Principles for designing a computer application specific to explosion risk management in explosive deposits

Florin Ionel Burdea[1*], and *Monica Crinela* Burdea[2]

[1]ITM Hunedoara, Muncii Alley, no.2, Deva, Hunedoara, Romania
[2]University of Petroșani, Management and Industrial Engineering Department, University Street, no.20, 332006, Petrosani, Hunedoara, Romania

Abstract. Industrial explosive storage sites are considered to be areas of major risk to industrial, public and occupational safety and security, due to the possibility of major accidents, due to the nature of the explosive substances and due to the serious consequences of an explosion.on these sites. The explosion risk assessment for explosives depots requires an analysis of all possible occurrences of the initiating events that could lead to a potential explosion, followed by an analysis of security measures, all of which are quantified by the development of accident trees and sequences. for each possible trigger. This paper presents the principles of designing a specialized computer application in the field of explosion risk management at explosives depots for civilian use. This application allows to ensure the necessary premises for the elaboration, in objective and specific conditions, of the necessary documents for these types of technical infrastructures, from their design phase and the quantification of the degree of damage on the analyzed locations but also in the areas that are located.

1. Introduction

Industrial sites where explosives are stored or produced are always took into consideration as major risk areas for industrial, public, and occupational safety and security. Risk areas due to the possibility of major accidents, both due to seriousness of the consequences that a possible explosion phenomenon produced on these sites can generate. The major accident prevention policy must be compatible with the general policy in the field of activity of the organization and with the policies of other branches of management, such as quality or environmental management. This policy must have the principle of preventive action and the concept of sustainable development so that economically feasible technical safety measures prevent and limit the consequences of the use of hazardous substances on public health and the environment.

According to the definition, "major accident" means "an adverse phenomenon, such as major emissions, fire or explosion". These accidents resulting from uncontrolled events during the operation of an objective covered by the presence of the Seveso Directives and

*Corresponding author: ionelburdea@yahoo.com

which poses a serious danger to human health and / or the environment, immediately or late, inside or outside the target, involving one or more hazardous substances" [1], [2].

For the prevention at source of industrial accidents, it is particularly important that this prevention policy must be more than a simple statement of intent of the management at the highest level (top management). The company must ensure that the policy is applied and that a high level of protection is ensured by implementing all necessary measures (not only technical, but also those aimed at the organizational structure and management of the company) to achieve this goal [3], [4].

Safety professionals are increasingly interested in quantitative risk assessment and understand that no occupational activity, including those involving explosives, is risk-free [5], [3], [6].

The simple quantitative risk assessment does not eliminate the risk of events caused by activities involving explosives. Thus being necessary tools to ensure the application of a management system as efficient as possible, which ensures both the assessment of the level of risk in the activities carried out and the measures, which must be taken to eliminate, reduce both the risks and the consequences of possible events [7], [6].

As a result, for sites where various activities involving explosive substances are carried out, both the assessment of the security of the systems and the conduct of activities on those sites and the proper management of risks are mandatory objectives for industrial units and competent authorities in the field.

The quantified explosion risk assessment for explosives depots requires a complete analysis of all possible occurrences of the initiating events that could lead to a potential explosion. An explosion materialized either by detonation or deflagration or a combination of these two types of explosive phenomena, followed by an analysis of the security measures that could be adopted, by installing technical security barriers or by applying other measures of an organizational or other nature, so as to aim at preventing any possibility of the initiating event already identified. Risk assessment is a structured procedure for qualitative and / or quantitative assessment of the level of risk generated by hazard sources identified in installations [8], [9]. The purpose of the risk assessment is to provide the information needed to make a decision.

It is increasingly recommended that risk identification, assessment and control processes be carried out especially proactively rather than reactively. The implementation of technical means of protection can increase costs, if these means are implemented after the completion of the design of a storage site or after its construction In general, changes made in the design phase are less costly and more efficient than those made later, which fully justifies the start of the risk analysis and assessment process from this stage.

2. Development of accident scenarios starting from the triggering factor

The direct causes (initiating events) that may underlie the explosion-type events on the sites where operations with explosives are carried out, identified based on the literature and following the analysis of events in Romania, were organized in the form of a logical scheme *Master Logic Diagram* (MLD) type, as shown in **Figure 2.1** [5].

