ISSN 2229-5518

Assessing the Risk of Threat Due to Hostile Threats in Pardis Petrochemical Complex (Assaluyeh) Using FEMA Method and Investigating Its Consequences by PHAST Software

Morteza Naghshvar*, Mohammadali Zahed, Seyed Mostafa Khezri
Department of Management, West Tehran Branch, Islamic Azad University, Tehran, Iran

Abstract—The ammonia storage tanks have been considered as the potential sources of major accidents according to the above mentioned methodology. Risk of ammonia storage tank in Pardis petrochemical complex were investigated using FEMA 452 technique. Additionally, PHAST by DNV production software employed for assessment of consequences. The result indicated that, in this study, after investigating the risk of hostile threats during peacetime and war, a rocket attack with ammonia storage tank in this facility has the highest risk assessment, which was selected as a probable scenario. Due to the collision of the rocket and the rupture of the storage tank, a dangerous concentration of ammonia vapor is dispersed in the environment. Hazardous concentrations of ammonia vapor (IDLH) are released in the summer season and in atmospheric weather conditions (2F), and in the wind direction, the dangerous concentration can be released up to 12 (km) from the Pardis petrochemical complex. The maximum calculated distance can include the cities of Assaluyeh and Nakhl Taqi. The outcome of this study is applicable for further planning as well as HSE management system and in the future planning for emergency response in the city of Assaluyeh and Nakhl Taqi.

Index Terms— Hostile Threats, Pardis Petrochemical Complex, Ammonia Leakage, PHAST Software, Risk of Threat, FEMA Method, HSE

1 Introduction

With the historical overview of the ongoing wars in the past century, we find that there were attractive and constant goals in all wars that, having regard to their importance and important role in the economic cycle of countries and the affiliations of industries to them, have always been threatened by various enemies. Storage tanks and petrochemical infrastructure are one of the key factors for the sustainability of the national economy, stability of security and an increase in the quality of life of the people. The petrochemical industry is identified as the second most important source of income in the country after oil reserves, and because of the high sensitivity and potential of hazards (flammable, explosive and chemical release), products manufactured against enemy attacks are highly vulnerable and require a comprehensive program to prevent the occurrence of threats and the possible consequences of it. Considering the dependence of the world and the oil-rich countries on the production and sale of petrochemical products, there is a history of numerous attacks on these facilities during World Wars (I) and (II), the Persian Gulf War, the Iran-Iraq War, the ISIL terrorist attacks in Iraq and Syria and the Middle East region. Nowadays, with increasing population density and the proximity of industrial and productive areas, adverse consequences of events are not limited to the same industrial areas or damaged units, but the harmful effects of any industrial unit can spread to areas beyond the scope of monitoring and control, and residential areas affects your surroundings. Ammonia is a chemical that is produced in a large volume of petrochemical industry. Ammonia has both flammability and toxicity, but ammonia does not have much flammability and its toxicity is most likely to be present. Ammonia has a sharp odor, and thus provides a range of warnings about its presence and can damage the vital organs of the body, including the skin, the skin and the eyes, and should not breathe in any way. Ammonia reacts with moisture in the body's moist layers, and an alkaline solution called ammonium hydroxide is produced and affects the entire human respiratory system, causing severe damage to the mucous membrane and lung tissue and results in lethal results. Ammonia has a low IDLH (300 ppm) and TLV-TWA (25 ppm) values, which are indicative of its highly hazardous nature [1-22]. There are several reports on accidents involving ammonia and subject of many risk studies [5]. Ammonia is widely used in most industries, and is stored in a variety of ways. The conventional and industrial species of ammonia storage can be mentioned in the use of cold storage tanks. The design and operation of these types of reservoirs is at atmospheric pressure and a negative temperature of 33°C. Evaluation and designation of probable scenarios are of great importance. On the other hand, as ammonia production units play a major role in the country's infrastructure and funda-

- *Morteza Naghshvar, Corrsponding Author.*

mental progress in various sectors, including agricultural and industrial countries. Ammonia is one of the causes of environmental degradation, including in the Earth's climate and can endanger human health. The evaluation of the consequences of the publication is important and meaningful. The Storage is at ambient temperature, atmospheric pressure under cryogenic condition. Usually the risk in such storage facilities results from the rapture of the storage tank at ground level, which leads to evolution of large amounts of ammonia [19]. Such release can results in serious consequence, including fatalities and injuries depending on the wind direction concentration to which the plant petrochemical workers and the surrounding public are exposed.

In the storage tank ammonia facility under investigation, ammonia is stored at ambient temperature, atmospheric pressure under cryogenic condition. The storage area is the outer periphery of operation plant so that the supply tanks do not have to enter the main plant area. However implies that much ammonia release can easily travel across the boundary and affect the nearby habitation. This report presents the result of attack risk analysis for the case and release of ammonia under different prevalent weather condition from storage tank [17].

