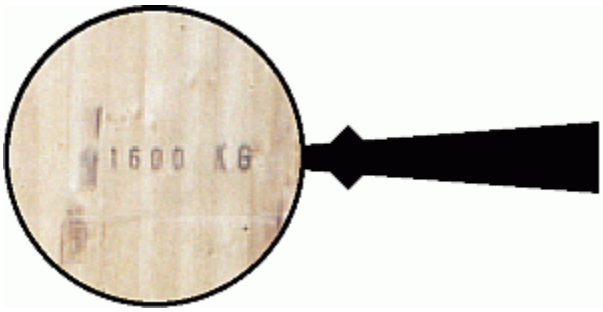
It is unlikely that the 0.2 mm thick (200 µ) film membrane additionally applied to the box would be enough to keep it dry for the entire voyage. Because of its overheight, the flatrack is best transported on board ship in a stowage space in the top tier below deck. However, it is more likely that the flatrack will be stowed on deck. It is unlikely that the film will be able to withstand the full rigors of a voyage, or indeed of onward carriage by railroad or truck.

Only passing mention will be made of the fact that the marking complies only in part with the standards; however, each of these shortcomings is relevant in the broadest sense to "cargo safety".



Sensibly and correctly affixed handling symbols

According to its markings, the case has a gross weight of 1,600 kg.



Gross weight of the case

The securing forces required according to the CTU packing guidelines are relatively simple to calculate,

although the coefficient of sliding friction is incalculable. Because it is probable that the case will be loaded on deck or will be uncovered during onward transport, occasional precipitation must also be anticipated. Therefore, a coefficient of sliding friction of $\mu = 0.2$ is assumed for the example, i.e. a friction value of 20% is used for calculation purposes. All numerical values are stated in decanewtons (daN).

The securing forces required for a voyage during which the flatrack is stowed "fore and aft" (fore and aft stowage) are calculated as follows:

Normal force of the package	Acceleration forces in		Friction forces, where coefficient of sliding friction $\mu = 0.2$	Required securing forces	
	Lengthwise at 0.4 g	Crosswise at 0.8 g		Lengthwise	Crosswise
1,600	**640**	**1,280**	**320**	**320**	**960**

In the unlikely event of the flatrack being stowed athwartships on board ship, the following securing forces would be required:

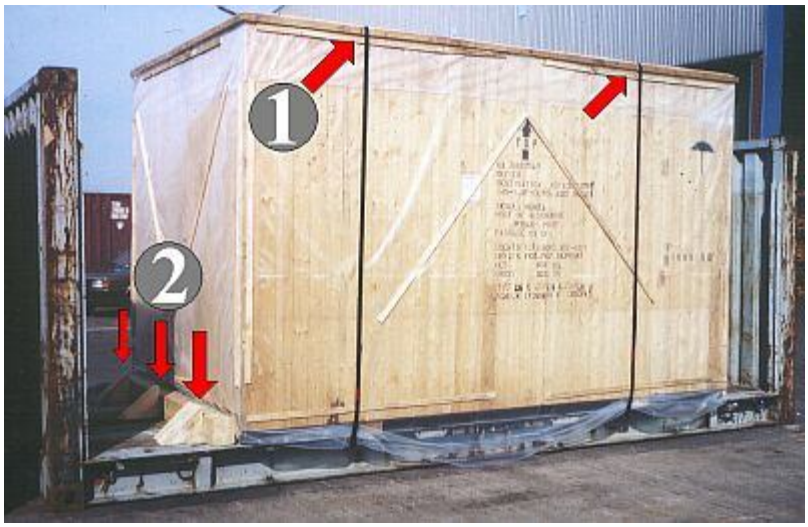
Normal force of the package	Acceleration forces in		Friction forces, where coefficient of sliding friction $\mu = 0.2$	Required securing forces	
	Lengthwise at 0.8 g	Crosswise at 0.4 g		Lengthwise	Crosswise
1,600	**1,280**	**640**	**320**	**960**	**320**

The case will probably be taken off the flatrack at the port of destination and carried onwards conventionally. However, to be on the safe side, it should be assumed that the case remains on the flatrack for onward carriage. It is not known how the flatrack would be positioned on a truck for road transport, but for rail transport it is assumed that no switching stresses arise. Under these conditions, the securing forces would be calculated as follows:

Normal force of the package	Acceleration forces in		Friction forces, where coefficient of sliding friction $\mu = 0.2$	Required securing forces	
	Lengthwise at 1.0 g	Crosswise at 0.5 g		Lengthwise	Crosswise

1,600	**1,600**	**800**	**320**	**1,280**	**480**

With the selected securing method using tie-down lashings (friction loops) (numeral 1 in the Figure), the stowage direction of the flatrack is irrelevant, since tie-down lashings act in all directions. For the assumed coefficient of sliding friction of μ=0.2 and required securing forces of 960 daN for example, a total pretension of 4,800 daN would be necessary for the voyage (960 daN × 0.2 = 4,800 daN). If two tie-down lashings are present, each would have to be pretensioned to 2,400 daN and be capable of retaining this pretension through the voyage. In the example illustrated, steel strapping was used for the tie-down lashings, and was tensioned only over the top edges of the case. Even if it cuts into the lumber by only a few millimeters as the result of a jolt during transport, all pretension would be lost and the tie-down lashings would no longer have any securing effect on the case.

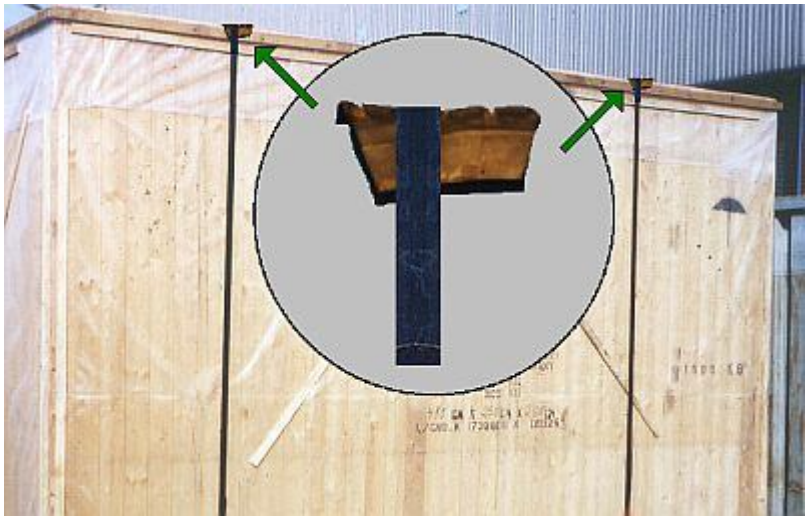


Shortcomings in case securing

The cohesive resistance of the nails in the wedges used for cargo securing (numeral 2 in the Figure) should be estimated at approx. 100 daN per nail due to the small plank thickness of the flatrack floor and the resultant low penetration depth. If there are three retaining nails hammered in vertically per wedge, the lengthwise securing forces produced by the three wedges amount to 900 daN. If the effect of the tie-down lashings is ignored, there is a slight cargo securing deficit.

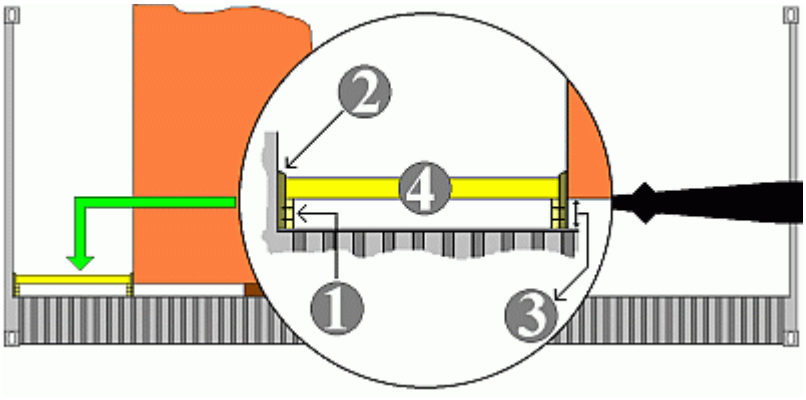
Given the low case mass of 1,600 kg, steel strapping tie-down lashings can also be used if it is ensured that the calculated pretension can be maintained throughout the voyage.

This may be ensured by combining the steel strapping with a material with good recovery. The use of automobile tire segments provides an economic solution.



Tire segment for improving elasticity and maintaining pretension

If it is assumed that the tools and lashing points used allow at most 1,500 daN of pretension per tie-down lashing, a securing force of around 300 daN may be achieved per tie-down lashing for a coefficient of sliding friction of 0.2. It is accordingly possible to achieve the securing forces required for maritime transport with four steel strapping tie-down lashings, while the forces required for onward carriage by road or rail would be covered with five.

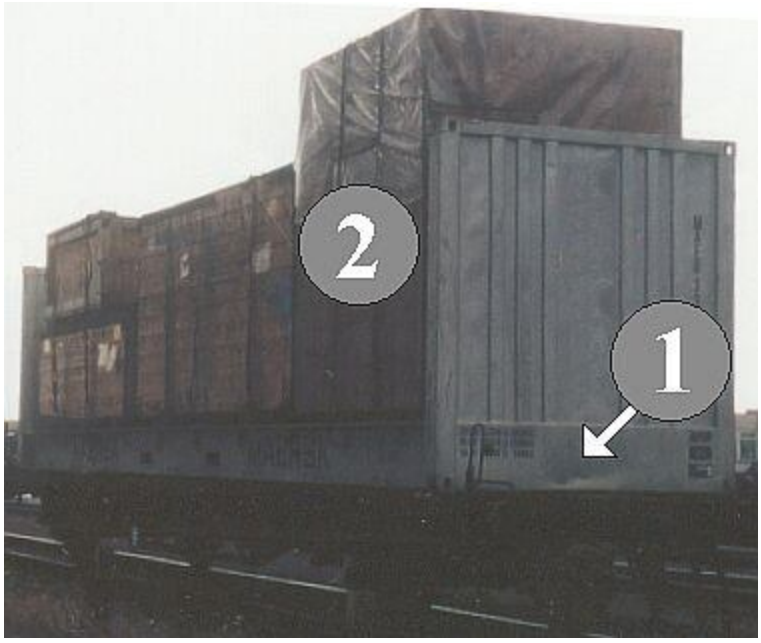


Producing simple bracing from wooden boards and squared lumber beams

In general, securing with wedges should be avoided with cases. If a tight fit is required in the lengthwise direction, much can be achieved with wooden bracing. For a case with a low mass of 1,600 kg, such wooden bracing is simple and cheap to produce. One narrow (1) and one wide board (2) are nailed together in each case in such a way that a step-shaped double board is obtained. The height of the narrow board must match the height of the case props (3). Bracing made from simple beams (4) is fitted - cheap 6 cm x 8 cm softwood is quite sufficient.

5.2.8.4 Overheight cases on flatracks, example 2

Various wooden cases, including one overheight case, on a 20' flatrack



Cases on a 40' flatrack on an Lgjs container car

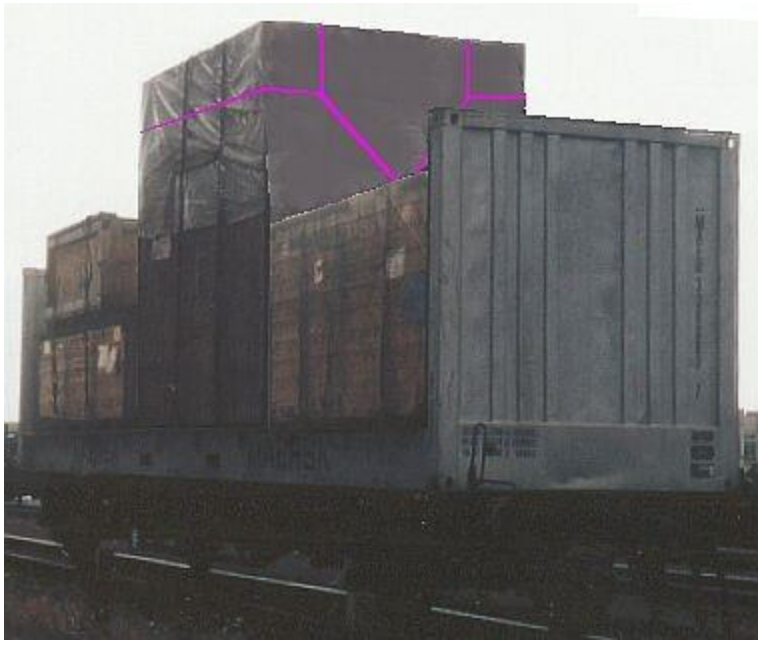
The end of the flatrack shows signs of rough treatment (1) - perhaps, in contravention of the rules, a forklift truck was used for switching. The case (2) is unfavorably positioned. All the cases are secured with tie-down lashings.

In the pictures, all the cases have been shifted somewhat to the other side, which would have made it possible to use stanchions on the flatrack.

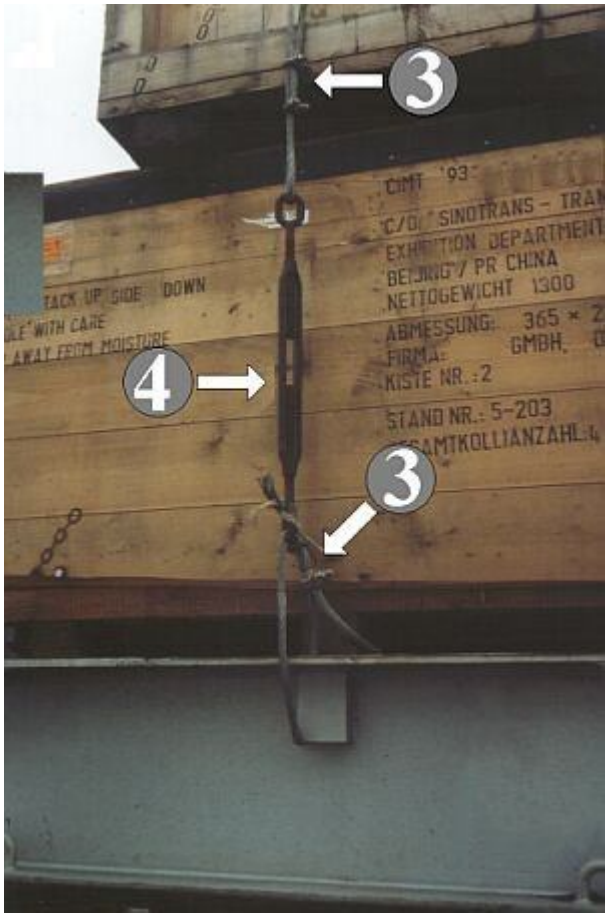


The use of stanchions would have improved cargo securing.

Other cargo securing options would also have been feasible:

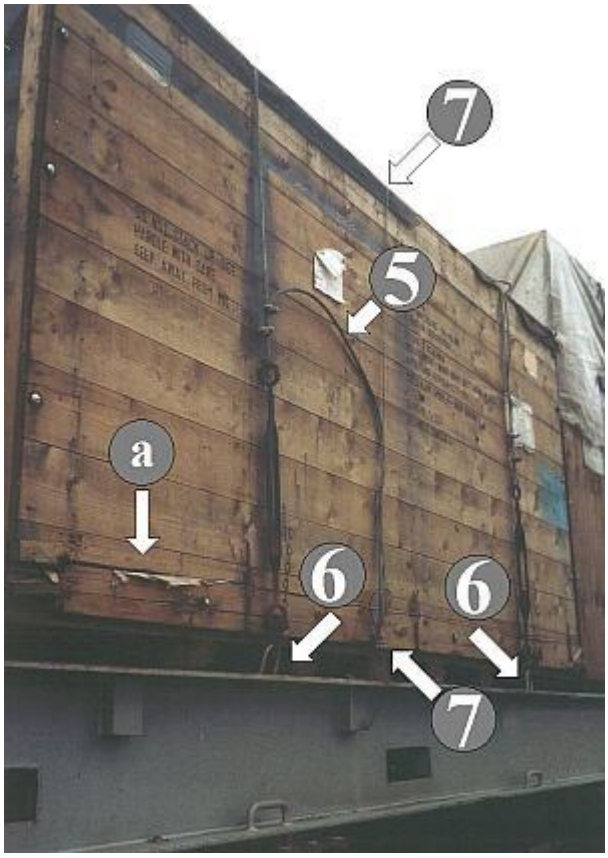


Restowed case with additional direct spring lashings



Nonuniform securing wastes materials

Tie-down lashing made from 16 mm diameter steel wire rope, together with two wire clips (3) and sharp edges, does not come anywhere near to achieving the maximum securing load of the turnbuckle (4) used. For cost reasons, uniform securing is essential.



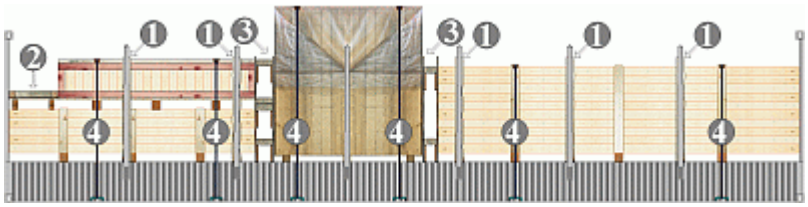
Nonuniform securing wastes materials

Even at the port of departure, the first packaging deficiencies are visible at (a) - the statement made above about using two wire clips, the turnbuckles and nonuniformity applies. The wire rope end (5) which is hanging loose constitutes both a waste of materials and an accident risk. With a maximum securing load of 3,000 daN, the lashing points at (6) ought to be fully utilized, and, if the thin wire (7) had been used correctly and sensibly, uniform securing could have been produced. However, here the wire was passed round sharp edges and fastened with one wire clip.

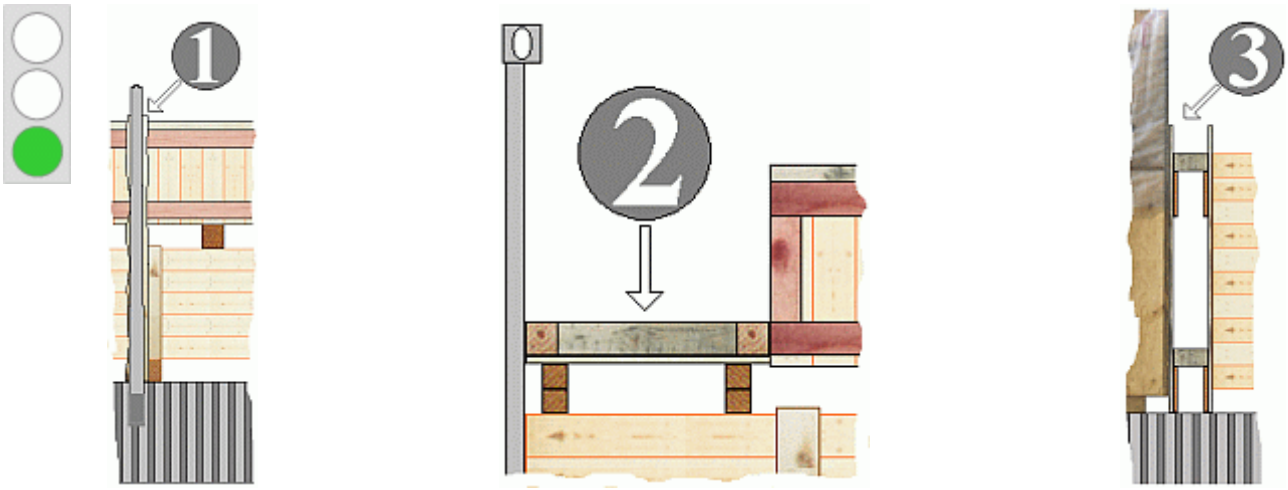


Unbraced gaps in the load are a securing risk.

The cargo has been loaded in such a way that the overheight case can be positioned so that it is held precisely centrally by a stanchion. The long case rests against the right-hand end wall, the mid-length one against the left-hand end wall. The smallest case is positioned on the mid-length one, but is packed flush with the inner end wall thereof.



Securing a number of cases on a 40' flatrack



Details of gap bracing

The smaller gaps between stanchions and the outsides of cases are filled with boards (1). The gaps between the overheight case and the adjacent cases are braced by means of a structure consisting of wooden lattices, i.e. boards nailed together vertically and transversely, and squared lumber ends (3). The gap between the end wall and the small case packed on the top contains squared lumber bracing (2). Since the end walls and stanchions provide a tight fit in the horizontal directions, supplementary securing comprising two steel strapping tie-down lashings (4) per case or case stack can now readily be provided. Segments of automobile tires are used as edge protectors.

Leaving gaps at the end walls would not save any labor or material. The advantage of the load distribution chosen is that the overheight case could be readily provided with additional securing means if the individual stanchion proved insufficient. Lateral securing with direct lashings would then be feasible, together with spring lashings.

5.2.8.5 Overheight cases on flatracks, example 3

Two overheight wooden cases on a 20' flatrack



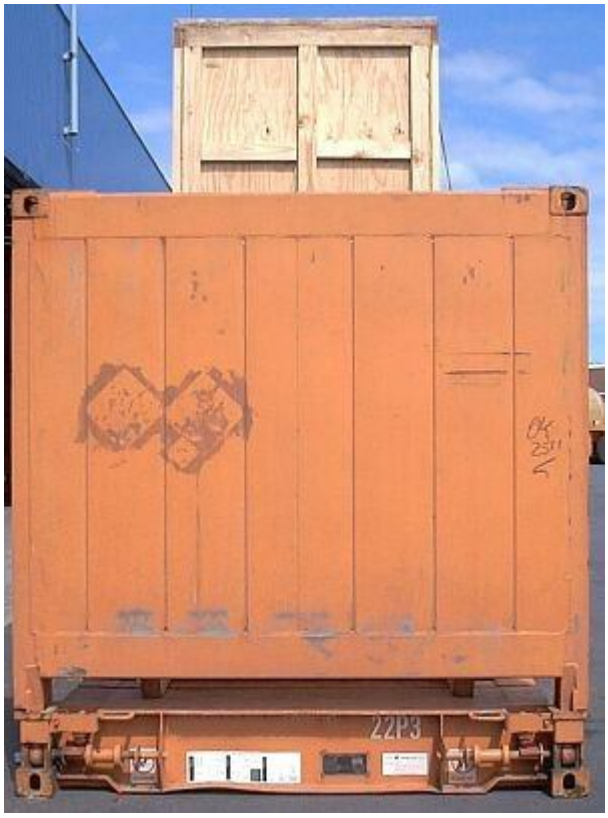
Inadequately secured cases

The two cases are "secured" in the floor area by wooden members nailed in front of them, or "wooden fixings", only the shearing forces of the nails being capable of furnishing any resistance against shifting.



Inadequate securing with wooden fixings

The cases are more than three times as tall as they are wide, so, given their small standing area, they are at any rate to be classified as at risk of tipping. Two tie-down lashings per case are not enough to make them safe.



Two tie-down lashings per case cannot prevent them from tipping.

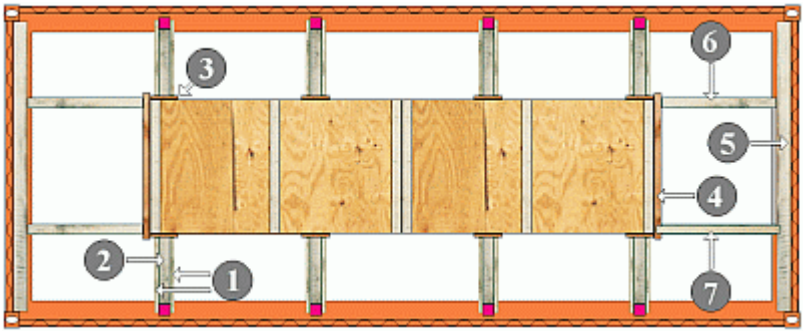
This is particularly obvious if the flatrack is inclined sideways by 30°.



Case at risk of tipping, inclined by 30°

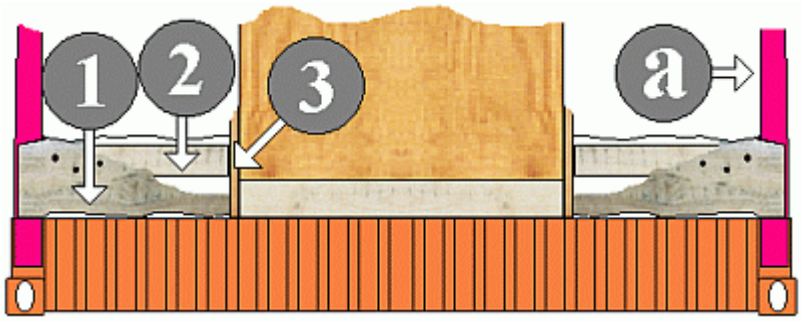


The container type 22P3 used has four stanchions on each side, each with a loading capacity of 2,000 daN. Relatively low mass cases are therefore easy to secure.



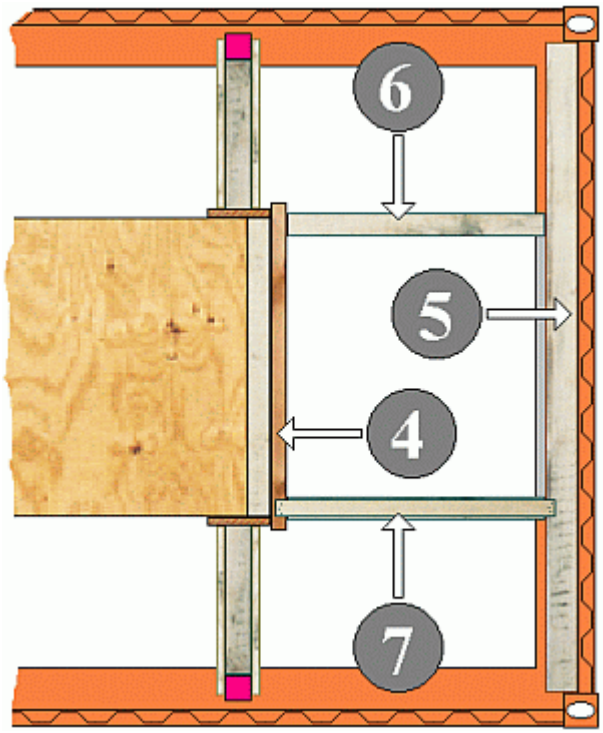
Cases secured in the floor area against stanchions and flatrack end walls

A total of eight struts are built each from two boards (1) and one squared lumber member (2) and are placed between the stanchions and the boards (3) positioned in front of the cases.



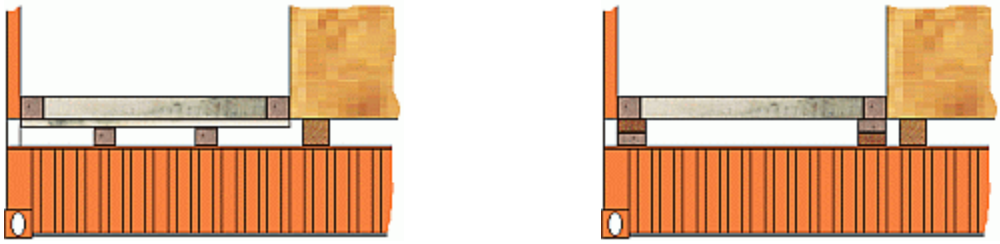
Securing the cases transversely - end-on view - details

Reasonably priced, unsquared boards can be used as the transverse (1) and vertical boards (3), while the sizes of the transverse braces (2) should be matched to the stanchions (4) from the point of view of width. Their height depends on the masses to be braced.

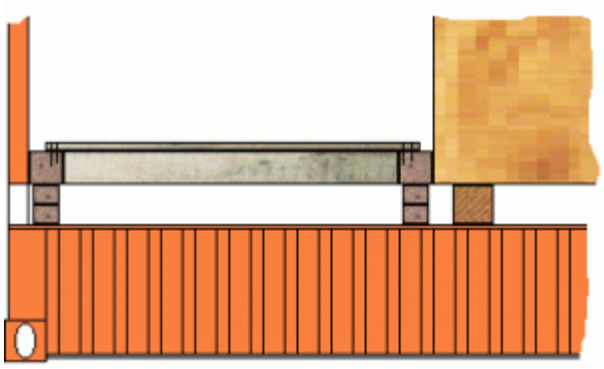


Securing the cases longitudinally
- plan view - details

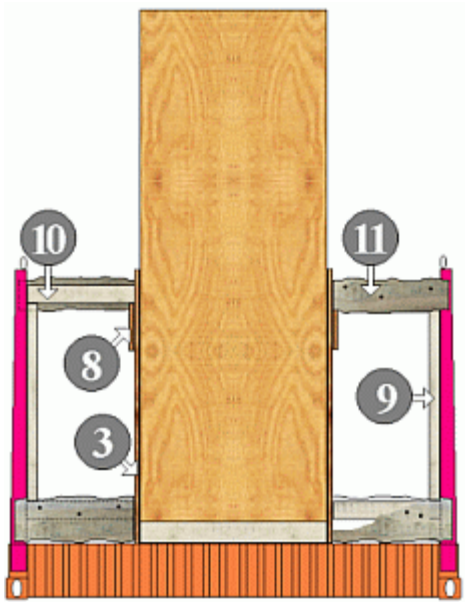
At each end of the cases, a squared lumber member or a beam (4) is firred in such a way that it lies horizontally at the level of the sufficiently strong case bottom. A squared lumber member (5) is raised in such a way at the ends of the flatrack that it is at the same height as the squared lumber member (4). These squared lumber members serve to distribute pressure to the flatrack end walls. Other squared lumber members are fitted precisely between the squared lumber members or beams (4) and (5) in parallel with the longitudinal sides of the cases. These members may either be built up from the bottom (6) or suspended on boards nailed over them (7).



End bracing built up from below (6)



End bracing with suspended bracing members (7)



Securing against tipping by bracing against the stanchions

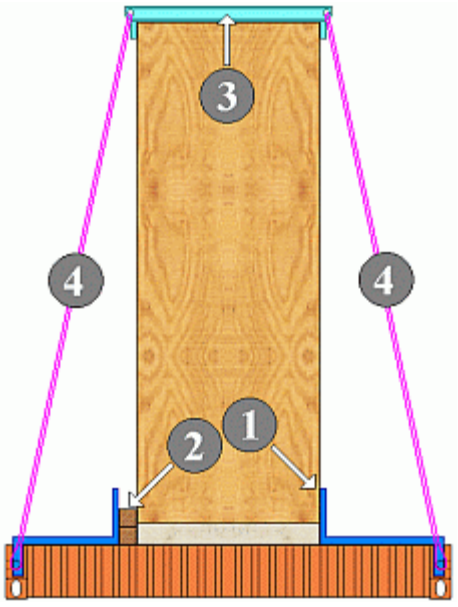
Lateral securing against tipping is provided approximately half-way up the package by bracing similar to that in the floor area. Eight bracing members are constructed from two boards (11) and one squared lumber member (10). These are held in place by squared lumber (9) attached vertically to the inner edge of the stanchions and boards (8) nailed horizontally to the uprights (3).

Two tie-down lashings are applied per case for the purpose of stabilization and to prevent "popping out" of the bracing under dynamic loads. At the case edges, the steel strapping lashings are tensioned over automobile tire segments, in order artificially to improve the elasticity of the steel strapping and to be able to maintain the pretension.



Automobile tire rubber improves elasticity and maintains pretension in steel strapping lashings.

Efficient securing options are achieved if special devices are available for cargo securing.



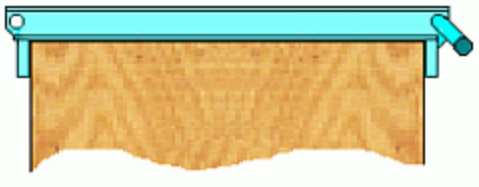
Transverse securing in the floor area by specially shaped stanchions

Securing against tipping using a steel crosspiece and direct lashings

In the floor area, specially shaped stanchions can be used to secure the cases transversely either directly (1) or indirectly by using squared lumber, planks or boards (2). Securing against tipping may be achieved using direct lashings (4) passing via steel crosspieces (3).

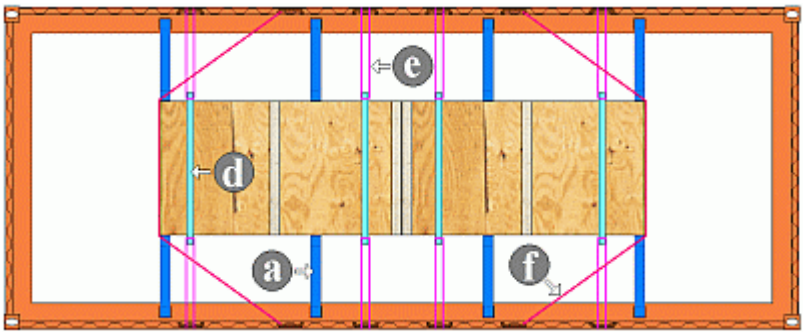
Steel crosspieces should have appropriate lugs or angles which are capable of gripping the tops of the

cases. Appropriate lashing bars, lashing rings, holes or similar components must be present, in which lashing materials such as steel wire ropes, chains, webbing belts etc. can be fastened directly or indirectly using shackles, hooks or other components. It would be sensible for such aids to be supplied directly by the producer or packer - the small expenditure should be worthwhile.



Steel crosspiece incorporated onto the case top

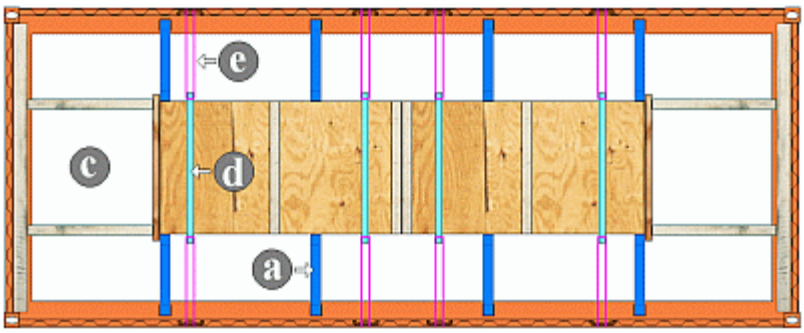
Integral lashing points should be provided as standard on large or heavy cases, since the small additional cost is more than justified by the considerably reduced shipping risk.



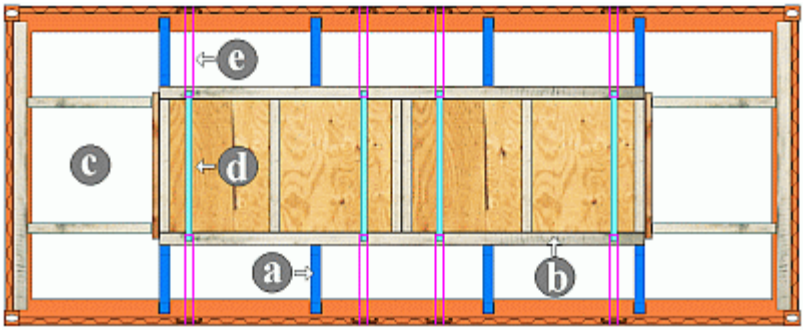
Specially shaped stanchions as transverse securing in the floor area, direct lashings for lengthwise securing and securing against tipping

The effort involved in securing using specially shaped stanchions and direct lashings is minimal. In the floor area, the cases are secured transversely by specially shaped stanchions (1 and a). The means of securing against tipping (e) are fitted to affixed or integral steel crosspieces or lashing points (d). Lengthwise securing is achieved by direct lashings (f), which are held at an appropriate height at the case corners by the vertical components of the specially shaped stanchions.

From the standpoint of labor costs, building wooden bracing (c) for lengthwise securing is more costly:



Specially shaped stanchions as transverse securing in the floor area, direct lashings for securing against tipping, bracing as lengthwise securing



Specially shaped stanchions and laterally fitted wooden members as transverse securing in the floor area, direct lashings for securing against tipping, bracing as lengthwise securing

If the dimensions of the specially shaped stanchions and cases do not allow a direct tight fit, the gaps must be filled with squared lumber (b), planks or boards. Small stowage gaps can be filled with driving wedges.

5.2.8.6 Overheight cases on flatracks, example 4

Wooden cases on a 20' flatrack, these being one overheight case and two cases of different lengths positioned next to one another



Inadequately secured cases ... from one side ...

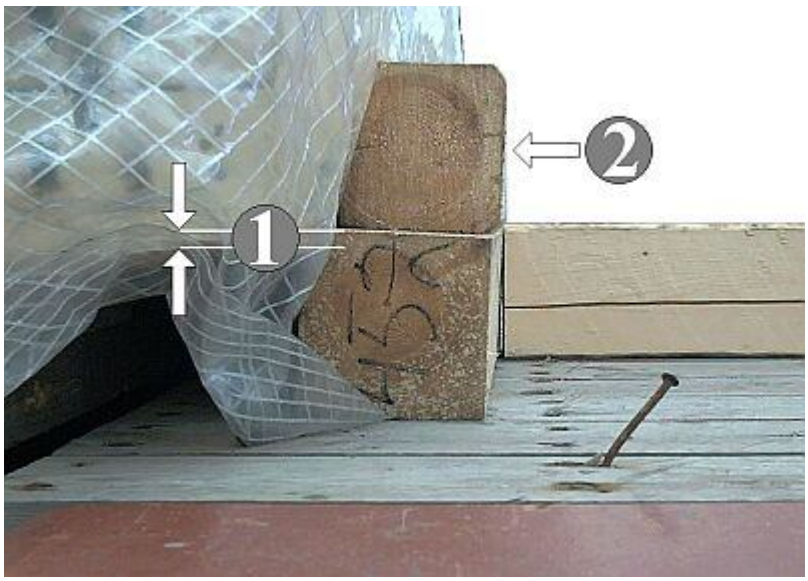


... and from the other

The fundamental deficiencies are:

- The inexpertly constructed wooden bracing

- The use of tie-down lashings
- The knotted webbing belts



Largely ineffective bracing

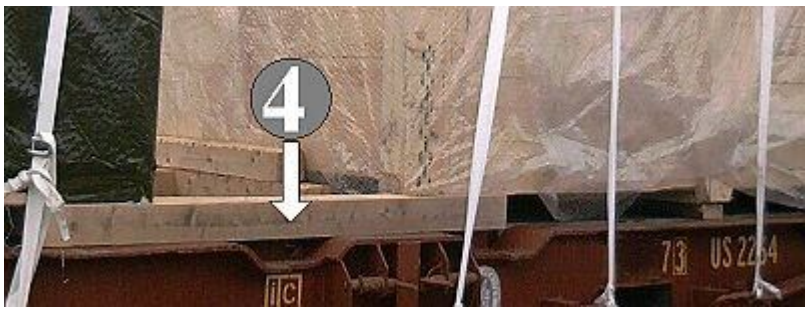
The effective height of the squared lumber (1) is much too little to be able to provide appropriate bracing. Squared lumber (2) achieves nothing. The protruding nail is an accident waiting to happen.



Effective bracing

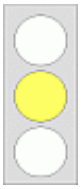
By fitting in a further squared lumber member (3), effective lengthwise bracing can be achieved.

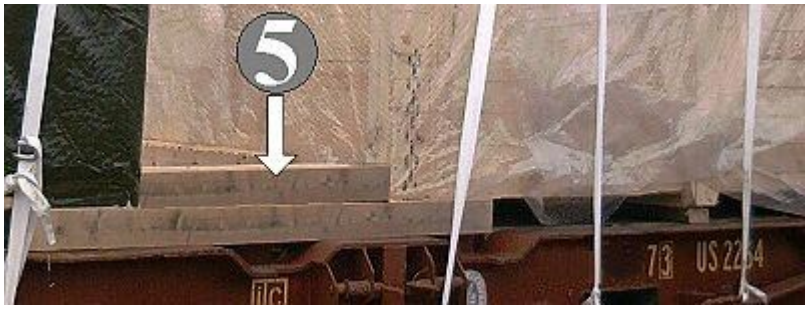




Pointless wooden member

The squared lumber (4) is performing no sensible function. It is too long for building up bracing from underneath and could have been omitted.

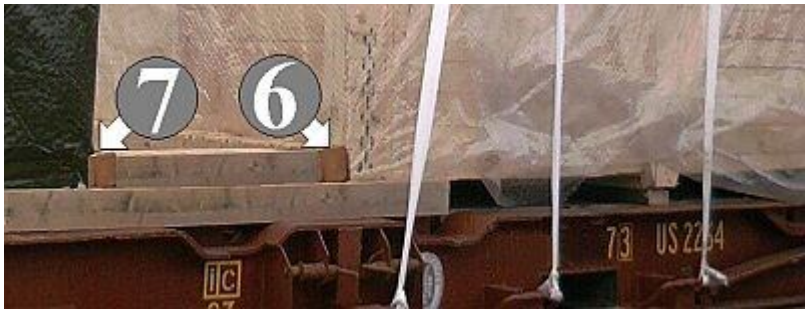




Effective small area bracing

Bracing can be achieved by fitting in a wooden member (5), but the supporting surface is very small.





Effective bracing with appropriate pressure distribution

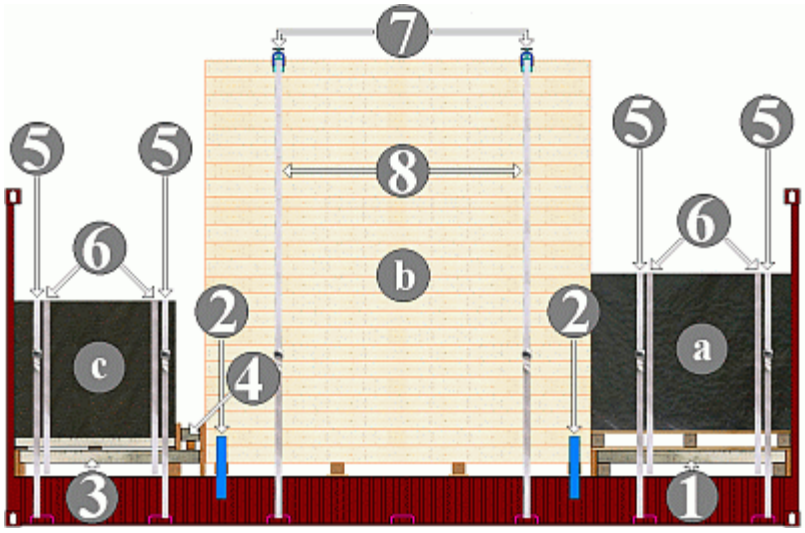
The forces arising can be distributed over a larger area by fitting crosspieces (6) (7).



Inadmissible use of textile webbing or belts

Woven webbing or belts must not be knotted. They must lie flat and must not be twisted.

Correct packing and securing of the flatrack might look like this:



All the cases secured with a tight fit on a flatrack

Wooden bracing (1) is prepared for the large case (b) and serves at the same time as a base for the case (a) to be loaded first. The height of the bracing must be such that the case (b) is braced at the bottom.

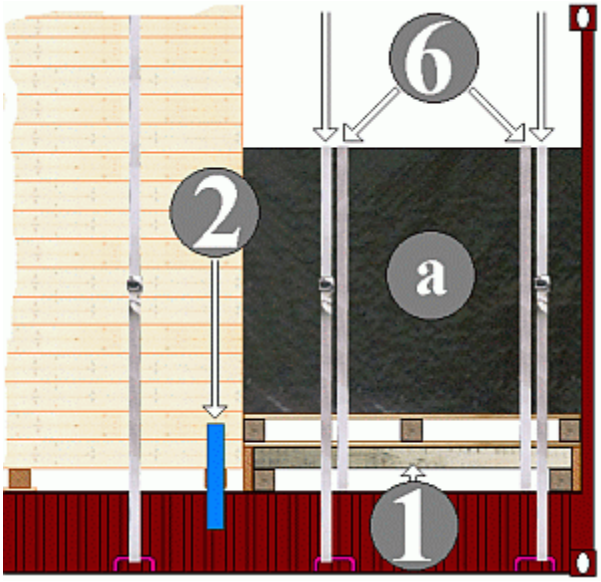
Two "case restraint shoes" (2) are so positioned on the flatrack that case (b) may be placed thereon with two of its transverse skids. So that the case does not sag at the bottom, the other two transverse skids are firred with boards which are as thick as the crossbars of the case restraint shoes.

Other securing methods for holding the case secure transversely at the bottom are feasible instead of the case restraint shoes, for example loop lashings. If a flatrack with stanchions was available, stanchions could also be inserted and lateral gaps between them and the case filled with lumber.

At the left-hand end of the flatrack , the case (b) is blocked with wooden bracing (3), which serves at the same time as a support for case (c), which is packed crosswise. The gap between cases (b) and (c) is braced (4).

The cases (a) and (c) are each laterally secured with 2 loop lashings (5) (6). Two steel crosspieces (7) are positioned on the top of the tall case (b), to provide lashing bars for securing the case against tipping by using two direct lashings (8) on each side.

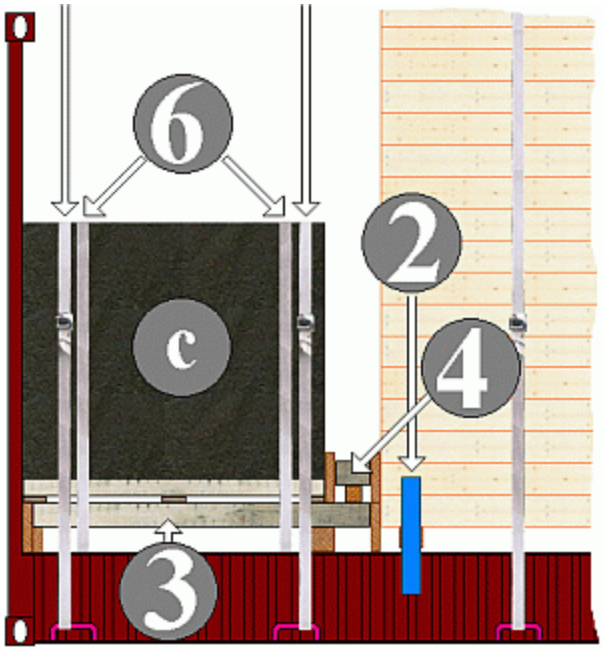
The following Figures show details of the above arrangement:



Detail of the case (a) and the right-hand side of case (b)

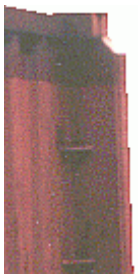


Detail of the steel crosspiece consisting of a small H-beam to which lashing stirrups with bars are welded at the sides, webbing belts being passed through the stirrups.



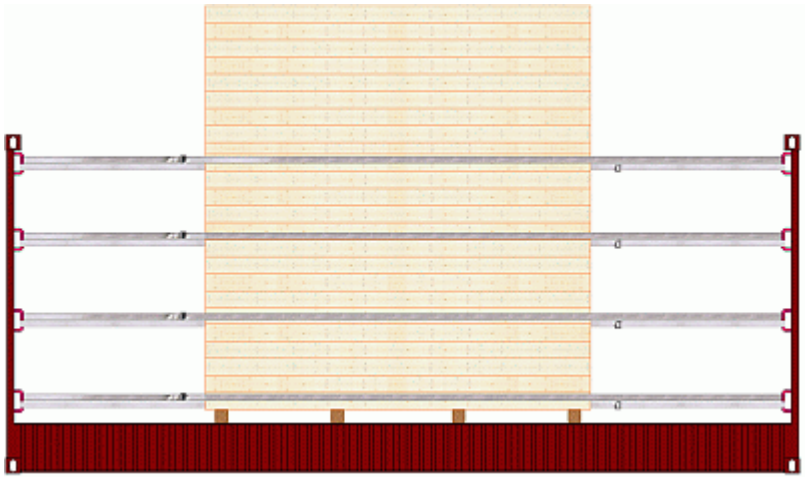
Detail of the case (c) and the left-hand side of case (b)

To provide more flexible cargo securing, it would be desirable if more container manufacturers would decide to affix lashing points fully capable of bearing loads over a quadrant to the insides of the end walls in the vicinity of or on the corner posts.

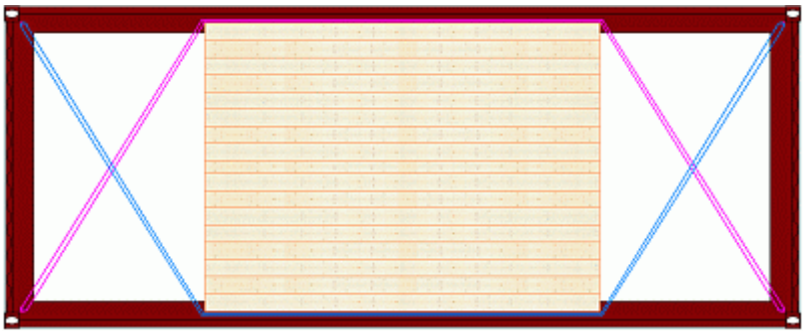


Lashing eyes on the corner posts of a flatrack end wall

The degree to which this extends securing options is illustrated by taking the tall case as an example.



Securing using direct lashings - side view



Securing using direct lashings around the case - plan view

A note of caution should be sounded here - this form of direct lashing can only produce transverse forces. It

would be different if the securing materials were attached to the case corners. However, with the angles shown, transverse forces arise which are of the order of approx. 85% of the maximum securing load of the selected securing materials. In the case of single-use webbing belts with a maximum securing load of, for example, 1,000 daN per single run, transverse forces of 2 x 0.85 x 2,000 daN = 3,400 daN could be produced per "bight" if the strapping is laid double as it is here. If it is assumed that each of the four lashing points on the corner posts has a maximum securing load of 2,000 daN, transverse securing forces of 2 x 4 x 2,000 daN, i.e. 16,000 daN could be produced on each side.



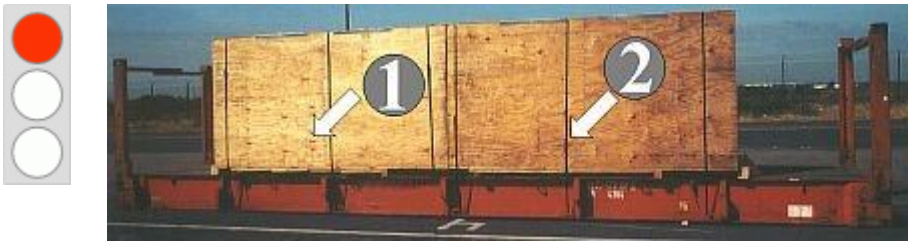
Securing using direct lashings
- plan view of two stowage variants

The decisive factors as far as the achievable cargo securing forces are concerned are the width of the shipping packages and their distance from the end walls or their position relative to the lashing points, with the resultant angles. In the left-hand variant, transverse securing forces of approx. 80% of the maximum securing loads are achieved . To the right, the transverse securing forces amount to only 60% of the maximum securing loads due to the large distance from the end wall.

5.2.8.7 Overheight and overwidth cases on flatracks, example 1

Two plywood cases on a 40' flatrack

Without performing any calculations, it is obvious that the securing means provided are inadequate.



Inadequately secured cases on a 40' flatrack

- side view

The two plywood cases each weigh 4,000 kg and are each 4.10 m long, 2.50 m wide and 2.20 m tall. Their eccentric center of gravity is labeled as required and is relatively low (at (1) and (2) in the Figure).

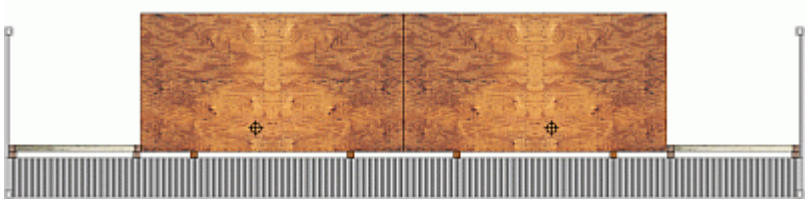


Inadequately secured cases on a 40' flatrack
- oblique view

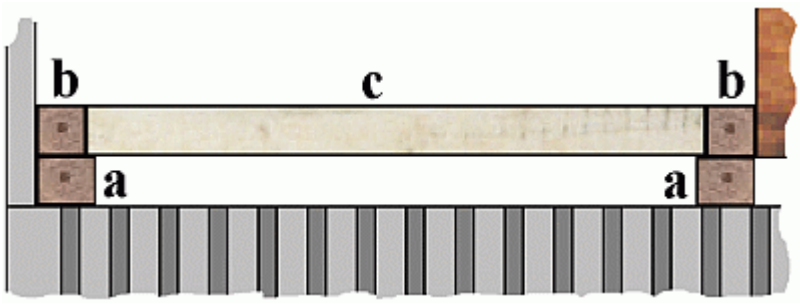
The three steel straps used per case lose their pretension if they cut any further into the outside of the case and are then no longer able to fulfill their holding-down function. They then act as pre-loosened direct lashings predominantly only in the vertical direction.

In each case, three nails have been hammered into the four wedges, but they do not provide adequate lengthwise securing. In particular, the nails can be easily levered out of the wedges, since the wooden crosspiece laid between case and wedges has only a very low effective height (3).

Appropriate lengthwise securing can be achieved by stowing the cases so that their centers of gravity are symmetrical and blocking them against the end walls:



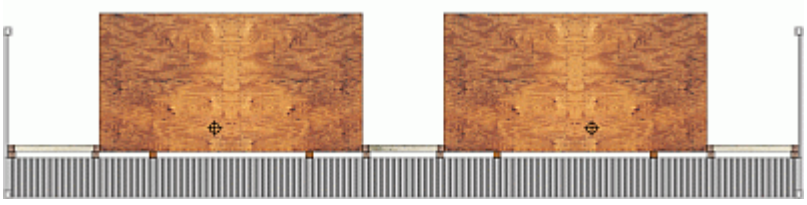
Variant for lengthwise securing of two cases using wooden bracing



Detail of wooden bracing

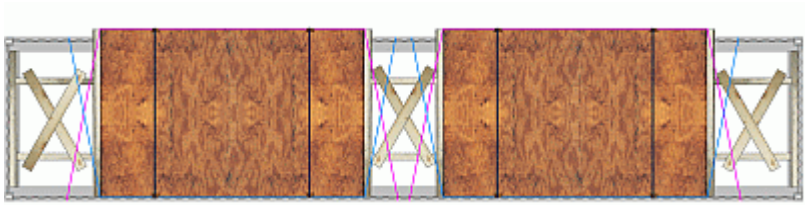
In order to be able to provide bracing in the load-bearing bottom area of the cases using bracing lumber, two crosspieces (a) are placed in front of the end walls of the flatrack and the cases. The height of these wooden members must match that of the case props. Two further crosspieces (b), which must be somewhat narrower than the crosspieces (a) are placed on the crosspieces (a), to produce an appropriate abutment for the bracing consisting of the precisely fitting wooden members (c). All the wooden members must be attached to one another and the wooden members (a) to the flatrack floor. If necessary, the wooden members (c) must be X-braced together with wooden boards.

So as not have to rely on tie-down lashings for transverse securing of the cases, it is better to space them from one another and to block them:



Variant for lengthwise securing of two cases using wooden bracing

The method of stowing the case is different from that originally used: the cases overhang on only one side, not both, so that only two slots are occupied instead of three.



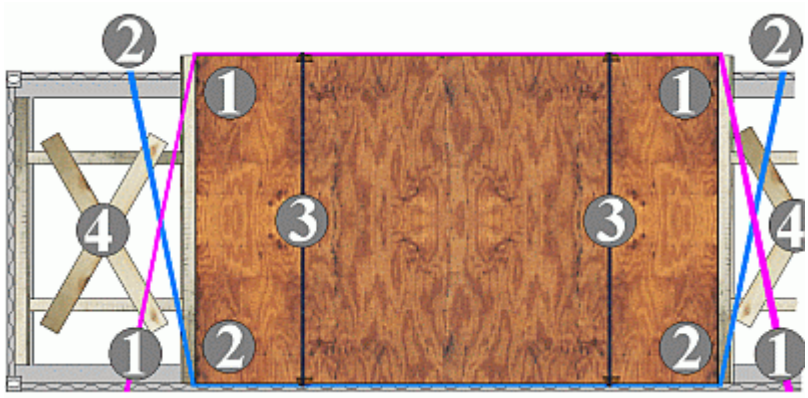
Securing of overwidth, overheight cases - side view

Appropriate transverse securing can be achieved using loop lashings passed around the sides. These would provide sufficient securing if the center of gravity of the cases is very low, but to avoid any risk it is advisable also to fit two steel strapping tie-down lashings per case to secure against tipping. To ensure that the steel strapping is adequately pretensioned and to prevent it from cutting into the outsides of the boxes, the steel strapping should be passed over automobile tire segments.



Steel strapping for tie-down lashings tensioned over an automobile tire segment

Detailed view:

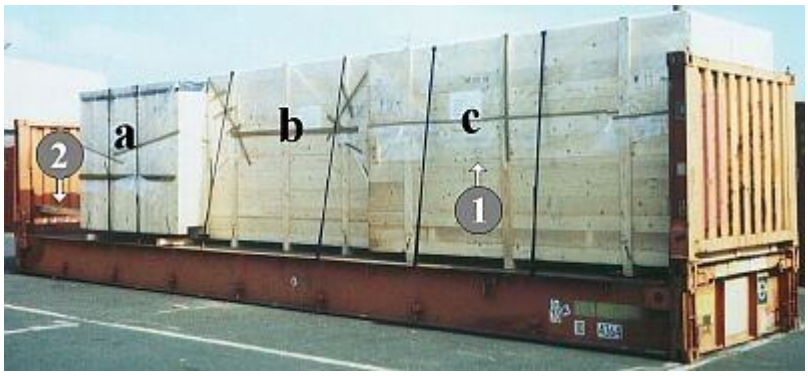


Expert securing of overwidth, overheight cases - detailed plan view

1 and 2 = horizontally arranged loop lashings for lateral securing
3 = tie-down lashings for securing against tipping
4 = X-bracing of wooden bracing

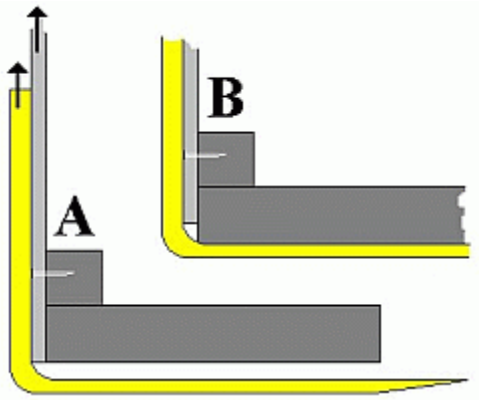
5.2.8.8 Overheight and overwidth cases on flatracks, example 2

Three wooden cases on a 40' flatrack



Three wooden cases, secured with nothing but steel strapping tie-down lashings

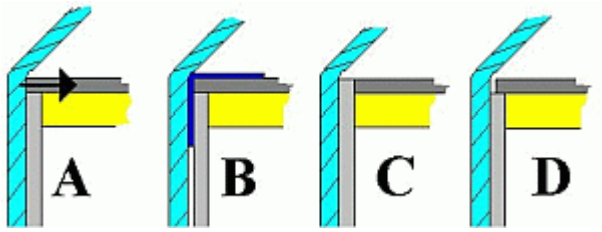
A problem with all these cases is that the side boarding ends flush with the underside of the bottom. When being picked up with forklift trucks, the boarding might be damaged by being pushed up by the channels in the fork face (see A in the Figure below):



Incorrect (A) and correct (B) side boarding arrangement

In arrangement B, the case sides end above the lower edge of the bottom by approximately their own board thickness, so meaning that the side boarding cannot be forced upwards when lifted by the forks.

The top boarding of all three cases is unfavorable, since it ends flush with the side boarding of the case (as at A). If cargo handling is not performed with frame spreader beams or spreader beams with cross beams, the vertical cable tension may pull top boards up during handling.



Incorrect (A) and correct (B, C, D) top boarding arrangement

This risk may be countered by using "heavy-lift cornerpieces" (B), lowering the top (C) or by "indenting" the top by approx. half its board thickness (D).

Another problem is that the side boarding of cases b and c is horizontal. Even small gaps between the boards considerably reduce the overall strength of the case and horizontal side boarding should only be selected if high flexural forces have to be taken up.

All three cases carry the following standard handling symbols:

- Glass, as symbol for fragile goods
- Two upright arrows, as symbol for "keep upright
- Umbrella, as symbol for "keep dry".

As far as the latter symbol is concerned, consideration should be given to whether the films 200 µ, i.e. 0.2 mm, thick which only partially cover the boxes provide sufficient protection against the weather. This seems less than likely, given that the overheight of the cases is sure to mean that the flatrack is stowed on deck.

The slinging symbols used on all three cases are non-standard, arrows and the word UP being used instead of the standard chain symbol:



Standard "slinging" marking

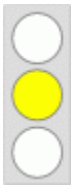


Non-standard "slinging" marking

The center of gravity of case c is off-center, a fact which is correctly marked at (1) with the appropriate DIN or ISO symbol.



Standard symbol for center of gravity



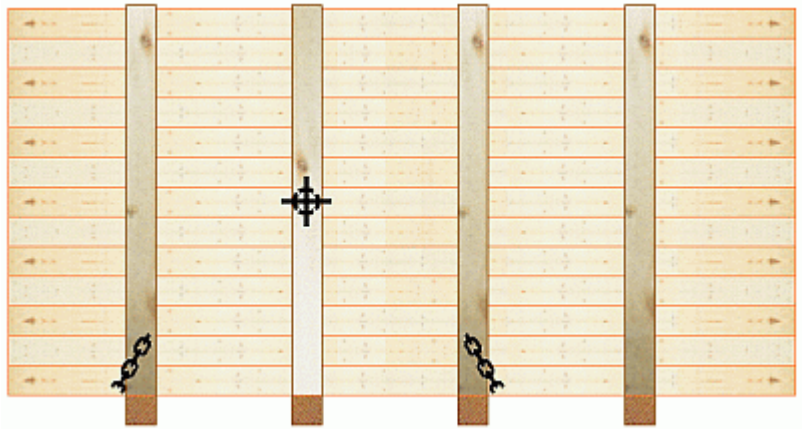


Marking of case c with regard to center of gravity and slinging (The arrows and UP have been replaced by chain symbols.)

- slinging means of different lengths have to be used.

The selected case construction and slinging point marking are completely correct, but not optimal. When the case is picked up with lifting gear, the slinging personnel must shorten the left-hand ropes so that the case hangs straight.





Optimized construction and marking

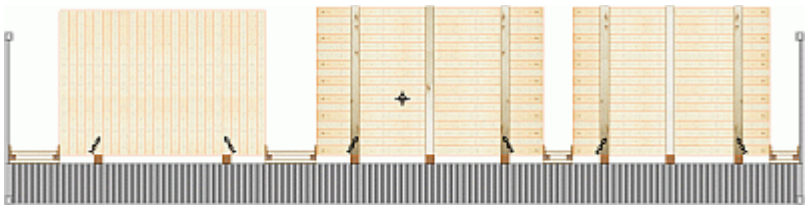
- slinging means of the same length can be used.

In this example, the case is constructed in such a way that the slinglift points are equidistant from the center of gravity, so meaning that ropes of the same length can be used.

As can be seen from the first picture on this page, originally, the three cases were close-packed as a block. This kind of loading makes it difficult to use different cargo securing methods. Steel strapping tie-down lashings were therefore used, together with wooden bracing (2) in the lengthwise direction.

If loading is modified, other cargo securing methods can be used.

In this example, the cases are spaced out and again secured in the lengthwise direction by wooden bracing:

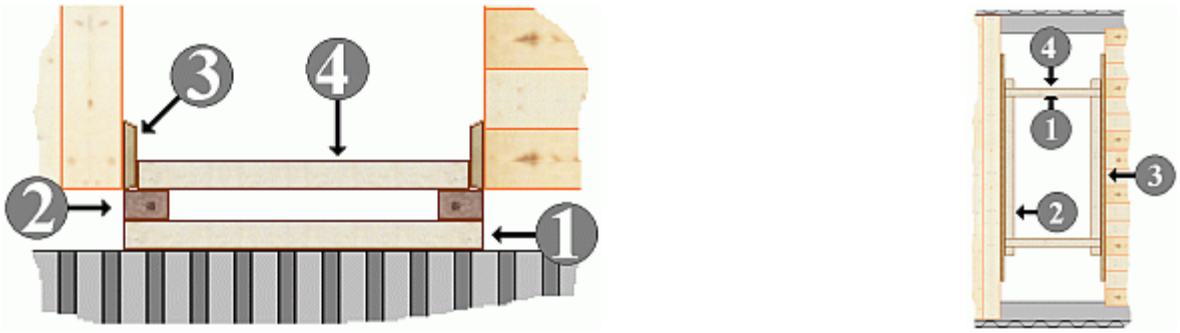


Spaced cases, cases secured lengthwise by bracing the gaps
- side view



Spaced cases, cases secured lengthwise by bracing the gaps - plan view

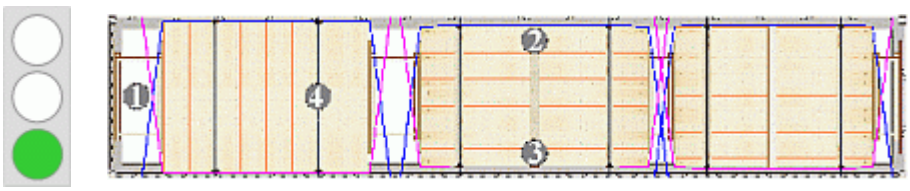
The following Figures give a better view of the details:



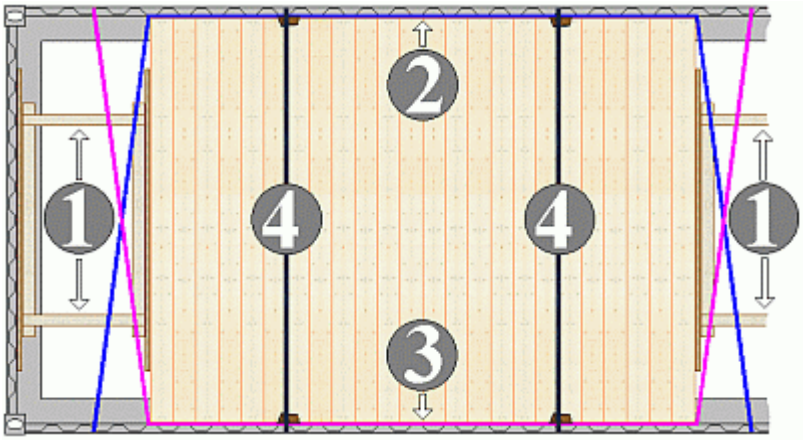
Details of bracing - side and plan view

The squared lumber (1) is laid lengthwise, at a distance from the corners which corresponds to approx. a quarter of the case width. The wooden members (2) are laid crosswise thereon. The pairs of wooden members (1) and (2) match the height between the bottom edge of the case bottom and the flatrack floor. Boards or squared lumber are positioned on the wooden members (2) to the left and right of the gap against the cases or against a case and a flatrack end wall (3) to distribute pressure. The squared lumber (4) is inserted between these wooden members for lengthwise bracing.

