CONTROL OF MAJOR-ACCIDENTS INVOLVING DANGEROUS SUBSTANCES RELATING TO COMBINED TERMINALS

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Abstract

In the course of combined transport of dangerous goods the cargo is reloaded from one vehicle to another in the territory of combined terminals. Although combined terminals do not fall under the scope of Seveso III Directive, major-accidents involving dangerous substances might occur in their territory, the consequences of which could even extend outside their territory or might even have an impact on the neighbouring civil population. Based on our experience the causes of such major-accidents can always be traced back to deficiencies of the management system, therefore, in the present article the authors aim to analyse the aspects to be considered in case of combined terminals for the purpose of control of major-accidents involving dangerous substances.

Key words

Disaster management, industrial safety, control of major-accidents involving dangerous substances.

1 Regulation on the control of major-accidents involving dangerous substances

In case significant quantities of dangerous substances might be present in an establishment, the minimal requirements for the control of major-accidents involving dangerous substances (hereinafter referred to as “major-accidents”) are regulated by the Directive 2012/18/EU Of The European Parliament and of The Council of 4 July 2012 on the control of major-accident hazards involving dangerous substances, amending and subsequently repealing Council Directive 96/82/EC (hereinafter referred to as “Seveso III. Directive” or “Directive”), a single directive within the European Union. The complete implementation of the Directive is obligatory for the Member States; however, they might introduce stricter regulations in the national legislation.

The Directive lays down rules for the prevention of major-accidents which might result from certain industrial activities and the limitation of their consequences for human health and the environment. Major accidents often have serious consequences, as evidenced by accidents like Seveso, Bhopal, Schweizerhalle, Enschede, Toulouse and Buncefield. Moreover the impact can extend beyond national borders. This underlines the need to ensure that appropriate precautionary action is taken to ensure a high level of protection throughout the Union for citizens, communities and the environment. There is therefore a need to ensure that the existing high level of protection remains at least the same or increases. [1]

Despite the strict regulation, in the last couple of years there have been more chemical accidents[1] which had an impact on the civil population as well. It is a common characteristic of these chemical accidents, that at the time of the occurrence of such accidents the concerned establishments were not falling under the scope of the Seveso Directive. The Seveso III Directive shall only apply to establishments as defined in Article 3 (1). The Seveso III Directive shall not apply to any of the following:

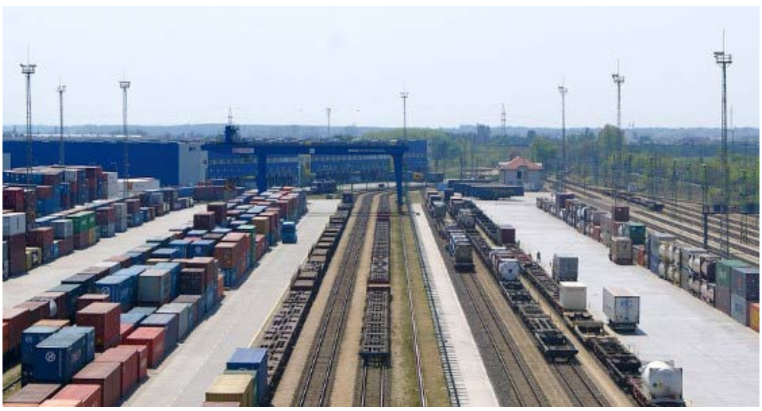
a) military establishments, installations or storage facilities;
b) hazards created by ionising radiation originating from substances;

c) the transport of dangerous substances and directly related intermediate temporary storage by road, rail, internal waterways, sea or air, outside the establishments covered by this Directive, including loading and unloading and transport to and from another means of transport at docks, wharves or marshalling yards;
d) the transport of dangerous substances in pipelines, including pumping stations, outside establishments covered by this Directive;
e) the exploitation, namely the exploration, extraction and processing, of minerals in mines and quarries, including by means of boreholes;
f) the offshore exploration and exploitation of minerals, including hydrocarbons;
g) the storage of gas at underground offshore sites including both dedicated storage sites and sites where exploration and exploitation of minerals, including hydrocarbons are also carried out;
h) waste land-fill sites, including underground waste storage. [1]

In the present article the authors aim to raise the attention to hazards caused by the activity of combined terminals and present the minimal requirements for the control of major-accidents involving dangerous substances.