2 Results and Discussion

In this investigation Methodology using FEMA 452 technique. Additionally, PHAST by DNV production software employed for assessment of consequences. The risk assessment methodology presented in this publication has been refined by FEMA for this audience. The first step is to conduct a threat assessment where in the threat or hazard is identified, defined, and quantified (Step 1). For terrorism, the threat is the aggressors (people or groups) that are known to exist and that have the capability and a history of using hostile actions, or that have expressed intentions for using hostile actions against potential targets as well as on whom there is current credible information on targeting activity (surveillance of potential targets) or indica¬tions of preparation for terrorist acts. The capabilities and histories of the aggressors include the tactics they have used to achieve their ends. The next step of the assessment process is to identify the value of a building's assets that need to be protected (Step 2).

After conducting an asset value assessment, the next step is to conduct a vulner¬ability assessment (Step 3). A vulnerability assessment evaluates the potential vulnerability of the critical assets against a broad range of identified threats/hazards. In and of itself, the vulnerability assessment provides a basis for determining mitigation measures for protection of the critical assets. The vulnerability assessment is the bridge in the methodology between threat/hazard, asset value, and the resultant level of risk [1]. Risk is the potential for a loss of or damage to an asset. It is measured based upon the value of the asset in relation to the threats and vulnerabilities associated with it:

Risk = Asset Value × Threat Rating × Vulnerability Rating

The PHAST software is a tool for analyzing the outcome that HSE engineers use to assess the risks of industrial activities and determine the extent of the risks and casualties resulting from accidents. There are several techniques and methods, but the modeling of the consequences of incidents without the use of professional software is very time consuming and is mainly due to error. The PHAST software is one of several production products developed by DNV (one of the pioneers of hazard and industrial disaster risk assessment). This software is one of the key tools in deciding on the modeling of industrial hazards and safety. PHAST software has fire modeling, explosion and release of toxic and chemical substances in the industrial environment. The results and diagrams of the PHAST software are used to determine the layout of complexes, emergency response planning guideline and hazard integrity systems [18].

The ammonia atmospheric storage tank under investigation three tanks each of 20 thousand tons are failed to 80% of their working capacity. Each of these tanks is 20 (m) radios and has a diameter of 19.55 (m) high.

Ammonia has a low IDLH (300 ppm) and TLV-TWA (25 ppm). The flammable limits of ammonia are 16-25% by volume in air with an ignition temperature of 651ºC. Ignition of ammonia and air mixtures is improbable under ordinary conditions, but it occurs in a confined space it may be results in an explosion. The major hazard identified from the FEMA method is "Release of ammonia due to leakage caused by Rocket Armed Attack-Ballistics and catastrophic rupture of storage tanks".

Agencies use the term "hazard" in several different contexts. In this research, only manmade terrorist threats will be used in the critical functions and infrastructure matrices. The importance of technological hazards is that they can become a threat if they are targets of malicious attacks. Identifying the threats can be a difficult task. Because manmade hazards are different from other hazards such as armed Attack-Ballistics Rocket, Vehicle Bomb is difficult to predict. The fact that data for manmade hazards are scarce and that the magnitude and recurrence of terrorist attacks are almost unpredictable makes the determination of a particular threat for any particular site or building difficult and largely subjective [1, 13]:

STEP 1: Thereat identification
- Attack intellect indicator
- Hostile ability indicator
- Cost and profit indicator
- Extremity severity indicator

Step 2: Asset value assessment
- Asset value indicator
- Asset turnover indicator
- Amplitude effect indicator
- Monopoly and a situation indicator

Step 3: Vulnerability assessment
- Identity indicator
- Infirmity conservation indicator
- Infirmity process indicator
- Adjacent indicator

Step 4: Risk assessment
- Threat rating
- Asset value
- Vulnerability rating

There are numerous methodologies and technologies for conducting a risk assessment. The approach is to assemble the results of the threat assessment, asset value assessment, and vulnerability assessment, and determine a numeric value of risk for each asset and threat/hazard pair in accordance with the following formula:

Risk = Asset Value × Threat Rating × Vulnerability Rating

Threats are divided into two groups: peacetime and wartime. Each of these groups can be divided into the following subcategories:

- Armed Attack-Ballistics Rocket
- Armed Attack-Graphite Rocket
- Armed Attack-Electromagnetic Rocket
- Armed Attack-Rocket Propelled
- Cyber Attack
- Terrorism Electromagnetic Bomb
- Vehicle Bomb
- Suicide Bomber

The objective of consequence analysis is to quantify the harmful impacts in case of occurrence of top event. Toxicity is the major hazard associated with the accidental release of this chemical. Ammonia gas is colorless, with an extraordinary spicy tasting taste, which is teasing and suffocating. Ammonia gas is lighter than air and easily converted to liquid. Ammonia stored at pressure possess considerable potential energy and should a rapture of primary container occur, the liquid will flash into a vapor spontaneously as the thermodynamic state of the ammonia adjusts itself the diminished pressure. Hazardous concentrations of ammonia gas will fill up closed spaces or poorly ventilated spaces.

