SECURING LOADS ON ROAD VEHICLES, NATIONAL REGULATIONS AND TEST METHOD IN ACCORDANCE WITH PN-EN 12642

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Abstract

The objective of this work is to develop a method of safe vehicle testing for compliance with the PN-EN 12642 standard. Vehicle tests can be carried out in a static and dynamic form. Dynamic tests better reflect the forces exerted by loads on the walls of the cargo space of vehicles. Heavy goods vehicles with certified walls of the cargo space ensure the safe transport of cargo in road traffic. Improper load securing is the cause of approximately 25% of truck accidents. Reducing the number of road accidents is the responsibility of each EU Member State. In Poland, the requirements for securing loads and appropriate vehicle construction have been introduced in the national regulations regarding the technical conditions of vehicles and their necessary equipment. The article presents the current legal status regarding cargo securing, as well as the designed and implemented solution and the method of safe conducting dynamic tests of vehicles in accordance with the PN-EN 12642 standard.

Keywords:

Road safety, cargo securing, vehicle testing

Citation:

Gołowicz A., Kidawski A., Kowalczyk M., Ogłaza J., Włodarczyk A. ZSecuring loads on road vehicles, national regulations and test method in accordance with PN-EN 12642 Motor Transport, 65(1), (36-40)
DOI: 10.5604/01.3001.0015.8715

1. Introduction

Road transport is crucial to the EU economy: it carries more cargo and passengers than all other modes of transport combined, and it provides jobs for 10.6 million people. It must ensure safety for hauliers and other road users. Europe's roads are the safest in the world and road safety has improved significantly in recent decades. Nevertheless, the number of fatalities and injuries is still too high on the roads, not only in Poland, and progress in reducing the number of accidents and fatalities has slowed down significantly [1]. The European Union works closely with the authorities in the Member States to improve road safety. Cooperation is to be based on national initiatives, i.e. setting targets for all factors that play a role in accidents. These factors include: infrastructure, vehicle safety, driver behaviour, and crisis response.

It does so by adopting legislation at national level, supporting public education campaigns, helping Member States and other actors in the road safety, sharing relevant experiences and providing funding for these purposes.

An important factor in the road transport safety is securing loads on vehicles. A poorly secured load can fall off the vehicle during a violent manoeuvre or situation (e.g. braking, overtaking or a collision) and cause injury or death to road users. At the same time, such incidents always cause traffic difficulties. It should be emphasized that, apart from securing the load, its improper placement also hinders the safe manoeuvring and vehicle control. Every year, there are incidents and accidents on the roads of the European Union caused by the wrong distribution or securing of the load. One of the most common accidents caused by inappropriate load distribution is vehicle rollover [2]. Most Member States require that the load is placed on the vehicle in such a way that it does not endanger persons or goods and that it does not get dragged behind or fall off the vehicle. Every year, there are incidents and accidents on the roads of the European Union caused by poor stowage and/or securing of loads. Some Member States have specific rules on cargo securing, but their content and scope may differ from country to country, making it very difficult for international hauliers to define their national requirements in this area.

For this reason, more and more EU countries require that vehicles carrying cargo have walls of the cargo space that meet the requirements of PN-EN 12642: 2016. In accordance with this standard, static or dynamic tests of the vehicle can be carried out. Due to the safety of dynamic tests, it was necessary to design and implement a roll-over protection during the tests. For this purpose, a support axle has been designed and manufactured, which is characterized by high versatility, thanks to which it can be easily attached to the frame of a truck or trailer/semi-trailer.

2. National regulations regarding cargo securing and safety

It is estimated that 25% of accidents involving trucks are due to improper load securing. Some Member States have rules on cargo securing, the content and scope of which often differ, however, making it very difficult for international carriers to try to define minimum cargo securing requirements for a given cross-border journey. [4]
The issues noticed have caused that countries, including Poland, have implemented provisions on securing loads. Until August 2004, Polish law treated the securing of cargo in a general way. In the European Union, the rules for securing cargo in transport are precisely regulated in the EN-12195 standard, which has also been in force in Poland since August 2004 as PN-EN 12195. Due to the need of domestic producers to certify their vehicles for compliance with the standard, a support axle was developed, which is used to safely conduct dynamic tests of vehicles for compliance with the standard.

