PRACTICE HANDBOOK

Loading and Securing

Loading and Securing on commercial vehicles for goods transport

Volume 2: Securing Loads in Combined Freight Transport Road/Rail

Bundesverband Güterkraftverkehr Logistik und Entsorgung (BGL) e.V.

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BGL/BG Verkehr Practice Handbook Loading and Securing

Volume 2

Securing Loads in Combined Freight Transport Road/Rail

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Up to now various volumes have been published in the series of publications „Practice Handbook Loading and Securing“. A current overview can be found on the BGL homepage:

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1 Combined Freight Transport and its Special Aspects

1.1 Types of Transport and Differences

Combined Freight Transport is a type of freight transport in which different carriers at all times organize and carry out the transfer of the transport object (loads, large loading units) using different means of transport but are regulated by a single transport contract. Combined freight transports can be carried out using all types of carriers such as road and rail transport, barges, sea and air transport.

Combined Freight Transport (CFT) is a combined goods transport with large loading units (containers, swap bodies, semi-trailers) or entire vehicle units.

Combined Freight Transport Road/Rail (CFT Road/Rail) is a combined goods transport using road and rail vehicles on land.

The most important types of combined freight transport road/rail are:

- **Piggyback transport with large loading units**

Large loading units: containers, swap bodies, semi-trailers

Road vehicles: special trucks, trailers and semi-trailers for the transport of containers and swap bodies

Rail vehicles: flat wagons for containers and swap bodies; pocket wagons for semi-trailers

Handling equipment: cranes; forklifts for the handling of empty containers or for special constructions also for the handling of filled containers; truck unloading equipment for containers

Piggyback transport with large loading units is the most common kind of combined freight transport road/rail and can be found almost everywhere in Europe.

- **"Rolling Road"**

Complete road vehicles drive onto special flat wagons of the railway on their own power. The "rolling road" is only possible with purposely-built lines. The road vehicles must fit into the structure gauge of the trains.

- **Bimodal Transport**

Special semi-trailers can be driven on the road by trucks as well as between bogies running on the rails. The semi-trailers must assume certain properties of the freight wagons, e.g. carry electrical and braking lines and possess sufficient tensile strength and impact resistance. Freight train stations must be equipped for bimodal transport.

The by far longest distance of CFT road/rail is carried out by rail transport (so-called main run by train). The forerun and on-carriage of the main run by train is carried out by road transport (Fig. 1.1). In this case the maximum permissable total weight for trailer and semi-trailer trucks with more than four axles is 44 tons [4].

The present volume of the BGL/BG Verkehr practice handbook „Loading and Securing“ specifically describes the securing of loads with large loading units in combined freight transports road/rail.

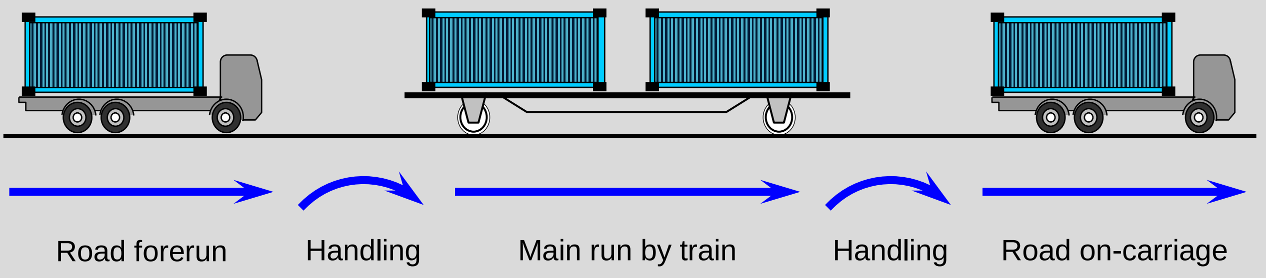


Fig. 1.1: Traffic flow of combined freight transports road/rail

1.2 Special Aspects of Load Securing

The special aspects of load securing for combined freight transport road/rail relative to simple road freight transport is mainly based on the different acceleration coefficients that apply for combined freight transport road/rail (Fig. 1.2).

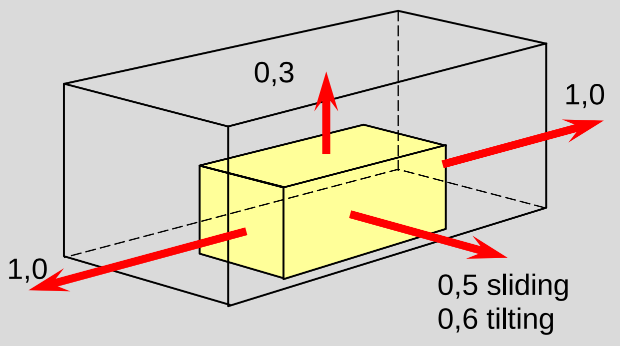


Fig. 1.2: Acceleration coefficients for combined freight transport road/rail [DIN EN 12195-1:2011] [VDI 2700-7:2014]

Sometimes a downwards value of 1,0 g is indicated. However, this is not a dynamic acceleration coefficient, but rather the weight force itself, which anyway basically acts straight downwards. The occasionally mentioned value of 0,3 downwards indeed denotes a dynamic acceleration coefficient, but is not of importance as it reinforces (for a short time) the weight force, as a result no additional securing measure is required.

If road vehicles are foreseen for a transfer onto a "rolling road" or a bimodal transport, then the loads are to be secured according to the same rules as for large loading units in piggyback transport.

Regulations may restrict or exclude certain procedures for securing loads. Thus an exchange of pallets is not possible in all European countries; empty pallets used as gap fillers would have to be returned to such countries. Certain countries also restrict the use of wood, for example, due to phytosanitary regulations [3].

In this context it also must be checked, whether or not the transport must be carried out according to the requirements of the international CTU Code [5]. This is particularly applicable for transports by sea of dangerous goods that must be labelled on the basis of the IMDG code or the German Dangerous Goods Directive for Sea Transports (GGVSee) [6]. From 2018 onwards the CTU Code has to be implemented mandatory as a part of the legal field of the IMDG Code. Furthermore the CTU Code is only a recommendation and is not binding according to international law. National regulations are not affected by the requirements of the CTU Code and furthermore possess priority.

Prior to shipment it must be determined, which types of transport a load must undergo in order to properly secure it during the entire transport route.

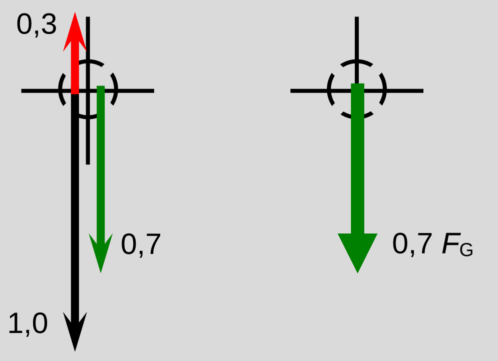
Large loading units (containers, swap bodies, semi-trailers) must be secured on the vehicles according to the respective valid requirements.

1.3 Taking into Consideration Vertical Accelerations

For simple road freight transport vertical accelerations during transport are not taken into consideration in the calculations of load securing measures. However, the rule exists that loads must nonetheless be secured against possible shifting and turning as a result of vertical accelerations [VDI 2700:2004-11] [1, sections 3.1, 5.5.2, 8.10].

However, an upwards directed vertical acceleration coefficient of 0.3 must be taken into consideration for combined freight transports road/rail (Fig.1.2), which generates an upwards-acting movement force of 30% of the weight force. Consequently, only 70% of the weight force may be assumed to be acting downwards, if frictional forces are to be calculated as holding forces against sliding or the static moments as holding forces against tilting (Fig. 1.3).

This has implications on the dimensioning of load securings. Three examples below illustrate how securing loads is to be calculated for combined freight transports road/rail.



a) Vertical acceleration coefficients   b) Reduced weight force

Fig.1.3: Calculational consideration of an upwards acceleration coefficient

Example 1: A load is to be secured against sliding sideways through frictional lashings

Given:	Weight	m	2.400 kg	Acceleration coefficient	c	0,5
	Gravitational acceleration	g	9,81 m/s²	Transfer factor	k	1,8
					(k	2,0)
	Movement force	F_a		Lashing angle	α	75°
	Weight force	F_G		sin α		0,966
	Standard tension force	S_{TF} =	250 daN 2.500 N	Friction factor	μ	0,3

Wanted: Number of web lashings n

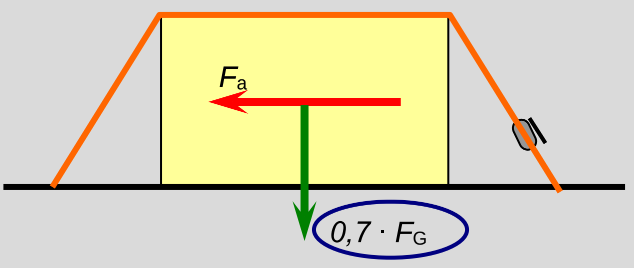
Generally valid equation for the calculation of the number of lashing straps [VDI 2700-2:2014], [1, section 5.5.3, Eq. 5.9]:

$$n \geq \frac{m \cdot g}{k \cdot S_{TF}} \cdot \frac{1}{\sin\alpha} \cdot \left(\frac{c-\mu}{\mu}\right)$$

Adjusted for combined freight transports road/rail:

$$n \geq \frac{m \cdot g}{k \cdot S_{TF}} \cdot \frac{1}{\sin\alpha} \cdot \left(\frac{c - 0{,}7 \cdot \mu}{\mu}\right)$$

$$n \geq \frac{2.400 \cdot 9{,}81}{1{,}8 \cdot 2.500} \cdot \frac{1}{0{,}966} \cdot \left(\frac{0{,}5 - 0{,}7 \cdot 0{,}3}{0{,}3}\right)$$



***n* ≥ 5,23 ≈ 6 web lashings (*k* = 1,8)**

(*n* ≥ 4,71 ≈ 5 web lashings (*k* = 2,0))

Example 2: A load resting on a friction-enhanced mat should be kept positively locked away from the front wall.

