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IMPROVEMENT OF DANGEROUS GOODS TRANSPORTATION TECHNOLOGY AND REDUCING THE ACCIDENTS

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Analysis of transportation of dangerous goods capacity according to different kinds of transport characterizes demands, while transporting dangerous goods, development degree of the process and describes organizational means, for the purpose of scientifically motivated process of transportation of dangerous goods. It is noted that the solution of transport technology problems is based on the improvement of technological supply, the rational usage of informational modelling methodology of the whole transportation process. The main possibilities to reduce accident probability and to raise transportation safety are described. The summaries of regulations describe the main duties of the Consignor, Sender, the Carrier or Driver under the various Regulations and the ADR (European Inter-State) Rules.

Keywords: *dangerous goods, technology, transportation, accident*

1. Introduction

Dangerous goods include explosives, gases, flammable solids or substances, oxidising and toxic substances, radioactive materials, acrid materials and hazardous waste. It is impossible to do without dangerous materials for most branches of industry.

The transportation of dangerous goods is one of the most complicated spheres of transport and the one that requires the most safety measures because if there is an accident, dangerous goods can get into the environment and cause grave consequences.

In every day life from the viewpoint of road safety, the vehicle, which carries dangerous goods, is treated the same as every other mean of transport. It is not asked for any particular safety requirements. However, during vehicle crash or traffic accident, despite subsequence, which has every vehicle crash, adds after-effect when dangerous load gets into surrounding environment. If during the biggest accident several or many people dies, several or many people are being injured, when during the vehicle crash the mean of transport, which carries dangerous load, hundreds or thousands of people can be killed or catch a disease. Besides, the consequences of traffic accident can't be evaluated at once, because the impact on human health and life may appear even after many years. It looks like after eliminating the consequences of vehicle crash, it can't be any effect of dangerous load spill to environment and directly to person. Though it isn't so. Even having up-to-date achievements in research technologies, it very hard to estimate, how deep dangerous substance affected the soil, whether reached and how hard ground water is polluted, the concentration of the dangerous substance in the soil after the spill. The devices may not notice all these affects in the air or water, but who can predict the dangerous substance's harm to plants, animals and eventually to the person?

There are regulations to deal with the carriage of dangerous goods, the purpose of which is to protect everyone either directly involved (such as consignors or carriers), or who might become involved (such as members of the emergency services and public). Regulations place duties upon everyone involved in the carriage of dangerous goods, to ensure that they know what they have to do to minimize the risk of incidents and guarantee an effective response.

The main task of my researches and the paper is to ensure safe transportation of dangerous goods, to manage and minimize risk of transportation of such cargo along the whole route by using the same technical measures and equipment.

An important part is grouping of dangerous goods according to transportation reliability criterion, the opportunity to assure service of customer independent of hazardous properties of transported goods [1].

Other analogical examples of dangerous goods grouping, may be listed but all of them have one disadvantage – they don't have the criterion, which complementary could describe characteristics of dangerous goods.

While analysing all types of grouping, it is easy to see that their nature is based on one criterion – danger.

Methodology of technological processes and the listing of dangerous goods grouping have a big practical benefit, organizing safe transportation of hazardous groups.

2. Principles of Grouping Dangerous Goods According to Danger Features

Organizing dangerous goods transportation and establishing informational-technological models, it is very important that the dangerous goods were distributed according to appropriate features. This may help to gather concrete information for separate parameters of transportation process.

Characteristics of dangerous goods transportation may be:

- Physical-chemical properties of transported materials;
- Running parameters of containers and packages;
- Degree of danger;
- Conditions that describes specific properties of good.

Containers may be grouped according to different aspects: according to goods unit weight, goods clearance, according to technique of loading-unloading, according to possible ways to load a transport unit, transportation and storage conditions, protection and outside influence conditions. Otherwise a united system, according to which dangerous goods may be safely transported, can't be created according to this criterion. That's way in this chapter principals of grouping dangerous goods are offered, according to which optimal criterion way be selected, which will be used to establish the probability model of car-accidents and to create informational system.

