4. 1 Load securing / Load securing basics / allsafe

6.0 Load restraint

Introduction to load restraint

Who is responsible?

The shipping agent, the vehicle owner and the driver. The shipping agent (shipping either for himself or for third parties) is responsible for roadworthy loads. The owner (the person who owns the vehicle and has control of it) is responsible for the suitability of the vehicle. The driver is the person who knowingly operates or controls a vehicle and is responsible for roadworthy stowage of the load and making sure load platform, bodywork and any load securing equipment are in sound and serviceable condition. Everybody has responsibilities.

Duties of shipper, vehicle owner and driver:

§ 22 of the German Road Traffic Act states: the load, including load restraint equipment, should be stowed and secured that it cannot slide, roll-over in any direction, wander because of vibration, fall off vehicle or make the vehicle tip over or produce avoidable noise, even during heavy braking or dangerous maneuvers. Generally accepted technical rules should be followed. § 37 (4) of the German Accident Prevention Regulations states that the load should be secured to hinder cargo from falling over and to prevent avoidable noises.

§ 412 of the German Commercial Code: Unless circumstances or common usage dictates otherwise, the dispatcher must load, stow, secure and unload the goods safely. The carrier is responsible for safe loading. § 823 of the German Civil Code define compensation. § 831 of the German Civil Code contains definitions of liability.

§ 30 of the German Road Traffic Licensing Regulations governs the requirements relating to the condition of vehicles; § 31 of the same legislation stipulates that responsibility for vehicle operation lies with the owner and driver. The vehicles must be safe to operate, for example, show no technical defects and all load restraint required for the intended journey must be available. The vehicle must also be roadworthy, which includes the vehicle operator being trained accordingly to secure the load adequately (§ 30 + § 31).

Areas of responsibility

Shipper	Owner	Driver
responsible for:		
roadworthy load § 22 StVO § 412 HGB § 823, 831 BGB	Sound and suitable vehicles § 30 StVZO § 31 StVZO	Load to be stowed safely § 22 StVO § 23 StVO

EN 12 195 Part 1 – Calculation of securing forces

Vehicles over 3.5 t total weight, use various securing methods such as blocking, lashing or a combination thereof for securing loads in road vehicles which are defined in part 1.

Information about the blocking force „BC in daN" of shoring elements is important for the calculation (BC = blocking capacity).

Recognized technical rules – VDI 2700 ff

In addition to EN 12 195-1, VDI Guideline 2700 ff provides a summary of physical principles and specific examples for load restraint.

The guidelines make many references to the relevant statutory rules and standards. The list of specific examples of load restraint is being extended continuously. The training requirements for people responsible for the load restraint is also described.

The VDI guidelines are definitive in legal disputes in Germany.

EN 12 195 Part 2 – Lashing straps

- EN 12195-2 regulates the labeling and handling of lashing straps.
- All lashing straps must be marked with a legible label.
- If label is no longer attached or if it is no longer legible, the strap can not be used.
- Straps can not be used if they show clear signs of damage, e.g. tears, cuts stitching breakage or corrosion
- It is not permitted to knot the straps.
- The driver must carry at least one set of instructions for use (supplied with the product) and be able to provide these upon request.
- There is no general expiration date for lashing straps.

Standards for securing loads

ISO 27955	ISO 27956	EN 12 640	EN 12 641	EN 12 642	EN 283/284	EN 12 195	EN 12 195	additionally: VDI 2700 ff
Lashing points	Lashing points	Lashing points	Trailers	Trailers	Trailers	Load restraint		
Passenger vehicle, wagon, light commercial vehicle	Light commercial vehicle	Flatbed trucks - > 3.5t	Tarpaulin		Swap bodies	Section 1: Calculating securing forces	Section 2: Lashing strap made from synthetic fibers	Recognized regulations for securing loads

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6.0 Load restraint

Securing loads using positive locking with Faktor 4

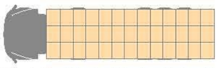
Fig. 1: Positive locking in all directions

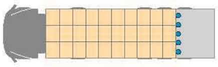
Fig. 2: Positive locking in all directions

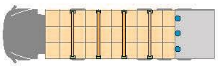
Fig. 3: Positive locking in all directions

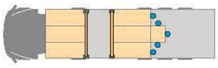
Fig. 4: Positive locking forwards, to the back and laterally

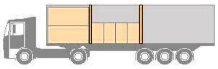
Fig. 5:

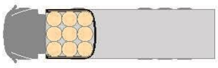
Fig. 6: Forward lashing

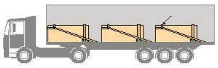
Fig. 7: Load secured using positive locking with head nooses

The symbols used below, along with the graphics are part of the EN 12195.

