CONSEQUENCE MODELING OF AMMONIA STORAGE TANK IN A CHEMICAL PLANT-A CASE STUDY

[1]NADER NABHANI, [2]AMIR ROSTAMZADEH

[1,2]Petroleum University of Technology, Abadan, Iran
E-mail: Nabhani@put.ac.ir, Amir.rostemzadeh@yahoo.com

Abstract- Huge number of accidents every year happens because of adequate attention to the Health and Safety Engineering Management System (HSE.MS). Consequence assessment is one of the most important steps in safety and risk assessment. Consequence modeling refers to the calculation or estimation of numerical values (or graphical representations of these) that describe the credible physical outcomes of loss of containment scenarios involving flammable, explosive and toxic materials with respect to their potential impact on people, assets, or safety functions. This paper presents recommended approaches to consequence modeling for accidental releases of hazardous materials, with the potential to cause harm to people, damage to assets and impairment of safety functions, from offshore and onshore installations. Among consequence modeling soft wares PHAST (DNV software) is explained and a case study is done at one of the Petrochemical Complex in Asalooyein the Persian Gulf on the ammonia storage tanks. Finally some conclusions and recommendations are made.

Keywords- Chemical Plant, Ammonia Storage, Consequence Modeling

I. INTRODUCTION

Risk assessment in chemical process industry is a very important issue for safeguarding human and the ecosystem from damages caused to them. Consequence assessment is an integral part of risk assessment. In the last decades, world has seen a wide range of major accidents with a number of fatalities, economic losses, and damage to the environment. Attempts have been undertaken to prevent these accidents and to reduce risk to a level as low as reasonably practicable (ALARP) without resorting to costly protective systems. This has been done through the identification and assessment of major risk contributors, which can be accomplished using quantitative risk assessment (QRA) techniques. QRA involves four main steps: hazard identification, consequence assessment, probability calculation, and risk quantification.

In order to prevent to accident international organizations study their experiences and their management history for construct an Integrated Health and Safety Management System.

The consequence analysis aims to quantify the negative impacts when a hazardous event takes place. The consequences are generally quantified in terms of production loss, human health loss, assets loss, and environmental loss. The assessment of consequences can be done using a wide variety of mathematical and empirical models. Generally first, source models are used to predict the rate of release of hazardous material, the degree of flashing, and the rate of evaporation.

These models are used to find the initial sizes of fires and explosions. Secondly, the impact intensity models are used to estimate the damage area due to fires and explosion load. Finally, the toxic gas models are used to estimate human response to different levels of exposures to toxic chemicals. Commercially, there are many software packages available for consequence and risk assessment in chemical industries such as PHAST, ALOHA, SAFETI, QRA Works SUPERCHEMS, TRACE that has been developed specifically to estimate the impacts of accidents involving explosion, fire and toxic release. In this paper we use PHAST for estimating effects of release of ammonia. We use actual data from one of the storage tanks of Asalooyeh Petrochemical Company in South Pars districtin the Persian Gulf for modeling and estimation of release and effects of Ammonia.

Ammonia, or azane, is a compound of nitrogen and hydrogen with the formula NH_3. It is a colorless gas with a characteristic pungent smell. Ammonia contributes significantly to the nutritional needs of terrestrial organisms by serving as a precursor to food and fertilizers.. The toxicity of ammonia solutions does not usually cause problems for humans and other mammals, as a specific mechanism exists to prevent its build-up in the bloodstream. Ammonia is converted to carbamoyl phosphate by the enzyme carbamoyl phosphate synthetase, and then enters the urea cycle to be either incorporated into amino acids or excreted in the urine[citation needed]. However, fish and amphibians lack this mechanism, as they can usually eliminate ammonia from their bodies by direct excretion. Ammonia even at dilute concentrations is highly toxic to aquatic animals, and for this reason it is classified as dangerous for the environment.

NH_3 boils at −33.34 °C (−28.012 °F) at a pressure of one atmosphere, so the liquid must be stored under high pressure or at low temperature.

Weather condition is one of the effective parameters

on results, so parameter which specify it are important requirement in consequence modeling. Actual weather data are used for these purpose (temperature, wind velocity, and…). The consequences analysis for one session is shown in this paper. A large number of parameters affect the dispersion of gases. These include (1) atmospheric stability (2) wind speed (3) local terrain effects (4) height of the release above the ground (5) release geometry, that is, from a point, line, or area source (6) momentum of the material released, and (7) buoyancy of the material released.

Table 1- Operational Condition

T(°C)	P(atm)	V(m^3)
-40	Atmospheric pressure	20000

II. OPERATION AND WEATHER CONDITION

The ammonia produce in this complex is kept in cylindrical vessel which has 2m height and 20000m^3 with 1atm operational pressure.

A. Weather Condition

Average weather conditions used for modeling are as follows according to the Asalooye meteorological office are listed in following table.

According the wind speed and solar radiation weather stability class was taken' D' .Surface roughness with considering district condition is taken 1m.

B. Defining Scenario

In these study consequence analysis of leakage in ammonia storage is taken. According to standards rupture of largest inlet/outlet pipe consider as scenario. Diameter of largest inlet pipe is 30cm.

Table 2- Atmospheric condition

Session	*Average Temperature(°C)*	*Relative Humidity*	*Wind Speed(m/s)*
Spring	*36.33*	*82٪*	*8.29*

III. RESULTS AND CONCLUSION

A. Vapor Cloud Explosion (VCE)

As mention above in environment pressure and temperature is in gas state. When a large amount of flammable vaporizing liquid or gas is rapidly released, a vapor cloud forms and disperses with the surrounding air. If this cloud is ignited before the cloud is diluted below its lower flammability limit (LFL), a VCE or flash fire will occur.