Given:	Weight	m	20.000 kg	Frictional force	F_R	
	Gravitational acceleration	g	9,81 m/s²	Weight force	F_G	
				Acceleration coefficient	c	1,0
	Movement force	F_a		Friction factor (Friction-enhanced mat)	μ	0,6

Wanted: Required holding force F_H of end wall

Generally accepted equation for the calculation of the holding force [1, section 3.6.2, Eq. 3.25]:

$$F_H = m \cdot g \cdot (c - \mu)$$

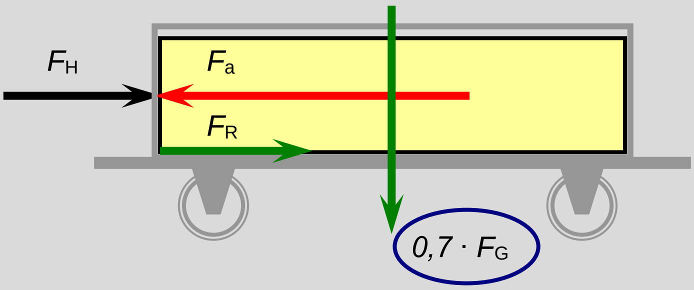
Adjusted for CFT road/rail:

$$F_H = m \cdot g \cdot (c - 0{,}7 \cdot \mu)$$

$$F_H = 20.000 \cdot 9{,}81 \cdot (1 - 0{,}7 \cdot 0{,}6)$$

$$\mathbf{F_H = 113.796\ N \approx 11.400\ daN}$$

For comparison with the actual holding force (stability) of front wall see [1, section. 5.33].



Example 3: A load is to be secured in the longitudinal direction of the vehicle using diagonal lashes

Given:	Weight	m	8.000 kg	Acceleration coefficient	c	1,0
	Gravitational acceleration	g	9,81 m/s²	Friction factor	μ	0,2
	Weight force	F_G				
	Vertical angle	α	30°	$\sin \alpha = 0{,}5$	$\cos \alpha = 0{,}87$	
	Horizontal angle	β	10°	$\sin \beta = 0{,}17$	$\cos \beta = 0{,}98$	

Wanted: Lashing force LC of lashings

Generally accepted equation for the calculation of the lashing force [1, section 5.6.5, Eq. 5.25]:

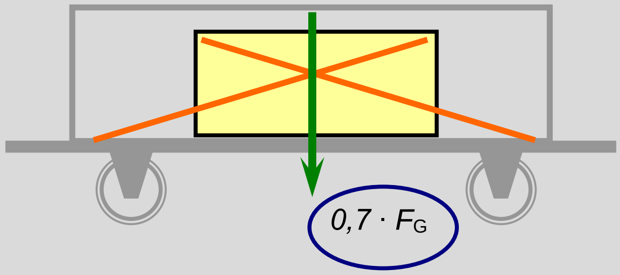
$$LC = \frac{m \cdot g \cdot (c - \mu)}{2 \cdot (\mu \cdot \sin\alpha + \cos\alpha \cdot \cos\beta)}$$

Adjusted for CFT road/rail:

$$LC = \frac{m \cdot g \cdot (c - 0{,}7 \cdot \mu)}{2 \cdot (\mu \cdot \sin\alpha + \cos\alpha \cdot \cos\beta)}$$

$$LC = \frac{8.000 \cdot 9{,}81 \cdot (1 - 0{,}7 \cdot 0{,}2)}{2 \cdot (0{,}2 \cdot 0{,}5 + 0{,}87 \cdot 0{,}98)}$$

$$\mathbf{LC = 35.426\ N \approx 3.540\ daN}$$



1.4 Liabilities for Damages to Goods in Combined Freight Transport Road/Rail

The responsibility for **securing loads** in CFT road/rail is basically the same as in road freight transport, since combined transports road/rail generally start with the road forerun. The essential difference between both modes of transport, however, consists in the liability for **damages to goods.**

Through the transport law reform act German law was given a modern version of contracts of carriage concerning the carriage of goods by various means of transport, the so-called multimodal transport (combined transport).

The terms „combined transport/intermodal transport“ or „combined freight transport (CFT)“ are transport terms, whereas „multimodal transport“ denotes a traffic law term. An international agreement, which regulates multimodal contracts as such, is not yet in force.

Principle § 452 Commercial Code

According to § 452 Commercial Code a multimodal contract is a contract of carriage, which involves the carriage of goods based on a **standardised** contract of carriage with various modes of transport, provided that separate contracts were concluded for at least two of the legs and different legal regulations are to be applied. This is not the case for national CFT since the transport law reform act. For the modes of transport - road, railway and barge vessels - §§ 407ff Commercial Code is directly applicable for the national transport law. This is only possible for international transports. The law considers a multimodal contract to be a subcase of the general contract of carriage, for which only a few special provisions apply. As a result it is regulated in the third subsection of the section concerning freight business with only five regulations. The practical meaning of the regulation lies above all in the right concerning liability for damaged goods.

If the carriage of goods is carried out using different modes of transport on the basis of numerous relevant single carriage contracts, then the relevant transport legislation for the mode of transport used is to be applied to each of these single carriage contracts.

The provisions of a multimodal contract are valid – contrary to the general provisions of the first subsection of the carriage contract – even if the carriage includes a carriage by sea. They are valid even if one of the routes underlies foreign legislation or an international convention. The basic principle of the regulation is that the general freight law §§ 407 – 450 and § 452 is valid for all of these combinations. It is assumed that German law is to be applied to the entire contract.

Applicability of the Carriage Contract Rules

The referral to the general freight law implies that the contract as a whole complies with it. Mutual rights and obligations of the contracting parties – for example, concerning payment obligations, right to give instructions, circumstances preventing carriage, transport documents, obligation to cooperate and liability of the shipper – are defined by §§ 407 ff HGB. These provisions, however, are designed by law to be entirely dispositive and thus can be modified by general terms and conditions. Of particular importance is that the requirements for the bill of lading (§ 444 ff HGB) were also referred to, which gives the through bill of lading of multimodal contracts a clear legal framework that, until recently, was missing under German law.

Liability provisions

The focus of practical importance lies on the liability for damages to goods and delays. The liability of the carrier, also in multimodal contracts, is basically determined as a result of the reference to § 452 Commercial Code by common freight law with a far-reaching custodial liability, that is only excluded for certain statutory reasons (§ 425 ff Commercial Code). It is limited to 8,33 SDR (special drawing rights) per kg. Applicable are also the regulations on the liability limits for claims arising from breaches of contract and tort (§§ 433 ff Commercial Code) as well as – of practical importance – the joint liability of the actual carrier (§ 437 Commercial Code).

Even for multimodal contracts the liability for damages to goods and losses due to delays cannot be categorically waived by general terms and conditions (GT&C) (§§ 449, 452d); here as well on the other hand an exception to the liability limitation amount is valid, which can also be altered by GT&C to a range from 2 - 40 SDR (§ 449 (2) line 2) – subject, however, to a judicial review under German law on General Terms and Conditions.

Liability for known place of damage

International conventions can be applied to partial routes and may not be ignored without breaching obligations under international law, if their conditions for application – in particular therefore the occurrence of damages on the relevant regulated routes – are evident. On the other hand foreign transport rights to some extent exhibit special features compared to the liability indicated by general freight law, whose ignorance does not necessarily lie in the interest of the contracting parties.

Hence, once it has been established on which part of the route the damage occurred, § 450a Commercial Code allows each of the contracting parties, – who have to prove when the damage on this route took place – to rely on the more advantageous partial-route rights (§ 452a). In doing so the law follows an internationally widely-observed and as "network-principle" referred to liability principle for multimodal contracts: standard liability in case place of damage is unknown, but the possibility of recourse to partial-route rights for known places of damage.

The new law created by the transport law reform act restricts, however, the necessity to fall back on the rights of the partial route for known places of damage, insofar as this is internationally allowable. It assumes that the liability according to standard liability (freight law) is also fundamentally appropriate for multimodal transports. That is why it allows liability according to §§ 425 ff to be agreed upon also for partial routes that per se underly a different law: in practice this is the same as excluding recourse on the rights of partial-routes; however, since the liability sum can be modified within a "corridor" by the GT&C, a different amount can be agreed upon for standard liability and the rights of partial routes. This agreement is only subject to a limit for partial routes that necessarily underly an international convention (e.g. CMR, CIM, Warsaw Convention, Hague/Visby Rules).

CIM has similar clear rules for the international (pure) transport of goods by train. Their application requires the issuance of an international (train) consignment note. Since such a note is not issued for a multimodal contract – for the entire route – in principle CIM does not hinder deviating agreements. The multimodal freight carrier must look after his own interests by drafting appropriate contract conditions.

Claims and Limitation Period (§ 452b)

The notice of damage to be issued by the receiver or shipper should always comply with the rights of the last partial route. A failure to notify always underlies the effect of the general freight law, i.e. a mere reverse onus.

Should the rights of the last partial route impose lower demands on the form of the claim than § 438 Commercial Code (written form for complaint after delivery), then their observance should suffice.

More difficult is the issue of the limitation of a claim. Without doubt this is a part of every liability settlement and as a result underlies the network principle. As it can occur that only very late - perhaps during ligitation - it is determined where the damage originated and which unimodal liability settlement is to be applied, it may be that the applicable statute of limitation has already expired or indeed has been unreasonably shortened. For this reason the delivery of the goods after completion of this partial route is not decisive for the start of the statute of limitations in applying the limitations regulation of a partial route law, but rather the final delivery to the receiver. Furthermore it is valid that the statute of limitations does not apply according to the partial-route law. The receiver can always rely on this guideline, even if subsequently a partial-route law turns out to be applicable. The statute of limitations is one year starting from the day of delivery to the receiver (§ 439 Commercial Code).

Summary

1. The multimodal contract is regulated in §§ 452 to 452d as a special version of the general contract of carriage with several additional provisions.

2. The general conditions of the freight contract (§§ 407ff) are to be applied to the multimodal contract. This is also generally valid for the liability for damages to goods and for delays (§ 452).

3. The liability requirements such as those of general freight law – except for the liability amounts of around 2 to 40 SDR – can only be contractually modified by “individually negotiated agreements” (§ 459) not by GT&C.

4. If it can be determined on which part of the route the damage occurred, then each of the contracting parties can – who have to prove that the damage occurred on this route – insist on the for them more advantageous partial-route rights (§ 452a).