F_z = Weight
m = Mass
$F_{x,y}$ = Mass force forward, rearward or laterally
$c_{x,y}$ = lateral, forwards or rearward acceleration
μ = Friction value
F_S = Securing force
F_F = Friction
BC = Blocking force shoring beams
X = Number of shoring beams

Simplified formula for calculating securing force

Rearward inertia

$F_{x,y} = c_{x,y} \cdot F_Z$
$F_{x,y} = 0.5 \cdot 4000\ \text{daN} = 2000\ \text{daN}$

Friction force

$F_F = \mu \cdot F_Z$
$F_F = 0.25 \cdot 4000\ \text{daN} = 1000\ \text{daN}$

Required securing force

$F_S = F - F_R$
$F_S = 2\,000\ \text{daN} - 1\,000\ \text{daN} = 1\,000\ \text{daN}$

$$X = \frac{F_S}{BC} \qquad \frac{1\,000\ \text{daN}}{1\,000\ \text{daN}} = 1\ \text{shoring beam BC } 1\,000\ \text{daN}$$

$$X = \frac{F_S}{BC} \qquad \frac{1\,000\ \text{daN}}{500\ \text{daN}} = 2\ \text{shoring beams BC } 500\ \text{daN}$$

Load restraint by means of positive locking is where the load is tightly packed towards a part of the vehicle such as the headboard. As a result, there is no room for movement.

The simplest case is shown in Figure 1, where the load space is completely filled with stable load units.

Figure 2 shows positive locking to the front and side using the vehicle body and to the back using shoring poles.

Figure 3 shows positive locking with shoring poles to the front and to the back. This is especially desirable when large blocking forces are needed. There is no force exerted on the front wall in the direction of movement.

Figure 4 illustrates positive locking to the back using shoring poles (horizontal and vertical). The gap allows further positive locking to the front using horizontal shoring poles.

Positive locking can also be achieved with different load heights withhelp of shoring poles as shown in Figure 5.

Shoring poles are usually used to secure loads with positive locking. Figures 6 and 7 show positive locking using lashing straps.

The spring lashing shown in Figure 7 can also be used to build an artificial front wall, for example with an upright pallet in front of the load, which is then strapped to the back.

Calculation

In addition to the specified friction (FF = FZ · μ), the blocking capacity BC of the load restraint counteracts the inert mass. The system is balanced, i.e. the cargo does not slide, if:
$BC > (c_{x,y} - \mu)\ m \cdot g$

How to determine possible load weights

Using the blocking force of the shoring poles and beams (information on sticker), the following load weights can be secured for vehicles with maximum permissible weight (MPW) > 3.5 t: The load should be secured laterally and towards the rear with 0.5 g. With a load of 4.0 tons and a friction value of μ = 0.25, the following sample calculation is the result (gravity is rounded to 10 for simplification): with BC 1000 daN, a 4000 kg load can be secured towards the rear and laterally.

Faktor 4 shoring elements are labeled with BC (blocking force in daN) in accordance with EN 12 195-1.

Put simply, by using the formula "BC times 4= load weight" most common loads are sufficiently secured towards the sides and the back with our Faktor 4 products.

„BC times 2 = Load weight" secures loads sufficiently towards the front.

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6.0 Load restraint

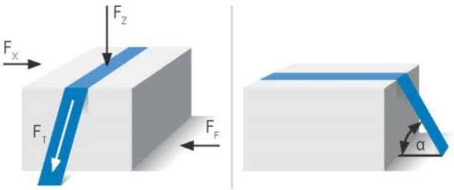
Load restraint using force locking

The symbols, units and terms used are in compliance with DIN EN 12195:

$F_{X,Y}$ = Mass force of load towards the front, back and sides
F_Z = Weight (normal force)
F_T = Tension force lashing device
F_F = Friction force
$c_{X,Y}$ = Front, rear or lateral acceleration
μ = Friction coefficient
$\sin\alpha$ = Angle
STF = Standard tension force lashing strap
mGVM = Gross vehicle mass

Friction force F_F can be increased for example by top-over lashing. The load is balanced, meaning the load can not slide if the following applies:

Sum $F_F > F_X$, with sum $F_F = (F_Z + F_T) \cdot \mu$.



Simple calculation of necessary tension force for load securing with top-over-lashing at a 90° angle:

$$\text{Standard tension force FT} = \frac{F_Z \cdot (c_{X,Y} - \mu)}{\mu}$$

Calculation for number of straps required:

$$\text{Number of straps} = \frac{F_T}{2 \cdot \text{STF}}$$

Example: mGVM 20.000 kg, friction coefficient $\mu = 0.25$, load weight 4000 kg, restraint in direction of travel, over-lashing at 90° angle, standard tension force STF = 500 daN:
$F_T = 4000 \cdot (0.8 - 0.25) : 0.25 = 8800$ daN
Number of straps needed = 8800 daN / (2 · 500 daN) = 9

Calculation of necessary tension force for load restraint with top-over lashing at <90° angle (α):

$$\text{Number of straps required} = \frac{F_Z \cdot (c_{X,Y} - \mu)}{F_T \cdot 2 \cdot \mu \cdot \sin\alpha}$$

Example: Friction coefficient $\mu = 0.25$, load weight 4000 kg, restraint in direction of travel, over-lashing at 60° angle:

$$\text{11 Straps} = \frac{4000 \cdot (0.8 - 0.25)}{500 \cdot 2 \cdot 0{,}25 \cdot \sin 60°}$$

The friction coefficient between load and vehicle floor surface can be increased with force locking. The friction force can be increased with top-over-lashing or equipment that increases friction (e.g. friction mats). With stable loads this should be increased until the load is no longer able to slide, taking accelerating factors into account.