Following figure shows distance can be affected by explosion. The following results are obtained.

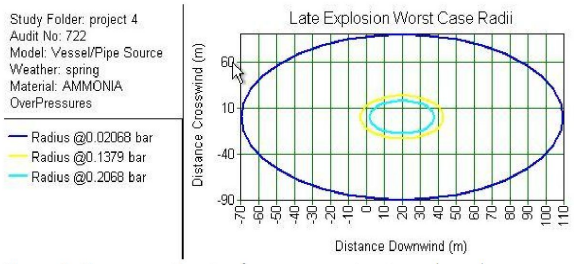


Figure 1- Damage estimates for common structures based on over pressure

Table 3- Damage estimates for common structures based on over presser

P(psi)	Consequence
0.5	Large and small windows usually shatter, occasional damage to window frames
1	Partial demolition of houses, made uninhabitable
2	Partial collapse of walls and roofs of houses
3	Heavy machines industrial building suffer little damage, steel frame building distorted and pulled away from foundation
10	Probable total destruction of building, heavy machine tools moved and badly damage, very heavy machine tools (1200lb) survive
30	Total destruction

- An over pressure of more than 0.02068 bar (0.3 psi) is created at the distance of about 110 m downwind, 70m upwind and about 90m to the sides. According to figure 1 this amount of over pressure can cause some damages to buildings and structures.
- An over pressure of more than 0.1379bar (2psi) is created at the distance of about 40 m downwind, 5m upwind and 20m to the sides. According to figure 1 this amount of over pressure can cause serious damages to concrete structures and walls.
- An over pressure of more than 0.2068bar (3psi) is created at the distance less than 40m downwind, and more than 10m to the sides. According to figure 1 this amount of over pressure can destroy everything.

B. Jet fire

Jet fires typically result from the combustion of a material as it is being released from a pressurized process unit. The main concern, is in local radiation effects.

According to following figure these object can be obtained:

i. At the distance of more than 101m downwind the radiation is more than 4KW/m^2. According to table this radiation amount could cause burns to the personnel.

ii. At the distance of less than 91m downwind the radiation is more than 12.5KW/m^2. According to table this radiation amount could cause fires to the wooden instruments.

C. Pool fire

Pool fires tend to be localized in effect and are mainly of concern in establishing the potential for domino effects and employee safety zones, rather than for community risk. The primary effects of such fires are

due to thermal radiation from the flame source. According to following figure,it can be observed that:

At the distance more than 150m downwind the radiation is more than 4KW/m^2. According to table 4 this radiation amount could cause burns to the personnel.

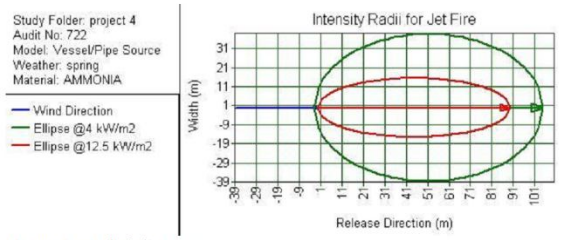


Figure 2- Radial distance

Table 4- Effects of thermal radiation

Radiation intensity (kW/m^2)	Observed effect
37.5	Sufficient to cause damage to process equipment
25	Minimum energy required to ignite wood at indefinitely long exposure(nonpiloted)
12.5	Minimum energy required for piloted ignition of wood, melting of plastic tubing
9.5	Pain threshold reached after 8 sec; second degree burns after 20 se
4	Sufficient to cause pain to personnel if unable to reach cover within 20 sec, however blistering of the skin (second degree burns) is likely; 0% lethality

At the distance of about 120m downwind the radiation is more than 12.5KW/m^2. According to table 4 this radiation amount could cause fires to the wooden instruments.

At distance about 80m downwind the radiation is more than 37.5KW/m^2. According to table4 these radiation amount could cause damage to process equipment.

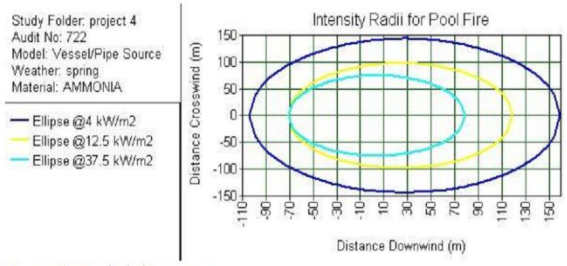


Figure 3- Radial distance

IV. RECOMMENDATION

As we said before the purpose of consequence modeling is to determine the risk level of a scenario. As described in last part the risk level is too high as the severity is too high, so a corrective action must be taken to reduce the risk. Some actions are recommended bellow to:

i. One of the best ways is to use smaller storage tanks. This will lead to inherently safer design. But this is suitable in the process design phase and is not practicable in the operation phase.

ii. Another way that is practicable in the operation phase is to use predictive and preventive maintenance programs that can prevent the tanks from being corroded and therefore leakage. This is done currently by the company by discharging tanks in a specific schedule and tests it by using the Non Destructive Tests (NDT) methods and fixing the failures.

iii. Surrounding building should be heat shielded and should be used to strong material against the explosion also windows should has little size and protected.

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