The cases are secured laterally by loop lashings, while securing against tipping is provided by tie-down lashings. For overall securing of the three cases, a total of four bracing members, six loop lashings and six tie-down lashings are required. The following two Figures show an overview of the securing arrangements and a detail thereof:

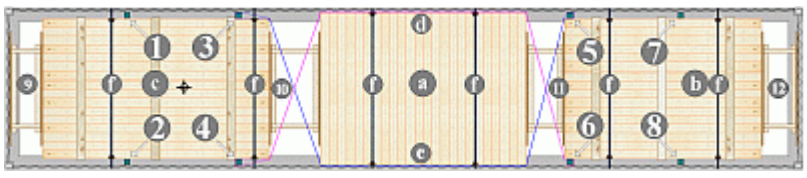


Overall securing of the cases:
Lengthwise securing using bracing (1). Transverse securing in each case using two loop lashings (2) and (3) and securing against tipping provided by in each case two tie-down lashings (4)



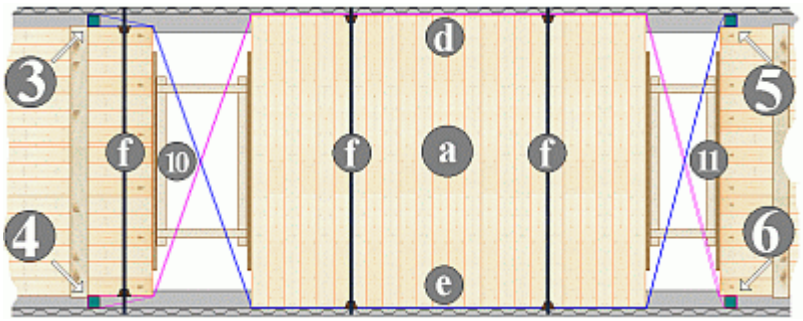
Case securing detail:
Lengthwise by bracing (1) against the flatrack end wall and the adjacent case, crosswise by in each case two loop lashings (2) and (3) and against tipping by in each case two tie-down lashings (4)

The three cases could be secured somewhat more cheaply if a flatrack with stanchions were used. The cases would be arranged differently on the flatrack, with the widest case (a) arranged in the middle and cases (b) and (c) positioned in the vicinity of the end walls, in such a way that they are secured crosswise in each case by two pairs of stanchions, case (c) being secured by stanchion pairs (1)/(2) and (3)/(4) and case (b) by stanchion pairs (5)/(6) and (7)/(8). The gaps are filled with bracing (9), (10), (11) and (12). No stanchions are used for case (a) because of its width; instead, it is secured crosswise by the two loop lashings (d) and (e). Each of the three cases is secured against tipping by two tie-down lashings (f).



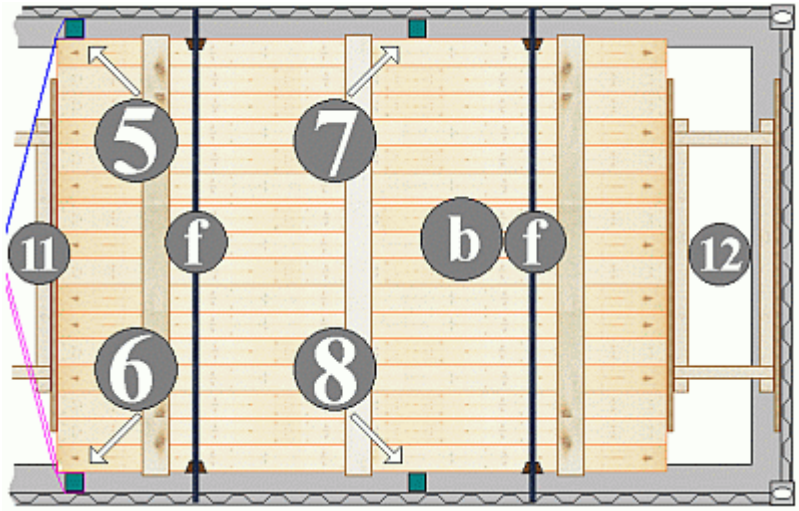
Securing of three cases on a flatrack with stanchions

To make the cargo securing clearer, the securing arrangements used here for each case are shown in detail.

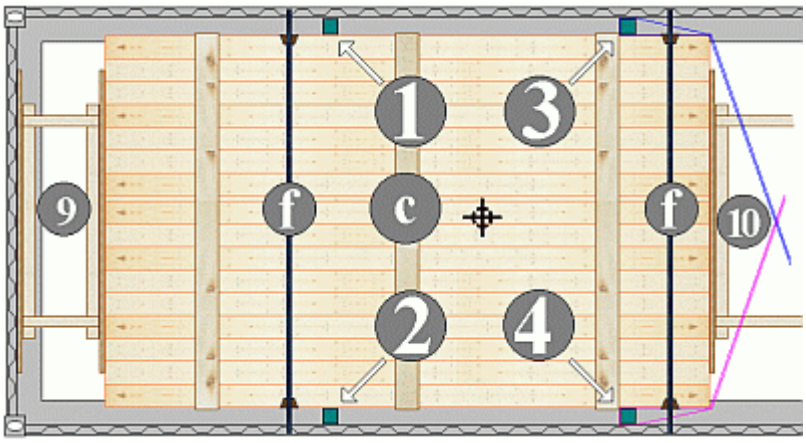


Securing of the centrally positioned case (a)

The crimson-colored loop lashing (d) extends at the level of the center of gravity of the case from stanchion(4) around the outside of the case to stanchion (6). The bluish-purple loop lashing (e) is likewise passed at the level of the center of gravity of the case from stanchion (3) around the outside of the case to stanchion (5).

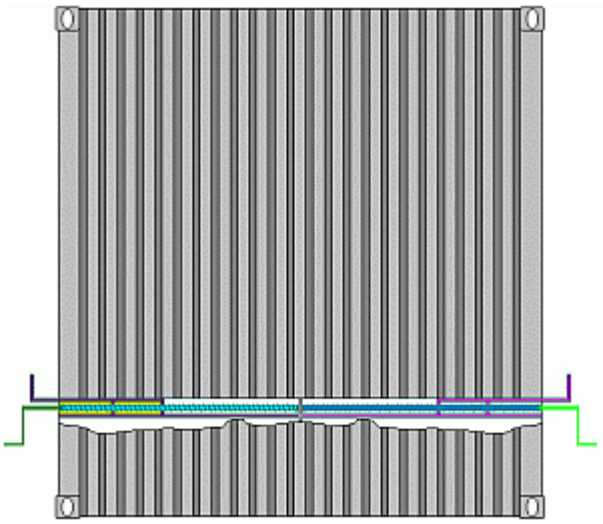


Securing of case (b) positioned in vicinity of end wall

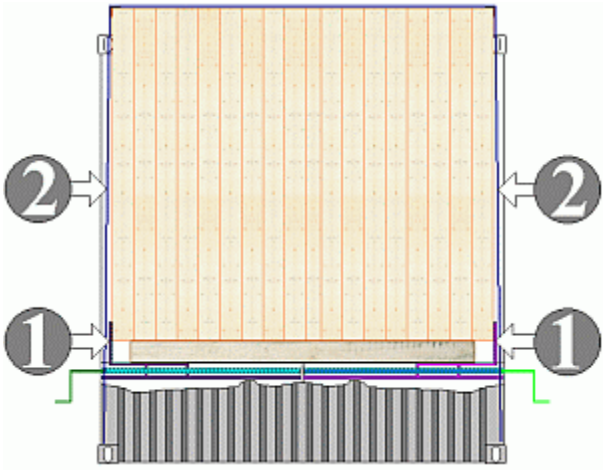


Securing of case (c) positioned in vicinity of end wall

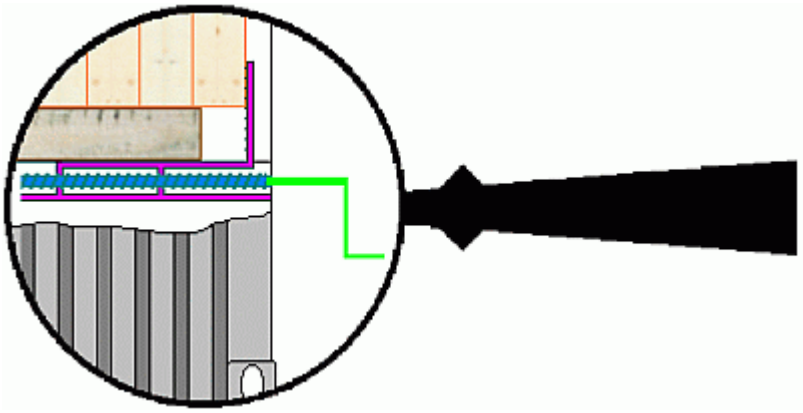
The wooden members used for bracing must be attached in such a way as to make slippage impossible. If necessary, they should be X-braced. The tie-down lashings should be positioned as far as possible equidistantly from the center of gravity of the case. When using steel strapping, the tie-down lashings should be passed over edge protectors with good recovery. Very favorable securing options would be achieved if special flatracks with clamping jaws were available for transporting large cases and similar shipping packages.



Flatrack with clamping jaws



Securing a case with spindle-guided clamping jaws (1) and tie-down lashings (2)

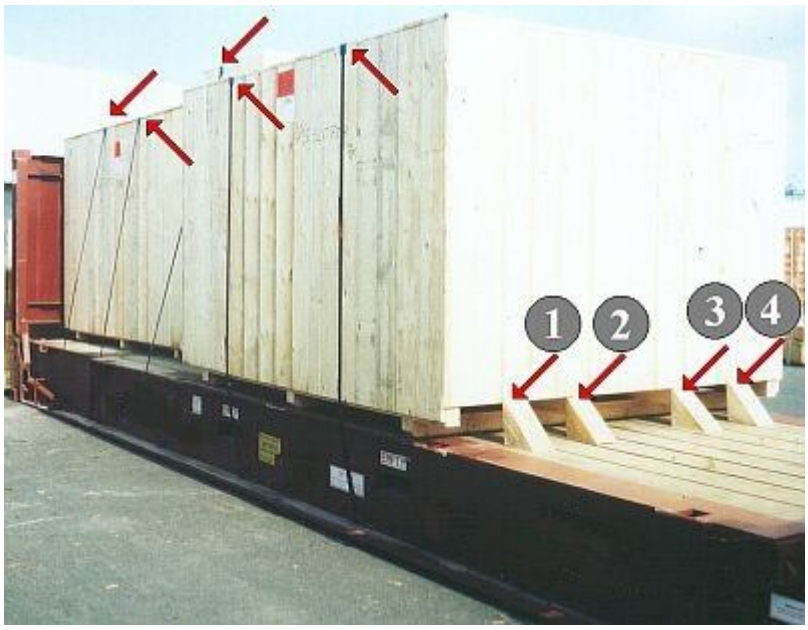


Detail of securing using clamping jaws

The clamping jaws must be ridged or spiked, to achieve a tight fit in the lengthwise direction by penetrating into the outside of the case. The availability of such flatracks would simplify cargo securing enormously. If the cases were expertly constructed, it would at any rate be possible to dispense with any further lengthwise and transverse securing. If conditions were particularly favorable, it would even be possible to do without tie-down lashings.

5.2.8.9 Overheight and overwidth cases on flatracks, example 3

Inadequate load distribution and securing of three wooden cases on a 40' flatrack



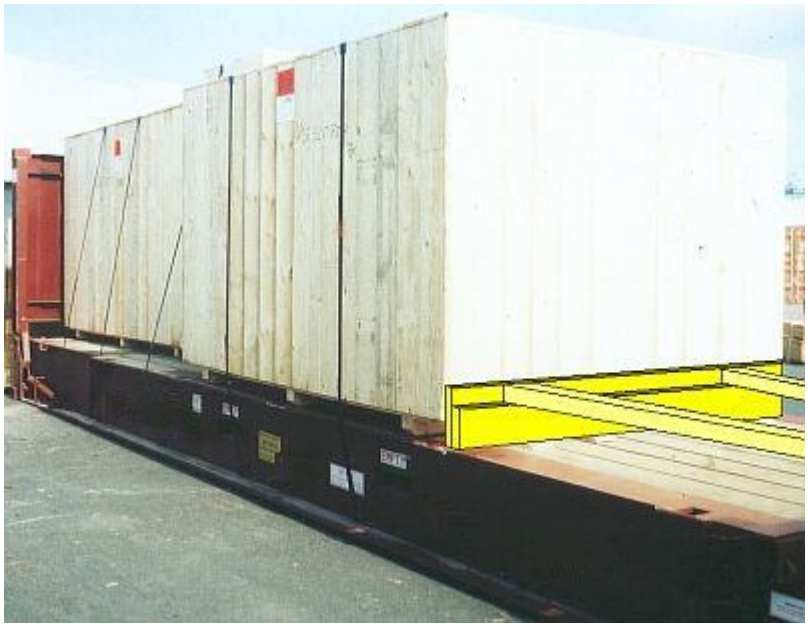
Incorrect load distribution and inadequate securing

Steel strapping tie-down lashings have been fitted. Since simple plastic cornerpieces have been used, the steel strapping will press into the wooden boards of the case top under load and its pretension will gradually diminish, resulting in the loss of its securing action. With a steel strapping lashing length of 7 m, pretension would drop to zero if the strapping were to press into the top boards by only approx. 10 mm.

Another problem is that the front case is overwidth and is nonetheless secured with tie-down lashings.

Securing by the wedges nailed in front of the cases has virtually no effect, since the effective height of wedges (1) and (4) is minimal and that of wedges (2) and (3) immaterial.

Use of very close fitting wooden bracing ensures adequate lengthwise securing:



Using wooden bracing instead of wedges



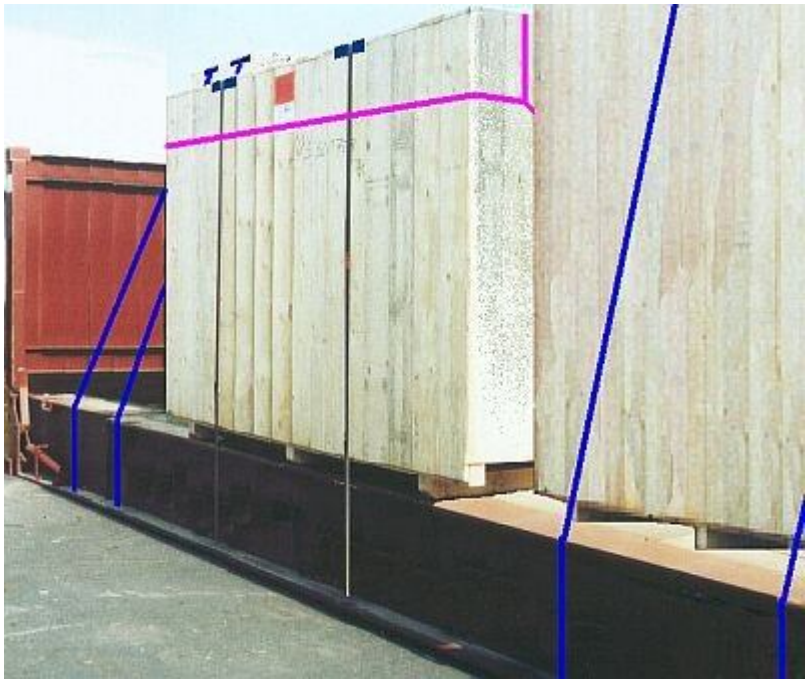
Options for maintaining pretension

Heavy-lift cornerpieces, as shown at (1), are rigid and allow prestressing forces to be maintained under favorable conditions. It is better to use edge protectors of a resilient material with good recovery properties - such materials, as with a piece of tire at (2), allow maintenance of pretension under usual carriage conditions.

The load distribution on the flatrack contravenes the regulations outlined in particular in the CTU packing guidelines, which state:

3.2.5 The weight of the cargo should be evenly distributed over the floor of a container. Where cargo items of a varying weight are to be packed into a container or where a container will not be full (either because of insufficient cargo or because the maximum weight allowed will be reached before the container is full), the stow should be so arranged and secured that the approximate center of gravity of the cargo is close to the

mid-length of the container. If it is not, then special handling of the container may be necessary. In no case should more than 80% of the load be concentrated in less than half of the length of a container measured from one end. For vehicles, special attention should be paid to axle loads.



Acceptable packing and securing of the flatrack

By calculating the moments, the best position may be determined for the cases. The Figure shows roughly how they might be packed and secured:

- All the cases are positioned on strips of friction-enhancing material.
- The heavy overwidth case is positioned in such a way that the center of gravity lies approximately one meter to the left of center. It is secured against lateral shifting and tipping by using spring lashings with two direct lashings.
- The lightest, tall, slim case is packed to the left thereof and blocked against the end wall.
- The medium-weight case is positioned in front of the overwidth case and braced against the other end wall.
- Each case has two tie-down lashings.

5.2.8.10 Overheight and overwidth cases on flatracks, example 4

Single case on a 20' flatrack

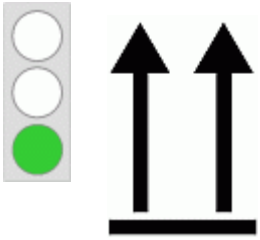


Inadequate packing of a 20' flatrack with an overwidth case

A few hints are required with regard to packaging and securing. The standards state that marking should preferably be in black and expressly prohibit the use of scarlet.

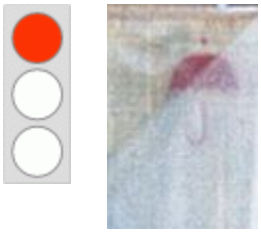


Unclear marking



Correct marking

The single arrow symbol (a) with the word UP is not standard. As an abbreviated version of "This way up", it means that the case should be carried upright, which is normally symbolized by two upright arrows.



Inadmissible color:
scarlet



Admissible color:
black

The incorrect choice of color for the symbol (b) is of course a minor defect. What is more important is that the case, which needs to be kept dry, is only partially covered with a simple PE film 200 µ thick. This film will definitely not keep the package dry during a voyage, especially not if the flatrack is stowed on deck. Depending on its stowage space, the film will be damaged by exposure to the wind and possibly also by solar radiation.



Correctly affixed information marks



The symbols relevant to handling of the case should be affixed together as far to the top right as possible on two sides, which again is not the case here.

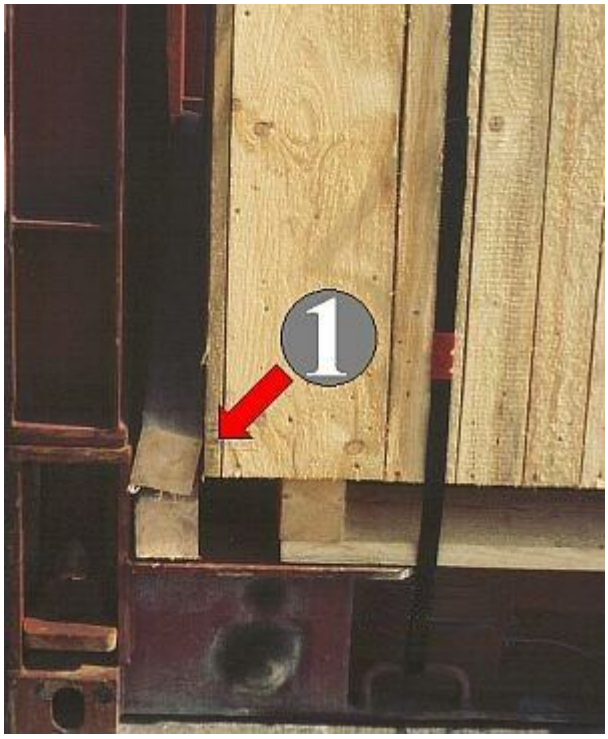
The marking relating to slinging of the case (c) is not standard either, but the least favorable feature is that the case has been so constructed that the slinglift points lie very close together and there is a risk that the case may fall out of the slinging means. There is no need to go into this unnecessary cargo handling risk.



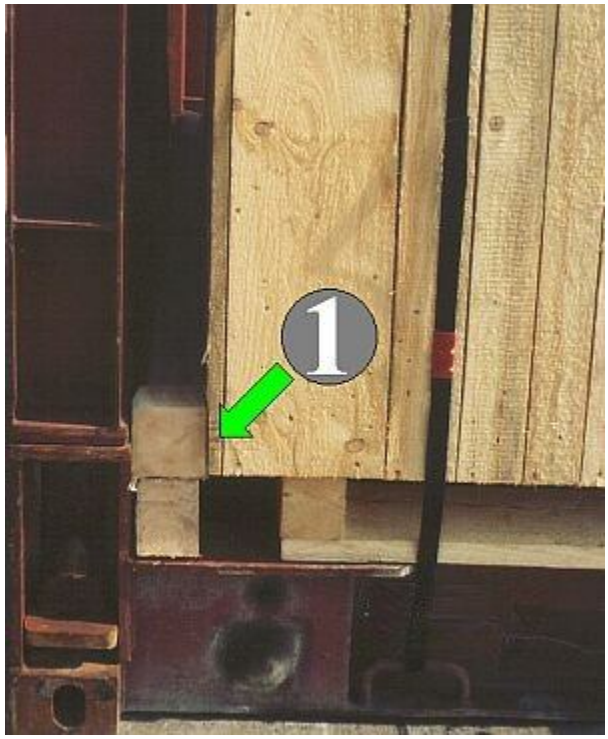
Red: unfavorable slinglift points
Black: favorable slinglift points

At (d), the mass of the case is stated as 4600 kg. Calculation of the moments shows that the center of gravity of the packed flatrack is more than 60 cm away from the middle of the flatrack, which is inadmissible.

The cargo securing is inadequate. The crosspiece (1) is too low - it does not lie with its whole height against the bottom of the case. Other shapes or the additional use of a board could put things right.

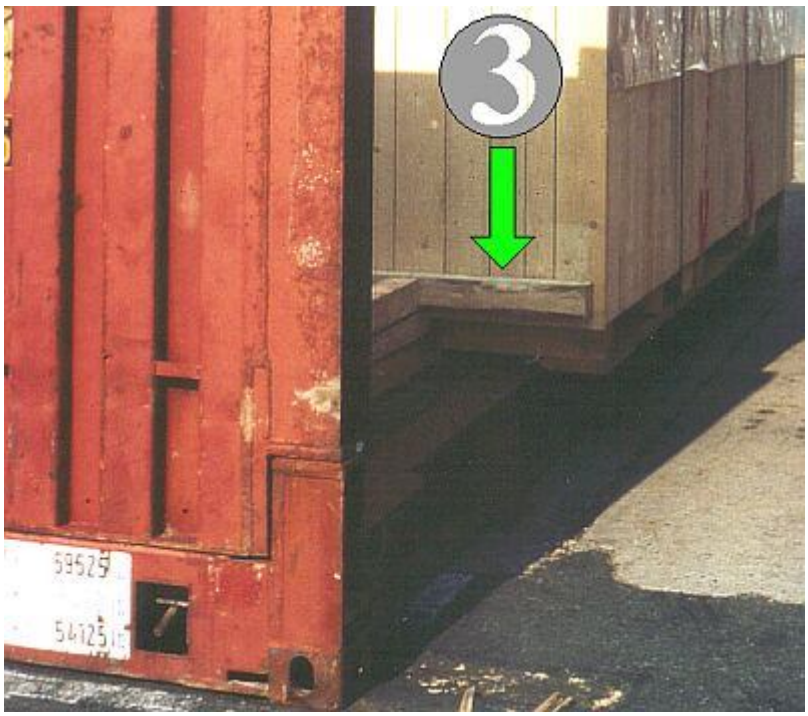


Incorrect position of the squared lumber



Correct position of the squared lumber

The cross piece (3) is correctly positioned, and transmits the forces into the case bottom:



Correctly positioned crosspiece for lengthwise securing (green light)
But: inadequate transverse securing (red light)

The lengthwise wooden members (2) are correctly positioned, but apply point loads to the end wall of the flatrack at (4).



Point-loading of the flatrack end wall by the lengthwise wooden members

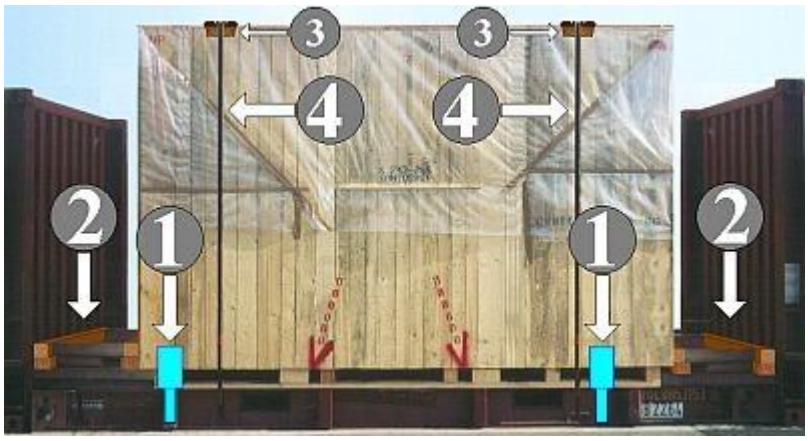
An additional squared lumber member fitted against the end wall can effect pressure distribution.



Correct pressure distribution by an inserted crosspiece

The tie-down lashings (5) are stretched over the case top and film without further measures. They are already cutting visibly into the lumber and damaging the film and will not in the long term retain the pretension required for securing. The problems with using tie-down lashings on overwidth packages have already been discussed.

Appropriate securing might have looked like this:

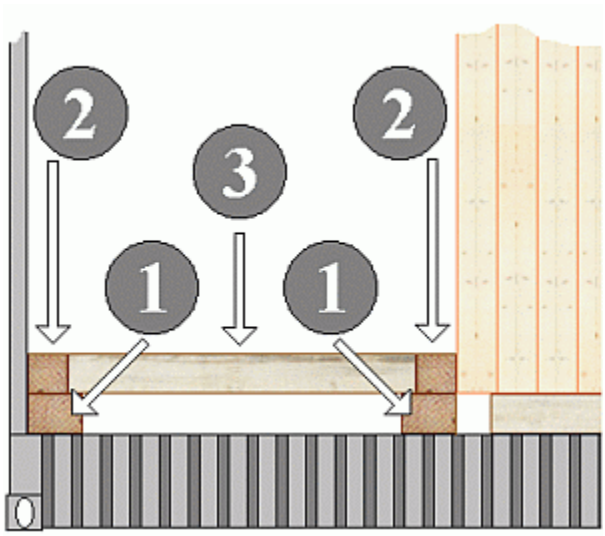


Correct securing of the overwidth and overheight case

The shipping package is loaded centrally. The overwidth case is secured laterally by special "case restraint shoes" (1), the design and mode of action of which will be described below, with possible alternatives. Lengthwise securing is achieved with wooden bracing (2), which consists in each case of two crosspieces

and lengthwise members, which are "chocked up" far enough for them to transfer forces in the area of the case bottom.

The two steel strapping tie-down lashings (4) are designed to hold the case in the "case restraint shoes". In order to protect the case and ensure their efficacy, they are tensioned over cornerpieces of elastic material (3).



Expert bracing

To shore the case, squared lumber of rectangular cross-section is selected (1), whose narrow side matches the height of the "case restraint shoes". The wooden members are positioned crosswise in front of the case and the flatrack end wall. On these are laid square or rectangular lumber (2), whose dimensions are somewhat smaller than those of (1). It is important for the wooden members (2) to be able to rest against load-bearing parts of the case, the best place being the bottom area of the case. Squared lumber (3) is fitted between these wooden members and lies on the protruding part of the wooden members (1).

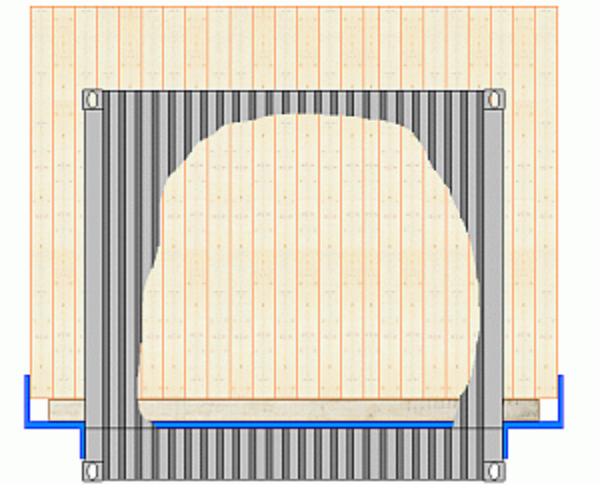
To ensure securing of their own product, the exporting company should provide "case restraint shoes", given that they know that their case is an overwidth case and will have to be transported on a flatrack.



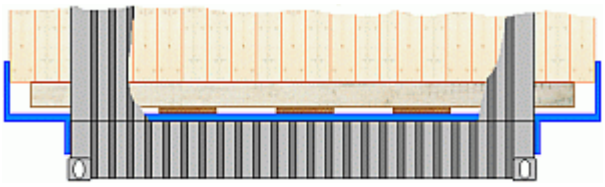
Case restraint shoes

The case restraint shoes may be easily made from flat or profiled steel. The distance between the upper lugs (1) must match the width of the case, that of the lower lugs (2) the width of the flatrack. At least two

of these shoes are positioned on the flatrack at suitable points and the case is loaded onto them.



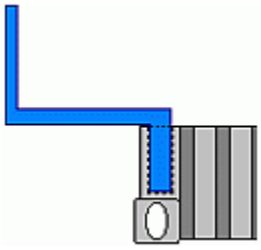
Tight-fit lateral securing of a package in case restraint shoes



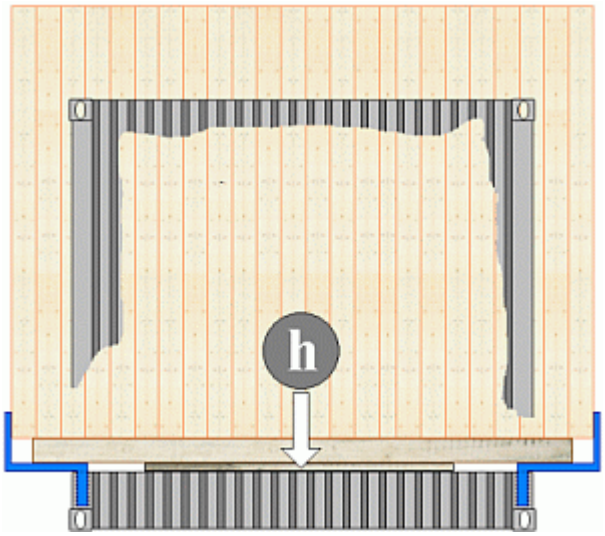
Longitudinal planks between case and case restraint shoe

It is important for the lugs of the case restraint shoes to be "meaty" enough to hold the case. Slight dimensional tolerances between the lugs of the case restraint shoes and the cases can be compensated with hardwood driving wedges.

It would be better and more favorable if flatracks with stanchion pockets were commercially available which carried a corresponding number of different-sized specially shaped stanchions. This would markedly improve and rationalize the securing of many cargoes.



Specially shaped stanchion for a 20' flat - for insertion into stanchion pockets

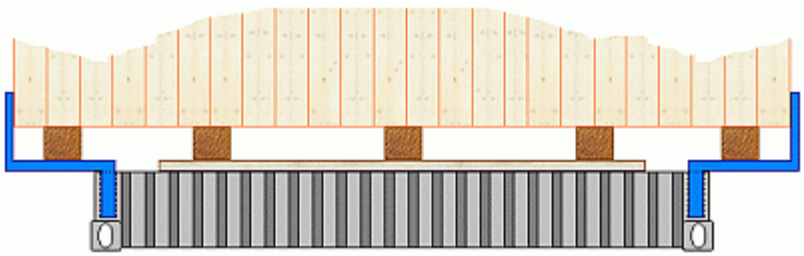


Use of two specially shaped stanchions for securing a case on a 20' flatrack - crosspieces are positioned beneath the case to prevent its bottom from sagging

In the case of cases with transverse skids, crosspieces or lengthwise members corresponding in height to that of the horizontal specially shaped stanchion components should be laid under the case bottom to support it against sagging (h).

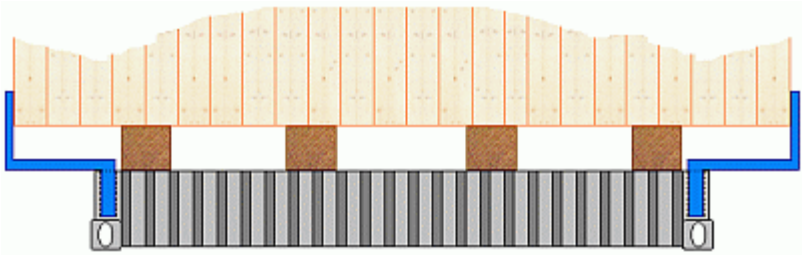


Measure taken against sagging of the bottom: lengthwise wooden members laid thereunder



Measure taken against sagging of the bottom in cases with longitudinal skids: crosspieces laid thereunder

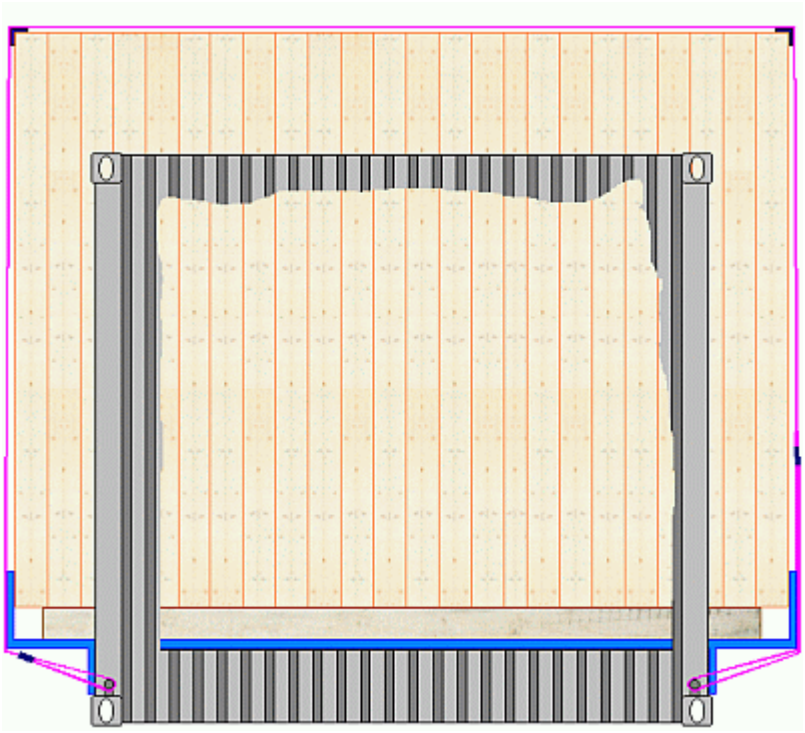
Firring should also be provided in the case of cases with longitudinal skids, if the outer longitudinal skids stand on the specially shaped stanchions.



No measures need be taken against sagging of the bottom, if the case restraint shoes apply load to the load-carrying parts of the flatrack.

Firring can be omitted if the longitudinal skids are free of the specially shaped stanchions and the load is evenly distributed over load-carrying container components.

To hold the packages in the case restraint shoes or specially shaped stanchions, at least two tie-down lashings are also fitted per shipping package.



High quality securing of a case using case restraint shoes and tie-down lashings

The tie-down lashings act in this and similar cases to prevent "popping out" of the case restraint shoes or specially shaped stanchions under dynamic loads. They are actually being used here as direct lashing.

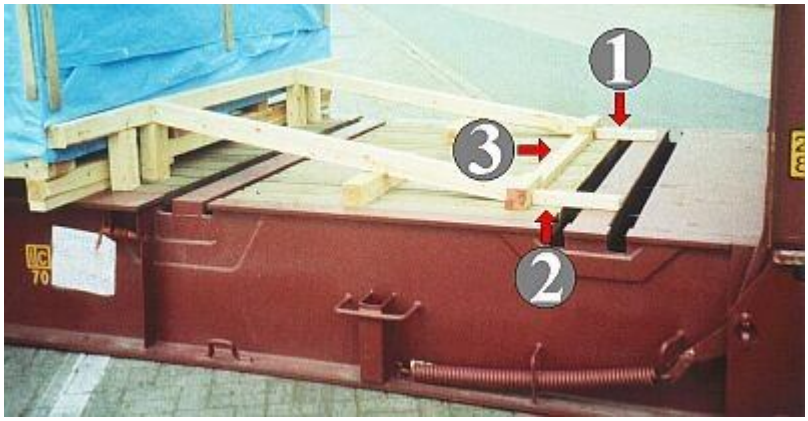
5.2.8.11 Overheight and overwidth cases on flatracks, example 5

Two cases of approximately equal weight on a 40' flatrack



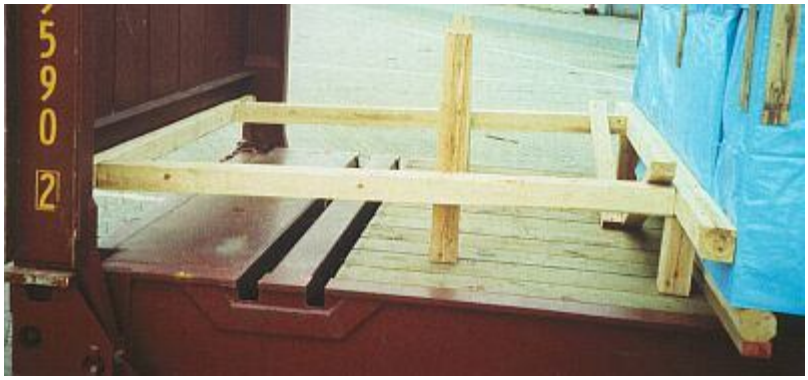
Inadequately secured cases on a 40' flatrack

It is immediately obvious that the lengthwise securing on the right-hand side of the flatrack is inadequate, since nailed-on wooden members have been used. To assess the rest of the securing arrangement, a closer look is required. Positive features are that the weather protection is better than that provided for the previous cases and that the steel wire tie-down lashings are passed over elastic edge protectors.



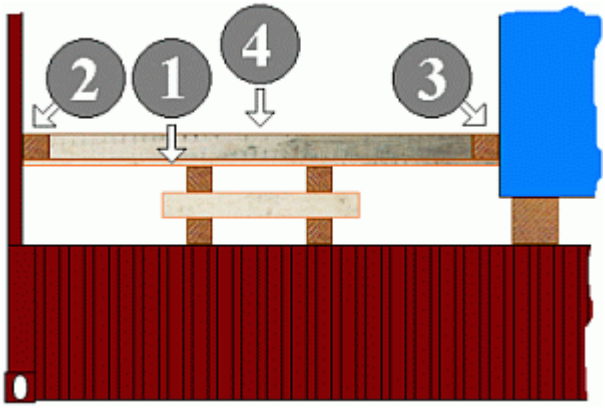
Inadequate securing with wooden fixings

When building the technically skillful construction, no consideration was given to the fact that only the shear action of the nails hammered into wooden members (1), (2) and (3) is relevant to the strength of the overall structure. Depending on the thickness of the flatrack planking and the selected wire nail diameters, together with their depth of penetration into the wooden members and the floor, cohesive resistance of approx. 100 - 400 daN per nail may be anticipated.



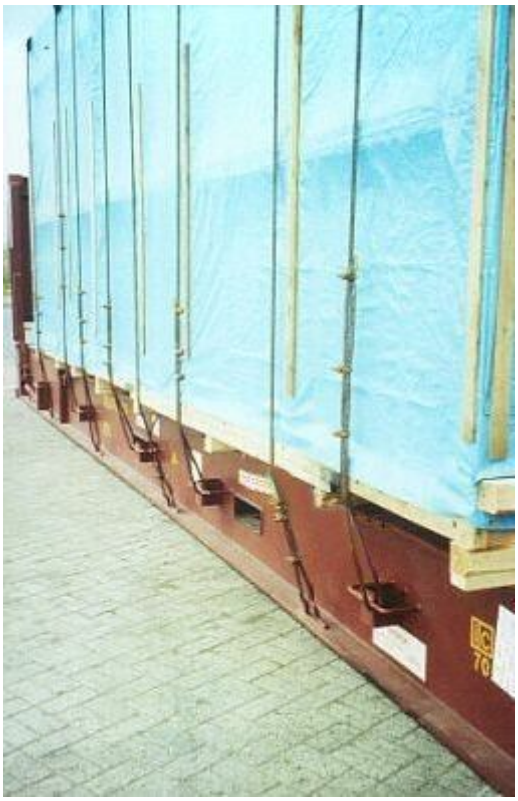
Wooden bracing on the left-hand side of the flatrack

The bracing on the left-hand side of the cases is passable. However, it must be ensured that the bracing cannot loosen, for which purpose the squared lumber must be carefully tacked down. The following approach is somewhat more elegant.



Variant of bracing on left-hand side

Depending on the desired height, a number of wooden members laid cross- and lengthwise are used as a base. Two boards (1) cut to the right dimensions are laid lengthwise thereon. The wooden members (2) and (3) serving to distribute pressure are placed crosswise on the ends thereof. Finally, the wooden members (4) need to be cut precisely to size and fitted in place.



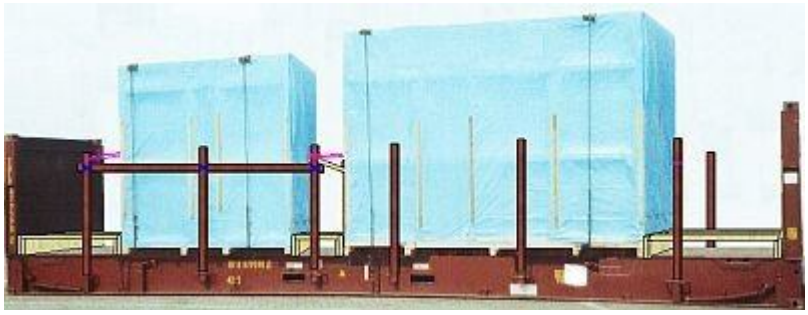
Inadequate securing against crosswise and tipping movement using tie-down lashings

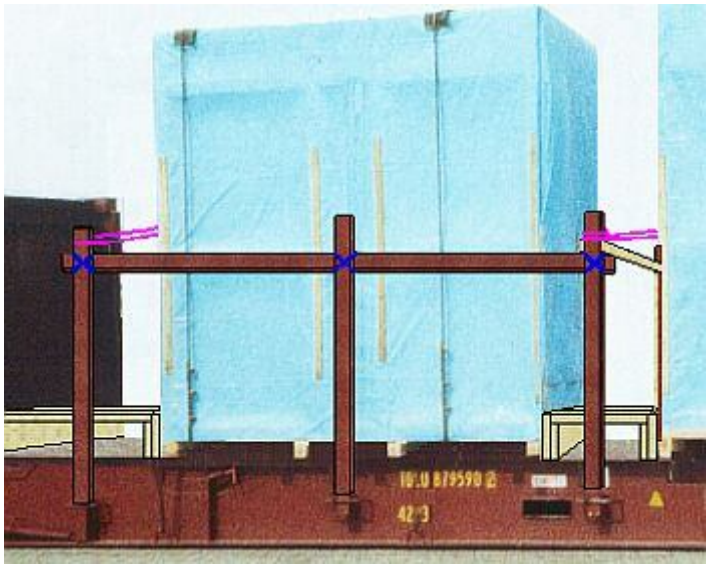
The front case is secured with five tie-down lashings made from steel wire ropes 16 mm in diameter, while the rear case is secured with three. The maximum securing load of the wire ropes may be calculated by rule of thumb in decanewtons on the basis of d x d x 40, i.e. 16 x 16 x 40 = 10,240 daN. If three wire clips are used, a maximum of 7,680 daN is achieved per single run of lashing. The lashing points used have on average a maximum securing load of approx. 3,000 daN. The wires are pretensioned with turnbuckles. If the maximum allowable pretension is 50% of the admissible lashing force on each side, a total of 2 x 1,500 daN = 3,000 daN pretension could be applied per lashing. Assuming a coefficient of sliding friction of $\mu = 0.2$, securing forces of 600 daN should be anticipated per tie-down lashing. The reduction in forces due to the lashing angle of approx. 70° was disregarded. The large case has accordingly been secured by the tie-down lashings in all horizontal directions with 5 x 600 daN = 3,000 daN, while the small one has been secured with 3 x 600 daN = 1,800 daN. By using friction-enhancing material with a possible coefficient of sliding friction of $\mu = 0.4$ under the stowed cargo, the values could have been doubled.

The best possible securing arrangement for the two cases would be:

- use of case restraint shoes or specially shaped stanchions for lateral securing
- use of two tie-down lashings in each case to secure against tipping
- application of wooden bracing for lengthwise securing

The fact that the flatrack has stanchions and stanchion pockets at the sides opens up the way to another securing variant, which is possible if the unilaterally overhanging cargo does not cause the center of gravity of the flatrack to lie inadmissibly far from the longitudinal center line.

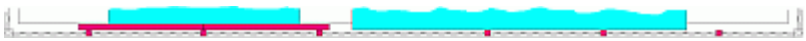




Securing variant for unilaterally overhanging cargo, using the stanchions provided (selective enlargement below)

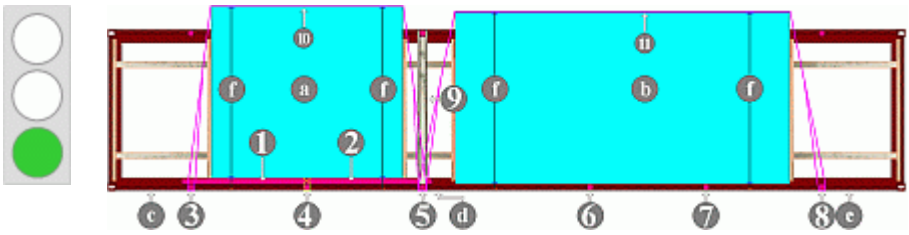
On the side of the flatrack remote from view, the third stanchion from the left is inserted. On the visible side, all the stanchions are inserted. A squared lumber member is fastened vertically to the inside of each of the three front stanchions on the left-hand side. The height of these squared lumber members should correspond to half the case height. Two of the unused stanchions from the other side are laid lengthwise on these squared lumber members and attached to the stanchions.

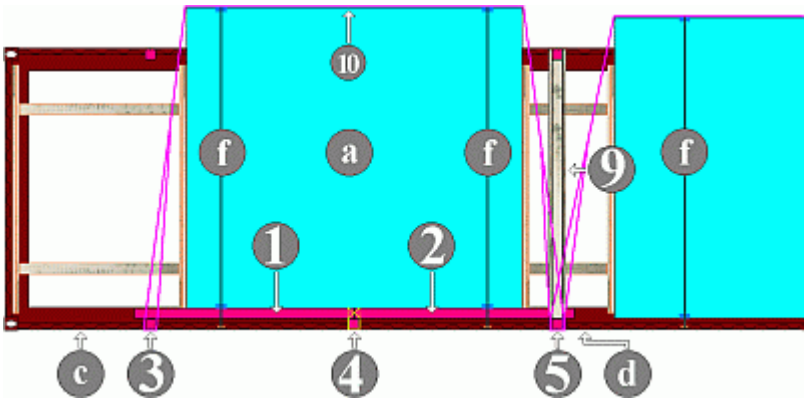


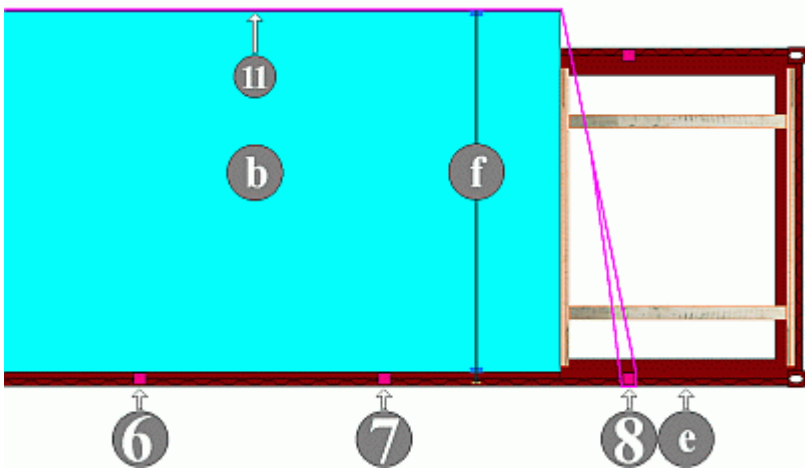


Inserted stanchions on the flatrack sides - plan view

The two cases are loaded and secured as illustrated.

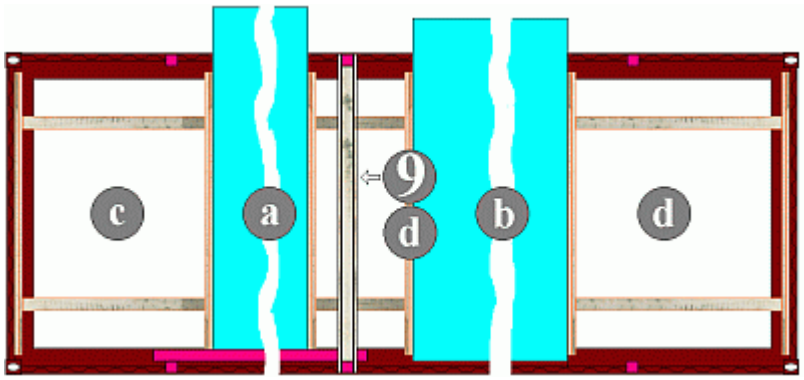






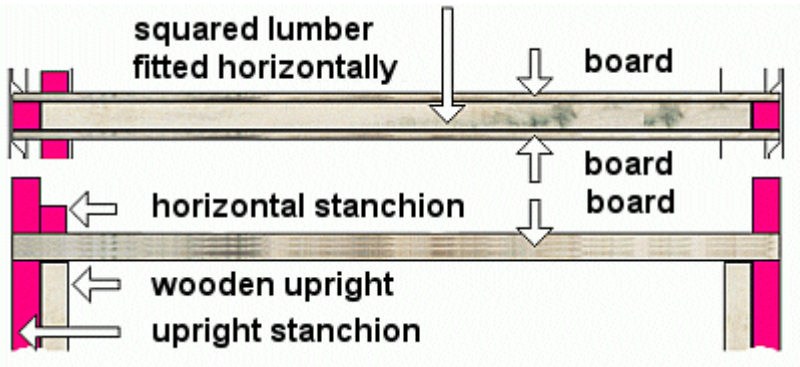
Overview of securing arrangements
(center and bottom: enlargement of the first picture in two halves)

Case (a) is supported by means of the horizontally attached stanchions (1) and (2), which are fastened to the inside edge of the stanchions (3), (4) and (5). Case (b) is supported against stanchions (6) and (7). Bracing is provided in gaps (c), (d) and (e) between the cases and the end walls of the flatrack and those between the cases in the form of squared lumber and planks. Likewise, the stanchion (5) is braced crosswise at (9) with the opposite stanchion. The bracing is shown in detail below:



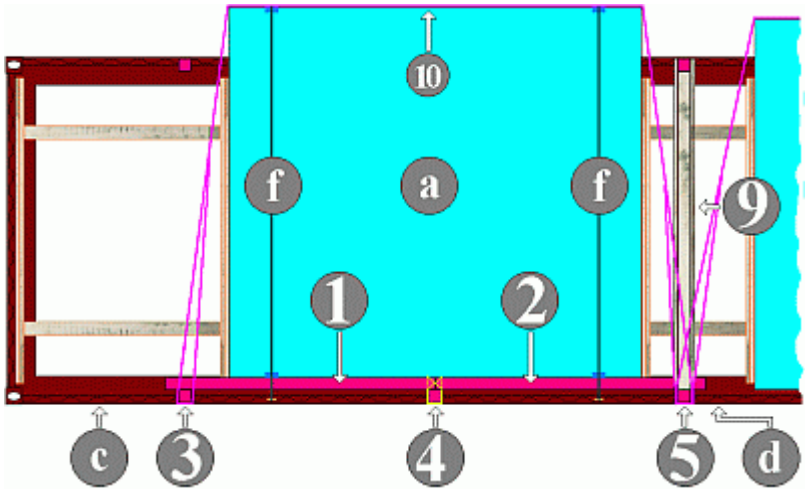
Bracing of the gaps (c), (d) and (e) and the stanchion pair at (9)

Bracing of the stanchions is intended to ensure that, when the cases are subsequently lashed at stanchion (5), the moments of resistance of two stanchions can be utilized due to the bracing (9), given that two lashings are attached to the stanchion (5).



Mutual bracing by the pairs of stanchions
Top: plan view - Bottom: end-on view

The following Figure shows securing of the left-hand case in detail:



Detail: securing of left-hand case

Key to reference numerals/letters:

a = left-hand case

c = gap between case and flatrack end wall

1 and 2 = stanchions attached horizontally lengthwise

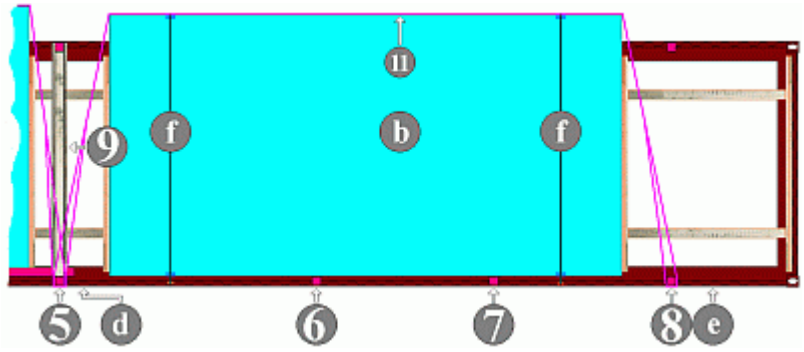
3, 4 and 5 = stanchions

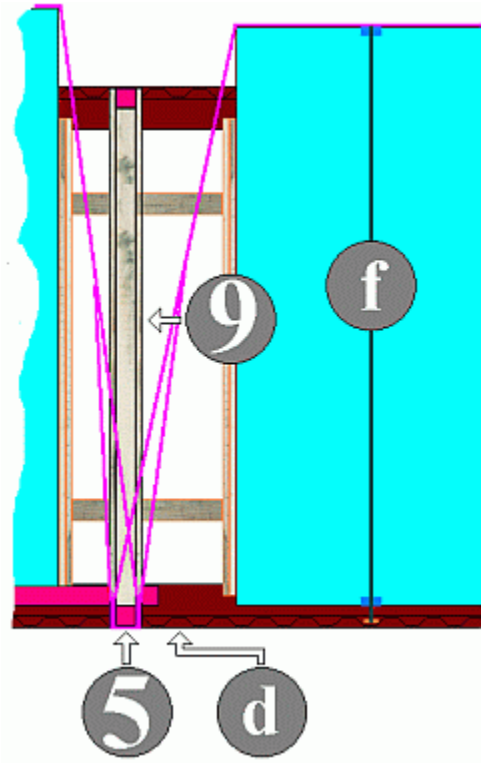
9 = bracing between stanchion 5 and opposite stanchion

10 = direct lashing to hold the case laterally on the "open side"; the lashing means is passed from stanchion 3 horizontally around the case to stanchion 5

f = tie-down lashings

The following Figure shows securing of the right-hand case in detail:





Detail: securing of right-hand case
(left: enlargement of the left-hand part of the top picture)

Key to reference numerals/letters:

b = right-hand case

d = gap between cases a and b

e = gap between case and flatrack end wall

5, 6, 7 and = stanchions

8

9 = bracing between stanchion 5 and opposite stanchion

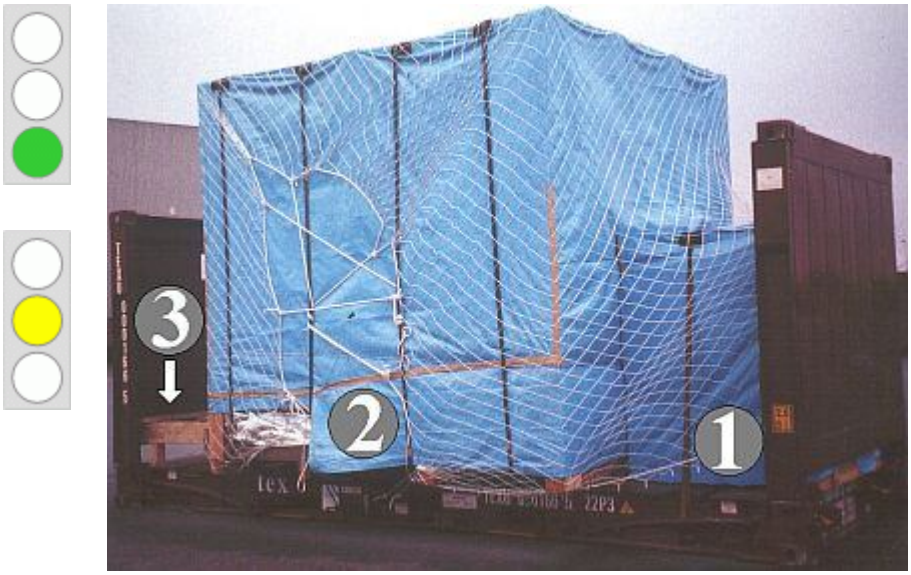
11 = direct lashing to hold the case laterally on the "open side"; the lashing means is passed from stanchion 5 horizontally around the case to stanchion 8

f = tie-down lashings

5.2.8.12 Overheight and overwidth cases on flatracks, example 6

Two cases of unequal weight on a 20' flatrack

The following example is basically positive.



Securing two cases on a 20' flatrack

The case (1), which is neither overwidth nor overheight, is loaded tight against the end wall. The overheight and overwidth case (2) is positioned next to it. The gap between this case and the flatrack end wall is braced (3). The case's weather protection looks good - the case carries an umbrella as information mark and has consequently to be kept dry. The tear-resistant woven tarpaulin has been secured against wind with an additional net.

The steel strapping tie-down lashings all pass over edge protectors consisting of rubber tire segments, which ensures that their pretension is retained in transit. In addition, both cases have been positioned on strips of friction-enhancing material. Since case (1) had a very low mass and was clamped in place by the

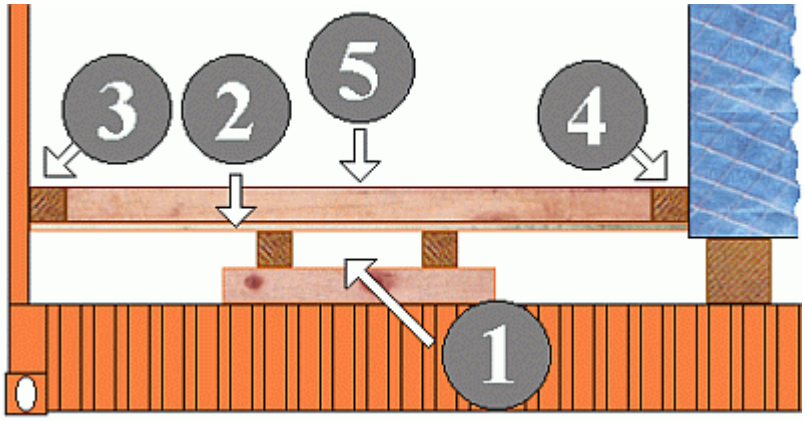
large case and the bracing, securing with only one tie-down lashing is tenable in this particular case.

It would have been still better if the large case had been placed on two case restraint shoes, which would have guaranteed a long-term lateral tight fit at floor level. If these had been used together with two tie-down lashings to secure against tipping, the securing arrangement could have been described as optimum.



Bracing at the end of the flatrack

The wooden bracing is technically very well made. Nonetheless, it too could be improved upon.



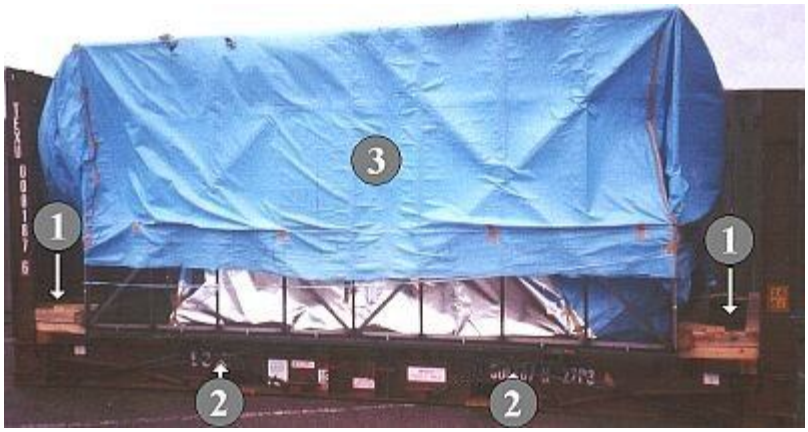
Modified wooden bracing for filling the end wall gap

Key to reference numerals:
(1) = base made of a crossover bed of wooden members or beams laid crosswise and lengthwise

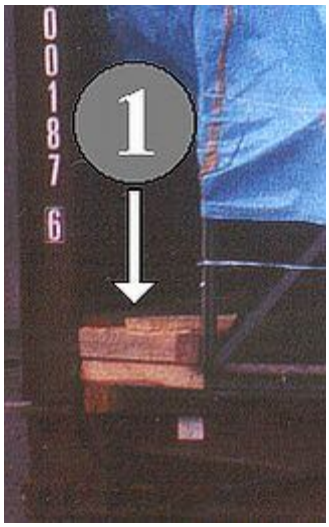
(2) = boards fitted lengthwise
(3) and (4) = crosspieces at the ends of flatrack and case
(5) = bracing members fitted lengthwise

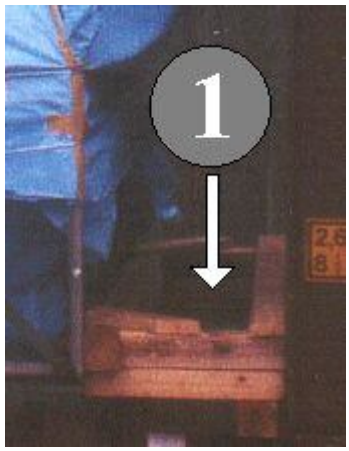
5.2.8.13 Overheight and overwidth cases on flatracks, example 7

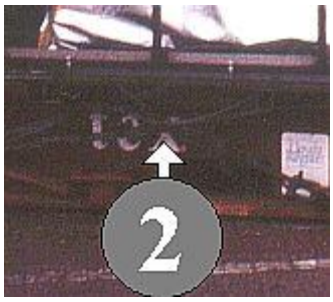
Crate made from steel angle sections on a 20' flatrack



High-quality machine in a steel crate on a 20' flatrack



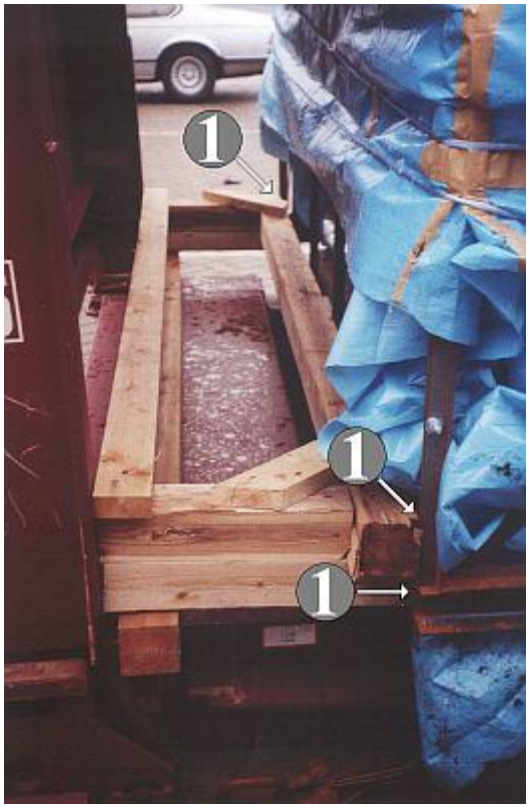




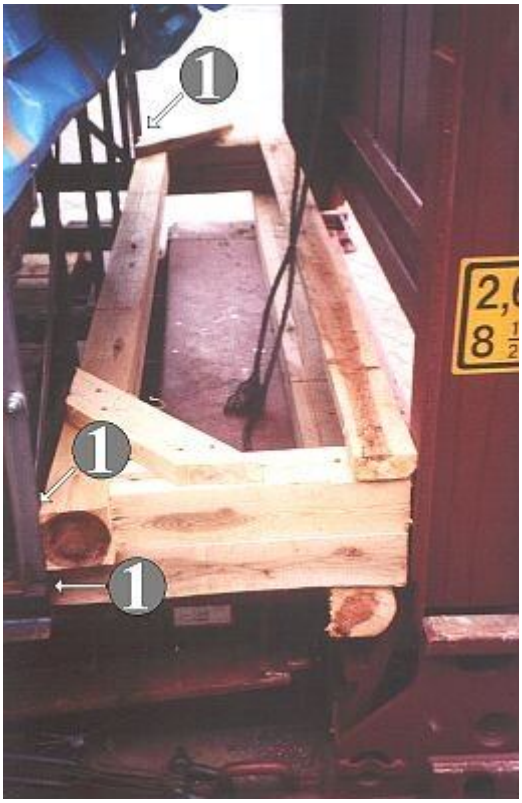


For clarification, the details from the picture which bear numbers 1 and 2 are shown at an enlarged scale.