2 Activity of combined terminals

The transportation of dangerous goods – similarly to any other goods – can be carried out either in a single way involving only one mode of transport or a combined way involving more modes of transport. In the course of a combined (or multimodal) transportation, the transportation task is carried out with the participation of two or more transport modes. Due to the cooperation of different modes of transport in the course of combined goods transportation and establishment of shipment chains, the advantages of each transport mode can be combined while eliminating the disadvantages. Combined transportation can contribute to reduce the deterioration of public roads, public traffic jams as well as environmental polluting effects. In the course of combined transportation the so-called intermodal transport unit containing the goods is moved with the help of special loading equipment. The movement of a unit cargo, i.e. the loading from one vehicle to another is carried out in the combined terminals. [4, 5]



Picture 1
View of a combined terminal [5]

The reloading between means of transport in the combined terminals can be carried out by cranes or loading machines.

In case of cranes the rail stands on the ground and the crane structure forms a frame. One of the vertical pillars of the crane is fixedly attached while the other is hinge-joined to the bridge so that the structure is statically determinate, i.e. it does not hinder thermal expansion. Cranes can mainly move on special heavy-duty rails, alongside the loading rail-tracks.

Picture 2
Crane [5]

Every fifth container in the world is moved by Kalmar loaders. These machines are equipped with special frames and are designed to move empty and loaded containers in port terminals. They are special advanced loading machines developed from fork lift trucks with a container holding frame in the place of the fork cart, which holds the loaded container at its four corners. The frame is adjustable; therefore it is not only able to lift 40 ft containers, but also 20 and 30 ft containers. [6] In the below picture a Kalmar loader is lifting a so-called tanktainer (a tank container) from a lorry.

Picture 3
Kalmar loader during operation [5]

3 Hazard analysis of combined terminals

It is a common characteristic of combined terminals that any dangerous goods might be present in their territory any time in line with the current market demands, however, the time of presence is very short; in many cases the transfer takes place immediately (within one day), but usually a 1-3-day long transfer should be considered. Direct activity involving dangerous substances is not carried out in the territory of combined terminals, and as such the certified packaging of dangerous goods does not get opened or removed.

3.1 Possible consequences of the release of dangerous substances

In the territory of combined terminals the dangerous substance might be released basically the following ways:

a) by the instant release of dangerous substance in case of significant damage of the packaging (catastrophic breakage of packaging);
b) by continuous release in case of minor damage of the packaging.

As a deterrent example, with the help of DNV Phast consequence analysing software we present the toxic consequences resulting from the catastrophic damage of a 25-ton acrylonitrile cargo.

The below figure indicates how the probability of fatality varies depending on distance.

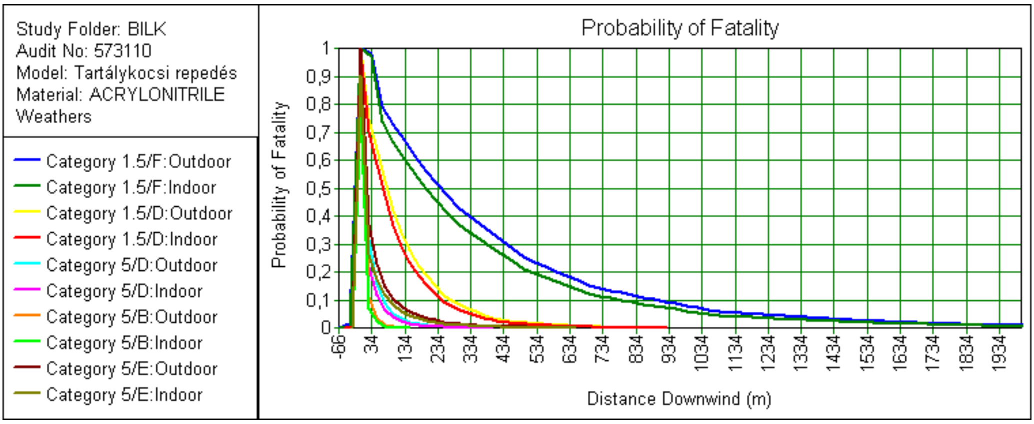


Fig. 1
Probability of fatality in relation to distance

Based on the below figure in case of persons staying outside of 1,685 m the probability of fatality is less than 1%.

