HVTT13 - INTERNATIONAL GUIDELINES ON SAFE LOAD SECURING FOR ROAD TRANSPORT

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Summary

Unsafe loads cause accidents in the workplace and on the road. Every year loading, unloading and load shift accidents injure many people and cost businesses millions in damaged goods, vehicles, reputation and lost work time.

Vehicles carrying poorly restrained loads are a safety risk to their drivers, to road users and to people involved in unloading operations. Poorly restrained loads can greatly enhance the risk of vehicle instability and rollover and loss of load on road journeys.

The International Guidelines on Safe Load Securing for Road Transport were developed to provide basic practical advice and instructions to all persons involved in loading/unloading and securing cargo on vehicles, including carriers and shippers. They should also be useful for enforcement bodies performing technical roadside inspections and rulings of courts of law.

They could also serve as a basis for individual countries and the transport industry when taking the necessary steps for the initial qualification and periodic training of drivers of goods vehicles.

The International Guidelines on Safe Load Securing for Road Transport aim to provide a guide for safe and effective load securing for all situations that may occur in normal traffic conditions.

The guidelines should also serve as a common basis for both practical application and enforcement of cargo securing.

Keywords: Safety, liability, responsibility, restraining methods EN 12195-1, heavy vehicles load securing.* * *

1. General Background

Properly securing all cargo is essential to ensure the safety of a road transport operation. When mistakes are made in this area, damage to the cargo is nothing compared the risk to road traffic safety and other serious consequences. In extreme cases, vehicles can roll over or parts of the load can be lost during the journey and hit other road users.

Occasionally the newspapers report that, unfortunately, incorrect or no load securing has caused a serious accident with fatalities. Every accident is one too many!
One thing is certain: each load must be secured, regardless of its size and weight, to withstand expected constraints in a normal driving situation.

During transport, all cargo items should be prevented from sliding, tipping, rolling, wandering or undergoing substantial deformation and rotation in any direction, by methods such as locking, blocking, lashing or combinations of these. This is to protect the people involved in loading, unloading and driving the vehicle, together with other road users, pedestrians, the load itself and the vehicle.

Loads must be placed on the vehicle so that they will not injure persons, cause vehicle instability in transit, shift or move within the vehicle or fall from the vehicle.

Nevertheless, every day incidents and collisions occur in the workplace and on the road as a result of loads that have not been properly stowed and/or secured. These IRU International Safe Load Securing Guidelines for Road Transport provide physical and technical background information as well as practical load securing rules for road transport. For more details reference is made to international standards. They do not report the extensive test results available all over Europe for specific types of loads or specific transport conditions, nor do they describe in detail all possible solutions for all possible loads. These international guidelines are aimed to help all participants involved in the transport chain who plan, prepare, supervise or check the transport of goods by road to achieve efficient, safe and sustainable transport of all goods moved by road.

The International Guidelines provide clear practical information on how to achieve safe load securing practices in the workplace. Load safety begins and ends in the workplace. It provides several examples of good practices and of calculations related to load securing.

The International Guidelines on Safe Load Securing for Road Transport are based on physical laws related to friction, dynamics and strength of materials. However, the daily application of such laws can be complex. To simplify, load securing arrangements, strength and performance of superstructure, lashing and fittings requirements can be found in the many ISO and EN standards.

Article 30 of the 1968 Vienna Convention on Road Traffic makes reference to the loading of vehicles and specifically indicates that:

“2. Every load on a vehicle shall be so arranged and, if necessary, stowed as to prevent it from:
(a) Endangering persons or causing damage to public or private property, more particularly by trailing on or falling on to the road;
(b) Obstructing the driver’s view or impairing the stability or driving of the vehicle;
(c) Causing noise, raising dust, or creating any other nuisance which can be avoided;
(d) Masking lights, including stop lights and direction-indicators, reflex reflectors, registration numbers and the distinguishing sign of the State of registration with which, under this Convention or under domestic legislation, the vehicle is required to be equipped, or masking signals given by arm in accordance with Article 14, paragraph 3, or Article 17, paragraph 2, of this Convention”.