A high-quality machine heat-sealed into a sealed package to protect it from corrosion is being transported in the crate. In principle, the sensitive sealed packages should be protected by a closed container or a case. In this case, loading in a closed container is out of the question because of the dimensions of the package. Therefore, stowage in a case with sufficient load-carrying capacity is essential.



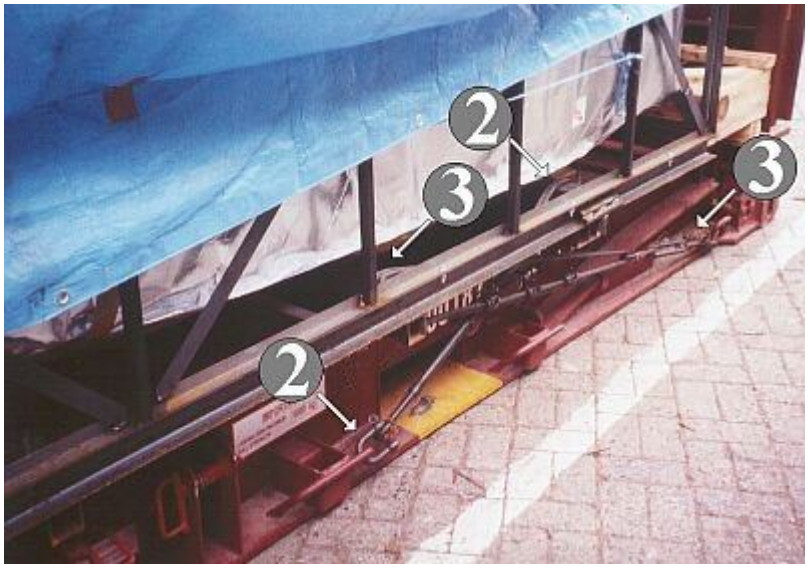
Above and right:
very small contact surface of the wooden bracing



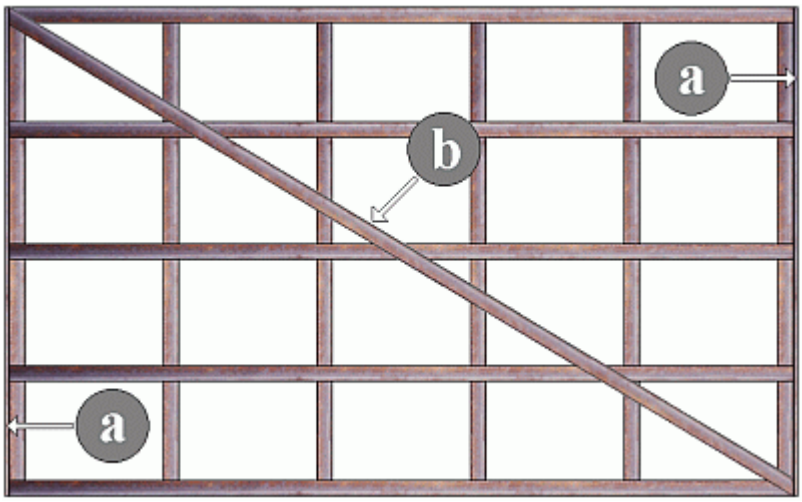
The lengthwise securing of the crate on the flatrack merits criticism insofar as only very narrow strips (1) of the steel angle sections are used as an effective area for bracing.

This may be the reason why steel wire ropes 16 mm in diameter are additionally used, together with turnbuckles and shackles, for lengthwise securing to prevent forward movement (2) and backward movement (3).

What is completely lacking is transverse securing of the crate.

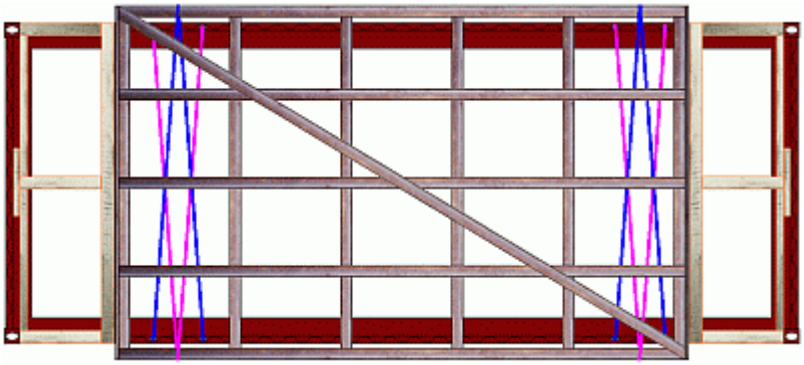


Lengthwise securing of the crate by steel wire lashings



Desirable steel crate base - plan view

So as to provide sufficiently large surface areas for bracing, flat steel profiles should be selected at the ends (a). For greater rigidity, diagonal stiffeners should be fitted (b).



Lengthwise and transverse securing of the steel crate at floor level - illustrated without the cargo for greater clarity

The steel crate may be easily braced lengthwise with wooden members, if appropriately constructed. Transverse securing may be effected at floor level by loop lashings, which are applied to the outer beams. Depending on the strength of the crate components, further loop lashings may be fitted.

Additional securing against tipping is recommended at the ends of the crate in the form of tie-down lashings or "cross lashings".

5.2.8.14 Overheight and overwidth cases on flatracks, example 8

Two crates made from steel angle sections on a 40' flatrack



This flatrack is loaded with two crates made from steel profiles. Wooden bracing has been positioned against the end walls to provide lengthwise securing. Lateral securing was provided for the longer crate in the form of four tie-down lashings and for the shorter crate in the form of two tie-down lashings made from steel wire ropes 16 mm in diameter.





Waste of materials due to nonuniformity of lashings

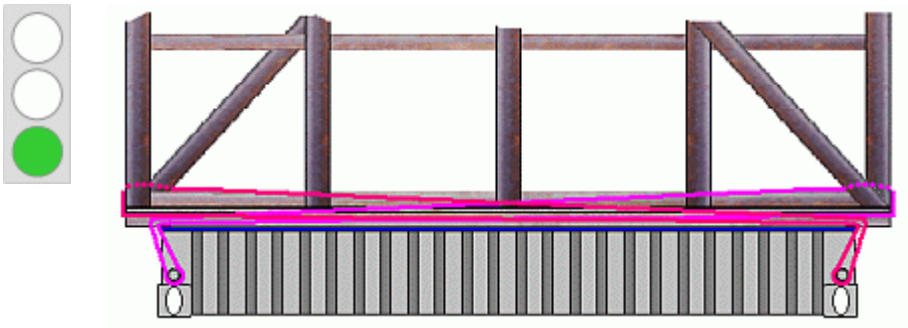
With a 16 mm steel wire rope, a maximum securing load of at most 10,240 daN can be achieved per single run. These values are reduced as a result of small deflection radii, using fewer than 4 wire clips, angles of spread (such as the 120° here) and similar factors. The lashing points probably have a maximum securing load of approx. 3,000 daN. A not inconsiderable amount of material has consequently been wasted. When selecting the lashing materials, the lashing personnel should have ascertained the maximum securing load of the lashing points.





Expert bracing at the ends

The bracing against the corner protectors of the flatracks does not merit any criticism. The use of the small board at (1) constitutes a minor defect and reduces the effective cross-sectional area of the bracing a little.

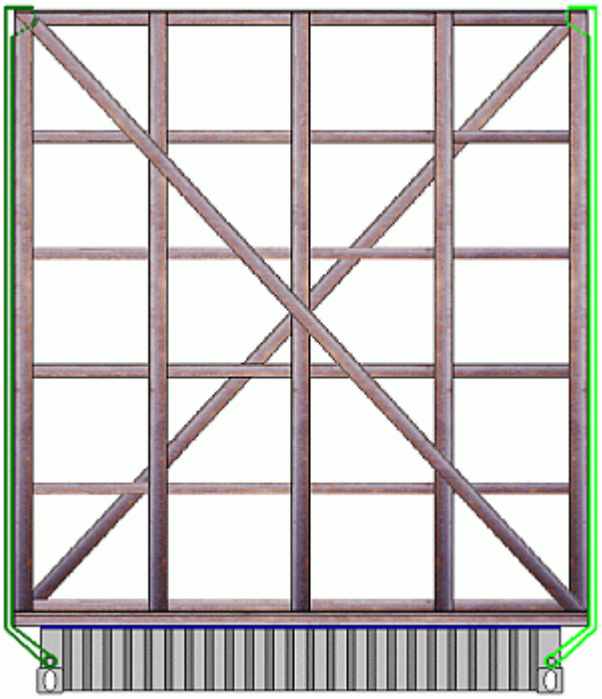


Transverse securing using loop lashings at floor level
- end-on view



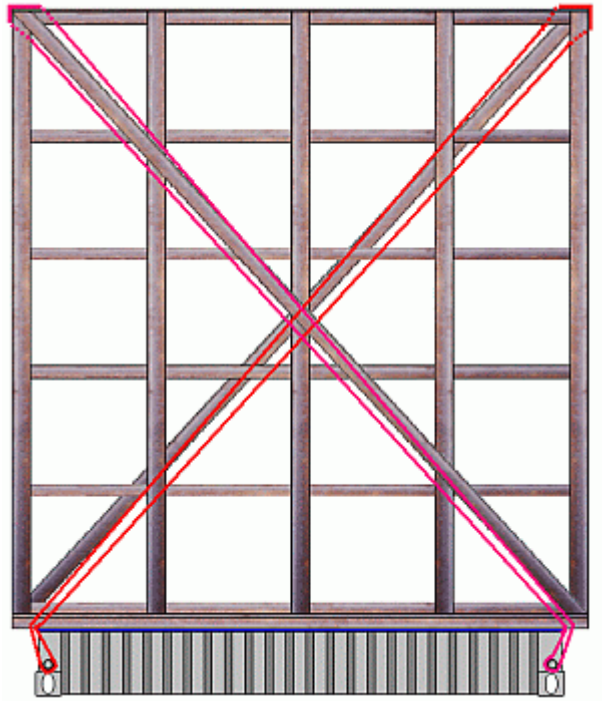
Transverse securing using loop lashings at floor level
- plan view

The most favorable force components for good transverse securing can be achieved by loop lashings. The maximum securing load of the lashing wires, lashing belts or other securing materials can be doubled by positioning the ends at separate lashing points. By laying friction-enhancing materials under the steel crates, the total securing forces required can be reduced.



Direct lashing against tipping

Rather than tie-down lashings, direct lashings should be used against tipping. Depending on the strength of the crates, these do not necessarily have to extend as far as the upper side rails, but can be attached lower down.



Unfavorable securing using diagonal lashings (cross lashings)

Cross lashings as shown have both corresponding transverse and vertical components. Nevertheless, the other methods described above (for separate application) are preferable to this combined method.



Diagonal lashings are virtually incapable of preventing tipping.

The Figures show that cross lashings are virtually incapable of preventing the shipping packages from tipping.

5.2.8.15 Overheight and overwidth cases on flatracks, example 9

Crate made from steel angle sections on a 20' flatrack



Inadequate transverse securing of a steel crate

Here too, transverse securing is provided solely by tie-down lashings. A negative feature is once again the nonuniformity of the 16 mm thick steel cable lashings. Another unfavorable feature is that all the turnbuckles are located on one side. One positive feature is the use of automobile tire segments as edge protection and to provide additional elasticity.



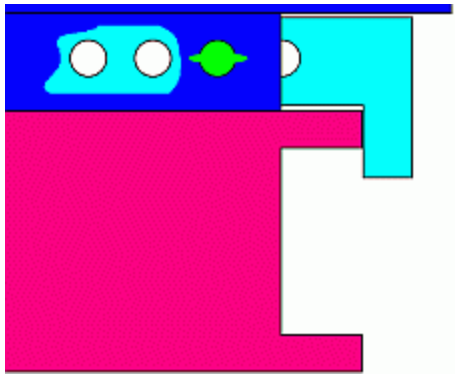
Left and below: lengthwise bracing in need of improvement





The lengthwise securing made from squared lumber is not as good as it could be. The wooden members are not applied against the parts with the best loading capacities, which in this case would be right at the bottom, where the crate of steel profiles is at its strongest. The unilaterally overhanging stowage arrangement adopted is cost-effective, as it allows one less slot to be used.





Transverse securing option provided on crate

Since steel profile crates are regularly used for carriage, a transverse securing option could be provided on the structure by the manufacturer. The bottom cross members of the crate often consist of rectangular tubing. These could be prepared in such a way that telescopic tubes with welded-on angles can be inserted

and secured with pins, such that the angles grip with a tight fit over the outer edges of the flatrack. With such crates, only means providing lengthwise securing and securing against tipping have to be fitted, which is cheap to achieve.

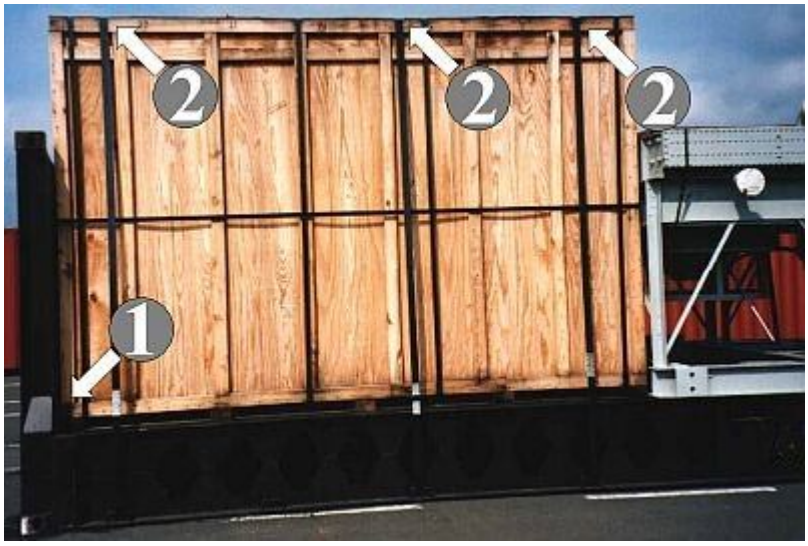
5.2.8.16 Overheight and overwidth cases on flatracks, example 10

Cases, some overheight and slightly overwidth, together with an overwidth plant part on a 40' flatrack



Export cargo on a 40' flatrack

The left-hand case is approx. 10 cm from the end wall of the flatrack and is secured with three tie-down lashings, the plant part and the case packed to the right thereof being secured with two tie-down lashings. The smaller wooden case is blocked into the lengthwise bracing.



Inadequate securing of the long wooden case

The gap at (1) could easily have been filled with 10 cm x 10 cm squared lumber. Steel strapping tie-down lashings tensioned over wooden edges (2) cut in, lose their pretension and are then only capable of providing a limited degree of securing. Securing with case restraint shoes at floor level is advisable. The steel strapping tie-down lashings could remain as securing against tipping, if segments of rubber tire were laid under them. Heavy-lift steel cornerpieces can prevent cutting into wooden members. However, these measures do not alter the fundamental disadvantage of steel strapping, i.e. its low elasticity.



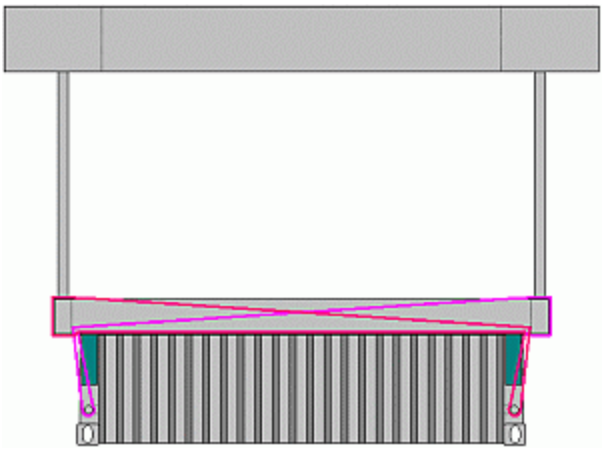
Inadequately secured plant part

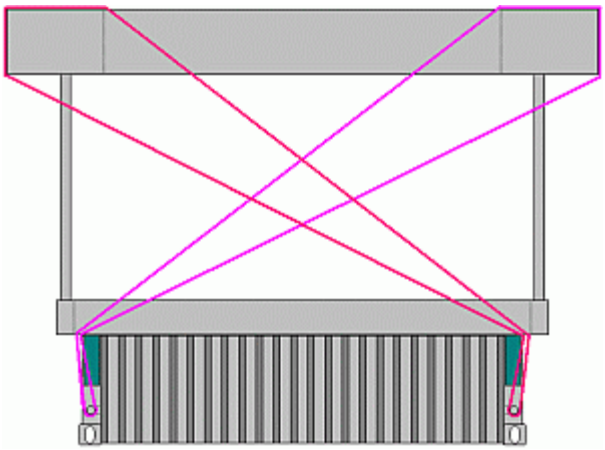
The two tie-down lashings alone cannot secure the cargo in the long term, given that steel is here stowed

on steel. The plant part is freely movable sideways in the tie-down lashings.

The plant part should as a bare minimum have been placed on friction-enhancing material, or at the very least wooden boards.

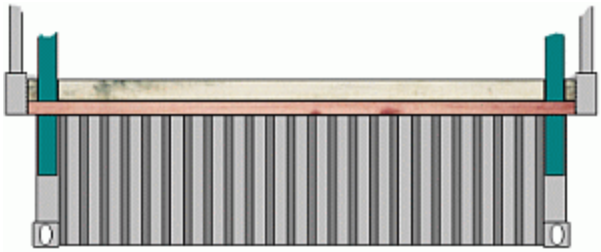
Right and below: possible securing using loop lashings



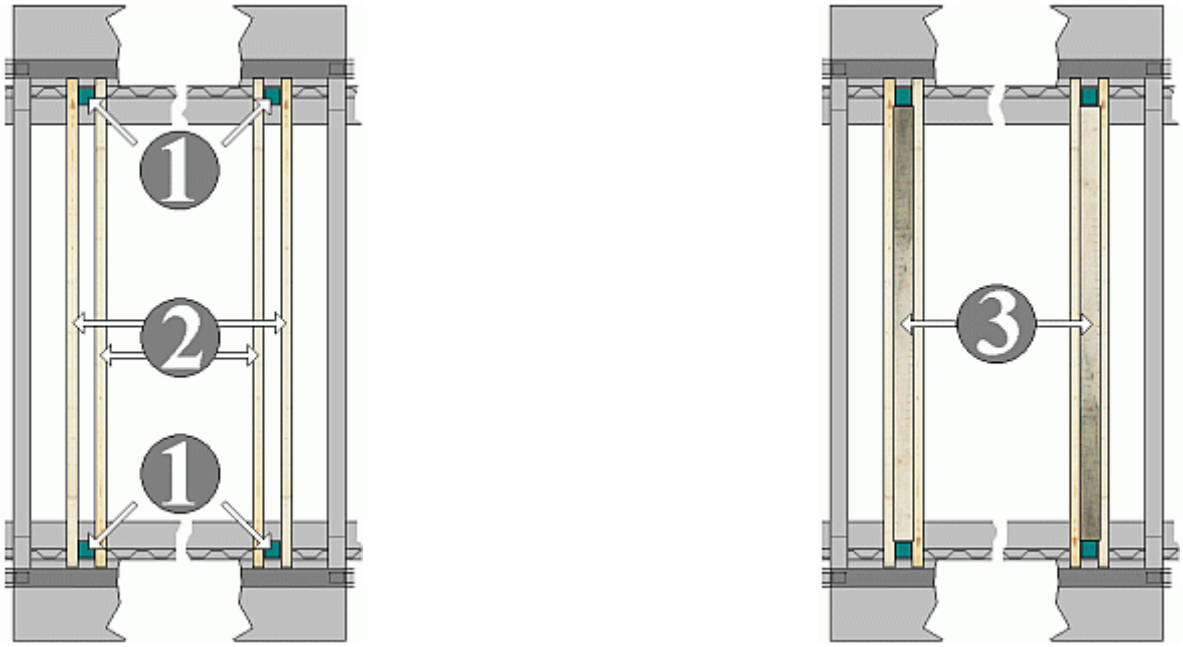


Loop lashings have already been suggested so often in this section that this option should generally be considered and assessed for possible ways of implementing it. However, another securing method is feasible:

Since the base frame of the plant part projects over the sides of the flatrack, internal bracing is an option. For this purpose, short steel profiles corresponding to the stanchion cross-section are inserted into the stanchion pockets. If the flatrack has very low stanchions, these may of course be used.

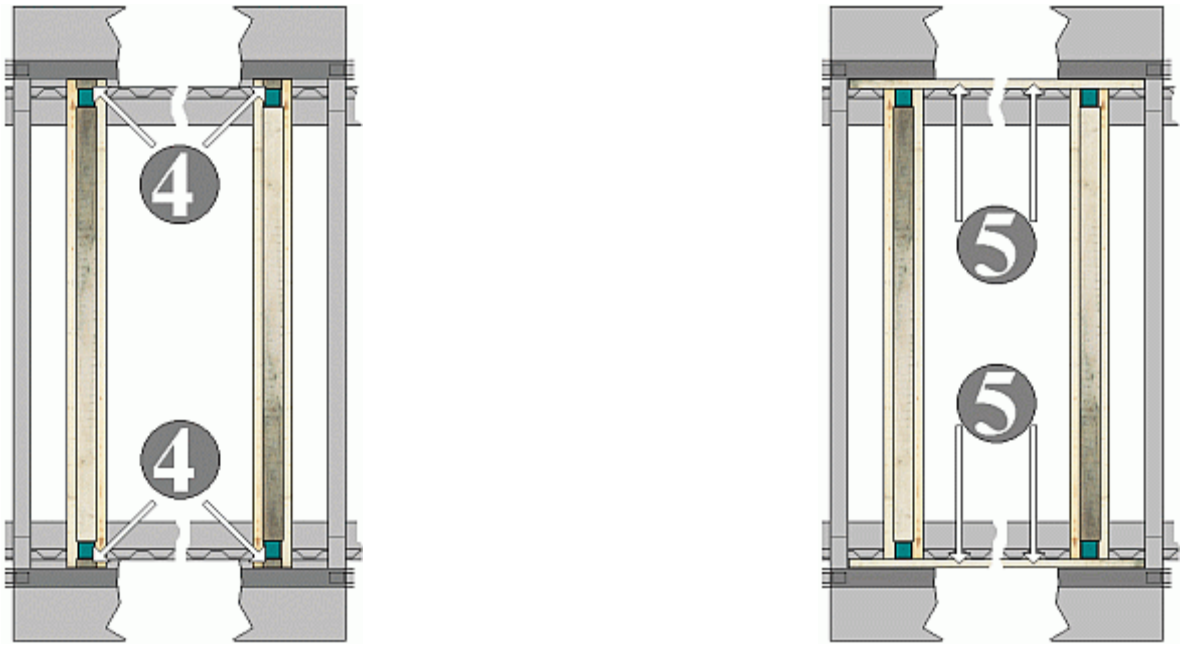


Bracing against steel profiles
inserted into the stanchion pockets



Producing internally acting wooden bracing
- steps 1 to 3

Wooden beams, for example 6 cm x 8 cm beams, are laid on their edges to the left and right of the inserted steel profiles or stanchions (1) and attached to the flatrack floor (2). The length of the beams must be matched to the internal dimensions of the structure to be secured, but they do not have to be cut absolutely exactly to size, since they are just auxiliary wooden members. A squared lumber member (3) cut precisely to length is fitted onto each pair of beams between the steel profiles or stanchions and fastened to the beams. Each squared lumber member is intended to allow utilization of the strength of two profiles or stanchions. This step can be omitted if the cargo items are light.



Producing internally acting wooden bracing
- steps 4 or 5

Squared lumber pieces (4) are fitted precisely in the crosswise direction or squared lumber is fitted in the lengthwise direction (5) between the internal edge of the plant part and the external edge of the steel profile or stanchion and in each case fastened to the beams beneath.

The squared lumber at (4) is loaded against the end grain, i.e. end on to the grain. A maximum securing load of 400 daN per square centimeter of effective supporting surface area may therefore be expected. The squared lumber at (5) is loaded perpendicularly to the grain. In this case, an effective supporting surface area of only 30 daN per square centimeter can be expected.



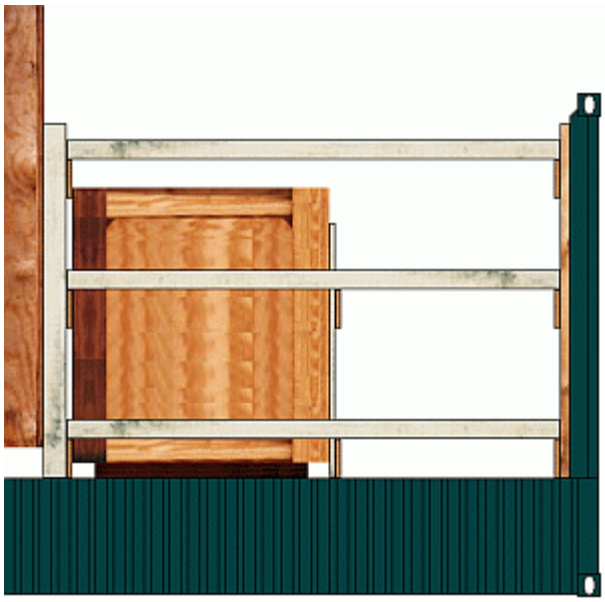
Wooden case secured inadequately in the crosswise direction

The statements already made in relation to the longer case also apply to securing of this taller case.



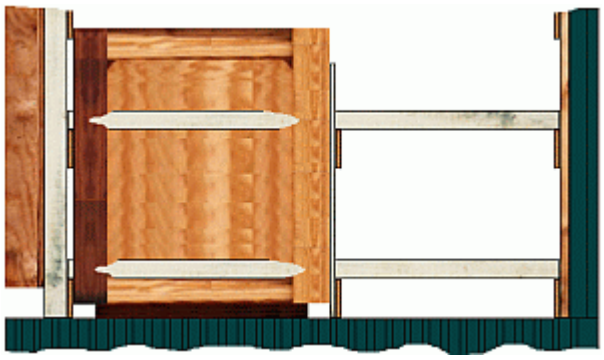
Lengthwise case securing in need of improvement

Positive comments first: The bracing for the tall case has been fitted in such a way that the plate action of the sides of the case (a) is exploited. The small case, positioned in the stowage gap, is only secured by wooden fixings (b), i.e. planks nailed on crosswise. The diagonal boards serve to stabilize the structure.



Expertly braced cases

The tall case is braced by horizontal wooden members, which lie on the transverse boards of lattices. The lattice in front of the case consists of two vertical squared lumber members and three transverse boards, while the lattice in front of the flatrack end wall is made from two vertical and three transverse boards.



Securing of the small case

The small case is secured by building a small lattice from two vertical and two transverse boards and positioning it against the case end wall. Squared lumber is fitted between this lattice and the one against the flatrack end wall. To provide lateral securing, squared lumber is additionally threaded through and fitted next to the case.

5.2.9 Palletized cargo

The advantage of correctly palletized cargo is that cargo handling can be mechanized and, provided the pallets fit the container, securing can largely be dispensed with. Provisos are that the pallets are sensibly packed, the dimensions of the packed pallets in the lengthwise and crosswise directions each correspond to fractions of the internal container width, length and height and the pallets are stackable. If these conditions are met, and strictly speaking only if they are, can cargo be described as "fully palletized". Many cargo handling and packing companies offer special terms for fully palletized cargoes.





Packing a container with palletized cargo without interlayer dunnage

If the packages are strong enough, they can be stacked on top of one another without interlayer dunnage.







Packing palletized hazardous materials with interlayer dunnage

If the pallets or goods are more sensitive, interlayer dunnage made of lumber, hardboard, chipboard or similar materials should be put in place to distribute pressure.





Palletized cargo - incorrect





Palletized cargo - correct

Even small gaps and slightly sloppy packing methods can cause the packages to cave in and goods to be damaged. If the pallets delivered are neatly packed and interlayer dunnage is used for packing, such shortcomings can be prevented. Even the smallest gaps must be filled, be it with wooden boards, airbags

or, as here, with old pallets.





Packing a 40' container with palletized cargo





Deficiently packed palletized cargo



The shipping packages are not well packed. Interlayer dunnage is essential with the type of pallet base used. The gaps left are too big.

Packing gaps = packing deficiencies

Every packing gap constitutes a potential risk. Damage can only be prevented by absolutely compact stowage.

The greatest deficiencies which occur when packing palletized cargo are that the pallets are not properly packed and the pallet dimensions are not conformed to the containers used. A few examples follow:



Who could load pallets like this without having to put an unusually large amount of effort into securing them? At the same time, such pallets are in contravention of the dangerous cargo regulations and the CTU packing guidelines. The general introduction to the IMDG Code reads.:

> *For the purposes of this Code, a "unit load" means a number of packages that are:*
>
> *1.) placed or stacked on and secured by strapping, shrink-wrapping or other suitable means to a load board such as a pallet; or;*
>
> *2.) placed in a protective outer enclosure such as a pallet box; or;*
>
> *3.) permanently secured together in a sling.*
>
> *10.18.2 packages that contain hazardous goods, that are permitted to be transported in accordance with the code, may only be transported in unit loads if the following conditions are fulfilled.*
>
> *10.18.2.1 It may occur that the packages in a unit load will need to be separated. In this event, it must be ensured that the individual packages can be handled safely.*
>
> *10.18.2.2 The unit loads should be compact, have as regular a form as possible, and for the most part, vertical sides. The top of the unit load should be level. It must be possible to stack the unit loads. They must be constructed and secured in such a way that it is unlikely that the individual shipping packages can become damaged.*

10.18.2.3 The unit loads must be sufficiently strong to withstand repeated loading and stowing operations and they must be able to bear unit loads with a similar specific mass which are stacked on them to a height commonly occurring during transportation.





What conclusion would one draw from a comparison of the text of the regulations with reality?

The CTU packing guidelines contain a similar comment under point 4.2.8:

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





It may be noted also with regard to these requirements that there is general ignorance of the law and of transport safety.





Unsecured cargo





Secured cargo

Although this cargo is not palletized, it resembles palletized cargo from the point of view of base and overall treatment. As is clear, appropriate compact stowage can be achieved without much effort.

5.2.10 Paper rolls

5.2.10.1 Paper rolls, vertical axis

Examples of paper and other roll-shaped cargoes

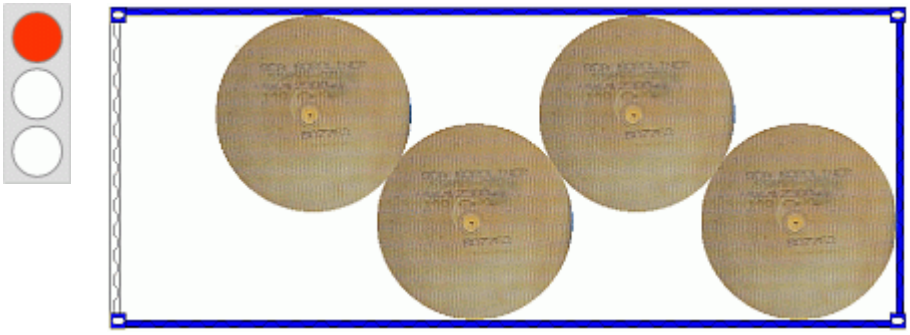
In the case of newsprint, it is important for the container floor to be absolutely clean. Even the smallest amount of dirt from the floor could bring a printing line to a standstill if it becomes pressed into the rolls. Kraft paper or the like is recommended as floor dunnage. Friction-enhancing materials may also be used under the load, corresponding at least to the cross-sectional areas of the rolls.





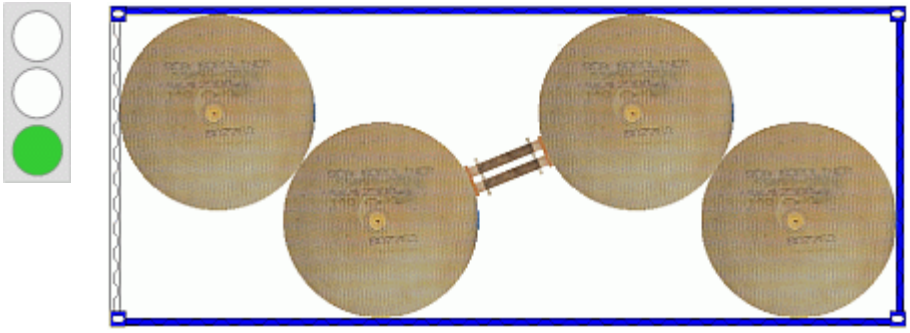
Compact packing for roll diameters of 1,300 mm

Packing of paper or kraftliner rolls is problem-free, if the diameters allow absolutely compact packing, as is the case here for rolls with a diameter of 1,300 mm.



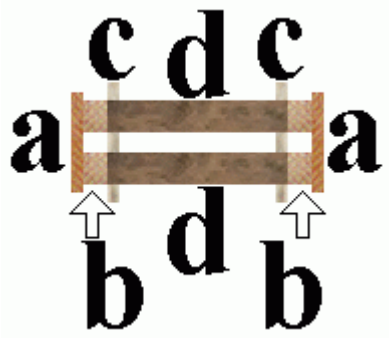
Gaps left in the case of roll diameters of 1,500 mm

Where rolls have diameters of, for example, 1,500 mm, gaps are left. For reasons of load distribution, these must not be left in the door area, as here.



Bracing of a gap for roll diameters of 1,500 mm

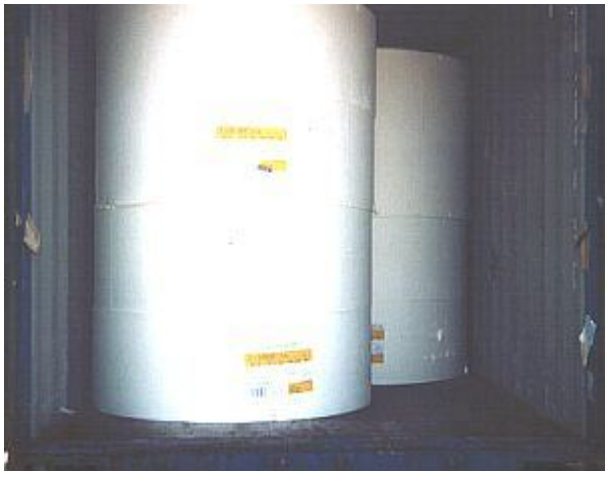
The first two rolls are loaded The third is placed in the position of the last roll and the semicircle of the roll which points forward and to the middle is traced on the floor with chalk. Roll three is then brought into its final position. Wooden bracing is applied and fixed between rolls two and three. Roll four completes the packing operation.



Wooden bracing for bracing rolls - plan view

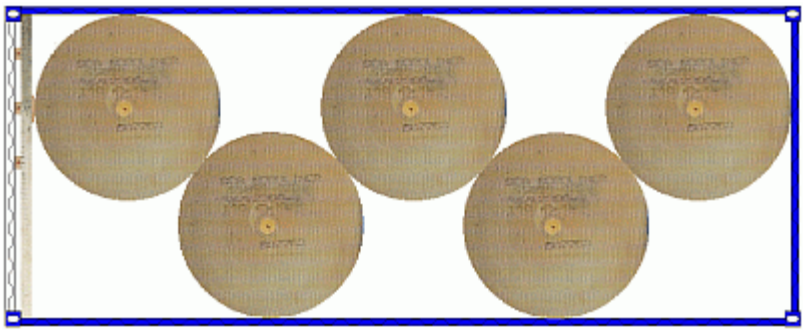
The bracing consists to the left and right of a wide board (a), to each of which two beams (b) have been nailed vertically. Transverse boards (c) or beams are nailed to these beams at quarter and three-quarter height of the roll, and serve as supports for the bracing members (d).

To ensure that the bracing does not change position, it is essential for it to be fixed, but how this is done depends on the conditions in the container.



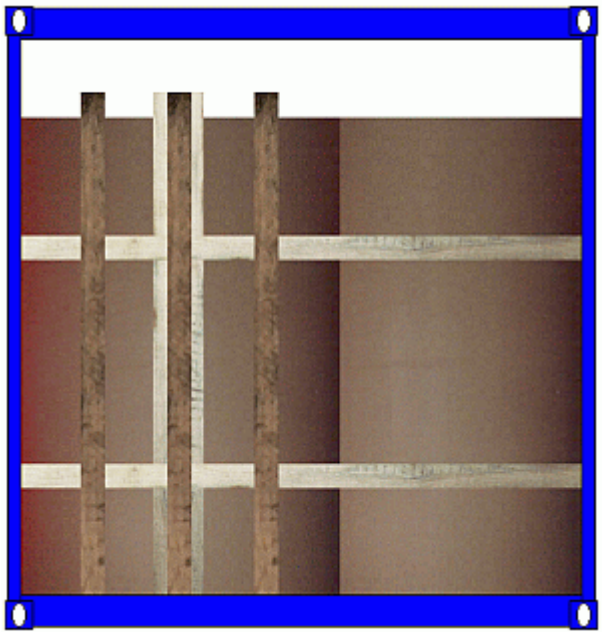
Small gap in the door area with roll diameters of 1,425 mm

Even a relatively small gap should be closed, while absolutely avoiding point loads.

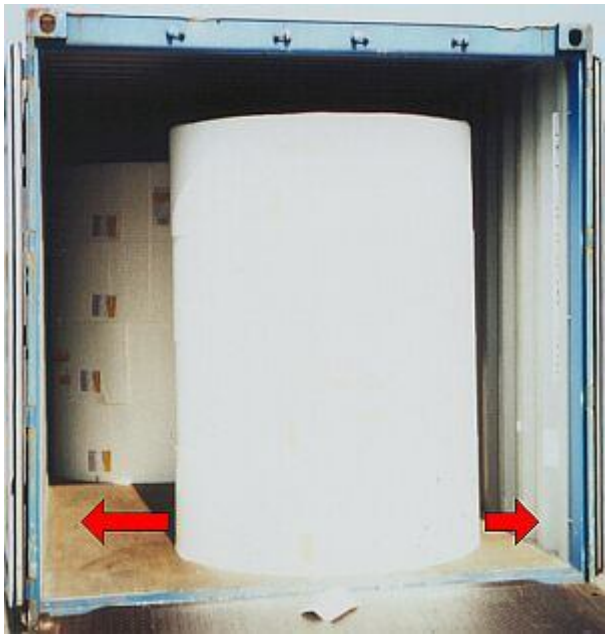


Bracing of a gap in the door area - plan view

A board is positioned vertically against the center of the roll(s). Squared lumber is fitted transversely between the container corrugations at quarter and three-quarter height, and if required also in the middle. Boards, beams or squared lumber are fitted in perpendicularly thereto in such a way that the remaining gap is filled as far as the door leaf.

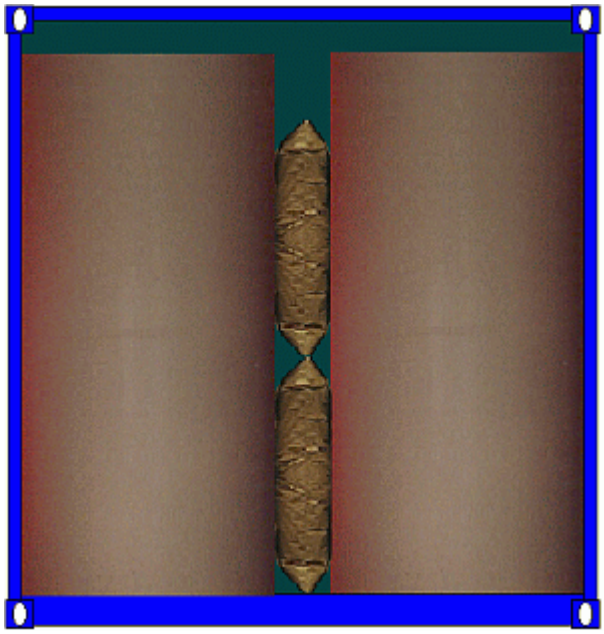


Bracing of a gap in the door area



Inadequate packing of paper rolls

Under no circumstances should gaps be left on both sides, unless they are filled in.



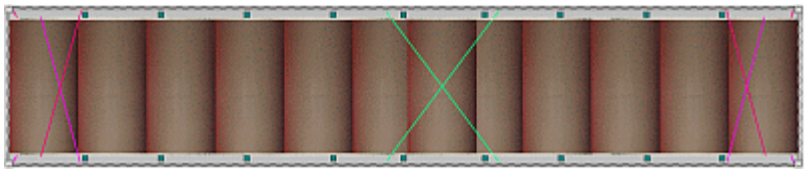
Paper rolls secured with airbags
- end-on view

Vertical rolls can be secured cheaply with airbags if the gaps left are narrow, e.g. approx. 20 cm.

5.2.10.2 Paper rolls, axis lying crosswise

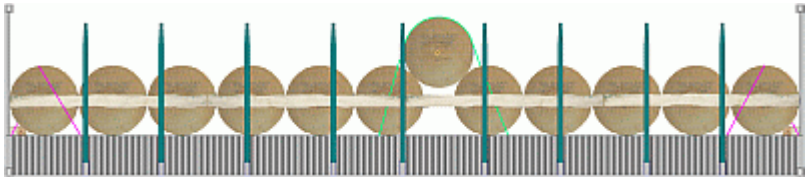
Rolls could also be stowed with their winding axes lying crosswise but this makes packing and unpacking far more difficult. The method is not therefore to be recommended.

Kraftliner rolls on flatracks with stanchions are an exception. Both packing and unpacking and securing are then cheap to implement.



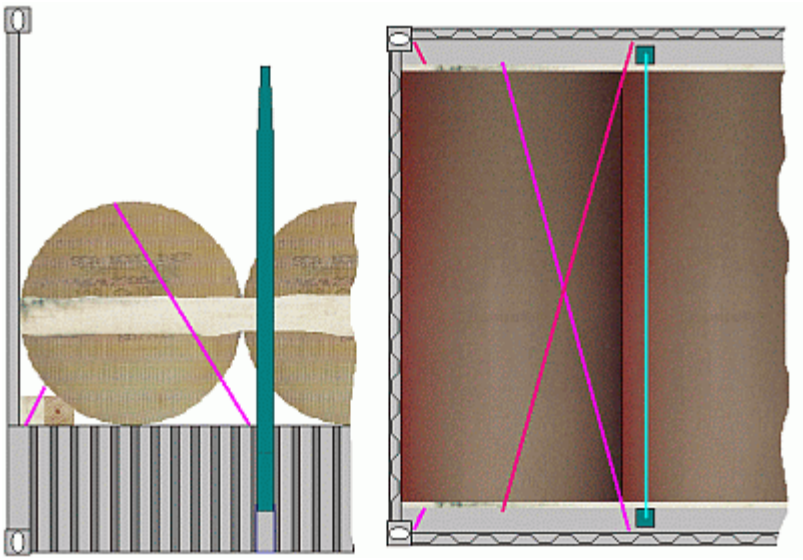
Kraftliner rolls on a 40' flatrack - plan view

Because of their dimensions, six rolls are loaded from the left-hand end wall and five from the right-hand end wall towards the middle and the twelfth roll is positioned in the cantline.



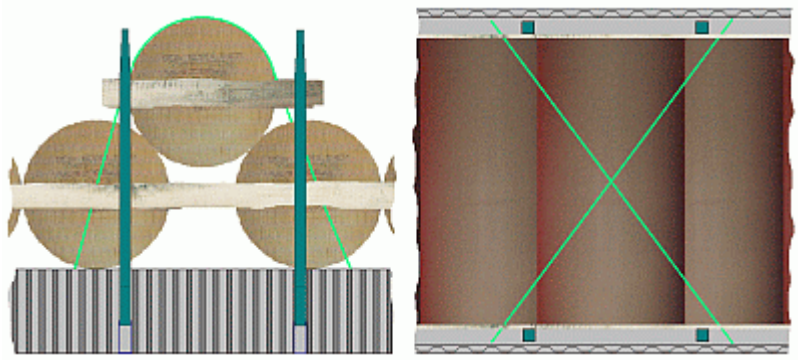
Kraftliner rolls on a 40' flatrack - side view

Crosswise, virtually all the rolls are secured with a tight fit by filling the small gap between them and the stanchions with boards attached at the level of the roll eye. All the stanchions are lashed together (this detail was omitted from the overall views). To relieve the end walls, the outer rolls are propped by crosswise wedge beams and braced against the end walls.



Securing of the outer rolls - side view and plan view

Crosswise, the outer rolls are secured with loop lashings, which pass around the securing boards.

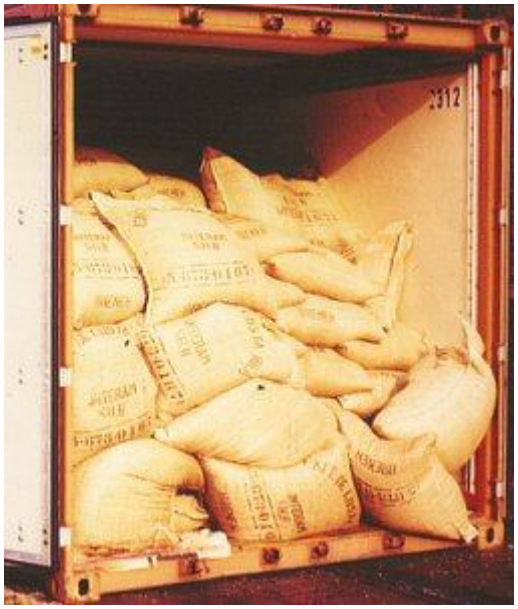


Securing the roll in the cantline - side view and plan view

The roll lying in the cantline is also secured by means of boards fixed to the stanchion and overlashings. Strips of friction-enhancing material are positioned at the points of contact with the rolls packed underneath.

5.2.11 Bagged cargo

Bagged cargo Some information has already been provided about bagged cargo and the various packing methods in the sections on packing and basic stowage methods. In general, packing patterns should be used with which the containers can be packed with the fewest possible gaps and to a uniform height.



Import container with coffee bags

An example of a chaotic "stowage pattern". The stow was not anchored.



Jumbled plastic bags

In neither of the cases shown had the cargo yet suffered any damage, but the high additional costs of additional manual labor must be borne in mind.

In the light of these two pictures, it is worth taking a look at the CTU packing guidelines, which state in point 5, which provides advice on receipt of CTUs:

> *5.1 When receiving a CTU, the receiver should ascertain that the unit is externally in good condition and without damage. If there is any damage, the receiver should document and notify it as appropriate. Specific attention should be paid to damage that may have influenced the condition of the cargo within the unit. If the receiver detects any damage during the discharge of the unit, this should be documented and notified as appropriate. If a package containing dangerous cargoes is found to be so damaged that the contents leak out, the immediate area should be evacuated until the hazard potential can be assessed.*
>
> *5.2 Persons opening a CTU should be aware of the risk of cargo falling out. Doors, when opened, should be secured in the fully opened position.*

5.2.11.1 Bagged cargo, unpalletized

It is essential to load unpalletized bagged cargo in a compact manner. Plywood or aluminum containers with a plywood liner are to be preferred to corrugated steel containers. When inspecting fitness for loading, one very important point is to check for the absence of pointed or sharp-edged parts which could damage the cargo; even small splinters of wood on the container floor, residues of old cargo securing material, protruding nail ends or the like may cause such damage. If such sources of damage cannot be eliminated, they should be carefully covered over. It is often recommended to pack bags in a crisscross arrangement. This ensures good stability within individual stacks, but not an interlocking stow. Labor costs are higher because the bags have to be rotated or alternately positioned in different directions.



Non-interlocking stow:
alternate longitudinal and crosswise packing

However a cargo is packed, an interlocking stow must be created in some way. This can be achieved by

including "anchors" in the stow. These anchors may take the form of wooden dunnage boards, walking boards, plywood sheets and similar materials inserted as interlayer dunnage. In the case of bags with very smooth surfaces of plastic or plastic-coated paper, anchors may also consist of grayboard, kraft paper or the like. Application of antislip sprays may also be of assistance.



Absence of anchors promotes bag slippage.

In this case, the bags were simply stacked in a "tower" without any interlayer dunnage as the anchor. No interlock means no stability.

5.2.11.2 Bagged cargo, palletized



Excessively large gaps in the stow

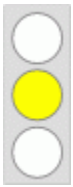
These small gaps are enough for the bags, when exposed to the movement of the sea, gradually to work

free under the relatively loosely shrink-wrapped cover and be abraded at the bottom on the pallet boards. If some of the bags are damaged and "bleed", they will create ever more free space which may result in damage to the remainder of the cargo. The gaps are there because of the dimensions of pool pallets. With dimensions of 800 mm x 1,200 mm, one pallet loaded crosswise and another longitudinally will together occupy a width of 1.2 m + 0.8 m = 2.00 m, while the internal width of the container is approx. 2.34 m, so leaving a gap of 34 cm.



Unacceptably large gap in the stow and non-flush packed pallets

Bigger gaps mean an even bigger risk. It is favorable if pallets are adapted to the container door dimensions and virtually match the internal dimensions. So that, during packing with forklift trucks, bags on any already loaded pallets are not damaged by pallets which have been lifted up for subsequent loading, it is worthwhile placing walking boards or hardboard sheets vertically between the pallets.





Without separation by walking boards





With separation by walking boards

Some of the bags are so slackly filled that the lower layers have already been squashed. When packed in corrugated containers, such pallets can cause problems during unpacking as they may adapt to the shape of the corrugations, making them difficult to unpack.

5.2.11.3 Big Bags

The same rules apply to Big Bags as to all other goods. It is essential to avoid gaps in the load as this is the only way to ensure that damage will not occur in transit.



Exemplary container packing with Big Bags

If packing is continued in the same manner and proper bracing is provided in the gaps in the door area, this will be a copybook example of packing. Such compact loading is only feasible and a positive example because the bag fabric is sufficiently strong for the Big Bags not to be able to conform to the corrugations. The amber traffic light is intended to signify "Caution" because, with a softer fabric, hardboard or similar material should be placed against the side walls to stop the Big Bags from meshing with the corrugations in the walls.





The wooden interlayer dunnage is not enough on its own.



No comment!

5.2.12 Cartons

Other Sections have already addressed cartons and how to load them in some detail, so this Section will provide only a few notes.

The loading area should be filled as completely as possible. When the orientation of the corrugations in corrugated board can be determined, it should be taken into account during loading, if possible being kept upright. If this is contradicted by handling symbols such as "Keep upright", the symbols should be obeyed. As early as during preliminary planning, it is possible to calculate the stacking height at which it is possible to achieve a uniform cargo block over the entire length of the container. Depending upon the strength of the cartons, interlayer dunnage may have to be used. In the case of very weak cartons, the interlayer dunnage may be supported like a "false deck". If gaps occur during packing, they must be filled immediately as it will not subsequently be possible to reach the gaps without damaging the cargo. Stacking in an interlocking pattern is sometimes recommended. In the present author's opinion, this is inadvisable because higher levels of strength are achieved if the outsides of the cartons are arranged perpendicularly one above the other. An interlocking stow is better achieved by using anchors of kraft paper, grayboard or similar material.

Any remaining gaps in the door area can be filled with wooden lattices and squared lumber bracing against the corner posts.



How it actually was ...



... and how it

could have been!



Manual packing of cartons and trays

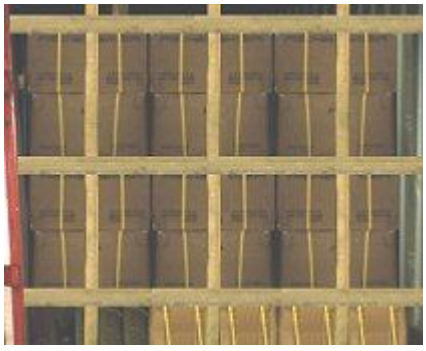




Even with "big cartons" the gaps must be filled.



Compactly packed container



Securing in the door area with a lattice

5.2.13 Pipes, nonmetallic

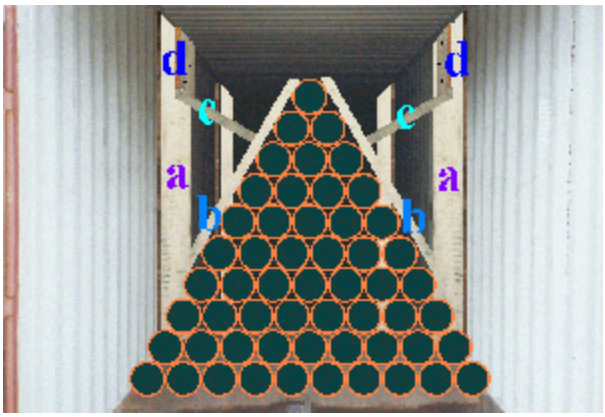
The basic stowage methods section has already described how to pack and secure pipes with sockets. The metallic pipes examples included tips for packing and securing socketless pipes. Nonmetallic pipes, whether made from ceramics, plastics or other materials, can be secured very effectively in the sideways direction with loop lashings. Lattices can be used in the lengthwise direction. Neither securing method exerts harmful pressure on the pipes to be carried. Only once inertia forces come into play due to acceleration do the securing means become effective and exert forces on the cargo.

The following example is simply meant to demonstrate that even sensitive pipes can be secured with lumber, in particular when a container lacks lashing points.



Securing a stack of pipes with boards and beams

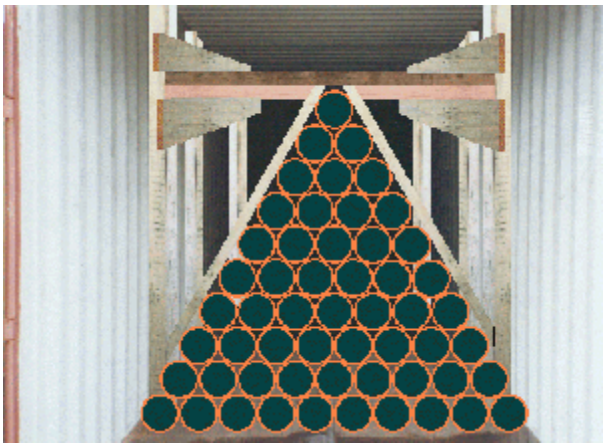
This method is relatively simple to implement. For clarity's sake, only the front part is drawn in.



Securing with boards and beams - key

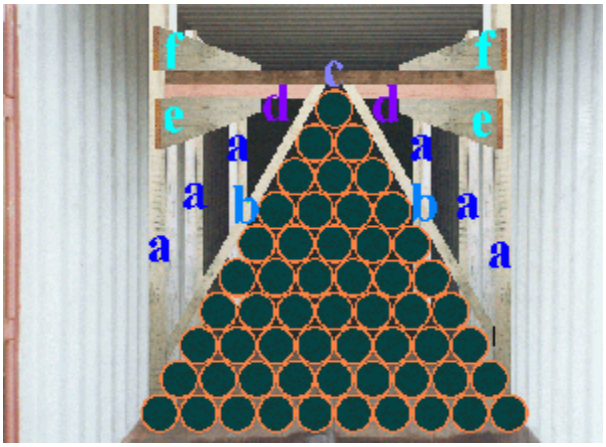
Boards (a) are arranged in pairs against the container side walls before the pipes are placed inside. Once the pipes have been packed, squared lumber beams (b) are laid on the sides of the pipe stack in such a manner that the cut bevels are wedged against the boards. The wooden securing members are fixed in place using further beams (c) and nailed-down board ends (d). Additional longitudinal boards or wooden X-bracing, which may be used to reinforce the overall structure, have not been drawn in.

The following Figure shows another possible design:



Securing a stack of pipes with squared lumber, beams and boards

In order to clarify the order in which the securing operations are carried out, the same diagram is given below with an added key:



Securing with squared lumber, beams and boards - key

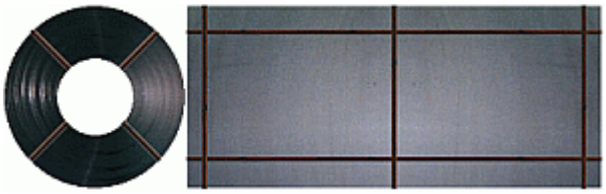
Before loading, squared lumber members (a) are arranged in pairs against the container side walls, either fitted exactly into the corrugations or fixed with driving wedges. Depending on their mass, once the pipes have been loaded, squared lumber members or beams (b) are placed on the sides of the pipe stack and wedged against the squared lumber uprights with their beveled ends which have been cut to size. In order to fix these wooden members at the top, a squared lumber member (c) with two wooden members (d) nailed on underneath is in each case fitted between the squared lumber uprights in such a manner that the wooden members (b) are held together at the top. The boards (e) and (f) are provided in order to fasten the members (c) and (d) together and they moreover provide additional stability to the entire structure. Some of these operations can, indeed should, be carried out outside the container or before packing.

5.2.14 Steel and metal cargoes

5.2.14.1 Steel coils: general information

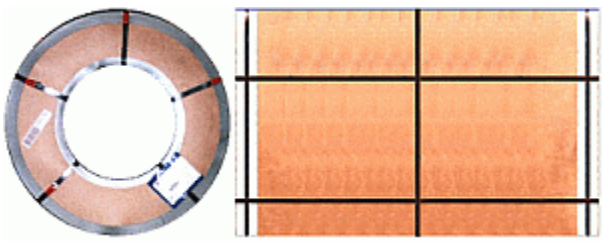
Coils: general information

(Steel) coils are rolls of steel sheet, which are primarily classed as either hot-rolled strip or cold-rolled strip. Slit strip coils with a shorter winding axis are produced from wide strip in special slitting plants; slit strip coils may be transported individually or consolidated into bundles. Slit strip coils are often supplied on wooden sleds or skids with the winding axis vertical. Other coils may, however, also be supplied for shipment fastened onto skids with the winding axis vertical or horizontal. Coil remnants are lower grade goods and are often only loosely wound.



Hot-rolled strip, only bundled

Hot-rolled strip is almost always shipped unpackaged, only being held together with a variable number of steel straps. While attention must be paid to protecting such goods from damage also with regard to cargo securing measures, the risks are not so great for hot-rolled sheet. Edge protection, for example, is not so important. The situation is quite different with cold-rolled sheet, which has almost always been pretreated and is very sensitive. Transport risk varies as a function of the mode and route of transport and such products are often provided with different grades of packaging as a consequence.



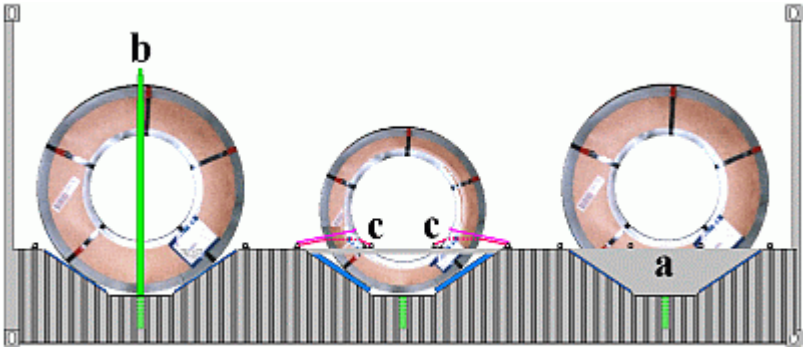
Cold-rolled sheet in packaging of special paper, hardboard and folded sheet metal edge protectors

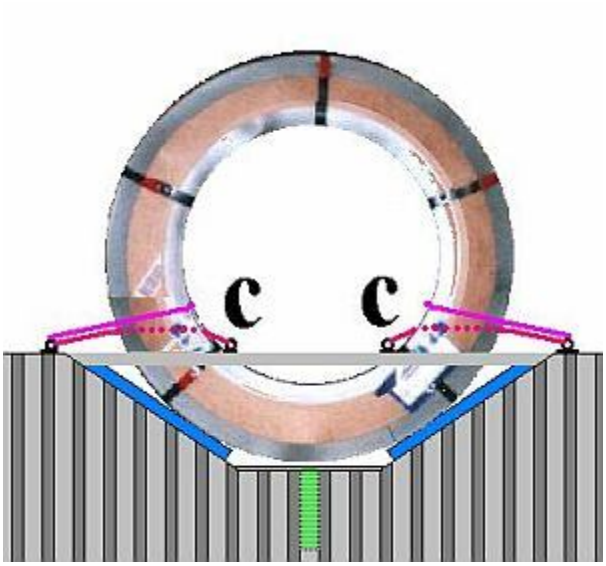
Special container for coil transport

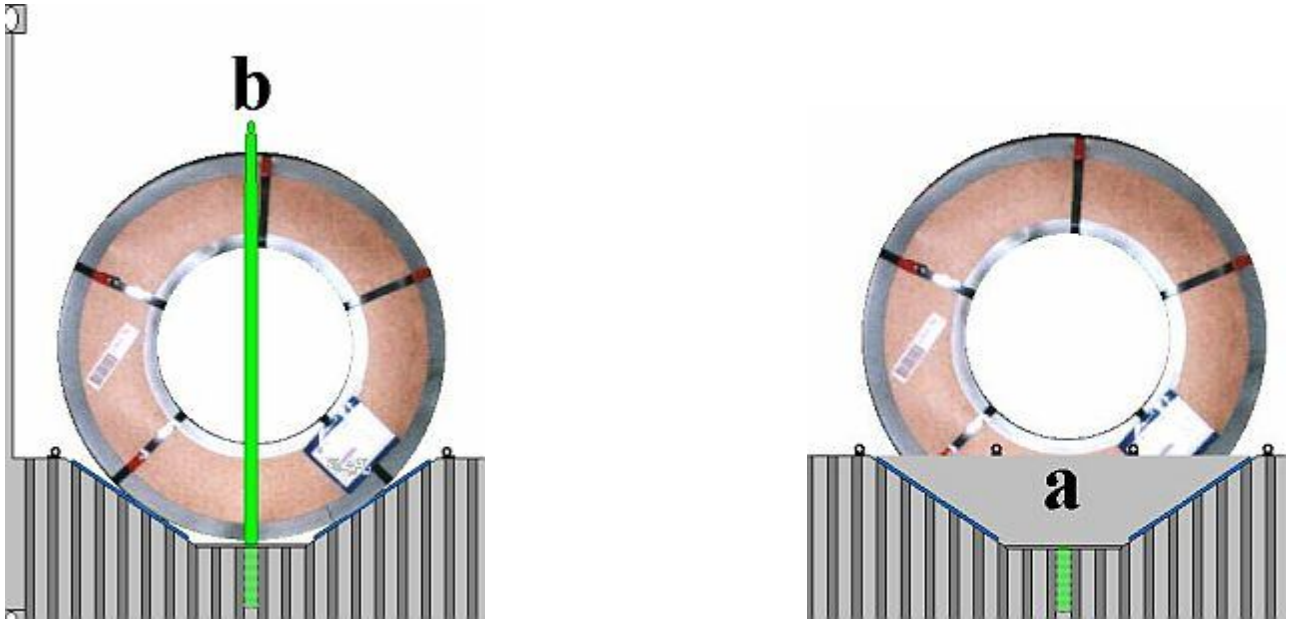
Shipowners will always tend to prefer to carry containers which are as versatile as possible. From the standpoint of cargo securing, i.e. disregarding climatic and chemical transport risks, coils are best shipped on coil containers. These are flatracks which have special troughs for coils and, in some cases, also additional cargo securing equipment.

In conventional coil containers, the coils are carried with the winding axis lying crosswise. So that these containers do not have to be used solely for carrying steel coils, the troughs can, or could, have covers making it feasible to a limited extent also to carry other goods on these flatracks.

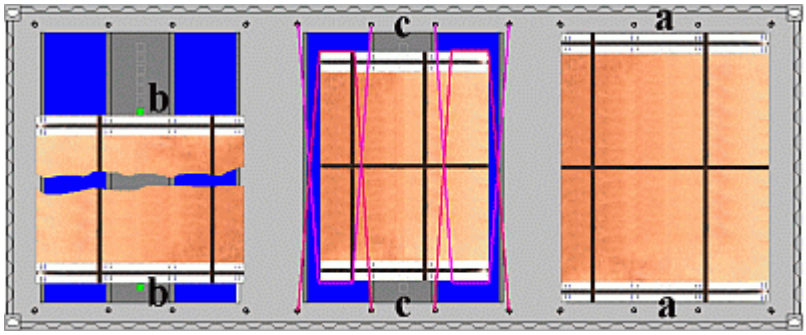
5.2.14.2 Coils on coil containers





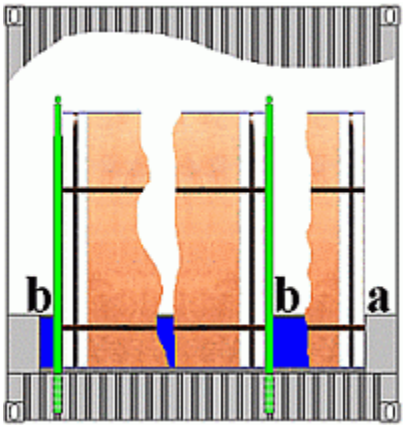


Top and selective enlargements below:
Coils loaded on a coil container - side view

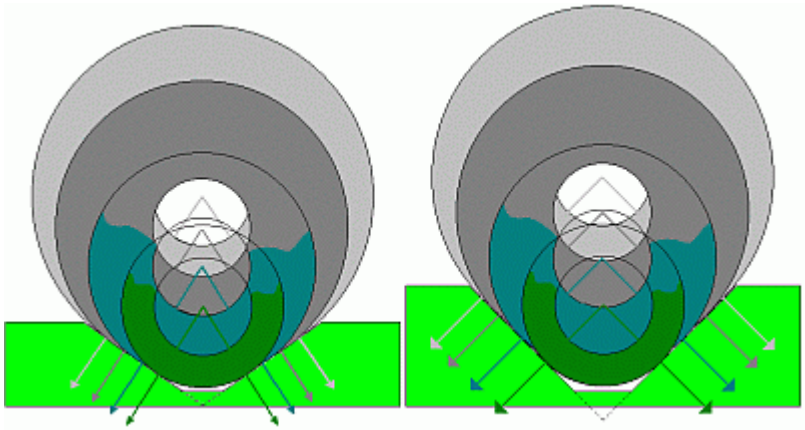


Coils loaded on a coil container - plan view

Depending on their dimensions, coils may rest directly against the sides of the coil trough (a), be secured by stanchions (b) or be held in position by loop lashings passed through the coil eye (c).



