

# Safety of railway transport of dangerous cargo

**Dragutin Jovanović**

University „Adriatik“, Montenegro, The Faculty for traffic, communication and logistics, Budva, gutajov@gmail.com

**Zoran Ž. Avramović**

Pan-European University „Apeiron“, Banjaluka, Republic of Serpska, Bosnia and Herzegovina, zoran.z.avramovic@apeiron-edu.eu

**Siniša Arsić**

Belgrade Politehnika, Belgrade, Serbia, sinisaars@telekom.rs

**Miloš Arsić**

Faculty of Maritime Academic Studies, Belgrade, Serbia, misaarsa@yahoo.com

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**Abstract:** By railway, according to its technological characteristics, the respective amounts of dangerous cargo are being transported. Numerous hazards for people, assets and environment during the dangerous railway cargo transport processes, are expressed in the case of an extraordinary case or any other mismanagement, where the transport becomes risky, but the same risk is an opportunity for improvements if it's recognized on the way and measures are defined and established for its management. For achieving safety goals within transport of dangerous cargo, it means minimizing the number of extraordinary circumstances and overall consequences with undisturbed transport process support, it's necessary to manage and to work constantly on the safety improvements. In the safety management process, the whole railroad staff must take part according to the work duties, responsibilities and competences.

**Keywords:** dangerous cargo, railway, transport, safety, management.

## INTRODUCTION

The transport, or, dangerous cargo transport by railway, from one place to another, which takes action through continuous realization of actions, is usually linked, using mutual transport means (truck and tow vehicles and overhaul mechanics) people and railway communication – track and following infrastructure elements. The transport process takes action in three phases: dangerous cargo preparation for sender, dangerous cargo transport and dangerous cargo dispatch for recipient. In the process of dangerous cargo preparation by sender, packer, loader, filler and containers tank user/portable tanks, the person who takes part in this process is entitled as lighterman. The role of other participants in the process of transport is, also significant, but their role is less complex.

The dangerous cargo transport should be observed with its input (dangerous cargo intended for transporting, transport means, equipment, information, people and other and with its output (dangerous cargo transport service realization) [1].

Also, transport of dangerous cargo by railway can be observed like a service, or, like an aspect of logistics service. The transport process itself is, both according to the International classification of goods and services<sup>1</sup>

and United Nations methodology<sup>2</sup>, separated as an individual type of service.

Dangerous cargo can be transported by railway only under the conditions that are defined by Annex A and B, RID [7], respecting the requirements of the dangerous goods transport law [8] and laws brought by this law. All dangerous goods transport activities process by railway are planned and realized; to be able to ensure that transport service is realized with all of its value elements and needed safety level.

In the railway traffic, about 16% of dangerous goods are being transported. According to statistic data, most part of the dangerous cargo consists of flammable liquid substances, about 70% of the total dangerous cargo transport volume. It is expected from railway and other subjects also, to transport dangerous cargo with secured maximum safety level for people, infrastructure, environment and the dangerous cargo itself as well. The fulfillment is possible with qualitative and consistent dangerous cargo safety management. In overall management, processes should include all members according to their competences and roles [4].

<sup>1</sup> (Alphabetic list) in which is given the classifying of each good or service. Following that way, transport services are classified into **Class 39: The Transport services**, packing and storage of goods, route organization.

<sup>2</sup> World organization for intellectual property protection designed the International classification of goods and services, in which list of unique goods and services

## THE DANGEROUS CARGO TRANSPORT BY RAILWAY THE PROCESS WITH INCREASED RISK

It is needed to define criteria of classification, to be able to define conditions for safe transport of dangerous cargo, and, also to determine potential hazards of dangerous substance. Those criteria are in Recommendations of the United Nations for the Dangerous Goods Transport (UN RTDG)<sup>3</sup>.

In general, (the term) risk can be defined as certain exposure to functioning of factors whose activity can cause unexpected consequence. The main definition of the OH & S risk is that OH & S risk is a probability of occurrence of a dangerous event' combination, or exposure, and serious injuries(health vulnerability), which can be caused by a dangerous act or exposure (quotation: standard SRPS BS OHSAS 18001:2008). There is a clear need for different technical or organizational solutions, to enable its reduction, to a level where it can be controlled and managed with ease.