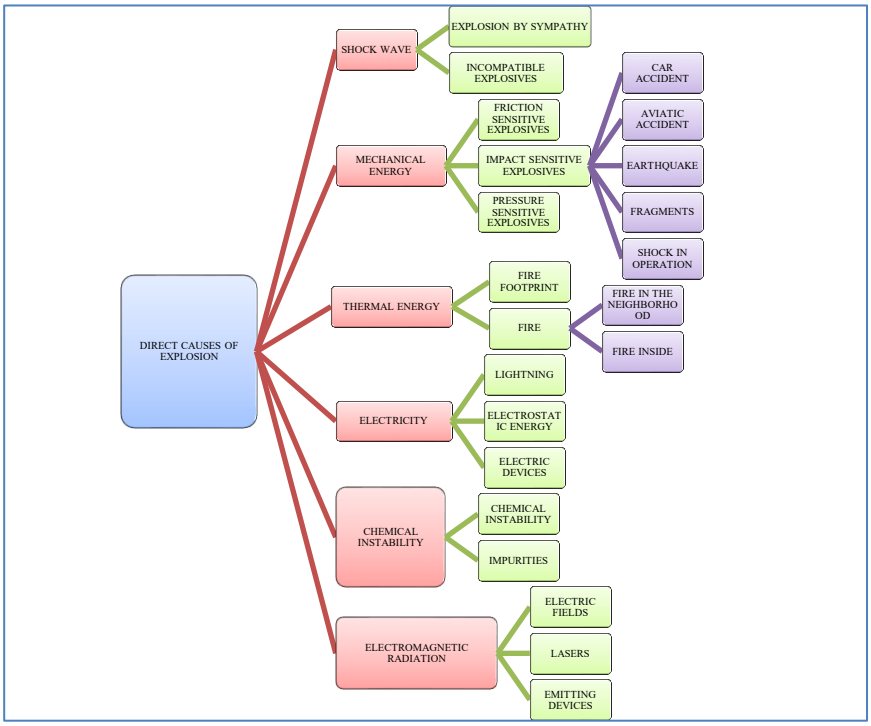

Fig. 2.1 - MLD Diagram Causes of initiation of the explosion

From the research of the specialized literature and of the events produced in the past on the Romanian territory but also in other countries, several initiating events (triggering factors) have been identified that can evolve towards a direct cause of an explosion, as presented in **Table 2.1.**

Table 2.1 - Triggers identified

Symbol	Description
D1	Incompatible explosives
D2	Car accident inside the warehouse
D3	Plane crash
D4	Earthquake
D5	Explosions in the neighborhood
D6	Impact sensitive explosives
D7	Friction sensitive explosives
D8	Atmospheric surges, lightning
D9	Sparks from malfunction of electrical equipment
D10	Sparks due to static electricity
D11	Chemically unstable explosives
D12	Impurities in the composition of explosives
D13	Electro-explosive devices
D14	Outdoor fires
D15	Indoor fires

For each of these triggers, several safety measures have been identified that can be adopted and implemented both to prevent the explosion and to limit the effects. These safety measures may be of a technical nature. represented by the installation of some

technical protection and / or organizational barriers, represented by the implementation of some procedures and good practices, as they are presented in **Table 2.2**.

Table 2.2 - Inventory table of safety measures

Safety measures		
Symbol	**Name of the measure**	**Description**
TECHNICAL MEASURES		
T1	Constructive protection of the warehouse (building) - type of warehouse	
T2	Arrangement of separate rooms for storage of incompatible explosives	
T3	Protective barriers between storage rooms	
T4	Shock-resistant equipment	
T5	Racks and shelves arranged so that the impact energy is less than the ignition energy	
T6	Storage of explosives on shelves racks in packing boxes so as to avoid friction and / or frictional energy less than the ignition energy	
T7	Lightning protection	
T8	Earthing of electrical equipment and protection of personnel	
T9	Explosive distribution flow adapted to reduce storage time	
T10	Prevention of contact with impurities - Maintenance and cleaning of storage spaces	
T11	Explosion-proof encapsulation of electrical equipment	
T12	Disposal of sources	
T13	Dispersion currents with energy lower than ignition energy	
T14	Elimination of laser radiation sources	
T15	Elimination of radio sources	
T16	Elimination of mobile telephone radiation sources	
T17	Outdoor and indoor fire detectors	
T18	Trained operators for fire detection and operational intervention	
T19	Water tanks, wells water or connection of the storage to the water network, fire hydrants	
T20	Equipped with high pressure pumps, diesel or electric pumps	
T21	Equipped with sprinklers, sprinklers	
T22	ADR authorized vehicles, fire protected	
T23	Fire extinguishers	
T24	Barricades, fences, earth waves for protection of the deposit	
MĂSURI ORGANIZATORICE		
O1	Procedures for avoiding the joint storage of incompatible explosives	
O2	Procedures for labeling explosives by compatibility groups	
O3	Procedures for licensing and licensing of vehicles and drivers for the transport of dangerous goods (ADR)	
O4	Procedures for limiting the speed of vehicles transporting explosives inside the site	
O5	Procedures for clearing of vegetation inside the warehouse	
O6	Procedures for operating / maintenance procedures to avoid shocks caused by impact	
O7	Procedures for handling, loading / unloading and transport to avoid shocks caused by impact	
O8	Procedures for selecting equipment to reduce impact, shock absorption	
O9	Procedures for handling, transport and storage for prevention and reduction of contact and friction between stored explosives	
O10	Verification of equipment according to ATEX procedures	