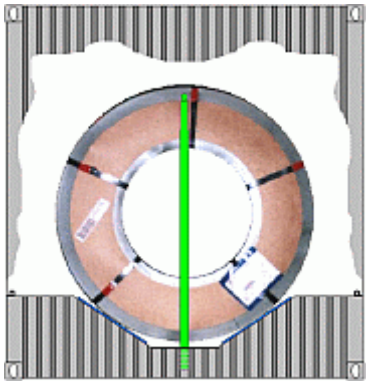
Coils loaded on a coil container - cross-section



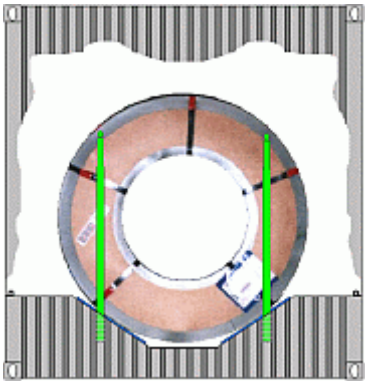
Coils of various diameters in a 35° and 45° coil trough

The flank angle directly determines the degree of securing and the strength of the components to be selected by the designer. Components must be dimensioned in accordance with the highest acceleration forces encountered.

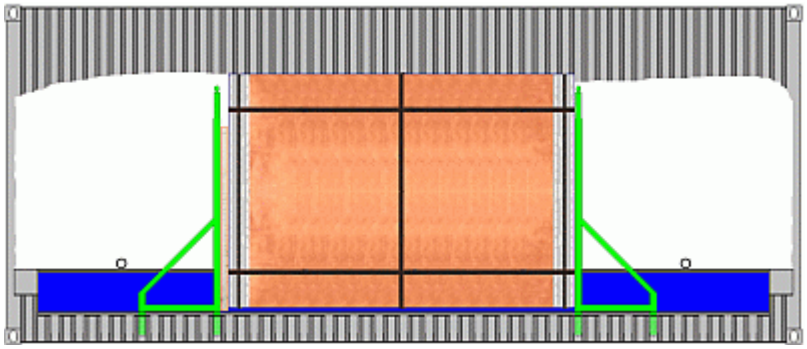
At present, it is not yet usual to find special box containers which have lengthwise cargo troughs which can be covered over and are thus also suitable for carrying general cargo of relatively low stowage factors. Due to their depth, once the troughs are covered over, all that remains is a container with a small volume-to-payload ratio. For some regions of service, constructing such containers may prove entirely worthwhile.



Cross-section of coil box container with one row of stanchions

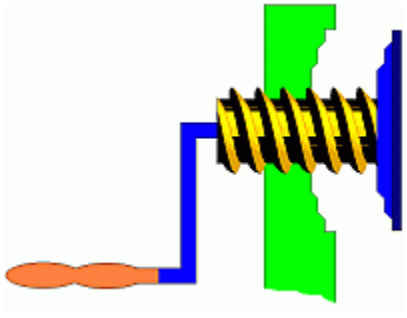


Cross-section of coil box container with two rows of stanchions



Coil box container - side view

Coil box containers with ordinary or special stanchions which can be inserted in one or two rows of stanchion pockets are conceivable. In conjunction with the trough, the stanchions may provide the basis for tight fit securing. Small gaps may be filled with lumber or other similar materials. All stanchions should on principle be secured against being lifted out.

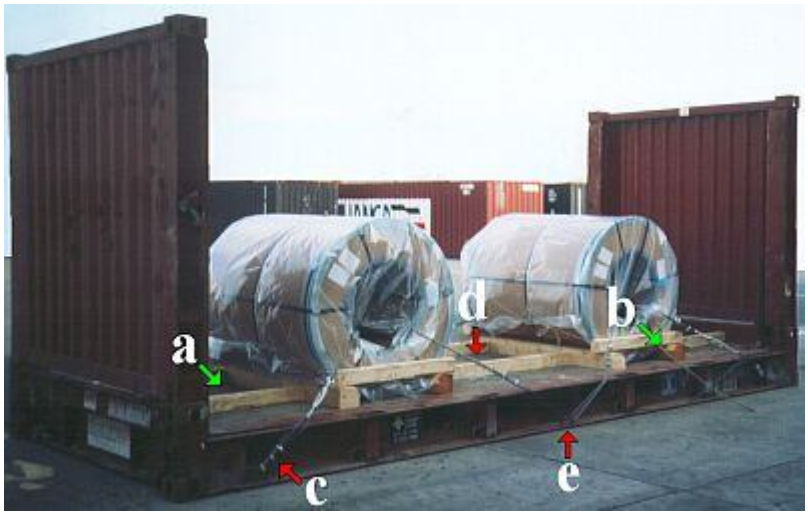


Jack screw fitted into a stanchion to close gaps in the stow

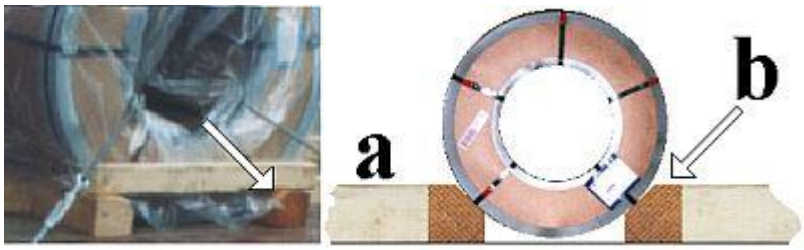
Additional special fitting on stanchions could make it possible to close small gaps with little effort. Cranks, hand wheels or the like are conceivable.

Standard equipment for coil containers or special coil box containers, or indeed for any means of transport, should include a sufficient number of lashing points with a sufficient loading capacity.

5.2.14.3 Coils on flatracks with winding axis lying crosswise



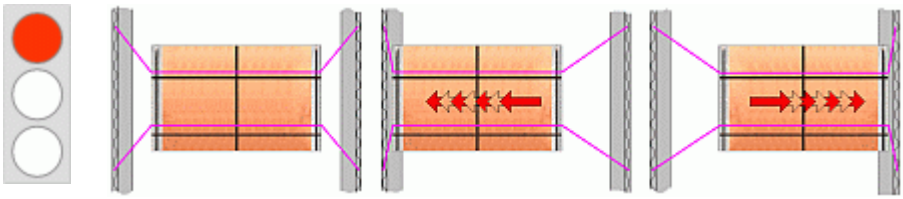
Inadequately secured coils on a 20' flatrack



Wooden beams (a) hold the wedge beams (b) in position.

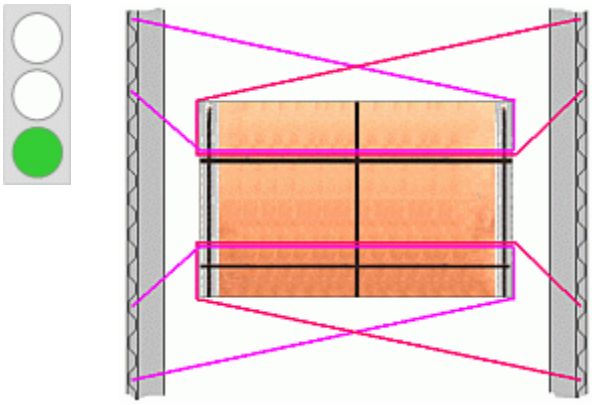
Good features include the use of the chamfered wooden members (b) and the fact that these "wedge" beams are held tightly in place by the lengthwise members (a). The steel sheet rolls rest on the wedge beams in such a way that they are not in contact with the floor of the flatrack in the middle.

However, the lashings have been applied nonuniformly. It can be seen at (c) and (d) that only three, i.e. too few, wire clips have been used. At (e), two lashings have clearly been attached to a single lashing point, which does not have the necessary maximum securing load.



Coils able to move freely in their lashings

However, it is the arrangement of the lashings which is particularly disadvantageous as the coils can move freely in the lashings.



Coil fixed with loop lashings

Using loop lashings can prevent the coils from moving sideways.

Depending upon the angle, loop lashings can generate horizontal securing forces in the crosswise and lengthwise directions as well as in the vertical direction. The wooden crosspieces nailed onto the wedge beams can be dispensed with as they are relatively ineffective.

In this case, securing was provided by the above-described method using steel strapping.



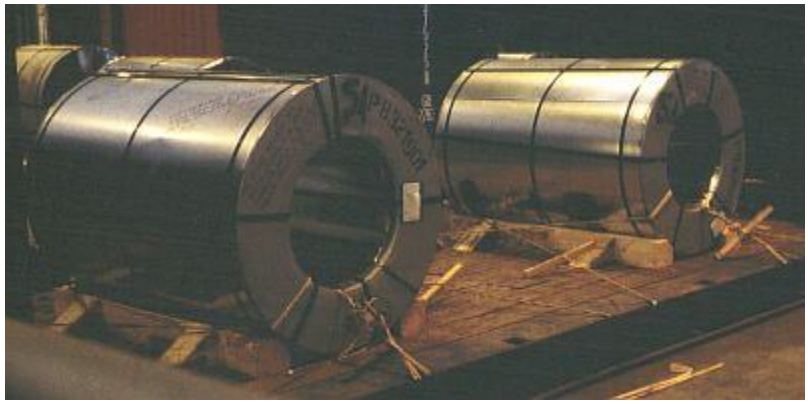
Each coil is secured with two loop lashings per side.

Using wedges to retain the wedge members is unfavorable as they are incapable of holding the latter in position over an extended period. It would have been better to use squared lumber bracing.



Coil securing with two steel strapping loop lashings on each side

The path taken by the loop lashings is more clearly visible in this photograph. It would be better to use edge protectors made from segments of used tires. In this way, it is possible to make up for steel strapping's disadvantageously inadequate elasticity. Moreover, the greatest possible protection is provided for the cold-rolled sheet.



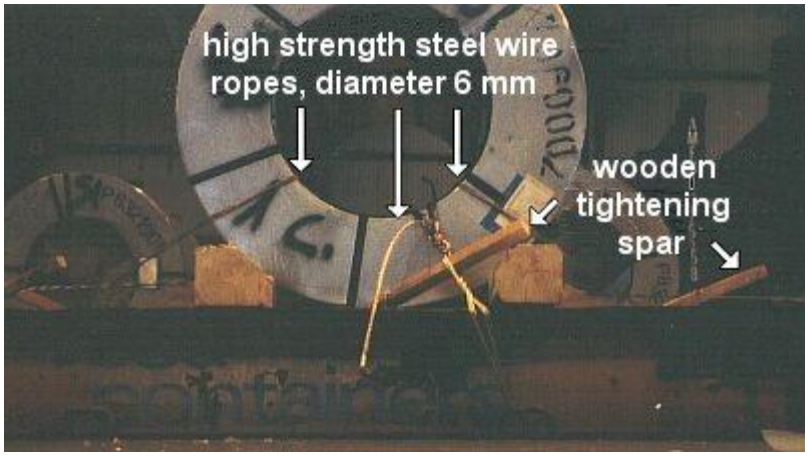
Coil securing with two 6 diameter steel wire rope loop lashings on each side

In this case, the coils are located centrally. Otherwise, the above comment applies here too: it would have been better to fasten the wedge members with wooden bracing. This would not generate additional costs. The costs of the wedges are almost the same as for the squared lumber and labor costs are hardly any higher.



Tensioning steel wire ropes with a "Spanish windlass"

In this case, the steel wire ropes have been knotted and pretensioned with tightening spars. Such fastenings can be applied very quickly. The tightening spars must be made from hardwood and must be properly secured against coming undone. Further details may be found in the general section on cargo securing.

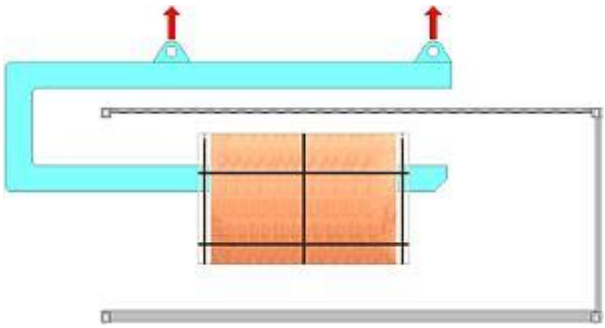


Detail view of wedge members and steel wire rope lashings

5.2.14.4 Coils in box containers with winding axis lying lengthwise

Coils in 20' box containers: winding axis lying lengthwise
General information and options

Introducing coils into open-top containers causes no difficulty. When ordinary box containers are used special equipment or precautions must be used during cargo handling.



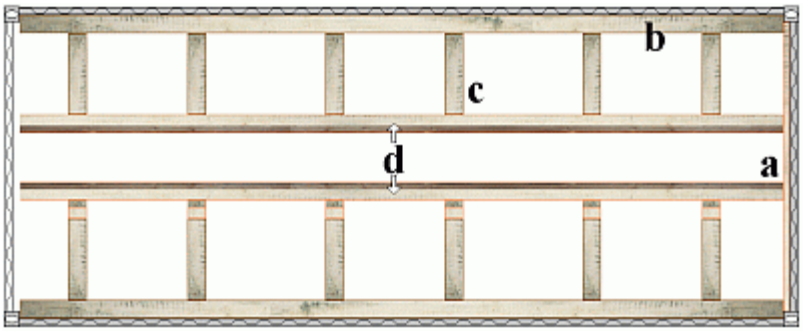
Introducing coils into a box container using a special C hook

Forklift trucks can only be used for direct handling of low mass coils of up to approx. 2.5 metric tons. Heavier coils must be pushed into the container. This requires special working methods in order to prevent tearing of the strapping and to avoid bruising the coils.

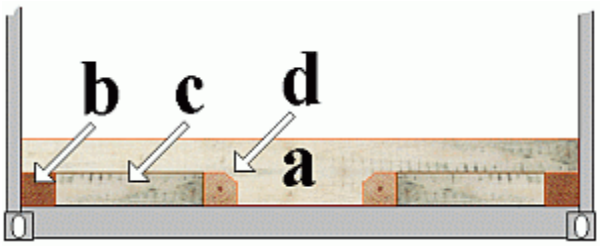
Coils can be pushed in if auxiliary materials are used which have a high coefficient of sliding friction on the coil side and a lower coefficient of sliding friction on the outside. If this is the case, the materials stick to the coil

and are "entrained" as the coil is pushed in.

Suitable cradles must be prepared before loading is begun.

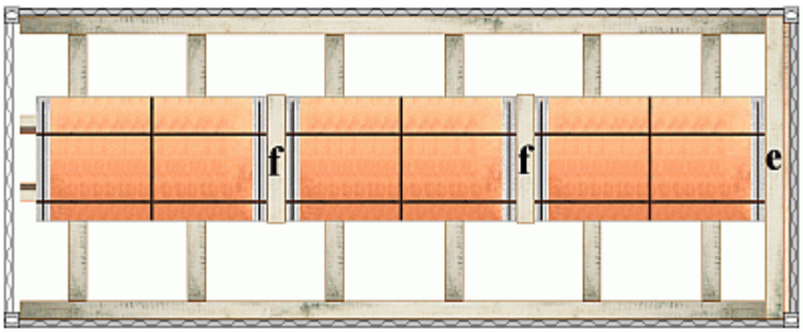


Coil cradle - plan view

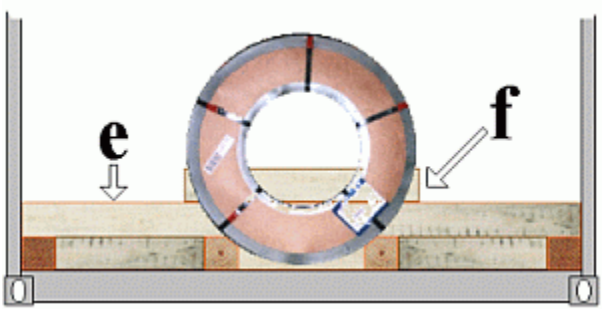


Using boards or planks, the front end wall is braced (a) flush with the corner posts up to twice the height of the lumber size used. Squared lumber (b) is laid down at the sides of the container to distribute pressure. Depending upon the number of coils to be loaded and their mass, crosspieces (c) are laid at right angles to the side beams. Wedge members (d) are then laid lengthwise.

N.B.: Since the coils are subsequently to be lashed, the lashing points must remain accessible. Should these be located under the lengthwise beams (b), the necessary lashing means can be attached to the lashing points before the wooden members are laid. The lengthwise beams (b) can then be placed on small boards.

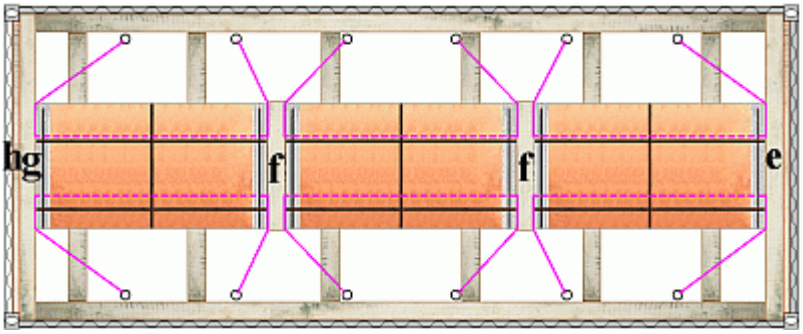


Loading and interim securing of coils - plan view

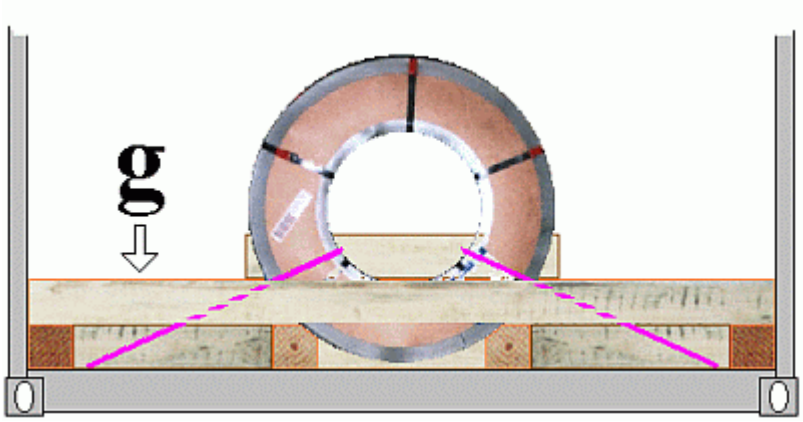


Loading and interim securing of coils - cross-section

Before loading begins, a beam (e) is laid crosswise in front of the boards or planks (a) and the corner posts. This beam (e) lies on the lengthwise members (b) and (d). The first coil is laid against this crosswise beam (e). A shorter beam (f) acting as a spacer relative to the next coil is laid crosswise over the wedge beams (d) and the second coil is loaded against it. The same method is used for the third coil. (f) is at the level of (e) and is only shown higher to make it more visible.



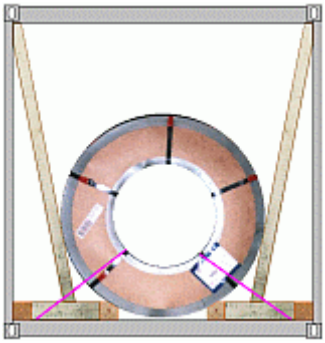
Three coils: blocked and lashed - plan view



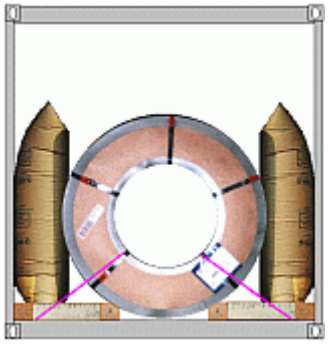
Three coils: blocked and lashed - cross-section

Once the last coil has been placed, the remaining gap towards the container door is filled with squared lumber (g) and boards or planks (h). Each coil is secured with two loop lashings passed through the eye. These lashings secure the coils laterally and prevent them from popping vertically out of the wedge beams under dynamic loads.

Since some of the lashing points are unfavorably located, as is often observed in practice, the resultant angle of the lashings means that they provide, for example, only 60 - 70% of their maximum securing load.



Additional securing by bracing beams



Additional securing with airbags

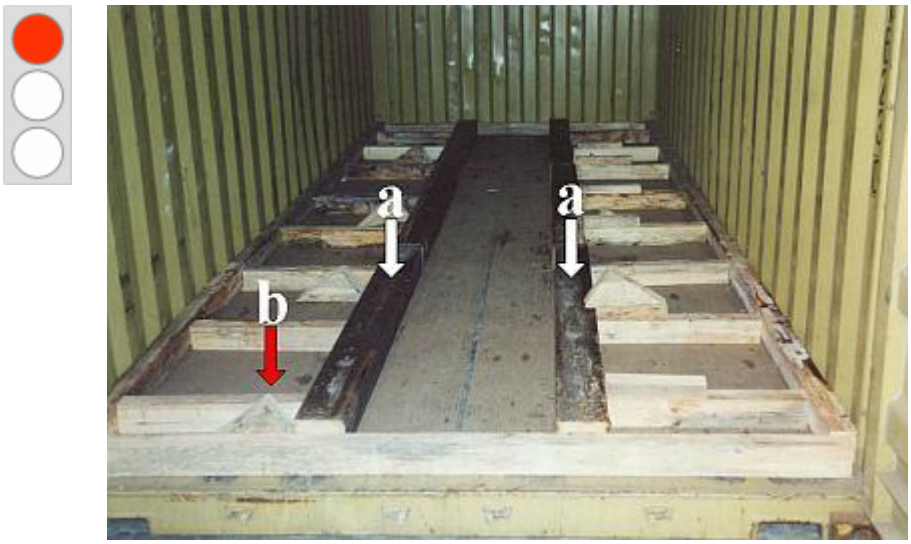
With larger diameter coils, the flanks of the wedge beams must be at a different angle.

If lashings are inadequate due to unfavorable lashing angles or relatively weak lashing points, additional securing can be provided with shoring beams. As shown in the diagram, the shoring beams are located against

the top side rail and, to prevent slippage, between the container corrugations. The greater the web height of the beams, the greater is the flexural strength. In order to save materials, half-size lumber, such as 6 cm x 12 cm or 8 cm x 16, should be preferred.

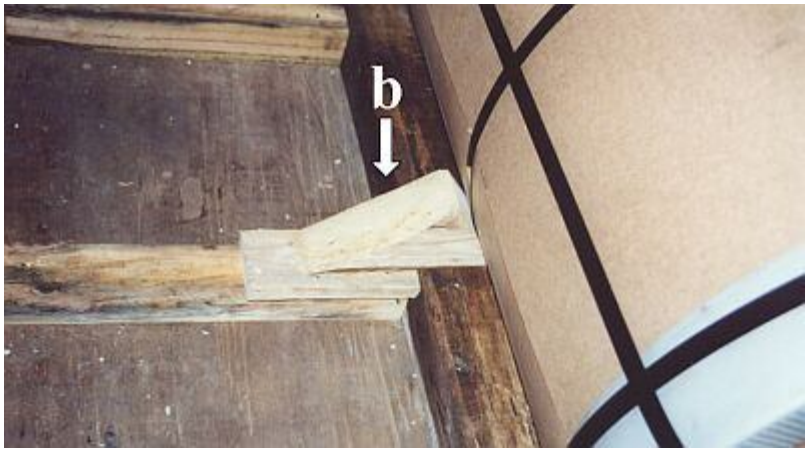
If airbags are to be used, they must be used in sufficient numbers for the forces to apply uniformly over the container walls. However, no significant gain can be expected because, although the container walls can be loaded with 60% of the payload, the majority of the forces are already transferred into the side walls via the wooden crosspieces on the floor. The most important factor, however, when using airbags is that the gaps in the stow must not be excessively large. Experience has shown that gaps of 30 cm should be regarded as the maximum, but smaller gaps are better. The shape of the cargo should moreover be as uniform as possible, as airbags are only able to conform to the shape of the cargo to a limited extent.

Example: Three coils in a 20' box container



Inadequate cradle for accommodating coils

The lengthwise wooden members (a) are not chamfered. If, as should be the case, the coils rest clear of the floor, they will bear down directly on the two longitudinal edges. Wedge beams should have been used. The large number of wedges would indicate that they are intended to provide sideways securing. However, they have not been correctly cut for this purpose.



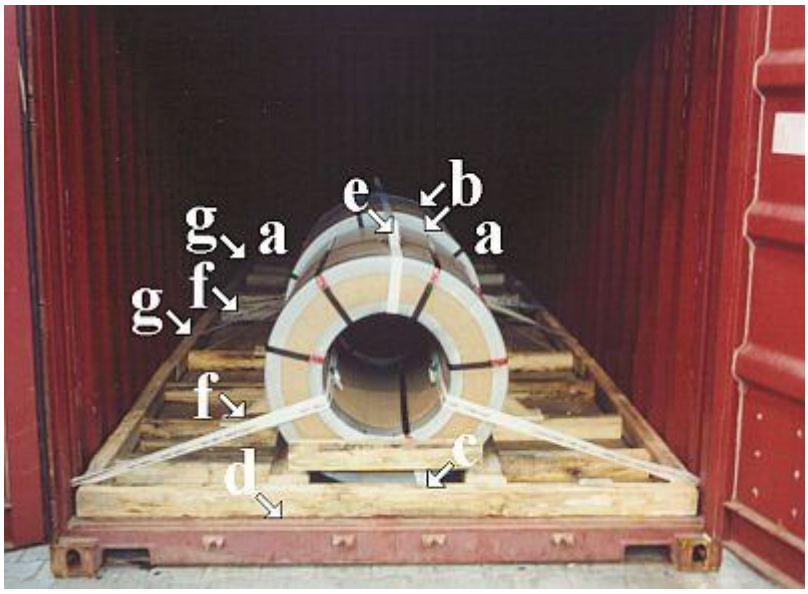
Incorrectly cut wedges - nails will have to be driven into the end grain

The wedges have been cut so that the nails will have to be driven into the end grain. This will result in the wedges splitting, at the latest when exposed to impact in transit . The wedges rely solely on the nail shear forces. High maximum securing loads cannot be expected.



Inadequate lateral securing with wedges

Two wedges were placed by the front coil (the one by the front end wall). Only one wedge was placed by each of the middle and rear coils, the latter closest to the door.



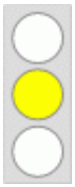
Inadequately applied cargo securing

No wooden members were fitted to provide a tight fit between the front end wall and the first coil (a). There is likewise no squared lumber to provide a tight fit between the coils and the door, (b) and (c). The squared lumber (d) is performing no useful function. The coils are bound together with single-use webbing belts (e). This type of unitization provides no additional securing action. The loop lashings (g) are holding the front and middle coils together, while the loop lashing (f) is holding the middle and rear coils together, latter being closest to the door.



Improved securing with squared lumber members fitted crosswise

The shortcomings in the lengthwise securing can be eliminated by fitting squared lumber in the gaps. The crosspieces at the front end wall and the door have to transfer compressive forces over a large area. The green light only relates to lengthwise securing.

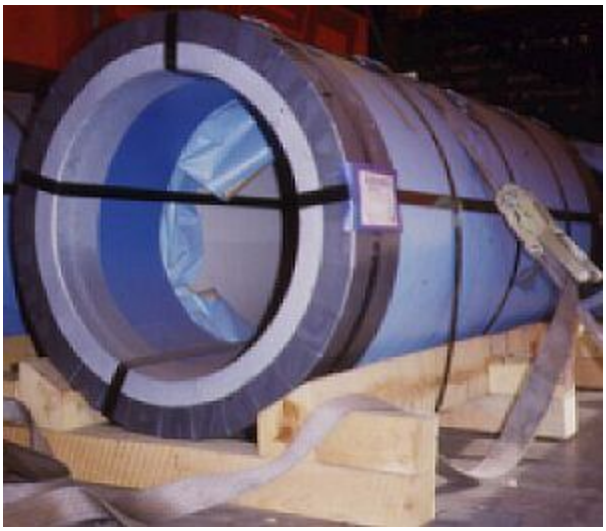




Loop lashings with single-use webbing belts

It is essential to take note of the labels on the belts or other information from the manufacturer. The maximum securing load should be assumed to amount to at most 70% of the breaking load, or better still only 50%. Note the uniformity. The belts shown in the picture have a higher maximum securing load than the lashing points. Moreover, the lashing points are round and thus not suitable for fastening belts. Shackles should be used to join the belt to the lashing point, with the webbing belts being passed over the shackle pin.

5.2.14.5 Coils on skids, horizontal winding axis



Coil set down on a skid and fastened with steel strapping

There is no need to address the securing of these cargoes separately. Where possible, packing should be carried out so that the lower layer of the wooden sled members are at right angles to the container bottom cross members. If dimensions do not permit this, the cargo must be packed either crosswise or lengthwise. If the bottom wooden sled members run parallel to the container bottom cross members, it must be verified that the container line load is not exceeded. If this is the case, additional wooden members must be provided to distribute the pressure. Any remaining gaps should be filled with lumber at the height of the load-bearing parts. Loop lashings should also be passed though the eye to provide further securing. In no event should tie-down lashings, as shown in the picture, be used. If bracing and/or loop lashings are not enough, or if they are difficult or impossible to apply, the option still remains of applying shoring against the load-bearing wedge beams or the other wooden sled members encompassed by the strapping. In individual cases, subject to compliance with the basic rules for using airbags, it may be possible to use airbags alone or in addition to other securing means. If the steel strapping is too weak or could slacken because, as shown in the picture, it has been passed over the edge of the lumber without an edge protector, it must be securely fastened to the skids by additional means.

Where possible, friction-enhancing materials should be laid under the skids. If the cargo has to be slid into its stowage space, such materials can only be laid, if at all, once the cargo is in position. This requirement also applies to the following examples.

5.2.14.6 Coils on skids, vertical winding axis



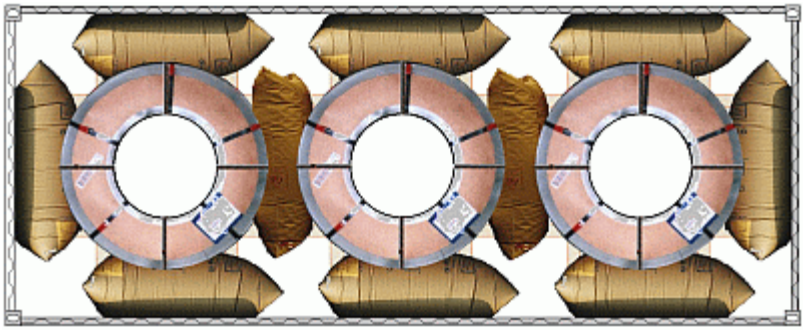
Slit strip coils - fastened onto wooden sleds with steel strapping

Before loading, attachment to the skids should be checked. If the method of application or condition of the straps gives the impression that they could slacken or be unable of withstanding anticipated acceleration forces, additional attachment to the skids should be ensured.

Depending on their dimensions, coils should where possible be packed without gaps. Any remaining gaps should be filled with lumber members. Lashings may be passed through the eye, but only if the coil is not completely shrink-wrapped. If lashings cannot be passed through the eye, shoring is very effective in preventing slit strip coils from moving.

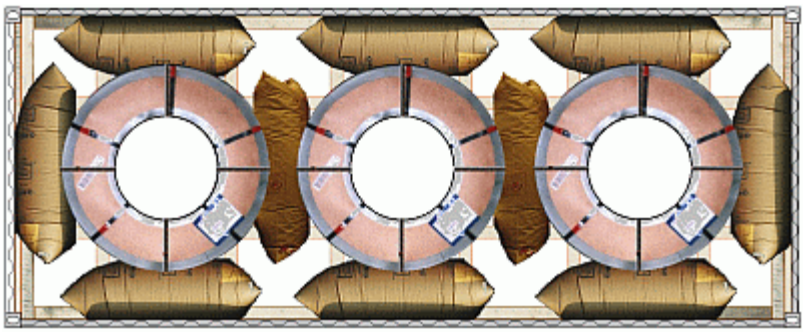
In some cases, it is entirely possible to secure even slit strip coils with airbags.

Some suggestions and comments on securing are given below. Some may be applied as alternatives, some in combinations while still others should not be used.



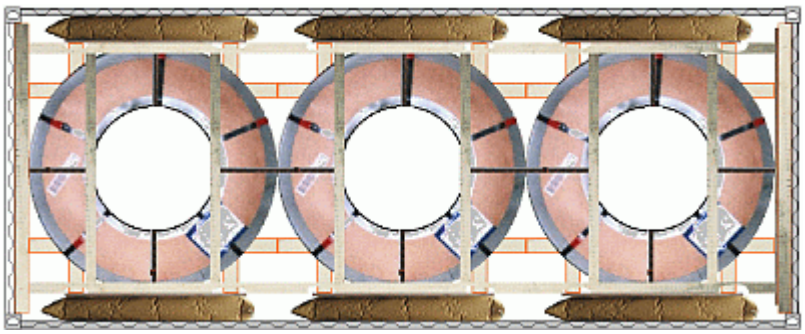
Not like this, please: securing of coils/slit strip coils with airbags - plan view





Inadmissible use of airbags - plan view

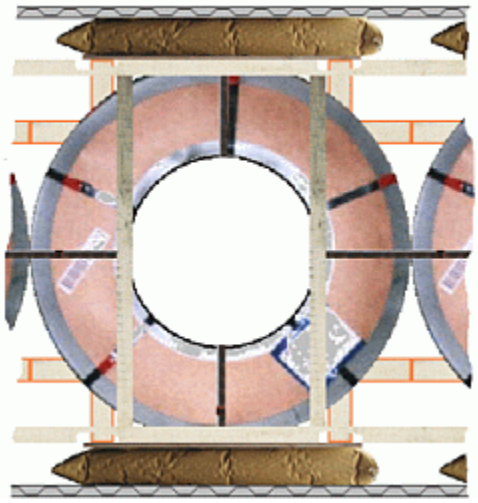




Possible: sideways securing with airbags - plan view

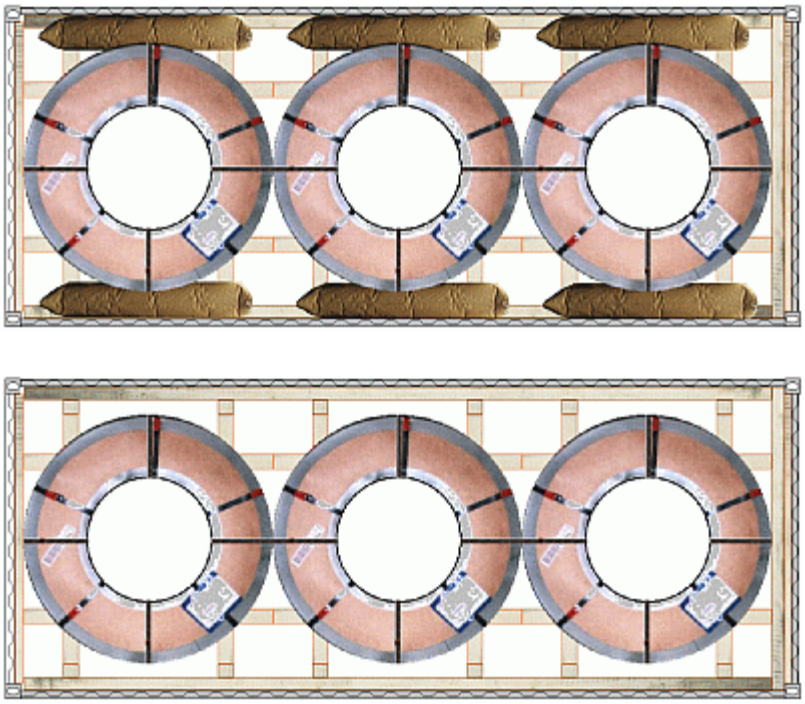
Securing was provided at the front end with a beam lattice and a walking board. A walking board was stood at the side of each coil, the board being braced at the bottom against the sled and at the top against a wooden frame. Each walking board also rests against the outer edge of the coil. The airbags have only a small gap to fill. Bracing with beams is provided in the door area. In the drawing, the upper frames are shown slightly offset to give a better view of the overall securing arrangement. In practice, they should be positioned perpendicularly above the wooden sled members.

This detail drawing clarifies the situation:



Possible: sideways securing with airbags - plan view

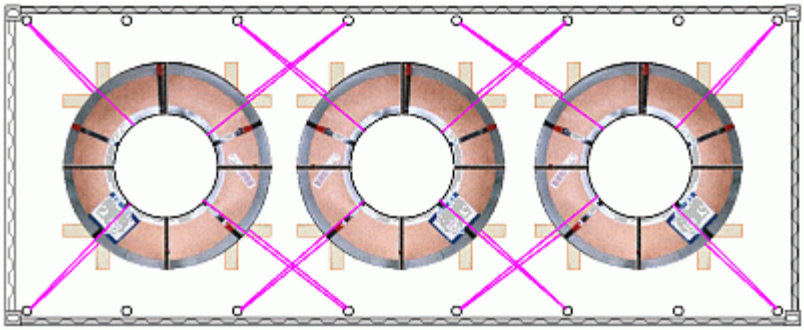
It should be noted, however, that these and the following examples with three coils are not entirely realistic as the coil diameters are very large and they can accordingly only be coils or slit strip coils with a short winding axis, as the masses would otherwise exceed the container payload.



Feasible: securing of tightly fastened coils with bracing at floor level, airbags to provide support - plan view

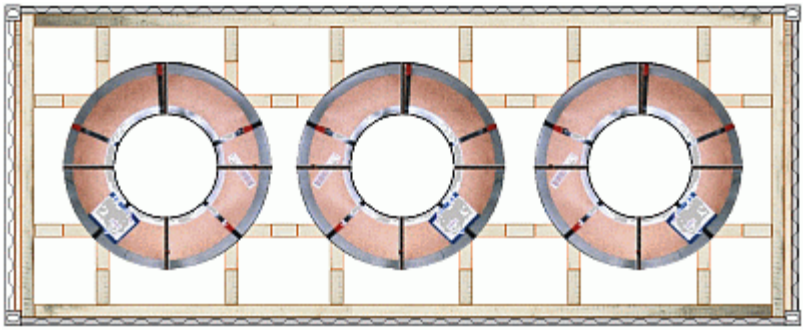
In this variant, the use of airbags is quite likely. The coils are wide, but flat and not at risk of tipping. The coil

is blocked at floor level and towards the ends. Strapping to the skids is sufficiently strong. The airbags are merely intended to relieve the load on the coil strapping on the sleds.

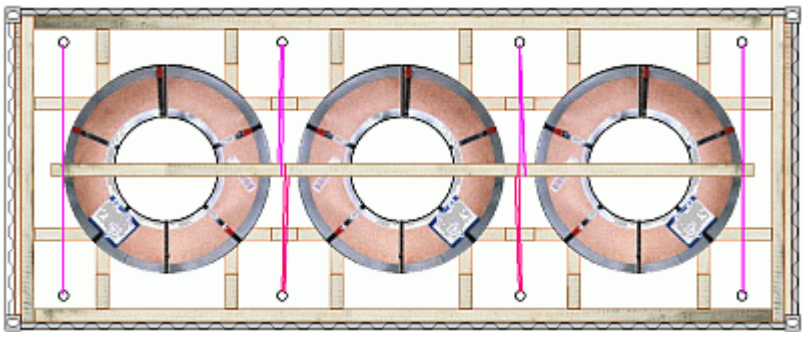


Securing of coils/slit strip coils with loop lashings passed through the eye - plan view

Depending on the mass of the cargo and the maximum securing loads of the lashings, this method may be adequate by itself. With high cargo masses or low maximum securing loads of the lashings, additional measures should be taken.

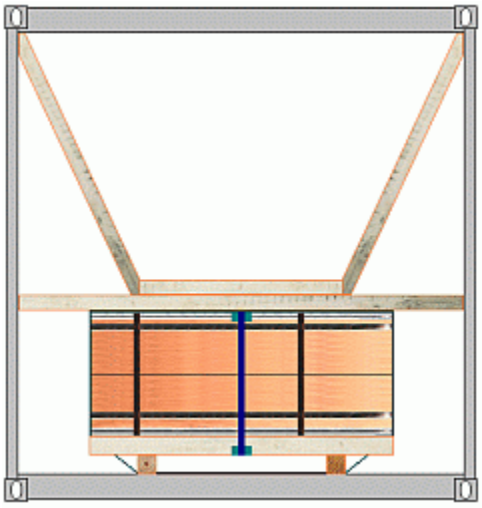


Securing coils/slit strip coils with wooden bracing - plan view



Securing with squared lumber and hold-down members

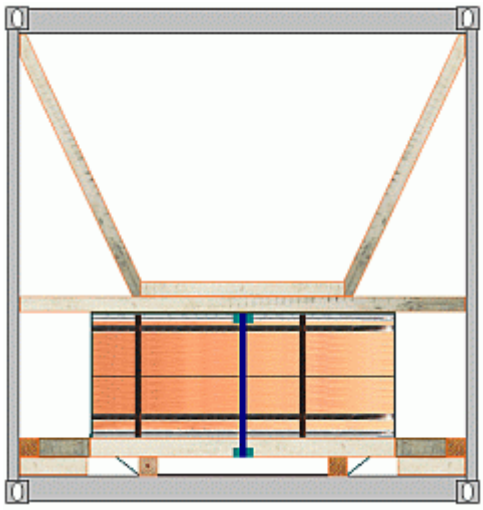
Skids braced only at floor level could escape the bracing if tipped up. In order to counter this risk, they must additionally be held down. This may be achieved by using squared lumber together with "tie-down lashings" and/or loop lashings. When applied in this manner, "tie-down lashings" act as direct lashings against upward motion. Tie-down lashings cannot be used alone because the lumber used to hold down the cargo could otherwise shift.



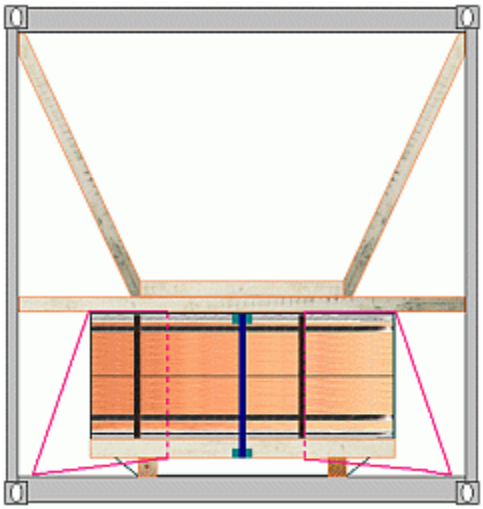
Securing of coils/ slit strip coils with shoring - cross-section

Shoring in conjunction with friction-enhancing materials, may be sufficient if the shoring members are driven strongly apart and so generate large pressure forces. This cannot be done with large masses because admissible line loads would be exceeded.

Securing with wooden bracing at floor level and shoring - cross-section



If the cargo is secured at floor level by wooden bracing, the shoring members need only be set in place, but not driven strongly apart. It is vital in all cases for the strapping to be able to hold the coils onto the sleds over an extended period.



Securing with loop lashings through the eye and shoring - plan view

Passing loop lashings through the eye has the advantage that the load on the strapping is relieved.

5.2.14.7 Wire rod coils with winding axis lying crosswise

Depending on the nature of the goods and any intended subsequent processing, coils of wire rod are sensitive to corrosion and to mechanical damage, for example, kinks forming in the wire. The length of the winding axis is a critical factor in determining the way they are stowed.



Shortcomings in packaging a wire rod coil

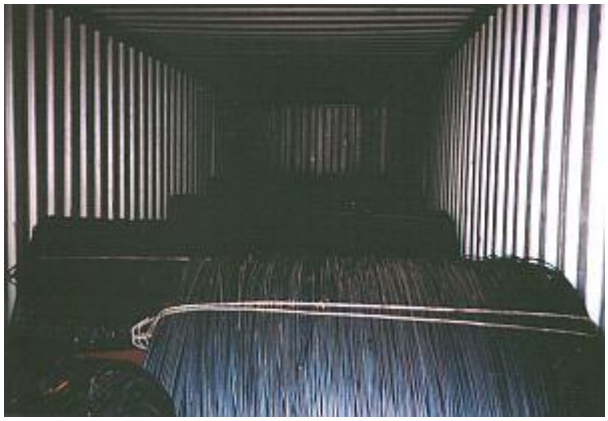
The base of the wire coil protrudes and thus complicates loading and securing. Including lumber components in the plastic wrapping increases the risk of corrosion as condensation can form under the covering.



Inadequate stowage and securing of wire rod coils

The wire rod coils have simply been set down alternately against the container side walls. Sheets of

cardboard have been inserted at the contact points between the coils.



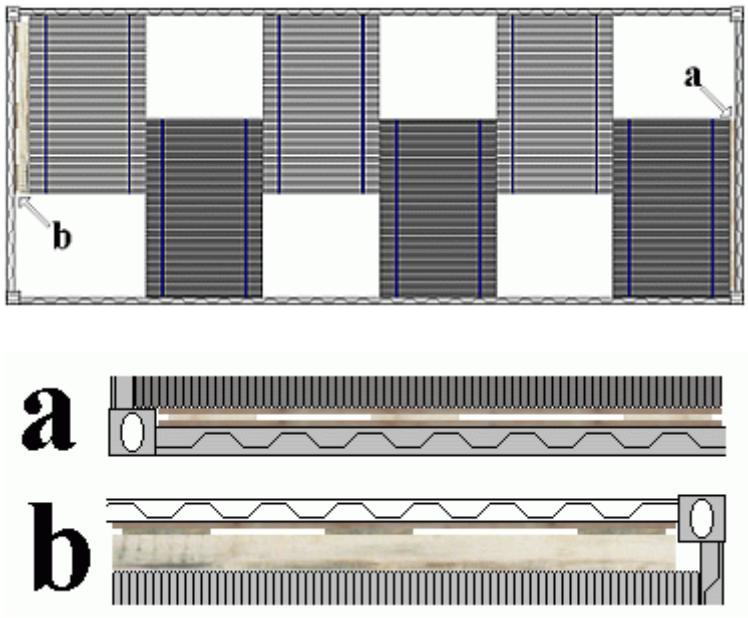
View into a container with wire rod coils

The wire rod coils are in direct contact with the container side walls. This may result in chafing of the container side walls. The wire rod could then suffer corrosion if water vapor from the cardboard, the container floor and similar sources were to condense in relatively large quantities on the container roof and walls and be able to wet the wire rod coils.



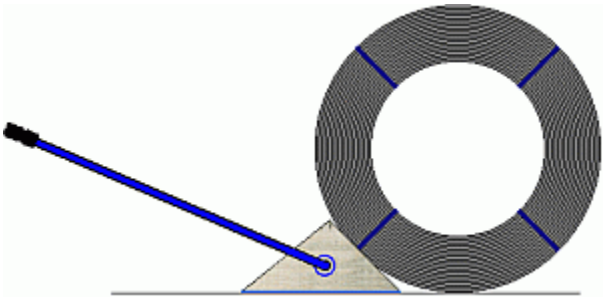
Gaps in a container packed with wire rod coils

The gaps in the container cargo would only present no risk if the wire coils were 100% solidly intermeshed.



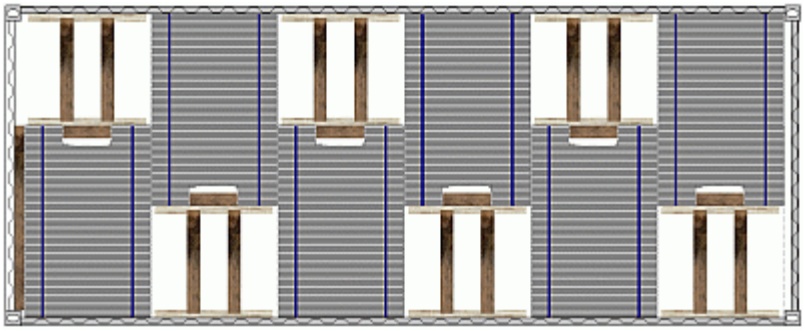
Compact, intermeshed stowage - lengthwise gaps filled

This may be an acceptable loading method not entailing major securing effort if dimensions permit extremely compact packing and the wire coils are able to intermesh effectively without resulting in damage to the goods. In the example shown in the diagram, the gap between the front end wall and the inner edge of the corner post is filled with a wooden lattice (a) of horizontal and vertical boards, onto which a board is nailed horizontally at winding axis height. The coils are arranged on alternate sides and tightly pressed towards the front end wall. Once the left door leaf had been closed, the remaining gap was filled with a lattice (b) of boards and a squared lumber member at winding axis height.



Wedge with handle for restraining wire coils

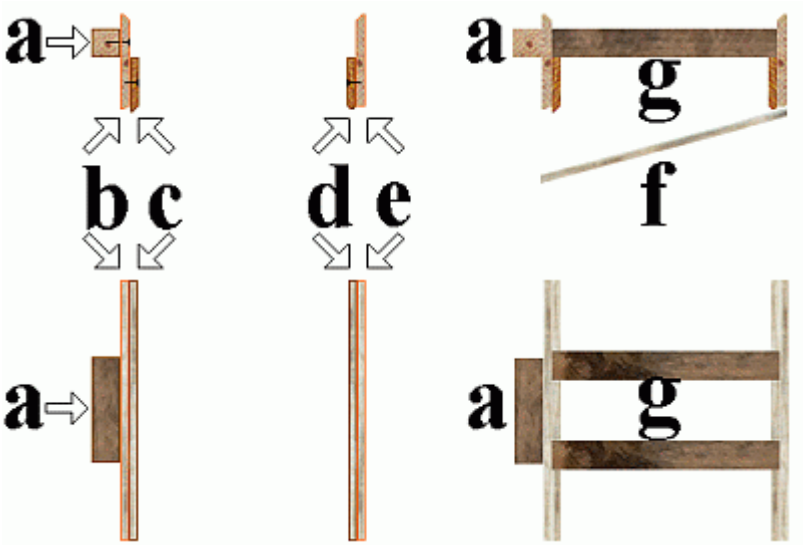
To stop the preceding coil from "slackening" before the next one is loaded, the first one can be held in its initially loaded position using a wedge with a handle.



Wire rod coils packed with winding axis crosswise - secured with wooden bracing

Provided that there is no risk of corrosion or kiln dry lumber is used, the wire rod coils could be secured as shown here in the diagram.

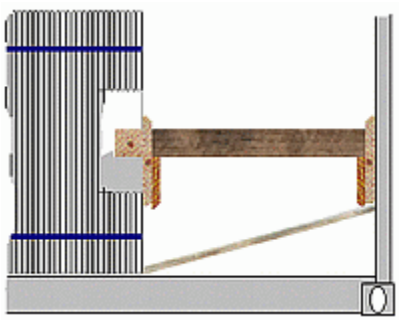
The coils could each be secured in the lengthwise direction with wedges. In this example, however, in order to prevent wetting damage, it is important to place as little kiln dry lumber in the container as possible.



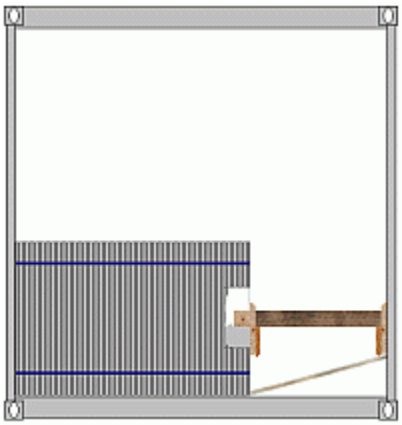
Preparation of wooden bracing

Short squared lumber members (a) and two boards (b) and (c) are nailed together. The short squared lumber members should be of dimensions such that they exactly fit into the wire rod coil eye. The boards (b) and (c) overlap one another in steps. Two further boards (d) and (e) are joined together in the same manner. Between these pairs of boards are fitted two squared lumber members (g) which are dimensioned such that, together with the thickness of the four boards, they fill the gap in the load. These bracing structures are located with the squared lumber members (a) in the eyes of the wire coils in such a manner

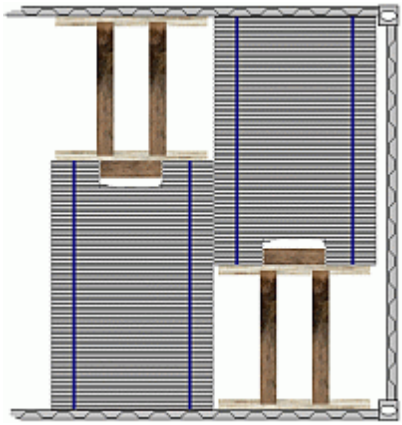
that the boards (d) and (e) rest against the container walls. They are prevented from slipping down by inserting oblique boards (f).



Bracing fitted into the eye of a wire coil



Section through the container



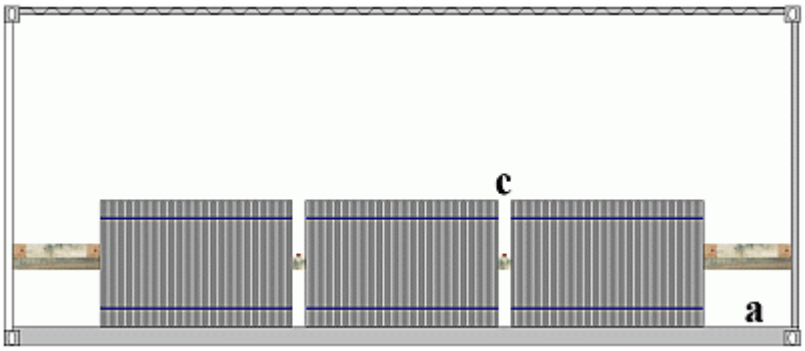
Plan view of two wire coils

Assuming a coefficient of sliding friction of $\mu = 0.2$ and transport acceleration values of 0.8 g in the sideways direction, the container's full payload can be utilized as the container side walls are capable of withstanding 0.6 times the payload uniformly applied. It is, however, recommended that strips of friction-enhancing material be laid under the wire rod coils.

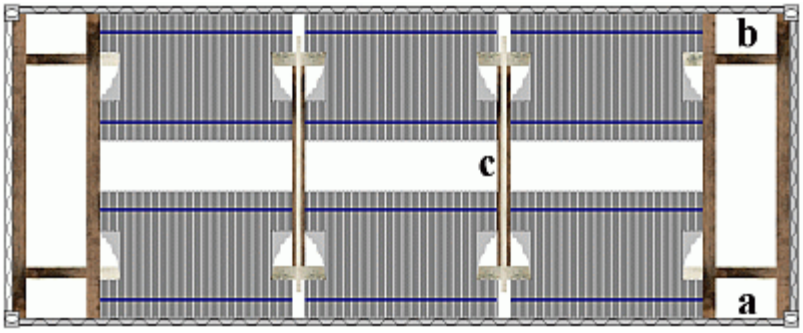
Since the wire coils are able to roll in the lengthwise direction of the container, no coefficients of sliding friction need be assumed for the lengthwise direction. Compact packing in the lengthwise direction is only adequate if (due to the loading capacity of the container end walls of 0.4 times the payload) the acceleration values anticipated during shipping do not exceed 0.4 g. If higher levels of acceleration are anticipated, the wire coils should be secured in the lengthwise direction with additional wedges or wedge beams which are capable of absorbing a proportion of the forces.

5.2.14.8 Wire rod coils with winding axis lying lengthwise

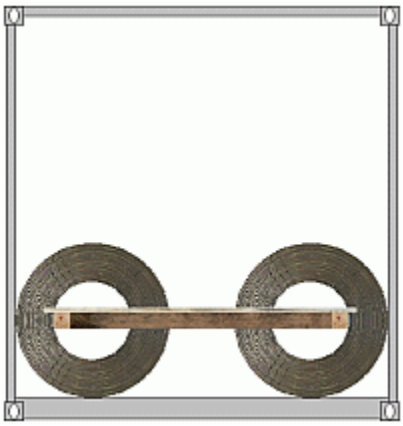
The following variant shows securing options using wooden members which are passed through the eyes of two rolls or coils and braced together. In this case, the coils rest with their sides against the container walls.

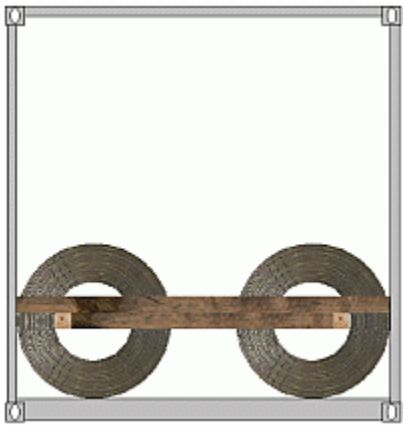


Wooden members passing through rows of coil eyes - side view



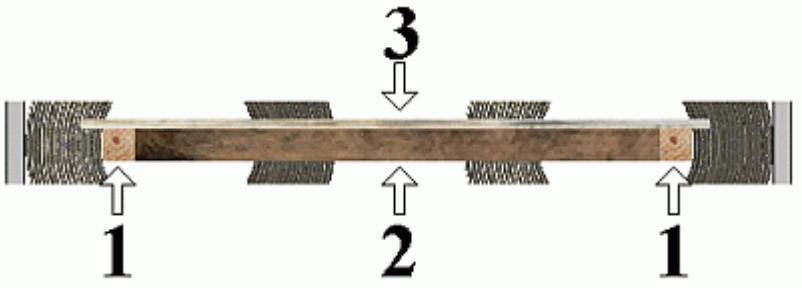
Overall arrangement of wooden members - plan view





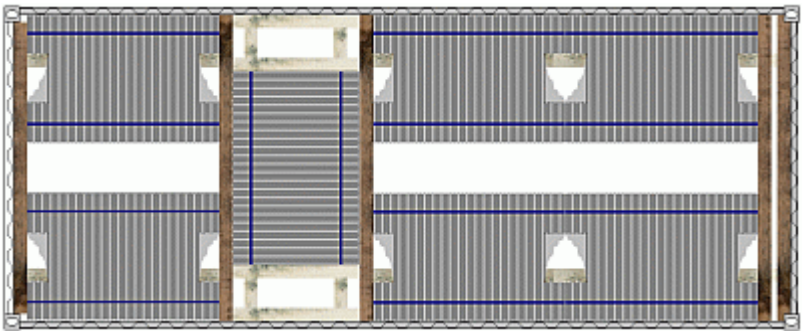
Cross-section at c **Cross-section through a and b**

This method is technically relatively simple to implement.



Detail of sideways acting bracing

The squared lumber members (1) passed lengthwise through the coil eyes are pressed apart by the squared lumber member (2) fitted crosswise between them. This wooden member is held in place by the board (3) nailed onto it. This securing method on the one hand results in the formation of a compact block and on the other prevents the coils from rolling, so preventing overloading of the container walls. Without this "braking" action, the container side walls would be subjected to excessive loads.

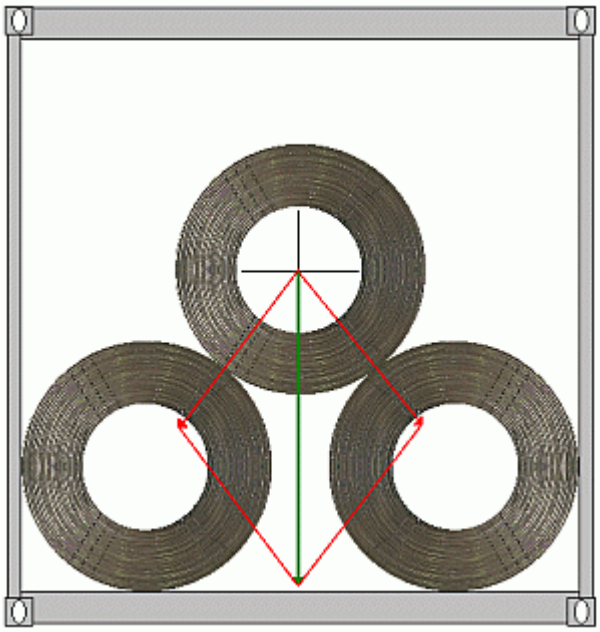


Packing and securing variant with seven wire rod coils

Packing and securing means should be decided before loading by means of appropriate stowage planning.

Heavier wire coils in box containers

This diagram indicates what additional measures may be required.



Aluminum wire coils packed in the cantline

The lower layer is subjected to additional forces due to the "angle of rest" of the upper layer. Since the coils can roll apart, the container walls will be exposed to the entirety of the forces which can arise from acceleration of shipment. If this type of packing is to be used, some way must be found to relieve the load on the container walls. This could be achieved by loop lashings passed through the eyes of the bottom pair of coils.

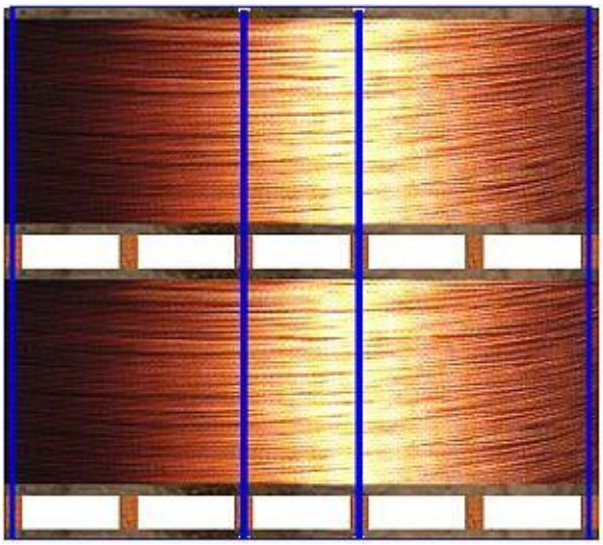
5.2.14.9 Electrolytic copper coils on pallets

Copper wire is denser than steel. A pallet with a coil of 8 mm thick wire with base dimensions of 1.60 m x 1.60 m and a height of 0.70 m weighs approx. 3.5 metric tons. The coils themselves are 1.60 m in diameter and 0.55 m tall.

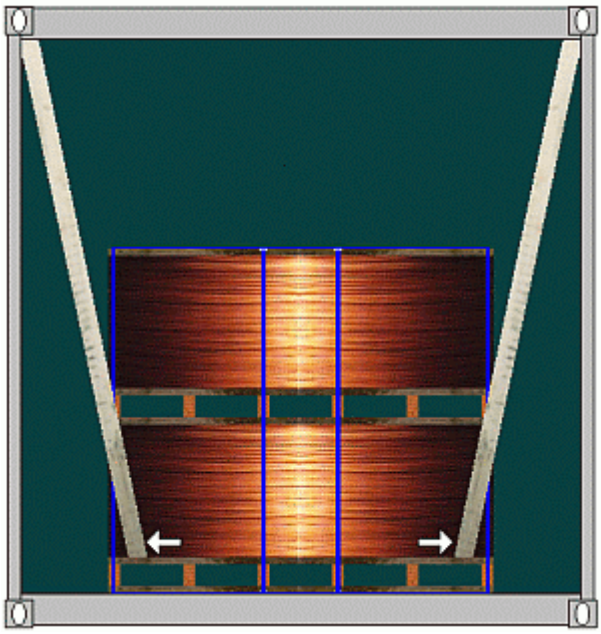


Pallet with copper coil

The pallets can be shrink wrapped and strapped for transport purposes. This makes it impossible to secure the coils by loop lashings through the eye. One option for packing in containers is to group together pairs of pallets into an intrinsically very strong transport unit.



Cargo unit comprising two copper wire coils

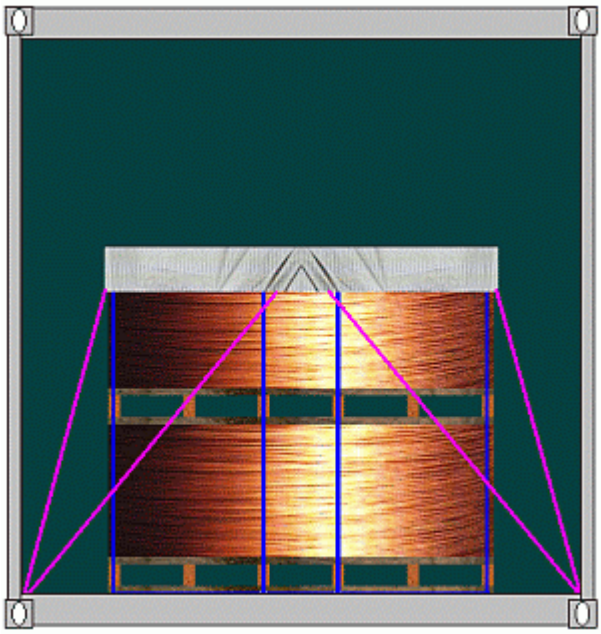


Cargo units secured by shoring

Warning: Due to the particular shape of the pallets used, particular care must be taken not to damage the copper when driving the wooden members apart. Shoring can only be nailed down into the pallet corner members, while wooden cross pieces cannot be used to fix shoring in place when pallets are flush loaded.

The feasibility of other variants using additional wooden members or similar methods must be assessed on the spot.

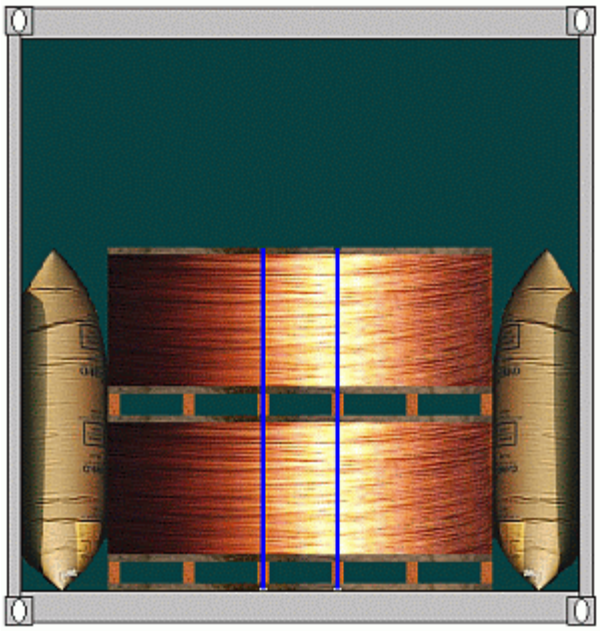
With open-top containers, the cargo units can easily be set down on friction-enhancing material, which ensures that only very slight securing forces need be applied. However, if the pallets are pushed into place with forklift trucks, this is not possible. The pallets may, however, be securely shored in place with four dry squared wooden members per pallet. The wooden members required for this purpose rest on the pallet corners which are not occupied with cargo and against the container top side rail between the corrugations. They are driven apart at the bottom and nailed down to stop them slipping back. Alternatively, the wooden members may also be held in place relative to the container sides with strapping or rope.