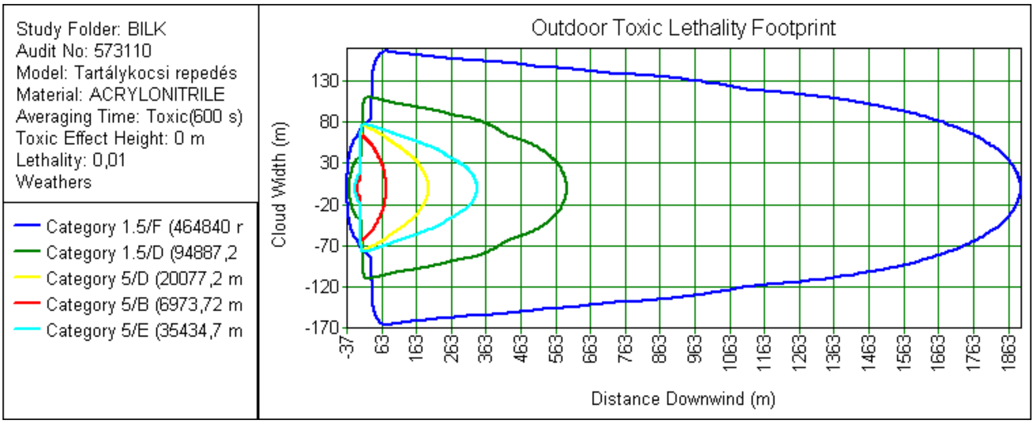


Fig. 2
1% probability of fatality of persons staying outside depending on distance

Based on the above it can be seen, that in case of damage of the a dangerous goods cargo the consequences presumably might also extend outside the territory of the combined terminal, as a result of which concentration values might be considered even in 1 km distance that could trigger human injuries.

3.2 Possible causes of the release of dangerous substances

To identify the possible causes of the release of dangerous substances and an accident affecting the civil population we apply the method of fault tree analysis. Fault tree analysis is a "reverse logic technic", which, after the definition of the unwanted event, determines its basic causes and their combinations with the application of logic relations. The fault tree analysis basically consists of the following 4 steps:

1. Definition of the problem (top event),
2. Creation of the fault tree,
3. Solution of the fault tree (determination of the fault event combinations), and
4. Grading the fault event combinations.

We define "Dangerous substance accident affecting the civil population" as a top event. Based on the experiences on combined terminal operating in Hungary, we created the fault tree shown in Fig. 3 below.

