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Managing the Environmental Risks of Dangerous Goods Warehouses

Veszélyesáru-raktárak környezeti kockázatainak kezelése

Industrial accidents occurring at logistics facilities used for the storage of dangerous goods can have, as a result of contaminated water generated during fires, major environmental consequences to the surface and ground waters. In the present study, the author presents the causes and effects of major industrial accidents that may occur in logistics warehouses used for the storage of dangerous goods, as well as the interpretation of the series of serious accident events. Then he examines the design of facilities for the collection and storage of contaminated fire water.

Keywords: dangerous goods' logistics, industrial accidents, environmental damages, firewater pollution

A veszélyes anyagok tárolására szolgáló logisztikai létesítményekben bekövetkező ipari balesetek, tüzek oltásánál keletkezett szennyezett oltóvíz a felszíni és felszín alatti vizekbe vagy a talajba kerülve jelentős környezeti károkat okozhatnak. Jelen tanulmányban a szerző bemutatja a veszélyes áruk tárolására szolgáló logisztikai raktárbázisban esetlegesen bekövetkező súlyos ipari balesetek okait, hatásait, illetve a súlyos baleseti eseménysorainak értelmezését. Ezt követően foglalkozik a szennyezett oltóvíz felfogására és tárolására szolgáló létesítmények kialakításának vizsgálatával.

Kulcsszavak: veszélyesáru-logisztika, ipari balesetek, környezeti károk, oltóvíz-szennyezés

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1. Introduction

There have been a number of serious industrial accidents involving dangerous substances around the world, often with fatal consequences, which have spread beyond the site and have had a catastrophic effect on both surface and groundwater. In Hungary, the analysis of the processes of such serious accidents, as well as the scientific examination of the application of prevention and emergency response measures, are still pending. The scientifically appropriate solution of the research problem is the domestic application of the recommendations of the methodological guide *Safety Guidelines and Good Practice for the Management and Retention of Firefighting Water*² developed by the United Nations Economic Commission for Europe.

In this article, my objective is to analyse the environmental risks posed by logistics warehouses for the storage of dangerous goods. In the course of my research, I used publicly available international and domestic literature, legislation related to the topic, and internal regulations containing disaster management procedures. Furthermore, I consulted with renowned experts in the fields of water quality, industrial safety, disaster management and remediation, as well as operators of dangerous establishments, whose opinions I took into account when writing this article.

2. General characterisation of dangerous goods warehouses

The most common locations for dangerous substances and dangerous goods are plants manufacturing, storing, processing dangerous substances and transporting dangerous goods. As a general rule, logistics facilities for the transport of dangerous goods are not subject to the regulation of major accidents involving dangerous goods. Among the plant facilities used for the transport of dangerous goods by road, we have in mind the dangerous goods storage bases in which dangerous goods with special packaging are stored. Railway transport operating facilities are mainly railway marshalling yards. Inland waterway transport facilities include the loading, unloading and storage facilities of dangerous substances plants, as well as ports handling dangerous goods. In the case of air transport preparation facilities, the dangerous goods warehouses located in the airport area can be identified primarily.

In this article I will deal with industrial, agricultural and commercial facilities used for the storage of dangerous substances and dangerous goods; these facilities can be logistical warehouses for the storage of dangerous substances, or warehouses for raw materials, semi-finished products or finished products that process, store or manufacture dangerous substances.

² *Safety Guidelines and Good Practices for the Management and Retention of firefighting water*, UN Economic Commission for Europe. Geneva, 2019.

3. Analysis of major industrial accident scenarios during storage of dangerous substances

Risk assessment is the comprehensive process of the identification, analysis, and assessment of risk. In the course of risk identification the potential risks in the area concerned and their effects have to be defined. The procedure also includes the identification of danger sources as well. In the course of the procedure the statistical data of the area examined, historical data, empirical facts and the results of the available risk analyses carried out earlier shall be considered.

There are basically three types of major accident events in logistics warehouses: the dusting of solids caused by the packaging of dangerous goods, the effects of liquids from the packaging of dangerous goods, and the effects of toxic combustion products and unburned dangerous substances in the event of a fire. The specific course of major accident sequences depends primarily on the properties of the dangerous substances and the composition of the mixtures of these substances. The identification of mixtures of dangerous substances can be a professional and scientific problem in several cases.

3.1. Examination of the quantitative and qualitative properties of dangerous substances stored in warehouses

A common feature of logistics organisations engaged in the storage of dangerous goods is that the quantity and type of dangerous goods in their territory are controlled by the legislation on the prevention of major industrial accidents; this legislation may change at any time. Therefore, the safety documentation (safety analysis and report) prepared for the industrial safety authorisation of dangerous activities should provide a high degree of flexibility in the quantity and quality of dangerous substances and allow for adaptation to continuous change. In addition to the qualitative analysis of dangerous goods stored in dangerous goods logistics warehouses, their quantitative data must also be determined. The amount of dangerous substances stored depends primarily on the manner, shape, and vulnerability of storage and packaging. Storage tanks containing liquid dangerous substances may release dangerous substances into the environment in quantities appropriate to the size of the tanks and the conditions of discharge. In case of damage to the collection package (pallet) consisting of unit packages, the amount of escaping material depends on the design and nature of the package and may exceed the maximum weight of the collection package.³

³ *Guidelines for quantitative risk assessment – CPR 18E*, Publication Series on Dangerous Substances (PGS 3). Ministry for Housing, Spatial Planning and the Environment (VROM). The Hague, October 1997.