The standard tension force, not the lashing capacity of the strap, is relevant for the calculation of the number of straps needed!

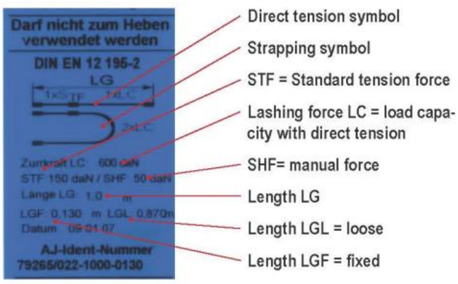
To calculate the number of straps required, information about the strap itself and the load is required.

This information can be found on the label.

A standard tension force STF of 500 daN is displayed on the label of the „Ergo long-lever ratchet strap". To achieve this 500 daN standard tension force (STF) in the ratchet, a manual force (SHF) of 50 daN has to be applied.

In addition to practical instructions, indications of the need to replace components can be found. Potential damage which can occur to the strap can be taken from the label. The strap can be used as long as it does not show signs of the potential damages listed.

To calculate the number of straps required, information about the strap itself and the load is required. This information is always on the label.



Label (blue label)

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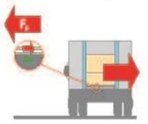
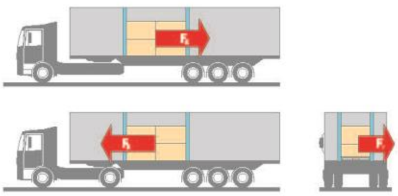
Physical principles

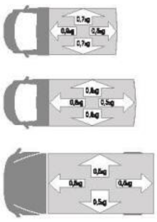
Weight	= Mass	x Gravity
F_z	= m	x g
1 daN	~ 1 kg	x 9.81 m/s



Friction	= Weight	x Friction coefficient
F_F	= F_Z	x μ



Inertia	= Mass	x Acceleration coefficient	x Gravity
F_{XY}	= m	x c_{xy}	x g

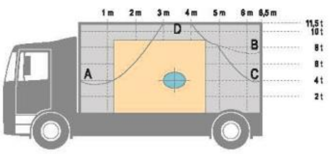


MPW > 2.0 t

MPW 2.0 - 3.5 t

MPW > 3.5 t

Acceleration value c_{xy} depending on MPW



Limited by:
A = permissible front axle load
B = permissible rear axle load
C = safe steerability
D = maximum permissible weight

Weight

The load applies a downward force on the load space of weight F_z. Forces like weight are measured in Newton (N). The weight of mass of 1 kg is approximately 9,81 N which for practical purposes can be rounded off to 10 N or 1 decaNewton (daN).

The weight of 1 kg of mass is 1 daN.

Friction

Friction hinders movement of the load and helps to secure it by working against the force of inertia. Friction forces depend on the mutual cargo and truck bed surface. The rougher the surface is, the higher the friction.

Friction can be calculated by multiplying the weight F_z by μ which stands for friction coefficient.

Longitudinal and transverse force of load in relation to the maximum permissible weight (MPW)

Acceleration tends to cause the load to slide backwards.

As a result of the retarding force when braking, the load tends to slide forwards. This vehicle movement is in the direction of the longitudinal axis (x-axis).

Centrifugal forces on the vehicle and its load occur when driving around bends. This vehicle movement exerts a force in the direction of the transverse axis (y-axis).

Centrifugal forces try to tilt the vehicle and push the cargo to the outside of the curve. Movement of the load while driving around a bend can cause the vehicle to topple over.

Based on the driving dynamics of vehicles with different total masses, different longitudinal and diagonal acceleration takes place in practice, see illustration.

Starting from a standstill position, the load acts with an inertia force directed towards the rear of the vehicle equal to 0,5 times the weight of the load. When braking, the inertial force directed towards the vehicle may equal 0,8 times the weight of the load. When cornering, the lateral inertia force may reach 0,5 times the weight of the load.

These longitudinal and transverse accelerations exert longitudinal force F_x or lateral force F_y on the load.

Mass x Acceleration coefficient x gravity = Inertia

Load distribution

Guideline VDI 2700 sheet 4 requires the load to be stowed so that the center of gravity of the entire load is along the longitudinal centerline of the vehicle if possible. Even weight and load distribution for partial loads is also desirable.

Positive locking is not usually achieved with heavy weights as you cannot load from the front bulkhead to the rear due to the vehicle's axle loads.This produces gaps in the cargo and suitable load restraint equipment must therefore be used. Shoring elements can secure against large forces, especially in the direction of travel.

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