2. Responsibilities

Responsibilities for load securing are based on international conventions, national legislation and/or contracts between the parties involved and can differ from country to country.

Notwithstanding any legislation, the International Guidelines include a list which identifies proper functional responsibilities to be included in contracts between partners to ensure that appropriate measures for safety are taken by all stakeholders in the freight chain.

3. Physical Background

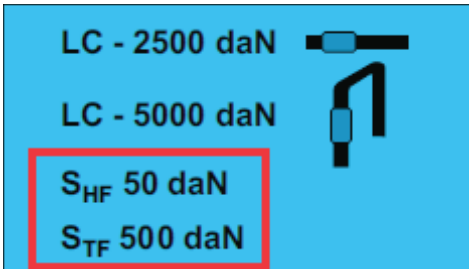
The design of load securing arrangements has to be based on:

- Force of gravity (the force of gravity is the main unit to size stowage)

The force of gravity G is the loading force that pushes down weight on the vehicle platform. The force of gravity is calculated by the mass in kilograms multiplied by the acceleration due to gravity in m/s^2.

If the value is rounded to the acceleration of gravity in 10 m/s^2, this gives: 1 kg of load = 10 N (Newton) force of gravity, which could easily be simplified by decaNewton(s), meaning that 1 kg of load= 1 daN.

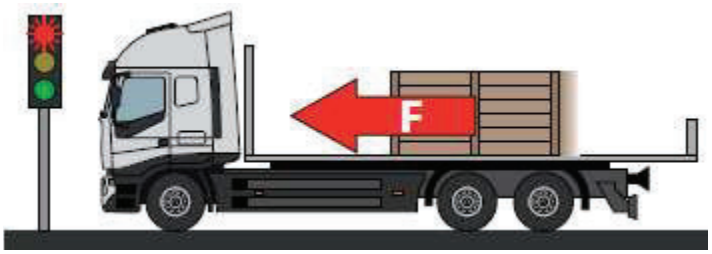
This unit, daN, is one of the indications on lashing devices.



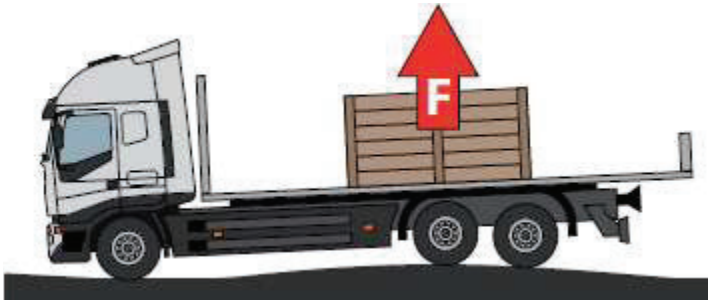
- Acceleration (Forces)

The inertia is calculated from the mass in kg and acceleration in m/s^2 in the direction concerned.

Acceleration force; when starting, the load tends to slide rearward

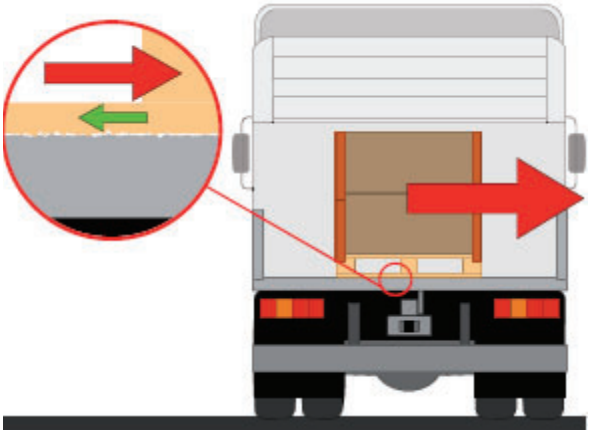


Deceleration forces; when braking, the load tends to slide forward



Buoyancy forces; shocks, vibrations and oscillations generate inertial forces that result in the load losing contact with the platform of the vehicle