Essentially, risk is defined as a product of probability of a future event, and the consequence weight of that event. The probability and consequences can be qualitatively and quantitative evaluated by using proper methods. So, the Law on safety and health on work defines risk as „a probability of injury emerging, disease and health damage of employees due to danger...“, but the SRPS OHS standard defines it as „a probability measure and potentially dangerous event consequence...“.

The risk included with dangerous cargo transport by railway represents the combination of extraordinary event emerging probability, or, accident with damaging consequences for human lives and general health, economic assets (mobile – transport railway capacity and infrastructure) and the environment. During the dangerous railway cargo transport, the possibility of emerging of an extraordinary event, with large consequences impose the need of professional and ecological risk management.

In the dangerous cargo transport, observed from the aspect of jeopardizing members of transport process, reflects in injuries or death of people, directly linked with the dangerous cargo transport and where such injury requires immediate intensive medical intervention, longer stay in hospital and incompetence for future work. Observed by the aspect of assets and life environment, jeopardizing reflects in damaging of transport capacities, infrastructure and life environment, directly linked with the dangerous cargo transport, where such kind of damage requires larger material investments and longer halt in the unfolding of dangerous cargo transport.



Figure 1. Disaster events during transport of hazardous materials [12]

During the transport of dangerous cargo by railway, extraordinary events with all aforementioned threats, are followed by numerous costs such as: the cost of damaged or lost dangerous cargo or costs linked with damage compensation- to the mismanaged environment, or eventually with injured persons, and all of those involved in transport process. Eventual damage for transport capacity, infrastructure and life environment is also the linked to extraordinary events by dangerous cargo transporting by railway, picture number 1.

The risk in the dangerous cargo transport simply exists and its very appearance does not mean something bad – it is real, but in the most cases, it can be avoided. The risk as well means the opportunity for improving if it is discovered on time, determined and defined with ways of measuring and being able to manage it. Instead, it is needed to take into account the fact that full risk elimination is not possible, or even necessary.

The professional risk evaluation and risk from the extraordinary event by dangerous cargo transporting, enables the establishment of preventive measures and action lines for minimization the probability of accident occurrence and its eventual consequences.

The numerous potential dangers per people, assets and environment are especially expressed in the case of an extraordinary event or any other omission during the process of unfolding the dangerous cargo transport by railway. The omissions are possible due to every single disrespect which arises from avoiding international and national regulations, where safe transport of dangerous cargo by railway is defined. All of this makes the dangerous cargo transport process too risky.

The tendency itself for the risk minimization of the extraordinary event and the dangerous cargo safety transport by railway, impose a large number of limitations to all transport process members that is determined by rules and conditional procedure.

<sup>3</sup>United Nations Recommendations on Transport of Dangerous Goods, Model Regulations

For the correct defining the dangerous cargo safety by railway, it must begin from the dangerous cargo safety transport basics of the railway traffic. Having in mind the general aim of traffic safety, the dangerous cargo transport specifics and possible safety risks during its unfolding, it can be said that the general goal of the dangerous cargo transport by railway is minimization of bad effects and ensuring security of undisturbed unfolding of dangerous cargo transport. If the dangerous cargo transport subject is narrowed, then the goal also can be narrowed on minimum effects of consequences of extraordinary events. The dangerous cargo safety transport by railway, defined like this, can be achieved by: extraordinary events number minimization and reduction of consequences, and also the professional training of all transport process members for the dangerous cargo treatment.

The transport and dangerous cargo manipulation, significantly, is different from the procedures with other types of cargo. The consequences of the extraordinary events point out that there is a need to do risk evaluation in the case of some dangerous cargo transport. The main rule is that the dangerous cargo transport is forbidden, unless it does not unfold under conditions which are correctly determined by national legal regulation or confirmed international agreements. It can be concluded that dangerous cargo transport process cannot be unfolded without knowing the conditions according to which it is possible.

From these reasons, it can be concluded that there is a clear need for all transport process members to be trained for jobs carried on a daily basis, which is predicted by the legislative prescription.

## **SAFETY MANAGEMENT OF DANGEROUS TRANSPORT BY RAILWAY**

Transport safety of dangerous cargo by railway, means the dangerous cargo transport service performance. The dangerous cargo safety transport can be and must be managed. Under dangerous cargo safety management by railway it implies the process of planning, organization and controlling and safety transport activities improvement and using the available (secured) activities.