O11	Procedures for performing explosives stability tests	
O12	Procedures for adapting explosives storage flow to shorten storage times	
O13	Quality control	
O14	Production control	
O15	Procedures for space maintenance and cleaning	
O16	Procedures and checks for measuring electromagnetic fields	
O17	Procedures for preventing laser radiation	

For each of the triggering factors analyzed, the corresponding accident sequences and event trees are elaborated, in **Figure 2.2** [5,10]. and in **Table 2.3** are presented the tree of events and the accident sequences corresponding to the trigger factor ***D1-*** *Incompatible explosives*

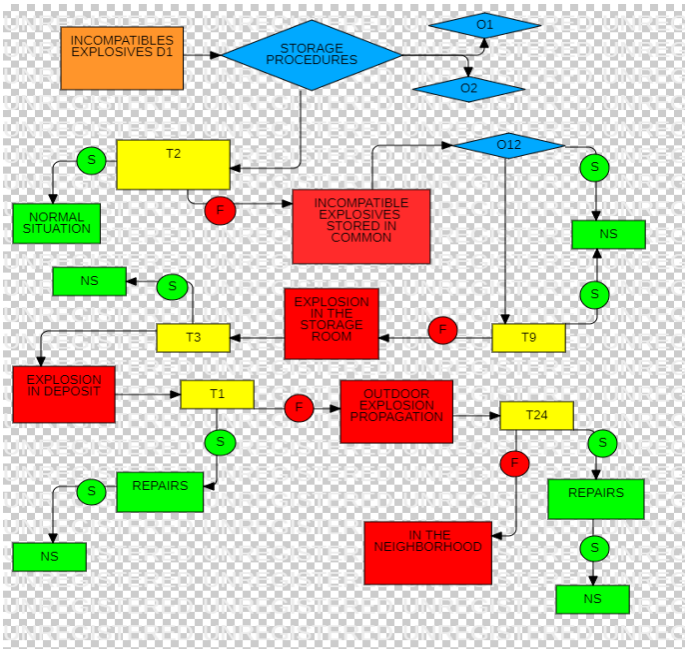

Figure 2.2 - Event tree for trigger factor D1 - Incompatible explosives

*where **O1**- Procedures for avoiding the joint storage of incompatible explosives; **O2** - Procedures for Labeling Explosives by Compatibility Groups; **T2** - Arranging separate rooms for storing incompatible explosives; **O12** - Procedures for adapting the explosives storage flow to shorten storage times; **T9** - Explosive distribution flow adapted to reduce storage time; **T3**- Concrete protection barriers between the storage rooms; **T1** - Constructive protection of the warehouse (building) - type of warehouse; **T24** - Barricades, fences, earth waves for the protection of the deposit*

Table 2.3- Accident sequence table for trigger factor D1 - Incompatible explosives

D1*O2e*O1e*O12e*T2e*T9e*T3e*T1e*T24e
D1 D1*O2e*O1e* O12e *T2e*T9e*T3e*T1e*T24 r
D1*O2e*O1e* O12e *T2e*T9e*T3e*T1r*T24r
D1*O2e*O1e* O12e *T2e*T9e*T3e*T1r
D1*O2e*O1e* O12e **T2e*T9e*T3r*T1r*T24r
D1*O2e*O1e *O12e **T2e*T9e*T3r*T1r
D1*O2e*O1e* O12e *T2e*T9e*T3r
D1*O2e*O1e* O12e *T2e*T9r

D1*O2e*O1e* O12e *T2r*T9r
D1*O2e*O1e*T2r
D1*O2r*O1r*T2r

In order to perform the explosion risk analysis in the industrial explosive storage sites, a logical scheme was developed, based on the comparison between the analyzed site and a hypothetical complete site, in which it is considered that all safety measures have been successfully planned and implemented. scheme being presented in **Figure 2.3**.

