

## Load securing

# Transport and carrying of equipment on road transport

(Translation from Russian original)

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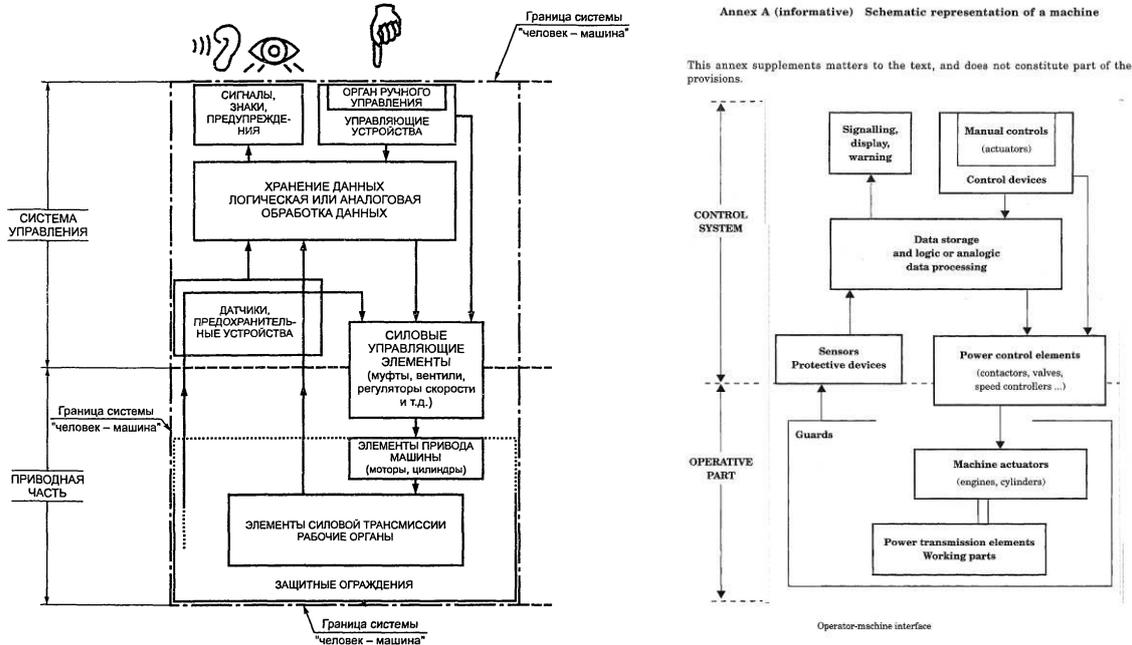
*Many lawyers distinguish the concepts of “transportation” and “carrying” and even “transportation” and “transporting”. From the legal point of view it is possible to reveal some distinctions and nuances, but for the purpose of this article we will assume that all these concepts mean only one thing, i.e. the transfer of a cargo by means of a motor vehicle intended for transportation by public roads. First of all, I refer to the regulations of standard GOST 26653-90 “Preparation of general cargo for transportation. General requirements”.*

This Standard determines general requirements regarding general cargoes preparing for single- and multimodal transportation by sea, water, railway, motor or air transport.

The requirements of this standard should be considered while elaborating standards and technical conditions concerning packaging, marking, and transportation and storing for the products being prepared for transportation when planning and organizing cargo shipment, concluding export, import supply agreements and contracts.

Now let’s clarify what does “equipment” means and whether it can be categorized as “general cargo”. Intergovernmental standard GOST EN 1070-2003 Group T51 “Safety of equipment. Terms and definitions” is an identical text of European standard EN 1070-98 “Safety of machinery. Terms and definitions”. The standard was implemented as a Russian Federation national standard on the 1<sup>st</sup> of July 2004 by the Standardization and metrology State Committee of the Russian Federation Resolution No. 346-ср dd. 5<sup>th</sup> of December 2003.. There is another Intergovernmental standard – GOST ISO/TO 12100-1-2001 “Safety of equipment. Fundamentals, general maxims of designing. Part1. General terms, methods” (implemented by the State Standard Committee of the Russian Federation Resolution No. 199-ср dd. 23<sup>d</sup> of May 2002). This standard, comprising the authentic text of ISO/TO 12100-1-92 (EH 292-1-91), explains the basic requirements regarding the safety of equipment, necessary to comply with the European legislation, to design engineers, manufactures and other interested parties. Both standards give the following definitions with regard to the cargo in question:

3.4. **Equipment (machinery)** is a machine assembly fitted with or intended to be fitted with a drive system consisting of linked parts or components, at least one of which moves, and which are joined together for a specific application, in particular, for proceeding, manufacturing, moving or packaging purposes. The term “equipment (machinery)” also covers an assembly of machines which, in order to achieve the same end, are arranged and controlled so that they function as an integral whole.



Pic. 01 General schematic representation of a machine. Picture from Russian standard GOST ISO/TO 12100-1-2001 “Safety of equipment. Fundamentals, general maxims of designing. Part1. General terms, methods”

Schematic representation of a machine. Picture from ISO standard.

3.11. **Safety of machine** is the ability of a machine to fulfill its functions under conditions of intended use, and **to be transported**, installed, adjusted, operated, dismantled and utilized under designed use conditions according to the manufacturer’s instruction (and in some cases during prescribed time according to the maintenance manual) without injure or another health hazard (the sentence “to transported” is bold typed by me, A.Sh.)

3.14. Design of a machine is a sequence of operations including:

a) analysis of the very machine, taking into consideration all the stages of its life-cycle:

- 1) design;
- 2) **transportation** and putting into operation:
  - assembling;
  - mounting;
  - adjusting;
- 3) application (use):
  - setting, training/ programming or process of reset;
  - operation (work);
  - cleaning;
  - search for consequences of failures and damages;
  - maintenance;
- 4) decommissioning, dismantling, utilization;

b) working out a maintenance manual for all the aforesaid stages (excluding design) according to 5.5 GOST ISO/TO 12100-2 [2]. (See 3.11 GOST ISO/TO 12100-1.)

(Item 2 – word “transportation” again is bold typed by me, A.Sh. advisedly).

According to the above-stated, a machine must **have the ability to be transported** at the stage of designing, which should be reflected in the manufacturer's instruction or maintenance manual.

However the practice of our survey examinations proves that the equipment is rarely prepared for transportation, and transportation often ends up with cargo damage. Manufacturers' instructions often mislead shippers and carriers, sometimes no instructions are given at all. The situation shown in the photos below is bright example. The shipper and the carrier applied the securing plan provided by the shipper, but the transformer fell out of the vehicle in a thousand kilometers.