Ammonia is stored in tank at -33 °C and kept as liquid. During the study, the chemical and physical properties of ammonia indicate that during the tear of the tank and entering the environment, the phase change and the gas mass become warmer than the boiling point. As a result of rupture, ammonia is flowing in a concrete dike and starts to evaporate with a variable evaporation trap. In this case, the formation of the pond evaporates. After a certain time and depending on the environmental conditions, ammonia is converted from the surface of the dike to ambient temperature, due to the ammonia vaporization of the air, ammonia vapor deviates from the surface of the earth. The gas generated by the evaporation of the liquid ammonia fluid can be produced mist and the release of liquid droplets with gas. In this case, heavy gas is considered. Ammonia is one of the chemicals that, when discharged in the environment, is a heavy gas, and displays its own special effects. Due to the decrease in the evaporation and cooling point of the fluid surface and the reduction of ammonia in the dike, the limits of dangerous concentrations are constantly decreasing [17].

(a) In scenario distance is from the edge of the pool (PHAST considers the as rectangular and calculated the effective diameter (In this case, the pool dimension =200×90×3 meter).

(b) According to international standards, we can use the lethal concentration 0.1%, 0.01% and 0.001% for 30 minutes exposure time as a toxic level of concern for vulnerable (national roads, crowded traffic) or very vulnerable targets (townships, Pars petrochemical).

The main objective of the PHAST environment distribution modeling is to estimate the concentration of matter released in the environment at a given distance from the source at a specific time. The release of vaporous chemicals in the environment can be viewed from the perspective of cloud-based behavior, including positive and negative floating gases. Positive floating gases have a lower density than air and gases with negative floating are denser than air. Ammonia is dispersed when it is released on the surface of the earth, which indicates the behavior of the gas with negative flotation. The weather data provided by the local meteorological department of Assaloye (ten year data) was analysis. The year was divided into one Seasons namely summer (Jun) as five was substantial change in the wind direction. Base on the wind rose pattern, the probability wind direction during summer (51% of the time) is WNW so probability of ammonia dispersing in this direction is maximum concentration.

The highest pollutant emission concentration is related to atmospheric stability F in the output report of the software PHAST (atmospheric stability of F is less volatile than D) due to the high temperature and the amount of received solar radiation This summer, it facilitates and increases the evaporation of liquid ammonia and its phase change. Output data from PHAST software is compatible with expectations from the summer season. Locations with a dangerous concentration of ammonia require Emergency Response Planning Guideline and locations with lower concentrations requiring precautionary measures [2].

After 600 seconds, the lethality rate due to the toxicity of ammonia emission in the direction of the dominant wind of the region in the indoor and outdoor environments is shown in the following forms.

In the worst case, weather conditions and atmospheric stability of 2F affect the toxicity of ammonia emissions in indoor environments up to 10 kilometers and external environments up to 12 kilometers from the pollutant emissions center of its perimeter environment.

If there is a source of ignition, an upper explosion limit (UFL) at 96 meters and a lower explosion limit (LFL) of 265 meters will occur in atmospheric conditions 2F.

In the event of fire inside the dike and the creation of Pool Fire, the greatest disturbance to personnel with the amount of thermal radiation of the fire at a distance of 273 meters in atmospheric conditions 3.4D and damage to structures and equipment with the amount of thermal radiation of the fire at a distance of 138 meters, it will be in the stable condition of 15D.

Based on the results obtained from this study, the most serious threat posed by the general public and petrochemical personnel located in the Pardis petrochemical complex is the consequences of inhalation of dangerous concentrations of discharged ammonia vapor in the environment and can be the maximum distance of hazardous concentrations (IDLH) in the summer with F sustainability, which affects the perimeter area up to 12 (km) in the direction of the prevailing wind blowing (WNW).

The maximum distance of the occurrence of ERPG1 concentrations up to 50 kilometers radius in the direction of the wind blow in the region, which should be planned and implemented in emergency situations in this regard [8].

3 Conclusion

In this research from the Pardis petrochemical industry, it can be claimed that ammonia production is one of the most complex industries that is grouped in the environmental pollutants industry. The pollution created in this industry in various parts of the environment, including air, water and soil, has a major impact, which in many cases is irreparable.

