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INVESTIGATING DAMAGE EVENTS RELATED TO THE TRANSPORT OF DANGEROUS GASES

VESZÉLYES GÁZOK SZÁLLÍTÁSÁVAL KAPCSOLATOS KÁRESEMÉNYEK VIZSGÁLATA

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Abstract

In the article, I will present four different, dangerous-gas-related accidents that occurred in railway, road and partly industrial conditions. These accidents took place in Hungary or abroad, and are based on true events. I would argue that conclusions drawn from these tragic events confirm the significance of safety regulations applying to storing and transporting dangerous goods on the road in avoiding further accidents of this kind. I would also like to prove that an adequate public safety plan, including personal education and technical preparation, is equally important

Keywords: *dangerous goods, safety, accident, dangerous gases, case study*

Absztrakt

A cikkben bemutatok négy darab, veszélyes gázokhoz köthető közúti, vasúti és részben üzemi körülmények között bekövetkezett balesetet. Az ismertetett haváriák hazai és külföldi, valós eseteket dolgoznak fel, melyek tanulságaiból és az azokból levont következetésekből a veszélyes áru szállítás tárolási és szállítási biztonságát szeretném tovább erősíteni. Szeretném bebizonyítani a megfelelő védelmi tervek alkalmazásának szükségességét, valamint a személyi és technikai állomány felkészítésének fontosságát is.

Kulcsszavak: *veszélyes áru, biztonság, baleset, veszélyes gáz, esettanulmány*

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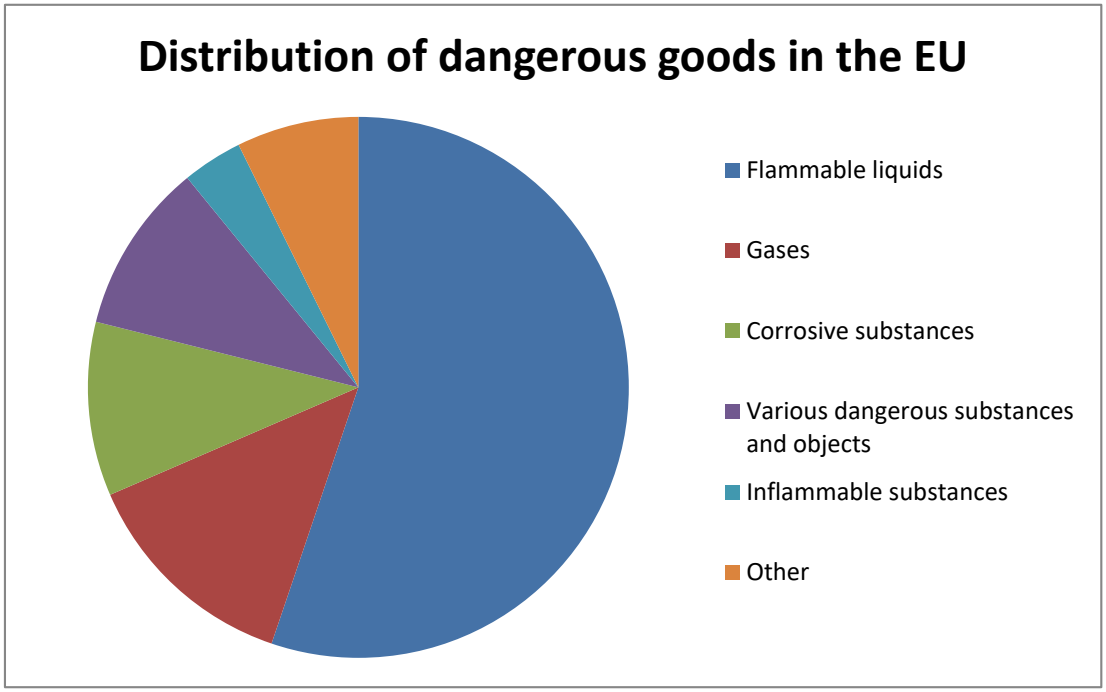
INTRODUCTION

Given the general characteristics of dangerous goods, dangerous gases constitute the second most transported substance group on EU roads. As mentioned in my previous article, 55% of all dangerous goods are flammable liquids, and 14% of this portion is made up by gases. As a result of this, accidents related to dangerous gases occur more often than those of any other types of dangerous goods. [1]



1. **figure** Distribution of dangerous goods within the European Union (Self-made Diagram Based on [1])

What is more, even the apparent results of the increasing green house effect are unable to stop the production of these dangerous gases on a massive scale because of the developing chemical industry creating high demands for them. [2]

Definitions of these dangerous gases differ from one another, and these diverging names are based on the aspects of examination of their components.