In regard that the safety transport process is conditioned by way of individual activities from all members of the transport process, mismanagement parameters can be avoided by following its required procedure.

Those are the parameters-elements, in its basis, otherwise, safety factors. Having in mind the nature and specificity of the dangerous cargo transport process, defined parameters in such a way can serve as the main lever for transport management safety.

The requirement fulfillment for the realization of main and elemental dangerous cargo transport process

activities, which are relevant for the dangerous cargo transport area given in sources [7,8], it can be used for the dangerous cargo safety transport parameters management. So it can be singled out separately:

- classification, entrance and dangerous cargo transport according to RID,
- security of necessary documents,
- usage of allowed and suitable packaging for the dangerous cargo transport,
- correct packaging marking with dangerous cargo,
- requirement adherence about the shipping method and limitations by dangerous cargo shipping,
- correct marking of loaded driving and transport means by the danger leaflets, orange boards and necessary markings, picture number 2.
- visual checking of obvious driving deficiencies, transport means or dangerous cargo,
- fulfillment requirement checking refers to packaging, loading, discharge and manipulation,
- conditions respect of joint loading ban,
- checking of the permissible car load,
- prescribed equipment existing in the cab engineer,
- driving staff notice checking about loaded dangerous cargo and its position in train,
- entrance goods no delay without forced reasons,
- do not start loading until the suitable measures are undertaken to eradicate shortcomings and irregularities,
- checking, before or during discharge, if packaging, tanks, vehicle or containers are damaged in a way that could jeopardize the discharge procedure,
- accordance checking of unloaded dangerous cargo with quotes in the transport documents,
- discharge checking of eventual damaged packaging, cargo and rolling stock,
- dangerous substance displacement that arrive, during discharge, on the exterior side of vehicle or container,
- valve checking for closing after the tank discharge, hatch control, closing seal of empty and uncleaned tanks,
- prescribed cleaning safety and decontamination wagon and container,
- removal safety or leaflets danger covering, orange tables and necessary markings by empty and cleaned wagon and container.

Disturbance of above mentioned parameters that is not fulfilling of prescribed and determined necessary requirements jeopardize the dangerous cargo transport safety by railway, but also the need for proper safety management.

Railroad management has to plan and manage processes and goals, which are needed for the **constant improvement** of safety in dangerous cargo transport. It must constantly be improved, in terms of system efficiency, by using goals for safety, checking all results of conducting transport activities and processes, data analysis, corrective and preventive measures and reconsideration of responsible persons.

Constant dangerous safety transport improvement lies in gradual conducting process of improving and determination of it's effectively. The dangerous cargo safety transport improvements by railway are often random and unplanned, the result are urgent measures for problem removal during the transport, as a reaction on the appearance of danger, which should be prevented to ensure safety storage. Those are not real and essential dangerous cargo safety transport improvements, just only performance safety returns, in the expected-needed stain. It would be desirable to do plans of preventive and corrective measures.

The dangerous cargo safety transport management starts by projection and use of necessary **preventive measures** that should be result of adequate safety risk management, picture number 3. [5].

The preventive measures must take action because of potential deviation risk removing that jeopardizes safety in order to prevent its appearance. It must suit to the consequences of potential problems. The possible jeopardizing of dangerous cargo safety transport by railway, which can arise because of danger substance nature, as a subject of transport or because of the very transport process characteristics.

The reporting probability, character effect and ex-quisiteness regarding the risk prevention of dangerous cargo transport safety can be taking into account during the process of planning and preventive measures design.

The potential for jeopardizing of transport safety are all those actions which did not occur. The potential determination for endangering is embedded in the search for transport process characteristics.

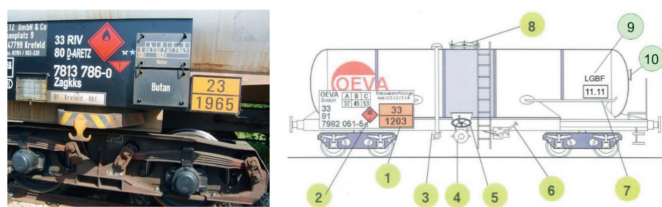


Figure 2. Marking of vehicles with dangerous cargo in the function of safe transport

The potential jeopardizing determination includes analysis and risk evaluation. During the need for determination of possible preventive measures, one should evaluate existing mechanisms for realization of transport

process. And, on these basics, its evaluation should determine the requirements for certain measure of prevention all threats to safe transport.