The law and common sense dictate to secure any loads that are being transported. The aim is to protect those involved in loading, unloading, driving the vehicle and other road users, pedestrians, the load itself and the vehicle. Loading and unloading should be carried out by properly trained employees who are aware of the existing risks. In addition, drivers should be aware of the additional risk that the load or parts of it may shift while driving. This applies to all vehicles and types of roads. All entities involved in loading the vehicle must be aware of their responsibility. The Group of Experts of the European Union has prepared a document entitled: "Lashing down loads in the road transport. Guidelines for good European practice".[2] These guidelines are intended to provide practical tips and instructions for all persons involved in loading or unloading. They can also be useful for competent services and inspections as well as courts.

The state law that regulates the issues of securing cargo on a vehicle is:

Regulation of the Minister of Infrastructure and Construction of 27 October 2016 on the publication of a uniform text of the regulation of the Minister of Infrastructure on the technical conditions of vehicles and the scope of their necessary equipment. The text of this Regulation has been amended many times by subsequent Regulations, among the others, by THE REGULATION OF THE MINISTER OF INFRASTRUCTURE of 18 April 2018 amending the regulation on the technical conditions of vehicles and the scope of their necessary equipment.

According to this Regulation, the §1 reads:

§ 1. The Regulation of the Minister of Infrastructure of 31 December 2002 on the technical conditions of vehicles and the scope of their necessary

equipment (Journal of Laws of 2016, item 2022 and of 2017, item 2338) shall be amended as follows:

2) in § 9, the following 6-9 passage shall be added as follows:

„6. The structure of the cargo space of a N2, N3, O3 and O4 category vehicle should be made in accordance with the current level of engineering knowledge, ensuring road safety. The level of knowledge is described in the PN-EN 12642 standard; the provision does not apply to lorries of the VAN subtype with a maximum total weight of up to 7.5 tons.

3. Requirements of the PN-EN 12642 standard [3]

The standard PN-EN 12642 listed in this point concerns the securing of loads on the road vehicles, construction of vehicle bodies for the transport of goods and minimum requirements.
Verification of compliance with the requirements of this standard should be performed according to one of the following tests:

a) Dynamic drive tests
b) Static tests

The above-mentioned standard regulates the technical characteristics of vehicles and equipment used in vehicles for the immobilization of loads. A suitable vehicle should be selected for the transported load, whose load platform and immobilizing elements meet the requirements of the standard, and checked whether properly constructed front, side and rear walls, connected to the vehicle, restrict the movement of the load.

From the point of view of cargo safety, it is extremely important to check in the vehicle properties tests whether its structure and its components can be treated as a cargo securing system. The tested vehicle must also have documents confirming compliance with the standards, such as: manufacturer's declaration, certificate of compliance issued by a certification body.

The basic requirements for the essential elements of the vehicle body, regarded as a load securing system, are the front wall of the load compartment, side walls and rear wall. These elements are tested and must meet certain requirements.

3.1. Front wall of the cargo area of trucks and their trailers

The front wall of trucks with a technically permissible total weight exceeding 3.5 tons should be designed in accordance with the PN-EN 12642 standard or equivalent. Based on the requirements of this standard, the front wall must withstand a force equal to 40% of the maximum load weight, but not more than 5000 daN. This force is directed forward and is evenly distributed over the surface of the front wall. The action of the force on the wall must not cause its excessive and permanent deformation.

3.2. Cargo area side walls

The side walls of the cargo space of trucks and trailers with a technically permissible total weight exceeding 3.5 tons should be designed at least in accordance with PN-EN 12642 or an equivalent standard. These requirements apply as long as the walls are also used for securing loads. Based on the requirements of the standard, the sidewall must withstand a force equal to 30% of the maximum load weight, without causing excessive and permanent deformation.

3.3. The rear wall of the cargo area

The rear wall of the cargo space of a truck or trailer should be designed at least in accordance with PN-EN 12642 or equivalent, if it is used for securing loads. This means that the wall must withstand a force equal to 25% of the maximum load weight, but not more than 5000 daN.