5. A recourse on the partial–route rights cannot be contractually ruled out through the GT&C, however it can be agreed upon – also through the GT&C – that the freight law is valid for partial routes §§ 425ff. Such an agreement is only then not valid if an international convention is necessarily to be applied to the partial route.

CMR

The most well-known and in practice most significant special regulation is that in Art. 2 CMR. It regulates the piggyback or Ro/Ro transport in the framework of an international contract for carriage of goods by road, in which – without reloading the goods themselves – the truck loaded with the goods is transported on a part of the transport route using a different mode of transport. In this case the liability regime CMR is valid for the road carrier. Only if other conditions prevail is the liability of the road carrier subjected to the requirements valid for the other mode of transport, if 1. the damage was caused by an event that could only have occurred during and due to the transport by the other mode of transport, and if it 2. concerns liability requirements that are applied to the other mode of transport and are mandatory.

FIATA Bill of Lading for Multimodal Transports (FBL)

FBL are GT&C drawn up by the international freight forwarders association (FIATA) for multimodal transports.

In practice the FBL are above all applied in those cases, in which **transports by sea** are included in the transport chain. The FBL differentiates between known and unknown place of damage. For known places of damage the respective partial-route law comes into effect. If neither international nor mandatory national liability requirements exist for these partial routes, then the FBL does not refer to the appropriate dispositive partial route law in line with the network system, but regulates a standard liability, that likewise is foreseen for the case of an unknown place of damage.

2 Containers

2.1 Loading and Stowing a Container

2.1.1 Construction Types and Technical Data of Containers

Containers are stackable “boxes” that can be repeatedly used for the transport, handling and storage of all kinds of goods, especially of single loads. Containers are suitable for transporting by different modes of transport (road and rail vehicles, barges and seagoing vessels) without reloading the goods. They must be easily loaded and emptied [DIN ISO 668].

If containers are used in international transport, they must be tested (time limit: five years) according to CSC (Convention for Safe Containers).

The most important **construction types** of containers are [according to DIN EN ISO 6346]:

- General cargo containers with one or two front wall doors (Fig. 2.1), with one or more side wall doors (standard container); with or without ventilation.
- General cargo containers with opening roof (open-top container, cover with fixed roof or tarpaulin, Fig. 2.2).
- Platform without superstructures, with fixed or hinged front walls (flat, Fig. 2.3).
- Insulated container, refrigerated container (with individual refrigeration unit).
- General cargo container.
- Tank container.

In addition special types exist that are constructed as described in the UIC leaflet 592.

Fig. 2.1: General cargo-standard container with front wall door

Fig. 2.2: Open-top container with tarpaulin

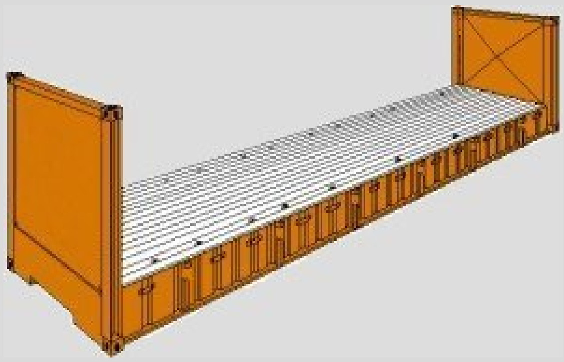


Fig. 2.3: Flat with fixed front walls

Table 2.1: Selected technical data for standard general cargo containers [DIN ISO 668]

Size (designation based on external length)	Internal dimensions in mm			Gross weight in kg	Loading weight in kg	Volume in m³
	Length	Width	Height			
20-foot container	≈ 5.870	min. 2.330	≈ 2.350	24.000	≈ 21.700	≈ 33
40-foot container	≈ 12.000	min. 2.330	≈ 2.350	30.480	≈ 26.700	≈ 68

The **technical data** of containers differ slightly depending on the manufacturer and the construction material. This may need to be considered in the stowage plan. Containers of 20 and 40 foot length are most frequently used. A selection of technical data for general cargo containers is listed in Table 2.1.

2.1.2 Load-carrying Capacity of Container Floor

It must be assured that the weight of the load is distributed as **evenly** as possible over the floor area and that **point loads** are **avoided**. A point load arises when a heavy weight lies on a small surface, e.g. when passed by forklifts.

In order not to damage the container floor, **limits on the load on the container floor** are to be observed during forklift usage (Table 2.2). Thus, forklifts with a load-carrying capacity up to approximately 2,5 t should be used to load containers.

Table 2.2: Permissible loads for containers using forklifts [ISO 1496-1]

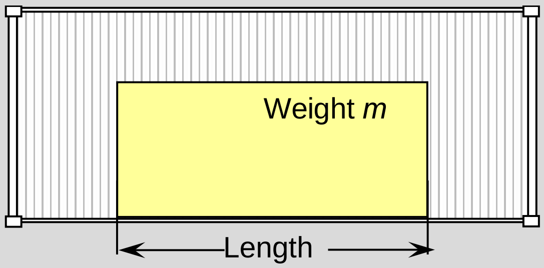
Type of load	Limit
Axle load	max. 5.460 kg
Wheel load	max. 2.730 kg
Wheel contact area	min. 142 cm²
Wheel width	approx. 180 mm
Track width	approx. 760 mm

The **line load** is the weight of the load divided by the length of the floor area that the load covers (Fig. 2.4).

Permissible line load according to [7]

- In 20-foot container: 4,5 t/m.
- In 40-foot-container: 3,0 t/m.

Several sample calculations may clarify the determination of the line load:



$$\text{Line load} = \frac{\text{Weight of goods}}{\text{Length of goods}}$$

Fig. 2.4: Definition of line load in a container

Example 1:

Weight of load: 5,4 t

Length of load: 3,2 m

Line load: 5,4: 3,2 = 1,69 t/m

Example 2:

Weight of load: 11,7 t

Permissible line load: 4,5 t/m

Needed contact length of load:
11,7: 4,5 = 2,6 m

Example 3:

Weight of load: 11,7 t

Permissible line load: 3,0 t/m

Needed contact length of load:
11,7: 3,0 = 3,9 m

Example 4:

Weight of load: 13,0 t

Length of load: 4,0 m

Line load: 13,0: 4,0 = 3,25 t/m

This load is permitted to be transported in 20-foot but not in a 40-foot container. A remedy if a 40-foot container is to be used: extension of the contact area (see following section).

2.1.3 Load Distribution over Container Floor

The floor cross beams are the supporting components of the floor construction. They take over the vertical forces of the load from the container floor and divert them to the side beams. In order not to overload the floor cross beams, the floor load from the load – as just discussed - is limited to a permissible line load.

If a load exceeds the permissible load line, one can place square timbers in the longitudinal direction of the container and thereby distribute the vertical forces over a larger number of floor cross beams than are actually covered by the load (Fig. 2.5).

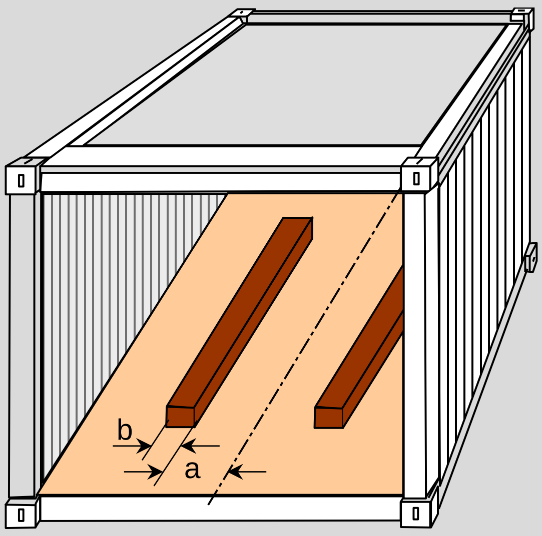


Fig. 2.5: Square timbers in the longitudinal direction of the container

In order that the load can be set down safely without sagging, one must possibly provide cross pieces (Fig. 2.6).

The pieces of timber must be connected to one another and the container such that they cannot shift. Minimum dimensions of the square timber are shown in Table 2.3. The height of the square timber should be about 80% of the width.

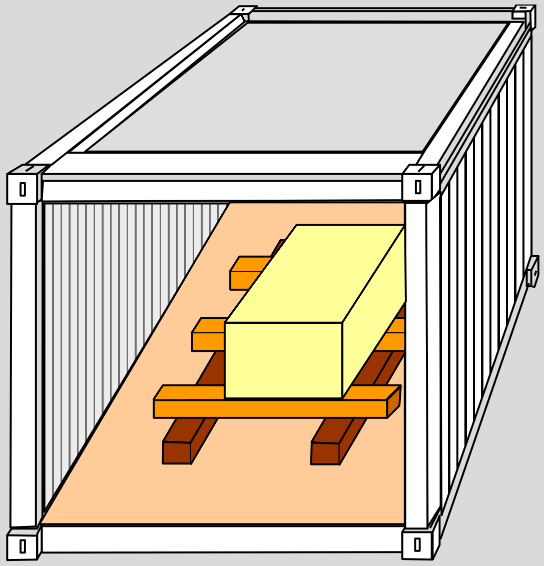


Fig. 2.6: Square timbers in longitudinal and transverse directions in the container

Note: *The diagram does not show the completely required securing of the load!*

The minimum length of underlaid square timber is to be chosen so that the permissible line load is maintained. According to section 2.1.2 it should be e.g.:

- In ***Example 2*:** 2,6 m.
- In ***Example 3*:** 3,9 m.

Table 2.3: Minimum dimensions of square timber under load in container according to [7]

Container length	20-foot-container	40-foot-container
Minimum width of square timber (dimension b in Fig. 2.5)	100 mm	150 mm
Minimum distance of the square timbers from the longitudinal centre line of the container (dimension a in Fig. 2.5)	400 mm	400 mm

2.1.4 Rearrangement and Loading of Containers

To **rearrange** containers between road and rail vehicles one mainly uses the following handling equipment:

- **Cranes,** mainly full portal cranes with adjustable arms and rotatable spreaders as special slings for containers.
- **Forklift trucks,** such as straddle carriers, portal stackers, heavy load stackers, reach stackers (forklifts with variable range), front loaders (for empty containers, load-carrying capacity up to approx. 6,3t).