Legislative basis of dangerous goods transportation, analysis of carriage extend characterizes the demand of dangerous goods transportation, degree of development and describes organizational-technical means, when seeking to organize scientifically reasoned process of dangerous goods transportation.

While transporting dangerous goods it is important to insure safety, so that not bigger than minimal danger will be reached. Minimal danger – it is danger, which could be avoided while transporting dangerous goods or in the case of the accident efficiency of working people is not harmed, technical means, buildings and road are not damaged, environment is not polluted. To insure safety of transportation and to select means, primary it is necessary to investigate factors, which has influence to danger of transportation. Organizing transportation of dangerous goods, it is necessary to consider such factors:

- Technology of transportation process,
- Interaction with other ways of transportation,
- Selection of technical means,
- Estimation of courses,
- Permission to goods transportation system,
- Transportation control,
- Elimination of accident results.

All these factors depend on informational supply.

The danger of transportation is determined by three main elements of dangerous goods transportation: capacity of transportation, course of transportation and technology of transportation. Each of these elements has influence on danger of transportation, their parameters and various qualitative and quantitative compatibility features show their level and degree. It is advisable to arrange transportation danger according to degree of danger, which is determinedly choosing and estimating technological transportation processes. In this way we estimate danger degree of transportation, as mathematical expected loss magnitude, which can increase, while transporting dangerous goods [2, 3].

3. Selection of Parameters for Statistical Models

While analyzing a system of dangerous goods transportation by road transport, it is necessary to bring definition of traffic accident, as one of the basic terms in the theory of dangerous goods transportation. Such term can be used solving particular problems, as one of them: selection of exploitation parameters for specialized means of transport, estimation degree of danger and parameters of goods according to used technological processes, optimal organizational motivation of transportation process and etc. Analytical solution of these problems is complicated because of formalization of

dangerous goods transportation processes and assignment of experimental researches ask for plenty of time and finance or practically these problems are not solvable. That's way it is advisable to use mathematical modelling methods for dangerous goods transportation processes. Created models can be basis of scientifically based methodic, which lets:

- To estimate exploitation parameters, which probability of traffic accident depends on and regulations which can diminish this probability;
- To offer typical prophylactic means and to estimate their effectiveness;
- To evaluate probability of traffic accident this may happen depending on class of good.

The following improvement of methodology, estimating the probability of traffic accident, are used to find all and each optimal element parameters of transportation process, safest course of dangerous goods transportation.

According to methodology which is being created according to statistical models, the model of traffic accident is the most important, because it lets to estimate the probability of its appearance. For practical realization of estimation of traffic accidents probability it is necessary to estimate and classify parameters, which have influence on traffic accident probability. Conditionally we can divide parameters into 6 groups (table 1).

While gathering statistics of traffic accidents, it is necessary to notice every parameter, type of vehicle and type of dangerous goods.

Table 1. Parameters which have influence on traffic accidents probability

1.	Parameters of dangerous goods: type of goods, which shows its dangerous properties; physical state of goods.
2.	Operating parameters of vehicles, means of mechanisms of loading-unloading operations, containers and packages, equipment of goods storage. Technical means of transport, loading-unloading operation mechanisms, containers and packages, parameters of equipment for goods storage (possible load, capacity, obstruction of dust and damp and etc.). Usage of other equipment.
3.	Technological parameters: distances of transportation; time of the day; number of unloadings; conditions of storage; composite loading with other dangerous and not dangerous goods.
4.	Parameters of road traffic: speed of traffic, special transportation service (accompaniment of goods, underlying train, "green street" and alike.); specialization and signs of danger, intensity of traffic; sort of road.
5.	Parameters, which characterize drivers and operational personnel: professional classification, state of health, experience in working with dangerous goods, special training.
6.	Parameters, which characterize surrounding environment: climate conditions, meteorology; character of course.