Securing with a special cargo securing tarpaulin

One option for securing cargo units without using additional wooden members is to use special cargo securing tarpaulins. In this case too it is advisable, where possible, to set the cargo units down on friction-enhancing material.

It is not generally possible to secure such cargoes with loop lashings through the eye as the cargo is generally shrink wrapped on the pallets.



Securing with airbags

Securing with airbags is theoretically feasible, but given the size of the gaps to be filled rather inexpedient. Airbags must not be used in the door area for safety reasons. In order to ensure uniform load distribution, one cargo unit would have to be placed by the front end wall, one in the middle and one flush with the doors of the rear end wall. With pallet dimensions of 1.60 m x 1.60 m, a gap of approx. 0.60 m will be left between the first and second and between the second and third cargo units. This is larger than it is reasonable to fill with airbags.

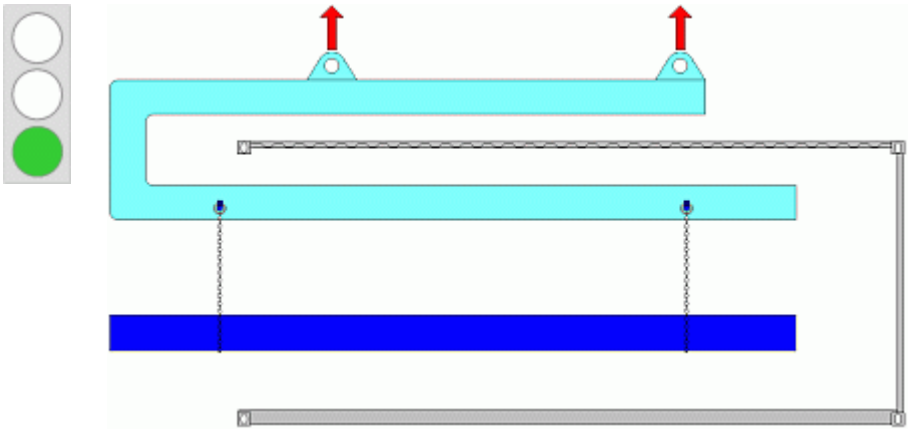
5.2.14.10 Round bars and profiles

Long round bars, profiles and similar cargoes, especially when carried in large weights, are ideally suited to transport on flatracks, providing that there is no risk of depreciation due to corrosion.

It is generally straightforward to load, pack and secure such cargoes on flatracks, especially those equipped with stanchions. Loop lashings to the side and wooden bracing in the lengthwise direction are usually a quick and economic solution for virtually any long loads. Open-top containers provide better protection from weather and can also be packed straightforwardly, but have fewer cargo securing options than do flatracks.

It is only with difficulty and using special aids and working methods that the above-stated cargoes can be packed in standard box containers, with packing often being easier than the subsequent unpacking.

Packing can proceed relatively straightforwardly if special load suspension devices, such as specially designed C hooks, are available.



Inserting a round bar into a box container using a C hook

For various reasons, packing with conventional ground conveyors, such as forklift trucks with a low load-carrying capacity, is not very economic:

- Repeated forklift truck maneuvers are needed in order to position the cargo lengthwise in the container door area.
- The cargoes must be pushed into the container with the forklift truck, so dramatically increasing the risk of floor damage.

Cargo handling can be carried out more efficiently if it is possible to use forklift trucks with a very high load-carrying capacity (relative to the weight of the cargo), as, in the method shown, the load center distance is a very long way from the fork face.



Using a high capacity forklift truck

The load-carrying capacity of the forklift trucks used must vastly exceed requirements, as the forks and lifting apparatus may be damaged by unevenly applied forces.



Wrong - the container floor can be scratched when pushing cargoes in and equipment may be damaged too.

The chain used here with the forklift truck is too long. The forward end of the round bar is touching the floor. No further adjustment of the mast is possible. Lifting the forks is of only limited assistance, as not all forklift trucks have such a large free lift or such a low overall height that the cargo can be set down directly. In most cases, such cargoes will end up being pushed into place.



Inserting a round bar with a forklift truck

With two chains attached, the round bar can be steered better. Placing wedges once the roll has been set

down to secure it provisionally and prevent it from rolling away is a useful accident prevention measure. They are not entirely suitable for cargo securing.



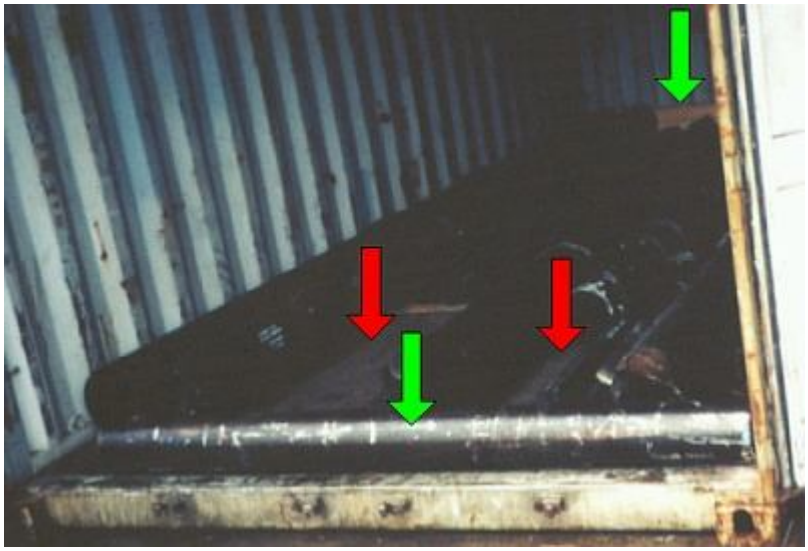
Risk of dangerous sagging

It must be checked in every case whether the cargo can tolerate being handled as illustrated or whether it could be damaged in this way.

Warning: A forklift truck should only be used in this way if there is no risk of breaking accident prevention regulations or damaging the cargo.



Inserting profiles with a forklift truck



Stowing without gaps or filling any gaps which occur is a fundamental requirement.
Advantageous: Buffer stow in the door area

It is certainly correct and important to protect the front end wall of the container with sufficiently strong

and tall squared lumber members before round bars are pushed in or set down. If, as in the door area, a suitably sized round bar is available, it should be used as a buffer, but obviously only, as in the present case, with a single layer stow. Correct sizing of the wooden members or using cargo as a buffer precludes penetration through the front end wall and the doors.



Incorrect use of material: the wedges:

It makes no sense to use costly wedges to "plug" gaps or as "wooden fixings". On the plus side, it should be noted that the wedges have been correctly cut for the use shown. Nailing into the face grain is possible. The only problem is, just what can two, three or four nails driven into a 1 inch container floor do to withstand such masses? Filling the gaps with squared lumber offcuts or beam format lumber (e.g. 6 cm x 8 cm) is entirely sufficient. Even roofing laths (e.g. 3 cm x 5 cm or 4 cm x 6 cm) would still be sufficient. Such wooden members need only be fitted into place and attached to the floor.



Incorrect use of wooden wedges

Incorrect use of the wedges is even more obvious in this case and there are incorrectly cut wedges there

too.



Inadequate result, despite the correctly cut wedges

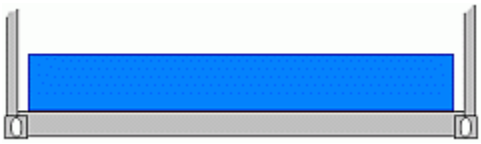
Although the wedges have been correctly cut, adequate securing force cannot be achieved with them. The nails driven into an approx. 1 inch container floor cannot provide sufficient cohesive resistance. However, the wedges are placed incorrectly by the round bars to provide a sideways securing action.

The following method may be used for a single layer stow:

Wooden buffer member at the container front end wall



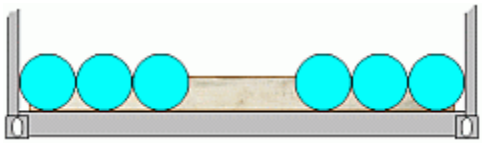
First of all a sufficiently thick and tall squared lumber member is fitted between the container front corner posts. If wooden members of an appropriate thickness and height are not available, the buffer is produced from several pieces of squared lumber. The wooden members should be at least half as tall as the round bars to be stowed.



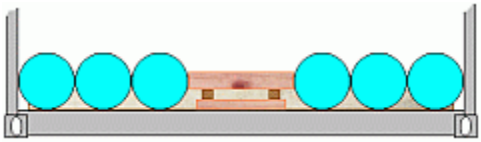
Round bar from the cargo as buffer

Alternatively, if the batch to be stowed also includes shorter round bars, which can fit crosswise into the container, one of them can be used as a buffer. In this way, there is no need to use lumber to create the buffer.

Round bars stowed against the front end wall buffer



The round bars are stowed against the front end wall buffer and tightly against the container side. For safety reasons, small wooden wedges should be laid beside each bar as it is put in place so that the bars remain in position.



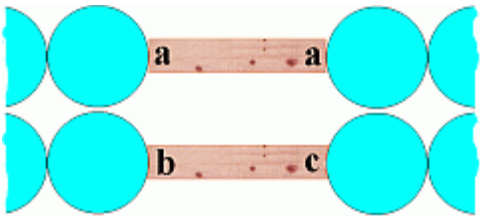
Gap between round bars filled with bracing

Wooden bracing to fill the gaps between the bars



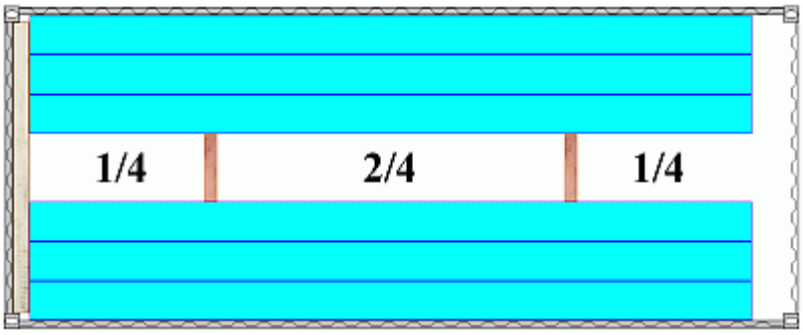
The precise distance between the bars and the height of the center point are determined. Two of the wooden braces shown are built outside the container from offcuts and a wooden member cut a few millimeters longer than to fit and are then fitted between the bars.

Only the squared lumber member at the central bar axis height must be correctly cut to size. Since the wooden members are a few millimeters too long, they have to be driven in crosswise and so provide a somewhat larger contact area. The other wooden members can be waste and offcuts.



Enlargement of contact area

The strip-like bearing surface at (a) can be calculated to apply 100 daN per square centimeter of contact area. Hollowing out the ends with a chain saw (b) or cutting a slight bird's mouth (c) can increase the bearing area and also improve the grip of the wooden members.



Placement of cross braces - plan view

The bracing members should be placed in each case a quarter of the bar length from the ends of the bars.

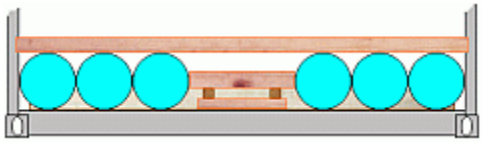
If the calculated values for two cross braces are insufficient for the mass of the cargo, appropriately thicker wooden members or a larger number of cross braces should be used.



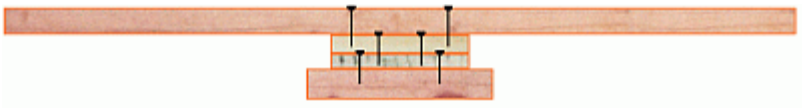
Base beam for shoring

Close to the bracing, the internal width of the container is measured within the corrugations. A 6 cm x 8 cm beam or an 8 cm x 8 cm squared lumber member is cut to exactly this length and then fitted into the container.

Bracing and base member for shoring

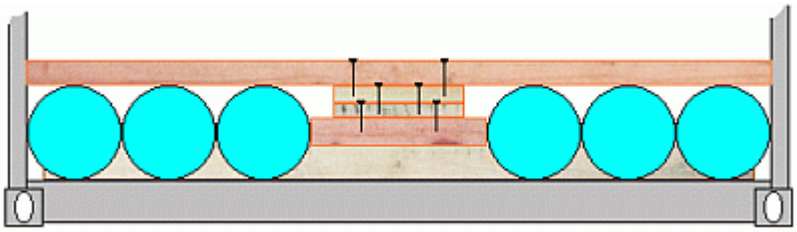


As an alternative to the four preceding operations, the following method may be used:



Combined wooden member for suspension from above

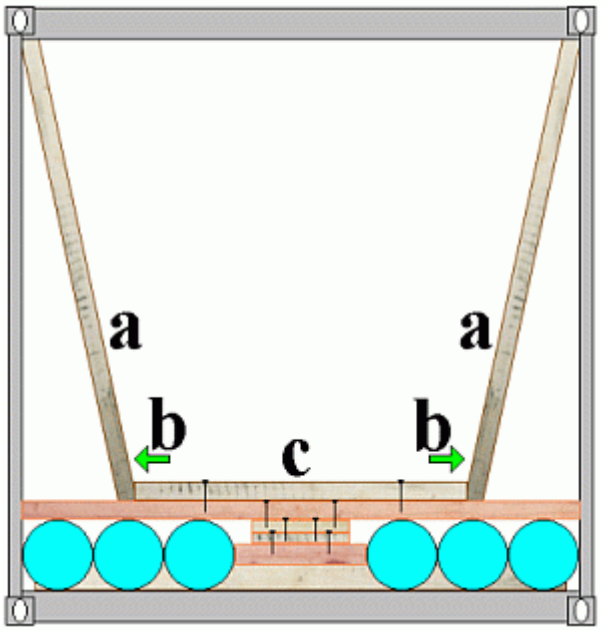
A squared lumber member is cut exactly to the size of the gap. As described previously, a beam is cut to the internal width of the container between the corrugations and, using a few pieces of waste lumber, the bracing member is nailed centrally under the base member for the shoring so that it exactly fills the gap between the round bars:



"Combined member" in place

The details stated above regarding the size of the contact areas and calculating the achievable strengths apply here too.

Two shoring members (a) are cut to size to rest on the base member and set in place in accordance with the following diagram so that they are braced against the top side rails. The wooden members are driven apart with a few hammer blows (b) and a securing member (c) is nailed in place to prevent the shoring members from moving back inwards.



Shoring for securing round bars

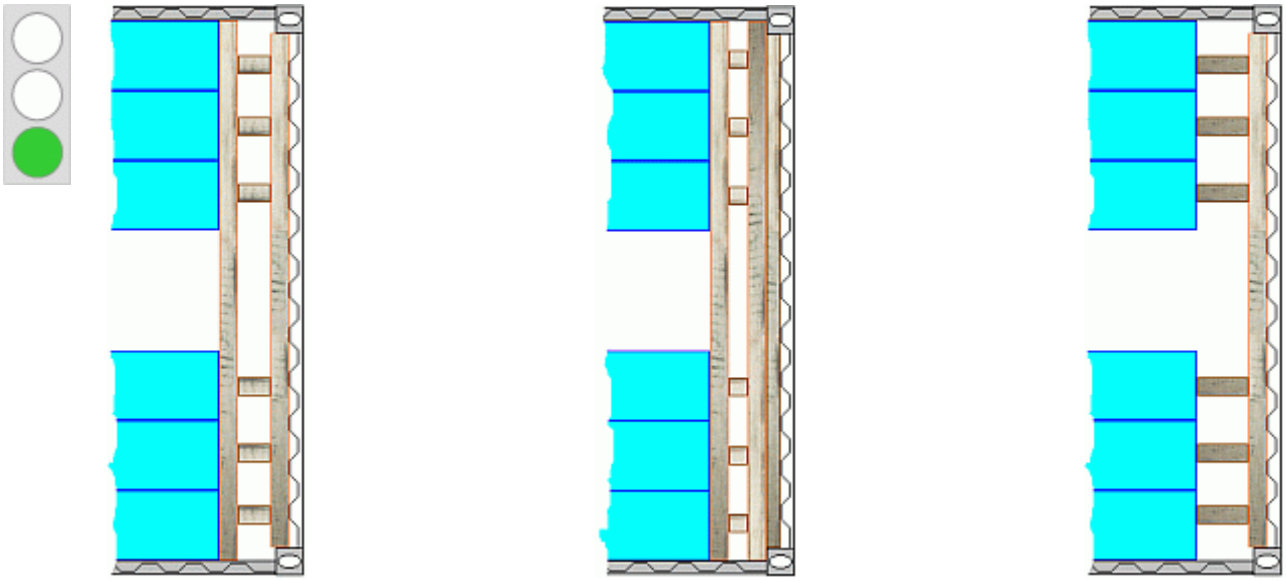
It is not necessary to secure the shoring members against shifting in the lengthwise direction if they are fitted directly into the container corrugations at the top. With smooth container walls, however, "X-bracing" in the lengthwise direction would be essential.

The round bars are now fixed in the crosswise direction in such a way that they can withstand any movements which will occur in transit:



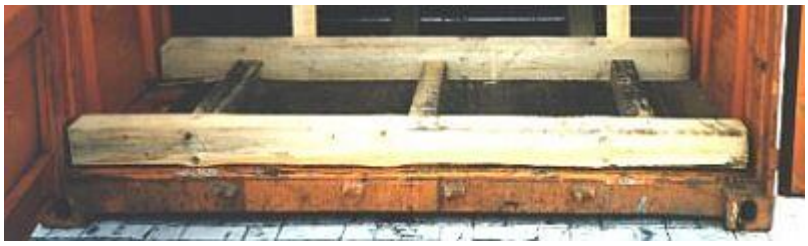
Effectiveness of shoring at a tilt of 45° to the side

Gaps in the door area must be filled with bracing to counter lengthwise movement. The method used is selected on the basis of the cargo mass, size of the gaps and similar factors.



Lengthwise bracing variants

This Figure shows bracing for moderate cargo weights:



The lengthwise wooden members are 10 cm x 10 cm in size. A total cross-sectional area of 300 cm² is thus available which bears perpendicularly to the grain of the 14 cm x 14 cm crosspieces. On the basis of a rough calculation, the bracing can withstand a lengthwise load of 300 cm² lumber cross-section x 30 daN/cm² of cross-sectional area = 9,000 daN. If the lengthwise members had also been 14 cm x 14 cm in size, loading capacity would have been almost doubled: 3 x 14 cm x 14 cm x 30 daN/cm = 17,640 daN.

Example: Bundles of round bars and pipes in a 20' box container



Inadequate securing in the door area and in the vertical direction

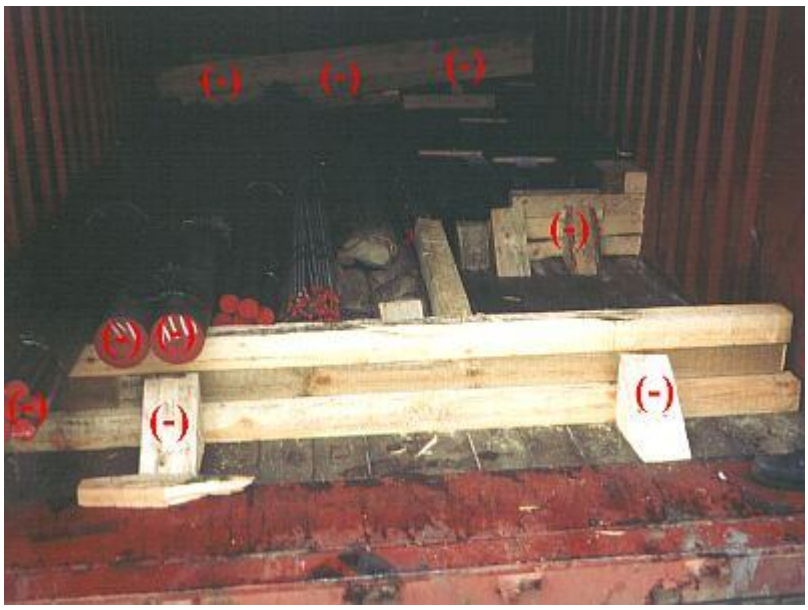
If this container is carried on a container ship in a fore and aft stow, the round bars could shift sideways, causing severe damage to the container and to adjacent containers. The shoring described in detail above would in that case be absolutely essential to secure the cargo. Since the simple steel wires used to bundle both the pipes and the round bars are incapable of keeping either the pipes or the round bars in the bundles, the wooden bracing in the door area must be raised to the height of the upper layers.



Greased pipes can "shoot" out of their bundles

Pipe bundles and similar cargoes should thus generally be braced up to their full height as they tend to "shoot" out of their bundles, with this risk being particularly pronounced with greased pipes.

Example:
Round bars, bundled steel bars and profiles in a 20' box container



Inadequately secured cargo of steel

The wedges will be completely unable to withstand the anticipated lengthwise forces. The bundles and bars on the left are completely unsecured in the lengthwise direction. The wooden members in the background fitted between the corrugations cannot protect the cargo from vertical forces nor prevent it from shifting out of its layers on exposure to sideways stresses.

Example: Round bars in 20' box containers



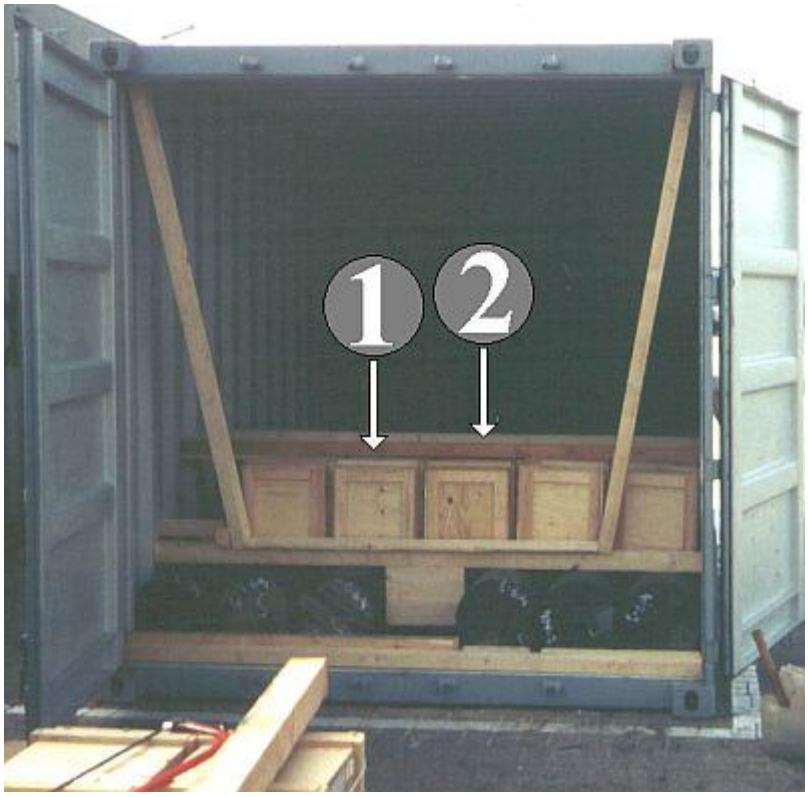
Shoring in the front of the container

These round bars, in contrast, are secured so that they cannot shift on exposure to sideways stresses and tilting.



Two shoring structures for six round bars

Example: Round bars and accompanying cases in a 20' box container

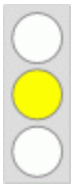


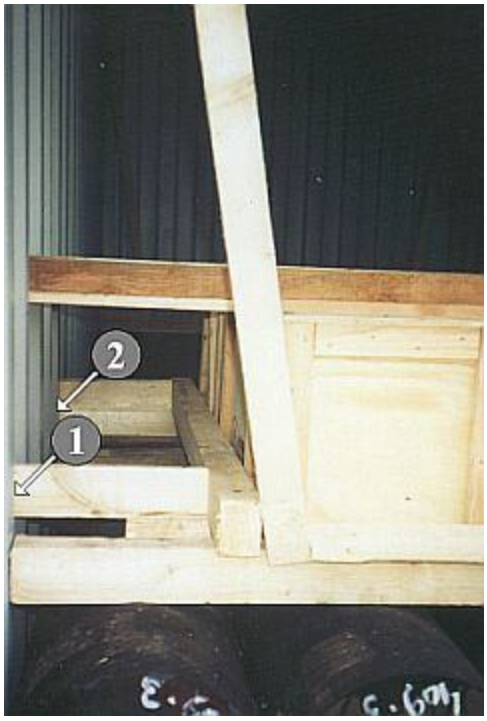
Appropriate cargo securing for round bars and wooden cases

The round bars are well secured. The cases are only light, so the securing provided by the wooden members (1) and (2) fitted tightly between the corrugations may be considered adequate. If the cases had been heavy, shoring would have been an appropriate way of securing the cases too.



View of case securing to the rear

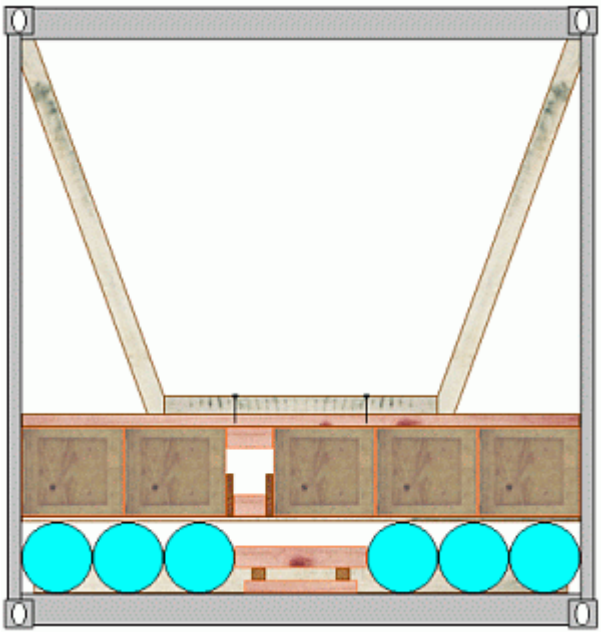




Detail

For light cases such as these, bracing with squared lumber against the container wall is sufficient. For heavier weights, boards or planks would have to be laid between the squared lumber members (1) and (2) and the container side wall.





Securing the entire cargo with shoring

Appropriate securing could also have been achieved by loading the cases directly onto the round bars and securing the entire cargo with shoring. For this to be feasible, the cases must be sufficiently strong.

Example: Round bars and cases of hazardous materials in a 20' box container



Round bars of different weights and lengths in a 20' box container

The round bars are adequately blocked relative to one another and to the end walls. The base members for the shoring, which is yet to be put in place, have already been laid.

The following Figures show the additional cases and how they are secured by nailed wooden fixings and bracing. Since these operations were not carried out ideally in the first Figure, a feasible loading variant is also provided.





Adequate securing of round bars with small errors in securing the additional wooden cases.



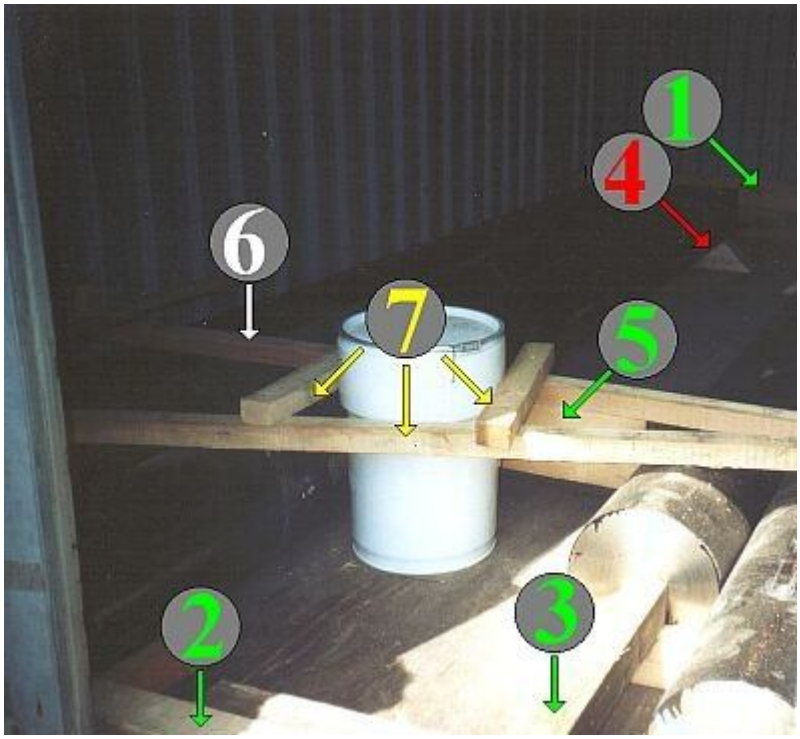
Possible securing variant using horizontally fitted wooden members

Wooden members fitted horizontally at the height of the cases' center of gravity prevent the cases from moving. It must be ensured that the boards, planks or squared lumber used for this purpose cannot slacken in transit. This can simply and effectively be achieved by wooden uprights, such as thin boards or laths.



Additional securing of horizontal wooden members

Example:
Round bars and paint bucket as accompanying cargo in a 20' box container

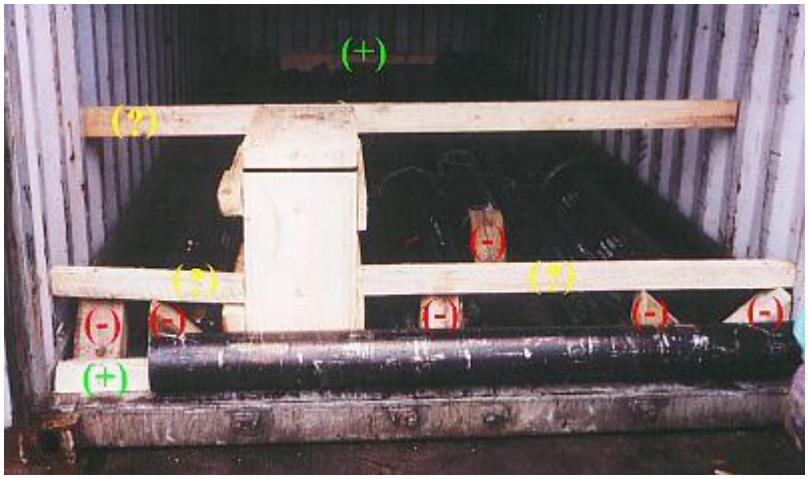


"Shadow and light" in securing

No criticism need be leveled at the lengthwise securing of the round bars by the wooden buffer members (1) against the front end wall and in the door area (2) nor at the lengthwise squared lumber member (3). The sideways securing by wedges (4) in the front part of the container is inadequate. Crosswise bracing must be provided here in a similar way to that provided with the wooden members (5). Securing for the paint bucket has been constructed from the squared lumber members (6) and (7), which is a somewhat unusual method. Despite considerable amounts of material being used, only little labor is involved, so the method is perfectly reasonable. The wooden member (6) has merely been forced into place between the container sides. The cargo is thus insufficiently secured and the overall securing action must be regarded as inadequate.

If the wooden member (6) were used as the base member for shoring and the same method were used in the front part of the container, the overall securing action could be described as good. The paint bucket could be tied to the wooden crosspieces and one of the shoring members.

Example:
Round bars of different lengths and a wooden case as accompanying cargo

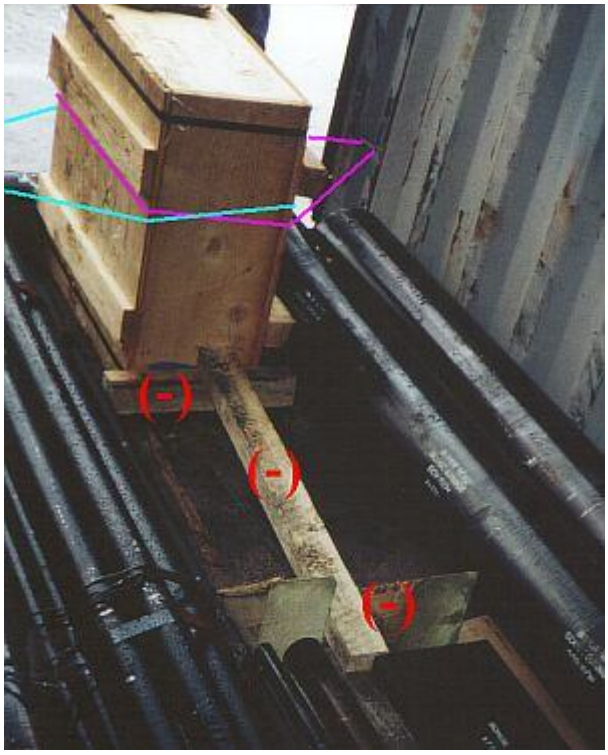




Above and left:
Overall inadequate cargo securing for round bars

Lengthwise movement of the round bars has been sufficiently restricted by wooden buffer members at the front end and a short round bar by the door. Lengthwise movement of the round bars is not prevented by the use of wedges. Vertical securing, which could simultaneously prevent sideways shifting, is absent, however.

The case is not satisfactorily secured.



Securing the case with loop lashings would have been a good idea.

The case could have been secured at the floor level of the gap with wooden members. Loop lashings from the left and right could have been provided to prevent tipping. If shoring had been used, the case could have been secured to one of the wooden shoring members.

5.2.14.11 Slabs

Definition

Slabs are cuboid semi-finished steel products that are converted into sheet and strip products at the rolling mill.
Cakes are a cuboid semi-finished copper product that is used to make other semi-finished or finished products.
The securing methods used for these semi-finished products vary only slightly due to their different dimensions so no differentiation is made below.

Transport options

As in the past, this type of cargo remains particularly suitable for conventional shipment. If container transport is the only option, flatracks are the most suitable CTUs, as slabs can be set down most rapidly and secured most effectively on them. Since flatracks are not carried in certain seasons or there are no return cargoes for flatracks in some regions of service, open-top containers or entirely standard box containers are often used.



Stainless steel slabs in port storage

5.2.14.12 Slabs - line loads

Variation in loading and securing as a function of the dimensions and masses of the slabs

Transport options

In order better to clarify any differences in packing and securing, the following examples relate to the two slabs shown, which are of the following dimensions.

Upper slab:

Length	4,270 mm
Width	1,400 mm
Height	510 mm

Its mass is 23,160 kg (23.160 metric tons). An exact conversion reveals a weight-force or normal force of 227,199.6 newtons or 22,712 daN or 22.712 kN (23,160 kg x 9.81 m/s² = 227,199.6 newtons).

The line load of the slab can be determined by dividing its mass or weight by its length, so producing the following Figures:

Mass/weight	Length of slab	Line load
23,160 kg	4.27 m	5,423.888 kg/m
227.1996 kN	4.27 m	53.208 kN/m

Lower slab:

Length	3,100 mm
Width	1,400 mm
Height	710 mm

Its mass is 23,463 kg or 23.463 metric tons. An exact conversion reveals a weight-force or normal force of 230,172 newtons or 23,017.2 daN or 230.712 kN.

The line load of the slab can be determined by dividing its mass or weight by its length, so producing the following Figures:

Mass/weight	Length of slab	Line load
23,463 kg	3.10 m	7,568.710 kg/m
230.17203 kN	3.10 m	74.249 kN/m

In box containers the floor is constructed from the transverse bottom cross members with textured coated board or plywood sheet or plank flooring. Floors are intended to carry uniformly distributed loads.

The admissible line load of 20' containers is determined by dividing the admissible payload by the value obtained after subtracting 2 m from the container's length. A completely accurate calculation would require this value to be deducted from the container's loading length.
In rough terms, the admissible line load for 20' containers can be calculated by dividing payload by 4 m (approx. container length of 6 m minus 2 m).

Since older types of standard containers with a payload of approx. 18,000 kg have admissible line loads of only 4,500 kg/m, such containers cannot be used. Even special measures to distribute the pressure are of no assistance here as the mass of the cargo exceeds the container's payload.

However, any container having a payload or line load which matches or even exceeds the mass of the slab or the line load it applies may be considered.

The minimum container payload required for individual heavy cargoes can be calculated by multiplying the line load applied by the cargo by the reference size used for calculating the line load for the particular container length, i.e. 4 m for 20' containers:

The minimum container payload required to accommodate the upper of the above-stated stainless steel slabs may accordingly be calculated as follows:

Line load applied by slab	Reference length of container	Minimum required container payload
5,423.888 kg/m	4.00 m	21,695.552 kg
53.208 kN/m	4.00 m	212.832 kN

The calculation shows that no older type ISO containers can be considered, only newer types. Purely theoretically, older type 40' containers could be used to transport the slab as they have a payload of approx. 27 metric tons. However, since the admissible line loads of these containers are only approx. 3 metric tons/m, considerable quantities of material would be required for propping/load distribution. It is accordingly uneconomic to use 40' containers.

The minimum container payload required to accommodate the lower of the above-stated stainless steel slabs may accordingly be calculated as follows:

Line load applied by slab	Reference length of container	Minimum required container payload
7,568.710 kg/m	4.00 m	30,274.840 kg
74.249 kN/m	4.00 m	296.996 kN

The calculation shows that, at the time of loading, neither older type ISO containers nor newer type 20' containers could be considered for this slab, as there was at that time no commercially available 20' box container with a payload of more than 30 metric tons.

Purely theoretically, newer type 40' containers could have been used to transport the slab as some would have the necessary payload. However, since the admissible line loads of these containers are only approx.

3.3 to 3.5 metric tons/m, even greater quantities of material would be required for propping or for load distribution than for the "upper slab". For these reasons, box containers cannot be used to carry the "lower slab".

5.2.14.13 Slabs - load distribution on flatracks

The flooring of flatracks is also designed to be uniformly loaded. However, unlike in box containers, loads can very readily be distributed on the strong bottom side rails of flatracks. This requirement presents no problems for cargo handling. If this requirement is met, no problems will arise with using either lifting gear or ground conveyors, such as forklift trucks.

In order to minimize the costs involved in securing, friction forces should be maximized. Using "sandwich" supports made from squared lumber with strips of friction-enhancing material laid on top and beneath is one way of achieving this.



Sandwich support of the structure
"friction-enhancing mat/wood/friction-enhancing mat"

The friction-enhancing material used should comprise non-slip mats with a coefficient of sliding friction stated by the manufacturer of at least $\mu = 0.6$. In the case of the large masses being loaded in the example, it must be borne in mind that, given the relatively small contact areas and consequently high pressures, the coefficient of friction will be reduced due to material compaction. It is not unusual for the coefficient of sliding friction to fall, for example, from $\mu = 0.6$ to $\mu = 0.40$. Accordingly, only the lower value should be used for calculation purposes. If contact areas are very small, the coefficient of sliding friction could drop even further. For this reason, supports with an excessively small surface area must not be used.

The greater the height of the selected support relative to its contact area, the greater are the forces which can be transferred into the load-bearing components (in the present case, the bottom side rails of the flatrack), but the greater too is the risk of tipping. Obviously, the opposite also applies: the smaller the height of the selected support relative to its contact area, the smaller are the forces which can be transferred into the load-bearing components of the means of transport, but the smaller too is the risk of tipping.

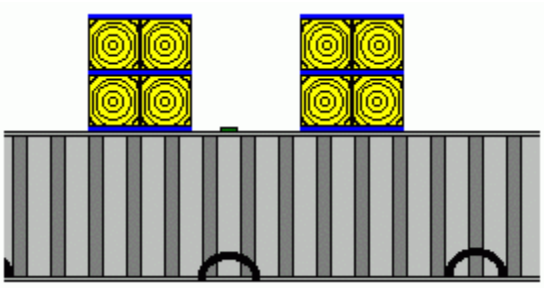


Different heights of sandwich supports at greater or lesser risk of tipping

To maximize efficiency of operation, the necessary strength of the supports and thus their dimensions should be roughly calculated before loading. Anticipated shipping stresses and the best cargo securing methods are also determined. Once these parameters have been established, material strengths can be determined in accordance with the available lashing points and load-bearing components of the container.

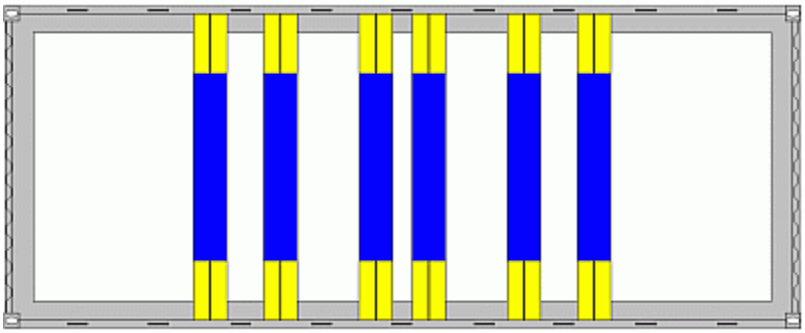
In the present case, 14 cm x 14 cm squared lumber supports are selected and laid in pairs side by side and one on top of the other, so producing a high support and minimizing the risk of tipping, for example when the cargo is laid down. In order to minimize cargo securing effort, these supports are provided with strips of 10 mm thick non-slip mats to make "sandwich" supports.





Above and selective enlargement to the left:

Side view of "sandwich" support consisting of 14 cm x 14 cm squared lumber and strips of 10 mm thick friction-enhancing material



Plan view of "sandwich" support consisting of 14 cm x 14 cm squared lumber and strips of 10 mm thick friction-enhancing material, arranged in a block of four

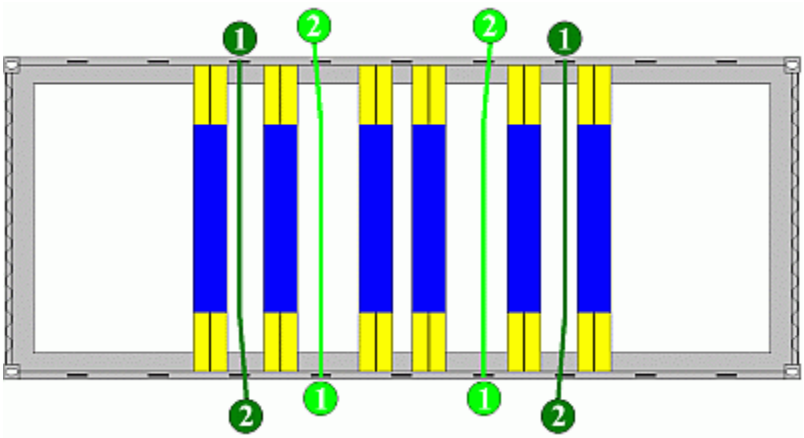
The choice of 14 cm x 14 cm squared lumber and the manner in which they are arranged produces twelve squared lumber "beams", each of a height of 28 cm, which bear on the side rails of the flatrack. Due to compression by the heavy slab, the coefficient of sliding friction is assumed to be $\mu = 0.4$.

5.2.14.14 Slabs - securing - lateral

Shipping stresses are assumed to be 0.8 g in the sideways direction and 1.0 g in the lengthwise direction. The difference between these values and $\mu = 0.4$ must be made up by additional securing. It is decided to provide only tight-fit securing. Sideways securing will be provided by "loop lashings" (half loops). There are two options for lengthwise securing:

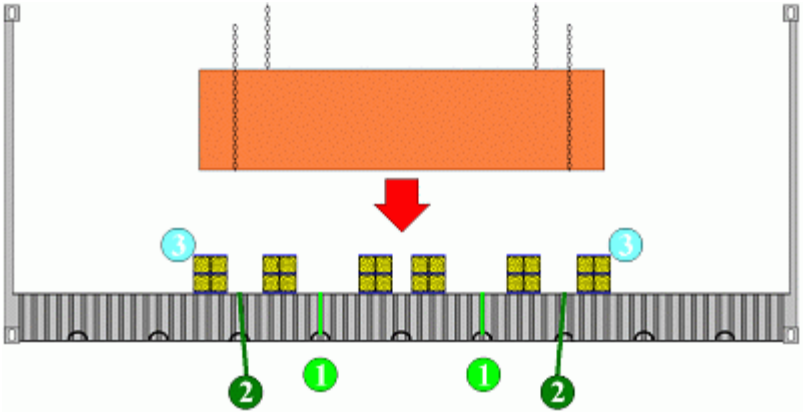
- If the end walls are sufficiently strong, bracing is enough.
- If the end walls are weaker, the necessary securing forces can be achieved by a combination of bracing and lashing.

The sideways lashings are prepared before the cargo is set down:



Initial attachment and arrangement of loop lashings

The lashing materials used, such as steel strapping, wire ropes, chains or the like, are attached to the lashing points (1) and the other ends are passed over to the opposite side (2), where they are laid down loose. For the slab which is to be secured, each loop lashing will require a length of approx. 5 m plus a little extra, the length of which will be determined by the materials used and how they are tensioned. The outermost crosswise supports, labeled (3) in the following diagram, at each end should in each case be laid so that they extend beyond the slab in the direction of the end wall. In this way, these wooden crosspieces can act as an abutment for the bracing towards the end walls of the flatrack.

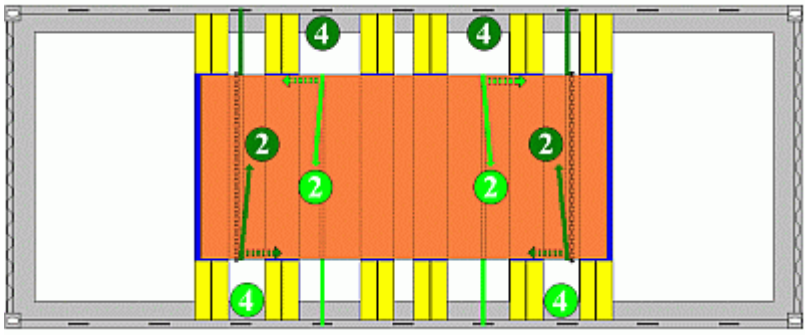


Setting down the slab:

(1) = attached ends of the loop lashings
(2) = loose ends of the loop lashings
(3) = wooden crosspieces protruding towards the end walls

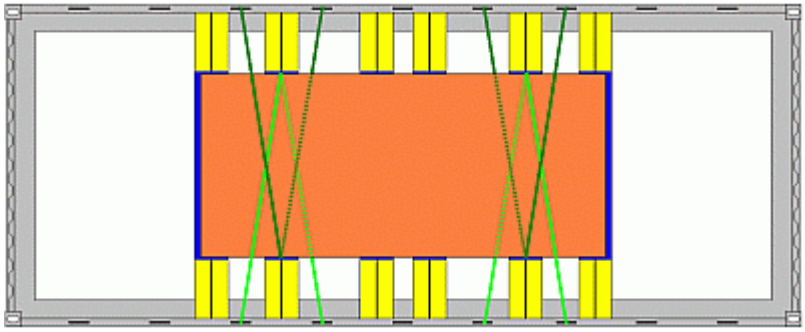
Once the cargo has been set down, the loose ends of the lashings (2) are each passed over the slab to the lashing points (4) on the other side of the flatrack. Before finally fastening the ends to these lashing points,

the path taken by the loop lashings must be carefully checked. At the deflection points shown by the dotted arrows in the following diagram, the lashing means must be adjusted manually, preferably by a second person, so that the parts of the loop lashing running above and below the slab are symmetrical. In simple terms, the shortest path between the lashing points must be chosen. At no point during transport must it be possible for the lashing materials to shift or move of their own accord.

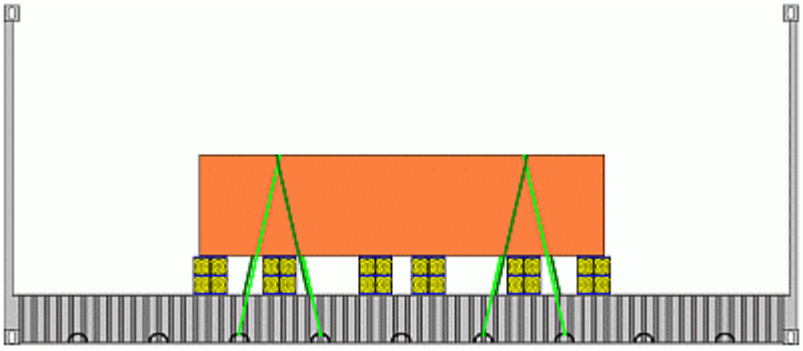


Positioning and fastening of loop lashings

Once properly fastened, the loop lashings look like this:

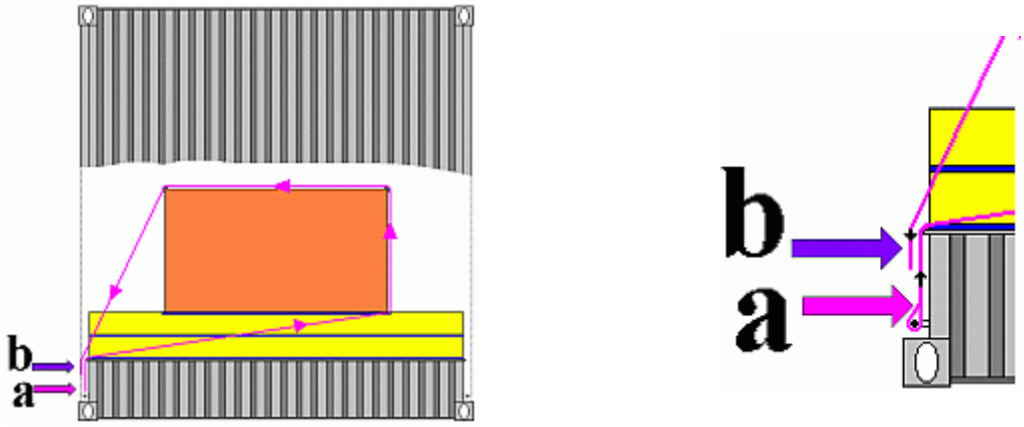


Plan view - slab secured with two loop lashings on each side



Side view - slab secured with two loop lashings on each side

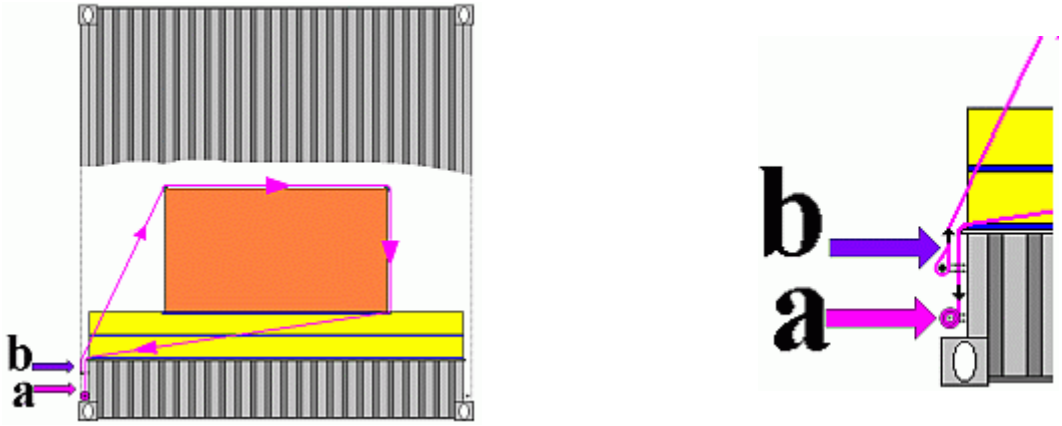
The path taken by the loop lashings is clarified again in the following Figure:



Front view - path of a loop lashing to one side

Point a is the initial attachment point for all conventionally used cargo securing materials such as steel strapping, steel wire ropes, chains and "single-use" belts as well as prefabricated cargo securing materials such as lashing belts with ratchet tensioners, chains with integral tensioners etc. The loop lashing is passed from point a beneath the item of cargo to be secured. As already mentioned, this end is advantageously positioned before the item of cargo is loaded. Point b represents an adjacent lashing point with an identical or at least similar maximum securing load. The end of the loop lashing which has been passed over the cargo is attached to this point. When tighteners are used, they are attached to point b either directly or by means of additional aids.

If the lashing means, such as for example wire or belt reels, are an integral part of the flatrack or similar means of transport, there are two basic securing methods:



Front view - path of a loop lashing to one side

The belts are unwound from the reels and passed over to the other side. Once the cargo has been loaded, they are hooked on to the opposite side and tightened. As a result, tension is applied from below in this case. Of course, if desired, tension may also be applied from above. However, in this case, the cargo must first be loaded. The belts should then be passed over the slab, then returned to the same side under the slab and hooked in on that side. Clearly, this method is somewhat more awkward and time-consuming.

Using the quicker method, lateral securing of the slab would entail:

- positioning sandwich supports crosswise on the flatrack
- unrolling two belts from each side and pulling them over to the other side of the flatrack
- setting down the slab on the flatrack
- throwing the belts back over the slab to the starting side and hooking them into a load-bearing lashing point, taking care to ensure that the belts are not twisted and to pad sharp edges
- and finishing the job by tightening the ratchet tensioners.

Due to design shortcomings, this ideal type of securing is currently not yet possible.

Lashing reels arranged on only one side of the flatrack are not entirely suitable for providing securing with loop lashings.



Flatrack with integral lashing reels and webbing belts

In this case, using one of the methods described above, tension may be applied from above or below with the lashing reels on one side. If possible, webbing belts of the same maximum securing load and tightenable with conventional ratchet tensioners should be used to provide securing to the other side. If such tighteners are not available, it is also entirely feasible to use equivalent single-use belts which are pretensioned by special tighteners.

5.2.14.15 Slabs - maximum securing load of lashing points

So that the good securing performance offered by loop lashings may in future be better utilized, container manufacturers should pay greater attention to cargo securing and install such aids on both sides of the container, while those commissioning containers should specify that such aids be fitted. In this way, one of the very best lashing methods, namely loop lashing, can be implemented particularly cost-effectively.

Effective securing forces can be calculated from material strengths and lashing angles. The strength of lashing points is sometimes shown on flatracks.



While the meaning of "safe working load" is clearly defined for load suspension devices in hoist operation and loading gear, it is not for lashing points on containers.



And what are packing personnel to make of "maximum pull strength"? The "Guidelines for the correct stowage and securing of cargoes for carriage in ocean-going ships" provide, in particular in Appendix 13, information about nominal breaking load (BL) and maximum securing load (MSL).

If no information is provided on CTUs with regard to the strength of lashing points, or if such information is unclear, the rules of thumb published in the above guidelines should be applied.

The breaking load of lashing rings or bars etc. may be calculated using the rule of thumb $d^2 \times 20$, i.e. diameter x diameter x 20. The maximum securing load (MSL) should amount to at most 50% of the breaking load. The result of this rough calculation is a value in kN if the diameter unit used is centimeters and in daN if the diameter unit used is millimeters: In accordance with the above explanations, maximum securing load is accordingly half the nominal breaking load (BL), i.e. MSL = BL/2.



Determining the diameter of lashing points

If the diameter of a lashing point is measured as 2 cm or 20 mm, the nominal breaking load (BL) can be calculated as follows:

$$BL = d \times d \times 20 = 2 \times 2 \times 20 = 80 \text{ [kN]}$$

$$BL = d \times d \times 20 = 20 \times 20 \times 20 = 8{,}000 \text{ [daN]}$$

Since the MSL can amount to at most half the BL, the MSL is determined as follows:

$$MSL = BL/2 = 80/2 = 40 \text{ [kN]}$$

$$MSL = BL/2 = 8{,}000/2 = 4{,}000 \text{ [daN]}$$

The flatrack loaded with the slab has lashing points 20 mm in diameter. Using the two loop lashings, it is possible to achieve lashing forces (in relation to the lashing points) in each sideways direction of 4 × 40 kN = 160 kN or 4 × 4,000 daN = 16,000 daN. This is entirely sufficient because with a mass of 23,463 kg or a normal force of 230,172 N and assuming sideways acceleration of 0.8 g and a coefficient of sliding friction of $\mu = 0.4$, securing forces of 92,065 N must be applied; these amount to 9,206.5 daN or 92.065 kN.

Obviously, in this case, the maximum securing load can be calculated without passing via the nominal breaking load. The maximum securing load of lashing points can be calculated from the rule of thumb $d^2 \times 10$, as the MSL may at most be only half the BL. The calculation is then as follows:

$$MSL = d \times d \times 10 = 2 \times 2 \times 10 = 40 \text{ [kN]}$$

$$MSL = d \times d \times 10 = 20 \times 20 \times 10 = 4{,}000 \text{ [daN]}$$

This simplified calculation can be used whenever the ratio between BL and MSL is a round number, otherwise it is always better to calculate the BL first and then the MSL.

5.2.14.16 Securing with steel strapping

The example uses 32x16 blued steel strap, i.e. steel strapping of a width of 3.2 cm or 32 mm and a thickness of 0.16 cm or 1.6 mm, because when specifying steel strap, the first number is the width in millimeters and the second number the thickness in tenths of a millimeter. The "Guidelines for the correct stowage and securing of cargoes for carriage in ocean-going ships" provide the following rule of thumb for the nominal breaking load (BL) of blued steel strap: width x thickness x 85. The maximum securing load should amount to at most 70% of the BL, so giving the following calculations:

BL = b x d x 85 = 3.2 x 0.16 x 85 = 43.52 [kN]

BL = b x d x 85 = 32 x 1.6 x 85 = 4,352 [daN]

Since the MSL can amount to at most 70% of the BL, the MSL is determined as follows:

MSL = BL x 0.7 = 43.52 x 0.7 = 30.464 [kN]

MSL = BL x 0.7 = 4,352 x 0.7 = 3,046.4 [daN]

Steel strapping of the stated quality and type is sufficient to provide lateral securing of the slab. The four working parts of the two loop lashings on each side could theoretically provide a securing force of 121.856 kN or 12,185.6 daN. Even if the effective forces are assumed to be reduced to a certain extent due to the lashing angle, securing will be adequate.

Steel strapping can only be used for securing if the lashing points are suitable for this purpose, i.e. they must have straight portions of sufficient width for the entire width of the steel strap to lie against. Unsuitable lashing points are those in which the steel strap does not lie flat over its width and, when subjected to tension, is bent in the transverse direction.

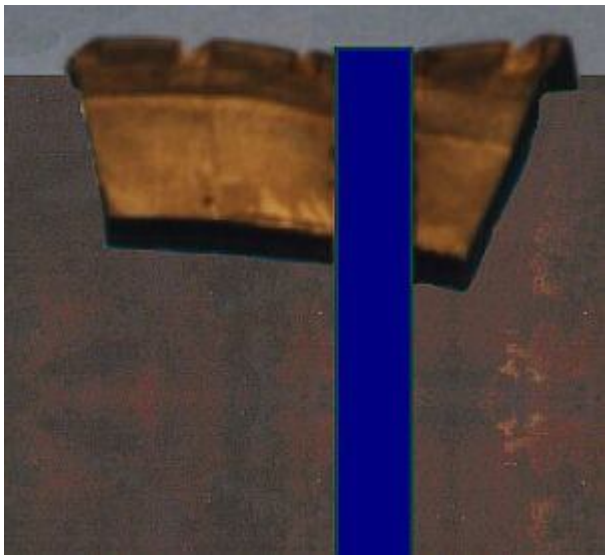


Lashing point suitable for steel strapping



Lashing point unsuitable for steel strapping

Advantages of steel strapping are that it can be applied very cheaply and it is relatively strong. Disadvantages, however, are its very low elasticity and the impossibility of retensioning. When applying steel strapping, it is thus advisable to combine it with an elastic material and segments of used tires are suitable for this purpose. This markedly increases the elasticity of the overall lashing and the tire rubber also provides excellent edge protection.



Securing a slab with steel strapping

5.2.14.17 Slabs - maximum securing load of wire ropes

Steel wire rope lashing is another option, for example wire ropes of the type 6 x 37 + 1 FC in conjunction with suitable shackles and turnbuckles would be a usable alternative.

The "Guidelines for the correct stowage and securing of cargoes for carriage in ocean-going ships" provide the following rule of thumb for calculating the nominal breaking load (BL) of steel wire ropes of the stated type: $BL = 50 \times d^2$.

The basic calculations for 10 mm thick wire ropes are as follows:

BL = d x d x 50 = 1 x 1 x 50 = 50 [kN]

BL = d x d x 50 = 10 x 10 x 50 = 5,000 [daN]

The basic calculations for 12 mm thick wire ropes are as follows:

BL = d x d x 50 = 1.2 x 1.2 x 50 = 72 [kN]

BL = d x d x 50 = 12 x 12 x 50 = 7,200 [daN]

Since the regulations state that the maximum securing load for "single-use wire ropes" can be assumed to be only 80% of the breaking load, the MSL of the above-described lashing wire ropes can be calculated as follows:

For 10 mm diameter wire ropes:

MSL = BL x 0.8 = 50 x 0.8 = 40 [kN]

MSL = BL x 0.8 = 5,000 x 0.8 = 4,000 [daN]

For 12 mm diameter wire ropes:

MSL = BL x 0.8 = 72 x 0.8 = 57.6 [kN]

MSL = BL x 0.8 = 7,200 x 0.8 = 5,760 [daN]

A direct rule of thumb can be used to calculate the MSL of "single-use wire lashing ropes" from the above-stated values without having to calculate the BL. Since the MSL can amount to at most 80% of the BL, the rule of thumb for the MSL of "single-use wire lashing ropes" is:

$MSL = d^2 \times 40$

The direct calculation using the rule of thumb for 10 mm wire ropes would thus have been:

MSL = d x d x 40 = 1 x 1 x 40 = 40 [kN]

MSL = d x d x 40 = 10 x 10 x 40 = 4,000 [daN]

The maximum securing load of 12 mm wire ropes could have been calculated as follows:

MSL = d x d x 40 = 1.2 x 1.2 x 40 = 57.6 [kN]

MSL = d x d x 40 = 12 x 12 x 40 = 5,760 [daN]

The calculated strengths apply per single run of the particular rope and should be multiplied appropriately for multiple runs of the rope. A note of caution must be sounded, however, as wire ropes are weakened by deflection around lashing points, shackles, turnbuckles or other fastening elements, the extent of which weakening being greater, the smaller is the ratio of diameter of deflection D to rope diameter d.

D/d ratio	**0.5**	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**	**4.5**	**5.0**
Strength per single run	50%	65%	72%	77%	81%	85%	89%	93%	96%	99%



Example of weakening of a wire rope of 16 mm diam. on deflection around a lashing point of 20 mm diam. and example of nonuniform securing

The lashing point has a diameter of D = 20 mm, the wire rope of d = 16 mm.

The D/d ratio is 20 mm / 16 mm = 1.25.

On the basis of the Table, strength per single run can be calculated as approx. 68% that of the single run.

On the basis of the above-stated rules of thumb, the theoretical nominal breaking load of the doubled, 1.6 cm or 16 mm diam. wire rope is thus

1.6 x 1.6 x 50 x 0.68 = 87.04 kN or
d^2 x 50 x 0.68 = 16 x 16 x 50 x 0.68 = 8,704 daN

Since the MSL of "single-use wire ropes" can amount to at most 80% of the BL, the maximum securing load of the doubled wire rope is

87.04 kN x 0.8 = 69 kN or
8,704 daN x 0.8 = 6,963.2 daN.

The MSL of the 20 mm diam. lashing point is 50% of the BL, i.e. d^2 x 20 x 0.5.
Depending upon whether the result is required in daN or kN, the calculations are as follows:

MSL = d^2 x 20 x 0.5 = 2 x 2 x 20 x 0.5 = 40 [kN]

MSL = d^2 x 20 x 0.5 = 20 x 20 x 20 x 0.5 = 4,000 [daN]

Since the doubled wire rope has a substantially greater loading capacity than the lashing point to which it is attached, material was wasted in this case. Applying 16 mm wire rope securing to a 20 mm lashing point is nonuniform and uneconomic.

However, as the following Table shows, this does not only apply to the 16 mm wire rope. With the 20 mm diameter lashing point in question, it is only economic to use the 8 mm diameter "single-use wire lashing ropes", because in this case the maximum securing load of the double run virtually matches the maximum securing load of the lashing point. Smaller diameters of rope do not fully utilize the strength of the lashing point, while larger diameters do not fully utilize the strength of the wire lashing ropes.

Rope diam-eter [mm]	**Breaking load of a double run**	**Percent-age MSL of BL**	**Ratio of lashing point & wire diam.**	**Residual strength after deflection**	**MSL of double run taking account of deflection**
d	2 × d^2 × 50	80%	D/d	as per Table	Rule of thumb [in kN]
6	2 × 0.6 × 0.6 × 50	0.8	20/6 = 3.33	approx. 87%	25.056
8	2 × 0.8 × 0.8 × 50	0.8	20/8 = 2.50	81%	41.472
10	2 × 1.0 × 1.0 × 50	0.8	20/10 = 2.00	77%	61.600
12	2 × 1.2 × 1.2 × 50	0.8	20/12 = 1.66	approx. 74%	85.248
14	2 × 1.4 × 1.4 × 50	0.8	20/14 = 1.43	approx. 71%	111.328
16	2 × 1.6 × 1.6 × 50	0.8	20/16 = 1.25	approx. 68%	139.264

In the case of reusable wire lashing ropes, the "Guidelines for the correct stowage and securing of cargoes for carriage in ocean-going ships" state that the maximum securing load may be deemed to be only 30% of the nominal breaking load.

The following Table states MSL values for various thicknesses and deflections of such wires:

Rope diam-eter [mm]	**Breaking load of a double run**	**Percent-age MSL of BL**	**Ratio of lashing point & wire diam.**	**Residual strength after deflection**	**MSL of double run taking account of deflection**
d	$2 \times d^2 \times 50$	30%	D/d	as per Table	Rule of thumb [in kN]
6	2 × 0.6 × 0.6 × 50	0.3	20/6 = 3.33	approx. 87%	9,396
8	2 × 0.8 × 0.8 × 50	0.3	20/8 = 2.50	81%	15.552
10	2 × 1.0 × 1.0 × 50	0.3	20/10 = 2.00	77%	23.100
12	2 × 1.2 × 1.2 × 50	0.3	20/12 = 1.66	approx. 74%	31.968
14	2 × 1.4 × 1.4 × 50	0.3	20/14 = 1.43	approx. 71%	41.748
16	2 × 1.6 × 1.6 × 50	0.8	20/16 = 1.25	approx. 68%	52.224

Clearly, according to this Table, only the use of 14 mm diameter "multiple-use wire ropes" makes sense.

"Sharp edges" bring about a particularly marked reduction in the strength of steel wire ropes. Appropriate protective measures are thus very highly advisable.

