Assessment of the consequences of a major accidents for the tank parks that store BTX

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Abstract - The current paper is a case study for a Romanian Refinery, classified as a high risk objective due to the type and amount of dangerous substances (BTX) handled. Assessing the probability that a technical accident takes place, respectively assessing the probability for an unwanted event to happen, requires knowing the probability for a primary event to take place. This condition implies the existence of a comprehensive data base that is constantly being updated, developed through the systemizing and processing of the information gathered both during the technical surveillance of the conduct in operation as well as after the accidents that occur during the exploitation of different technological equipments.

Keywords – chemical risk**,** dangerous substances, major accidents, tank parks,

The Refinery observed is categorized as a major risk objective according to the European Directive 96/82/CEE-SEVESO II adopted through the Government Decision 95/2003, given the type and quantities of dangerous substances handled.

The activities inside the tank park can be divided into 3 groups: storing, handling, pumping and loading-unloading tanks.

TABLE I

Dangerous substances and chemicals (listed in Annex 2-Part II of the Government Decision 95/2003)	**Classification and associated risk sentences**	**Aggregation stage**	**Storage**
Benzene	F; R11 Carc. Cat. 1; R45 Muta. Cat. 2; R46 T;R48/23/24/25 Xn; R65 Xi; R36/38	Liquid	Vertical cylindrical tanks with fixed roof
Toluene	F; R11 Repr.Cat.3; R63 Xn; R48/20-65 Xi; R38 R67	Liquid	Vertical cylindrical tanks with fixed roof
Xylols	R10 Xn; R20/21 Xi; R38	Liquid	Vertical cylindrical tanks with fixed roof

TABLE II
DANGEROUS CHEMICAL SUBSTANCES AND RISK CLASS

The dangerous chemical substance	Guidelines on special dangerous (risk sentences)	
Benzene	R11 R45 R46 R48/23/24/25 R65 R36/38	601-020-00-8
Toluene	R11 R63 R48/20-65 R38 R67	601-021-00-3
Xylols	R10 R20/21 R38	601-022-00-9

The main dangerous substances and chemicals that are found inside the Refinery's tank fields and that could determine a major accident are presented in Table I.

The dangerous substances and chemicals present inside the Refinery, mainly the liquid, gaseous and solid petroleum products, have a high risk of fire and explosion.

They are dangerous for the environment in case of massive accidents and present a high chemical risk in case of massive gas/vapor losses.

Their potential effects are:

Fires that can determine the increase of thermal radiation and/ or burned gas emissions, released as a result of the burning process. The increase in the level of thermal radiation can determine the burst into flames or the explosion of other substances that are nearby the fireplace.

Explosions, regardless of their nature, create a shock wave of subsonic, sonic or supersonic speed, with major consequences for the buildings, the infrastructure and the nearby installations.

Emissions of dangerous substances that can have unwanted effects on the human health and that can have negative effects on the biotic factor in the impact area, depending on the properties of released noxious gases/vapors, on the time of exposure and on meteorological factors determining the dispersion of gas into the low atmosphere.

Massive vapor losses of dangerous substances can lead to environment pollution.

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The field of the probability-seriousness diagram is divided into two fields by a separation line called the risk profile:

a) the field of acceptable proximity scenarios;

b) the field of unacceptable proximity scenarios.

TABLE IV
THE SCALE OF APPRECIATION OF THE CONSEQUENCES OF TECHNICAL ACCIDENTS FOLLOWED FIRE AND/ OR EXPLOSION

ID.	Seriousness of the consequences	Level of seriousness	Details
1.	Null consequences	**G = 0**	Sporadic effects, without the deterioration of the technological systems. For example: (accidental release of gas/ vapors that can be isolated without the risk of explosion) accidental opening of the safety valve, breathing valves, and sampling
2.	Minor consequences	**G = 1**	Minor local deterioration of the material (sub)systems, without any effects on the reliability and the technical security in operation. For example: (cracks on the welding seams on the pipelines, gaskets broke on the flanged joints, untight joints on the measure and control devices)
3.	Considerable consequences	**G = 2**	Minor body injury (burns, injuries) affecting only one person; Intoxication of a limited number of people (not more than 5) with toxic products of reduced/medium toxicity level. Malfunctions at to the material (sub) systems that can determine the failure/breakage of the technological equipments. For example: breaking of a pipe or leakage on a technological coupling/safety valve/vent
4.	Severe consequences	**G = 3**	Body injuries suffered by one ore more individuals or extremely severe body injury suffered by only one individual. Intoxication of a limited number of people (not more than 5) with highly toxic products. Destruction of the material components of the technical/ technological system that can put one tank out of operation. For example: blockage of the safety equipment on the roof can lead to partial damage of the tank.
5.	Internal catastrophic consequences	**G = 4**	Extremely severe body injuries of several people (more than 5) or decease of at least one person. Destruction of the material components of the technical/ technological system that can put the power block or the installation out of operation for a long time. For example: self-ignition and explosion of the gas-vapor cloud or of the tank during the intervention.
6.	External catastrophic consequences	**G = 5**	Body injuries and deceases amongst the population. Degradation or destruction of the material systems outside the tank park. For example: BLEVE and Domino effect on the tanks or the tank cars.