- Friction factors


Centrifugal forces are the forces acting on the vehicle and its load at cornering. They tend to push the vehicle and its load to the outside of the turn. The centrifugal force is calculated using the formula below:

$$F = \frac{m \cdot v^2}{r}$$

- Safety factors
- Test methods

The sum of effects of locking, blocking, direct and frictional lashing are allowed to be used to prevent the load from moving including sliding, tilting, rolling, wandering, substantial deformation and rotation.

4. Securing Arrangements

Load securing arrangements to prevent load from sliding, tilting and rolling should be designed in accordance with the instructions in the quick lashing guide in Annex III of the International Guidelines on Safe Load Securing for Road Transport or equivalent instruction.

To use the quick lashing guide in Annex III, the following need to be considered:

- Securing direction
- Securing method and equipment
- Friction
- Dimensions/centre of gravity
- Mass of the load.

If lashings are used to prevent both sliding and tipping over, proceed as follows:

Calculate separately the number of lashings required to prevent sliding and the number of lashings required to prevent tipping over. The highest figure is the minimum number of lashings required. In cases where the load is blocked, the weight of the load secured by the lashings can be reduced in relation to the friction and the strength of the blocking device.

If there is no risk of the goods sliding, tipping or rolling - as shown in the tables of the quick lashing guide - then the goods can be transported without the use of lashing straps. However, there is a risk that unlashed goods will move in transit because of vibration. To prevent unlashed / unblocked loads from being significantly displaced due to vibration, it is recommended to use one top-over lashing with S_{TF} 400 daN per four tonnes of load.

Specific load securing arrangements are described in the International Guidelines on Safe Load Securing for Road Transport.

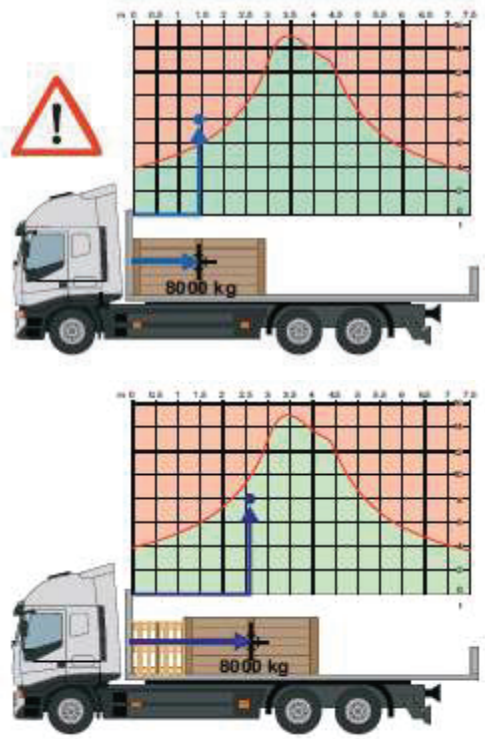
Alternatively load securing may be designed or tested in accordance with the European Standard EN12195-1:2010. In such a case, a certificate should be issued and available during transport.

5. Load Distribution

Transport units are particularly sensitive to the position of the centre of gravity of the load, due to specified axle loads for maintaining steering and braking ability. Minimum axle loads should also be considered to ensure adequate stability, steering and braking, as foreseen either by law or by the vehicle manufacturer. Such vehicles may be equipped with specific diagrams, which show the permissible pay load as a function of the longitudinal position of its centre of gravity.

Payload specified on the registration certificate of the vehicle is only applicable with an optimal location of the centre of gravity of the load. When any load is placed upon a vehicle, the maximum authorised dimensions, axle and gross weights must not be exceeded.