According to ADR and RID, gas is a substance with a vapour pressure of 300kPa at 50 °C and a completely gaseous state at normal pressure (101.3 kPa at 20 °C). This definition applies to clean or pure gases, gas mixes as well as mixtures of gases with one or more components. In other definitions, gas is built up by atoms and molecules moving randomly and "bumping into each other" in space. These molecules are expanding and their movement is dependent on temperature and pressure. [3]

GROUPING OF GASES

According to ADR's and RID's definition on gases, these substances can be grouped as follows:

- Compressed Gas: in wrapping for transportation under overpressure in in gaseous form, the critical temperature is at 50 degrees Celsius or below.
- Liquefied Gas: in wrapping for transportation under overpressure in a partly in liquid form; we have to distinguish high- or low-pressure liquid gas.
- Frozen Liquefied Gas: in wrapping for transportation at low temperature is partially in liquid form as a result of its low temperature

- Dissolved Gas: in wrapping for transportation under overpressure is dissolved in liquid phase solvent
- Aerosol Wrappings and Small Tanks Filled with Gas (gas cartridges)
- Other Objects Containing Excess Gas Under Overpressure
- Gases Without Overpressure, Regulated by Special Rules (gas samples)
- Chemicals Under Overpressure: liquid, paste or dust under pressure fuelled by a substance the definition of which equals that of compressed or liquefied gas and their mixture.
- Absorbed Gas: gas absorbed on a solid, porous substance with the containing tank's inner pressure less at 20 degrees Celsius than 101,3kPa and at 50 degrees than 300kPa.

Based on the characteristics of dangerousness, these gases can be divided further as laid out in the Agreement:

- *asphyxiant*
- *inflammatory*
- *F flammable*
- *T toxic*
- *TF toxic, flammable*
- *TC toxic, corrosive*
- *TO toxic, inflammatory*
- *TFC toxic, oxidative, corrosive*
- *TOC toxic, inflammatory, corrosive*

In the UN Sample Policy, the IMDG Code and the ICAO Technical Specification gases are proportioned according their main "danger characteristics" and are put into three subgroups:

- 2.1 subgroup: flammable gases (corresponds to gases belonging to group F)
- 2.2 subgroup: non-flammable, non-toxic gases (corresponds to gases of group A / O)
- 2.3 subgroup: toxic gases (corresponds to gases belonging to group T such as T, TF, TC, TO, TFC and TOC) [3]

In the following chapters, I will present Hungarian and foreign road accidents that are related to dangerous goods, especially to dangerous gases. And in which the process and approach of authorities show many differences from country to country. Chemical safety is a set of activities and institutions aimed at reducing and avoiding the risks damage the life cycle of chemical substances causes environment. [4]

In a dangerous goods factory or work it is necessary to invent safety measures to ensure proper operation. for example: moving machines, electronic devices, switchers, valves, pipelines, fittings, tanks, reactors, furnace, pressure-gauge control, renovation and maintenance. In a mean time it is essential to prepare the employment to danger, leakage, toxic cases and fire cases with the development of safety infrastructure. [5]

If there is a car accident on the road it is necessary to investigate the driver, the car/ lorry and the status of the road. Usually infrastructure development serves economic growth, but I think it is also important to highlight road safety too. [6]

Already a 45 year old British factory accident's minute book show an example that dangerous accidents can not be avoid 100%, but with proper preparation and measures the damage can be minimize / reduce. [7]

TOXIC GAS DOWNLOAD IN SZABOLCS-SZATMÁR-BEREG COUNTY (HU) [8]

On the 27th of July 2017. short after midday a call run into the emergency centre, according to that in between Komoró and Tiszabezdéd a tank car carrying UN 1040 etilen-oxid nitrogene called dangerous good, prostrated into a pit/ trench and the driver stuck in the lorry/ tank car driver's cabin. The fireman and disaster recovery unit arrived to the scene identifying the load of the truck by using safety equipment and gasmasks/scuba. The ambulance stated that the driver who was stuck in the driver's cabin is already dead. The police closed all the three road leading to the scene of the accident and the disaster recovery made a 300 metres safety zone plus they closed the area. The Romanian owner of the truck and the Austrian owner of the tank's Hungarian agent arrived on the scene, because of the carried dangerous good downloading a special equipment was needed a German technician group arrived to the scene as well. Using a gas sensor they have made a lot of measurements by proving that the disaster recovery measurement were right and the tank is not leaking.