3.2. Investigation of the consequences and effects of warehouse fires

The major accidents involving dangerous substances usually occur at process equipment, storing equipment, pipelines, loading and unloading installations, or during transportation of dangerous substances within the establishment. Modelling the consequences of a major accident requires input data such as physical and chemical properties of dangerous substances (flammability, toxicity etc.), emission potential (heat radiation, overpressure) releasing properties (quantity, state of aggregation etc.) and weather conditions.⁴ The results of this model calculation is specified in terms of seriousness of the (potential) effect. Potential effect is usually expressed in terms of risk to health in the safety reports, although relative damages to property or environment can also be specified.

The risk analysis of the dangerous establishment must cover the following important elements: a detailed description of the internal and external prerequisites (causes) and probability of occurrence of possible major accident scenarios; evaluation of the seriousness and possible consequences of the identified major accident hazards; description of the technical prerequisites and the applied equipment that are necessary for safe operation of the dangerous establishments; the emergency responses for mitigation of consequences of major accidents.⁵

In the case of fires in warehouses of dangerous goods, the most significant event endangering the environment is the release of toxic substances and combustion products. This can pose a serious environmental risk.

In the event of storage fires, various adverse effects on human health and the environment are to be expected. These dangerous substances, based on their flammable and / or toxic properties, may include: the toxic effect of the release of the toxic dangerous substance; the formation of a fire following the release of flammable substances and the effect of toxic combustion products in a fire which causes a serious accident. The latter can have both air and water pollution effects.

In case of fire, mainly due to the effect of heat radiation, plastic containers may be damaged, as a result of which toxic material may be released into the open air. Furthermore, toxic substances released under high temperature conditions evaporate faster, so their consequences for human health can have a more severe toxic effect than the release of dangerous substances under normal storage conditions.

In the event of an extensive storage fire, arsenic, sulfur, nitrogen, chlorine, fluorine, as well as toxic combustion products from bromine atoms will release such as arsenic oxide, sulfur dioxide, nitrogen dioxide, hydrochloric acid gas, hydrogen fluoride, or hydrogen bromide. Emissions of toxic combustion products generated by storage fires are expected to cause severe air and water pollution, and pose a direct threat to the facility's environment, including surface and groundwater. Examining this is one of the most important professional tasks for operators.

⁴ *Guidance on the preparation of a safety report to meet the requirements of directive 96/82/EC as amended by directive 2003/105/EC (SEVESO II)*. IPSC, 2005, 39.

⁵ Gergő Erces and Gyula Vass, 'Veszélyes ipari üzemek tűzvédelme ipari üzemek fenntartható tűzbiztonságának fejlesztési lehetőségei a komplex tűzvédelem tekintetében', *Műszaki Katonai Közlöny* 28, no 4 (2018), 2–22.

Dangerous goods generated during fires in dangerous goods and logistics warehouses can escape and pollute the environment of the site in several ways. According to the guidance used in the United Kingdom, these are: 'directly through the site's rainwater and leachate drainage system; by the discharge of the dangerous substance directly into the surface water in the vicinity of the installation or through the leakage of groundwater directly into the ground; through the sewage system or the sewage treatment plant; spreading in air, for example by evaporation.'⁶

3.3. Safety barriers to reduce the effects of extinguishing water

Identification of major accident scenarios creates connection between hazard identification and risk analysis in the form of model accident scenarios. We can use the model major accident scenarios to assess compliance of emergency measures (safety barriers), and to create emergency plans and land-use plans. The scenarios are usually based on supposition of incidents resulting in emission of dangerous substances. The major accident sequence in the safety report usually describes the way (technical nature) how dangerous substances are released; it can be a fracture of a tank, a pipeline, or leakage of a vessel containing dangerous substances. It also specifies the effect of the caused incident such as fire, explosion and release of dangerous substances (emission to the environment). The types of sequences resulting in release of dangerous substances are the following: pool fire; flash fire; tank fire; jet flame; VCE (explosion of evaporating steam gas cloud); propagation of a toxic cloud; BLEVE (expanding vapour explosion of a boiling liquid); pollution of soil, air and water.⁷

Contaminated fire-fighting water has a detrimental effect on the environment in the medium and long term. Remediation of the area requires significant efforts from both the operator and the authorities, especially if it has already infiltrated surface waters or soil layers. International documents clearly set out the remediation tasks to be performed by operators and its technical requirements, including the collection, storage, treatment and disposal of contaminated extinguishing water. It follows from the above that the best method of avoiding fire water pollution is the various protection structures, technical devices (technical locks), as well as the legal regulations and requirements ordering their mandatory application. In the next chapter, I will present the most typical international and domestic solutions related to their design and practical application.