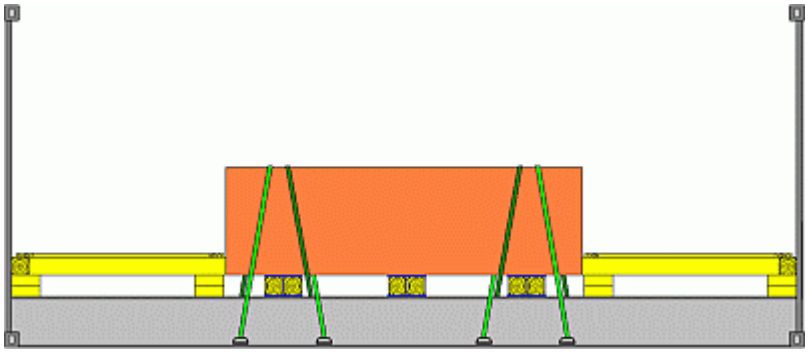


Edge protection for wire ropes on a slab provided by a tire segment

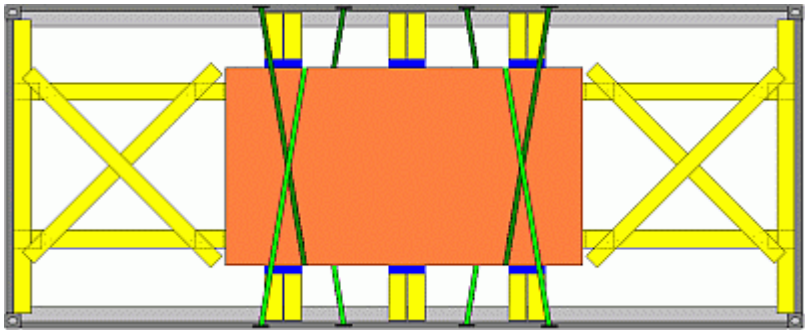
Wire ropes can be applied in various different ways. These various methods require the use of different strengths/thicknesses of materials and different kinds of aids.

5.2.14.18 Slabs - longitudinal securing by bracing

Wooden bracing is ideal for providing lengthwise securing of slabs.



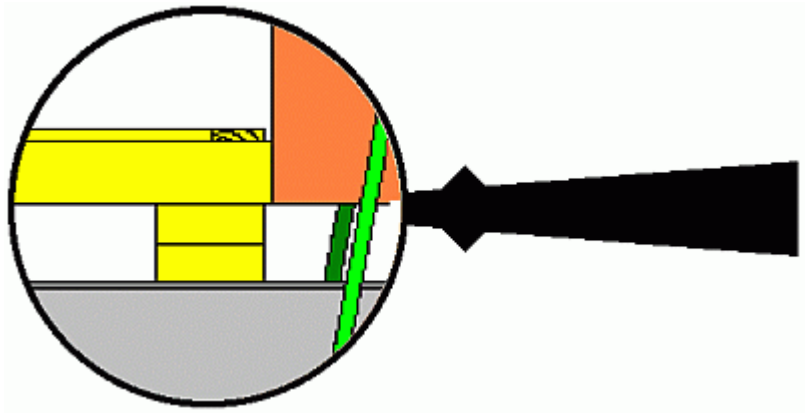
Lengthwise bracing of a slab - side view



Lengthwise bracing of a slab - plan view

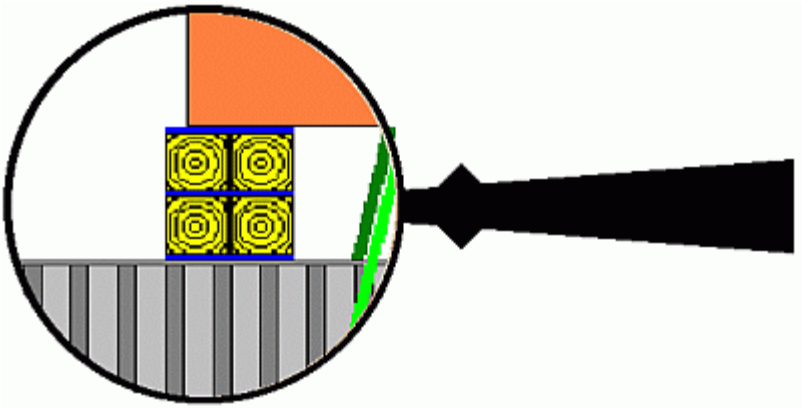
The drawings show the basic principles of lengthwise securing by means of wooden bracing. The essential components comprise the crosswise wooden members laid against the end walls to distribute pressure, longitudinal wooden members to absorb forces together with additional diagonally arranged wooden boards fastened with nails to provide "X-bracing". Some features should nevertheless be borne in mind. There are also various useful hints which can save materials.

It can be seen from the side view that the lengthwise wooden members are in each case firred at both ends.



Firring of lengthwise wooden members

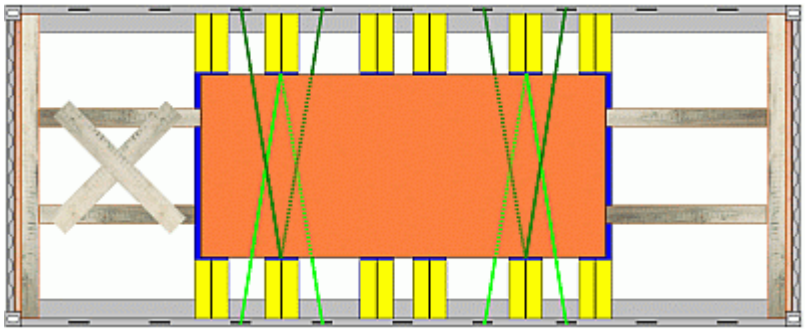
It has already been mentioned that it is advantageous, when placing the supports prior to loading of the slab, to ensure that these supports protrude a little at the sides.



Protruding supports save labor

The principal advantage is that firring need only be provided at the end walls of the flatrack.

Bracing for the slab could now be as below:

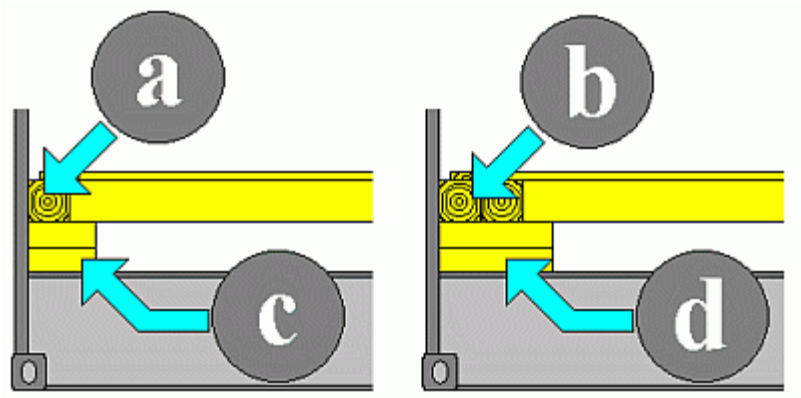


Wooden bracing - plan view

Whether or not the lengthwise members have to be X-braced is determined by the span, lumber cross-section and similar factors. In this case, 14 cm x 14 cm squared lumber of a length of just over 1.20 m was selected. No sagging or shifting is to be expected if the squared lumber members are attached to their firring. It is thus possible completely to dispense with X-bracing.

Each 14 cm x 14 cm squared lumber member can withstand bracing loads of approx. 6,000 daN. Two can thus withstand approx. 12,000 daN. Four wooden members of this size would accordingly be required to provide proper bracing.
(Specifically: 14 cm x 14 cm x 30 daN/cm² = 5,880 daN per wooden member)

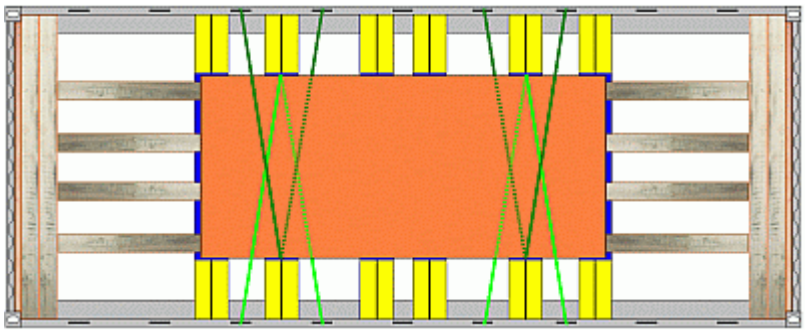
In order to ensure more reliable transfer of forces, the depth of the crosspieces in front of the flatrack end walls should be increased.



Increasing depth with a second wooden crosspiece

To this end, a second squared lumber member (b) is laid in front of (a). Longer firring may possibly be required for this purpose, in which case length (d) will be required instead of (c).

The slab is now secured against all eventualities in the lengthwise direction by the four wooden lengthwise members.



5.2.14.19 Slabs - packing into a box container

Packing a 23 metric ton stainless steel slab in a 20' box container

Introducing such a weight into a standard box container entails the use of particularly heavy equipment.



Introducing a 23 metric ton slab using a 35 metric ton forklift truck

In this case, a 35 metric ton forklift truck, which is capable of lifting the slab lengthwise, is being used and will set the slab down in the door area of the container. A 25 metric ton forklift truck would not be capable of picking up the slab in this way as the load-carrying capacity of 25 metric tons relates to a load center distance of 600 mm.

The slab must be positioned in such a way that, once it has been pushed into place, it will lie as centrally as possible in the container. During the initial phase, relatively small corrections to the starting position are possible from the side.
Squared lumber supports are intended to ensure that the slab lies as horizontally as possible and at the height of the container floor.



Correcting slab position in the container door area

The container to be packed should itself be immobilized as far as possible before the slab is pushed in.



Setting down the slab in the container door area

Friction-enhancing materials cannot be laid under the cargo in such cases. Not only would packing be complicated, but unpacking of the container would be made virtually impossible. The slab must be pushed in extremely carefully so that the sharp edges do not damage the container floor.

5.2.14.20 Slabs - lateral securing

Since standard box containers do not have a sufficient number of adequately dimensioned lashing points to withstand the necessary securing forces, wooden blocking must be used. Several variants are presented below.

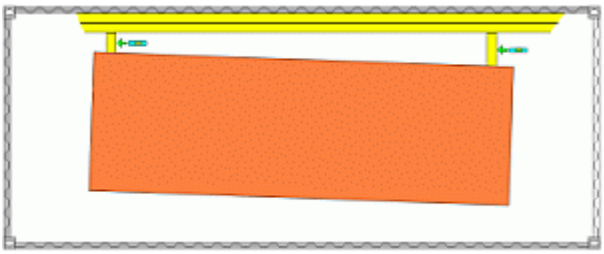
While exactly central placement of the slab in the container is theoretically desirable on load distribution grounds, it is not desirable with regard to the securing measures to be carried out.

All the squared lumber members for lateral and lengthwise bracing ought to be cut exactly to size.



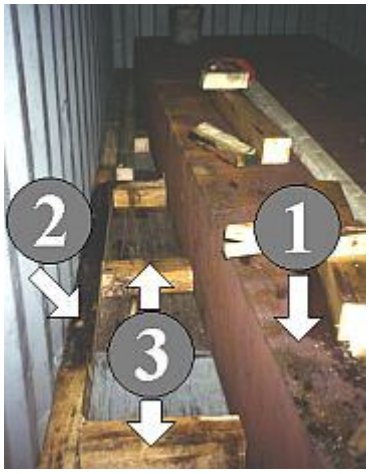
Exact positioning of the slab entails cutting the wood exactly to size.

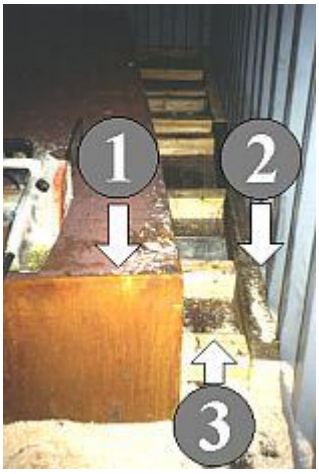
However, if the slab is introduced with a slight offset (which almost always happens anyway when the slab is pushed in), the wooden bracing members need not be cut so exactly. An appropriate number of members ranging in size from the smallest to greatest distance between the slab and the container walls is cut to length and each member can then be "braced in place". The diagrams deliberately exaggerate the offset somewhat in order to clarify the principle.



Slab inserted with offset in order to permit more effective blocking

If it is assumed that the slab will be exposed in transit to sideways inertia forces amounting to 80% of its normal force and that friction forces of 20% of its normal force will apply, securing must be provided for 60% of the normal force. Since, given a uniform load distribution, the container walls are capable of withstanding 60% of the payload, this value is a good match for the required securing forces.



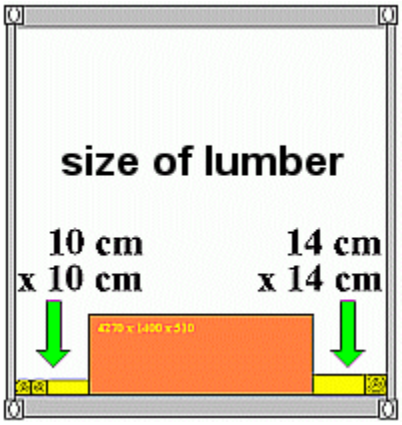


Lateral securing of a slab with 14 cm x 14 cm squared lumber

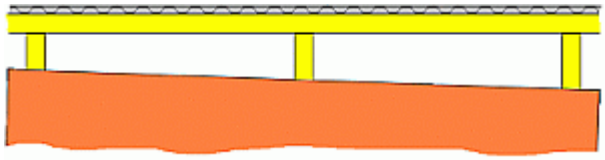
Key to reference numerals:
1 = slab
2 = squared lumber to distribute pressure
3 = squared lumber fixed to container floor for bracing

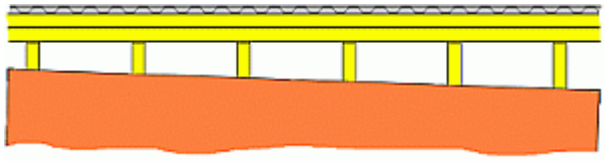
In this case, 14 cm x 14 cm squared lumber was used. If the price per cubic meter of lumber is identical, twice the length of 10 cm x 10 cm wooden members can be used.

The depth of the members for transferring forces to the container side walls can be improved in this way. If two 10 cm x 10 cm wooden members are positioned in each case against the container side walls instead of the singly positioned 14 cm x 14 cm wooden members, this depth is increased to 20 cm and flexural strength is improved. However, this increases labor costs, because the number of cross braces to be fitted is doubled.



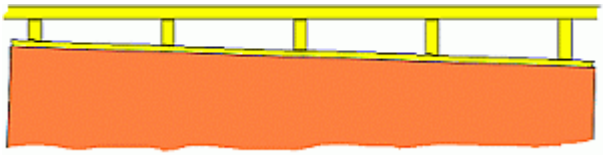
Options for use of different lumber sizes



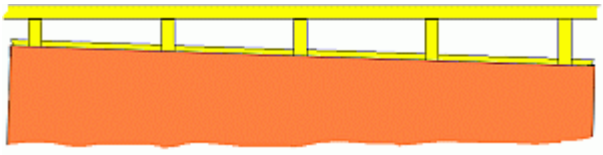


Use of different lumber sizes for transferring forces to the container side walls

The squared lumber should not be nailed to new container floors or those made from plywood and textured coated board. Instead, wooden members may be placed against the slab or fitted between the wooden bracing members. The methods which are generally possible are shown in the following diagrams.



Wooden members fitted against the slab for fixing the cross braces



Wooden members fitted between the cross braces to fix the latter in place

The following is a real example using 14 cm x 14 cm wooden members.



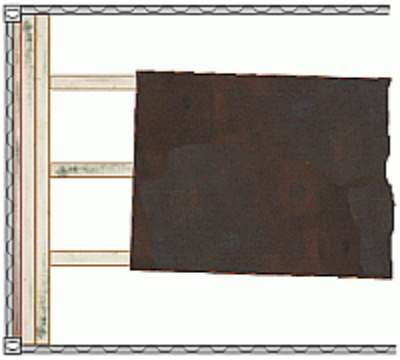
securing on left-hand side



securing on right-hand side

using 14 cm x 14 cm squared lumber

In the lengthwise direction, the container end walls can withstand uniformly distributed inertia forces amounting to 40% of the payload. If 20% friction is assumed, longitudinal forces of up to 60% of the cargo mass can be absorbed.

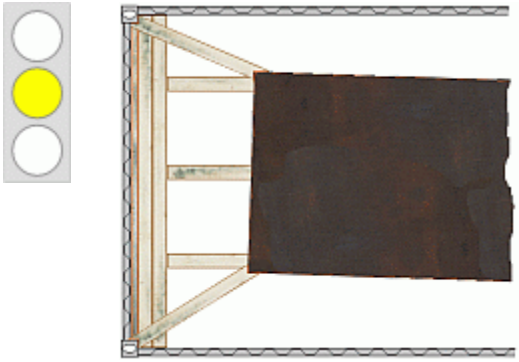


Bracing of the slab
against the front end wall

There is no point in using more wooden members than shown as the front end wall would otherwise give way, being the weak point. The maximum securing load of the lengthwise wooden members must

accordingly (almost) amount to 0.4 times the container payload.

If part of the transport operation is to take place in Europe by intermodal carriage by road or rail, stresses in the longitudinal direction of 80% to 100% of the slab's normal force must be expected. Given the assumed friction forces of 20%, 60% to 80% of the normal force must accordingly be applied as securing forces in the longitudinal direction. Since the front end wall cannot withstand such forces, bracing of 20% or 40% of the normal force must be provided against the container corner posts, in addition to the 40% against the front end wall.



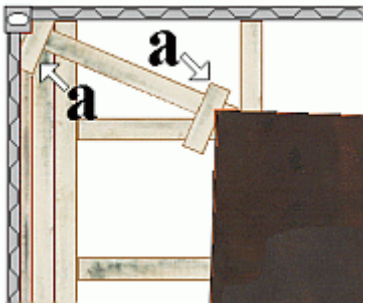
Bracing against corner posts with cut "birds' mouths"

This is implemented with wedge-shaped cuts, or "birds' mouths", in the ends of the wooden members. However, this is only feasible if they are not cut at too acute an angle and the components against which they are to be braced are not too sharp-edged, as there is otherwise a risk that the members will split. Measures which can be taken to counter this problem will be explained below.



Favorable angle **Excessively acute angle**

Since wood is relatively insensitive to notch effects at right-angles to the grain, one solution is to place additional wooden members between the oblique stays.



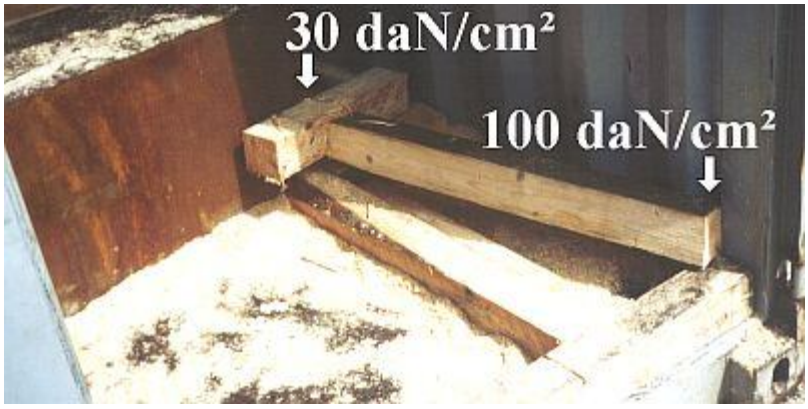
Oblique bracing using additional wooden members

Notches are cut in the additional wooden members (a). The wooden members are placed against the corner posts and the corners of the slabs and the space between is braced with the oblique stays. Since these wooden members are loaded perpendicularly to the grain, for the purposes of calculation they can only be assumed to withstand loads of 30 daN per cm². Directly applied wooden members, which are loaded on the end grain, i.e. parallel to the grain, can be assumed for the purposes of calculation to withstand loads of 100 daN per square centimeter of cross-sectional area.

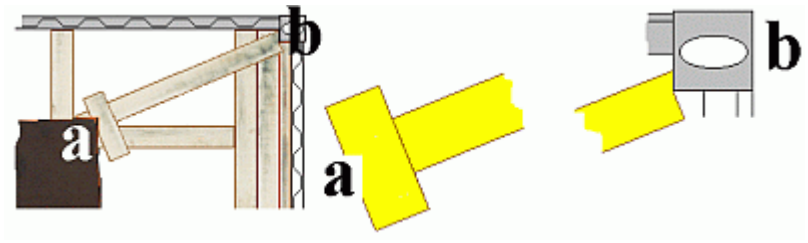


V-cut as notch in additional wooden member

Depending on the particular circumstances, the above variants may also be combined:



Different use of wooden members entails other calculations



Example of wooden members of varying effectiveness

At (a) on the slab, the V-cut provides an area of 10 cm x 10 cm for loading perpendicular to the grain. Loading capacity is accordingly 100 cm² ≈ 30 daN/cm = 3,000 daN. At the container corner posts, the wooden bracing member is loaded parallel to the grain. However, the forces act on only one third of the member. Loading capacity is 3.3 cm x 10 cm x 100 daN/cm² = 3,300 daN. This securing arrangement can be described as entirely homogeneous.

However, at the real angle of approx. 20°, approx. 94%, or 2,820 daN, of the securing is effective as a lengthwise component, as calculated from the cosine of 20°.



Left-hand end bracing

In the present real situation, the slab, once introduced, was braced first to the sides and then against the front end wall.



Additional transfer of forces to the corner posts

Subsequently, a squared lumber member was placed in the door area in such a manner that, with the doors closed, the forces are directly transferred onto the door leaves with lengthwise wooden members which are yet to be put in place. In addition, oblique stays were placed against the corner posts.

5.2.14.21 Slabs - vertical securing



Vertical securing to counter shifting out of the floor-level securing

In order to prevent the slab from shifting out from the wooden securing members in rough seas or on

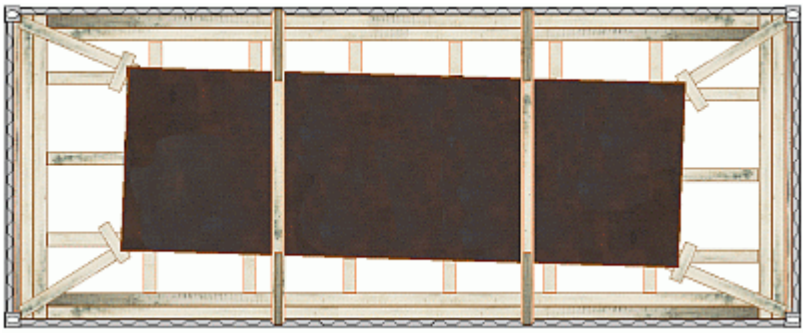
exposure to other vertical impacts, shoring was arranged against the top side rails.



Fitting the final lengthwise bracing

Only after the left-hand door leaf had been shut were the outstanding lengthwise bracing members fitted between the slab and the crosspiece placed in front of the door.

In this way, the slab was well secured. Since mainly 14 cm x 14 cm squared lumber was used, this securing does not entirely correspond to the following diagram, which is based on the use of 10 cm x 10 cm wooden members.



Optimum securing of a slab in a box container

The essential difference between the actual situation and this diagram is that the diagram shows the

doubled wooden members for distributing the pressure to the container walls in order to achieve a greater "depth".

It should be noted that the methods shown are virtually the only possible way to secure such heavy slabs in box containers. Securing by lashing is not possible. On the one hand for reasons of packing feasibility, because the slabs cannot be placed on supports, and on the other because conventional box containers only have lashing points with maximum securing loads of approx. 1,000 daN

5.2.14.22 Slabs - load distribution in open-top containers

Packing slabs in open-top containers

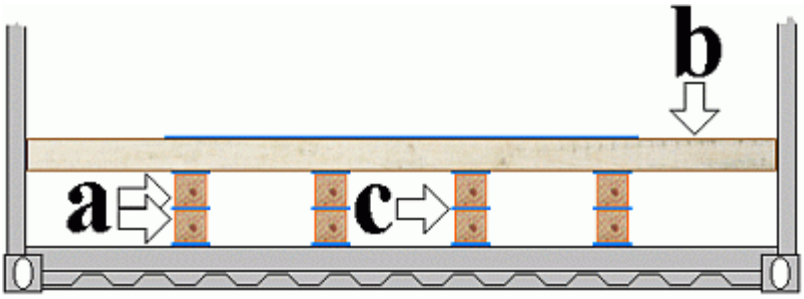
The advantage over packing in standard box containers is that friction-enhancing material can be used. This substantially reduces securing effort in terms of the necessary maximum securing loads. Moreover, many open-top containers have lashing points with a maximum securing load of 2,000 daN. However, these values are lower than those encountered when loading on flatracks.

Supports are required so that the slabs can be set down during packing and lifted up again on unpacking, unless special slab tongs were used which would allow the slabs to be set down directly on the container floor.



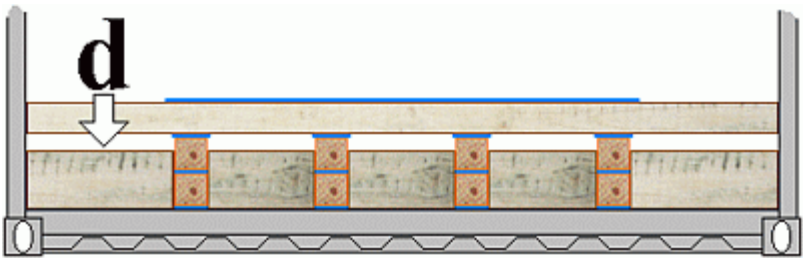
Bottom cross members of an open-top container

Lengthwise wooden members are required in order to distribute the mass of the cargo on the bottom cross members. Wooden crosspieces are necessary in order to be able to set down and lift up slabs using normal load suspension and slinging means. A lattice of wooden members must accordingly be laid before packing.

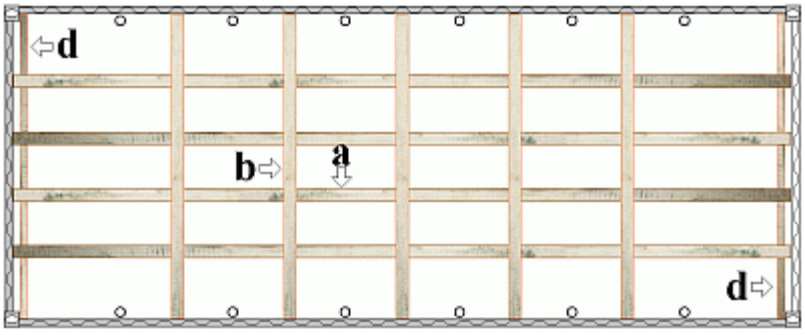


Cross-section of wooden lattice support for the slab

The stacked wooden beams (a) serve to transfer forces over the entire container floor, resulting in more effective transfer. Strips of friction-enhancing material are laid under, between and on top of the wooden members. The wooden crosspieces (b) are laid at right-angles across the lengthwise wooden members. Theoretically, they could finish at the outermost lengthwise wooden members. In this case, they are continued to the container side walls to ensure better stabilization of the overall securing arrangement. In order to prevent the stacked wooden members (a) from tipping, planks (d) are arranged vertically between them at the front and rear of the container).



Cross-section including lengths of plank (d) to prevent tipping



Lattice structure to transfer forces to container floor - plan view

A total of approx. 64 linear meters of squared lumber and planks are required for the lattice shown - a considerable expense.

5.2.14.23 Slabs - securing in open-top containers

In order to save time when crosswise securing is to be provided with loop lashings, single-use webbing belts or other equivalent lashing materials are laid out as shown in the following diagram:

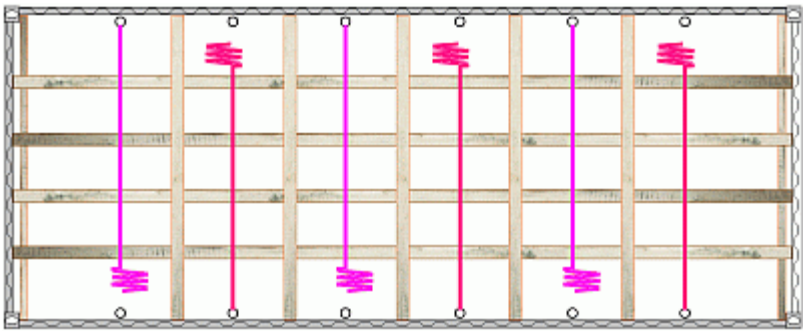
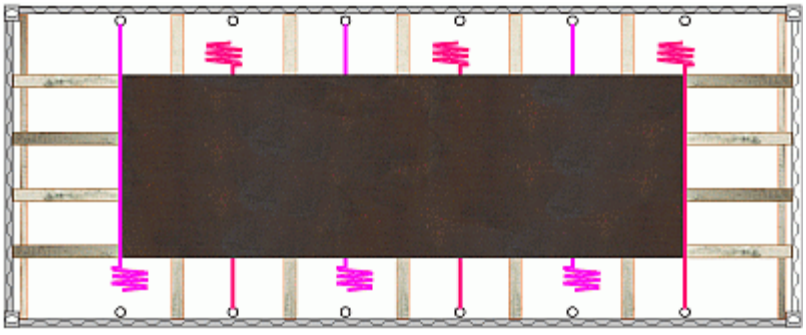


Diagram of layout of lashing belts - plan view

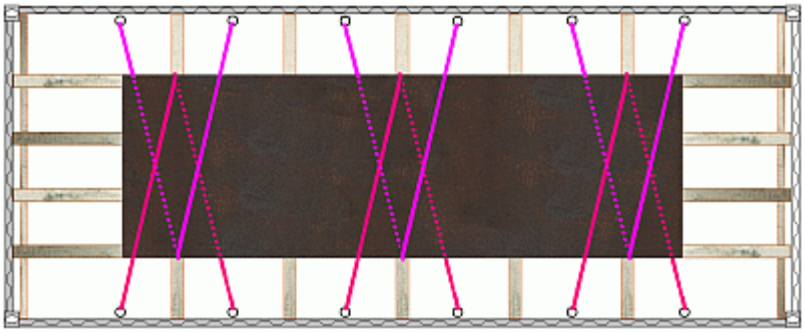
So as not to overload the diagram with details, the strips of friction-enhancing material which would also be laid are not shown.

After the preparatory work, the slab is set down ...

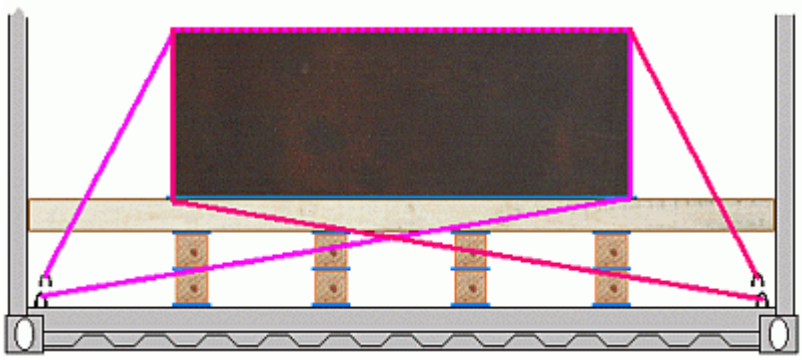


Slab set down on support - plan view

... and secured laterally with loop lashings.



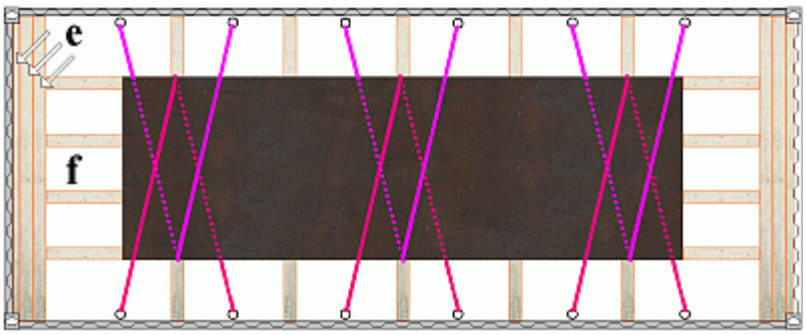
Slab with sideways tensioned lashings - plan view



Slabs with tensioned lashings - cross-section

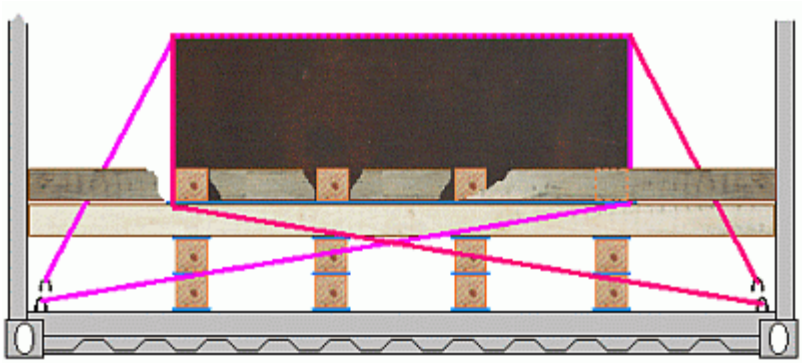
If webbing belts with a straight-line maximum securing load of approx. 2,500 daN are used, due to the horizontal and vertical lashing angle between the parts, they provide horizontal forces of 2,170 daN per run. This value is calculated from the maximum securing load of 2,500 daN multiplied by the cosine of half the angle between the parts in the vertical axis and multiplied by the cosine of half the angle between the parts in the horizontal axis. Since the lashing points can be subjected to loads of 2,000 daN in all directions and the ends of the loop lashings are attached to separate lashing points, the slab is tightly secured on each side with 6 x 2,000 daN = 12,000 daN. If the friction-enhancing materials are assumed to have a friction coefficient of $\mu = 0.4$, friction forces of approx. 9,400 daN are obtained, while if a friction coefficient of $\mu = 0.6$ is assumed, the friction forces could be as high as approx. 14,100 daN; In the latter case, just two loop lashings per side would then be sufficient.

The slab is braced to prevent lengthwise movement:



Lengthwise bracing of slab - plan view

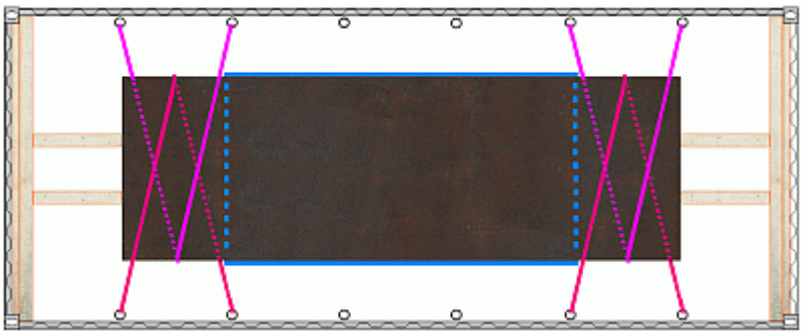
To this end, crosspieces (e) are placed against both end walls to distribute pressure and lengthwise wooden members (f) are inserted between these crosspieces and the slab and are nailed to the lattice members beneath.



Lengthwise bracing of slab - cross-section

The decision as to whether four lengthwise braces are inserted or whether two would be enough or whether smaller lumber could be used is taken on the basis of assumed loads and the estimated coefficient of sliding friction.

If lower mass slabs, which present no problems with regard to line load, are to be carried, the following securing method is very cost-effective with regard to both labor and use of materials.



Extremely cost-effective slab securing - plan view

Before the slab can be set down from above using webbing slings, an extensive area of the container floor in the area of the four central lashing points is covered with friction-enhancing material at least 10 mm in thickness and the slab is set down on this material so that the webbing slings can be removed from beneath the ends of the slab. (If the webbing slings are thicker than the material beneath the slab, a second layer of friction-enhancing material must be laid.) The single use textile lashing belts are slid beneath the ends of the slab, passed over the slab and tensioned. Lengthwise securing is provided by wooden bracing.

It should be noted in relation to any securing method using webbing belts that edge protectors must always be used with sharp-edged cargoes.

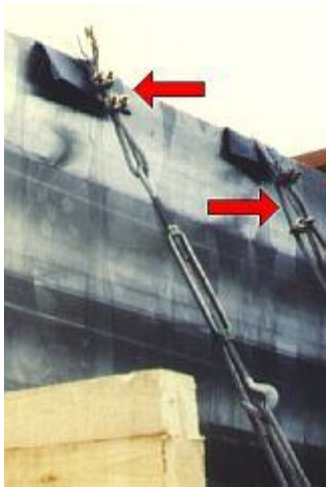
5.2.14.24 Slab-like steel parts on a flatrack

Inadequate cargo securing methods and poor workmanship mean that these slab-like parts are not sufficiently secured.

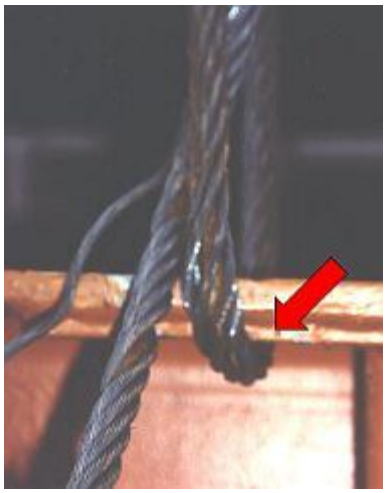


Inadequate securing

Only the lowermost part is secured in the lengthwise direction. The upper three parts can move freely in the lengthwise direction. None of the parts is secured in the sideways direction as sufficient securing forces cannot be applied even with several tie-down lashings.



Incorrectly attached wire clips in insufficient quantity

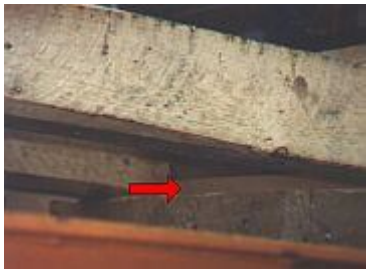


Sharp edges weaken the wire rope

Too few wire clips have been used. Some of them have also be placed on the wrong side. Spacing between the clamps is inadequate. The tightening moment is too low.



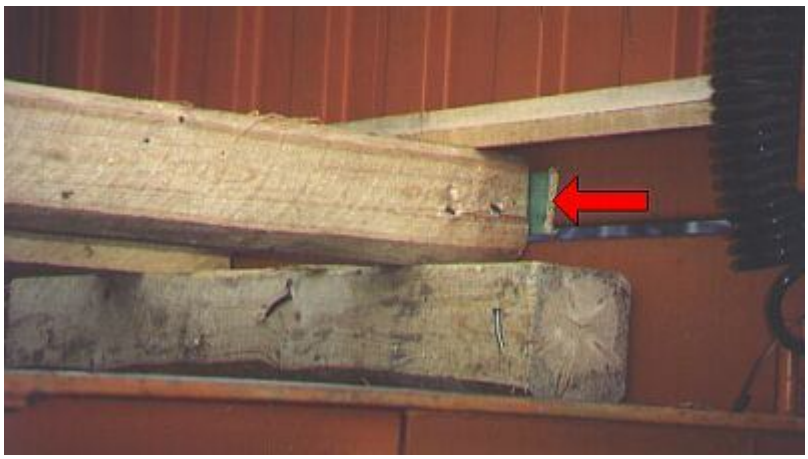
Only if four wire clips are correctly applied and properly tightened can the maximum securing load of the wire ropes and turnbuckles be fully utilized.





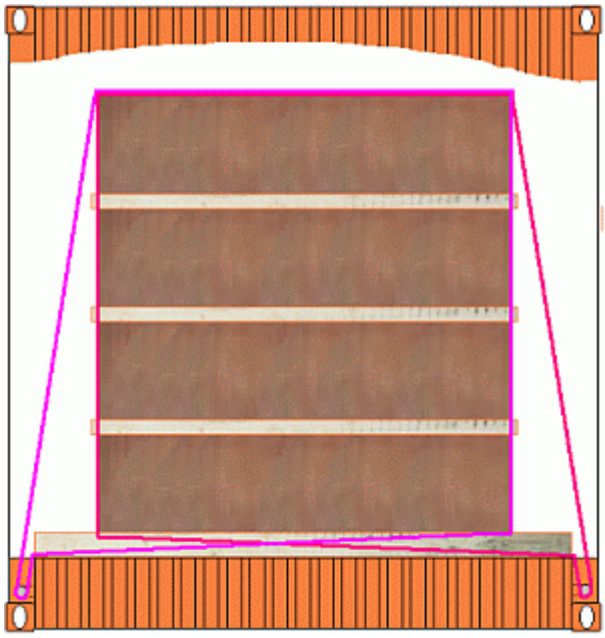
Inadequate effective height of wooden bracing members

Only approx. one quarter of the height of the squared lumber is actually effective, so that not only is little strength obtained, but much material is wasted too.



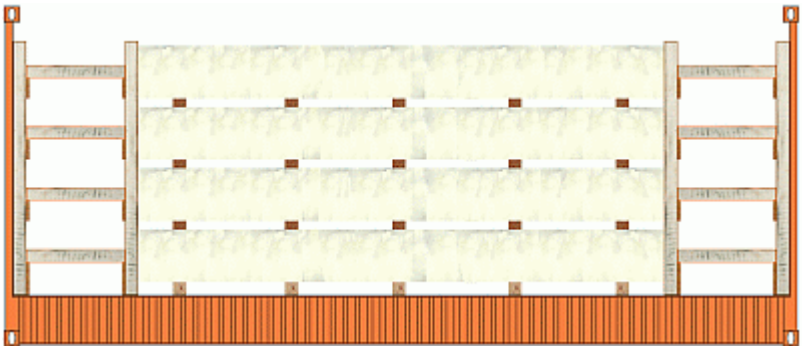
Effective cross-sectional area provided merely by small lengths of board.

Untidy workmanship has meant that short lengths of board have had to be inserted to fill the gaps in the squared lumber structure. The maximum securing load can be calculated from the contact area of the small board with the squared lumber and loading capacity perpendicular to the grain of 30 daN/cm². Without the board, the loading capacity would have been calculated in the case of a neat arrangement on the basis of the contact area of the squared lumber with the end wall of the flatrack with loading capacity parallel to the grain of 100 daN/cm², which would have produced a distinctly higher value.



Lateral securing using loop lashings - cross-section

The parts could have been provided with lateral securing relatively simply by using loop lashings. Their number is determined by the anticipated shipping stresses, the lashing materials used and how they are applied together with any materials laid beneath or between the layers.

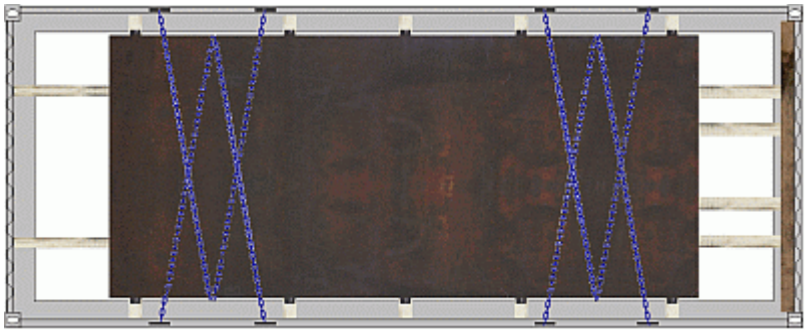


Lengthwise securing with wooden bracing - side view

In this case too, bracing with wooden members is an effective way of providing lengthwise securing. The loop lashings providing lateral securing have not been including in this drawing.

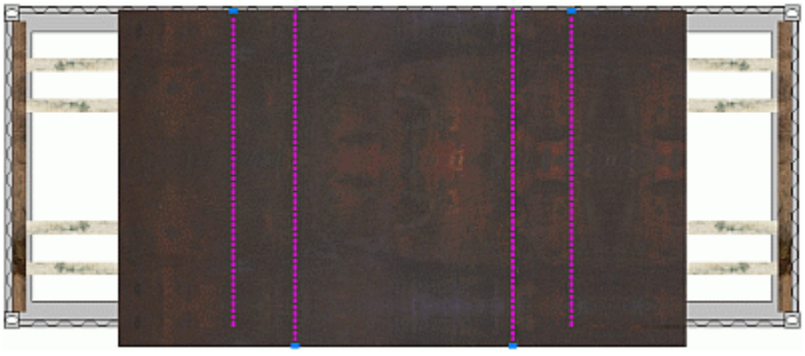
5.2.14.25 Heavy plate and sheet packages on flatracks

Heavy plate of a width less than the receptacles used can straightforwardly be secured on flatracks by wooden bracing and loop lashings. The crosspieces under the cargo should be laid in such a way firstly that they ensure adequate load transfer to the flatrack side rails and secondly that they do not obstruct placement of the necessary securing means. In order to minimize the securing forces which have to be applied, it is advisable to use "sandwich" supports, i.e. supports with strips of friction-enhancing material placed under and on top of the wooden members .



Heavy plate secured with loop lashings and wooden bracing

The nature of the flatrack's end walls determines whether it is possible to secure metal plates in the lengthwise direction only with wooden members loaded against the end grain (left) or whether wooden members loaded against the face grain have to be inserted to distribute the pressure (right). The different loading capacities of the wooden members can mean that different numbers of members have to be used.



Overwidth plate - loaded with overhang on one side and secured with claws

Slightly overwidth plates are loaded such that they overhang on only one side so that only two slot rates

rather than three need be paid. Securing can be provided by claws fasted to belts, wire ropes, chains or the ends of the lashings on permanently installed reels. Since the lashing means have to be passed and fastened from under the cargo, it is advantageous to lay them out prior to loading, to apply the claws after loading and then to apply tension. Claws may also be replaced with suitably strong hooks with an adequate throat size.

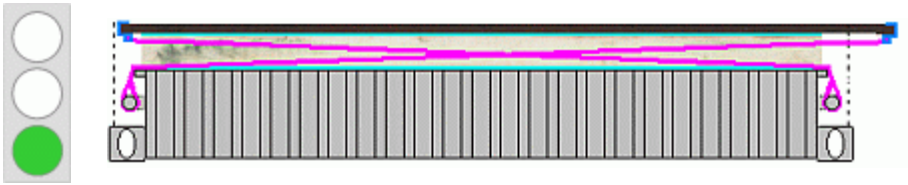
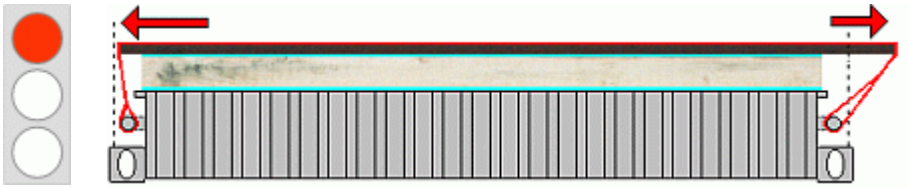


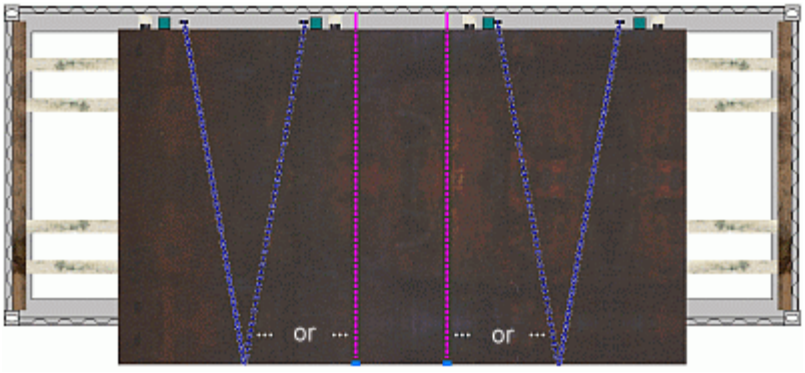
Plate overhanging on one side - secured with claws - cross-section

It is important for the lashings always to be applied from the opposite side. Otherwise, the angles are so unfavorable that sufficient lateral forces cannot be applied.



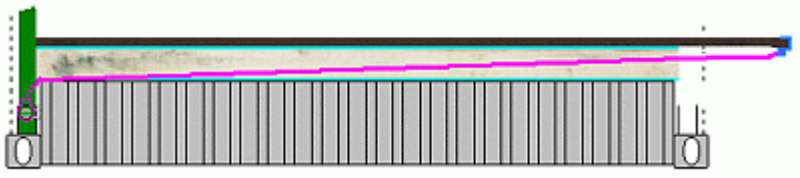
Unusable: tie-down lashings

Tie-down lashings must never be used to provide lateral securing as plates remain freely mobile under such lashings. However, such lashings can be used to provide vertical securing. In this case, they should then be viewed as direct lashings preventing upwards movement and so require only slight pretensioning. Such securing methods can ideally complement lateral securing with claws.



Overwidth plate - loaded with overhang on one side and secured with stanchions and loop lashings applied on one side

Using flatracks with stanchions simplifies securing. In this case, the plates are laid with one side against the stanchions, while movement towards the other side is prevented with loop lashings or lashings fitted with claws.



Overwidth plate - loaded with overhang on one side and secured with stanchions and direct lashings with claws applied on one side - cross section



Overwidth plate - loaded with overhang on one side. Secured with stanchions and specially shaped stanchions applied on one side - cross-section

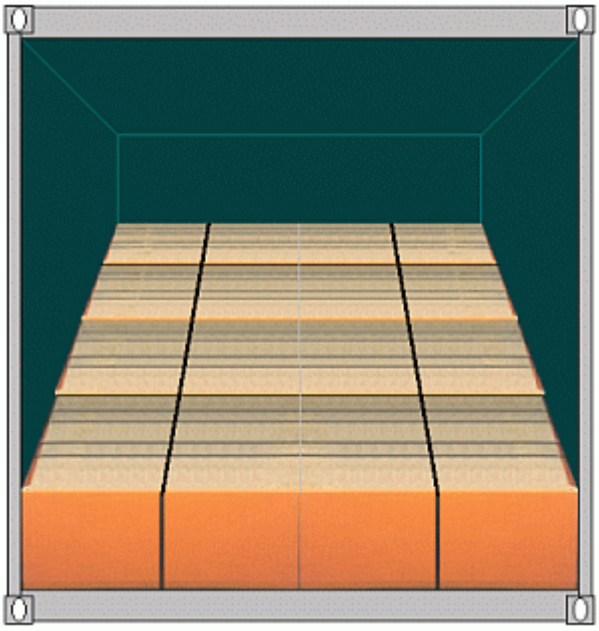


Overwidth plate - loaded with overhang on both sides
- secured with specially shaped stanchions
- cross section

Depending upon the plate sizes to be transported, it may be advisable to use specially shaped stanchions. If these are not an exact fit, relatively small gaps can be filled in with lumber. The securing action of stanchions or specially shaped stanchions should be complemented by direct overlashings. As already mentioned, such lashings are applied in the same way as tie-down lashings, but they are not tie-down lashings as they do not act in the same way.

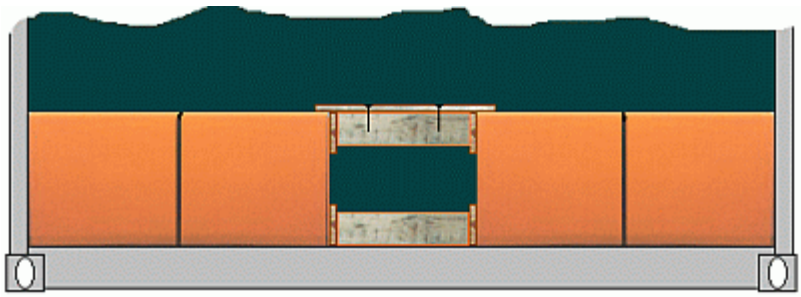
5.2.14.26 Sheet packages in box containers

Sheet packages



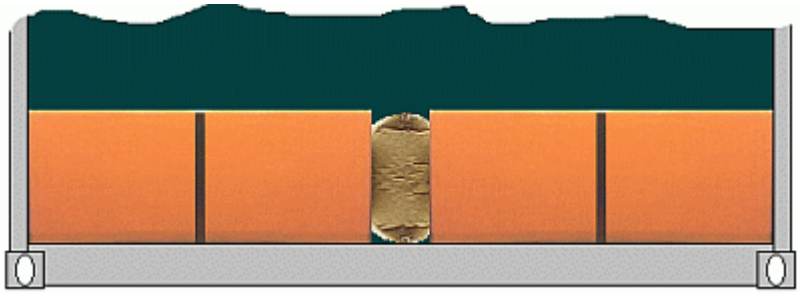
Box container compactly packed with sheet packages

It is ideal if the sheet packages to be packed are tailored to container dimensions as transport modules in such a manner that compact packing is possible.



"Aisle" braced with boards and squared lumber

Since this not usually the case, the packages should be packed flush against the container side walls and the "aisle" remaining in the middle should be braced with squared lumber and boards.



"Aisle" filled with airbags

If the aisle is around 20 cm wide, airbags can certainly be considered for filling the gap. It must, however, be ensured that jolting in transit cannot cause the airbags to shift upwards.

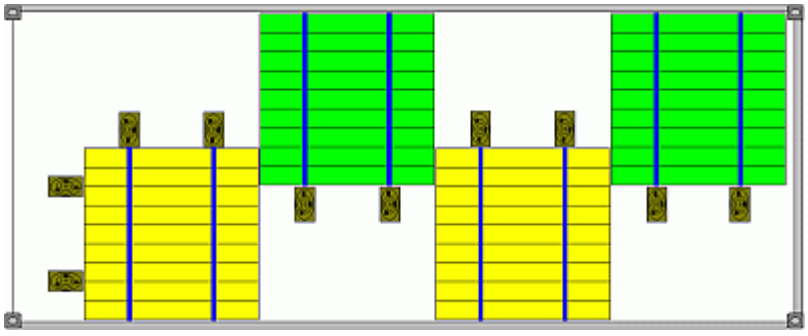
Stainless steel sheet in unitized wooden cases

Carefully thought out stowage patterns are a fundamental prerequisite for reasonable load securing and help to minimize labor and material costs. Good stowage planning also ensures that subsequently discovered securing shortcomings can be corrected more quickly and cheaply.



Unfavorable stowage pattern and inadequate securing

In this case, stainless steel sheet in wooden cases is being stowed, groups of ten cases being unitized with steel strapping to form a cargo unit. Neither the stowage plan nor the securing is adequate. Since each unit has a mass of approx. 4 metric tons, securing with wedges is not possible and is thus completely inappropriate.

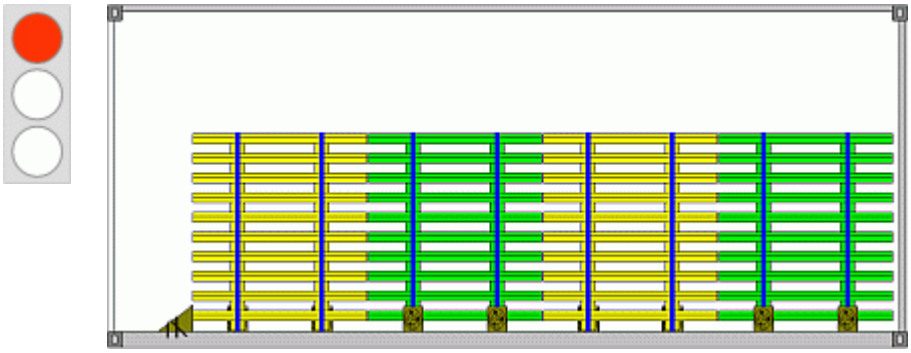


Stowage pattern and inadequate securing - plan view

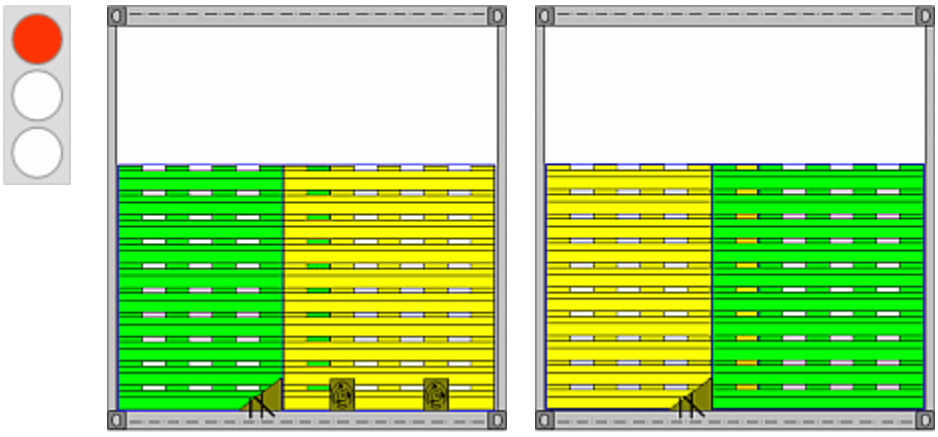
The plan view shows the overall packing method. Each cargo unit is "secured" laterally with 2 incorrectly cut wedges, each of which is fastened to the container floor with one tension nail and two retaining nails. Assuming normal shear strengths, the units are "secured" with a force of approx. 400 daN, instead of the necessary 3,200 daN.

No action has been taken to counter the tipping forces which occur in maritime transport. All four units,

with a total mass of approx. 16 metric tons, are also "secured" in the lengthwise direction with only two wedges which may likewise be expected to provide a securing force of only approx. 400 daN, instead of the 6,400 daN required to withstand the acceleration forces anticipated in maritime transport and the 12,800 daN in road transport.



Stowage pattern and inadequate securing - side view



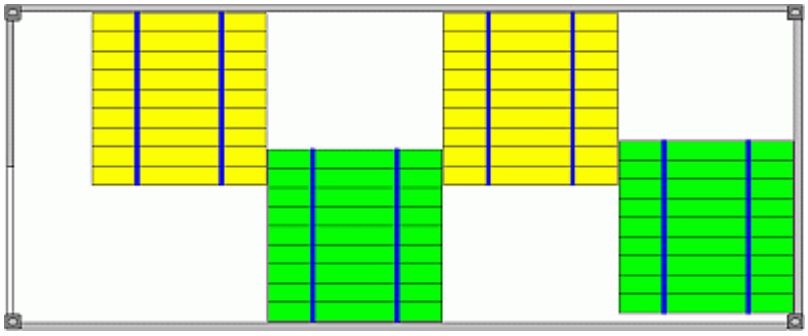
View from the door **View from the front end**

Due to inadequate stowage planning, it is difficult to remedy the securing deficiencies. Since the final unit is in the door area, sensible securing methods cannot be used. The result, as in the following similar case, is an unsatisfactory improvised stop gap.



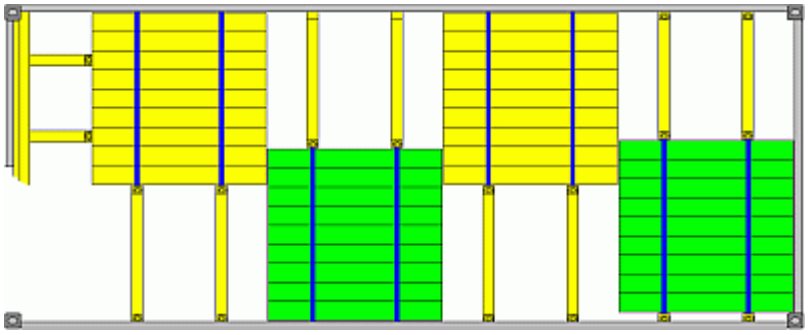
Improvised securing against a corner post and the left-hand door leaf

Just using a different packing method could have created ideal conditions for reasonable securing.



Advantageous packing method facilitates subsequent securing.

This packing method would mean that the final cargo unit would be located in the vicinity of the left-hand door leaf, so allowing it to be closed and act as an abutment for horizontally placed bracing.



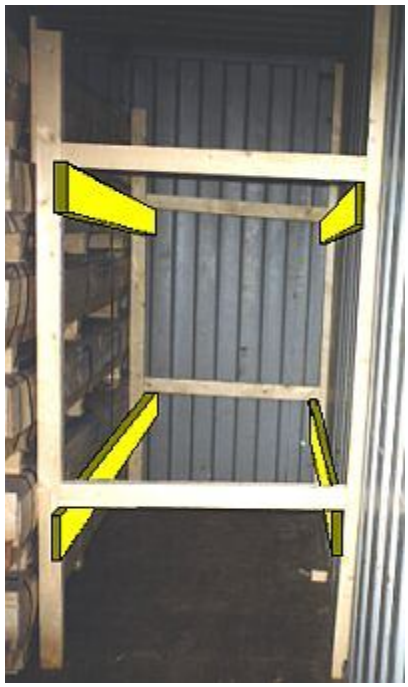
Securing by horizontal bracing with wooden beams

Once packed, each package is braced against the container walls. The final cargo unit is additionally braced against the left-hand door leaf.

In detail, the securing arrangements could look as follows:



Lateral securing with vertical uprights and transverse squared lumber beams



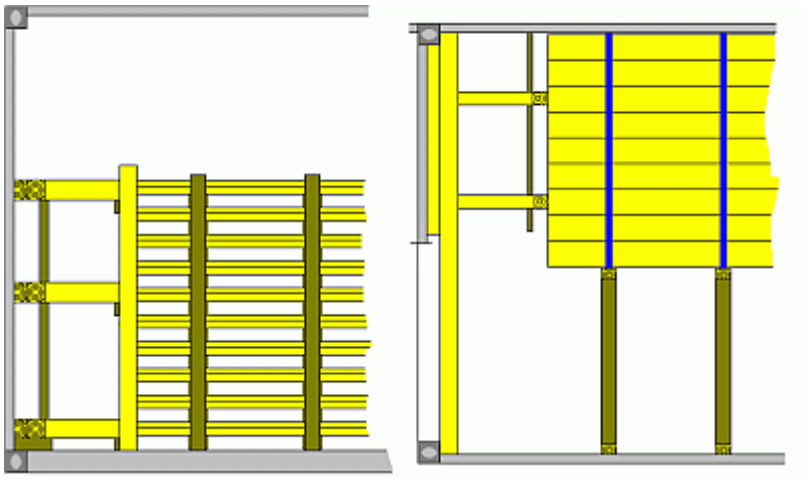
Securing as before, but joined together with boards

Sufficient lateral securing can be provided by inserting 6 cm x 8 cm wooden bracing members. The left-hand variant may be considered adequate if

- the upright members are firmly located between the container corrugations,
- the upright members can be nailed into place on the cargo and
- the horizontal wooden bracing members can be securely fasted onto the upright members.

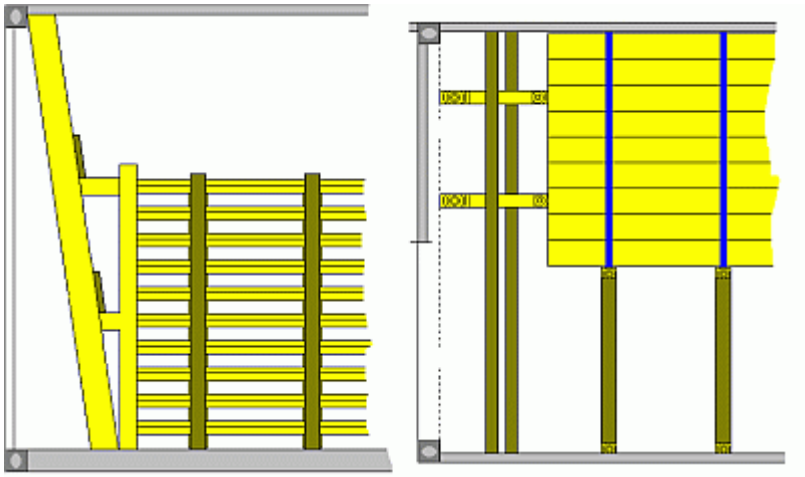
If the bracing is not durably fixed in place as in the left-hand Figure, additional lengthwise board connectors should be provided as in the right-hand Figure.

Various methods are feasible for final securing in the door area:



Horizontal bracing in the door area
- side view and plan view

Bracing applied horizontally against the door leaf is only advisable if the residual forces to be absorbed are not excessively large. This will be the case if friction-enhancing material has been laid beneath the cargo units so that relatively high friction forces already apply.



If there is a risk that transferring the forces to the door leaf could result in overloading, one solution is to use "shoring", which transfers the forces into the door header and the container floor.

5.2.14.27 Ingots in box containers

Ingots are blocks of metal which are cast into a particular shape. They can vary greatly from metal to metal and from production site to production site. Aluminum, lead, zinc and tin are very often transported in this form.



Loosely stacked tin ingots in storage

Individual bars are very often stacked at right angles to one another and bundled for transport.



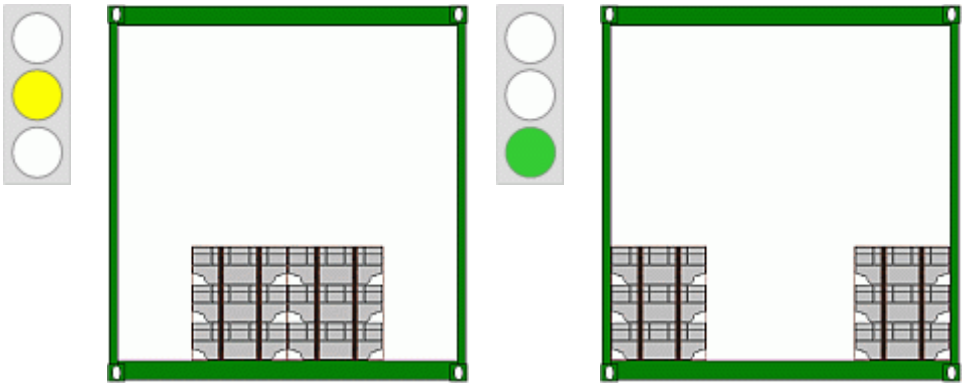
Lead ingots in a 20' foot box container

It may be suspected that this cargo was stowed on the basis of the age-old argument, "This cargo's so heavy, it will never slip!". However, it takes more than constant repetition of such erroneous ideas to overcome the laws of physics.