Right after this the hoist of the disaster recovery get down the semi-trailer from the tank car so via this they were able to cut out the driver from the wreck. To the technical rescue the German chemical company's expert gave advice. The tank car left on scene got secured more by the police and the disaster recovery whilst the Mobile Chemical Laboratory of the disaster recovery made measurements to control the air. Until this they were waiting to the special equipment to arrive from Germany as well more experts. In the view of the dangerousness of the transported substance, the need of the special equipment to download and the download system on scene that has never happened before in Hungary they could finish the download and the washing of the tank car with inert gas in the evening of the fourth night from the accident.

In the damaged tank car 1860 kg of etilen-oxid remained, but they could not download that quantity without moving the tank car and risking the environment. Therefore they started burning this substance with the torching method so they released the gas- harmless- in the air. Towards this a special machine was brought to scene and got installed together so they could finish torching and burning all the substance on the ninth day.

Besides of the total road close , with help of a Hungarian company the damaged tank car got rinsed with an inert gas (nitrogene), and after the Romanian owner transported away. The wind up of the accident and road close got finished on the tenth day from the accident.

The main risk of the operation was that the transported dangerous good was toxic and had an explosive characteristic. Therefore the wind up of the accident commanded high caution. It was also a challenge that the special equipment it's installations to download the dangerous good neither was in Hungary nor the torching machine so the rescue team had to wait for that to arrive from Germany and it took a long time.

Professional and measured intervention plus the Hungarian Authorities the inland company and the foreign company co-working resulted that no dangerous substance got released in the air. Throughout the intervention no personal injury has happened.

Parallel to the damage control the competent disaster recovery made the review of the scene and made it's proceeding as result of the last one they did not find any failure by transport the dangerous good or anything that was against the ADR. [8]

2. figure Picture of the accident [8**]**

TANK CAR ACCIDENT ON A HUNGARIAN HIGH-WAY [8]

On the 10th of January 2016 on the M2 high-way tank car transporting deep-frozen liquid nitrogene run into /crashed into a personal car and as a result of that both vehicle fired. The fire partment of the disaster recovery authority turn off the flames of the fire and until the technician rescue they diverted the traffic by closing two lanes. The driver of the truck got carried away by the ambulance whilst the other driver died in the accident.

A company from the side upset tank car download the 10.000 l liquid nitrogen and until this operation the police and the disaster recovery authority secured the scene. The transported gas on low degree is in a liquid form and choky, therefore without any sign can cause suffocation. [8]

3. figure Pictures of the accident [8]

THE RELEASE OF A TOXIC GAS IN GERMANY [9, 10]

The accident happened on 29th of December 2005 in the commercial port of Stuttgart. Various vehicles arrive here with different dangerous waste. Most of the waste was handled in the facility of the port but some of it was transported away for further consumption. In the accident on employee died and six other got injured out of this two was the member of the rescue team and needed hospital treatment. According the data the cause of the accident was the leakage of hydrogene- sulphid while the tank car was filled/ uploaded by liquid waste (purely sinthesized hydrogene- sulphid is an achromatic, see through, extremely stinky gas and has a toxic effect to the human body). [10]

The forklift operator who nearby died in the accident because of the toxic impact of the hydrogene-sulphid. The fire department has not measured any concentration of dangerous gas in the air therefore they have left the scene of the accident. The police secured the scene and they ordered the pipe for downloading the continent of the tank cars to be downdraught. As they restarted the sucking pump immediately dangerous substances started to leak from the download aperture. Therefore the driver of the truck/lorry collapsed so they finished the downloading and they called the ambulance/ emergency and the fire department to the scene. According to the tests what the expert made the reason why the toxic gas formed was that the liquid waste reacted with a hydrogene-sulphid. As the organic sulphur was mixed with the organic compound hydrogene- sulphid released. The previous measures that was made by the company was not enough to prevent the accident even the employee who made the upload was not prepared for a sudden action. There was no plan or measure to neutralize the released gases. Because of the accident the police started a crime investigation. as a result of the accident the previous practice got finished and from that point the operator transport away the dangerous waste to another plant to further treatment and that is not happening in the trucks.