Usually the risk profile is determined by establishing a reference value $(P \times G)_{ref}$ for the product between the P value associated to probability $\boldsymbol{\rho}$ [h^{-1}, an^{-1}] of having an unwanted final event (technical accident) and the G level of seriousness, according to the scale of appreciation for seriousness.

In order to be considered acceptable, any proximity scenario described as the product P x G, must be equal with the reference value $(P \times G)_{ref}$.

Considering the unacceptable events as **G = 3** as well as the danger of used substances (BTX) presented above for the tanks and car tanks, it is proposed to adopt a reference value $\mathbf{(P \times G)_{ref} = 4}$ and the probability-seriousness diagram presented in table V.

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TABLE V

External catastrophic consequences G= 5					
Internal catastrophic consequences G= 4				FIELD OF UNACCEPTABLE RISKS P x G > 4 **	
Severe consequences G= 3			Frontiers between the field of acceptable risks and the field of unacceptable risks		
Considerable consequences G= 2					
Minor consequences G= 1		FIELD OF ACCEPTABLE RISKS P x G ≤ 4 **			
Null consequences G= 0					
Seriousness	Improbable events	Extremely rare events	Rare events	Probable events	Frequent events
Probability	P = 1 ($\rho \leq 10^{-10}$)	P = 2 ($10^{-10} < \rho \leq 10^{-8}$)	P = 3 ($10^{-6} < \rho \leq 10^{-4}$)	P = 4 ($10^{-6} < \rho \leq 10^{-4}$)	P = 5 ($\rho > 10^{-4}$)

* the frequent events are the unwanted events (technical accidents) characterized by probabilities that are comparable with the probabilities (frequencies) admitted for the inherent human errors.

** in order to classify the possible proximity scenarios as acceptable and unacceptable, a reference value of $(P\ xG)_{ref} = 4$ was considered.

The assessment of the probability of occurrence of technical accidents and undesired events necessitates knowing the probability of occurrence of primary events. This condition implies the existence of a comprehensive data base that is constantly being updated, developed through the systemizing and processing of the information gathered both during the technical surveillance of the conduct in operation as well as after the accidents that occur during the exploitation of different technological equipments.

When assessing a final event (a technical accident) one must take into consideration the probability of all the events that contribute to the occurrence of the specific accident. According to the reference pattern for the evolution of the danger stage, the probability of occurrence of the technical accident is the product of the probabilities of all the involved determined events (the trigger event, the initial event, the main event and respectively the final event).

Information regarding the warning solution and the informing of the population

The alerting of the personnel is done through technical means such as the phone inside the installation plant, the radio stations and the mobile phones that can be used by the operator and the tank park fitter.

The personnel inside the park working on the first shift make the announcement to the park responsible (technologist) that coordinates the alerting activity according to the following chart:

a) During the working hours

Park responsible (technologist)→ manager→ the general inspectorate for emergency situations;

Park responsible → medical care unit-ambulance (according to the given situation);

Park responsible → local authorities (Town Hall);

Park responsible → police(according to the given situation).

b) Outside the working hours

Service officer → manager → park responsible (technologist)→ intervention team ;

Service officer → the general inspectorate for emergency situations;

Service officer → medical care unit-ambulance (according to the given situation);

Service officer → local authorities (Town Hall);

Service officer → police(according to the given situation).

Given the fact that an event that involves the presence of dangerous substances type BTX is not a long term event, of contamination with dangerous pollutants of the area or a danger to lead to collateral victims in time, informing the population implies:

The Emergency Plan can be found at the Refinery's headquarters where it can be consulted by the citizens and it incorporates the add-ins formulated as a result of the conclusions drawn from investigating the accident;

Posting parts of the Emergency Plan inside the unit, mainly those parts that refer to announcing, alarming, evacuating the personnel and to the actions that must be taken by the intervention units.

Information regarding the actions that must be undertaken by the part of the population that can be affected by a major accident:

Evacuating the area to a distance that is sufficient in order to avoid accidents, in the direction opposite to the direction of the wind;

Taking shelter behind buildings or constructions with concrete walls;

Protecting the head and those parts of the body that are exposed, against the objects that can be thrown by the blast of the explosion.