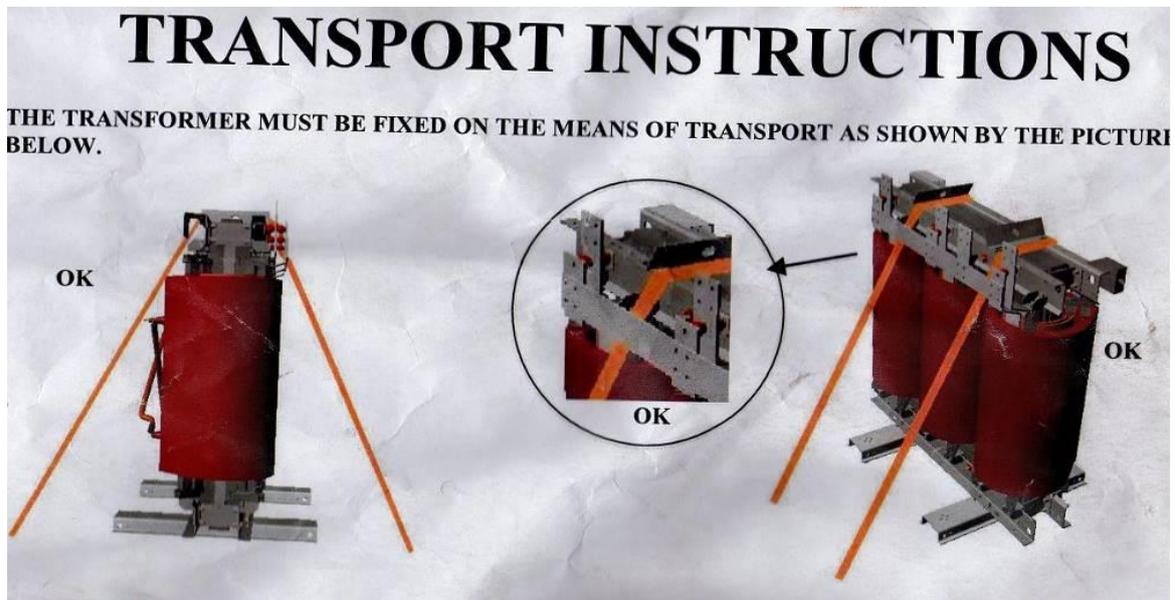
Here for further persuasiveness we give the very instruction where the manufacturer shows how exactly the transformer should be secured. But two straps has definitely nothing to do with the safe securing of such unstable cargo!



Pic. 02



Pic. 03

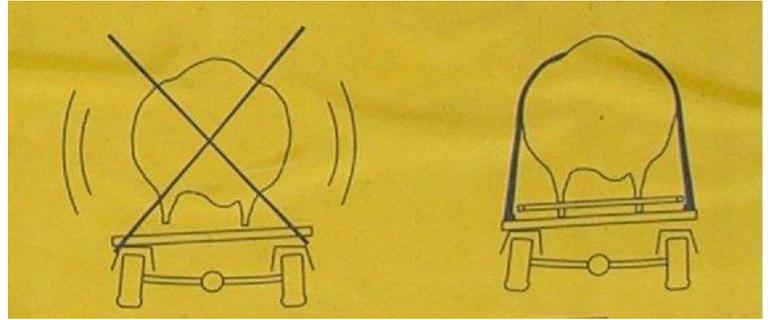


Pic. 04 Two hold-down belts for unstable cargo is not quite «OK» !

However, in most cases the manufacturers' instructions are simply ignored by the shipper, or applied in their own way.



Pic. 05



Pic. 06

For example, the following photos depict the case when a shipper was prohibited to apply hold-down securing, as it was directed by the marking, as it was considered that pressure might cause the damage of the tank. Another cause of the accident is the shifting of another cargo unit that was not prepared for transportation either, regardless the detailed description was provided in the maintenance manual accompanying the cargo.

Undoubtedly, in the course of transportation equipment has to be considered general cargo, therefore let's recollect the primary statements of the standard GOST 26653-90 "Preparation of general cargoes for transportation. General requirements".

Preparation of the cargo for transportation must ensure:

- The safety of cargo, motor vehicle and environment along the full course of transportation;
- Maximum utilization of vehicle and hoisting devices load-carrying and (or) cargo capacity under the condition of obligatory ensuring of the cargo safety and the transportation security;
- Necessary strength of the cargo packing for stacking and re-loading operations;
- The convenience of cargo operations, securing, loading into vehicles and storage at warehouses.



Pic. 07



Pic. 08

According to the requirements of GOST 1.5, the requirement concerning cargo packing, conditions and features of transportation; methods and means of cargo packages consolidation should be stated in normative-technical documents, section "Packaging, marking, transportation and storing", for each particular type of cargo.

As an example, I cite a standard for equipment where the requirements of GOST 26653-90 "Preparation of general cargo for transportation. General requirements" were fulfilled. It is the

standard GOST 2468681 (CT SEV 1923-79) “Equipment for electronic engineering and electrical engineering and electronics production. General technical requirements”, including the required chapter: “4. Marking, packaging, transportation and storing”. I will cite a few extracts having principled meaning in our case:

4.10. The packaging of equipment and its component parts must ensure the safety of equipment and its component parts, instruments, accessories and accompanying operational documentation against physical damages and deleterious effect of atmospheric factors in the course of transportation.