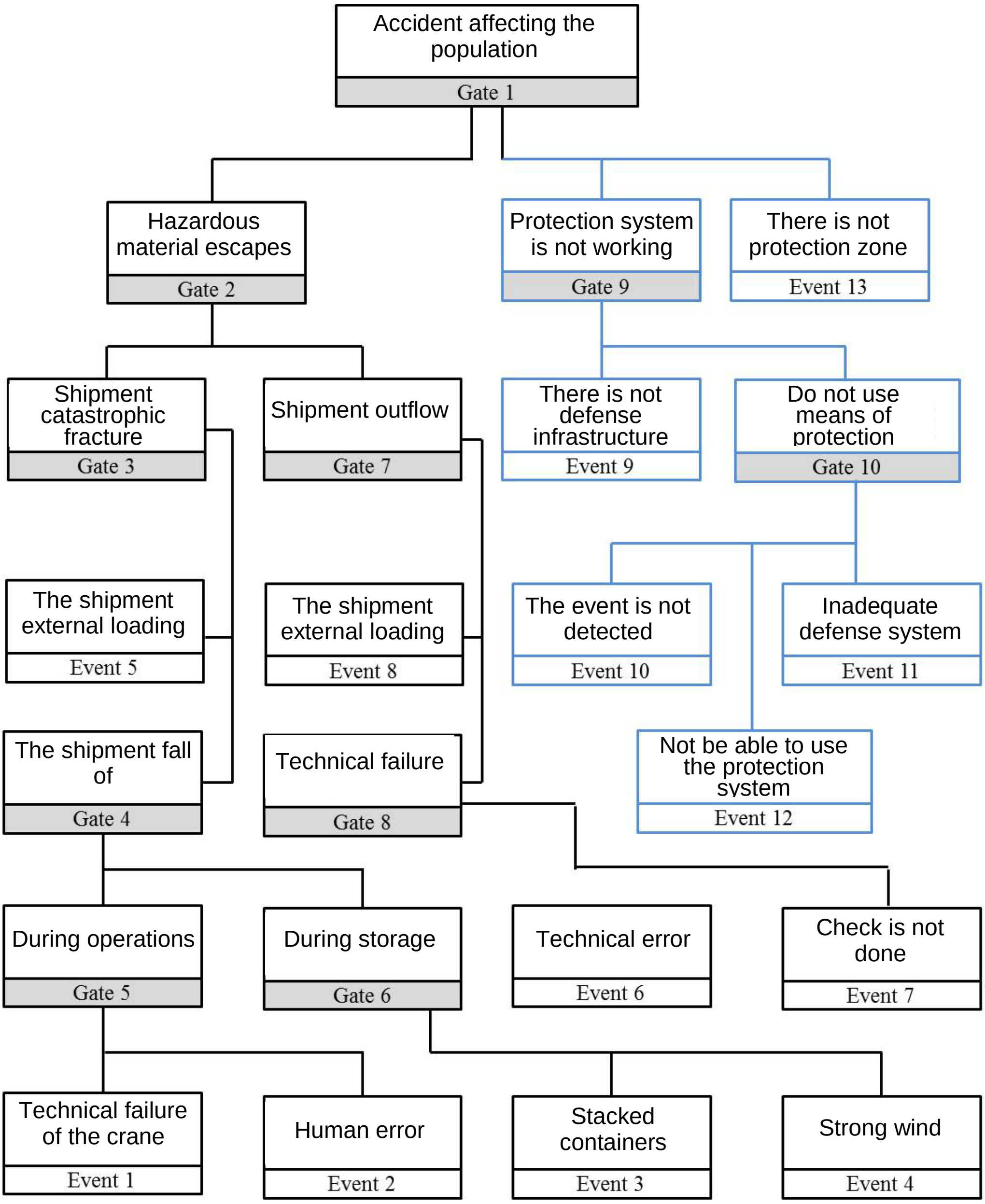


Fig. 3
Fault tree: Dangerous substance accident affecting the civil population

The following three simultaneous conditions shall be met in order a Dangerous substance accident affecting the civil population to happen:

- An accident takes place resulting in the release of dangerous substance (catastrophic damage of the dangerous goods cargo or the substance is flowing continuously), and
- The safety system serving for damage control does not work properly, and
- There is an inhabited area in the surroundings of the combined terminal.

The catastrophic damage of the dangerous goods cargo can be caused by:

- Damage of the lifting engine (Kalmar loader, crane) during the conveyance of materials (e.g. the revolving structure loosens (Event1) or human error (Event2);
- Fall of the dangerous cargo during storage (Event3, Event4);
- External force during storage (e.g. the Kalmar loader reverses against the dangerous goods cargo) (Event5).

The flow of the dangerous goods cargo can be caused by:

- Technical failure of the packaging (container) (e.g. the extracting stud does not close properly) (Event1) and the failure of ckeck-up (Event6, Event7);
- External force during storage (e.g. the Kalmar loader reverses/hits against the dangerous goods cargo and holes it) (Event8).

The improper operation of safety system serving for damage control can be caused by:

- There is no safety planning; the Operator is not prepared for the management of such events (Event9); or
- The Operator is prepared for the damage control on the level of safety infrastructure, but the safety equipment is not used, because
  - The event is not noticed or it is recognized too late;
  - The protectiveness of safety equipment is under-planned or insufficient;
  - The concerned persons are not able to use the safety equipment, lack of training and practice.

The revealed basic events, i.e. the causes triggering the occurrence of the top event can basically be traced back to the deficiencies of the management system.