The specific diagram on load distribution provides information on the weight of loads allowed depending on the location of the centre of gravity measured from the headboard.



Generally, the maximum pay load may be used only when the centre of gravity is positioned within narrow boundaries about half the length of the loading space.

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

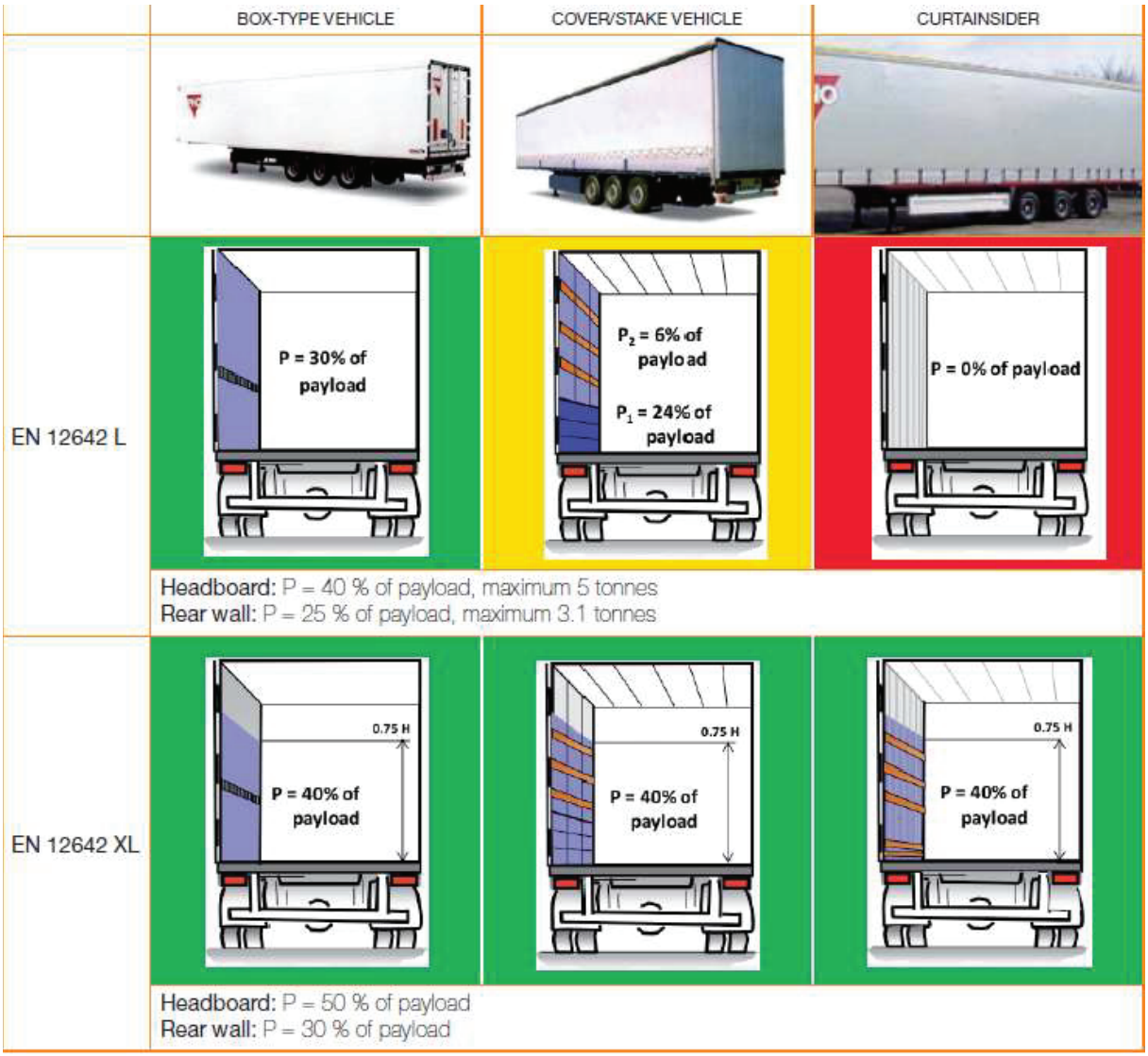
Distribution of load in accordance with the vehicle's load distribution diagram will help not to exceed the maximum permissible axle loads.