The container is to be properly secured to the vehicle after setting it down.

In order to **load (load and unload)** the containers with general cargo the containers remain either on the road or rail vehicle or are placed on the ground. They are attended to using or not using a ramp. In order to load the container, the following serve as handling devices:

- **Cranes** for containers with opening roofs, for large, heavy single loads e.g. machines, boxes, plant components, pipes.
- **Forklifts, pallet trucks** for containers with doors in the front and side walls, for smaller single loads, e.g. palleted and packaged goods, drums, bales, among other things often with special accessory equipment.

The notes with regards to **work safety** [1, section 4.2] are analogously valid for the setting down of containers onto vehicles as well as for the completion of the loading work.

2.1.5 Inspection of Containers

Prior to the start of loading an available container should be examined with regards to the following points:

- No visible external damages (cracks, holes, deformations).
- Corner posts and other handling equipment undamaged.
- Outer walls free of old labels.
- Doors, removable fixed roof and closures passable, seals intact.
- Tarpaulins on containers that can be opened on the top undamaged and watertight.
- Floor undamaged; nails, blocks, fill material similarly removed from previous securing of loads.
- Elements for securing loads complete and in working order.
- Interior empty, clean, dry and odourless.

2.1.6 Arrangement of Loads in Containers

Prior to starting the loading work it is recommended to record the internal dimensions of the container and draw up a true-to-scale stowage plan. For the structural stability of the container on the vehicles as well as the safe handling the centered arrangement of the load is of importance.

In general the following rules apply for the arrangement of the load:

- The loading space is to be loaded as uniformly as possible.
- The centre of gravity should lie in the middle of the longitudinal and lateral directions (Fig. 2.7).

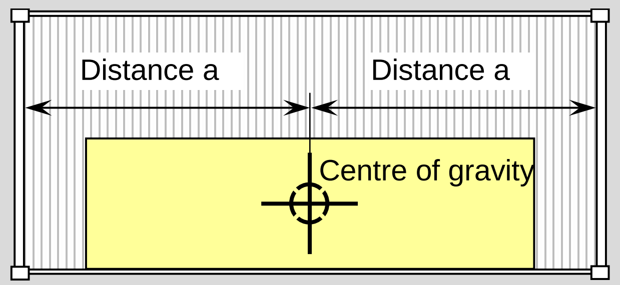


Fig. 2.7: Centered loading of container

- The centre of gravity should lie as low as possible. If the centre of gravity lies
  - more than 60 cm off the middle in longitudinal direction in a 20-foot container,
  - more than 90 cm off the middle in longitudinal direction in a 40-foot container,
  - more than 6 cm off the middle in transverse direction of the container,
  - above half the container height,

  then the position of the centre of gravity is to be marked with the centre of gravity symbol [1, section 3.2.2].

The **stowage rules** already listed in [1, section 4.3.4] are analogously valid for the stowage of single loads in containers.

See [2] and [5] for the stowage of dangerous goods.

2.2 General Conditions for Securing Loads in Containers

2.2.1 Elements for the Securing of Loads in Containers

Elements of load securing are fixed components in the container for the fastening of loads or accessories for securing loads.

Important elements are shown in Fig. 2.8:

- Front and side walls of the closed general cargo containers.
- Corner posts for mounting lashing elements onto lashing points as well as for bracing with square timber.
- Insertable stanchions (on flats) for a tight-fit securing of loads.
- Lashing points (on corner posts, floor and roof side rails) and lashing bars (e.g. welded into the corrugations of the walls) for mounting lashing elements; load-carrying capacity must be disclosed, e.g. 2.000 or 4.000 daN.
- Floor (made from wood, nailable) for anchoring with wooden connectors.

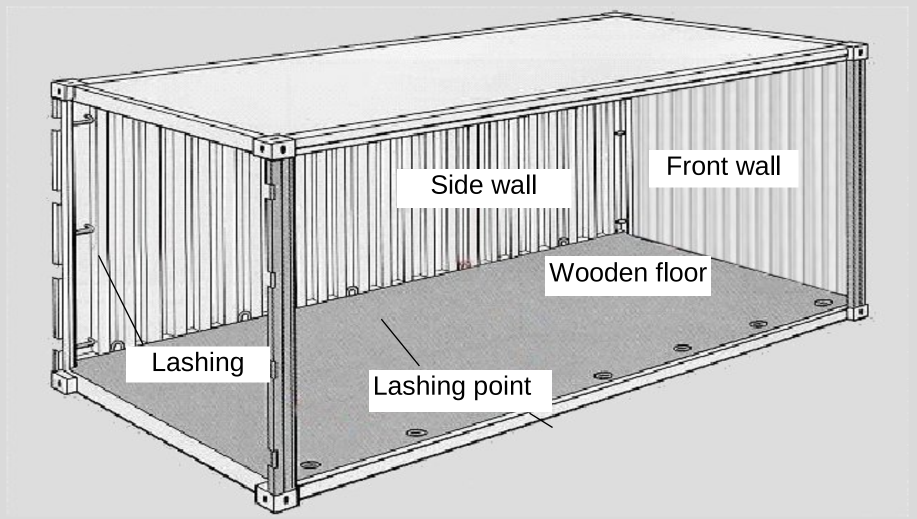


Fig 2.8: Elements for securing of loads in a container

2.2.2 Utilities for the Securing of Loads in Containers

Utilities for the securing of loads are accessories for the fastening of loads onto the loading surface or onto the loading surface boundaries.

Often used utilities for securing loads are:

- Square timber to place underneath load, to brace againgst the side walls, to distribute forces over the loading surface, to fasten onto the loading surface.
- Wedges to secure rollable loads and to fasten onto the loading surface.
- Lashing elements for fastening of loads to lashing points and bars in direct as well as tie-down lashings.
- Wedge angles under lashing elements as protection of loads and lashing elements and to reduce friction at the edges.
- Empty pallets, wooden struts, inflatable air bags, foams, cardboard as spacer and gap filler.
- Partition walls for separating or sectional securing of loads.
- Nets for holding small-sized loads.
- Wooden connectors for joining square timbers and pallets with one another as well as to the loading surface.
- Friction-enhancing mats to increase the friction between the loads and the loading surface.

Utilities for the securing of loads are discussed in detail in [1, section 6].

2.2.3 Load-carrying Capacity of Front and Side Walls of Containers

Front and side walls form the vertical boundaries of the loading space. They serve not only to protect the loads and the environment (especially for dangerous goods) but also ensure a blocking of the load.

The walls are integrated into the framework of the container. They usually consist of corrugated steel sheets. In road transport the side and front walls bear 30 and 40%, respectively, of the payload in the horizontal direction under uniform, extensive loads [UIC-592], (Fig. 2.9).

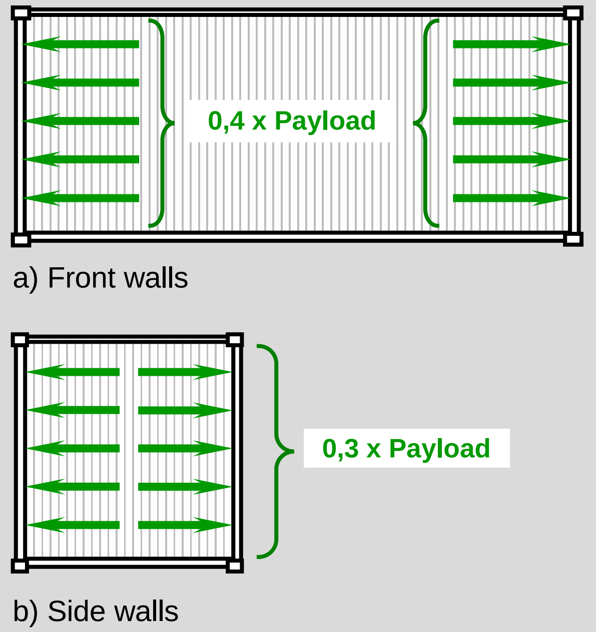


Fig. 2.9: Load-carrying capacity of the walls of containers in road transport [UIC-592], [VDI 2700-7:2014]

At least one of the walls is equipped with a door that is moveable due to hinges. The doors are furnished with seals and robust latches.

The front walls of the flats are occasionally hinged in order to save loading space during empty transports.

Containers according to ISO 1496-1 (ISO large container) or the CSC convention must be built such that the front walls (including doors) and the side walls can bear 40 and 60% of the payload, respectively, in each case under extensive loading.

2.2.4 Protection of Doors

In order for the doors to be easily and safely opened, the load must not braced against the doors.

A bracing against the corner posts as shown in Fig. 2.10 is appropriate for heavy single loads. In addition square timbers can be fitted into the corrugations of the side walls and braced using wedges (Fig. 2.11). In such cases the square timbers should be evenly loaded over their entire lengths.