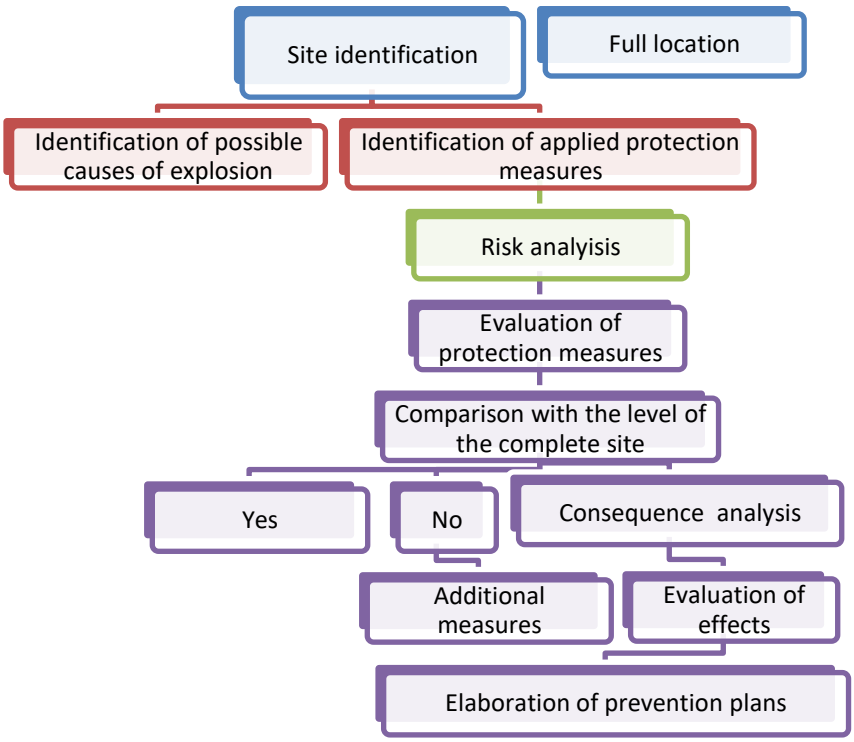

Figure 2.3. - Logical diagram of analysis of a storage location

3 Design of computer application specific to explosion risk management in explosives depots

3.1. Purpose and utility

The use of a computer application in the field of explosion risk management at explosives depots for civil use allows to ensure the necessary premises for the elaboration, in objective and specific conditions, of the necessary documents for these types of technical

infrastructures, from their design phase and quantification of damage to the analyzed locations but also to the areas that are located in their vicinity. The IT application is a viable solution to solve the problems in the field of major risks specific to technical infrastructure for storage of explosives, which can help perform a quick analysis of the site, to impose conditions prior to construction of the objective in its design phase.

The benefits that can be estimated are the following:

• Safer working and living conditions, as well as environmental sustainability, achieved following the decrease of the possibilities of an explosion

• The results provided by the application can bring important and real benefits to economic operators that have technical infrastructure for the storage of explosives for civilian use.

• Providing information support to the competent authorities with responsibilities in the authorization and verification of explosives depots, but also to persons designated by economic operators active in the field for a quick and concrete verification of a storage site.

In fact, the use of this application allows a fairly quick analysis of a storage location, the concrete identification in the field of the possibilities of possible triggers, the identification of the type of prevention and / or limitation measures to be applied, in finally providing a concrete image of the areas of influence in which a possible explosion manifests its effects. Based on this analysis, operators in the field can complete, modify or adapt prevention policies, safety plans, safety documentation and, in general, the entire explosion risk management process specific to an explosives storage site.

3.2. Principles of computer application design

In order to develop a computer application that can help the user in the process of explosion risk management specific to explosives depots, the following principles have been established, which were later included in the working stages of the application.

1. Identifying the possible triggers of an explosion;
2. Identification of organizational measures that can be applied at the level of an explosives depot;
3. Identification of technical measures that can be applied at the level of an explosives depot;
4. Identification and elaboration of sequences of specific events for each of the triggered factors analyzed, in association with the safety measures that can be applied;
5. Elaboration of event trees for each of the triggered factors analyzed;
6. Identification and delimitation of protection areas, emergency planning areas according to the amount of explosives stored, corresponding to each warehouse analyzed, an absolutely mandatory tool in the risk management process related to explosives depots.

In order to delimit the stages of this application, the following logic scheme was elaborated,which includes the application steps, presented in **Figure 3.1**.