The preventive measure for the control of potential jeopardizing dangerous cargo transport safety can be insight of transport planning or certain activities, warnings (alarms) – distracting attention on the possible jeopardizing, changing of persons behavior included in transport realization and similar. The railway infrastructure characteristics and other elements of environment can be the cause of endangered transport activities, and there is a need for change and intervention.

The efficiency of the conducted preventive measures must be examined, by determining its efficiency, in order to prevent all threats to safety of dangerous cargo transport. The reconsideration of conducted preventive measures should be realized through the following next steps:

- determine reconsideration of measures that are undertaken,
- evaluation as a result of determination, if the preventive measures are conducted in the most suitable way,
- to determine if the threat of dangerous cargo safety transport has appeared after applied preventive measures.

The persons responsible for the transport realization process must manage **corrective measures** because of the root of dangerous cargo safety transport disturbance, to be able to prevent its repetition. The corrective measures must respond to be applied to the base threat of safe transport of dangerous cargo.

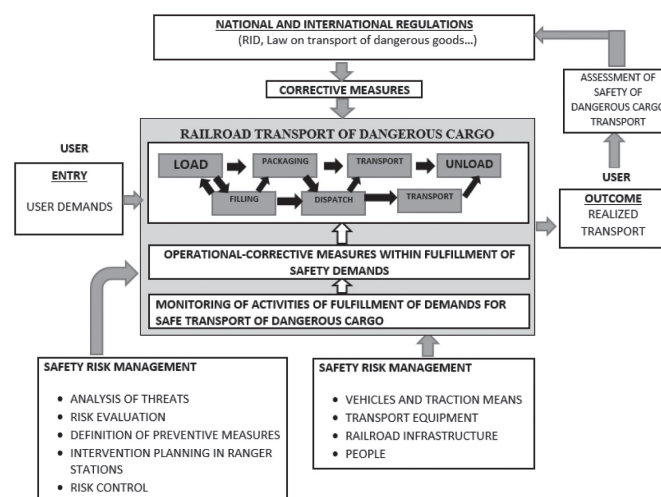


Figure 3. Safety management of railway transport of dangerous cargo [5]

The corrective measures should be followed by symptoms of jeopardized dangerous cargo transport safety problems until its cause, to give solutions for pre-

vention of repeated menace appearance. The corrective measure provides reverse connection in the transport management cycle.

If the transport threats to safety do appear, it also often guides directly to the system problem. In that case, the problem should be stopped by added or repeated training and education, by changing the realization path of transport activities and similar.

The data about factors which threaten transport can be collected and analyzed in terms of transport safety process revelation. Each threat to safety has its causes and reasons of emerging. The cause detection and its operation within dangerous cargo safety transport are very important for the removal of existing and potential prevention of threats.

The dangerous cargo safety transport threat is identified – uncovered during monitoring and transport control process. When the root problem for transport safety is determined, solution can be proposed – enforced corrective measures for consequences removal, and prevention of it reoccurring.

When a large number of cases threatening dangerous cargo transport appear, or the safety is endangered with significant number of transport process activities, such potential dangers should be ranked along the way, for example, according to its causes, so they can be revealed and explained, and eventually that they can be solved.

The endanger transport cause revelation is of vital interest for the selection and management of corrective measures. In principle, two types of separated corrective measures should be undertaken:

- measures for safety removal of threats and
- measures for prevention of the repeated appearance of threats to safety.

After revelation that threats to safety can occur during the transport process realization, it indicates to omissions of members –process decision makers, as well as indirect executors. It also proposes corrective measures which should be applied, in regard of transport process specifics and potential dangers and possible risks against safety.

In the end, one should examine the effects of all corrective measures conducted with the goal of eradicating all threats, and determine if the desired results are achieved at the end. The corrective measures are effective when, after a period of time, whether they are not recorded again.

The reconsideration of effectiveness of measures should be realized through several steps:

- reconsideration because of redetermining which corrective measures should be undertaken,
- evaluation in terms of determining if corrective measures are conducted in the best way and
- determination if threats to dangerous cargo transport occur again after applied corrective measures.

The state of safety conditions is analyzed and evaluated, with observation in which measure requirements are respected that reveal from national and international regulation. Based on the conducted analysis results, the eventual weakness is determined and the necessary corrective managerial measures are defined, that should bring to stain dangerous cargo safety improvement.