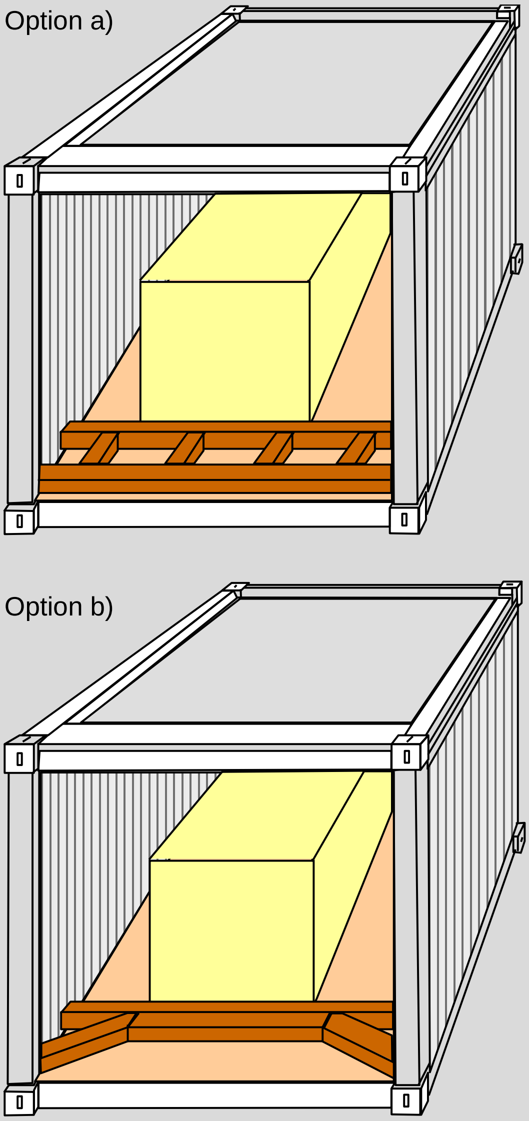


Fig. 2.10: Bracing of load against corner posts
Note: *The diagrams do not completely show the necessary securing of the load !*

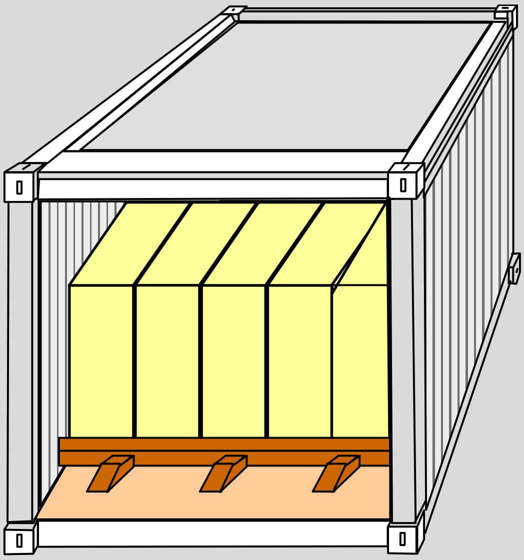


Fig. 2.11: Bracing of load in the corrugations

2.2.5 Rules for Securing Loads

- Loads are not allowed to move within a container! They must be secured against sliding, tilting, rolling and shifting.
- A **tight-fit stowage** of a container closed on all sides is especially suitable and safe.
- If the loading space cannot be completely utilized, the remaining gaps must be filled out. Partial loads may need to be secured block-wise.
- For single loads that do fill out the loading space, the **fastening onto the loading surface** is well suited as containers, in general, possess floors that can be nailed. The fastening to the floor does not prevent tilting!
- When bracing loads using square timber point loads may not arise on the side walls. Doors must be capable of being opened safely. In opening the doors no loading parts are allowed to fall out.
- For heavy loads, liable to tilting, a **direct lashing** is appropriate.

- For **tie-down lashing** it should be taken into consideration that the lashing elements are to be retightened during the course of the transport.
- The laying underneath of friction-enhancing mats significantly relieves loading space boundaries and load securing aids.
- Special rules for the securing of dangerous goods see [2, p. 22-27].

All explanations given in [1, sections 3 and 5] on the physical principles of securing loads as well as the processes of securing loads are also valid. However, the acceleration coefficients for CFT road/rail according to Fig. 1.2 (or according to CTU code [5]) should always be applied instead of the acceleration coefficients used there for mere road transport.

2.3 Securing of Selected Loads in Containers

2.3.1 Palletted Loads in Standard Containers

The dimensions of standard flat pallets (800 mm x 1.200 mm) and the internal dimensions of containers are **not** aligned with one another. As a result loading space is lost, on the one hand, and, on the other hand, a high effort must be undertaken to positively fill out the remaing gaps. Pallets of other dimensions can reduce these drawbacks.

Table 2.4 illustrates how unit loads on the standard flat pallet (800 mm x 1.200 mm) are unfavourable for container shipment. Almost a quarter of the loading surface of a 20-foot container remains unused and huge stowage gaps are created. If a container shipment is nevertheless to be carried out for specific reasons, it should be examined which pallet dimensions for the unit loads to be formed should be taken as a basis.

Non-modular pallets, which fill out up to 95% of the container floor area, have, however, the disadvantage that they deviate from the modular basic dimensions of the packages (600 mm x 400 mm). This in turn means that the pallet base area cannot be completely filled out with packages. The pallet base area that is not filled out again leads to stowage gaps, that likewise should be filled out in order to reach a positive locking of the load.

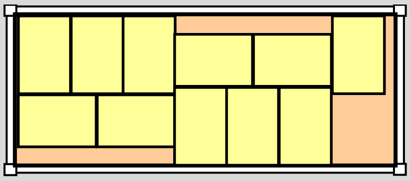
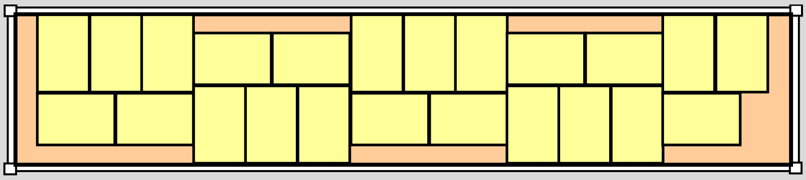
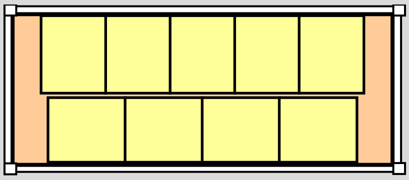
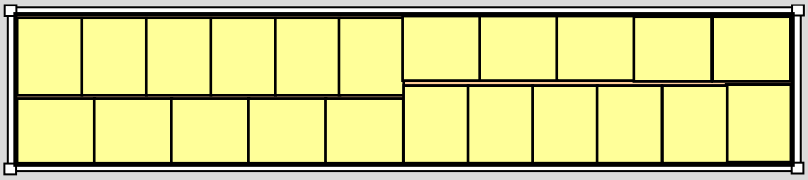
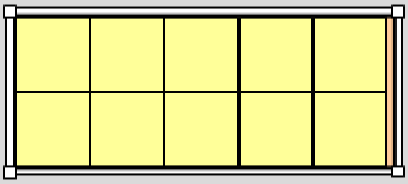
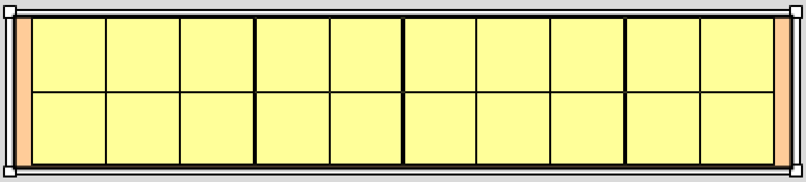
2.3.2 Rectangular Loads

Rectangular loads are most easily secured by stowing in tight fits (blocking). However, this presumes an earlier harmonisation of the dimensions. If stowage gaps cannot be avoided, they must be filled out with gap fillers. Suitable for this purpose are e.g.:

- Empty pallets (check possibilities for exchanging pallets, otherwise a costly return transport is necessary) (Fig. 2.12), bracings (Fig. 2.13), foams, cardboards.
- Inflatable air bags (Fig. 2.14), do not place air bags against doors.
- Fixed partition walls that at the same time can separate different loads from one another (Fig. 2.15).
- Raising of loads (Fig. 2.16).

Placing friction-enhancing mats under loads significantly relieves loading space boundaries and load securing accessories.

Table 2.4: Usability of container loading surface for palletted unit loads

Pallet type [DIN EN 13382] and storage scheme	Con-tainer length	Loading area to be filled out	Loading area usefully
Standard flat pallet 800 mm x 1.200 mm (e.g. Euro pallet) 	20 foot	77%	23%
	40 foot	79%	21%
Flat pallet 1.000 mm x 1.200 mm 	20 foot	79%	21%
	40 foot	94%	6%
Flat pallet 1.140 mm x 1.140 mm 	20 foot	95%	5%
	40 foot	93%	7%

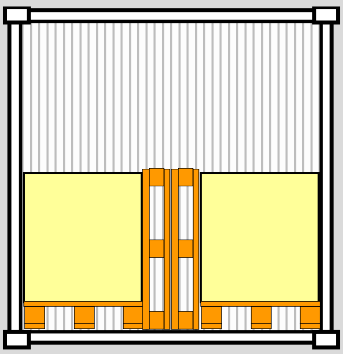


Fig. 2.12: Pallets used as gap fillers

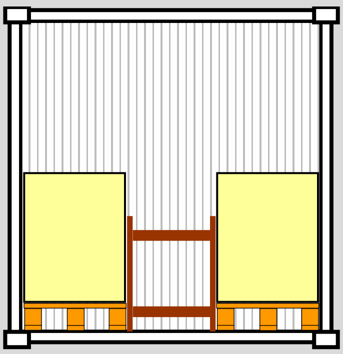


Fig. 2.13: Bracing out of wood

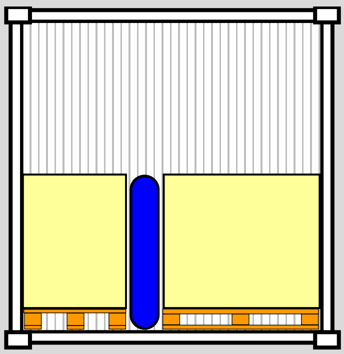


Fig. 2.14: Inflatable air bag

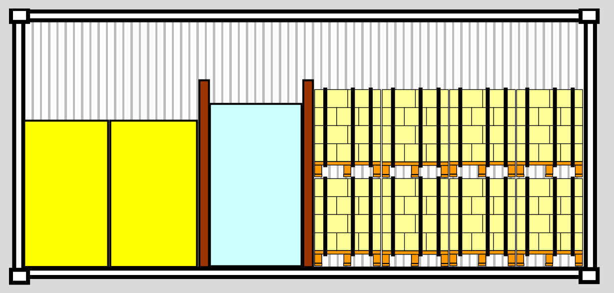


Fig. 2.15: Fixed partition walls

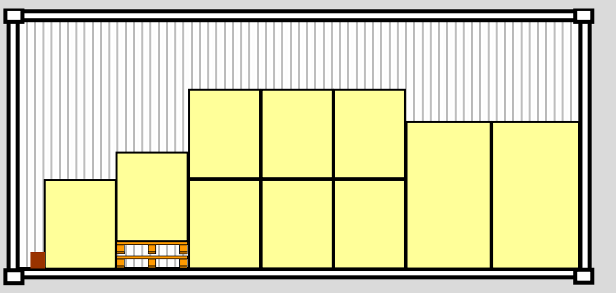


Fig. 2.16: Raised loads

2.3.3 Heavy Single Loads

The centre of gravity of heavy loads must be positioned in the middle of the container for a distribution of the load. In such a position two processes are suitable for the securing of the load:

Tight-fit securing (Blocking) of the load against the container walls

- Spacers (Fig. 2.17), secure against sliding.