As a consequence of the accident was that the attention of the employees must be raised that these trucks are dangerous and chemical reaction inside of them must be stopped. The treatment of the dangerous waste must be done in a proper environment among regulations and by using proper measurements and reactors.

To avoid further similar accidents safety plans should be made and only certified tanks, IBC-s should be use. The necessary examinations and measures, controls should be made and the results should be documented and used. The cargo should be transported with the documents and on it he dangerousness of the substance should be seen, just as when up/download is happening an exhaust system should in operation to neutralize the released gases. During u por download only the employee who makes the process can be ont he scene and the area should be clearly signed and closed with cordons.

The further lesson that we studied from the accident was that dangerous chemical reaction can happen so any kind of leakage must be banned/ stopped and the employees should be/ must be protected as well. The previously used vehicles are not proper to handle the waste, because this type of the handling requires more safety. The responsibility should be define and the system must be supervised constantly and should be tested too and the experiences that we can get from them should be documented and used. [9]

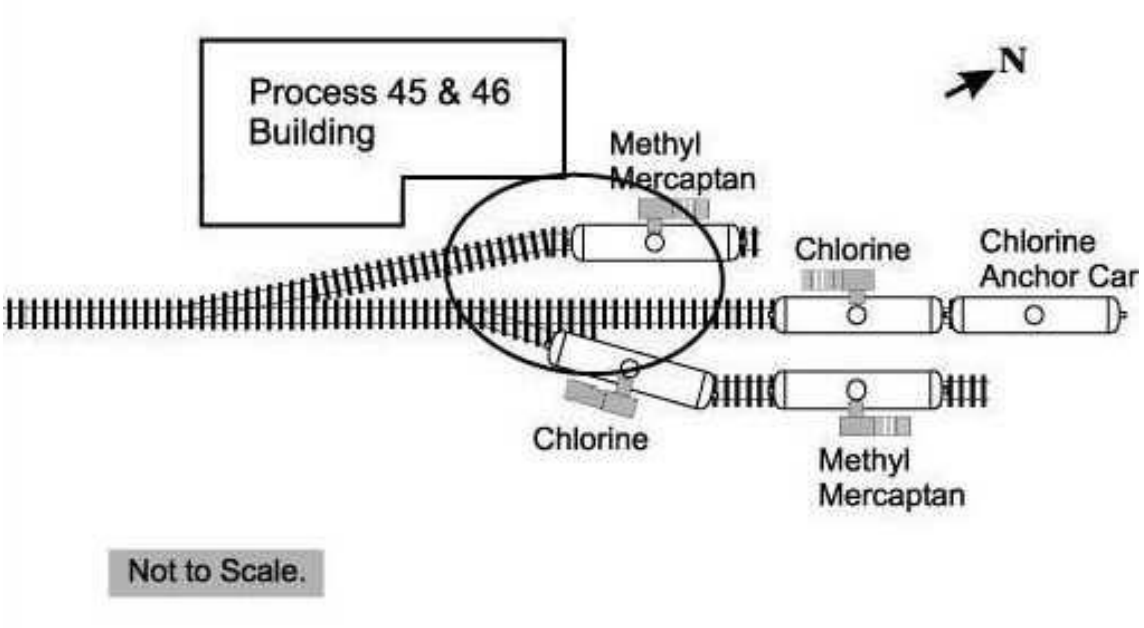
A RAILWAY TANK-CAR ACCIDENT IN THE USA [11]

In the United States, Phildelphia there is a chemical agent producer concern’s center. The concern employs 400 employees twenty on-site only in the Us and sixteen more all over the world. The concern has an Unit in Michingan which is operating since 1898 and employs 212 employee in Riverwiev .The company produces hidroxilamin, amil-fenol and disulphides, sulphur and it’s derives. These chemical agents are used for example: in pharmaceuticals, electronic devices (e.g.:PC-s, TV-s, CD player), beauty products, rubber/ tire, paint,

agricultural goods, water treatment, photo papers. during the manufacturing they use metilmercaptan too.