4. Safety Requirements for the Transportation of Dangerous Goods

Keeping experience in mind, the following safety requirements for dangerous goods transportation could be emphasized:

- Tunnels: limit transportation through tunnels.
- Routes: routes should be selected according to the situation, because there are some roads where transportation, without having a special permission, of dangerous goods is forbidden, if roads are not fitted for the transportation of dangerous goods. General statement indicates that dangerous goods should not be transported close to the habitable areas.
- Bad weather conditions: when visibility on the roads is bad, it is raining, snowing or foggy, the transportation of dangerous goods in major cases should be forbidden. Bad weather conditions are when visibility is less than 200 meters. Some dangerous materials should not be transported, when roads are slippery.
- Ferries: special requirements for the carriage by ferries should be set down. Corresponding ferriage requirements should be applied for every means of the transport, which carries dangerous goods. In some cases the ferriage of dangerous goods should be forbidden.

Effective and safe dangerous goods transportation is possible only by good provision of information [4].

Every two years computer variants for international transportation of dangerous goods by roads (ADR) and railways (RID) are already prepared, also regulation requirements for dangerous goods transportation by international roads are fitted for the transportation inside the country, requirements for dangerous goods transportation control are prepared for inspectors, according to the EU directives and other work. This work enables to improve the transportation process and to create an information system.

It describes the necessity of creating methodological basics for safer and more perfect transportation of dangerous goods.

5. The Main Requirement for Packing Dangerous Goods

Dangerous goods must be properly packed into a suitable container. Container must be credibly closed. The dangerous goods should be protected from any outside influence during transportation. If the transportation circumstances are normal, the package should be protected against vibration, temperature variations, pressure variations and moisture. There are the least marginal amounts of dangerous goods transportation. If the current amount does not exceed the marginal amount, the goods are considered as not dangerous. However, even the goods of the least marginal amount must be kept separated from any other packages. This requirement is applied to all known and new packages too.

Packing part, which has a direct contact with dangerous material, must be protected against chemical or any other influence of this dangerous material. If necessary, the packing surface must be covered with special materials, which prevent it from any chemical influence.

Every packing must have a design. If the container contents liquid, there should be enough free space. This requirement is valid for a container of any capacity. Liquid expands when heating and there coming gas out which can damage the normal package. The amount of these spaces (if necessary) is set to any material and it is calculating in every specification of material. However, the main requirement is – that the material must not fill the free space fully on +55⁰C. The inside packing of different packages has to be packed that they shouldn't be exposed, makes itself holes, should not allow the liquid to be spread outside. Inside packages should be protected by outside packing, because it is made of porcelain, glass, ceramics or plastics. Any leak from inside packing material should not damage outside packing carpet.

Dangerous goods could not be packed or kept closely to each other, because this contact can cause a dangerous reaction. Also it cannot be kept or packed with other innocuous goods. If the material can transform itself physical existence in particular conditions, it should be kept as any chemical reactions should not damage that physical existence. However, if the liquid can extricate harmful gas, there should be a special ventilator in a package, which could protect the package from an absolute damage. This package system is forbidden on air transport.

If the packing has been remade (has been installed or exchanged new facilities), this packing should be tried by following the primary requirements. Before loading such packages for transportation we make sure, that it has not been damaged by corrosion or damaged by any other way. If we detect that the resistance features have fallen down or the design has changed, we should stop using this packing and restore it until it gets primary features. However, after this repair we should check the design and attest it works properly. Liquids can be packed into packages, which can keep particular pressure of a normal transportation circumstances only. The liquid cannot spread outside of packing.

The empty packages, where dangerous goods have been packed, should be called than filled of the same dangerous goods. There are the same requirements for empty package as for full one. The main requirement for empty and unwashed containers: they must have the same safety features than full ones and make sure there is as little ability to leak or crumble away as possible.

Experimentations for leaking of packages are made:

- before the first transportation;
- after repair and technical changes.

In order to make the experiments, packing must have installed closing devices

Packages, which are used to heavy materials transportation, should pass the requirements of packages of liquids transportation if it can change itself physical existence from heavy to liquid material in some temperatures.

6. The Regulations of Balance of Safety and Economy

All packages must be made and tested by quality requirements of insurance program, which is made and ratified by competent government, which make sure that production and experiments would be made by recommendation rulebook. In this recommendation the main requirements for packages are claimed, because technological science is making new packages, which requires another testing condition. However, the safety requirements must be the same anytime: packages must be as save as possible and damage must be as little as possible then we use the least production expenditure.