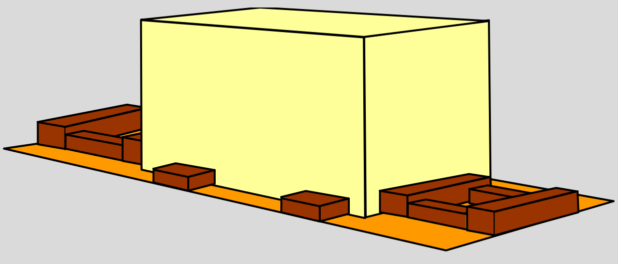


Fig. 2.17: Securing of heavy loads with spacers

- Bracings out of wood (Fig. 2.18), also secure against tilting.

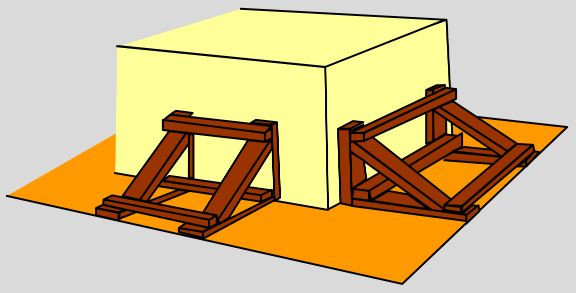


Fig. 2.18: Securing of heavy loads with bracings

Direct lashing at lashing points or lashing bars

- Mounting of lashing elements at the lashing points on load (Fig. 2.19).

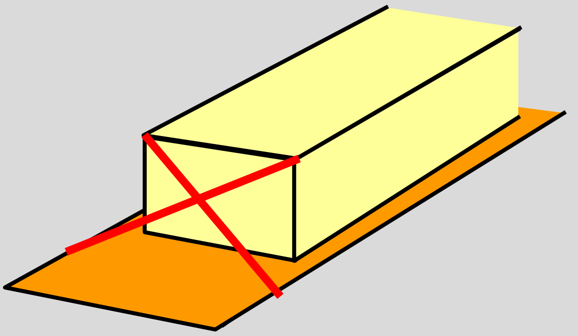


Fig. 2.19: Direct lashing at lashing points of the load

- Mounting of lashing elements in spring lashings, if lashing points exist on load (Fig. 2.20).

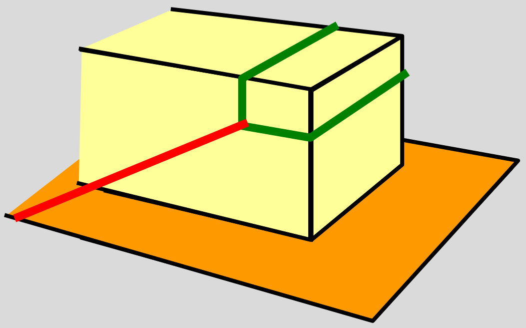


Fig. 2.20: Direct lashing with spring lashing

2.3.4 Roll-shaped Loads

Standing rolls, drums or similar objects are placed close to one another. The door side is secured by square timbers (Fig. 2.21), gaps are to be filled out.

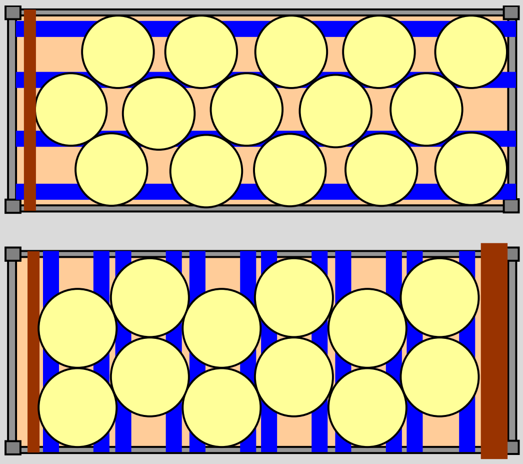


Fig. 2.21: Securing of standing rolls

Lying rolls must be secured against rolling away through sufficiently high wedges, empty spaces are to be filled out (Fig. 2.22).

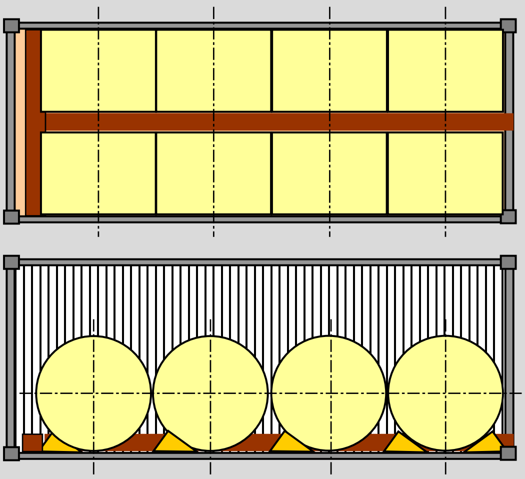


Fig. 2.22: Securing of lying rolls (top view and side view)

The placement of friction-enhancing mats (in Fig. 2.21 marked blue) significantly relieves the loading space boundaries and load securing elements.

For height of wedge see [1, section 5.4.4].

2.3.5 Long Goods

Long goods are most effectively secured using tight fits:

- By laying them at the side and front walls, if necessary with spacers, the door is to be kept free (Fig. 2.23).

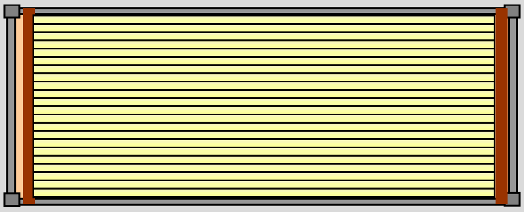


Fig. 2.23: Securing of long goods against the walls (top view)

- If the front walls cannot be used in the longitudinal direction, then e.g. bracings can be installed (Fig.2.24).

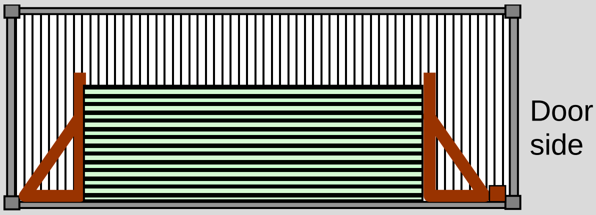


Fig. 2.24: Securing of long goods through bracings and square timbers in front of the door (side view)

- Long goods lie between the stanchions on flatracks, secured against jumping out through frictional lashing (Fig. 2.25).

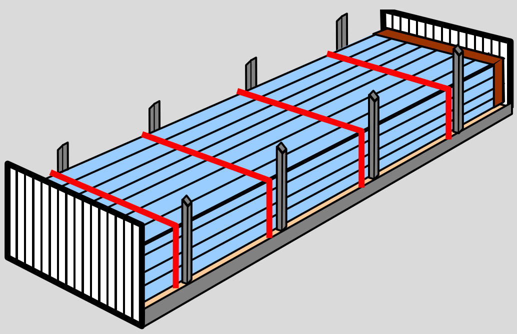


Fig. 2.25: Frictional lashing of long goods between stanchions

- For a lateral securing of loads loop lashings can be attached that, in each case, can be mounted on the same side of the lashing points (Fig. 2.26). Wedges on the square timbers prevent the long goods from rolling away prior to the attachment or after the removal of the loop lashings.
- Such long goods must rest on square timbers so that the lashing elements cannot be crushed. The square timbers should be arranged over the crossbeams of the container floor.

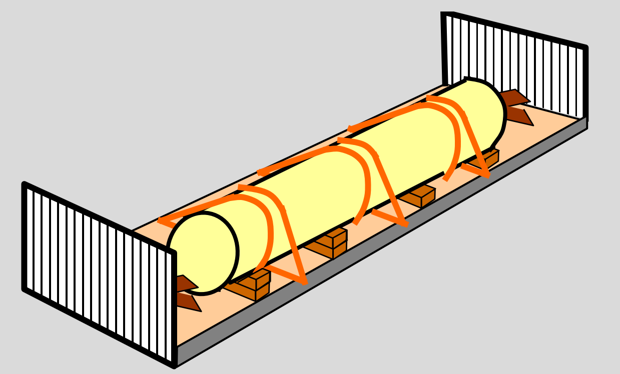


Fig. 2.26: Long goods secured by loop lashings

2.3.6 Dimensionally Unstable Loads

Dimensionally unstable loads – either palletted or unpalletted –, such as bagged goods, bales, wire coils, welded wire meshes, are preferentially to be secured in a tight-fit (blocked), namely either against the loading space boundaries or suitable aids such as empty pallets, partition walls, foams, inflatable air bags as spacers.

In general these loads cannot be frictional lashed as the lashing forces often cannot be taken up by the load without a shifting of the stack.

Even the use of friction-enhancing mats remains ineffective if the soft loads lie next to the mats on the loading surface. The friction-enhancing mats should be laid between each layer within the stack.

Bagged goods should be stacked interlockingly in order to give the load a certain stability, so that, for example, individual bags do not fall out during an opening of the doors (Fig. 2.27). Stowage gaps are hereby to be avoided or filled out.

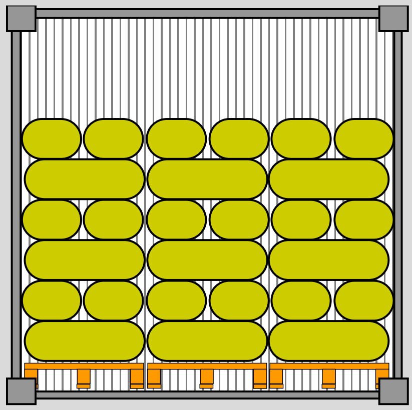


Fig. 2.27: Interlocking stowage of bags

3 Swap Bodies

3.1 Construction Types of Swap Bodies

Swap bodies are repeatedly usable, in general, not stackable containers for the transport and handling of single loads. They are suitable for transport on rail and road vehicles without a reloading of the goods. They must be easy to load and unload [DIN EN 283].