4. Dynamic tests of the vehicle for the compliance of the vehicle with the PN-EN 12642 standard

As described above, the strength of a vehicle structure with a load securing function can be proved by dynamic tests (drive test). The requirements for this test are described in the standard. According to the provisions of the standard, in order to achieve the accelerations determined by the standard, by making changes in the direction of movement (manoeuvres), it is necessary to protect the vehicle against overturning with an additional support axle. It is part of the accessories that are the subject of the work performed as part of the statutory work carried out at the Motor Transport Institute. In the case of semi-trailers, the supporting axle is positioned as close as possible to its first axle. For other vehicles (cars or trailers), the support axle should be mounted as close to their centre as possible.

An appropriate measurement system was built, equipped with acceleration sensors. If one sensor is used, it is placed under the floor in the centre of the vehicle. If two sensors are used, they should be positioned as follows: one sensor should be located in the middle of the front wall, and the other should be located under the floor of the vehicle, halfway its rear section.

The load securing equipment should fulfil its functions in each successive attempts. If the load is secured by the vehicle body structure, this means that, after the test, there will be no permanent or elastic deformations or tears on the side walls or at the joints with the frame. If the load is secured with securing devices, these accessories shall not show any damage.

In order to perform dynamic tests, the vehicle and the load must be properly prepared. The cargo space of the vehicle should be filled uniformly along its entire length and width and at, at least half the height of the cargo space, with a cargo that loses its stability as a result of lateral acceleration ≤0.25 g. An example of such a load, compliant with the stability criteria, is, among the others beverage boxes. These boxes must be placed on pallets in individual columns of 8 pcs. The weight of the load should be equal to the permissible weight for the vehicle submitted for evaluation. The description of the cargo should also include the value of the coefficient of friction between the cargo and the cargo space floor of the vehicle body. For specific applications, depending on the preferences of the end user of the vehicle, the tests may be performed with other types of load, however, the test conditions must be documented each time.

4.1. Description of the tests performed

The requirements for dynamic tests are specified in Annex B to PN-EN 12642 standard. The purpose of the tests is to achieve the required acceleration by performing appropriate road manoeuvres described below.

Test of a vehicle subject to deceleration in the direction of travel

In order to conduct this test, a rectilinear track section must be provided that allows the vehicle to accelerate to a speed of 35 - 40 km/h. Before commencing the braking, there should be a ride on the so-called retarder - an element with a height of 10 to 20 mm and a width of 500 mm, set at an angle of 60 to 80° in relation to the direction of travel. This is to induce vertical vibrations and "loosen the load". The retarder may be omitted from the test if the track has similar roughness. Then, from a speed of 35 km/h, full braking is applied to obtain a deceleration of 0.8 g. After three consecutive passes, the load securing equipment should continue to fulfil its function, without permanent or elastic deformations, tears at the front wall or at its attachment to the frame.

Test of a vehicle subjected to lateral acceleration due to a change in the direction of movement of the vehicle - U-turn test

For this test, a rectilinear track must be provided that allows the vehicle to accelerate to a speed of 30 - 40 km/h. The track shall end in an arc

with a radius of 25 m ± 2 m, along which the test vehicle will travel with its front middle plane at a steady speed of at least 30 km/h. The aim is to achieve a lateral acceleration of at least 0.5 g in three successive runs. The load securing equipment should continue to fulfil its function, without permanent or elastic deformations, tears on the side walls or at their attachments to the frame.

Study of the change in the direction of motion with an acceleration of 0.5 g on both curves – chicane test

The double-diversion test shall be performed after the reversal of direction test - U-turn test has been passed.

A rectilinear track shall be provided, allowing the vehicle to accelerate to 30 - 40 km/h, passing into two successively situated turns of opposite directions and radii of 25 m ± 2 m each. It is required that the tested vehicle, at a constant speed of at least 30 km/h, obtain an acceleration of at least 0.5 g at each change of direction. On exiting the second corner, full braking should be applied inducing a longitudinal deceleration of 0.6 g. After three consecutive passes as described above, the load securing equipment should continue to fulfil its function, without permanent or elastic deformations, tears at the front or side walls or at their attachment to the frame.