In order to warrant the maximum safety we can recommend to pack it into the packages, which are suitable for explosives or radioactive materials. By this way there would not be such term as “dangerous

goods". Also there would not be "dangerous" goods, because all kinds of materials should be packed good enough to be not damaged on the biggest emergency (except explosives and radioactive materials). However, the packages would cost much more than goods cost. By this way nobody would buy goods, it would cost too much. With a view to make economical efficiency, the recommendations introduce safety provisions, which let to reduce production expenditure for dangerous goods packing. For example, Sweden national testing and researching institute is researching for as cheaper as possible material, which pass requirements of recommendations. This institute (expect the scientific researches) performs packages testing (primary and permanent) for Sweden and foreign countries producers. The company is testing and trying examples, before starting the new kind of packages production. If experiments are successful, they start production of packages. Besides, these packages are marked by United Nations sign.

7. Managing the Risks from Dangerous Goods and Reducing the Accidents

Managing dangerous goods involves:

- identifying dangerous goods and site classification;
- providing information, training and supervision in evacuation and fire fighting procedures;
- controlling ignition sources such as naked lights, sparks and mobile phones where flammable atmospheres may exist;
- segregating incompatible goods;
- separating dangerous goods from 'protected places';
- spills management;
- selection, provision and maintenance of safety equipment and personal protective equipment;
- placarding of sites with dangerous goods in packages stored or handled above the prescribed quantities;
- displaying a clearly visible information placard on tanks holding more than 500L of LPG or 450L of other classes of stated dangerous goods and combustible liquids;
- using documented safety management systems;
- keeping unused storage or handling systems clean and safe.

To avoid the possibility of an explosion or the emission of toxic flammable or corrosive gases:

- store two incompatible goods at least 3 m apart.
- where the goods could react violently, store them at least 5 m apart.
- consider storing some goods (especially highly pyrophoric or unstable goods e.g. Class 4.2 or 5.2) in separate fire rated enclosures or separate buildings with appropriate fire suppression equipment.
- separate enclosures or buildings may also be required for those goods with special fire suppression requirements (e.g. Class 4.3 goods react adversely with water).

8. Regulations for the Transport of Dangerous Goods

Regulations exist throughout the world to ensure the safe transport of dangerous goods, whether by road, rail, sea, or air. These are mostly based on the UN Recommendations, and are enforced by the Governments of individual States [5]. For Road Transport Regulations, the main responsibilities of the various parties are generally as follows:

The Consignor or Sender, must:

- Correctly identify the goods;
- Package the goods correctly;
- Label the packages;
- Provide the documents and declarations.

The Carrier or Vehicle Operator must:

- Use a suitable vehicle;
- Provide the vehicle equipment;
- Mark the vehicle;
- Provide the driver with documentation for the journey.

The Driver must:

- Ensure that the cargo is correctly stowed;

- Maintain the vehicle marks;
- Keep the documents available for the Emergency Services;
- Carry out checks during the journey;
- Supervise the vehicle and load during stops;
- Take the correct action in an emergency situation.

9. Conclusions

1. Factors of transportation insecurity, principles and methods of grouping dangerous goods according to danger features, selection of parameters for statistical models enables to differentiate all the requirements and to collect fundamental information for the carriage of dangerous goods.

2. For supply of no emergency transportation of dangerous goods an effective developed examination transportation process and methodology of management is needed. For this purpose it is necessary to go from partial, though gross problems, to complex solutions of problems.

3. In order to ship dangerous goods we must take into account and estimate these main aspects:

- the technical base of type of transport;
- length of the road;
- the cost of the shipment;
- chemical properties of the material and its quantity;
- the preparedness and knowledge base of the staff;
- route;
- climate conditions;
- the level of probable damage.

4. Only full understanding and wide knowledge will allow to safely and economically ship dangerous goods which will not cause danger.

5. The risk assessment gives an opportunity for carriers to choose the main transportation criteria, flexibility, to use alternative using the risk assessment it is possible to reduce accident probability and to raise transportation safety.

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