⁶ *Managing fire water and major spillages: PPG18*, Environmental Alliance.

⁷ Béla Szakál and Zsolt Cimer, 'Major Disaster Recovery Plans', *Science For Population Protection* 6, no 1 (2014).

4. Investigation of the design of facilities for the collection and storage of contaminated extinguishing water

4.1. Requirements for the design of facilities and equipment for the prevention of extinguishing water pollution

The prevention of the harmful effects of potential environmental hazards can be interpreted in the framework of a complex system of tasks of technical protection, the aim of which is to reduce the probability and impact of an event.

Enforcement of the technical requirements for the capture of contaminated fire water is only one element of the regulation of the construction and use of modern dangerous substances and goods warehouses. The requirements for the storage of modern dangerous goods is based on the so-called 'VCI⁸ Guide to Chemicals Storage'⁹. The application of the VCI standards is recommended, inter alia, by the UNECE Guidelines as well, which set out basic design rules for the construction and use of storage facilities, for the storage of dangerous goods in the event of fire water pollution. In addition to the definition of storage classes, the VCI guide contains risk analysis procedures for the storage of dangerous goods, requirements for the introduction of general safety, health and fire protection measures, co-storage rules, information on dangerous substances (oxidising substances, pressurised gases, aerosols and gas cartridges, flammable liquids), specific safety measures, and so on. In addition, it lays down rules for the capture of contaminated extinguishing water, as well as ventilation and explosion protection requirements for flammable materials.¹⁰

The use of safety management systems is also essential for the operation of dangerous goods depots. In the chemical and dangerous goods logistics sectors, the Safety and Quality Assessment System (SQAS), established by the European Chemical Industry Association in the early 1990s, became widespread. The system, based on the association's recommendation, is excellent for the 'compliance' rating of logistics safety management systems for dangerous goods storage facilities. The SQAS evaluation system uses a standardised review procedure of about 600 questions, on the basis of which a detailed description of the given logistics base can be prepared. In the system, audit review questions are divided into several groups, which are: plant management system, chemical safety, occupational safety, environmental protection, safety engineering, design and operation inspection, physical safety, on-site inspection. In the remainder part of the study, I will examine the technical issues related to the perception of contaminated extinguishing water for the storage of dangerous substances and goods.

⁸ VCI is an abbreviation of the German Chemical Industry Association called 'Verband der Chemischen Industrie'.

⁹ *Leitfaden für die Zusammenlagerung von Chemikalien*. Verband der Chemischen Industrie e.V., Berlin, 2007.

¹⁰ György Sárosi, *Veszélyes áru raktárlogisztika – korszerű követelmények* (Budapest: Complex Kiadó, 2006).

4.2. Design of facilities for the collection and storage of contaminated fire water

Dangerous material storage systems can be divided into two groups: primary (operational) and secondary (emergency) storage. Primary storage includes emergency storage systems that are applicable as a mobile device for non-emergency situations. These can be stormwater storages, solid surface car parks, ditches, pools, mobile tanks and tank cars. In addition to the above, soaking materials, suitable absorbents, sealing means and material for damaged containers and piping, as well as mobile closing devices for channels and shafts may be used. The guide also sets out rules for the design of secondary storage capacities where contaminated extinguishing water or spilled dangerous material can be collected. It can be local or remote. The local storage is called a lifeguard, which, if required by the consequence analysis, should also be scaled to accommodate the extinguishing water generated during a fire. Remote storage can be storage pools or underground and above-ground storage tanks. These facilities must be fitted with a shut-off valve or lock and, in the case of hydrocarbon storage, with an oil separator.

5. Conclusions

Eliminating the consequences of emergencies now poses an increasing challenge to the protection system as a whole, including professional and civil rescue organisations, different levels of defence administration, businesses and citizens alike.

The risks of storage of dangerous substances in Hungary (as well as abroad) occur in plants engaged in such activities, in facilities storing raw materials, semi-finished and finished products below the threshold. These can be storage facilities for the production, processing or mainly commercial purposes of dangerous goods, or logistics warehouses for dangerous goods. Events that occur during the manufacture and storage of dangerous substances begin with the release of substances that are harmful to the environment and health; this can result in fire or explosion. Fires in dangerous activities pose a threat to environmental elements in the form of toxic clouds of combustion and contaminated fire-fighting water containing harmful substances (combustion products). Extinguishing water pollution has environmental effects in the medium and long term, the elimination of which poses a significant task for both the operator and the authorities. Examining the series of serious accidents in logistics warehouses, it can be concluded that the series of events can be: toxic effects caused by the release of dangerous toxic substances, the formation of a fire following the release of flammable substances, and air and water pollution by toxic combustion products.

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