Test of the vehicle subjected to deceleration while the vehicle is moving rearward - reversing

There must be a section of track to allow the vehicle to accelerate to its maximum reverse speed. When Vmax is reached, full braking occurs. Deceleration accelerations of at least 0.5 g during three consecutive tests should be recorded. The cargo securing equipment should continue to fulfil its function, without permanent or elastic deformations, tears at the rear wall or at its attachment to the frame.

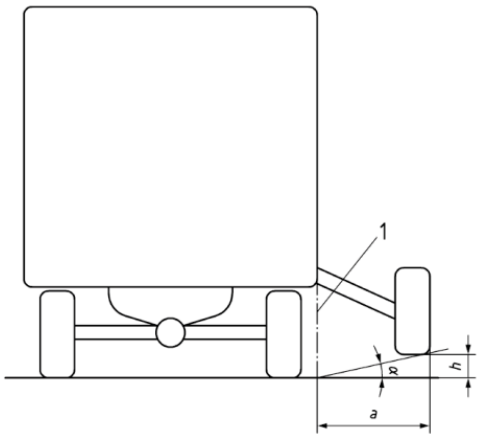
5. Safety measures during vehicle tests

During dynamic tests of the vehicle, the load and the vehicle may become unstable as a result of lateral, longitudinal and vertical acceleration, which in turn leads to its overturning.

The dynamics of tests requires securing the vehicle against rollover. This especially applies to tests with a change of driving direction, where the wheels of the inner side are pulled away from the surface. For this purpose, a support axle is mounted under the vehicle. This axle, in a critical moment, coming into contact with the ground, is designed to prevent the vehicle (set of vehicles) from tipping over to the side. The height of its operation is determined by the angle α with a value of at least 5 (Fig. 1)

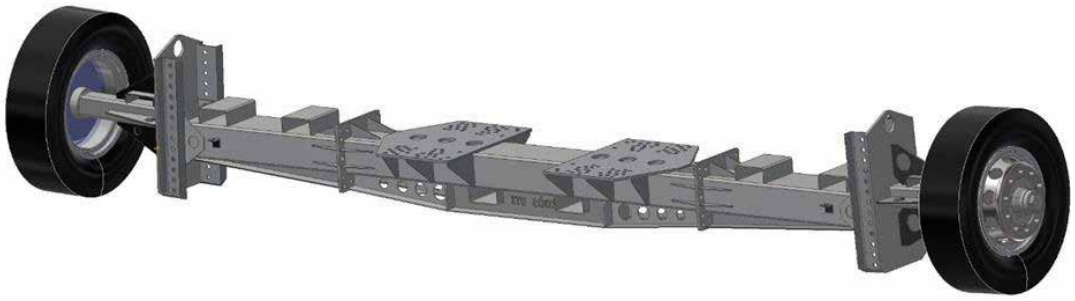
As part of the research work carried out at ITS, a support axle was made and developed according to our own design. This axle is mounted under the vehicle to its frame. Based on the accumulated knowledge and the analysis of similar existing design solutions, a 3D model of the support axis was designed. The axle is assembled from several elements: a centre beam and side beam assemblies (Fig. 2).

Fig. 1. Operating height of the supporting axis



The central beam is designed so that its length does not exceed the allowable width of the vehicle and that it can be assembled using a forklift. Rectangular mounting flanges were provided to allow the connection of the central beam to the side beam assembly. In order to increase the stiffness of the structure, the beam underneath was reinforced with a truss made of sheet metal, and the flanges with struts.

Fig. 2. A 3D model of the supporting axis

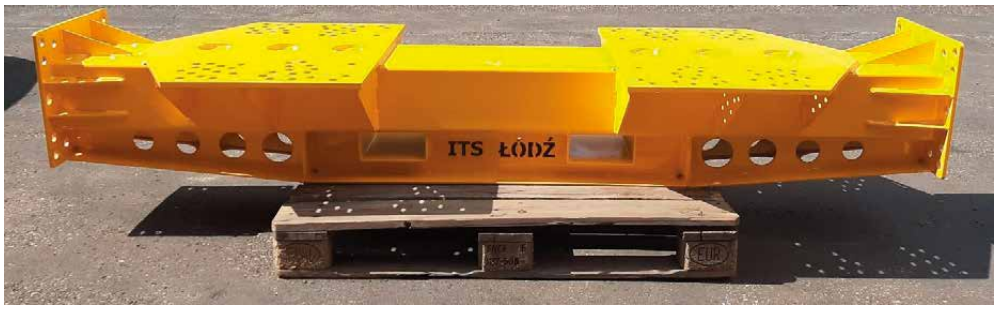


The beam is mounted to the vehicle frame by connecting it to two welded plates with self-adjusting clamps.