4.11. Oil, coolant and other technological liquids must be removed prior to the packaging and transporting.

4.12. All mobile equipment parts must be set in such position as to have the least overall dimensions, and in this very position must be secured by elements of packing (wood poles, elastic shock-absorbing elements of rubber, felt etc.) or must be set in such position (by means of stops, catches, locking devices etc.) in order to exclude spontaneous moving of mobile parts.

4.13. The tare and package must ensure the safety of equipment in the course transportation, considering possible transshipments, multimodal transportation, and climatic conditions.

4.14. It is recommended to pack spare parts, instrument and accessories, making up a set with the equipment in package of persistent storage (cases, covers, packing boxes).

4.18. The equipment as a whole or separate assembly units and their parts must be adapted for loading and transportation by motor, railway, aircraft or water transport.

Evidently, a carrier has all the reasons to expect that the cargo presented for carrying (transportation) is duly prepared to ensure safe conveyance.



*Pic. 09*

Shippers, in their turn, impose most strict requirements to cargo storing and transportation.

Very often high-performance sensitive equipment must under no circumstances be exposed to the influence of forces exceeding certain values during transportation or storing; e.g. acceleration along the x-, y-, z-axes, tilts, as well as influence of temperature and humidity.

The control of these transport conditions requirements execution is carried out by means of special recording devices attached to the vehicle, package or to the equipment itself.

Color indicator-sensors attached to the package changing color under certain temperature, humidity conditions, angles of tilt or under the influence of certain forces are another type of devices (though less effective) intended to control the fulfillment of transport conditions by carrier.



Pic. 10 Tilting Indicator



Pic. 11 Shock Indicator



Pic. 12 Tilt Indicator

We can talk endlessly that it is the shipper who is responsible for the correct loading and securing of the cargo, but we often come across the situation when shippers just do not realize what can happen with the cargo during transportation. And carrier is the only party that knows exactly what forces and hazards can cargo and vehicle be subjected to during transportation and can explain it to consignor.

Some cases are indeed ridiculous. The photos below bring us back to the year 2002. The carrier delivered an empty container to a Belarusian manufacturer for loading. The workers, who were accomplishing the loading, did not consider some forces; they asked the driver how it was better to load. Following the “smartest” driver’s instructions, 80% of the weight was loaded on a 3-m area by the front wall of the container, and the remaining parts of equipment were straddled along the side walls. Only by a pure fluke nothing happened during road transportation, although there were no obstacles to the shifting of cargo inside the container. During the transshipping in Hamburg loading terminal sensors determined inadmissible declination of container center of gravity. The extra expenses (for repacking, reloading, and securing) exceeded 7 thousand euro.



Pic. 13



Pic. 14

Thus, the situations, when a cargo is not prepared for transportation, and when no sufficient transport instructions were provided by a manufacturer, are quite widely-spread.

Cargo is prone to self-destruction under the influence of vibrational loads. Very often consignees claim huge amounts of loss even due to small visible physical damages referring to possible inner concealed damages and/ or the uniqueness of equipment and the absence of spare parts.

The carrying (transportation) along the roads of Russian Federation have typical features:

1. The prolonged effect of vibrational loads due to the bad quality of roads, which often causes the weakening and deformation of CTU (cargo transport unit) itself, because of the slacking of screw joints and/ or destruction of welding joints, as well as the weakening of securing (primarily, hold-down-belts)



*Pic. 15 Self-destruction of stand*



*Pic. 16 Destruction of the equipment legs*

2. Long duration of carrying (transportation) without possibility to open a sealed trailer for a check and further control of the securing.

Very often the cargo falls out of a vehicle after 1000 or even 500 kilometers after departure from the place of loading.