In the dangerous cargo safety system management by railway, special attention should be dedicated to prevention with the goal of avoiding danger and possible consequences. So observed preventive means that management risk is not completely avoidable and inevitably exist like a constant follower of all activities. The dangerous cargo process transport by railway are followed by risks connected with the source of dangers per health and workers life on the railway (professional risks) and dangers from the extraordinary event in the traffic, chemical accident, fire and explosions (ecological risks).

The danger existence means that real risks are existing from human jeopardizing, material goods and life environment, during the dangerous cargo transport. Before the process of transport, it should evaluate risks and determine protective preventive measures, and the measures of readiness also, respond to the extraordinary event and recovery of its consequences, from the aspect of all determined dangers. These activities mean essential management risks principles. In principle, the management risk is consisted of the analysis and risk control, where analysis should involve the danger analysis, risk evaluation, decision making process about risk acceptance and preventive measures prescription [9].

The risk control, should involve use of: preventive measures, readiness measures and response to extraordinary events and measures for the removal of extraordinary events, circumstances (recoveries), during the dangerous cargo transport by railway. It requires design of the proper protection plans, before initialization of transport activities, which should involve the use of all necessary measures for risk suppression or its reduction to minimum acceptable level.

The readiness can be defined as reached preparation stain of all transport process members, from sender to receiver, because of proper answer undertaking on the extraordinary events by minimal consequences.

The extraordinary event answer formed during the dangerous cargo transport by railway, should include a certain assemblage of measures and procedures, which should be further elaborated by proper protection plans.

In formation of a response to the extraordinary event, the following must be done: the extraordinary event volume evaluation and its consequences, constant jeopardized space observation establishment and conducting necessary measurements, precise and complete notification about extraordinary event by giving concrete instructions about next treatment, giving elements for the decision making process about necessary treat-

ment, proper professional service work coordination and competent authorities informing on the higher level.

Measures and procedures arise from the conducted analysis basics, and risk evaluation is deducted from extraordinary event and its circumstances. The proposed measures and procedures, according to the protection plan, should stop and isolate the emerging of a dangerous process during an extraordinary event, or limit its effects, minimize consequences and create conditions for contained post accident situation following recovery of the environment.

## THE TRAIN IN DANGEROUS CARGO SAFETY TRANSPORT IMPROVING BY RAILWAY

The goal of organization of railway transport of dangerous cargo is directed at constant improvement of transport safety. It includes work capacity of workers on the railway, and it can be under influence of external and internal factors. Also, it involves changes on the transport market service, transport technologies, international regulations and requirement of transport users. These changes can be requested by railroad officials, to analyze their needs connected with training process.

The dangerous cargo safety transport by railroad can be achieved, with minimization of number of extraordinary events and its consequences, or by increasing the professional training member's level in transport process for treatment of dangerous cargo.

During the dangerous cargo transport by railway, certain irregularities are possible to occur, and in a certain way, these fall to the responsibility of the staff – persons employed on the railway such as:

- staff in the exploitation process who are directly involved in the dangerous cargo transport (engineers, maneuvers and similar),
- staff responsible for control of technical safety of cars, which are using the dangerous cargo transport,
- staff responsible for management and conducting of cars and maneuvers service, such as railway infrastructure staff management (carriages, trainees, operational service officers, telecommunications officers and similar).

The aforementioned staff must be capable to answer to requirements for transport of dangerous cargo is imposing within its work duties, responsibilities and competences. The staff should strive to possess necessary skills, habits, but also the knowledge, which should be reached in the first place. The knowledge and skills are directed to concrete tasks and by basic (and supplementary) training for safe transport of dangerous cargo. It means that the staff must be trained, on a proper manner, for all regulations requirements to be fulfilled, and by regulating the transport of dangerous cargo, by railway, where on that base, safety parameters are defined.

The proper training is one of the possible preventive measures in line. The SRPS ISO 10015:2002 standard gives the frame for choosing appropriate training as an effective way of giving answer to the needs for improvement of transport safety, as in figure4.