3.3 The connection of basic events revealed by the fault tree analysis and the management system

As per Art. (12) of the Seveso III Directive: Operators should have a general obligation to take all necessary measures to prevent major accidents, to mitigate their consequences and to take recovery measures. The operator should draw up a major-accident prevention policy setting out the operator's overall approach and measures, including appropriate safety management systems, for controlling major-accident hazards. [1]

As the result of the above fault tree analysis indicates, the causes triggering the occurrence of the top event can basically be traced back to the deficiencies of the management system also in case of combined terminals. The frequency of the top event can be reduced by measures against the revealed basic events. Such measures should be included in some internal regulations as part of the operator's management system. Based on the result of the fault tree analysis we recommend drawing up and operating the following internal regulations:

1. Drawing up a regulation on the check-up of lifting engines (Kalmar loaders, cranes). The regulation should contain the method of daily, weekly, monthly, half-year and annual check-ups, the necessary technical conditions and the responsibility of the concerned personnel.
2. A regulation on the handling of dangerous goods is recommended, which includes the conditions for the acceptance of dangerous goods cargo (including carrying out the check-

ups), and determines the potential storing place, the exact method of placement as well as continuous check-ups of the dangerous goods.

The extent of consequences in case of an accident can be reduced by a safety planning based on the hazard analysis. In the frame of the safety planning it is necessary to determine the exact measures to be carried out in case of accidents involving dangerous substances as well as the human and material resources required to carry out such measures. The special training of the personnel involved in the safety interventions shall also be part of the safety planning, which should be tested by practical exercises. The safety planning shall be treated as part of the management system, and as such the results should be included in an internal regulation.

Considering the special characteristics of combines terminals, i.e. that the present types and quantities of dangerous substances are continuously changing, we recommend the following three effective technical solutions to be considered in the course of safety planning.

1. Water shield

A water shield is a special thrust nozzle with a standard Storz-clip usually made of aluminium. A vertical metal plate is joined to the horizontal entering pipe, with a special split between the metal plate and the pipe. Through this split the water streams free forming a water curtain in the shape of a peacock tail. The water shields have to be set 5-10 m far from the exit point also considering the wind direction, so that the explosive gas cloud is directed towards the water curtain. No gas can pass the water curtain without mixing; therefore, the water shields have to be set in a way that the neighbouring water curtains overlap but do not collide each other. Water shields set this way form a contiguous water wall. Usually a single water shield is not enough for the efficient protection, as a high amount of escaping gas can pass by the two sides of the water shield. To prevent such a case, it is recommended to set more water shields in a V or U form to demarcate the gas cloud. [7]

The water shield is relatively cheap; it is easy to set, so it can be used as a mobile tool, or it can be set as a fix structure sparing the installation time, and as such increasing the efficiency of protection. The disadvantage of water shields is that they cannot be used against dangerous substances reacting with water.

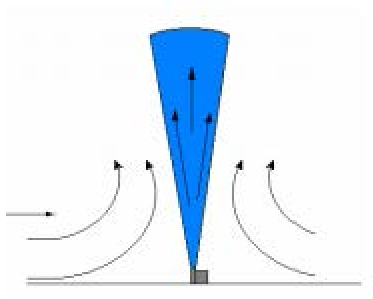


Fig. 4
The section of a water shield from profile [7]

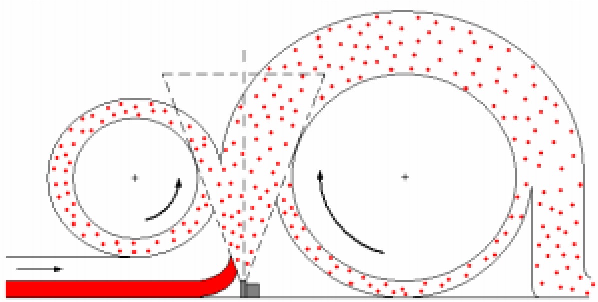


Fig. 5
Streams developed around the water shield [7]

2. Mobile safety bund

In case of accidents involving dangerous substances the extent of liquid flows can be reduced by applying mobile safety bunds. The mobile bund is a metal structure, on top of which the damaged container can be placed, so that it takes up the leaking substance. The substance getting into the bund can be extracted to an empty container either by gravity or by a pump.

The installation of a mobile safety bund is more expensive than a water shield.