4. figure State of Michigan, accident site [11**]**

The company's 46 on-site during the manufacturing uses chloride and methilmercaptan and through synthesis producing methansulphonil chloride and metansulphonil acid. The components of metansulphonil chloride group are used for photography goods and agricultural and pharmaceuticals, but as destabilizer and catalyst too, further as disinfectant.
The accident was on the 14th of July 2001. Three empty railway tank car was standing in the zone fr downloading close to the unit 46 building. The three empty car was changed to three filled railway tank car one was filled with metilmercaptan and the other two was filled with chlorine. all and all five railway tank car was waiting on the on-site two was filled with methilmercaptan the other two was with chlorine and the last one was an anchor car. The cars containing methilmercaptan was originally manufactured with pipes connected straight to the unit 46 as seen on the figure. The chlorine was download to the anchor car that was in a direct connection to the unit. At 3am both tank car filled with chlorine got connected and an expert employee connected the other car filled with methylmercaptan to the pipe system.



5. figure The location of railway wagons [11]

At 3:45 two employee download the mheytlmercaptan from the railway tank car when the connected and the secured pipe come off from the pipe system and the wrong valve. According to the accident reports and minute books approximately 67 and in between 74 tonnes of mhetylmercaptan released in the air. After recongnising the accident the mechanic pulled the alarm and the technician alerted the other employees and at the same/meantime the fire department. At 3:47 the signalling devices measured a high concentration of methylmercaptan on the second floor of the unit/building.

As the operator was stepping out of the building saw that the shift leader was lying on the floor close to the fire alarm and to the download zone. After the alert other employees arrived to the scene by wearing gas masks to be able to enter the zone. At the scene of the accident two dead body was found on was the operator and the other one was the shift leader. Meanwhile the fireman arrived whom started to water the tank cars that were constantly fumigating. At 3:52 other two fireman unit arrived to the scene and 3:68 two police squad arrived too. At 4:09 25 minutes after the accident as the result of the leakage toxic gas released followed by banging sounds and the tank car was in blaze the flames were approximately 60 metres tall.

The railway car exploded and as result of the explosion mhetylmercaptan released in the air. The released substance caused skin irritation, and heavy breathing. Because of the accident the fireman captain on the scene called the other fireman departments nearby for help for more fireman squads to come to the scene and as result of that they could water the the cars so the fire did not spread to the other car containing mhetylmercaptan and to the other three containing chlorine.

The weather conditions were favourable because the wind was blowing t the north-west direction so it blew away the fume from the city. The toxic cloud went to south-east direction toward the Grosseile island, that was close to the Detroit river and two brides connected to the mainland. At 5Am a smoke cloud was visible above on the northern part of the island. According to the police report the ones leaved nearby sensed some stubby smell in the air. As it was early in the morning most of the inhabitants were home at that time. To avoid further catastrophe and to measure what has happened, the decision was that they were calling the people living there and going to be evacuated from the island until the south bridge. To keep the security measure within a 1km circle 400 inhabitant got evacuated and within 10hrs 2000

people got evacuated from Riverview, Trenton, Grosseile and Wyandotte. Because of the fume the American and Canadian authorities decided that they prohibit sailing on the precise part of the Detroit river until 16:45 pm.

As to fulfil the previous request fireman arrived from five different cities and with their help they could circle the fire on the on-site within 8:30 and 9:30.

After extinguishing the fire the employees were wearing gas masks ad the found the body of the other operator lyg next to the railway tank car. After this they stated that the iron pipe was fractured and the first and the second adapter was turned out from the open valve. They could close the valve only later but the second valve that was connected to unit 46 was closed and as a luck only the sac got burned.

The sac was connecting the car containing chlorine and connected to the pipe system got damaged too. Every valve that was carrying chlorine was open so when the rescue team arrived ont he scene approximately 12 and in between 81 tonnes of chlorine released in the air and as the sac got ruptured they could only stop the leakage when they closed the valves.

The leakage stopped at 12:47.

after the accident on 14 July Saturday dawn the environmental authority at 13:00 pm with its mobil lab made measures in the air and they find the quality of the air fine and started to examine the environment too whether environmental damage happened or not.

At 14:48 the fire department ensured that the units valves and tanks dot closed and they resolve the evacuation order. From 15:00 the citizens could go back to their homes.