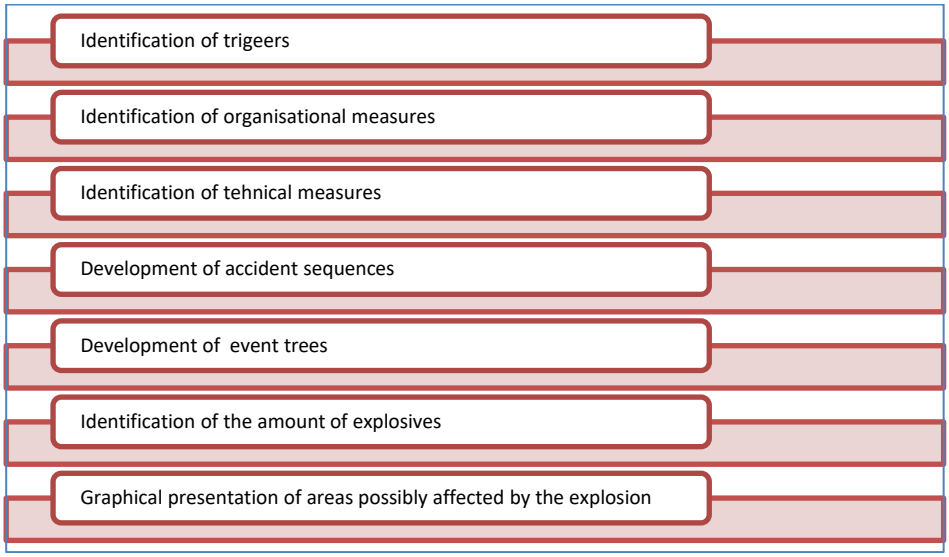

Figure 3.1. - Logic scheme used to develop the application

3.3. Working steps of the application

Stage 1 - Home page
It will include three components that delimit the working stages of the application, START, ACCIDENT SEQUENCES and PROTECTION AREAS

Stage 2 - Accident sequences
Step 1 - Open by clicking the ***Accident Sequences*** ;
Step 2 - In this stage, the first check-list is completed to identify the triggers, with ***Yes / No*** boxes corresponding to each factor, which are filled in according to the trigger factor (s) that will be analyzed;
Step 3- In this stage, a checklist is filled in to identify the organizational measures, with **Yes / No** boxes corresponding to each measure, which are filled in depending on its presence or absence. After completing the checklist, move on to the next step;
Step 4- In this stage, a check-list is completed to identify the technical measures, with **Yes / No** boxes corresponding to each measure, which are completed depending on its presence or absence. After completing the checklist, move on to the next step;
Step 5- After completing the previous checklists, depending on the triggers, the organizational and technical measures identified or not and completed in the application, the screen generates the name of the factor / factors completed in the application, the accident sequences and the corresponding event tree. If the appropriate safety measures have been implemented for the analyzed triggers and completed in the previous steps of the application, the accident sequences are marked in green, and the absence of one or more of the measures provided by the accident sequence leads to its marking red color.

Stage 3 - Determination of protection zones according to the amount of explosives
This stage of the application allows the analysis and delimitation of protection zones, an absolutely necessary tool for emergency management, so that, taking into account the most negative scenario possible, ie the explosion of the entire amount of explosive, equivalent to TNT, stored in the analyzed location, all necessary measures are provided to limit the

effects of a possible explosion on the neighborhoods, including primarily human communities and the environment.
The stage opens from the corresponding box on the home page
Step 1 – A box appears on the screen in which the quantity of explosives in TNT equivalent from the analyzed location is filled in numerically, stored in one or more storage rooms or in the entire warehouse;
Step 2-Depending on the amount of explosive completed in the previous step, the protection areas required for emergency planning activities appear on the screen, indicating the safety distances around the deposits corresponding to each area.;

4 Conclusions

This paper established the criteria for developing a specialized computer application that can be an analysis tool from the design phase of a warehouse, but also a tool that can be used to quickly identify existing risks on a site and security measures that can / should be implemented. The results highlighted in the paper are addressed to those involved in the explosion risk assessment specific to industrial sites for the storage of explosive materials, to establish the necessary prevention and protection measures to eliminate, limit and combat risk factors that may cause undesirable events. serious / devastating consequences and the use of safe practices to ensure the highest possible level of security.

The paper presents the procedural ways to configure the main danger scenarios generated in specific explosive activities, providing a technical solution for computer modeling of the risk of explosion, so as to achieve efficient site management and safety of communities and civil / industrial targets in the vicinity.

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