6. Vehicle Structure

Today, various standards such as EN 12640, EN 12641, EN 12642 and EN 283 provide requirements for vehicle structure and lashing points of cargo transport units (CTU), vehicles and swap bodies.

The load securing arrangement in the different Cargo Transport Units (CTU) depends on the type of load as well as side walls, headboard and rear wall strength.

The figure below compares strength requirements of CTU side walls, headboard and rear wall.

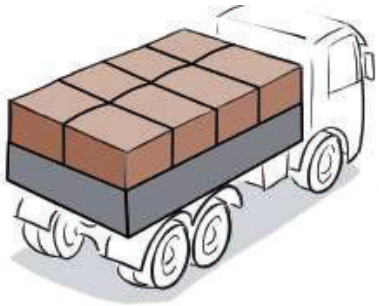


The vehicle types marked in green have strong side walls, those marked in yellow have sides for bottom blocking only, and the sides of the vehicles marked in red are to be regarded as weather protection only. The practical uses of the different strengths are described in the International Guidelines on Safe Load Securing for Road Transport.

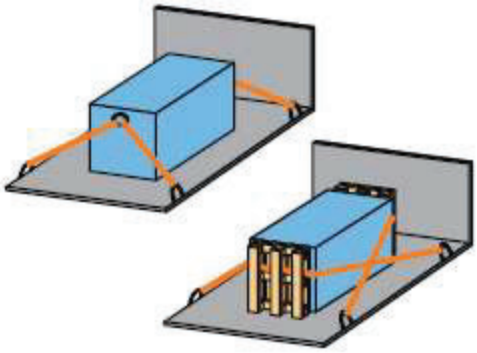
7. Restraining Methods

Restraining methods are mainly the following:

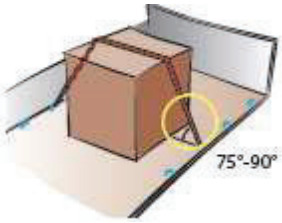
- locking
- blocking



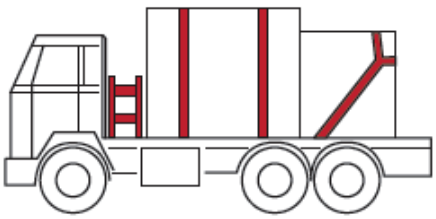
- direct lashing



- top-over lashing



- combinations of methods in conjunction with friction.



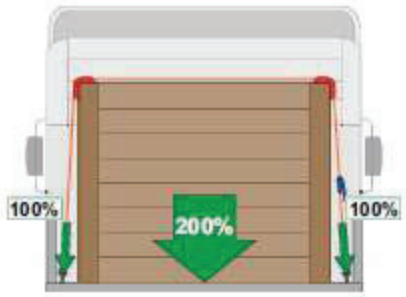
The restraining method(s) used should be able to withstand the varying climatic conditions (temperature, humidity, etc.) likely to be encountered during the journey.

Different lashing methods can be combined. One exception: *locking requires* specific locking devices on the vehicle and the cargo. The stiffness of a locking device is most often not compatible with other securing methods. Therefore, locking equipment should be strong enough so that other securing is redundant. The combination of blocking and top-over lashing is described in EN12195-1:2010. The blocking capacity and the securing capacity of the lashing can be added.

The contact force between a web of lashings and the cargo can increase considerably at the time when the inertia forces effectively occur, both for direct lashing and top-over lashing.

In case of deformable cargo, these high local forces will cause a deformation of the cargo, thus freeing space for the cargo to move, comparable to the movement of the cargo due to the elongation of a strap.