The fire department left the scene of the accident on the 15th of July at 2:00 am but a unit to ensure/ secure the area/stayed remained until the 17th of July.

As the result of the catastrophe huge property damage generated. The car containing methylmercaptan got destroyed 90%. The left side of the car containing the chlorine got damaged which was standing beside the car containing methylmercaptan. The tube connected to the car containing methylmercaptan melted in the fire. The guide under the car containing methylmercaptan deformed because of the intense heat. Because of the explosion the system used for measurement got destroyed.

Consequence of the accident: three lethal victim (employee) two out of them because of the inhalation of methylmercaptan and the third died because of the inhalation of fume and tissue damage. In the accident 9 worker, 3 fireman and 40 citizen got injured.1 employee after inhaling the methylmercaptan gas fainted and fall down and broke his ribs. Other 5 got injured slightly because of poisoning. The three of the rescue team got burned slightly and felt irritation in their. The citizens living close to the unit were complaining to headache, dry throat and dizziness.

Types of injury	Workers Rescue	Participants in rescue	Other persons	In total
Deadly	3	0	0	3
Serious	1	0	0	1
Easy	5	3	40	48
In total	9	3	40	52

1 table Number of injured (Self-made table Based on [11])

Characteristics of Methylmercaptan [11]

Extremely flammable, heavier than the air, and can be found above the soil. while the substance s burning toxic gas releases and it contains sulphuroxide and hydrogenesulphid. The methylmercaptan steps into a vehement reaction with oxidative substances and with water during the process steams and acid releases toxic gases (dymethil sulphid). Mixed with air and gas it creates explosive mixture, therefore in a closed system equipped with a ventilation system and explosive secure electronic device.

According to the competent authorities the main reason of the accident was that they did not keep the safety measures. The report stated that the pipes were corroded and was rusty inside and outside plus damaged was seen. At the download process they did not recognise the 1cm difference from 2,5 cm iron pipe. According to the measures the inner wall was 23% less at the fracture than a new pipe. The previously presented shows that one reason of the accident was the wrong maintenance and control of the pipe system and the other was the wrong supervision from the competent/centre authority. In the manufacturers statem stand that the pipes were not controlled the previous five year before the accident.

The manufacturer secured the provisions to download the methylmercaptan with the „usual practice script" in the users manual. This document includes the necessary processes how to install the pipes with the railway cars containing methylmercaptan and the tests to prohibit leakage during download. On the other hand the users manual did not highlighted enough that at download gas mask or respirator should be worn or an escape hood with a filter able to filter up to 5-10 minutes that would make the able to escape from the scene. The employees did not wear the proper equipment that would have detect the leaking methylmercaptan.

At the download of the chlorine the following provisions must be comply: the operator has to wear a gas mask and to detect chlorine ammonium should be used which makes white cloud when leaking, the only method to stop the leaking is to close the valve on the top of the car.

It was also stated that the on-site had no havaria plan. The local authorities stated that the released chlorine gas and other two chemical substance created the explosion sodoumhypoclorite and tefzel, which is a modified etilen, tetrafluoretilen and fluor polymer. The experts investigated on the scene the tefzel reaction with the methylmercaptan release result was heat and toxic gas. According to other opinions the sodiumhypoklorite (highly oxidative substance) and the methymercaptan reaction led to the flames.

If there would have been methylmercaptan sensor installed at zone 46 it would have been sensed the leakage between 0 and 30 ppm. The installed sensors did not sense any methylmercaptan or they showed 0 and probably they were not functioning for 24 hours.