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Making sure that the right internal measures are adopted

Measures for increasing the security of the tank park and for diminishing the risks

Measures for increasing the security inside the tank park, which are divided into:

a) Passive protections, that reduce the probability of accidents by taking preventive measures;

b) Active protections that are dedicated to operation, in case an accident occurs, and have the purpose of minimizing the consequences.

a) The passive protection measures are taken during the revisions and repairs, after observing some of the problems that we face. These measures refer mainly to:

-Selecting the materials used for building the machines, pipes, equipments that would resist under extreme working conditions;

-Surrounding the area and ensuring the safety of the visitors;

-Using electrical equipments, equipments for the automation, tools, transport means and lifting equipments that are in compliance with the explosion class for BTX;

-Designing independent water units for fire fighting, instrumental air, power generators capable to insure the independent operation of the facilities in case of a power failure, failure of the equipments, fires or explosions;

-Proper automation, between clearly established limits, with optical and acoustic signaling and partial or total cut off in case of danger;

-Periodical training and checking of the personnel, exercising the manner in which to act in case of danger and necessity;

-Periodical checking of the safety measures and equipments.

b) The active protective measures that must be undertaken by the Refinery imply all the necessary actions to be taken in order to minimize the extension of an accident, saving the neighboring equipments and installations, protecting the personnel that works inside the park and in the neighboring area, refer to:

-Detecting and sending the alarm signal in case of BTX leakages;

-Automatic and manual start of the fire fighting devices;

-Organizing the fire fighters unit and checking the manner in which they operate;

-Organizing the special rescue teams;

-Automatic cut off of the flow in case the normal parameters are not met;

-Using the safety valve (overpressure) for evacuation in case the maximum pressure is exceeded.

Description of the equipments that must exist inside the unit in order to limit the consequences of a major accident

The main equipments that must be present in the tank park that can ensure the limiting of the consequences in case of accidents that involve BTX substances are:

-Mounting automated vents that would ensure the isolation of the tank so that the BTX leakages on the pipelines would be reduced;

-Fire detectors that are equipped with pre-alarm and alarm for detecting the dangerous concentrations around the tanks, the pumps, the compressors and the loading/unloading rack. The sensors automatically start the installation that jets water for cooling and help minimize the possibility of fire;

-Emergency buttons for shutting down the pumps;

-Manometers, thermometers with local and centralized monitoring on which it can be observed the trend of the parameters in case of an incident (equipping the tanks with a TankRadar system);

-Fixed jet water installations that insure the cooling of the tanks, creating the isolating water walls around the tank inside the tank park where the incident occurred, thus protecting the neighboring tanks;

-External hydrants and water headers for feeding the fire fighters machines, to which the water hoses and the accessories for transferring the jet water can be attached.

Organizing alert and intervention

The personnel are alerted using the phone inside the installation plant, the radio stations and the mobile phones that can be used by the operator and the tank park fitter.

For any type of accident or incident, the Refinery has an obligation to draw intervention plans which are coordinated by a general quarters.

In order to stop and to limit the effects of an incident or an accident, the following must be informed: the toxicology lab, the civil fire-fighters unit of the company and the military fire-fighters unit, the medical care unit, using the previously established means of signaling and warning.

In case a major accident occurs, the population must leave the danger area as quick as possible, to stay away from the direction of the wind, not to panic, to be disciplined, obeying the indications/ requests of the local authorities representatives that are present as well as those of the Refinery's representatives.

The internal emergency plan of the refinery must foreseen all the possible scenarios and situations that may lead to a major accident/ incident as well as all the actions that must be taken in order to minimize the effects, by using both the internal resources as well as the help of the external emergency services.

The external plan for emergency situations must be prepared by the local authorities, for the area in which the refinery is located and it insures an organized frame for intervention in case of a major accident.

The cooperation of the population with the emergency services in case of an accident

In order to minimize the effects of a potential major accident on the population that lives in the incidence area, it has a legal obligation to cooperate on any instructions or request given by the emergency services: The Inspectorate for Emergency Situations, The Town Hall, The Ambulance Services, the Police.

Proposed solutions

With reference to the aspects related to preventing and predicting major events/ accidents in the tank park, the results of the analysis have shown the following:

The products that are present in the refinery are classified as dangerous chemical products;

It is necessary to train the operators on instructions related to the solutions to be used for giving the warning and sending the information in case an accident occurs;

A plan must be developed with reference to the actions that must be taken to warn the population in case of a major accident;

It is absolutely necessary to equip the tanks with equipments dedicated to limiting the consequences of major accidents;

Urgent measures must be taken in order to replace the safety equipments with new functional equipments.

Finally, we feel that the most efficient solution for avoiding a major accident is to automatically monitor the tank parks and to diminish the vapor losses by adopting measures that are consistent with the environmental legislation.

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