This is the main reason, apart from avoiding product damage, that high local contact forces on the cargo should be avoided.



The use of large corner protectors can contribute to the distribution of lashing forces over a greater zone and thus to the reduction of the movement of the cargo.

8. Calculations

The required number of lashings, for any given load, should be calculated based on the algorithms of EN 12195-1:2010.
By using the Quick Lashing Guide in Annex III, the securing arrangement fulfils the requirement in EN 12195-1:2010, with a safety margin as the quick lashing guide is a simplification.

When load securing arrangements are designed by calculations and/or practical tests the methods described in the EN 12195-1:2010 standard should be used. In such cases a document outlining the basis for the number of lashings used for the particular load should be prepared and made available during transport.

It is recommended to secure the load as usual and then check, using the tables in the quick lashing guide, whether the securing arrangement applied is sufficient to prevent sliding and tipping of the load in all directions.

In many cases calculations can be avoided. For example, when blocking the load in all directions, as per the manufacturer’s instructions, in an XL coded vehicle equipped as per the

certificate, no further securing is required if the friction factor between the loading platform and the load is 0.3 or higher, even for a full truck load.

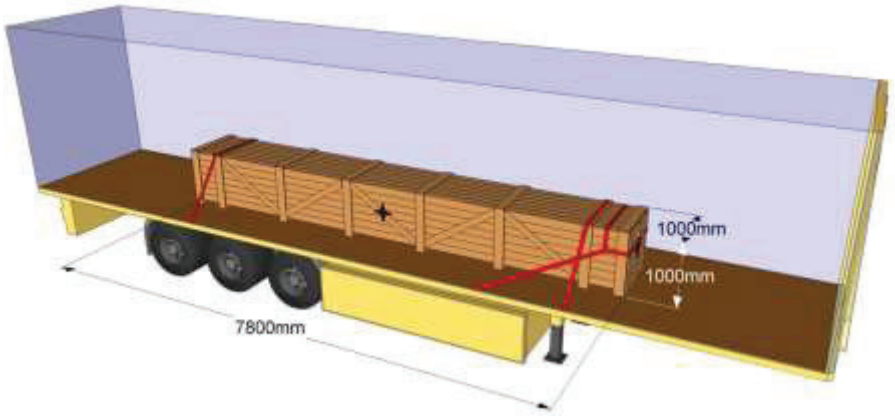
If calculations are necessary, they should be done in accordance with the EN 12195-1:2010 standard.

Alternatively, load securing arrangements can be tested in accordance with the instructions in the EN 12195-1:2010 standard.

In case two or more securing methods are combined, the formulas described in the EN 12195-1:2010 standard may be used in combination for calculation as described in the example below:

8.1 Wooden crate – low centre of gravity

Calculate the maximum allowed weight of the wooden box loaded on a trailer in accordance with the figure below using the tables in the quick lashing guide as well as the formulas in the EN 12195-1:2010 standard to avoid sliding and tipping sideways, forward and towards the rear.



The trailer has an ordinary plyfa floor that is swept clean and is free from frost, ice and snow. The trailer is built in accordance with the EN 12642 standard, XL class, and the lashing points on the trailer are designed in accordance with the EN 12640 standard, each with a lashing capacity (LC) of 2000 daN. The transverse distance between the lashing points is about 2.4 m.

The box is made of sawn wood and has the following dimensions: length x breath x height = 7.8 x 1.0 x 1.0 m. The centre of gravity is located in the geometrical centre of the box.

The box is secured by two top-over lashings and one spring lashing applied in forward direction. The lashings have an LC of 1600 daN and are pre-tensioned to 400 daN. The spring lashing is fixed to the trailer about 1 m behind the forward part of the box and the lashings thus have the following approximate angles:

- Top-over lashings: Vertical lashing angle between the lashings and the platform $\alpha \approx 55°$
- Spring lashing: Vertical lashing angle between the lashing and the platform $\alpha \approx 25°$ and the horizontal angle between the lashing and the longitudinal axle of the vehicle $\beta \approx 19°$

8.1.1 Sliding

The friction factor μ between the box of sawn wood and the plyfa floor of the trailer is 0.45 in accordance with annex B of the standard.