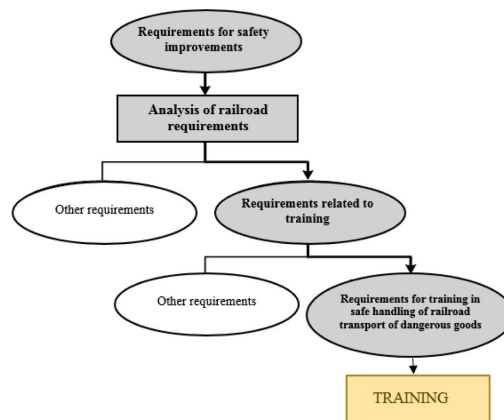


Figure 4. Improvement of safety by education

Through the education system, personnel employed on the railroad acquires general knowledge about transport of dangerous cargo, but only through training system skills necessary for dangerous cargo transport concrete tasks implementation. The training should provide increasing of individual knowledge, skills and problem understanding of dangerous cargo transport to the individuals and its safety.

The training process must be planned and systematically thought, to be able to give proper contribution to the railway. For improving its abilities and to achieve its goals in the sphere of dangerous cargo transport, and for the needs of conduction of such training, a general training model can be used, as displayed in figure 5.



Figure 5. Basic training phases

The railway organization must, according to specifics and dangerous cargo transport requirements to define needs for training, projects and plans training, be conducted on the proper way and evaluate the results of its training at the end.

In the appropriate chapter of RID, basic and supplementary themes are defined, which include elements linked with knowledge of dangerous cargo transport,

depending on workplace specificities<sup>4</sup>. Besides that, personnel must be trained to recognize risks and a danger which lies within dangerous cargo transport, in case of an extraordinary event during the transport process realization, for it can bring lots of bad things to human safety, assets and life environment.

The persons like sender and the railway infrastructure manager must be trained additionally, through basic and supplementary training, according to the railway traffic characteristics.

Amendments in regulations inevitably require re-education and refreshment of knowledge through certain courses. In the process of training, special attention must be directed to the case when dangerous cargo is being transported with high potential danger<sup>5</sup>. Persons, who participate in the dangerous cargo transport with high potential danger, must be capable for conducting and usage of safety plans, whose content is defined in point 1.10.3.2.2 of RID.

Certain persons, who work on the railroad station must be trained with urgent interventions planning, coordinated work, so the consequences for human lives and the environment are reduced to the minimum possible measure.

## CONCLUSION

In railroad traffic, a respective quantity of dangerous cargo is transported every day. Transport of dangerous cargo is a very complex process and it is significantly different from other types of cargo transport. It follows the possibility of an extraordinary event to occur, with inconspicuous consequences for human lives and the environment, which can put a lot of risk on the transport process.

The primary goal of safe transport of dangerous cargo must be to achieve orderly conduct with maximum level of safety for human beings, assets and the environment. To accomplish such a goal within transport management establishment, safety imposes as a vital transport service performance.

For dangerous cargo, basic parameters of safety in transport management should be prescribed, foreseen and required for all members of the process, and at the same time, they represent vital safety factors.

The large number of missions, which threaten transport safety, as a consequence of hierarchy failure within

management structure, they are tightly connected to the disrespect of requirements defined in relevant international and national regulation documents, which imposes conclusion about proper need for training of all transport process members. The training should be projected to ensure proper training, where the outcome disconnected to the requirements of dangerous cargo transport imposes in the frame of some work obligations, responsibilities and competence transport process member's competence.

The safe transport of dangerous cargo requires that all railroad personnel possess knowledge and skills, acquired by basic and supplementary training, and that they are directed at concrete tasks to ensure dangerous cargo transport. The training is realized in such a way that railroad personnel acquire abilities for correct and safe conduct, during the dangerous cargo transport realization.

With maximum engagement of all dangerous cargo transport members by railway, railroad professional staff and railroad infrastructure manager staff- on tracking, application and prescribed requirements fulfillment, all in the mentioned chain can expect satisfactory results when questioning transport safety.

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<sup>4</sup> Depending on possible dangers that might bring to injuries and damages, as an extraordinary event with consequences for dangerous cargo transport, employees must be trained about the risks and dangers that come with dangerous cargo, with the goal of dangerous cargo safety manipulation and measures in any case of escalation.

<sup>5</sup> Under the term „dangerous cargo“, with high potential of hazard, are all goods which are used in terroristic actions that might bring to the serious consequences such as the loss of human lives or massive destructions, or especially in the case of radioactive substances- massive social-economic destructions (subchapter 1.10.3 RID)