One of the effective measures to reduce the amount of damage and prevent human casualties at the time of the rupture of the reservoir and the release of toxic and dangerous ammonia vapors is to know the vapor mass flow path. The direction of displacement of the general population of neighboring areas and the personnel of neighboring petrochemicals is in opposition to the wind movement and the course of the cloudy mass of the cloud. Therefore, in order to reduce the adverse effects, the following measures should be taken at the time of full 20,000 tons of ammonia reservoir rupture or the destruction of all existing reservoirs in concrete dike The following are suggested:

(a) Using the online meteorological system in the South Pars region and the hardware meteorological attachment to the PHAST software can be effective in simulating and predicting areas, and will be used to make decisions on regional crisis management and implementation of emergency response plans.

(b) Preparing the emergency plan and establishing a crisis committee in the region, supplying appropriate equipment and appropriate hazards in the Pars Energy Region, evacuating areas affected by the release of ammonia from human resources and securing the environment of the periphery.

(c) Design and construction of a concrete dike proportional to the volume of the probable waste stream resulting from the potential for steam and fire in accordance with the slope of the area to prevent the flow of ammonia waste in open and natural evaporation.

(d) Equipping hazard zones to SCBA respiratory systems, rating events to levels 1, 2, and 3, separating job descriptions from rescue teams in case of need to evacuate the peripheral area.

(e) Create a protective coating layer and prevent the simultaneous evaporation of ammonia discharged into the dike.

(f) Reducing the volume of chemical accumulation in storage tanks.

(g) The use of automatic fire extinguishers is stepwise, first, water and foam, and then heavy foam to prevent fire and prevent evaporation of ammonia from the dike.

References

[1] Risk Assessment A How-To Guide to Mitigate Potential Terrorist Attacks Against Buildings FEMA452.

[2] CPG 201-Threat and Hazard Identification and Risk Assessment Guide - Second Edition - August 2013.

[3] Canadian Center For Occupational Health And Safety.

[4] Hanna, S.R , Chang, J.C and Strimaitis, D.G.,1993, Hazardous gas model evaluation with field observations Atmospheric Environment, 27A(15)2265-2285, PASQUILL.

[5] CCPS, Guidelines for evaluating the characteristics of vapor cloud Explosion, flash, fire and BELEVE, ALChE, New York, ISBN 0-8169-0474x,387 pp,, 1994.

[6] The quist quarterly "A comparison of vapor and cloud explosion models" volume 4, 1999.

[7] Robert, Alley-E, 1998, "Air Quality control Handbook".

[8] ERG, Emergency Response Guideline 2012.Apr. Graphicgroup.ir.

[9] Baeza. J, Gabriel. D, Bijar.J, Lafuente. J, 2009, «A Distributed Control System Based on 2012 Agent Architecture for Wastewater Treatment ». Computer-Aided Civil and Infrastructure Engineering 17: (2), PP. 93–103.

[10] ASIS (2003). "General Security Risk Assessment Guideline", International Advancing Security Worldwide, Virginia, USA.

[11] Gabriel, Paul (2009), "Victoria's state-level Emergency Risk Assessment Method", Australian Journal of energy Management. Vol 24, No.1.February.

[12] All Hazard Risk Assessment Methodology Guideline, 2012-2013.

[13] Coppola, Damon P (2006). "Introduction International Disaster Management", Butterworth Heinemann. Burlington. Pp 113-119.

[14] API/NPRA (2004). "Security Vulnerability Assessment Methodology".

[15] Petrochemical Industries Design & Engineering Company (PIDEC) Project No: 1216, Consequence Analysis Report, WEATHER CONDITION, page 8.

[16] Prasun Kumar Roy, Arti Bhatt (2011),, Consequence and risk assessment: Case study of ammonia storage facility ARCH.ENVIRON.SCI,5,25-36.

[17] Jordan Haddad, Salah Abu Salah (2016), Major hazard risk assessment on ammonia storage at Jordan phosphate mines company (JPMC) in Aqaba, Jordan.

[18] https://www.cdc.gov/niosh/idlh/7664417.

[19] https://www.iopdc.com.

[20] Nariman Nezhad, A.R., Ammonia Leakage Dispersion Modeling of Storage Vessels in Petrochemical Plant and Providing ERP (Case study: A Petrochemical Complex)', Master Thesis, Islamic Azad University Science and Research Branch, 2010.

[21] https://www.dnvgl.com/contact/index.html.

[22] Keshavarz M S, Zahed M A, Monfared A H, Roshani, F (2017) Introducing a conceptual model for prevention of accident in the oil and gas industries, 8th National seminar of chemistry and environment, September 6-7, 2017, Tehran-Iran.