8.1.2 Example of load prevented from sliding by two top-over lashings

8.1.2.1 Quick Lashing Guide

The tables for top-over lashings in the quick lashing guide in Annex 1 show that one top-over lashing prevents 6.4 tonnes from sliding sideways, 0.81 tonne from sliding forward and 6.4 tonnes from sliding towards the rear. These values are valid for a vertical lashing angle of 75 – 90 degrees. As the angle is about 55 degrees the lashing prevents half the load weight from sliding only. With two lashings the load weight m in tonnes prevented from sliding in the different directions by the two top-over lashings is as follows:

- Sideways: 6.4 tonnes
- Forward: 0.81 tonne
- Towards the rear: 6.4 tonnes

8.1.2.2 Formulas in the standard

In the EN 12195-1:2010 standard the load weight m prevented from sliding by the two top-over lashings is calculated with the help of equation 10 (EQ10) of the standard.

EQ10

$$m = \frac{n \cdot 2 \cdot \mu \cdot \sin\alpha \cdot F_T}{g(c_{x,y} - \mu \cdot c_Z) f_s}$$, where:

m = load weight. The weight is obtained in kg if F_T is given in Newtons (N) and in tonnes if F_T is given in kilo Newtons (kN). 1 daN = 10 N and 0.01 kN.
n = 2; number of top-over lashings
μ = 0.45; friction factor
α = 55°; vertical lashing angle in degrees
$F_T = S_{TF}$ = 400 daN = 4 kN
g = 9.81 m/s^2, the gravity acceleration
$c_{x,y}$ = 0.5 sideways, 0.8 forward and 0.5 towards the rear, the horizontal acceleration coefficient
c_z = 1.0; the vertical acceleration coefficient
f_s = 1.25 forward and 1.1 sideways and towards the rear; safety factor.

With these values the load weight m in tonnes prevented from sliding in the different directions by the two top-over lashings is:

- Sideways: 10.9 tonnes
- Forward: 1.4 tonnes
- Towards the rear: 10.9 tonnes.

8.1.3 Example of load weight prevented from sliding forward by the spring lashing

8.1.3.1 Quick Lashing Guide

From the tables for spring lashings in the quick lashing guide it can be seen that one spring lashing prevents 6.7 tonnes of load from sliding in forward direction. This is valid if the vertical lashing angle is maximum 45 degrees and the lashing is directed almost in parallel with the vehicle's side. With a longitudinal lashing angle β of 19 degrees the table value should be reduced by 15% to 5.7 tonnes.

8.1.3.2 Formulas in the standard

The load weight m prevented from sliding in forward direction by the spring lashing can alternatively be calculated using equation 35 (EQ35) of the standard. The influence of the spring lashing to prevent transverse sliding is negligible.

EQ35

$$m = \frac{2 \cdot n \cdot F_R \cdot (\mu \cdot f_\mu \cdot \sin\alpha + \cos\alpha \cdot \cos\beta)}{g \cdot (c_x - \mu \cdot f_\mu \cdot c_z)}$$

, where
m = load weight. The weight is obtained in kg if F_T is given in Newtons (N) and in tonnes if F_T is given in kiloNewtons (kN). 1 daN = 10 N and 0.01 kN.

n = 1; number of spring lashings
F_R = LC = 1600 daN = 16 kN
μ = 0.45; friction factor
f_μ = 0.75; safety factor
α = 25°; vertical lashing angle in degrees
β = 19°; horizontal lashing angle in degrees
g = 9.81 m/s^2, the gravity acceleration
c_x = 0.8; the horizontal acceleration coefficient in forward direction
c_z = 1.0; the vertical acceleration coefficient

With these values the load weight m in tonnes prevented from sliding in forward direction by the spring lashing is 7.1 tonnes.