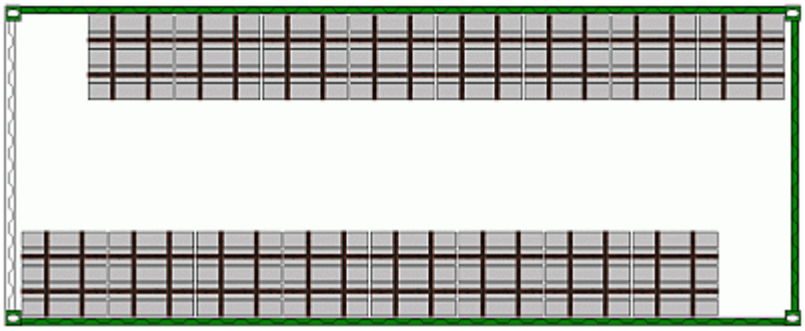
"Securing" with lengths of board nailed in front

Packing of this 20' container has been carried out with complete disregard for all the basic rules of stowage. The large gaps in the stow and the considerable mass of the ingots are capable of jeopardizing the container and the means of transport.



Centrally packed ingots **Laterally packed ingots**

It is not incorrect, just uneconomic, to pack ingots centrally, as considerably more effort is required to secure them than if they are packed against the sides of the container. If the gap in the stow is left in the center of the container, more than half the cargo securing material can be saved.



Laterally packed ingots - plan view

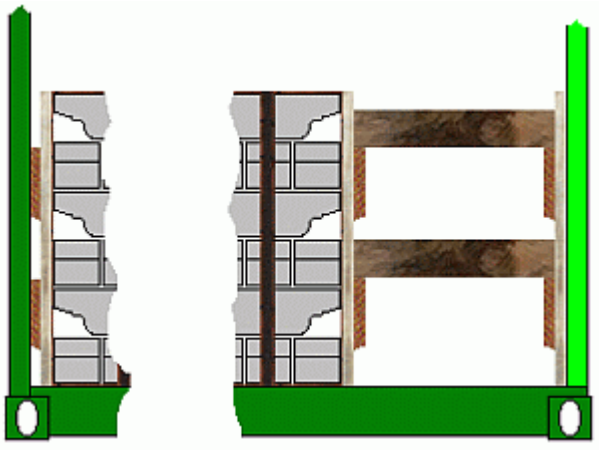
Ideally, transport modules should correspond to fractions of the internal container dimensions, but that is not the case here. The cargo has thus been packed so that bracing can be provided behind the first door leaf to be closed. On the side of the door leaf to be closed last, the cargo is packed in such a way that it can be blocked at the end face.



Side view of right-hand row of ingots bundles - door light green

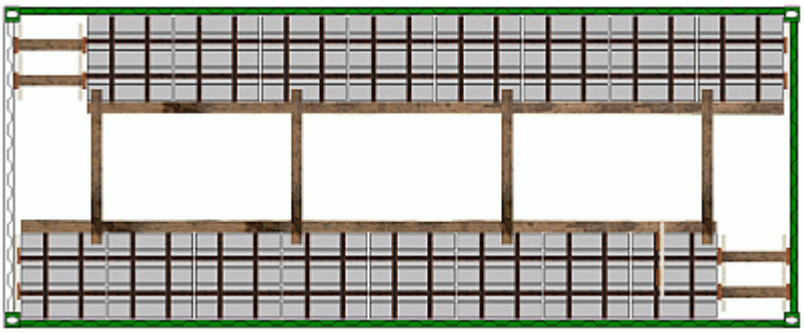


Side view of left-hand row of ingot bundles - door light green



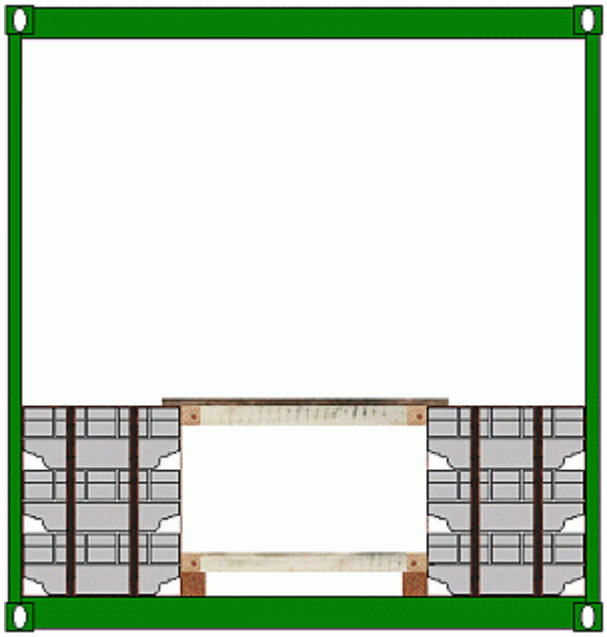
Detail of lengthwise securing

If narrow lengthwise gaps remain on the right-hand door side, they are filled with a lattice of two boards nailed to one another crosswise. The large lengthwise gaps are braced. Bracing is provided by two of the above-described lattices, between which two squared lumber members are fitted at top and bottom.



Bracing of transverse gaps - plan view

The large transverse gaps are braced with squared lumber members fitted lengthwise and crosswise as shown in the diagram.



Bracing of transverse gaps - cross-section



Bracing of transverse gaps
- detail of lower part

The bracing can be produced very quickly by laying a squared lumber member along the entire length of the lower edge of the internal sides of the bundles. A second squared lumber member of a smaller edge length is placed on top and the space between is braced in the crosswise direction with squared lumber members or beams which are cut to size.



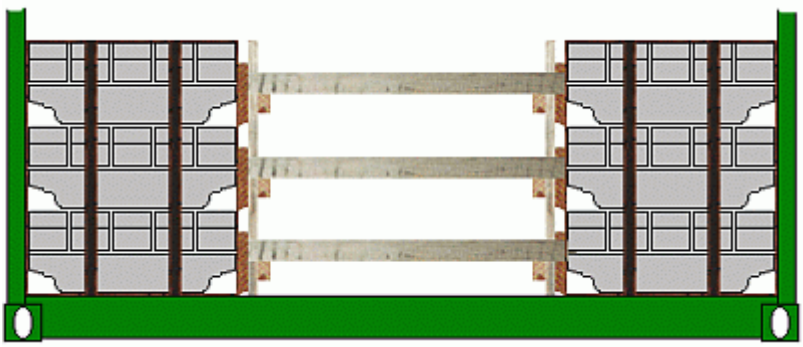
Bracing of transverse gaps
- detail of upper part

The bracing for the upper part can be prefabricated outside the container. Two squared lumber members are laid out lengthwise in accordance with the bundle position. The space between is filled with transverse squared lumber members. Boards, which overhang slightly on each side, are nailed onto the crosswise and lengthwise wooden members. The whole structure is suspended in the gap.



Bracing of transverse gaps - simpler variant

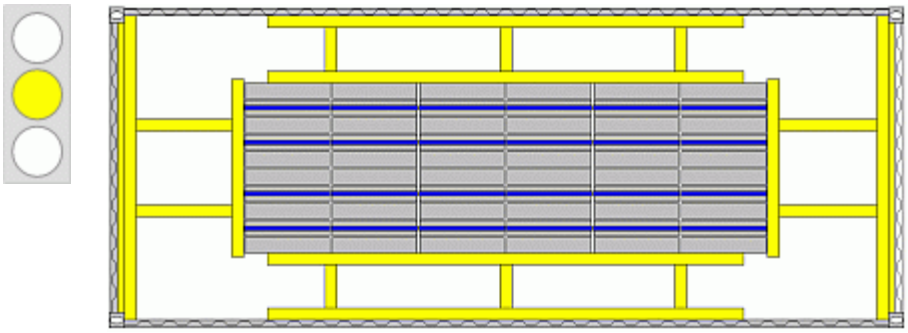
If the ingots are well bundled, crosswise bracing consisting in the lower part of boards nailed together in steps and crosswise wooden beams is sufficient. In the upper part, one bracing structure consisting of a wooden beam and a board nailed to it is suspended for each package.



Bracing of transverse gaps - complicated variant

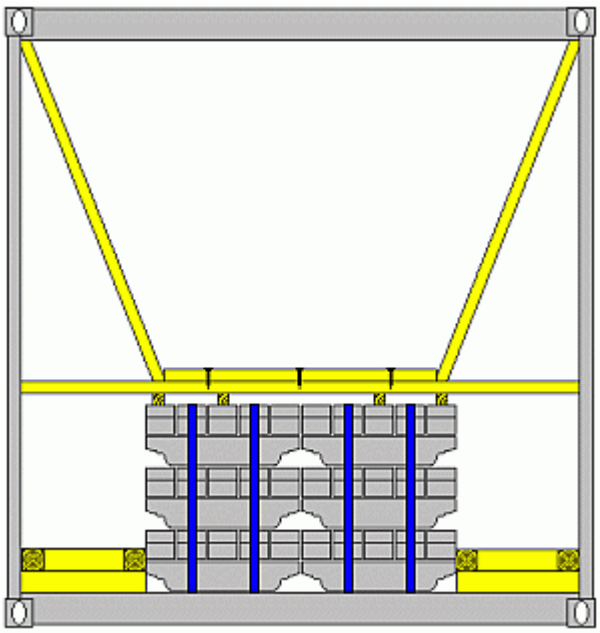
With poorly bundled ingots, where there is a risk that individual metal bars could come out of the bundle, bracing must be provided which retains every bar with a wooden member.

In all the bracing structures shown, the crosspieces must be secured against shifting by obliquely placed boards or "X-bracing". The dimensions of the lumber should be determined as a function of the masses to be secured and the necessary residual securing forces according to the rules of thumb stated in the general section.



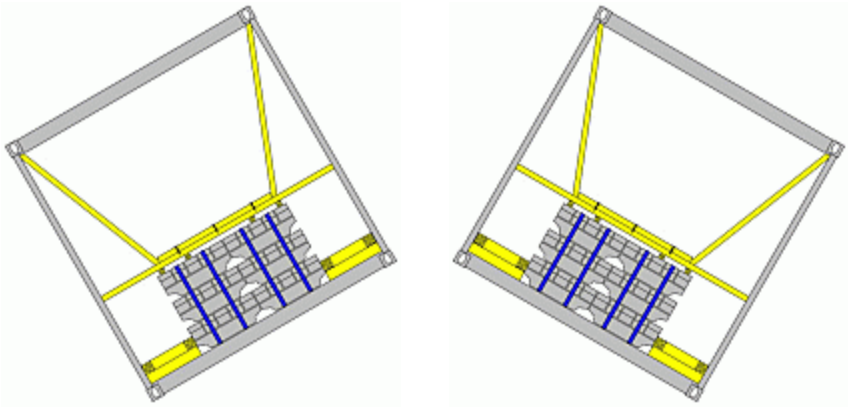
Bracing of a centrally placed cargo block - plan view

Stowing a complete block of bundles centrally entails higher material and labor costs. In order to keep such costs within acceptable limits, securing is only provided at floor level in the example.

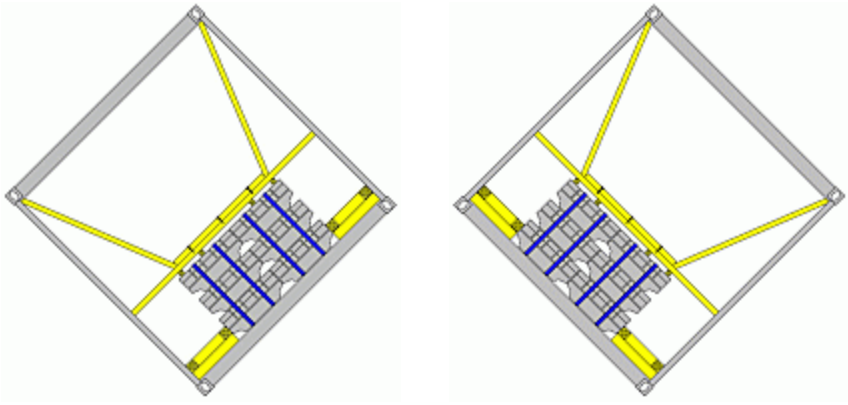


Securing a cargo block against tipping and vertically - cross-section

The block can be secured against tipping and vertical stresses by shoring. Lateral securing within the individual layers of cargo is provided by friction due to the pressure exerted by the shoring.



30° tilt of cargo block

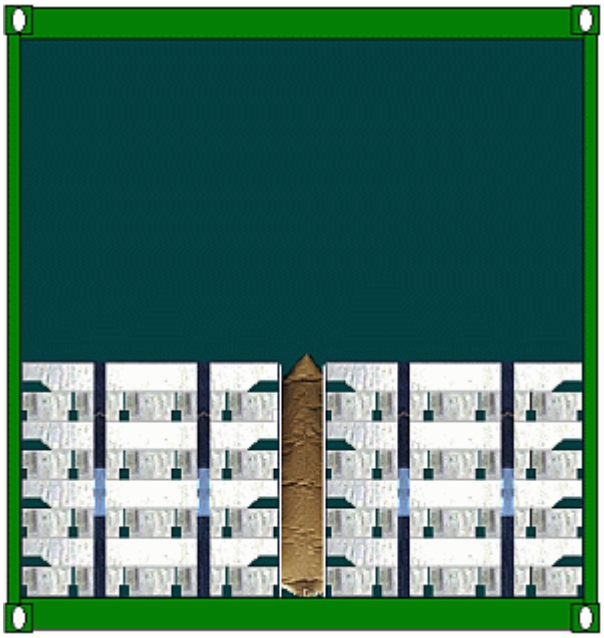


45° tilt of cargo block

A properly secured cargo must also be able to withstand a rolling angle of 30° or 45° on board ship.

In terms of labor and material costs, airbags are hard to beat pricewise, but the gaps to be filled in the stow

must only be narrow.



Aluminum ingots - secured with airbags

The aisle left between these aluminum ingots is so narrow that using airbags is feasible. Hardboard or thin sheets of plywood should be placed between the ingots and the airbags. Any airbags used must be secured against slipping out.

5.3 Primarily heterogeneous general cargoes

5.3.1 Bales/rolls

5.3.1.1 Bales, mixed cargo

In principle, bales tend to be loaded in unitized batches, whether they consist of natural rubber or latex, raw wool, raw cotton, combed top or the like. Occasionally, however, individual bales may be packed into an LCL container. Since most bales are only stable in large blocks but, apart perhaps from tobacco bales, are relatively insensitive to pressure, it is feasible to stow the bales in amongst other cargo. A hypothetical example is given below.



Because the bales are brought into their packing position using a forklift truck with bale clamp, they were packed with their narrow, curved side in the direction of the longitudinal axis. Floor dunnage was omitted, but wooden interlayer dunnage was put in place. If the ends are virtually flat, interlayer dunnage is unnecessary. Floor dunnage would be necessary, if the ends of the bales were not packaged and there was a risk of soiling.



For reasons of weight distribution, a batch of bales was stowed in this example with one case and two copper wire reels. Wooden interlayer dunnage was placed on the case, because the middle members of the pallet would otherwise have rested solely on the belt battens of the case. If the pallets were capable of

remaining secure without interlayer dunnage, the latter could have been omitted.





Another batch of cotton bales was placed in front of these stowed items and cases and cartons were packed in front of them. If there are no special reasons, such as weight distribution, why all the bales to be packed should not be stowed in one block, it is preferable to do just that, so that the forklift truck with bale clamp does not have to wait around unnecessarily or so that the forklift truck, if only one is available, does not have to be changed over repeatedly from clamp to fork tines and vice versa.

5.3.1.2 Rolls

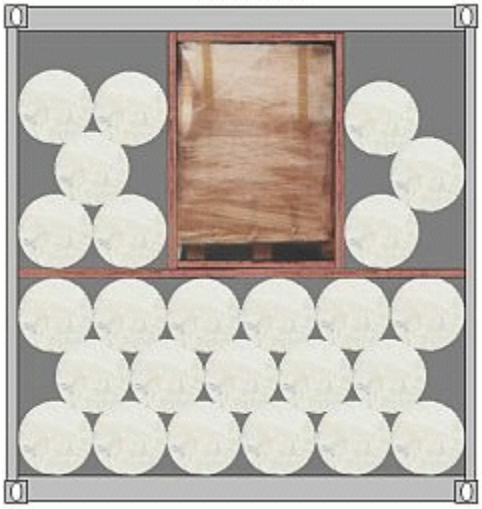




Inadequate packing of textile rolls and a pallet

It is unlikely that the textile rolls will be capable of standing the stowage method illustrated.

There are many ways of packing such cargoes appropriately into a container. Depending on the type of material in the rolls and how tightly they are wound, the layers are more or less firm when packed in the cantline. The following drawings all bear an amber light, because additional measures need to be taken which are not shown here.



Packing variant sample

Wooden dunnage consisting of walking boards has been laid on the lower layers, and the pallet loaded centrally on that. The pressure-sensitive sides of the pallet have been protected with lateral dunnage of equivalent material, which provides protection in the form of boards or the like against excessive pressure in the upper area of the pallet.

Packing variant sample



Here, the pallet was protected against harmful pressures by lateral and top dunnage. The textile rolls were all packed in the cantline.



Packing variant sample

As before, the pallet in the picture above was protected against harmful pressures. Some of the textile rolls were packed somewhat higher than the pallet in the cantline. Walking boards, similar flat materials or boards were used to provide a uniform packing support for the remaining rolls, so meaning that firring in the form of pieces of lumber had to be fitted in the area of the pallet. The upper rolls were also packed in the cantline.

The following pictures show that consideration must be given to securing the upper rolls by tying them together or similar measures. At tilt angles of up to 30° or acceleration of up to 0.5 g, the rolls would probably still remain in place, but this becomes highly questionable at larger tilt angles or greater acceleration.





Tilts of 30° correspond to 0.5 g acceleration



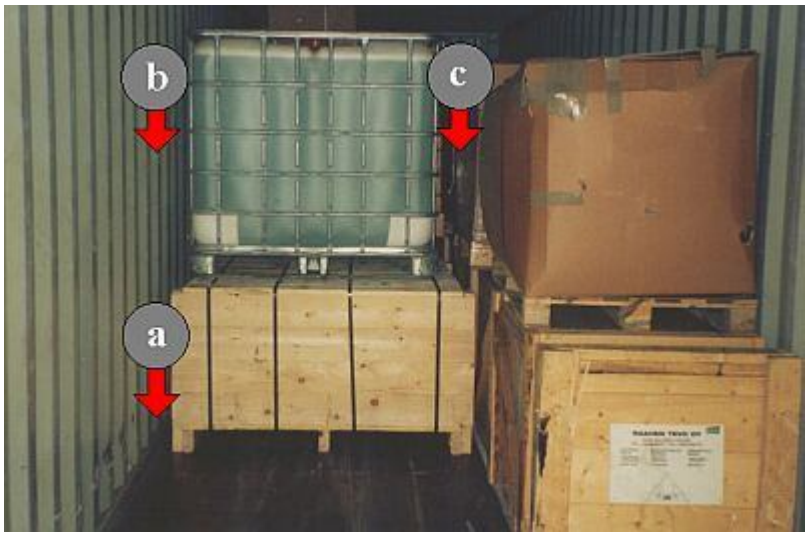


Tilts of 45° correspond to 0.7 g acceleration

In addition to bundling, it is also particularly expedient to use relatively softly inflated airbags at the sides to the left and right, to fix the rolls in their packing position.

In general, however, the question arises whether textile rolls are really strong enough to be packed in so many layers at all. Intensive thought should be given to other stowage methods. The producer's specialist knowledge of the product should definitely be utilized.

5.3.2 Receptacles, small and IBC The gaps (a), (b) and (c) are unacceptable.



Gaps in a box container

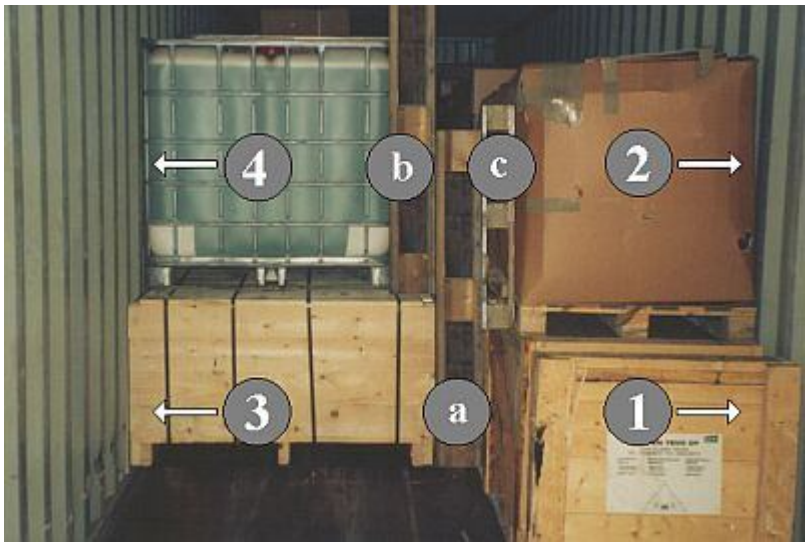
The deficiencies become clearer when the container is tilted 30° about its longitudinal axis.





This tilt corresponds to lateral acceleration of 0.5 g, as has to be taken into account in road and rail transport too.

The bare minimum required to eliminate these deficiencies is packing the packages (1), (2) and (3) and (4) tightly against the container side walls and filling the gaps then remaining in the middle with the pallets (a), (b) and (c).



Improvements to a packed container section

For maritime transport, the container section must not be left like this, since inertia forces stemming from the IBC (4) are transferred in part via the pallets to the package (2) and may compress and damage the latter. This may create enough space for the container contents to "self-destruct".

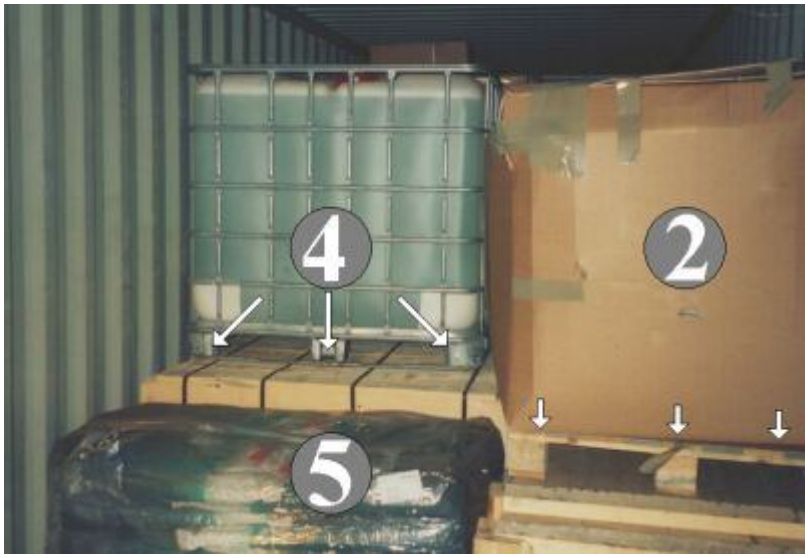




Bracing against a container side wall

Thus, if pallets are used to improve packing, they must be prevented from making any movement, which may be achieved with two squared lumber members (d) fitted crosswise. The compressive forces they may cause should be distributed to part of the container side wall using a board (e). The squared lumber should be secured from below against sliding down by squared lumber or board ends (f). In some cases, attachment to the pallet may suffice.

The packing inadequacies are clearly visible in this picture too:



The carton (2) is obviously too weak and is standing loosely on the pallet-like base.

Intermediate Bulk Containers (IBC) (4) generally have very small contact areas and can only be stowed without using dunnage on container floors or stable set-down surfaces, such as the wooden case shown here.

Individual bagged cargo pallets (5) should where possible to packed into the upper layers, since overstowing them with other cargo requires the use of interlayer dunnage.

5.3.3 Barrel cargoes, mixed cargo

5.3.3.1 Mixed cargo with barrels, example 1



Mixed cargo in a 20' box container

The cable reel at the front of the container is immediately obvious. It should be noted that this is not fully wound, so meaning that there are no problems with weight distribution in the container.

The securing of cable reels is covered in the special section relating to cable reels. Here, a critical eye will be cast over the packing and securing in the container door area.

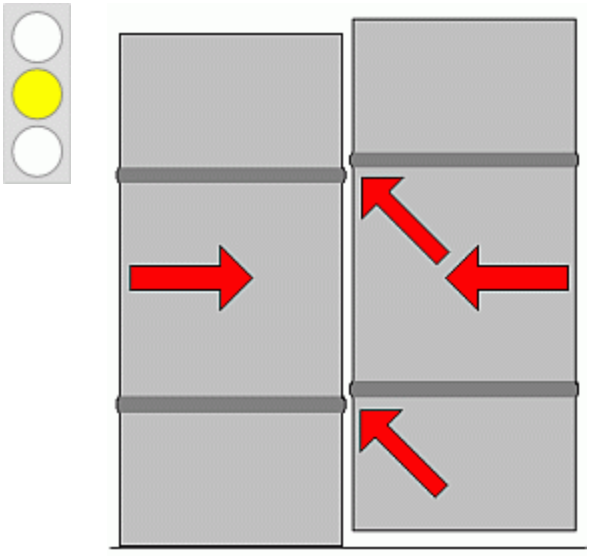


Cargo risks in the door area

If one looks closely, it is clear that any tilting of the container to the left could cause damage to the corners of the cartons on the pallet, if the forces exerted by the barrels press via the vertically positioned sheet package onto the corners of the cartons.

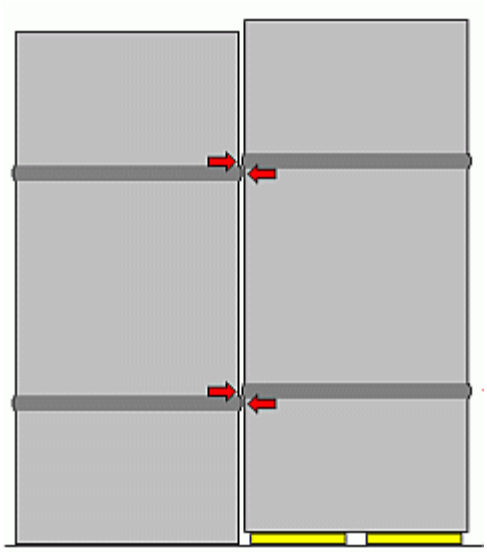
It may be noted that the right-hand barrel has been raised, with the intention of preventing the barrels from being pushed up by the corrugations. The idea is a good one, but is only feasible with two barrels stowed as a pair.

A better understanding will be gained from the following comments.



Barrels worked upwards by their corrugations

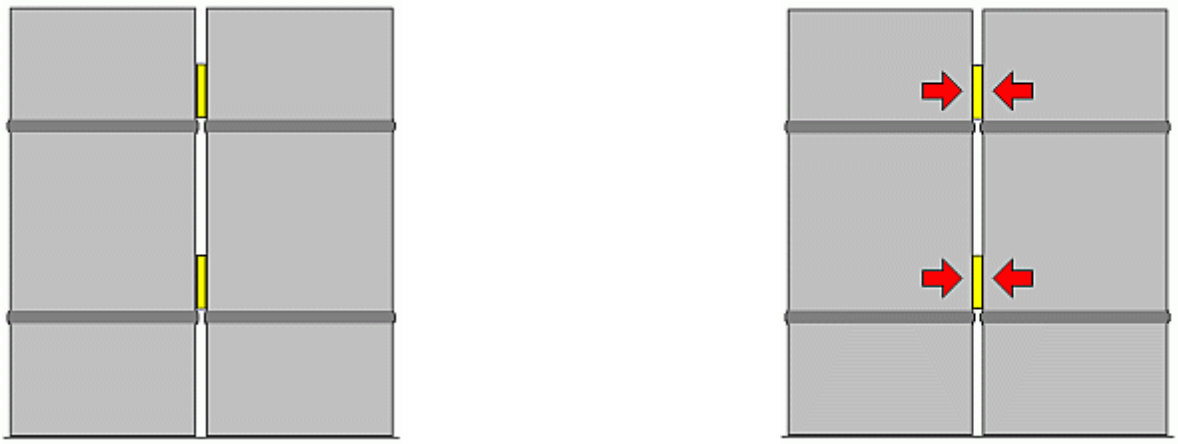
Conventional corrugated barrels have the unfortunate habit of pushing one another upwards by the corrugations and "hanging" from them. This disadvantageous design may thus lead directly to damage. Moreover, this pushing-up effect creates gaps in the cargo, which indirectly cause destruction of the drum due to the inertia forces which additionally arise.



Alternate raising of barrels using boards

Although barrels can be alternately raised using stowage supports, this method can only be applied to barrels stowed in pairs. In a block consisting of more than 2 barrels, the method is no longer usable, as well as being material- and labor-intensive. Moreover, damage may arise, since the loading capacity of the body of a barrel is less than that of the corrugations, so meaning that, under elevated forces, the corrugations may form dents in the barrel bodies.

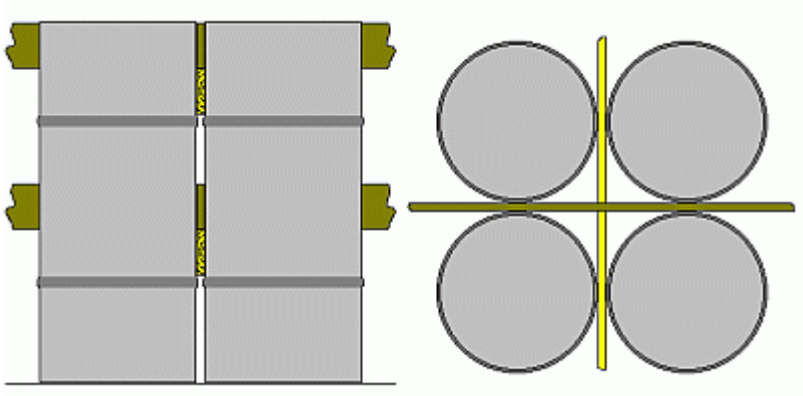
A possible way round the problem is to fill the gaps between the barrels with boards or the like.



Filling of gaps created by barrel corrugations

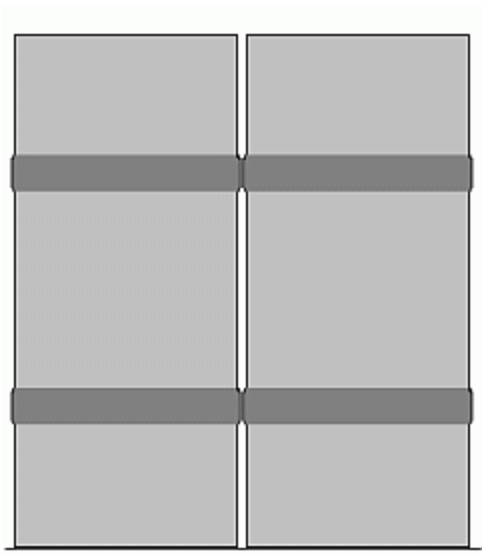
A note of caution must be sounded, however: if bearing areas are too small, excessive pressure may still cause denting of the barrel bodies.

The use of load securing foam would help avoid high pressures. However, such foams can only be used for rail and road container transport and are prohibited for maritime transport because their recovery is too low.



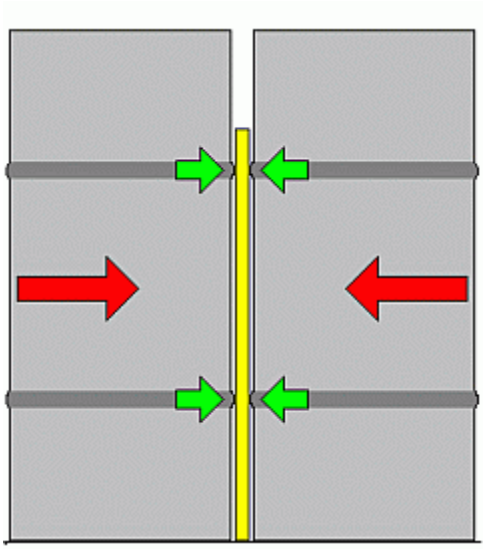
Filling of lengthwise and crosswise gaps created by barrel corrugations

The filling material has to be inserted in both the lengthwise and the crosswise direction. Preventive measures for loss prevention - caused by the inadequacies of commercially available barrels, pails, buckets, drums and similar receptacles - are expensive from the point of view both of materials and in particular of labor.



Problem-free stowage
of barrels with wide corrugations

It would be better if more drums were used with wide, tall corrugations, whose lids, closures, drop handles etc. do not project beyond their diameter.



Load transfer via barrel corrugations

In order to be able truly to prevent denting damage where several barrels are present, hardboard, chipboard or similar flat materials must be inserted in such a way that the corrugations can transfer load via these materials.



Measures for protecting pallet cargo from harmful pressures

To rule out damage, hardboard is placed (6) between the outer and inner row of barrels and between the inner row of barrels and the vertical metal sheet package. Above the cartons, the forces exerted by the barrels and the sheet package are taken up by squared lumber (8), whose compressive forces are distributed to part of the container side wall via a board (7).



Mixed cargo in a 20' corrugated steel container

This packing example is similar the one discussed above. Positive features are that the cargo is stowed under cover and the dock plate meets the requirements of the German accident prevention regulations.



Measures for protecting the cartons from mechanical damage

The cable reel (1) has been somewhat differently secured. Variants of this securing can be found in the cable reel section. The blue barrels are raised and the top securing member on the door side has been positioned at the level of the corrugations (2), since these are the parts of the barrels with sufficient loading capacity. Lateral forces which may be exerted by the barrels are transferred to the container walls via the squared lumber (3) and wooden members have been fitted lengthwise for pressure distribution. These measures prevent stress to the carton block.

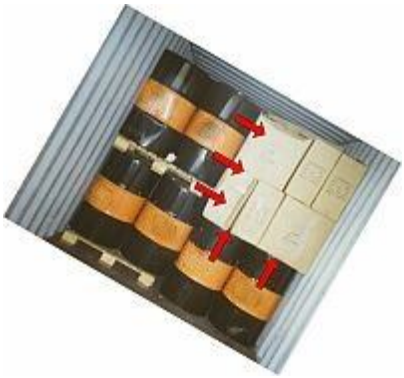
The situation is different here:



Risk of damage to cartons in a box container

The cartons may be squashed by the barrels. In addition, the bottoms of the cartons may be damaged because no appropriate interlayer dunnage has been provided and they are therefore exposed to high pressures from the barrel rims.

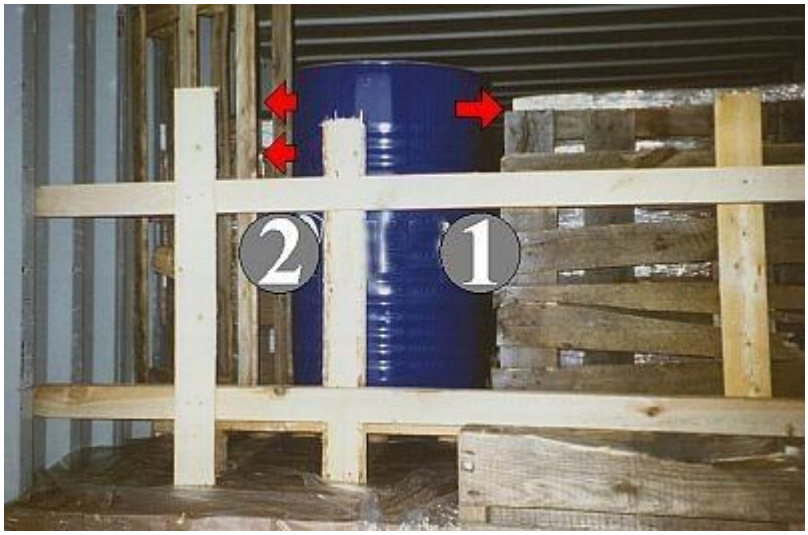




Rolling angles of 30° to each side occur.

The risk of damage becomes clearer if a rolling angle of 30° is assumed for ships and 30,000 alternating loads are assumed to occur during a voyage.

Such carelessness is not unusual during packing:



Inadequately packed 20' box container

Due to the stowage gap (1), the barrel may start to move and damage the cartons to the right of the gap (1) and behind the pallet (2). Packing personnel must always remember that changes in speed and direction occur during carriage which result in considerable inertia forces.



Stowage gaps in a packed 20' container

Even small gaps as at (1) may result in damage under unfavorable conditions. If further cartons were added here, interlayer dunnage would have to be laid on the barrels.

The gaps are still more obvious from this perspective.



Easily visible gaps in a 20' box container

5.3.3.2 Mixed cargo with barrels, example 2

At first glance, this container looks properly packed.



20' box container with packaging and packing deficiencies

On closer inspection, however, a whole series of deficiencies becomes apparent, which are mainly caused by inadequate packaging of the goods.



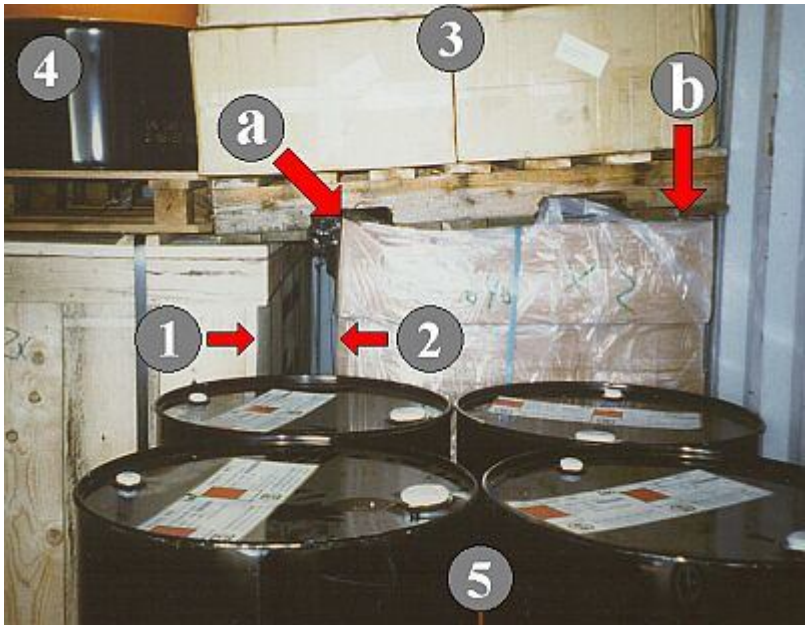
Labeling of the packaging and packing deficiencies

Package (1) is exposed to excessive stress during transport by (2) and (3), because there is no interlayer dunnage. Pallet (2) is not packed flush and has therefore been unfavorably wrapped. Package (3) is inadequately marked, lacking the two upright arrows symbolizing "keep upright". In the case of corrugated board cartons this marking is necessary, because the carton is only sufficiently strong if its corrugations are upright. Since it has not been appropriately marked, the carton has been laid horizontally. The pallet (4) positioned thereon is in a position to exert inadmissible pressures on the packages (6a-b) at (a). A positive feature is that interlayer dunnage of chipboard has been laid on the barrels (5). Package (6) has not been strapped flush on two pallet-like supports. In effect, it consists of two independent packages: namely (6a) and (6b). A pallet has been fastened to the top of package (9), so rendering overstowing impossible without additional pressure-distributing measures. The barrels (7) have been unfavorably packed, causing gaps in the cargo.

In total, these deficiencies increase the stowage factor of the cargo and generally complicate packing and utilization of containers.

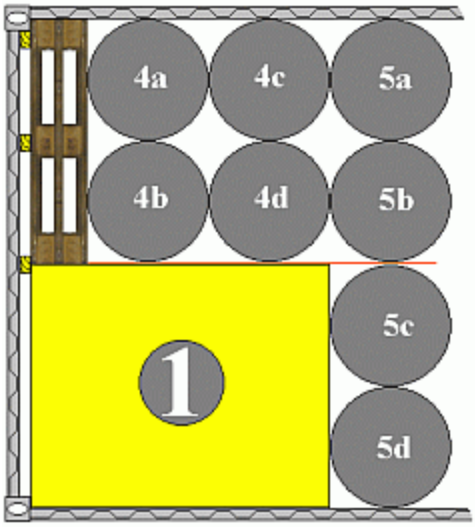
5.3.3.3 Mixed cargo with barrels, example 3

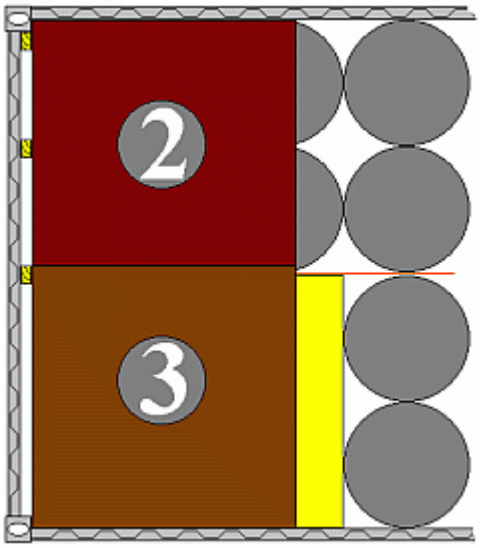
This stowage method cannot be tolerated.



Inadequate packing method in a 20' container

The gap between (1) and (2) should have been closed. The pallet (3) may damage the shipping package (2) at points (a) and (b). The case (1) may crush the cartons (2) and the barrels (4) will cause damage to the packages on pallet (3). It would be best to pack the container differently. The same applies to the barrels (5).





The case (1) should be turned through 90°, whereby barrels 4a-d and 5a-d can be stowed as illustrated. The gaps are filled beforehand or afterwards with wooden beams, pallets and hardboard sheets. The space on top of the barrels 4a-d is brought to the height of the case by filling with lumber or pallets. Packages two and three may then be loaded onto the now flat surface.

5.3.3.4 Mixed cargo with barrels, example 4

Should this container really be sent off on a journey in this state?

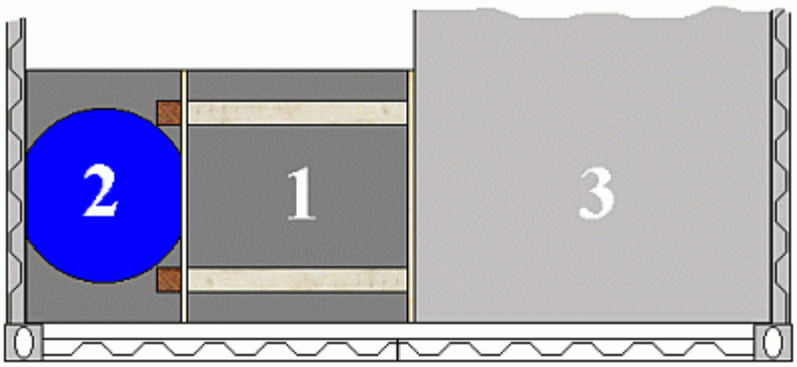


Inadequately packed container

The pallet (1) is not uniformly packed, which is one of the most common errors. The plastic drum (2) and the pallet (3) will destroy one another under stress and the contents of the drum may damage the other goods loaded in the container. Whether wooden members need to be laid under pallet (3) for pressure distribution depends on the strength of the pallet cargo beneath. Any gaps between pallet (1) and left-hand container wall must be filled with bracing.

Subsequent securing measures could include the following:

A wooden board is placed against the inside of the pallet (3). Top dunnage consisting of lumber or boards is laid on pallet (1), boards, and is fixed in place on the one hand by the above-mentioned wooden board and on the other hand by the left-hand container wall. The plastic drum (2) is lashed to pallet (3).



Bracing of the drum against a container side wall

Alternatively, the plastic drum could be pressed against the left-hand container wall with a lattice. The gap between lattice and pallet (3) must be braced. If package (3) is in a position to develop forces exceeding the strength of the barrel (2), bracing must additionally be provided between lattice and left-hand container wall.

5.3.3.5 Mixed cargo with barrels, example 5

Bracing this barrel cargo is very difficult. The addition of cartons and similar, generally pressure-sensitive goods is out of the question.



Gaps still to be filled in a box container

The ideal solution is for a shipping package of sufficient loading capacity, such as a case, to conclude the packing process:

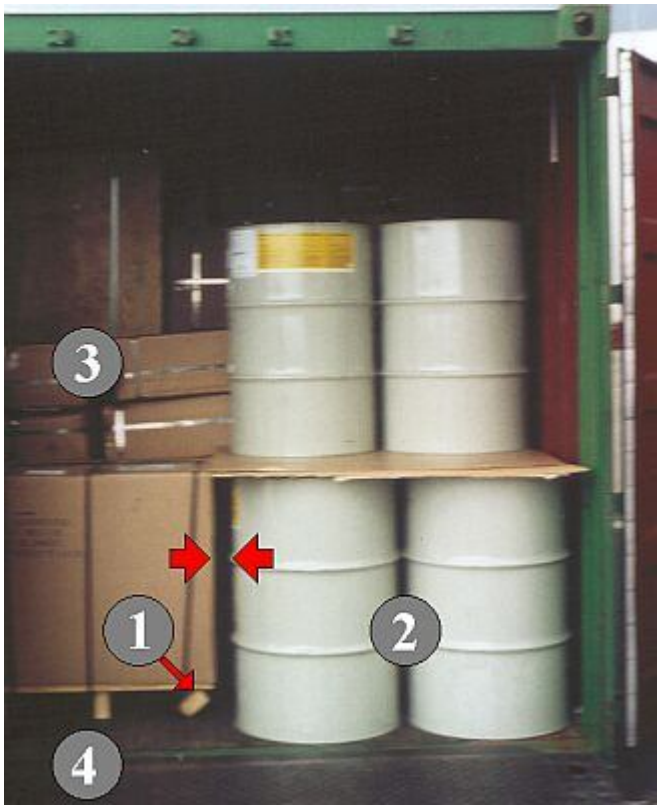




Above and left:
Bracing of a case at floor and lid level

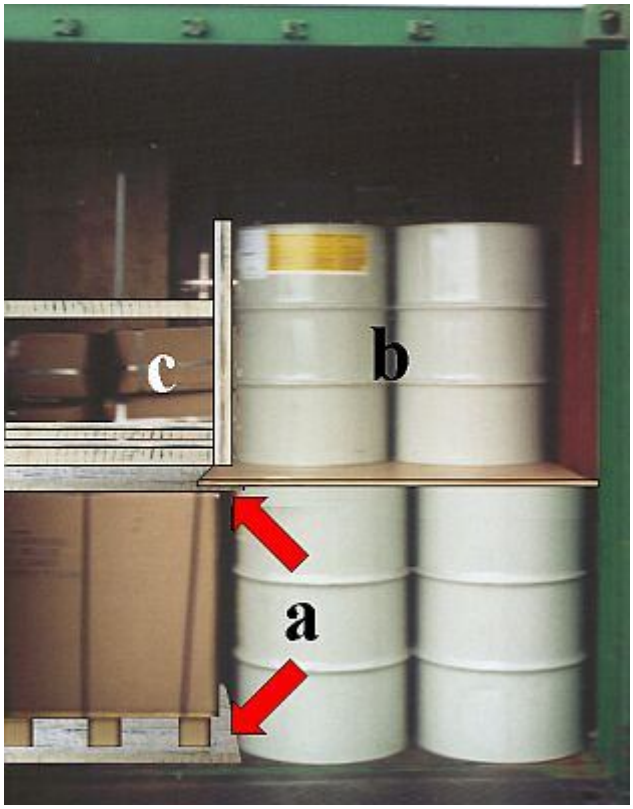
In order to relieve the barrels, the case must be braced against the container wall at least at floor level. Where cargoes are at risk of tipping, bracing in the upper area should also be provided.

5.3.3.6 Mixed cargo with barrels, example 6



Package (1) exhibits typical packaging deficiencies: the upright rectangular cross section of the skids has already resulted in one of them tipping over. A gap between package (1) and the barrel group (2) has not been filled. The stowage personnel originally intended to leave the gap (3) between the upper barrel layer and the container wall. If this container is sent off on its journey in this state, destruction of the contents cannot be ruled out.

The following improvements could have been made:



Package (1) was provided with stable skids and placed on a layer of boards as floor dunnage. A further layer of boards was fitted on item (1) as interlayer dunnage. Both board layers serve to secure the lower barrel layer (a) and thus alleviate the negative effect of the gap. The barrel layer (b) is braced with squared lumber bracing consisting of several uprights and crosspieces (c). The lower barrel layer has been loaded right up against the door line, but not so the upper barrel layer, so meaning that another pallet must be inserted to fill the lengthwise gap before the door is closed.

5.3.3.7 Mixed cargo with barrels, example 7





Stowage of these pails between cartons must be considered a packing deficiency. The position of the rear and front pails indicates that not inconsiderable gaps have been left. A disadvantage of all pails, and also of cans, buckets and similar receptacles, is that the handles (1) may press into and damage the bodies of other drums or sensitive items of cargo. It is advisable to use hardboard, boards or similar materials as additional protection and to separate them from other cargoes.

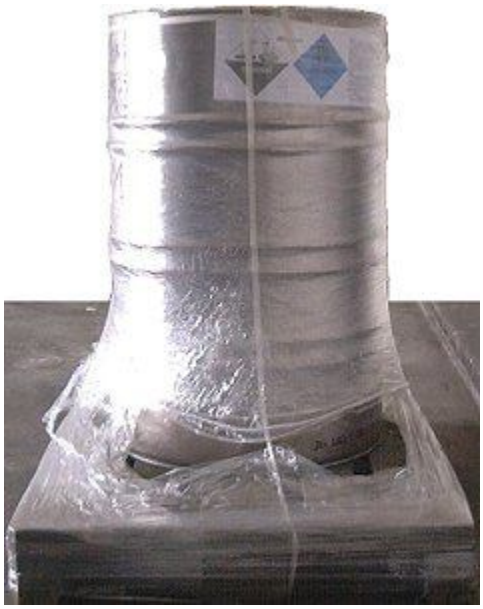
5.3.4 Hazardous materials

There are so many regulations relating to hazardous materials, and they are subject to such regular amendment, that they cannot be dealt with in this Handbook. This section will merely point out a few of the problems relating to these goods.

The general introduction to the IMDG Code gives important information about packaging. Good packaging is half the battle when it comes to cargo securing. Correct packaging should be the norm, but sadly is the exception.







Drum for hazardous materials, containing a corrosive substance, which evolves flammable gases on contact with water.

[N.B.: The drum itself, filling level and labeling would warrant a green light. However, the attempt to form a cargo unit warrants the red light.]

"Rule 3 - Packaging" of the general introduction states, among other things:

> *1 Dangerous goods should*
>
> *1 be carefully packaged and in good condition;*
>
> *2 be of a nature such that internal surfaces with which the contents can come into contact cannot be subjected to dangerous attack, and*

3 be resistant to the stresses produced in handling and transport at sea.

3 Receptacles which are filled with dangerous liquids should, at the filling temperature, have a liquid-free volume which makes sufficient allowance for the highest temperature occurring during normal carriage.

7.3.3 Markings on shipping packages containing dangerous goods must be applied in such a manner that the markings are still discernible on shipping packages which have spent at least three months in seawater. When considering suitable marking methods, the durability of the packaging material and the surface of the shipping package should be taken into account.



Non-regulation cargo unit

10.18.2 packages that contain hazardous goods, that are permitted to be transported in accordance with the code, may only be transported in unit loads if the following conditions are fulfilled.

10.18.2.1 It may occur that the packages in a unit load will need to be separated. In this event, it must be ensured that the individual packages can be handled safely.

10.18.2.2 The unit loads should be compact, have as regular a form as possible, and for the most part, vertical sides. The top of the unit load should be level. It must be possible to stack the unit loads. They must be constructed and secured in such a way that it is unlikely that the individual packages can become damaged.

10.18.2.3 The unit loads must be sufficiently strong to withstand repeated loading and stowing operations and they must be able to bear unit loads with a similar specific mass which are stacked on them to a height commonly occurring during transportation.

10.18.2.4 The material used to bind a unit load together must be compatible with the substances contained in the unit loads and must remain effective under the influence of moisture, extreme ambient temperatures and sunlight.

10.18.3 The individual shipping packages and the unit load must be marked in accordance with sections 7 and 8 of the general introduction.

10.18.4 Unit loads must be directly liftable with a forklift truck or other suitable equipment. Unless generally visible, lifting points must be marked on the unit load.

The CTU packing guidelines contain, among other things, the following regulations:

4.2.5 Dangerous cargoes should only be handled, packed and secured under direct and identifiable supervision of a responsible person who is familiar with the legal requirements and the risks involved and who knows the measures that should be taken in an emergency.

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

3.2.7 In order to avoid cargo damage from moisture, wet cargoes, moisture-inherent cargoes or cargoes liable to leak should not be packed with cargoes susceptible to damage by moisture. Wet dunnage, pallets or packaging should not be used. In certain cases, damage to equipment and cargo can be prevented by the use of protective material such as plastic films.



Damaged bucket - non-regulation cargo unit

3.2.8 Damaged packages should not be packed into CTUs unless precautions have been taken against harm from spillage or leakage (see 4.2.7 and 4.3.1 for dangerous cargoes).

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



Dangerous cargo with traces of liquid

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



Non-regulation cargo unit

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

4.2.9 The packing and method of securing of dangerous cargoes in a CTU should be planned before packing is started.



How well was this planned?

Nothing good ever comes of gaps in a container, especially not if no interlayer dunnage is used.

The result of such packing methods may look like this:





Consequence of stowage gaps in containers

The Container Packing Certificate must, among other things, confirm correct packing behavior. This states:

All packaged have been externally inspected for damage, and only sound packages have been loaded.

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

4.3.3 Dangerous cargoes should not be packed in the same CTU with incompatible cargoes. In some instances even cargoes of the same class are incompatible with each other and should not be packed in the same unit. The requirements of the IMDG Code concerning the segregation of dangerous cargoes inside CTUs are usually more stringent than those for road and rail transport. Whenever a combined transport operation does not include transport by sea, compliance with the respective inland transport regulations, such as ADR, RID, ADN and ADNR, may be sufficient. However, if it cannot be guaranteed that no part of the transport operation will be by sea, the segregation requirements of the IMDG Code should be strictly complied with.

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

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

- *cargoes marked "protect from frost" should be packed away from the walls of a CTU;*
- *cargoes marked "this way up" should be packed accordingly;*
- *maximum stacking height marked should not be exceeded; and*

where practicable, markings on packagings should conform to ISO 780-1983.

5.3.4.1 Examples

This container stuffed for a voyage overseas was packed with hazardous materials, among other things. In accordance with legal requirements, a signed Container Packing Certificate was also provided, which certified that the container had been properly packed and the cargo adequately secured. It is incomprehensible how anyone could make such a statement, given the packing situation illustrated.



Inadequately packed container with some hazardous materials



Incorrectly packed container with dangerous cargo

Class 3 and class 9 hazardous materials are laid on top without any securing whatsoever. Are the packing personnel completely unaware of the risks created here? The majority of the packages consisted of relatively expensive industrial goods.

The section of the CTU packing guidelines entitled "On completion of packing", states, among other things, that care should be taken during the final stages of packing a CTU, so far as is practicable, to build a secure face of the cargo so as to prevent "fall out" when the doors are opened. If there is any doubt about that, additional securing measures are necessary. It is also pointed out that a container on a trailer usually inclines towards the doors and that cargo may move against the doors due to jolts etc., during transport.

For road transport of the container illustrated, the applicable regulations on hazardous materials are also definitive. These require that the individual parts of a cargo of hazardous materials be so stowed on the vehicle and secured by suitable means that they can change position only slightly relative to one another and relative to the walls of the vehicle. It is additionally stated that these regulations also apply to containers and that shipping packages labeled with the "Fragile" symbol must be protected against damage by other shipping packages.



Fragile

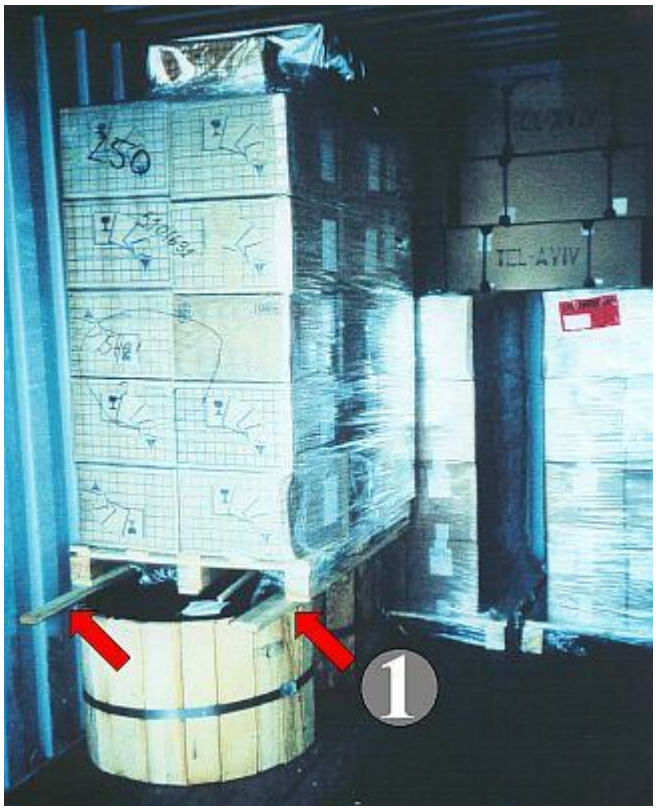
It is additionally stated that shipping packages carrying hazardous materials must be kept separate from the other shipping packages. This regulation has also been contravened.

Relevant regulations are also to be found in GGVSee. Contravention of legal requirements may incur fines.

Under certain circumstances, § 130 of the German Administrative Offences Act provides for fines of up to a 500,000 €, if the administrative offence is accompanied by punishable action.

5.3.5 Cable reels with other cargoes

The packing deficiencies at the container end wall are continued throughout. The incompletely packed pallet is not held securely on the cable reel by the interlayer dunnage consisting of two small boards (1) laid lengthwise.

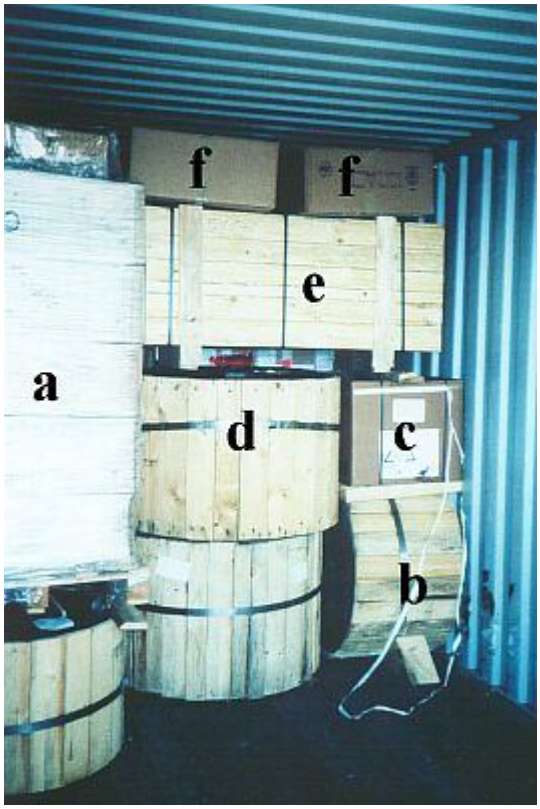


Inadequate interlayer dunnage

The wooden members should have been larger and laid crosswise (see left).



Interlayer dunnage made from strong planks



Various packing deficiencies



Remedied deficiencies

The method used to pack the container is deficient. However, the interlayer dunnage of planks (1) does give the pallet (a) a secure footing. The cable reel (b) has been stowed with its axis crosswise, which is not very advantageous when it comes to further packing. Even less advantageous is the use of the wedge, which prevents the introduction of further cargo, since additional materials would then be necessary for gap-free stowage. Furthermore, the wedge has been incorrectly cut, since only the end grain is available for nailing. This defect has been corrected at (2): now nails can be hammered into the face grain. The package (c) stands loose on its support and on the cable reel. It could be made reasonably stable by passing the strapping around the wooden skid (3) and stowing the package compactly among other cargo. The package (c) would be damaged by the case (e), a situation which can only be remedied by sufficient interlayer dunnage (4), laid on cable reel (d) and braced against the container wall by boards or the like positioned underneath. If the cartons (f) are very sensitive, interlayer dunnage (5) must be laid on the case (e), though this can be omitted if the box's belt battens are not in a position to damage the cartons. Irrespective of whether or not cartons carry two upright arrows, they should be positioned "right way up" (6).

5.3.6 Cases and crates with other cargoes

5.3.6.1 Cases and crates with other cargoes, example 1



Numbering of certain packages for error analysis

Packages (2) and (3) may slip towards the container side wall (1). Package (4) may slip and tip and damage packages (5), (6) and (7) and other shipping packages. Repeated to-and-fro movements will damage not only the cargo but also the container itself. Even adjacent containers may be affected.

Packing errors become particularly clear if the container is tilted.



Risks at 30° tilt

Improvements may be achieved by a small amount of restowing and the use of squared lumber and boards, but the result is by no means optimal:



Reasonably usable result achieved by restowing and bracing

With the method shown, the container wall is subjected to point-loading, as is the plywood case if it is not braced directly in the area of the front end wall. The latter measure results in plate action, so that no further damage would be likely to arise.
At any rate, boards or the like should be inserted at the side wall of the container for pressure distribution.



Possible variant of a well packed section

Only with careful stowage planning can sensible packing and securing be achieved. It remains to be seen whether the suggestion given here is the best, but at least cargo damage should no longer occur. This Figure is merely intended to illustrate the possibility of a compact stow.

However, optimum stowage and securing can always be achieved by timely stowage planning. According to the CTU packing guidelines, there is an obligation to do this:

> *3.1.4 Packing should be planned before it is started. This should make it possible to segregate incompatible cargoes and produce either a tight or secured stow, in which the compatibility of all items of cargo and the nature, i.e. type and strength, of any packages or packaging involved are taken into account. The possibility of cross-contamination by odor or dust, as well as physical or chemical compatibility, should be considered.*

It is almost always possible to draw stowage plans. Other options, such as previous "mapping" with "container templates" and similar methods have already been dealt with under the heading "Basic stowage rules and general notes".

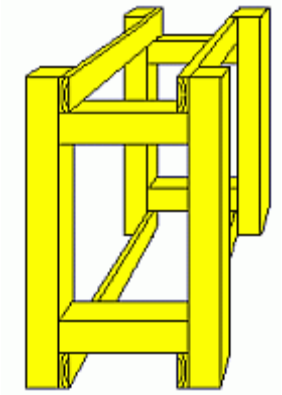
Sometimes it is just little things which can turn an inadequately packed container into a satisfactorily packed container. This picture shows a well thought out solution:



Well packed and secured section

Bracing has been inserted between the two cases in the bottom layer, the crosspieces of the bracing finishing flush with the floor and the top of the case. In this case, this is good, since the crosspieces introduce the forces satisfactorily into the lid areas. In the floor area, this is no longer ensured due to the different types of box.

It has been stated in the general section that the following arrangement of wooden members is the best for bracing, to ensure that the wooden members do not cave in at the face/end grain interface. This basic rule is particularly applicable to heavy cargoes.



Bracing variant for heavy cargoes

However, there are exceptions to every rule: In the packing example shown, it would have been

appropriate to use a hybrid which was flush at the top but not at the bottom.

The squared lumber members used to brace the gap between the cases in the second layer have been deliberately raised, so that the forces are introduced into the case bottoms. To protect the cargo, plywood interlayer dunnage has been inserted between the cartons in the upper area of the section. The tipping forces from the large plywood case acting on the cartons were absorbed in the upper area by inserting squared lumber between this upper area and a wooden board placed against the container wall to distribute the pressure.

5.3.6.2 Cases and crates with other cargoes, example 2

There is a slight risk here of the wooden case damaging the pallet by tipping. The case is secured at floor level against sideways shifting, since pallet bottom and case bottom lie at the same level and virtually touch. However, there is a risk for the pallet cargo because the cartons are lying down and no account has been taken of the handling symbols.



Compact stowage method for a container section with low risk of damage due to tipping of the case.

Disregarding the handling symbols on the pallet cargo

All risk of tipping of the case could definitely have been prevented by insertion of a small bracing member before the pallet was loaded.



Simple bracing for securing the case against slipping and tipping

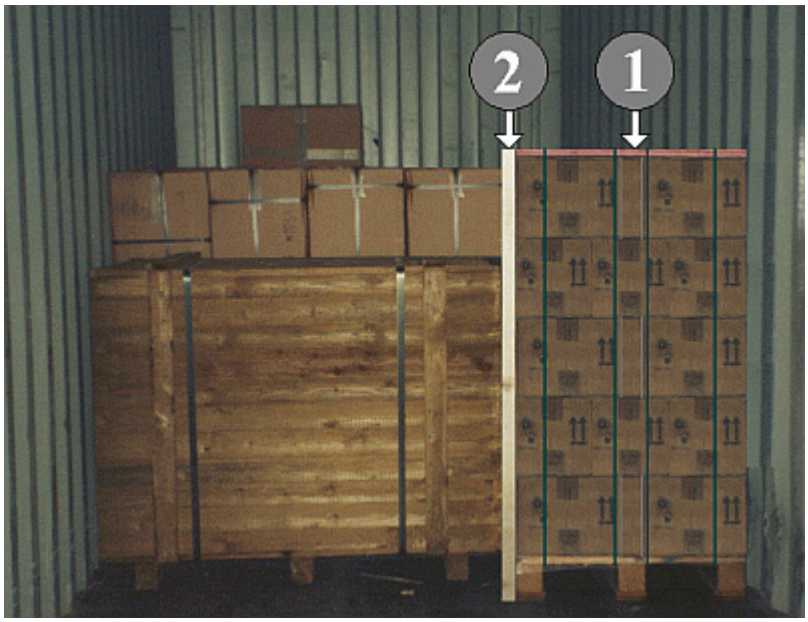
Here, the pallet was packed taking the handling symbols into account, covered with a plywood board (1) and strapped.



Expertly packed pallet

If this pallet is positioned in front of the bracing shown above, the case cannot have a damaging effect on the cartons on the pallet.

Alternatively, it would have been possible to dispense with the bracing behind the pallet and to fit some narrow beams (2) between case and pallet:



Separating the pallet from the case using wooden beams

5.3.6.3 Cases and crates with other cargoes, example 3

The gaps mean that the cargo can be damaged:



Risk of damage due to gaps

The cases and cartons on the pallets can be damaged as a result of the gap (1). First of all, the cartons in the area (2) are damaged. It can be seen at (3) that the pallet has not been packed flush.



Gaps mean that inertia forces can cause damage.