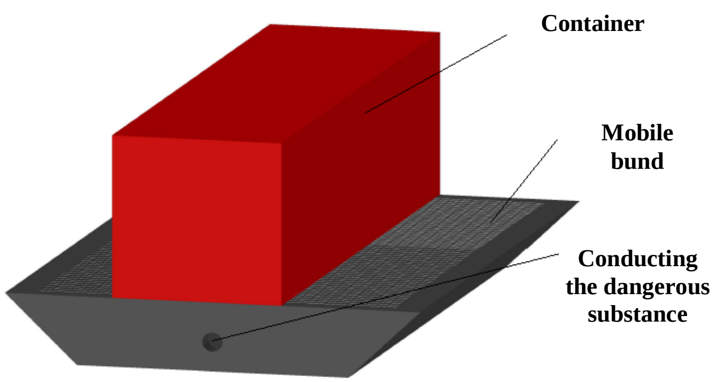


Fig. 6
The application of a mobile safety bund [8]

3. Safety bund connected to an underground collecting system

The storage of dangerous substances can take place in a separate area, which can also function as a safety bund. The storage area has a concreted base covered with an acid-proof, chemical-resistant plastic layer. Its slope ensures to conduct any potential dangerous substances and rain water into the metal barred drain hole. The liquid is channelled from the drain hole into the underground safety bund with a capacity at least 1.5 times the capacity of the container. The content of the safety bund can be emptied by opening/closing a gate valve.

The installation of the system is expensive; however, due to its very high efficiency the release of dangerous substance through an evaporating pool surface can be minimized.

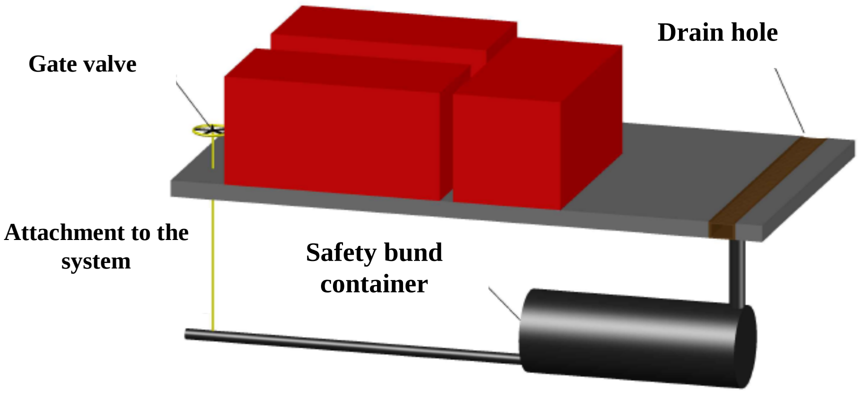


Fig. 7
Bund connected to an underground collecting system [8]

4 Summary

The scope of Seveso III Directive does not cover the – public road, rail, water, sea or air – transport of dangerous substances outside the establishment or their temporary storage during the transport, including loading and unloading or the movement of the substances from one vehicle to another in docks, piers, transfer stations.

In the course of combined transport of dangerous goods the movement/reload of the cargo from one vehicle to another takes place in combined terminals.

It is a common characteristic of combined terminals that any dangerous goods might be present in their territory any time in line with the current market demands, however, the time of presence is very short; in many cases the transfer takes place immediately (within one day), but usually a 1-3-day long transfer should be considered.

Based on the hazard analysis it can be concluded on the one hand, that such accidents involving dangerous substances could happen, which might even have an effect outside the territory of the combined terminal affecting the civil population, on the other hand that the causes of such accidents can basically be traced back to deficiencies of the management system.

In our opinion, operators of combined terminals, regardless that they do not fall under the scope of Seveso III Directive, should implement the conditions of response to accidents involving dangerous substances in their management systems, and as such their internal regulations should cover the prevention of such accidents as well as the measures of an efficient damage control.

NOTES:

[1] On 4 October 2010, in Ajka, Hungary, the dam of the MAL red mud reservoir collapsed, resulting in the death of 10 civils and more than 150 injured. [2]
On 12 February 2015, in Igualada, Spain, the explosion of a chemical plant resulted in the death of 3 and the civil population had to be locked in for some hours. [3]

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