8.1.4 Example of load prevented from sliding by two top-over lashings and a spring lashing

8.1.4.1Quick Lashing Guide

The previous calculations give that the two top-over lashings and the spring lashing can prevent the following cargo weight from sliding:

- Sideways: 6.4 tonnes
- Forward: 0.81 + 5.7 = 6.5 tonnes
- Towards the rear: 6.4 tonnes

The maximum load weight prevented from sliding by the actual securing arrangement is thus 6.4 tonnes.

8.1.4.2 Formulas in the standard

The above calculations give that the two top-over lashings and the spring lashing can prevent the following load weight from sliding:

- Sideways: 10.9 tonnes
- Forward: 1.4 + 7.1 = 8.5 tonnes
- Towards the rear: 10.9 tonnes

The maximum load weight prevented from sliding by the actual securing arrangement is thus 8.5 tonnes.

8.1.5 Tipping

The stability of the box is checked using equation 3 (EQ3) of the standard.

EQ3

$$b_{x,y} > \frac{c_{x,y}}{c_Z} d$$

, where:

$b_{x,y}$ = 0.5 sideways, 3.9 forward and 3.9 towards the rear; the horizontal distance from the centre of gravity and the tipping point in each direction
$c_{x,y}$ = 0.5 sideways, 0.8 forward and 0.5 towards the rear; the horizontal acceleration coefficient
c_z = 1.0; the vertical acceleration coefficient
d = 0.5; the vertical distance from the centre of gravity to the tipping point

With these values it can be concluded that the box is stable in all directions and no lashing is required to prevent tipping. This can also be seen using the tables in the quick lashing guide with H/B = 1.0/1.0 = 1.0 and H/L = 1.0/7.8 = 0.13.

8.1.6 Conclusion

The maximum allowed load weight of the box secured by two top-over lashings and one spring lashing is thus 6.4 tonnes to prevent sliding and tipping in all directions if the tables in the quick lashing guide are used, and 8.5 tonnes if the formulas in the standard are used.

9. Recommendations

Valuable advice is given by the "Quick Lashing Guide" in the International Guidelines on Safe Load Securing for Road Transport (Annex III), including the number of lashing straps or load securing devices needed based on the type of method, material, friction, weight, etc.

Load safety is about achieving safe load systems, which involve a suitable vehicle, suitable means of containment, a suitable load configuration and a suitable load restraint.

Participants in the transport chain need to have clear planned procedures for loading, unloading, load containment and securing.

In Europe a new procedure for roadworthiness tests has been adopted, which implies more international controls regarding load securing during vehicle roadside inspections. Therefore, there is a real need for practical guidelines on how to achieve effective and safe load securing for transport by road.

The European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR) – 48 Contracting Parties - considers the securing of dangerous goods in accordance with European standard EN 12195-1:2010 as an internationally accepted level for the safe lashing of dangerous goods on vehicles involved in goods transport by road.

These IRU International Safe Load Securing Guidelines for Road Transport are intended to ease cross-border transport operations in so far as load securing is concerned. When using these Guidelines, duty holders must ensure that the load securing methods used are adequate for the particular situation at hand and, where appropriate, take further precautions.

Additional guidelines can explain in more detail or can outline the necessary requirements for specific loads and/or specific vehicles, but they should avoid describing additional requirements or further limitations, and should always be in line with European standard EN 12195-1:2010.

International carriers should bear in mind that individual countries may have specific requirements relative to load securing not covered in these Guidelines. It is therefore always necessary to consult the relevant national authorities to enquire about specific requirements.

The IRU International Safe Load Securing Guidelines for Road Transport based on European standard EN 12195-1:2010 are not legally binding. However, they provide a much needed framework of practical information, instruction and guidance that will enable participants in the transport chain to achieve safe load conditions, compliance with legal obligations and conformance with EN 12195-1:2010.

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