Swap bodies that are approved for transport by rail are codified according to UIC leaflet 596-6 and carry an identification code.

The most important **construction types** of swap bodies are [according to DIN EN 283]:

- Box construction type with fixed walls, door in a front or side wall (Fig. 3.1).
- Flat beds with side walls.
- Superstructure with side walls, tarpaulin and roof bows.
- Sliding curtains on the side with fixed front walls and flexible, movable side walls.
- Insulated swap bodies (thermal containers), cooling swap bodies (with individual refrigeration units).
- Stackable swap bodies.
- Large-volume swap bodies.

3.2 Technical Data of Swap Bodies

The technical data of swap bodies differ depending on the manufacturer and the intended use. This should be taken into consideration in the stowage plan. A selection of technical data for swap bodies of standard construction is given in Table 3.1.

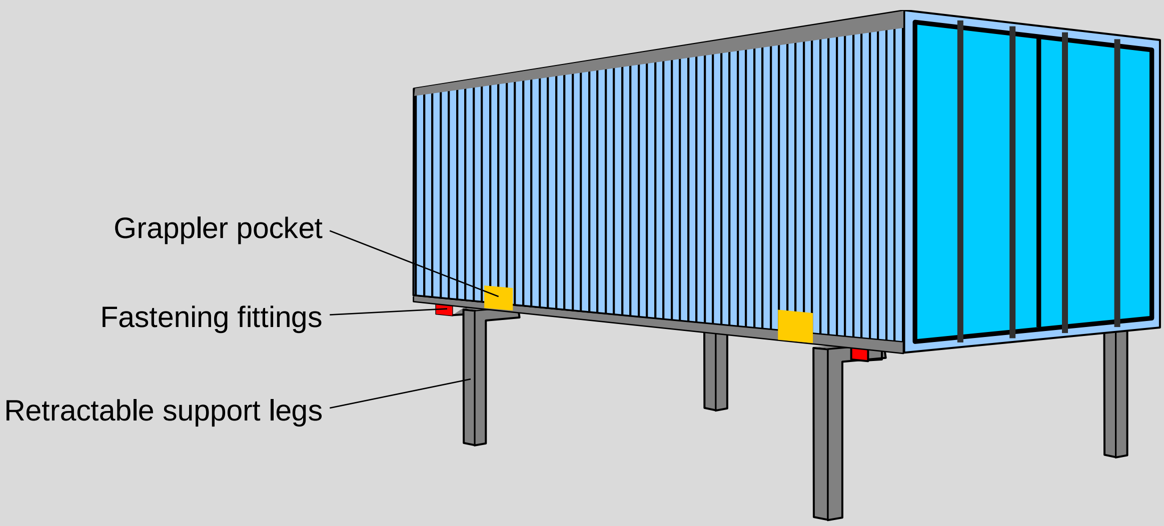


Fig 3.1: Swap body in box body type

Table 3.1: Selected technical data of swap bodies (according to DIN EN 284)

Classification (designation according to length)	Internal dimensions in mm			Gross weight in kg	Weight of load in kg
	Length	Width	Height		
C 715	7.020	2.480	2.400 ⋯ 2.500	16.000	≈ 13.500
C 745	7.300	2.480	2.270 ⋯ 2.360	16.000	≈ 13.000

In order not to damage the floor of the swap body, limits for the loading of the floor during the use of forklifts must be observed (Table 3.2). Accordingly only forklifts with a loading capacity of up to approximately 2,5 t should be used for the loading of swap bodies.

Table 3.2: Permissible loading of swap bodies using forklifts [DIN EN 283]

Type of load	Limit
Axle load	max. 4.400 kg
Wheel load	max. 2.200 kg
Wheel contact surface	min. 142 cm²
Wheel width	180 mm
Track width	760 mm

3.3 Rearrangement of Swap Bodies

Cranes (primarily full gantry cranes) are mainly used to rearrange swap bodies **between road and rail vehicles**. They use rotatable grappler arms that are usually combined with spreaders for the handling of containers. On the bottom edges of the swap bodies fastening hinges are attached for the handling with cranes (Fig. 3.1). Occasionally swap bodies are equipped with forklift pockets so that they can be reloaded using forklifts.

To handle the swap bodies **road vehicles** with special attachments are used that can take up the swap bodies standing on support legs or can place them onto these support legs (Fig. 3.2).

After the swap bodies are set down they must be properly secured onto the vehicles.

3.4 Inspection of Swap Bodies

Prior to loading a swap body that has been earmarked for loading the following points should be examined:

- No exterior damages (cracks, holes, deformations) are visible.
- Corner posts, grappler edges and supporting legs are not damaged.
- Doors and fasteners in working order, seals intact.
- Tarpaulins undamaged and water-tight.
- Elements for securing loads all available and functional.
- Interior empty, clean, dry and odourless.

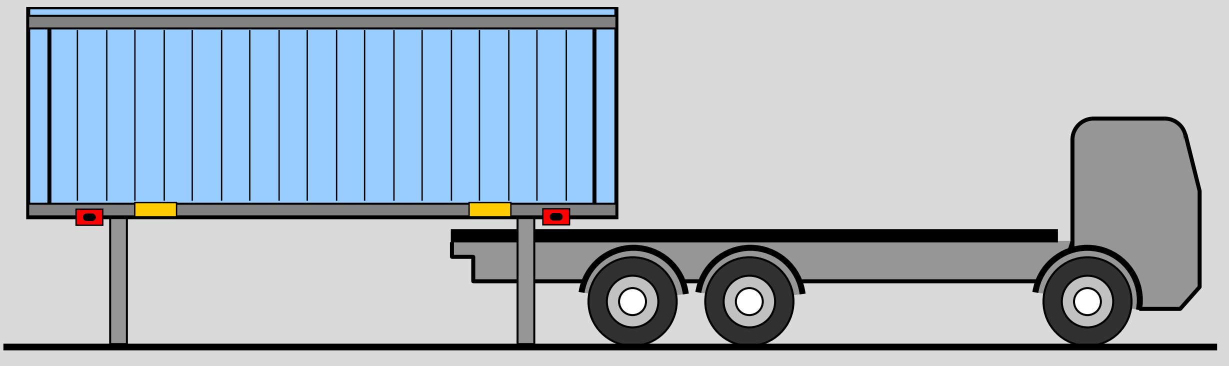


Bild 3.2: Underriding a swap body by a truck

3.5 Loading and Securing of Loads in Swap Bodies

In order to **load and unload (loading)** single loads swap bodies are positioned with one of the ends facing a ramp – remaining either on the road vehicle or placed in front of the ramp on the ground. The loading and unloading is usually carried out using forklifts and pallet trucks. Swap bodies that are open on the top or that can be opened can also be loaded or unloaded using bridge, gantry or vehicle cranes. For loading and stowing in swap bodies the explanations in [1, section 4] are similarly valid.

With regards to **securing of loads** the statements in [1, sections 3 and 5] are valid. Instead of using the acceleration for the pure road transport of goods, one should always use the acceleration values for the combined freight transport road/rail according to Fig. 1.2 (according to CTU code [5]).

The **load capacity of the front and side walls** of the swap body for a blocking of the load is regulated in DIN EN 283 (Fig. 3.3). Thereby a uniform load over a large surface area is assumed. On their own **tarpaulins** (also sliding curtains) are only suitable for securing loads, if enough stability is guaranteed together with the vehicle body (e.g. with stanchions, side slats, roof constructions). This has to be confirmed by the manufacturer.

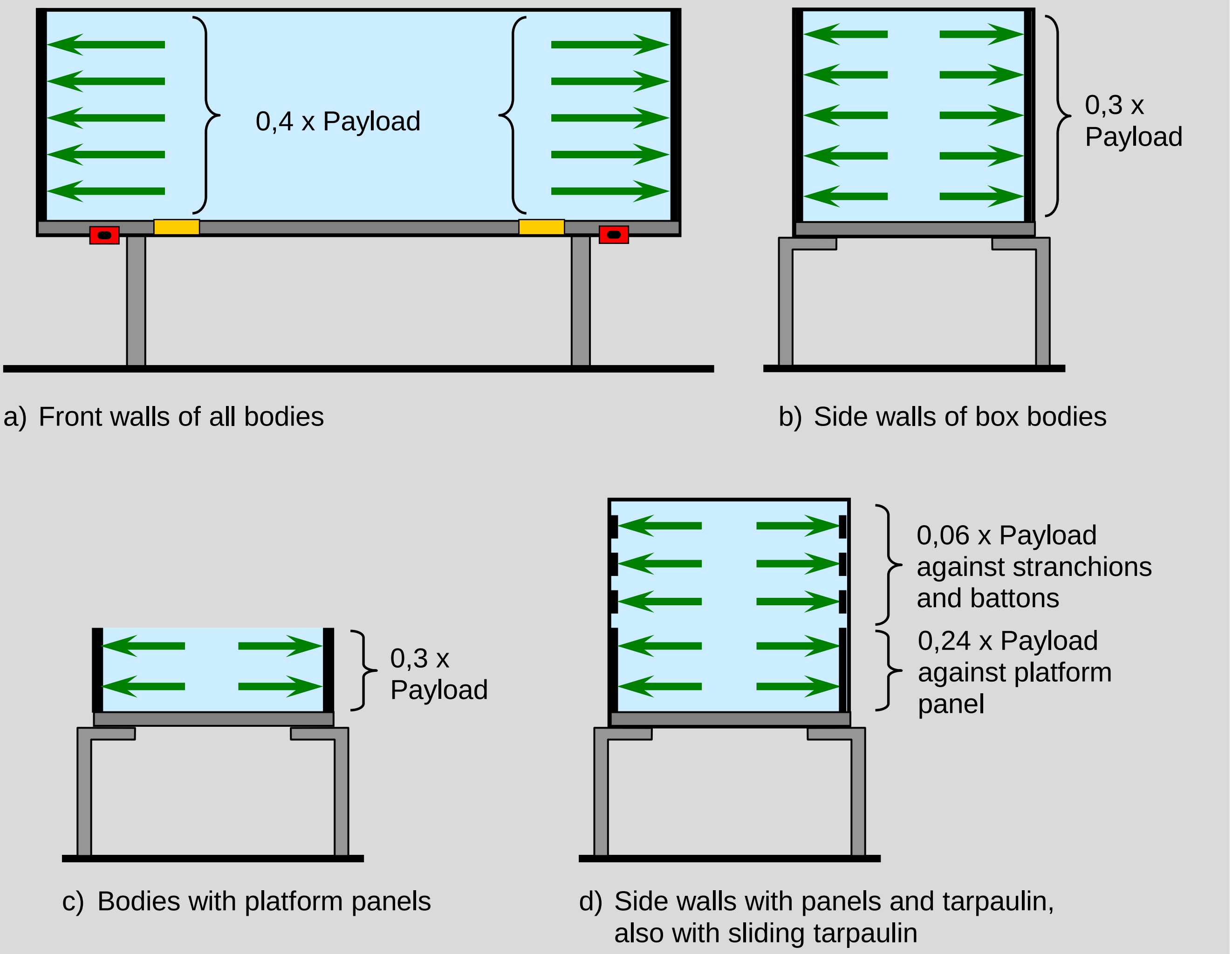


Fig. 3.3: Load carrying capacity of front and side walls of swap bodies [DIN EN 283]

4 Semi-trailers

4.1 Construction Types of Semi-trailers

A semi-trailer is a vehicle without a motor for the transport of goods. It is intended to be attached to a tractor unit. A semi-trailer is also known as a road semi-trailer.