*Pic. 17*



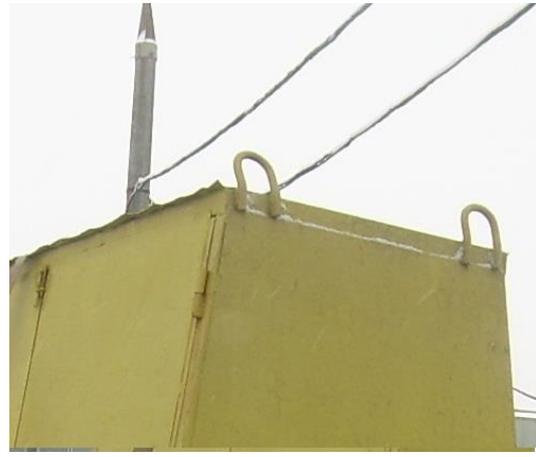
*Pic. 18*

Investigations showed that in 80% cases the cargo was secured by means of hold-down belts, which, in my opinion, was absolutely inadmissible for carrying (transporting) equipment. Our drivers, not even having a clue of the existence of other means of securing, continue using hold-down securing (with all its disadvantages) in insufficient quantity. For some reason, it is

commonly accepted that if there are 24 securing points for 12 hold-down belts, those 12 belts are enough to ensure the stability and safety of a cargo with a weight equal to the maximum carrying capacity.



*Pic. 19*



*Pic. 20*

The last photo was made at the end of winter this year. Moscow, Pokhodny passage to Volokolamsk highway gates. Before my very eyes the cargo shifted from one board to board at turns. And it is when the equipment had 4 spare securing points for applying direct lashing!

Due to the high-density traffic my car was pinned to this motor vehicle, and I was recalling Ryazan, 2005, with horror, when a transformer fell from a truck onto a bus. Ten years passed after this terrible tragedy, and no one learned anything...



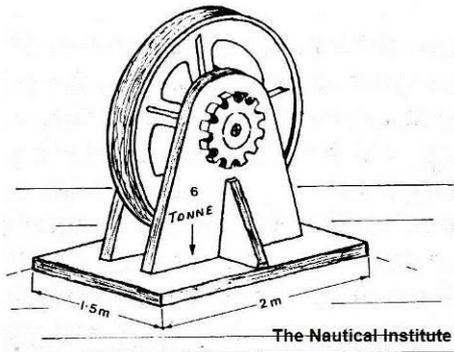
*Pic. 21*



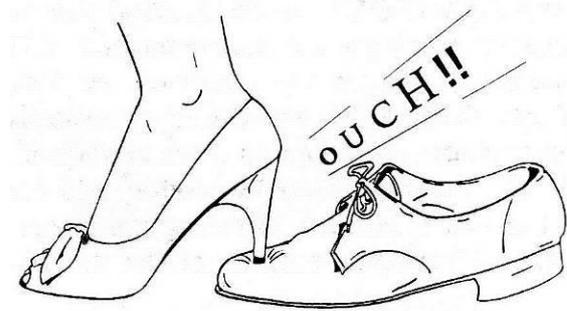
*Pic. 22*

To ensure safe and secure carrying it is necessary:

1. To sweep thoroughly the floor of the trailer, disposing it of garbage, ice and snow (if a trailer is open);
2. To increase the friction ratio by all available means. The best measure is to use special rubber gaskets providing a friction ratio not less than 0,6;
3. To distribute the load of equipment legs in order to avoid the damage of flooring and falling of equipment.



Pic. 23



The Nautical Institute

Pic. 24



Pic. 25



Pic. 26 The deck is broken by the leg of equipment. It looks like feminine heel, isn't it?

Compare:

- A 6 t winch with on a base, size: 1,5 x 2 m (3 m<sup>2</sup>), gives a load of 2 t/ m<sup>2</sup> on the deck;
- A 60 kg lady wearing evening shoes with the heel 50 mm<sup>2</sup> (0,00005 m<sup>2</sup>), stepping on your boot while dancing with all her weight on one heel imposes a load of 1200 t/ m<sup>2</sup>. That is why our ladies are 600 times more dangerous than machines transported by us!