After welding and painting, the central beam looks like on the picture below (Fig. 3). The total weight of the element is 313 kg.

itself is a commercial element in O3 and O4. trailers. The height of the wheel position can be adjusted every 60mm by bolting together the element with the side beam through the appropriate holes.
The road wheel consists of a steel rim size 22.5x9.00 "and a 315/80 R22.5" tire with a load index of 156/150 and K speed index.The main assumption for the resulting structure was the possibility of easy assembly

Fig. 3. Central beam



Side beam assemblies (left and right) are designed to connect the middle beam to the support wheels. They are designed based on 3 main elements: side beam, axle with hub and road wheel.

The same material is used for the construction of the side beam as for the construction of the central beam. Mounting to the central support is

and disassembly of its elements. Therefore, it was decided to incorporate bolted connections. This allows for easy transport by a N1 category vehicle (up to 3.5 t) and minimizes storage space. In order to attach the beam to the vehicle frame, self-adjusting clamps were used, making up the differences in thickness of the joined elements. Additionally, in order to stabilize, during the contact of the support wheels with the surface,

Fig. 4. Side beam

provided through the flange. Increasing the stiffness of the element was achieved thanks to the lower truss made of metal sheets. The outer side of the side beam is completed with a spatial structure that enables its assembly and, if necessary, adjustment of the wheel height. A welded handle is also provided for the side beam, which serves as an attachment point for the shackle of the tensioning chain. The photo is shown in Fig. 4.

The axle with the hub is designed to adjust the height of the wheel. The basis for this element is a vertical plate with appropriate holes. The axle

certified, one-piece chain lashings are provided. They are attached with Omega type shackles to the grips in the central beam and the front part of the vehicle frame.

6. Measuring equipment

The measuring system should have at least one acceleration sensor (at least for two-axis) located under the floor in the centre of the vehicle. However, it is recommended to use two acceleration sensors. In the case of two sen-

Fig. 5. Axle with hub and road wheel

sors, the first is mounted in the middle of the front wall halfway up the body, the second under the floor in the middle of the rear section of the vehicle. Sensor position tolerance ± 30 cm.

The data readout and recording should be performed using a low-pass filter with a minimum value of 25 Hz, with a sampling frequency of 2.56 times the filter frequency.

7. Summary

Poland, implementing the EU guidelines for reducing the number of road accidents and casualties, introduced in its internal regulations the requirements for the carriage of loads by N2, N3, O3 and O4 category vehicles. These regulations apply to load securing devices and the structure of the cargo space.

The state regulations on the technical conditions of vehicles and the scope of their necessary equipment list the PN-EN 12642 standard as a criterion for evaluating the above-mentioned vehicles in terms of cargo transport safety. The above-mentioned standard regulates the technical characteristics of vehicles and elements of equipment used in vehicles for the immobilization of loads and the methods of their testing. The research can be carried out statically and dynamically. The dynamic method better reflects the real conditions and forces to which the loads are subjected and the way they affect the load-bearing elements of the cargo space (walls). In order to conduct the tests, due to the possibility of the vehicle (or a combination of vehicles) overturning, it was necessary to develop a universal, easily attached support axle.

As a result of the research work, the support axle and the necessary measurement system recording the test conditions were developed and manufactured.

The equipment made and tests with its use have shown that it is an appropriate tool for the safe testing of all elements of the vehicle body structure and fastening devices. During dynamic tests subjecting the vehicle to lateral acceleration caused by the change of the vehicle's direction of movement - the turning test, it was found that the support was effective in preventing the vehicle from overturning during such tests. This confirms the functionality of the developed support for vehicle testing for compliance with PN-EN 12642 standard.

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