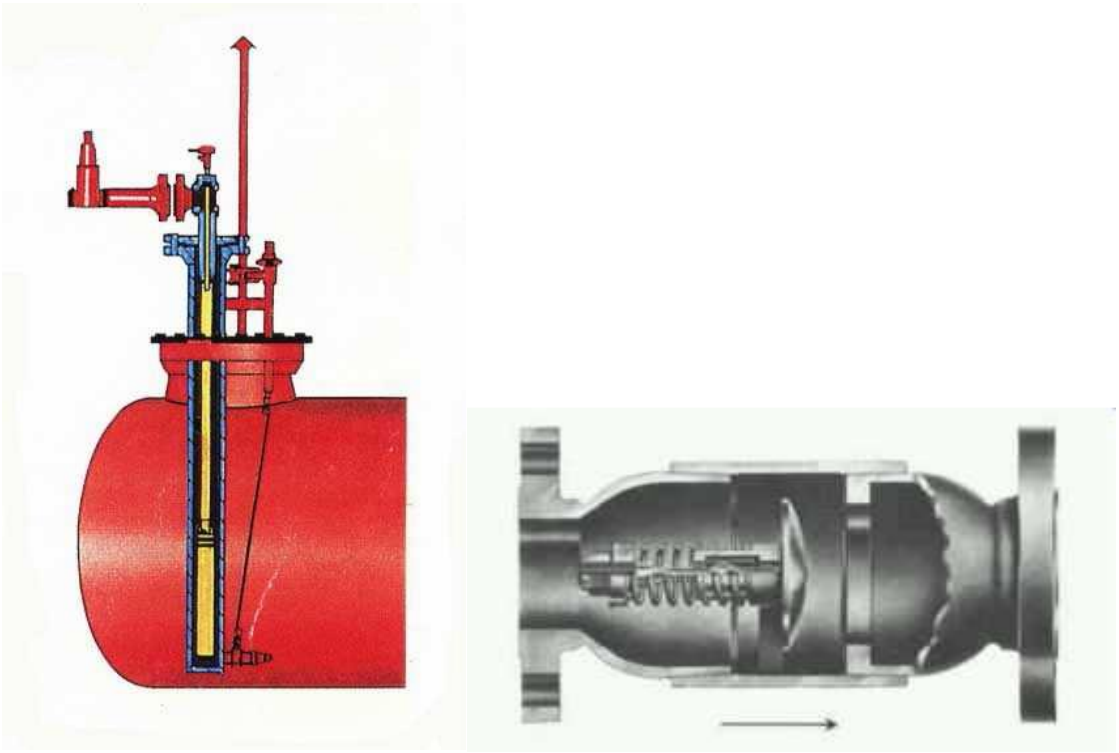
The factories in the US are supervised by several different authorities such as the central railway authority, the environmental authority, the labour and healthcare authority.

The railway authority checked the scene seven times between 1996 and 2001. These tests reflected that there were no proper equipment ot handle dangerous goods and the regulation was aslo missing so as the marking.

The environmental authority got the public safety plan only on the 3 of July 2000. At that time 14 different activities was done by the company one of it was at the unit 46 where they have to fulfil / live up to environmental a regulations/ standards. The public safety plan should be used from 4,5 tonnes for methylmercaptan and from 1,1 to chlorine. According to the scenarios at the release of the dangerous gases the installation should have been connected to the fixed parts of the building. Every each and single plan should have include the use of the safety valves to reduce the risk of an accident.

The public safety program determines the frequency with which a review is to be made between the discharging pipes, the gas detection systems and the leakage systems. Between July 2001 and June 1996, the environmental authority held an on-site visit and identified 3 of

the 2800 connection points as risky. Since the accident, the environmental authority has conducted several inspections on the site.



6. figure Safety valve [11]

From September 8 to November 2, 1994, the Labor and Health Authority of Michigan controlled the production, but Unit 46 was not tested. The inspectors found that, although they have a public safety programme, they have many shortcomings. 31 serious shortcomings and a casual offense took place. Of these 31 cases, 18 resulted from non-compliance with the safety rules and, in one case, tank, reactor and piping were not tested. Thereafter, the manufacturer agreed to introduce written procedures for checking the connection points and to carry out tests to ensure proper mechanical operation of the units. The Michigan Labor and Health Authority is not sure that these inspections have taken place at the manufacturer's premises. The manufacturer did not specify the frequency of reviews, which was why he had checked many times, sometimes did not reach the minimum. The authority emphasized the deformation of the devices and the pipe fracture. In the investigation following the accident, the authority found only 22 breaches of law regarding labor and health rules. The company paid USD 500.000 in fines and spent over USD 5.000.000 to improve worker safety.