And while there is nothing you can do in the situation with a lady, but silently endure the pain; putting several boards of appropriate size under the legs of equipment to distribute the load evenly is something that can be done and something a driver has the right to request during the loading.



Pic. 27



Pic. 28

4. To request a shipper to indicate anchorage points and to secure cargo units by direct lashing and/ or by any other means excluding the possibility of cargo shifting.
5. Blocking is another important mean of securing. However, it is necessary to remember that blocking presumes direct contact of cargo unit with a blocking element, which in turn can also damage cargo. Even tiniest scratches can have most serious consequences.

### Direct lashing

In my opinion, it is the most effective method of expensive equipment securing, which can provide complete immobility of a cargo unit. This method demands anchorage points both in the body of vehicle and on the cargo.

It should be borne on mind, that direct lashing involves calculation based on working load (LC) of a belt (see photo above) instead of tension force (STF). Direct lashing will only start working when a shift is already occurring, so there is no need to tighten a belt to its maximum, “hauling the slack” would be enough. A belt works only at one direction so there must be four of them. One has to calculate the horizontal and vertical projections of working load of a belt (LC). That is why it is very important to measure the lashing angles – vertical  $\alpha$  and horizontal  $\beta$ .

Sometimes one of angles can equal 0. For example, in the case of diagonal lashing a horizontal angle  $\beta$  equals 0; and in the case with horizontal lashing angle  $\alpha$  equals 0.