Secure bracing could look like this:



Bracing of a stowage gap with squared lumber

If it is assumed that the upper, inner corner of the carton pallet could be damaged by tipping forces from the box pallet, the right-hand wooden upright should extend higher and be braced against the container wall:



Additional shoring of bracing against the container wall

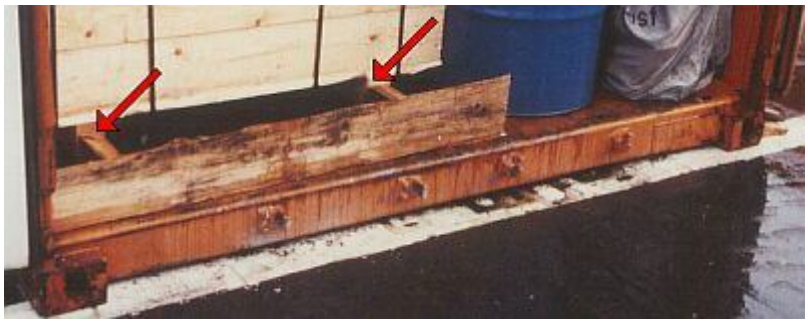
5.3.6.4 Cases and crates with other cargoes, example 4

What will happen to the contents of the mail bags when a case and six barrels fall on them?



Mail bags, at risk from case and barrels

The movement of the sea would gradually create more and more space between the barrels and cases, resulting in mutual damage. In the longitudinal direction, the case is only braced towards the door.



Incorrectly positioned bracing

The bracing should have been positioned in the area of the case bottom ...

.... As here:



Wooden bracing, positioned in the area of the case bottom

The simplest thing to do is to take the necessary measurements and to build appropriate bracing outside the container.



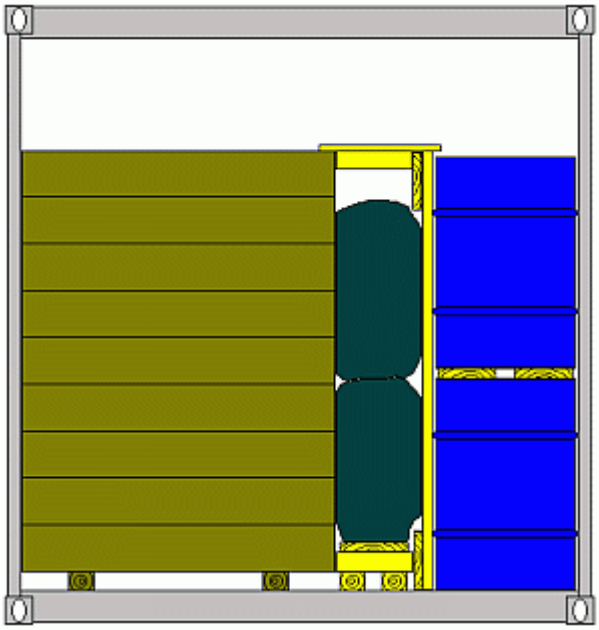
Bracing for the door area - plan view



Bracing for the door area - front view

The bracing is positioned in front of the case and the left door leaf is closed. If it has been sufficiently accurately made, no further measures will be necessary.

Securing for case and barrels which at the same time allows protection of the mail bags could look like this:



Protected space:
mail bags inside bracing for case and barrels

A simple lattice consisting of two vertical and two horizontal boards is positioned against the inner side of the barrels. Bracing is provided in the bottom and lid areas of the case. In this way, the mail bags are also protected from condensation on the container side walls.



If the mail bags are not at any risk from condensation water, the remaining space between case and door may serve to accommodate further bags.

Mail bags in the door area

5.3.6.5 Cases and crates with other cargoes, example 5

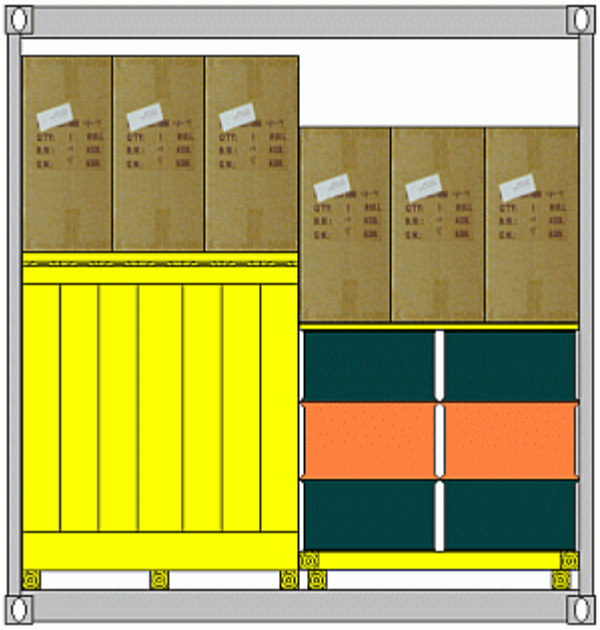
If this container is left stowed like this, it is almost certain that considerable cargo losses will eventually arise during the course of the voyage.





The wooden case (1) 2,856 kg in weight will crush the cartons (2) and ultimately even be damaged itself. The barrels (3), with a mass of approx. 220 kg each, will destroy the cartons (4) and possibly even leak. Further damage will occur in the front part of the container.

This is how the container could have been well packed:



The heavy wooden case is stowed tightly against the left-hand container wall. At floor level it is supported against the right-hand container side wall by wooden bracing. The barrels are loaded onto this bracing. Any remaining gaps are filled with material of sufficient loading capacity. Interlayer dunnage of wooden boards or the like is placed on the barrels, which additionally secures the case in the upper area against tipping forces and provides a clean supporting surface for the cartons to be loaded thereafter in stepped arrangement.

5.3.6.6 Cases and crates with other cargoes, example 6

The wooden crate has been produced without diagonal bracing. The incorrect design was partly responsible for the deformation. What pallets (2) and (3) are intended to achieve is unclear.



In addition, the loading bed has been positioned incorrectly - it must adjusted to the level of the container floor.



Improved packing

A different crate design and a modified packing method would have resulted in satisfactory packing of the container.

5.3.6.7 Cases and crates with other cargoes, example 7

Due to the low loading capacity of the plastic drums and the stowage gaps, the voyage could be a "wearing" one, since the gaps between sections 1 & 2 and 3 & 4 are too big:



Inadequate packing in a 20' standard container

The decision as to whether the plastic drums should be stowed at top or bottom depends essentially on a comparison of the case and drum masses. Primarily, the basic stowage rule "light on heavy" should be followed. Where the masses are virtually identical, the decision to adopt a particular stowage method should be based on the principle of "dry on wet", if the drums contain liquids. This principle is of little relevance in the case of pasty or powdery contents.

Depending on the contents of the drums, an acceptably packed container could look like this:



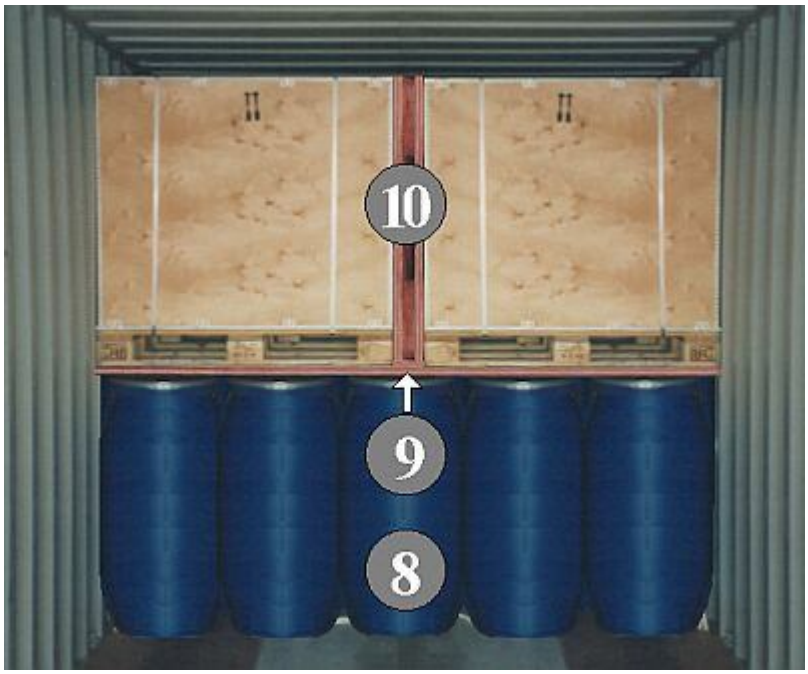
Gap-free container section using pallets for securing

The plywood cases are stowed to the left and right against the container side walls and the gap is filled with vertically positioned pallets (5). Interlayer dunnage consisting of walking boards (6) is laid on the cases, and the plastic drums are loaded on that. These are separated from the cargo to be packed subsequently with boards (7) fitted into the corrugations.



Appropriate cargo dimensions ensure gap-free packing

A stow is more cost-effective if the package dimensions fit the container. All that is needed here is for interlayer dunnage to be put in place and the drums to be separated from sections still to be packed.



Bracing of gaps in a 20' container

The plastic drums (8) can be stowed in the bottom layer, if the plywood cases in the second layer are no heavier. It is essential to lay interlayer dunnage made from walking boards (9) or similar materials on the drums. The pallets with the plywood cases attached to them are placed in the second layer against the container side walls. The gap (10) remaining in the middle is braced.



Appropriate cargo dimensions ensure gap-free packing

Where masses are relatively great or relatively high inertia forces are to be anticipated, sections inside the container must not be separated by means of boards fitted into the corrugations, since the container may otherwise be damaged. A substitute method uses lattices, which are supported against parts of the container which have sufficient loading capacity. At any rate, the boards must be secured against sliding down.

5.3.6.8 Cases and crates with other cargoes, example 8

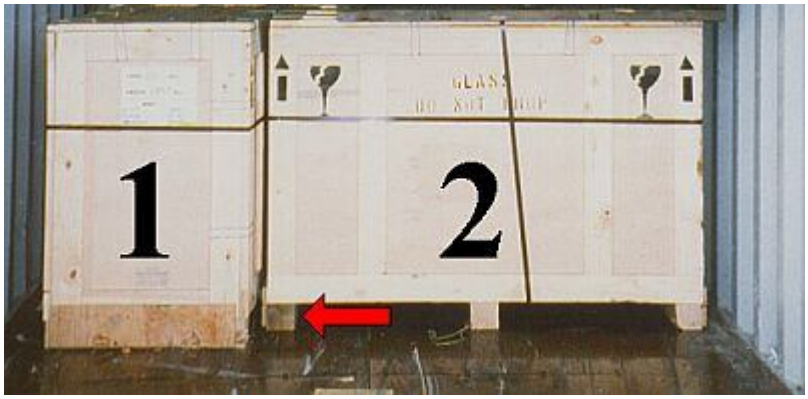


Considerable packaging and packing deficiencies

The fundamental deficiencies are:

Shipping package 1 can only be picked up with ground conveyors from two sides. With the stowage method illustrated, it was either additionally turned round or it was picked up with the forks under the cross beams, being "pushed in" with the forks between beam and container floor, thereby risking damage to the package and the container floor.

Package 2 lost a wooden member during handling and has been temporarily "jacked up"; in addition it is incorrectly marked: the individual arrows indicate the "top" of this package. Since the contents are made of glass, it must have been to say that the package should be carried upright. However, such a stowage instruction should be expressed by two upright arrows.



Unfavorable case skid on 1, broken wooden member and incorrect marking on 2



Incorrectly packed, incorrectly constructed shipping packages

Package 3 reaches down to the container floor and is therefore at risk of tipping. For this reason alone, the gap relative to the container wall should have been filled.

Shipping package 6 was handled "brutally" and was crammed into the container over package 4. Shipping packages 4 and 5 are not suitable for transportation as they are, since both are strapped onto pallets with steel strapping, despite the fact that their dimensions do not allow for flush loading. One steel strap is already torn. In addition, adequate edge protection has not been used.

Fully palletized cargo simplifies packing in containers carrying mixed consignments . However, when properly secured, the packages illustrated here incur higher costs.

5.3.9 Cartons

5.3.9.1 Cartons only





Pallets which have not been packed flush inevitably result in gaps in the stow which can only be eliminated at the cost of considerable labor and material. There is only one solution in this case - unpack the pallet and stow manually.



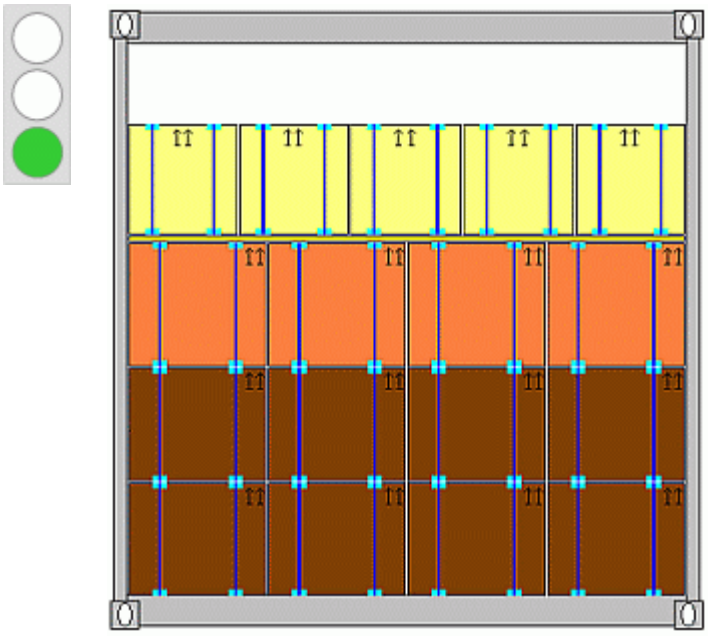
Container not entirely correctly packed due to packaging

The packages are here neatly packed edge to edge, as this is the only way for the underlying layers to withstand the forces from above; since this was not possible for the final layer due to the package dimensions, plywood interlayer dunnage had to be laid beneath the final layer.

The shortcomings in strapping due to the lack of edge protectors will not be discussed any further at this point. However, and this is why the traffic light is at amber, it is to be suspected that the cartons are not

correctly oriented. The appearance of the cartons and the adhesive taping could indicate that the flutes in the carton board are not vertical, but horizontal. Again: Adequate marking is an indispensable component of the packaging.

This is correct:



Correctly packed container with ideally harmonized packages

The lower layers are packed edge to edge, i.e. "flute" to "flute" in correctly constructed cartons. Since this is not possible in the final layer, interlayer dunnage ensures adequate distribution of pressure to the underlying layers. The remaining empty space at the top of the container presents no risk to the cargo as the package dimensions mean that there is no risk of their "popping up" out of the stow.

Additional measures such as side dunnage, nonwoven fabric covers etc. could be necessary if there were any risk that the packages could be damaged by container sweat.

5.3.9.2 Cartons, mixed cargo

5.3.9.2.1 Cartons, mixed cargo, example 1





"Bulk loading" of general cargo in a 20' steel corrugated container

Package 1 has a mass of 492 kg, while package 3 has a still greater mass. The packages 2 could fall into the gaps beneath or be crushed between 1 and 3 as a result of shipping stresses. Packages 4 and 5 are at considerable risk of damage. Package 6 can be seen to be inadequately packaged: steel strapping should be avoided on cartons. The lack of edge protectors has meant that the straps have already cut into the carton.

The pallet and board are useless in terms of cargo securing.



It is economically unacceptable for considerable investment to be made in the manufacture of goods if these

efforts are wasted during shipment.

"Bulk loaded" general cargo

With this container, all that can be hoped is that the ship has a calm voyage as there will otherwise be little left of the household goods in these packages.



Removal container inadequately packed with household goods

5.3.9.2.2 Cartons, mixed cargo, example 2



Packaging
and packing deficiencies

Most of the gaps in the packing are attributable to inadequate packaging and palletization. Package a has been damaged during stowage. Someone has obviously used the carton as a step in order to stow the upper layer of cartons manually.

A better stow could be achieved by unpacking the "palletized" cargo and stowing the packages conventionally.



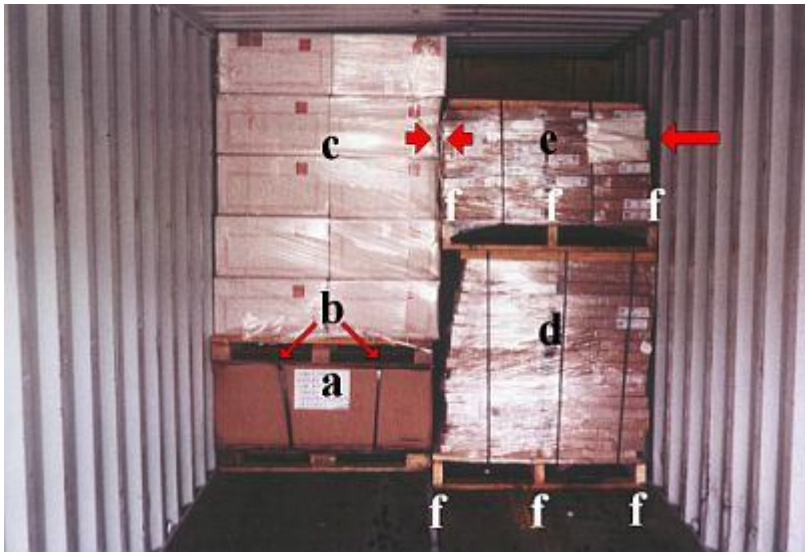
Gaps in the load due to inadequate palletization

The same problem again: the inadequately packed and wrapped pallets are virtually impossible to secure economically. Unpacking and manual stowing is virtually the only way to secure the cargo sensibly.

As already explained in the packaging section, it is essential

- to select appropriately sized packaging containers,
- to provide pallet bases which are suitable for container transport,
- to provide adequate edge protection when strapping, and
- to provide strong shrink wrapping or other wrapping around the pallets or bases.

The following example reemphasizes these basic rules:



Packaging and palletization deficiencies promote damage

Pallets (a) and (c) have been strapped together (b) to form a cargo unit. However, the lack of edge protectors and poor application of the strapping promote cargo slippage. Pallets (d) and (e) are likewise poorly strapped and rest on very "wobbly" feet (f). It is better if the pallet blocks are as wide as possible. Extended periods of bad weather during a voyage make damage virtually unavoidable.



Proper palletization facilitates container packing and securing of the cargo in the container.

No changes were made to the cargo dimensions. The cartons were merely set edge to edge and in some

cases different pallet bases were used. In this manner, in conjunction with suitable strapping, the cargo can be accommodated securely in the container.

A structure of walking boards and squared lumber offcuts was fabricated outside the container and used to brace the gap remaining in the center of the cargo. The same effect can be achieved with pallets which are no longer required.



Apparently insignificant errors can result in major damage.

The package (a) has not been stowed against the container side wall. Package (b) has only a very small bearing area where indicated. The gap (c) has not been filled. There are similar shortcomings throughout the container. Depending upon the mass and strength of the packages, interlayer dunnage of wooden sheets or boards would be necessary at certain points.

5.3.9.2.3 Cartons, mixed cargo, example 3

An ordinary, everyday situation:



Unfavorable pallet dimensions in a 20' ISO export container

The pallets used measure 800 mm x 1,200 mm and are thus not suitable for container use. The pallets are also not neatly packed and include gaps (1). Due to their design, they only have a strip-like bearing surface (2) which consequently generates high pressures. The edge of pallet (3) is sticking out beyond the cargo. Moreover, the strapping is so badly placed that it could break during forklift truck handling. The gaps between the pallets and at (4) between container side wall and pallet (3) and are too large.

Considerable effort would be required in order to achieve a compact stow without gaps.

5.3.9.2.4 Cartons, mixed cargo, example 4

The gap in the stow at (1) must be filled. The textile rolls (2) could possibly be damaged by rolling to and fro.



Packing deficiencies in a stow of cartons and textile rolls



Provisional securing by tie-down lashing

Subsequent repacking of textile rolls is difficult. Gaps remain at (3) and (4). However, if the rolls are lashed down tightly enough, they will remain in the cantline. If such securing is to be feasible, appropriate lashing points must be present and the lashing means must be attached to them in advance and lifted up as packing proceeds.



Excessively large number of pallets to fill gaps

Pallet (2) ought to be lifted up to allow placement of interlayer dunnage to distribute the pressure. Ten pallets would be required to fill the gaps (5) with pallets. Such a large number just for these gaps is unacceptable.

It is specifically stated in point 3.2.12 of the CTU packing guidelines that, when deciding on packaging and cargo securing material, it should be borne in mind that some countries enforce a garbage- and litter-avoidance policy. It is furthermore stated that this may lead to limitations on the use of certain materials and imply fees for the recovery of packaging.

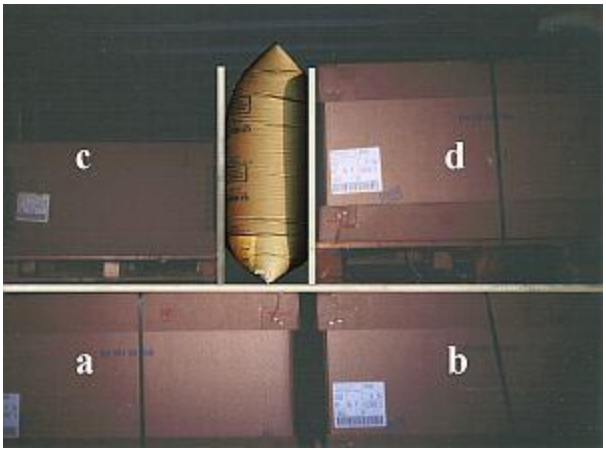
A compact stow achievable due to the dimensions of the cargo is the most economic method of cargo securing.

5.3.9.2.5 Cartons, mixed cargo, example 5

The gap between the upper left-hand package and the container side wall cannot be left as it is. Moreover, no interlayer dunnage has been laid .



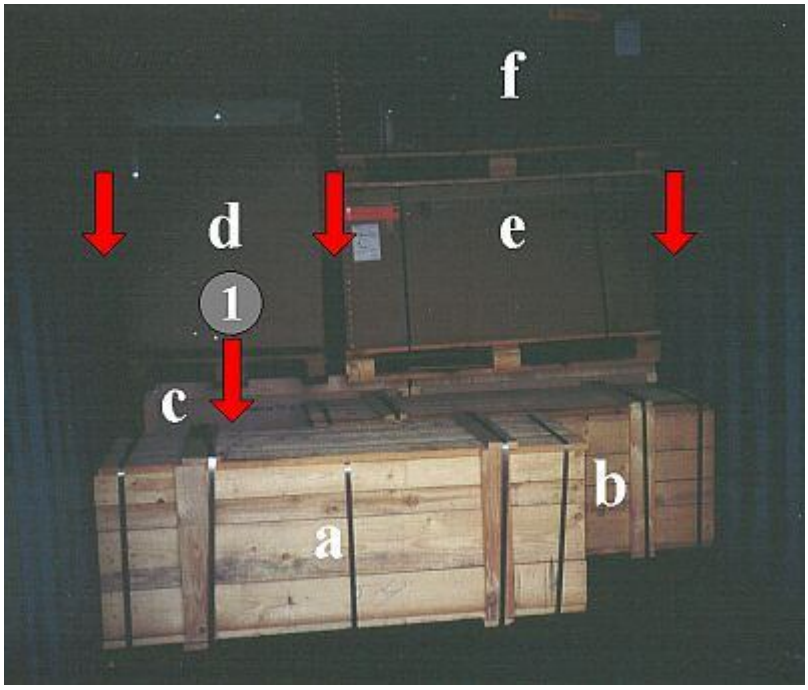
Gaps in the load constitute a transport risk.



Filling gaps with airbags

Interlayer dunnage should be laid between packages a & c and b & d. The inner sides of packages c and d are protected from point loads with sheets or boards and the gap between the items of cargo is filled with an airbag.

In this case too, the gaps in the load can result in damage.



Gaps in the stow are the root of all evil.

The gaps behind case (a) and between case (b) and the left-hand container side wall are particularly critical, but the other gaps (red arrows) may also be the root cause of damage. Steps could have been taken to prevent damage by laying dunnage on package (c), onto which packages (d) and (e) could have been placed. No interlayer dunnage would be required between (e) and (f), provided that the bearing area of the pallet-like base is sufficiently large and package (e) is not excessively sensitive.

A good alternative would have been to pack cases (a) and (b) on squared lumber supports placed lengthwise on the right and left of the container. Package (c) could then also have been placed lengthwise in the middle. The squared lumber supports would have had to be dimensioned so as to offset the difference in height between (a) and (b) and package (c). The other packages could then have been stowed on top without further interlayer dunnage in such a manner that they rested tightly against the container walls. The remaining gap in the middle could then have been filled with an airbag or pallet.





Compactly stowed container - partly staggered

Although packing was carefully carried out and gaps were avoided or filled, the traffic light is still at red.





Inadequate securing of a relatively large gap in door area

The squared lumber member placed between the container corrugations to block the gap remaining in the door area is not adequate. The lumber crosspiece used could not withstand inertia forces generated by the cargo, especially if this container were stowed athwartships on board ship or if precarriage or onward carriage were by rail.



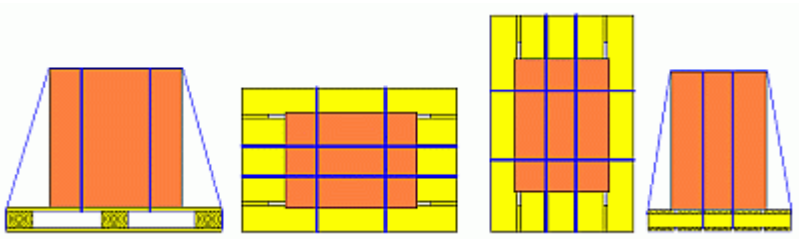
Risk of damage to container corrugations by squared lumber

The squared lumber could be forced out, probably also resulting in damage to the container walls.

5.3.9.3 Cartons on pallets

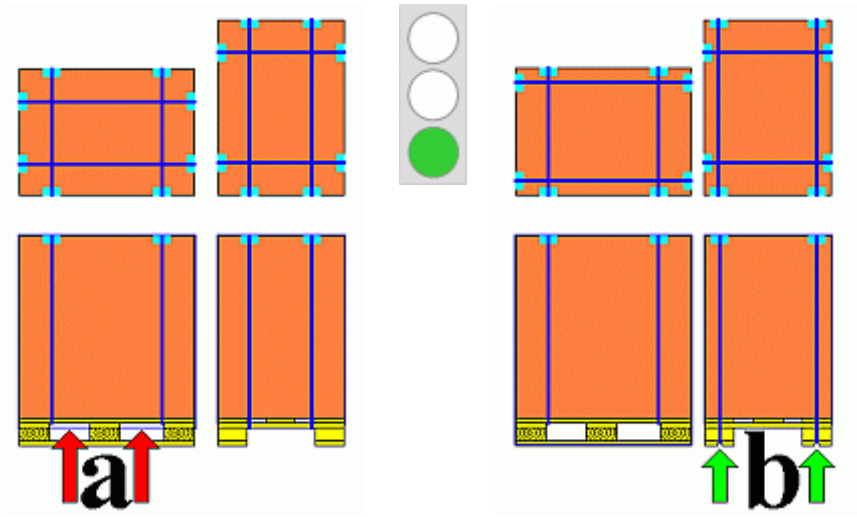
5.3.9.3.1 Cartons on pallets, example 1

Fully palletized cargo simplifies packing in containers carrying mixed consignments. However, when properly secured, the packages illustrated here entail considerable extra labor.



The packages are not "fully" palletized

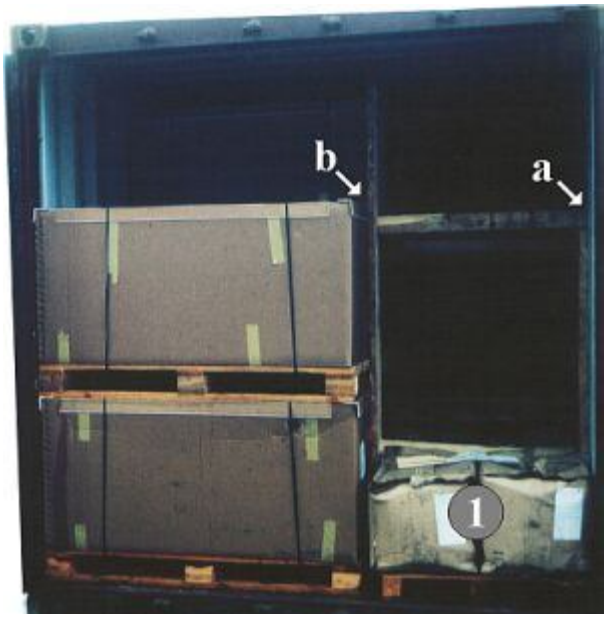
One option is to cut the cartons from the pallet and stow them manually, so entailing extra effort.



The packages would have been correctly prepared for shipment if they had been packed flush on a stackable base. It is important to ensure that the strapping is not jeopardized by handling with ground conveyors. They could be torn at (a), as this is where the forks are inserted. This cannot happen at (b) because the straps are accommodated in routed grooves.

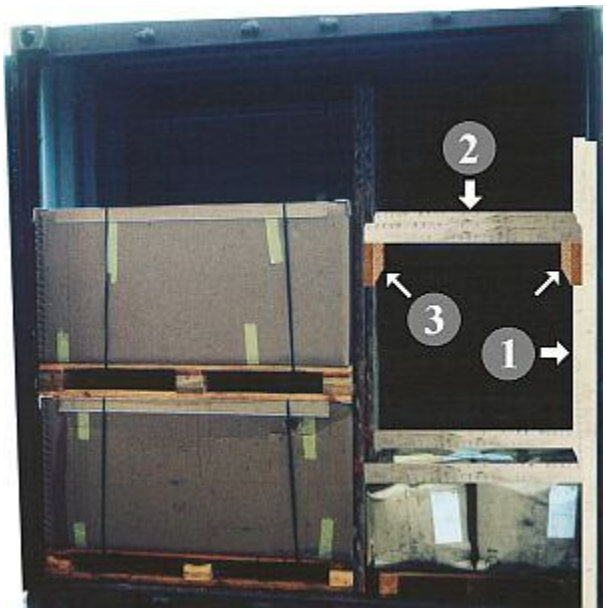
5.3.9.3.2 Cartons on pallets, example 2

While the simple wooden frame made from two upright boards and squared lumber crosspieces does secure the left-hand pallets and the protects the already damaged cartons, it is still in need of modification. As shown, the upper cross brace is applying a point load on the container side wall (a) and the single board on the pallet (b).



Cartons almost fit for transportation in a container

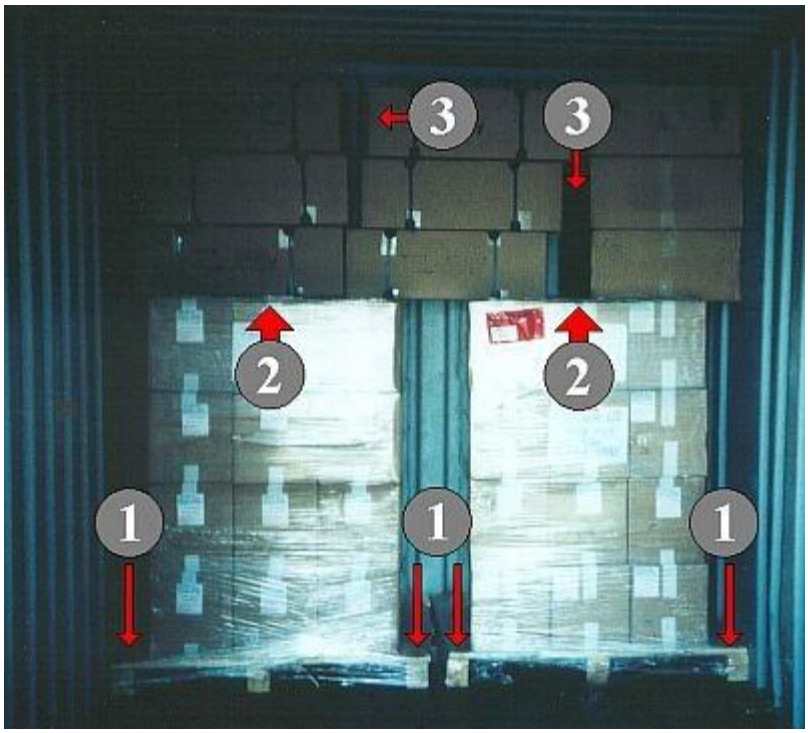
It is better to use two frames to provide the overall bracing and to modify the structure by choosing taller uprights (1). The wooden crosspieces (2) are not resting on top of the uprights, but against them, so resulting in better pressure distribution. Wooden members (3) nailed underneath hold the structure together and prevent the upper cross braces from slipping down.



Improved bracing frame

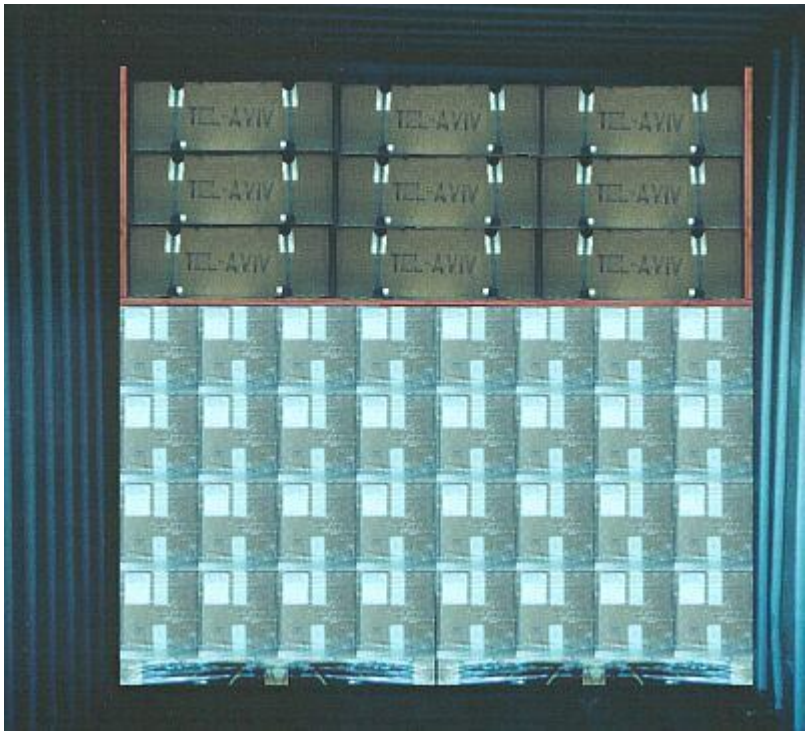
5.3.9.3.3 Cartons on pallets, example 3

The pallets are incorrectly packed and are not fit for container transport. The gaps in the stow (1) may result in damage. There is no interlayer dunnage between the pallets and cartons (2).
Inadequate packing of the cartons has given rise to gaps which promote damage (3).



Poorly packed section in a standard container

This ship en route for Israel has to pass through the North Sea, the English Channel and the Bay of Biscay, all regions which often suffer unfavorable sea conditions. Secure packing could easily have been achieved:



Excellently packed section in a standard container

If the pallets had been made two centimeters wider, they could have been packed flush. Interlayer dunnage made of plywood or chipboard is placed on the pallets, while the same material is used as side dunnage against the container walls. In this way, the cartons fit in the second layer without gaps and would even be protected from sweat from the container sides. If there were any risk of sweat formation, top dunnage of special nonwoven fabric or similar material would have to be laid.

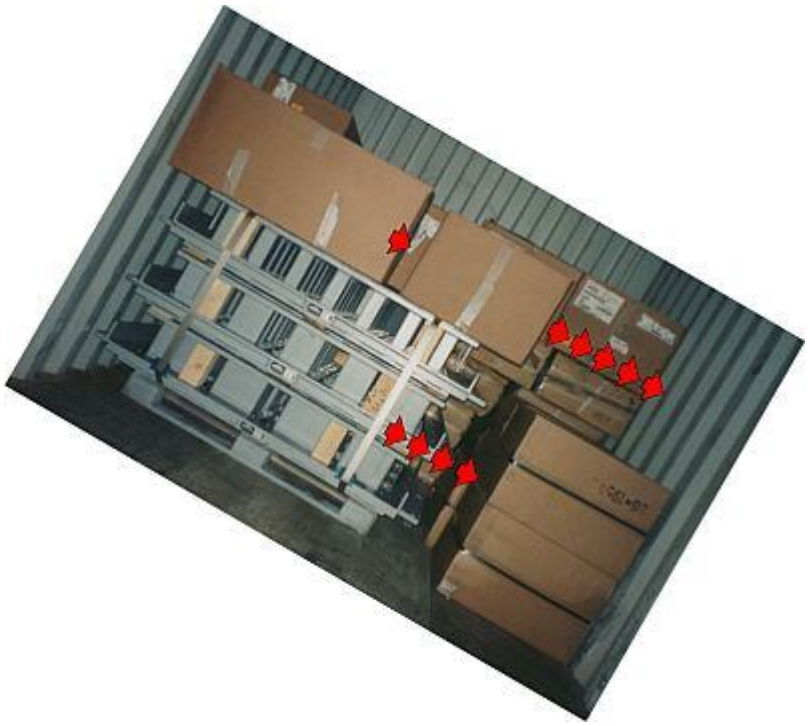
5.3.10 Steel and metal products, mixed cargo

5.3.10.1 Steel and metal products, mixed cargo, example 1



Inadequate packing increases the risk to which the goods are exposed.

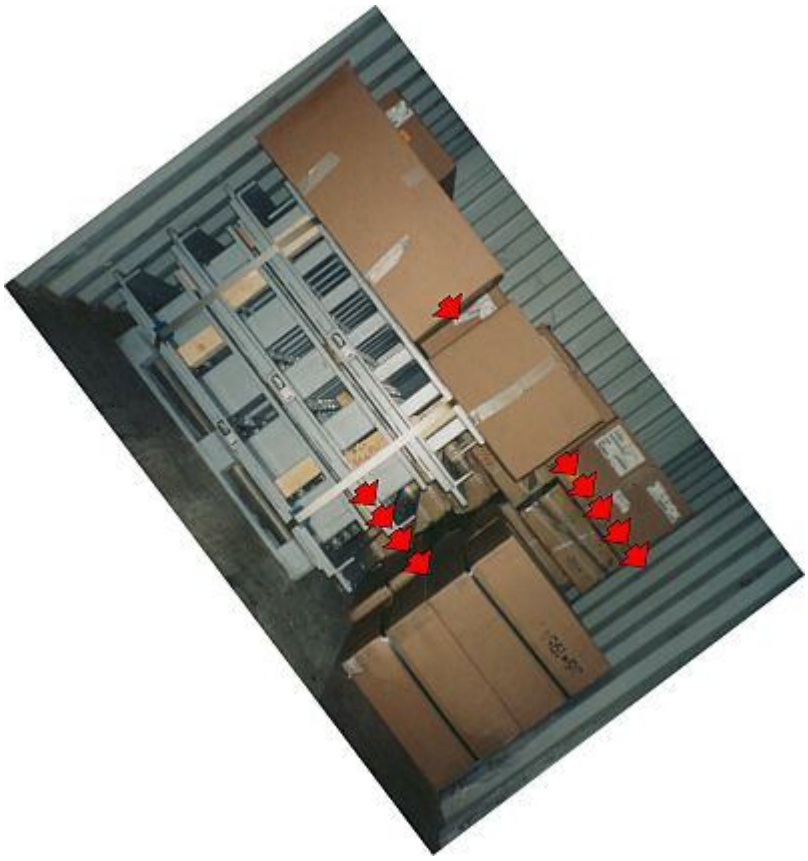
The fact that there is a potential for cargo damage becomes particularly clear if the container is tilted to an angle of 30°.



... An angle of 30° is enough to get a good part of the cargo sliding ...

This angle corresponds to rolling angles which are to be anticipated in overseas transport or the sideways acceleration forces of 0.5 g to be expected in road and rail transport.

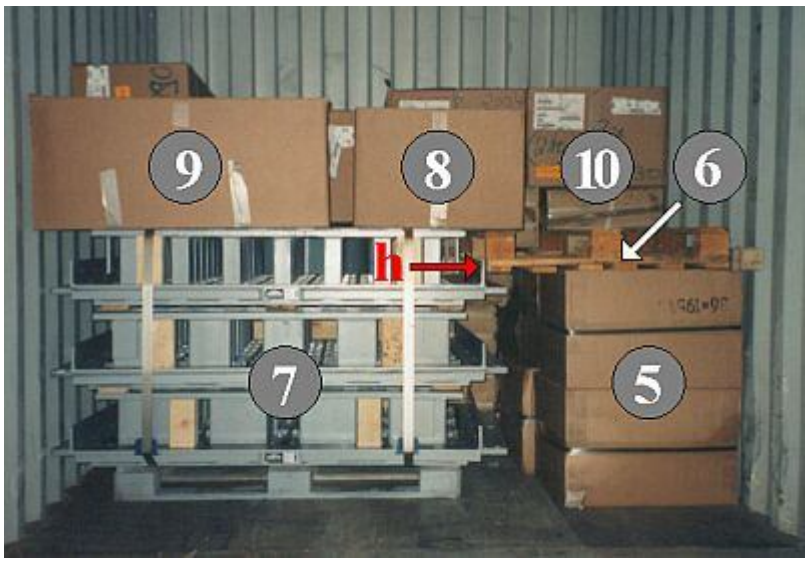
The consequences of inadequate stowage and securing are even clearer if acceleration forces of 0.8 g are presented as a tilt angle of 53°.



... At an angle of 53°, almost everything will slide ...

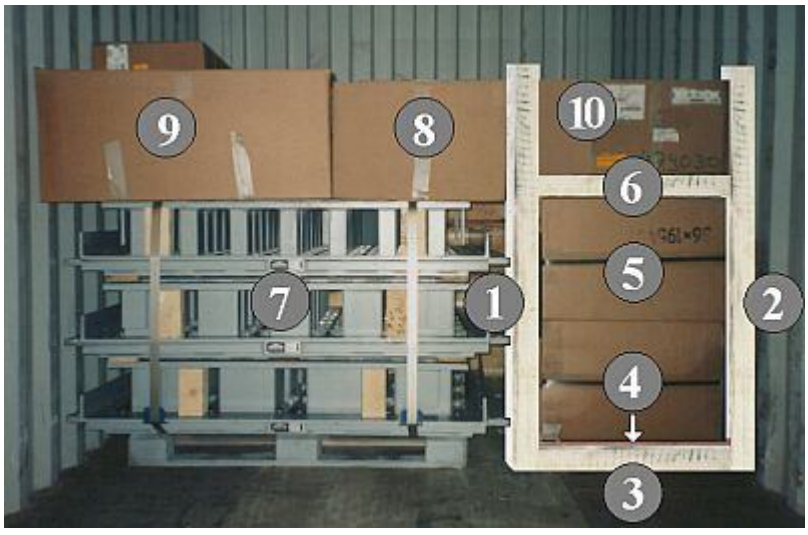
How much of the cartoned goods, truck parts and container will still be usable?

It will take more than putting a pallet on top to remedy the securing deficiencies:



Laying a pallet (6) on top of the cartons (5) is not a satisfactory solution. While the inertia forces generated by the bundled truck parts (7) will be transferred from the point (h) indicated with the red arrow via the pallet to the right-hand container wall, the result will be a point load over a very small effective height against a few container corrugations. The issue of the gaps in the stow between (5) and (7), (8) and (9) and (8) and the right-hand container wall remains unresolved and these gaps absolutely must be eliminated.

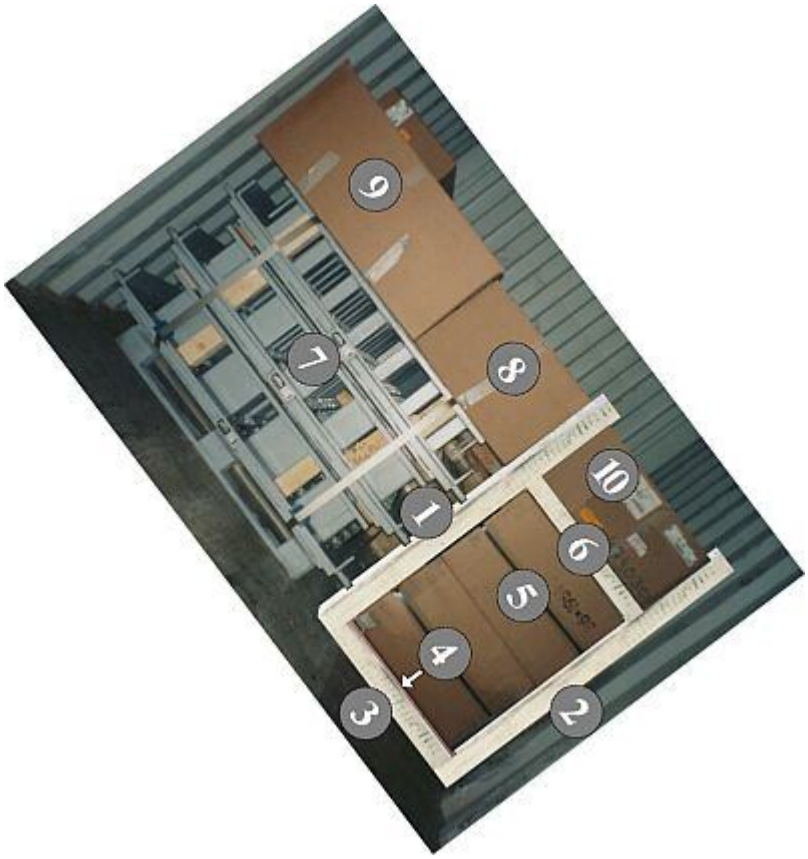
Reasonable securing is not very difficult to achieve:



Proposed securing method for truck parts and cartons

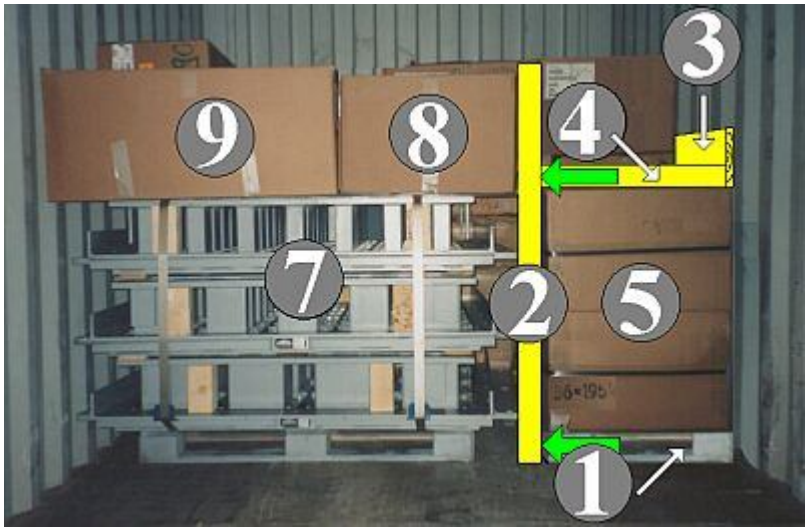
Two u-shaped frames are constructed from two approx. 1.70 m tall squared lumber uprights (1) and (2) together with two cross braces (3), the frames being connected together at floor level with a narrow plywood sheet or wooden dunnage boards (4) laid lengthwise, on which the carton (5) is stowed. The upper parts of the two squared lumber uprights (1) and (2) are braced with two crosspieces (6). The heavy package (7) and the lighter packages (8) and (9) can lean against this structure. Package (10) and other small parts can be stowed "without pressure" and thus protected in the gap between the members (6).

Securing in this manner will even withstand acceleration forces of 0.8 g. There is no risk of cargo damage.



Simulation of 0.8 g acceleration by tilting

Another variant:



Alternative securing method for packing truck parts and cartons

The packages (5) are placed on a pallet and stowed tightly against the right-hand container wall. The gap between the cartons (5) and truck parts (7) is filled with two squared lumber uprights (2) which extend sufficiently far upwards also to be able to prevent packages (8) and (9) from moving sideways. The gap above the cartons (5) is braced with a board (3) laid lengthwise against the container side wall to distribute the pressure and two squared lumber members (4).

5.3.10.2 Steel and metal products, mixed cargo, example 2



Plant parts in a 20' container
- unsecured in transverse direction

Before further cargo can be stowed, the gaps must be eliminated.

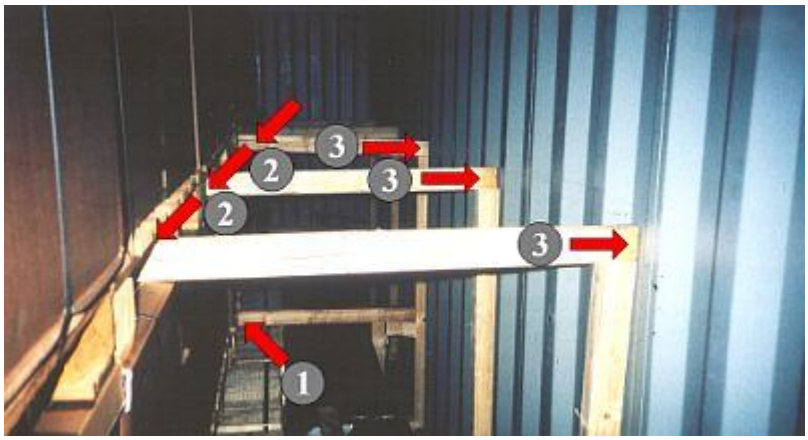
The gaps present must at least be filled with suitable squared lumber members, which should be fastened in place.



Plant parts in a 20' container
- gap braced in transverse direction

If a flat loading surface is required, the right-hand package can be raised on supports. Packing must be continued in accordance with the stated rules.

5.3.10.3 Steel and metal products, mixed cargo, example 3

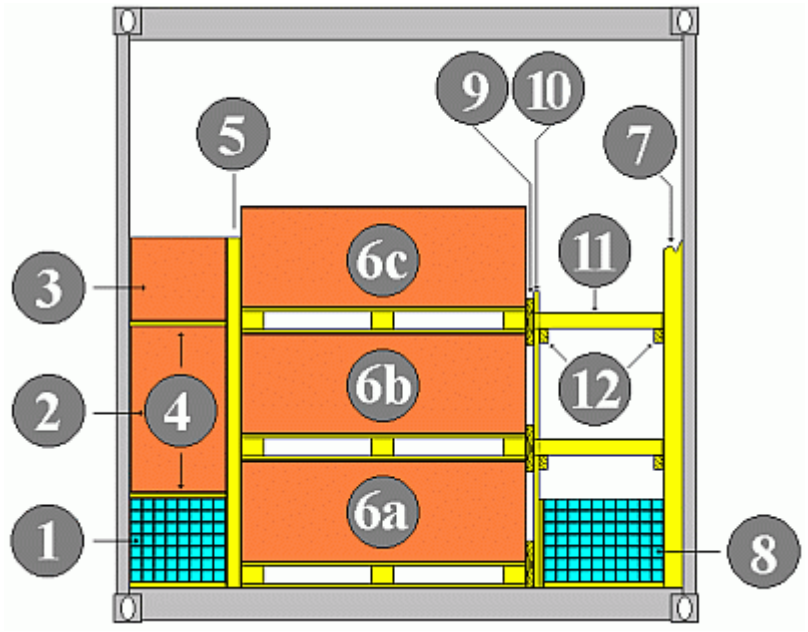


Inadequate "securing" with squared lumber members

An utter waste of materials. Just what is this "securing" intended to achieve? The wooden members (1) and (2) have just been inserted in the pallet-like package bases and fastened in place with nails.

The wooden members are exposing the container side wall to point loads at the ends (3) because the crosspieces are resting on the uprights.

Depending on the mass and nature of the cargo, appropriate securing might have looked like this:



Proper securing

The steel profiles (1) are stowed tightly to the left-hand container wall. Packages (2) and (3) are stacked on top of the profiles using interlayer dunnage (4) in the form of beams, boards or sheets. Squared lumber uprights (5) are placed in an appropriate number against this cargo and packages (6a), (6b) and (6c) are packed against these uprights. Squared lumber uprights (7) are set against the right-hand container side wall, the height of the uprights being determined by the forces to be absorbed. If severe stresses are anticipated, they are taken up to the container's top side rail. A lattice of boards (9) and (10) is fabricated (outside the container) and inserted into the gap between packages (6) and (8). The large space between the lattice and squared lumber uprights (7) is filled with cross braces (11). Lengthwise, nailed battens (12) or boards increase the stability of the bracing.

5.3.11 General cargo in open-top containers

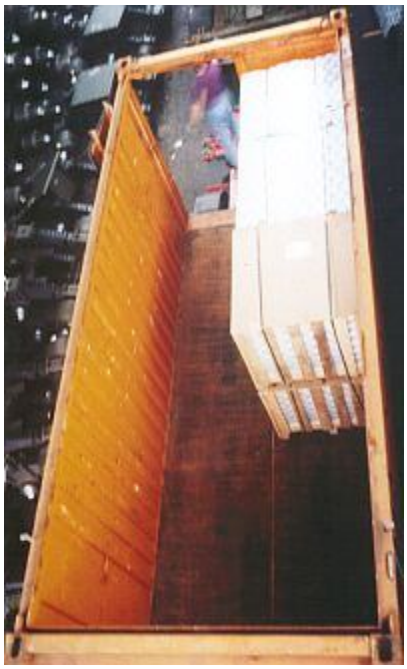
Example 1



Unsecured general cargo in a 20' open-top container

If this container is carried by sea in this state, damage is inevitable.

Example 2





Packing a 20' hard-top open-top container

A positive feature is that a secure cargo end face towards the doors is being constructed. Setting down the larger packages in the door area saves considerable labor. In the front part, the dimensions of the packages are such that some gaps are produced. These were filled in with smaller items of cargo, wooden members, old pallets etc. in such a manner that, overall, a compact stow was achieved. There is no risk of damage to individual items of cargo.



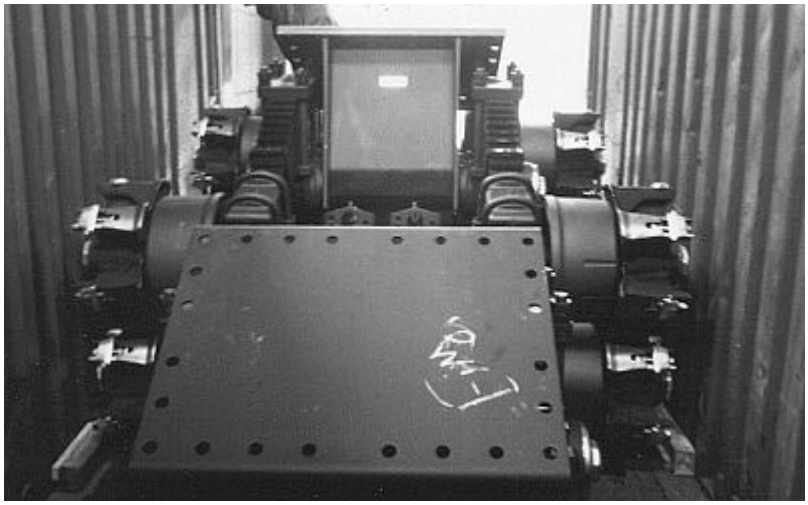
Final work on a 20'
hard-top open-top container

Example 3



Packing the first truck axles in the container

In the foreground of the picture, there is a roll of friction-enhancing material, which has a very high coefficient of sliding friction and is laid between layers. This thin material is not suitable for laying under cargo. Strips of friction-enhancing (FE) mats at least 10 mm in thickness are necessary under the lower layer of axles.



Upper part of unsecured stack of truck axles

Some wooden members used to fix the lower layers are visible underneath. In the upper layers, the friction-enhancing material laid between the layers is expected to provide sufficient stability. This otherwise inadequately secured stack will not withstand extended exposure to bad weather at sea.

Packing the axles centrally, as shown, is unfavorable for securing as the gaps left on both sides must be filled. Alternatively, the entire cargo block could be lashed.

One efficient securing method is to leave gaps towards the container side walls alternately to the left and to the right. In this way, only one gap need be filled in each case.

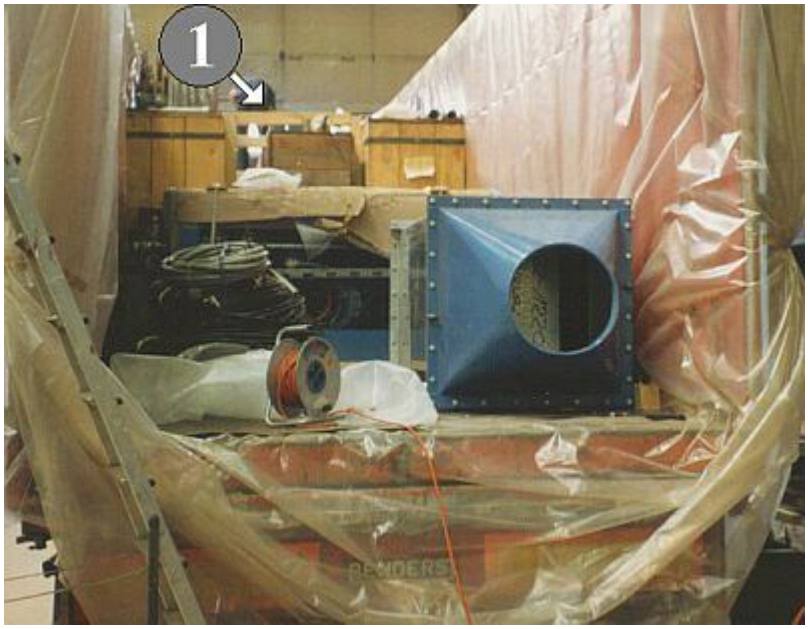
The sensitive axle heads must be protected. They are in each case packed tightly against the container wall on one side, while the gaps left on the other side must be filled with lumber, airbags or the like.

Example 4: Plant parts in a 20' open-top container

In order to provide the plant parts with protection from climatic conditions, the entire container is being lined with 200 µm gage polypropylene film. 200 µm corresponds to a thickness of 0.2 mm.



Lining a container with polypropylene (PP) film



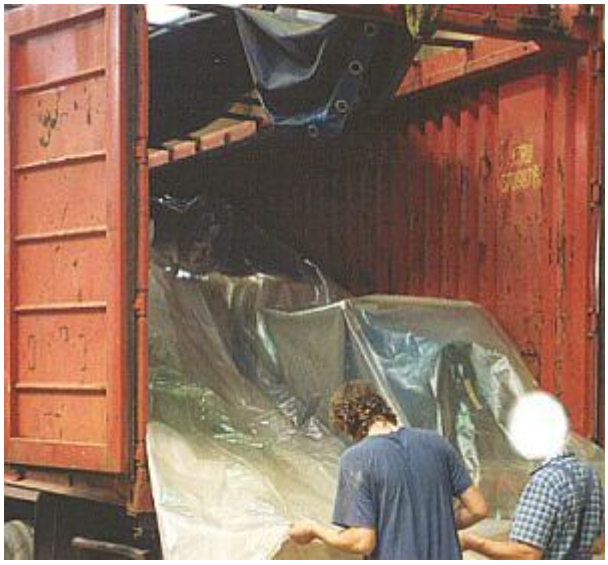
View into the partially packed container

The two wooden cases in the front part of the container are secured with wooden cross bracing. The vertical wooden members could have been dispensed with if wooden members fastened under a board had been suspended in the gap from above.



Wooden securing member which can be suspended between case lids

The problem with the planned measures to provide protection from climatic conditions is that desiccant would have to be placed inside the as yet unsealed PP package in quantities sufficient to absorb not only the moisture present in the package but also any water vapor which diffuses in through the film. Lumber, such as the case sides and wooden securing members, normally contains a very large amount of moisture, unless kiln dry lumber is used. The same applies to other packaging containers and packaging aids such as cardboard, paper etc. It is not very likely that the necessary quantity of desiccant will be calculated correctly and actually placed inside the package. The manner in which the other items of cargo have been arranged in the rear part of the container would lead one to suspect that the cargo will not be sufficiently tightly packed.



Heat sealing the protective film



Packing operations in an open-top container

This confirms the suspicion - the cargo is not sufficiently tightly packed and secured.

The container could only be considered to be packed in a manner fit for transport once the gaps still present have been completely filled and the heavy parts separately secured.

5.3.12 Kitchens in standard containers

Careless packing in the container considerably increases transport risks. Damage is inevitable if the ships carrying the containers encounter severe weather.

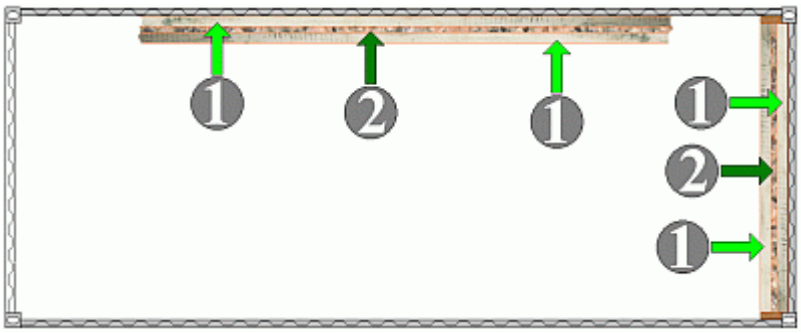


Careless packing of kitchens and kitchen accessories

Reference is made in connection with this photograph to the "General notes on packing box containers", "General cargo in box containers" and "Basic stowage methods". Packing without gaps is intended to deprive packages of the ability to move even slightly during container transport. Deciding how to pack fragile components, such as granite work surfaces or kitchen units with glass panels, is not simple. Such components are best packed lengthwise and on edge for road and rail transport and for athwartships stowage of the container on board ship. For standard transport on board ship in fore and aft stowage, they should preferably be packed crosswise and on edge.

This latter variant is only feasible for relatively short components whose length does not exceed the width or height of the container. Longer work surfaces inevitably have to packed lengthwise and on edge.

The work surfaces must be packed so compactly that they have absolutely no freedom of movement. Cushioning materials must not be used as the continual motion of the ship and the consequent compaction of the material will create space for the cargo to move about in, so greatly promoting the risk of damage.



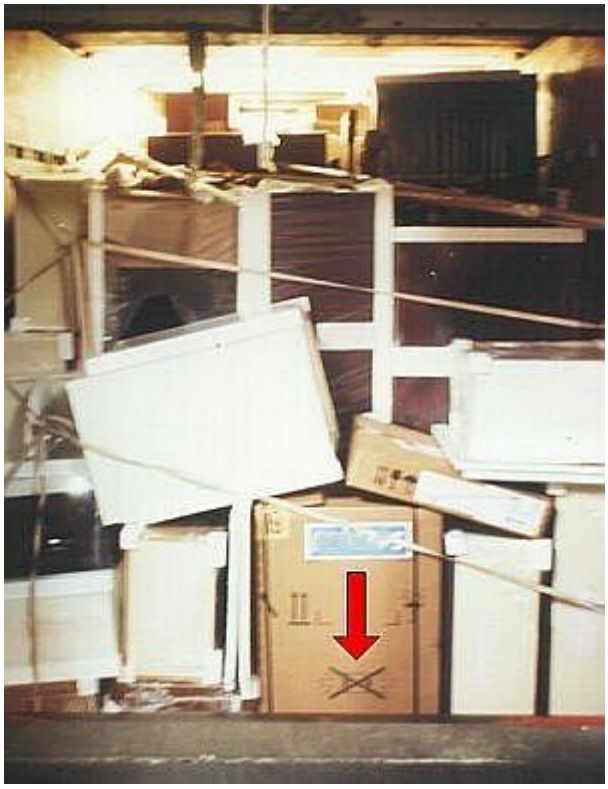
Rigid packing of granite slabs

Sufficiently rigid wooden members (1) protect the vertically packed granite slabs (2) from breakage. Another packing option is to use A-frames.



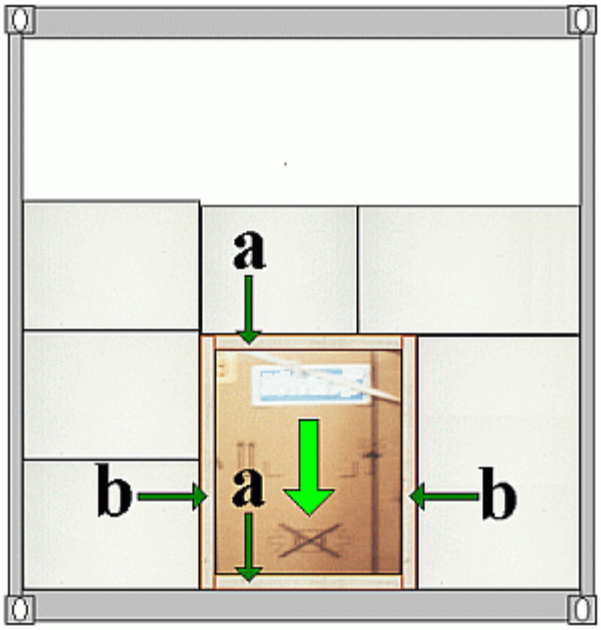
Granite slabs on A-frames

The granite slabs must be secured on the A-frames with a sufficient quantity of strapping. The frames themselves must either be blocked, lashed or stowed so compactly by other items of cargo that they are prevented from moving at all in the container.



Incorrect packing of electrical goods

Any packages containing electrical items must be packed in such a way that they are not exposed to harmful pressure: It is essential to comply with any printed handling symbols, in this case: protect from lateral stresses. If required, the items of cargo must be protected with inserted bracing.



Protecting a pressure-sensitive package with

wooden bracing

Lateral forces are kept away from the sensitive package by means of horizontal wooden members (a) in conjunction with wooden uprights (b).



Negligent and careless packing increases the risk of damage.

Consistently neat and tidy packing is an essential prerequisite. Damage is inevitable when cargo is packed as shown. "Securing" the packages in the door area with webbing belts is useless. If an interlocked stow cannot be created, wooden lattices or similarly effective methods must be used to provide a secure cargo end face.



Inadequate stowage and securing of kitchen furniture in a container

Depending on the destination, care may have to taken to ensure that cardboard packaging and the steel container walls do not come into direct contact. If cardboard packaging containers come into contact with condensation, they will soften and the contents will be damaged. In this case too, the negligent packing and inadequate cargo securing merit the severest criticism.