As a post-accident measure, in March 2000, the manufacturer established a general emergency program, in particular for Block 46. This document seeks to reduce the risk of explosion, fire extinguishing, and the release of toxic substances. A single copy of the document was sent to the Riverview Emergency Services and the surrounding cities. Further training programs have been introduced at the Riverview and Wyandot firefighting stations. As a result of the accident, the company changed its operating procedures and changed the equipment. Discharging units and pipes connected thereto are dismantled every two years and check the connection points. In connection with this, the reconditioning units were redesigned. Handlers must wear a breathing apparatus when they are near the mercaptan tank and wear a protective mask that, in case of emergency, provides adequate oxygen in the discharge zone. Since the accident, every worker has to run a leak check test on the landing gear before opening the rail wagon valve.

The company decided to develop its security support system.

- a new sprinkler system has been installed,
- an underground fire extinguisher was installed and an additional 11 fire hydrants,
- re-designed the recirculation zone to separate the ferrous wagon containing methyl mercaptans from the chlorine,
- a new, more efficient sewage system was introduced in the filling area,
- firewalls, alarm and sound system were built.

Federal law stipulates that a havaria plan must be drawn up for the Riverview site for civilians and emergency intervention authorities. Despite the fact that the site had such a plan, there was no adequate information on air testing.

Local residents were not satisfied with the evacuation, especially those who lived in the northern part of Grosseile Island, because the procedure was too long for them. The head of the fire department promised to review the authorities' evacuation methods.

Local residents sued the company for negligence. The State of Michigan agreed with the company on the following terms: 6.2 million dollars for damage management.

The Ontario State Emergency Service claimed that they did not receive information about the accident at the right time. Canadian Amhertzburgi authorities only received information about the accident after several hours of passing the toxic cloud, a cloud of clouds affecting its inhabitants. The Amhertsburg Fire Department has requested that an alienation protocol between the authorities be introduced on both sides of the river in case of chemical leakage.

The director of the Riverview site proposed a meeting between the five cities' authorities and the three manufacturers to prepare a coordinated emergency alert system.

In 2002, the company undertook to pay USD 6.2 million in damages. This agreement included inter alia:

- a fine of USD 500.000,
- compensation of the evacuees of USD 550 / person,
- USD 100.000 to Riverview, USD 50.000 to Grosseil, and USD 25.000 to Trenton and Wyandot,
- Developing and implementing a USD 250.000 evaluation and monitoring program that analyzes security and emergency procedures,
- organizing emergency exercises for USD 80.000,
- training a payment fund for the deceased and the injured in the accident for USD 250.000 worth of a security center to commemorate those who died in the accident. [11]

SUMMARY

In this article, in which I summarized the currently available definitions of hazardous gases, it became clear that the existing various sorting systems are due to the different approaches towards the characteristics of these gases. The presented cases – although counting as accidents on varying levels and of sorts – all well exemplify the general threat, danger and risk posed by dangerous goods and their transportation. From the closing section of this article, it hopefully became apparent and clear how divergent the data reporting, analysing and publicity of accidents is in various countries – even though I only presented two European and a US method. A common conclusion of these case studies is the significance of the widespread understanding and application of the protection and prevention plan. In my view, the pragmatic and practical application of the protection plan is not mature enough in Hungary, and as such, I believe it to be of absolute importance to adequately inform the

market about the various solutions. Unfortunately, in many cases the very people handling these dangerous substances aren't fully aware of the danger and hazard posed by these materials, despite the fact that even a minimal sense of the risk and preparedness would help reducing or even preventing the occurrence of such events. Since the accident analyses presented in the articles above also mention the existence of protection plans (havarias), I consider preparing them to be of great importance. It has also become proven that in these protection plans, realistic protective and damage control goals have to be set out and drawn up as the main and primary aim of these plans is the prevention of a minor accident becoming a serious one. The elimination of an already escalated and dangerous situation is impossible for a crew consisting usually of only a few people. In these cases, their task remains the notification of disaster recovery forces and their adequate informing. [12, 13, 14]

Within the field of dangerous goods, hazardous gases require special attention. Through the presented cases, we could see that it is rather difficult to identify the causes leading to an accident as these may be technical, electric and human-related errors. However, it is quite complicated to find a protective and preventive plan that applies to such a wide array of possible causes. As such, it would be useful to formulate and practice a set of safety and preventive measures centred around hazardous substance awareness and personnel responsibility. Finally, I deem it to be important for the intervening authorities to have a shared and unified (at least in the EU) protocol when it comes to crime scene investigation. Furthermore, I would also argue for the publication of these reports of common criteria as this would surely prove instrumental in planning safety measures for every market participant.

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