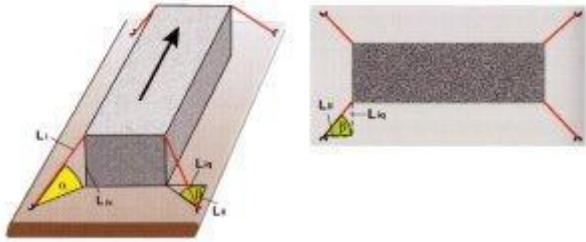


Pic. 29

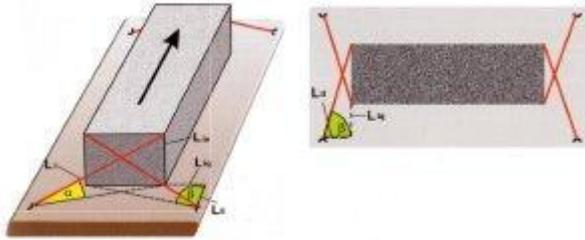


Pic. 30

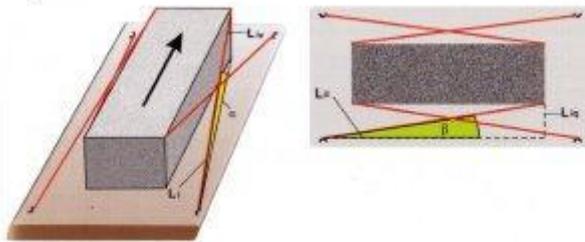
Вариант 1



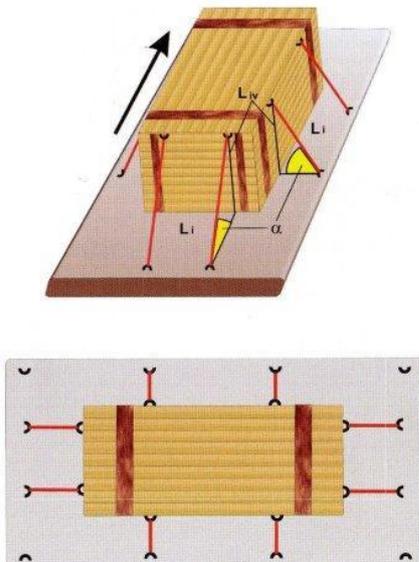
Вариант 2



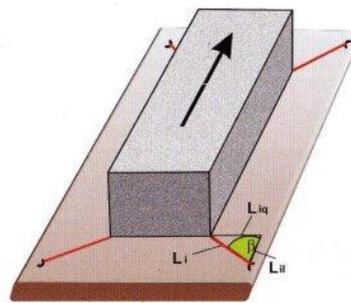
Вариант 3



Pic. 31 Variants of lashing



Pic. 32 Inclined lashings



Pic. 33 Horizontal lashing

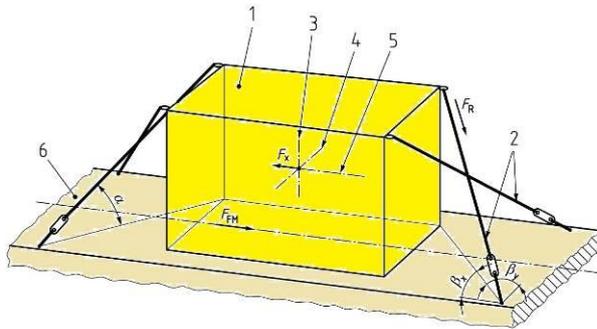


Figure 8 — Diagonal lashing of a load

**Key**

- 1 load
- 2 lashing device
- 3 vertical axis
- 4 transverse axis
- 5 longitudinal axis
- 6 loading plane

The equation for calculating the restraining force  $F_R$  is:

$$F_R = m \times g \frac{(c_{x,y} - \mu \times f_{\mu} \times c_z)}{2 (\cos \alpha \times \cos \beta_{x,y} + \mu \times f_{\mu} \times \sin \alpha)}$$

Pic. 32 Cargo stability condition is calculated in accordance with the standard EN 12195-1, where:

- $m$  cargo weight
- $g$  acceleration of gravity 9,81 m/c2
- $c_{x,y,z}$  inertial forces acceleration coefficients for road transport ( $C_x=0,8$ ;  $C_y=0,5$ ;  $C_z=1,0$ )
- $\mu$  friction coefficient
- $\alpha$  vertical angle,
- $\beta_x$  longitudinal horizontal angle
- $\beta_y$  transverse horizontal angle

The necessary calculations can easily plunge the vast majority into awe and despair: a common driver, they say, would never manage it. However, I could witness a dispute between a German policeman and a Belgian driver myself, when the driver with a calculator proved that his securing was sufficient. Knowledge is power, quite available to a driver.

The primary thing to remember is that longitudinal horizontal vectors of belts' working load (LC) must exceed the difference between longitudinal inertial force and opposing it friction force. The same comes for transverse loads.

This article is not a manual; therefore I will not impart many methods and modes of calculation. There are programs, tables, multiple devices allowing roughly estimate the necessary securing within a few seconds.

For example, Dolezych calculation circle allows calculating the necessary securing really fast. The Russian variant of the calculation circle is shown on the picture; the translation leaves much to be desired though. It is accepted that the majority of belts are installed at vertical angles  $\alpha$  from 20 to 65 degrees and horizontal angles  $\beta$  – between 6 and 55.

Since all securing means are designed with the working load values (LC) of certain resolution (1000, 2000, 2500 daN etc.), it also simplifies the calculations and application of the devices.

Placing the window with the cargo weight at a required value (in this case 10 t, simplification again), we see that four direct lashings with working load of 10000 daN each with friction constant 0,2 (chains) and only 2000 daN (ordinary belts) at friction constant 0,6, are enough.



Pic. 33 Calculation circle of Company DOLEZYCH

There are many devices like this circle. Every other security means manufacturer has their own shticks. Setting off to a long trip with the certainty that under no circumstances anything would break loose inside a trailer, and that expensive equipment would remain intact, is much easier.

At sea it is often said, “The better fixed – the less tossed!” In an Australian instruction for drivers I once came across a sentence: “The better fixed – the calmer road!” For everyone. Are we worse than the Australians?

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