As a special version for combined road/rail transport the semi-trailer is a container which can be moved by a grabber for the transport of general cargo and is suitable for transport on rail and road vehicles without reloading the goods.

Semi-trailers that are approved for transport by rail carry a code number plate.

The most important **construction types** of semi-trailers are:

- Box body with fixed walls.
- Slider curtain on the side with fixed front walls and flexible, movable side walls, with fixed or sliding roof.
- Flatbed with sideboards, open or with tarpaulins and bows.
- Isolated semi-trailer, refrigerated semi-trailer (with own cooling unit).
- Large-volume semi-trailer - cranes (mainly full gantry) are used.

4.2 Technical Data of Semi-trailers

Semi-trailers for combined road/rail transport significantly differ from those mainly used for pure road transports. Semi-trailers for combined road/rail transport are less effective for road transport than the volume- and weight-optimised semi-trailers for pure road transports, which cannot be moved by cranes. Table 4.1 lists selected technical data for semi-trailers used in combined road/rail transport.

Table 4.1: Technical data for semi-trailers in combined freight transport road/rail

External dimensions in mm			Gross weight	Weight of load	Volume
Length	Width	Height	in kg	in kg	in m³
13.600	2.500	4.000	34.000	25.000	84

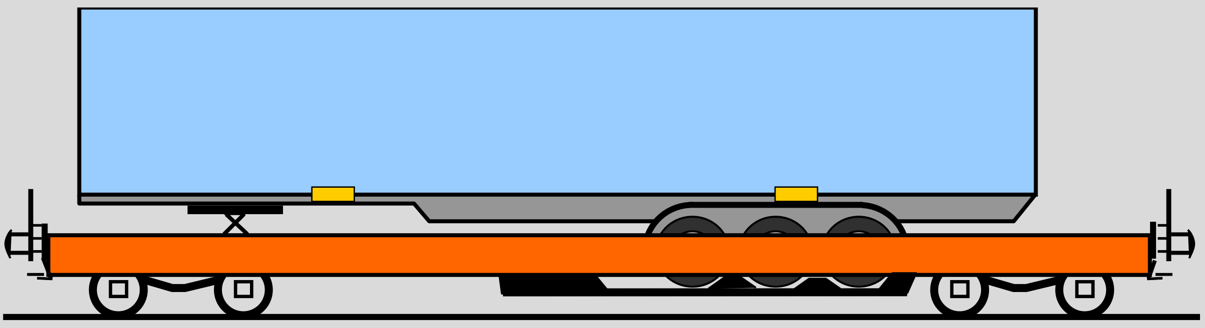


Fig. 4.1: Pocket wagon with semi-trailer

Grappler pockets

The adaptation of the semi-trailer for transportation on so-called pocket wagons (Fig. 4.1) mainly involves the following types of construction:

- Taking into consideration the loading gauge of the railroad during the measurements.
- Suitability for handling with cranes, implies the existence of grappler pockets.
- Adaptation of air reservoir as well as rear and lateral under-ride protection close to the bogie due to a lack of space on the pocket wagon (these adaptations are no longer required for pocket wagons of latest design).

4.3 Rearrangement of Semi-trailers

Mainly cranes (full gantry cranes) are used to rearrange semi-trailers **between road and rail vehicles**. They use rotatable grappler arms as lifting equipment that are usually combined with spreaders for the handling of containers. Grappler pockets are attached to the bottom edges of the semi-trailer for the handling by cranes (Fig. 4.1).

Tractor units are used for the road transport of the semi-trailers. They can pick up a semi-trailer standing on a support or set it down onto this support.

After the semi-trailer is set down, it must be properly secured onto the vehicle.

4.4 Inspection of Semi-trailers

Prior to the start of loading a semi-trailer ready for loading, the following points should be checked:

- No exterior damages (cracks, holes, deformations) visible.
- Grappler edges and support not damaged.
- Tarpaulins undamaged and water-tight.
- Fastening of tarpaulins flawless.
- Doors and fasteners in working order, seals intact.
- Devices for securing loads completely available and functional.
- Interior empty, clean, dry and odourless.

4.5 Loading and Securing of Loads in Semi-trailers

Semi-trailers are usually arranged facing the ramp in order to **load and unload (loading)** general cargo. They either remain on the truck unit or are set on the ground in front of the ramp. The loading and unloading is generally carried out with forklifts and lift trucks. Semi-trailers, that are open on the top or that can be opened, can also be loaded or unloaded using bridge, gantry or vehicle cranes.

For the loading and stowage in semi-trailers the explanations given in [1, section 4] are correspondingly valid.

Concerning the **load securing** the explanations given in [1, section 3 and 5] are valid. The acceleration coefficients for the combined road/rail transport as shown in Fig. 1.2 (if necessary according to CTU code [5]) should always be used instead of the acceleration coefficients used there for the pure road freight transport.

The **load capacity of the front and side walls** of the semi-trailer for blocking of goods is specified in DIN EN 12642 [1, section 7.1].

5 Directories

5.1 Literature

[1] BGL/BG Verkehr Practice Handbook Loading and Securing. Volume 1: Basic Principles of Securing Loads on Road Vehicles. Frankfurt/Main, 3rd edition, 2012.

[2] CTU packing practices. Regulations for the packing of cargo except general cargo in or on cargo transport units for carriage with all modes of transport by sea and land. German transport gazette issue 6, 1999. (Note: if necessary compare with guidelines in [6] and [5].

[3] Phytosanitary measures (IPPC): concern the prevention of the world-wide spreading of harmful organisms. The standard ISPM 15 contains guidelines on the treatment and branding of wood materials and solid wood. Further information: HPE e.V., Federal Association Wood Packaging Materials, Pallets and Packaging for Exports; Bonn; phytosanitary service of the respective state governments.
IPPC: International Plant Protection Convention; ISPM 15: International Standards for Phytosanitary Measures; “Guidelines for Regulating Wood Packaging Material in International Trade”.

[4] 53. derogation for StVZO dated 2nd of July 1997.

[5] IMO/ILO/UNECE Code of Practice for Packing of Cargo Transport Units (CTUs); CTU Code, issue 31. Januar 2014.

[6] IMDG-Code: International Maritime Dangerous Goods Code; Dangerous Goods Guidelines for Maritime Transports. Implementation in Germany through the „Verordnung über die Beförderung gefährlicher Güter mit Seeschiffen (Gefahrgutverordnung See - GGVSee).

[7] Container Packing. Hapag-Lloyd, Hamburg, April 2005.

Container Manual. Technical information from German Transportation Insurers. GDV Berlin, 2014.

DIN EN ISO 6346 (01/1996): Freight containers - Coding, identification and marking

DIN ISO 668 (10/1999): Series 1 freight containers - Classification, dimensions and ratings

DIN EN 283 (08/1991): Swap bodies, testing

DIN EN 284 (01/2007): Swap bodies - Non-stackable swap bodies of class C

DIN EN 12195-1:2011: Load restraining on road vehicles - Safety - Part 1: Calculation of securing forces

DIN EN 12640 (01/2001): Securing of cargo on road vehicles - Lashing points on commercial vehicles for goods transportation - Minimum requirements and testing

DIN EN 12641-1 (10/2005): Swap bodies; tarpaulins

DIN EN 12641-2 (01/2001): Swap bodies and commercial vehicles - tarpaulins - Minimum requirements for curtain sliders

DIN EN 12642 (01/2007): Body structure of commercial vehicles - Minimum requirements

DIN EN 13044 (12/2000): Swap bodies; Coding, identification and marking

DIN CEN/TS 13853 (07/2004): Stackable swap bodies type C 745-S 16; Dimensions, design requirements and testing

DIN CEN/TS 14993 (05/2005): Stackable swap bodies type A 1371; Dimensions, design requirements and testing

ISO 1496-1:2003-07: Series 1 Freight containers - Specification and testing - General cargo container for general purposes

ISO 830 (09/1999): Freight containers; Vocabulary

VDI 2700 (11/2004): Securing of loads on road vehicles

VDI 2700 part 7 (07/2014): Safety of loads in combined transport

UIC leaflet 592. Intermodal loading units for vertical handling, except semi-trailers, for transport on wagons - Minimum requirements; status: October 2013. (previously: UIC-592-2)

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5.2 Abbreviations

CFT	Combined Freight Transport
CIM	International Convention on Rail Freight Transport
CMR	Convention on the Contract for the International Carriage of Goods by Road
CSC	Container Safety Convention
CTU	Cargo Transport Unit
FBL	FIATA Bill of Lading
FEM	Friction-enhancing mats
FIATA	International Federation of Freight Forwarders Association
GT&C	general terms and conditions
HGB	German commercial code
Ro/Ro	roll-on/roll-off
SDR	special drawing rights
UIC	International Union of Railways; Paris

5.3 Keywords