



Hazard Analysis of Chlorine Cylinder Storage In Coal-Fired Power Plants using Aloha Simulation

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ABSTRACT: This Project considers the consequence and risk models for accidental releases of toxic or flammable chemicals to the atmosphere. This study includes an overview on how the Chlorine Explosion could be carried out in thermal power station for discharge, atmospheric dispersion (including pools) and flammable effects (e.g. pool fires, jet fires, BLEVE). A wide range of release scenarios is considered including sub-cooled liquid releases, superheated liquid releases, vapor releases, un-pressurized and pressurized releases and a wide range of hazardous chemicals is considered (e.g. Chlorine etc). The objective of this project is to find out the Hazards and Risk in Storage of Chlorine gas. Using the ALOHA hazard assessment Techniques to calculate the risk assessment and ensure to developed preventive action and control measures of fire and explosion hazard.

Keywords: Chlorine release, ALOHA modeling, Behavior-Based Safety (BBS), industrial hazard evaluation, chemical storage safety.

SDGs: Atmospheric stability classes, vapor cloud explosion, thermal radiation, risk assessment, emergency response planning.

I. INTRODUCTION

Chlorine is a highly toxic and reactive chemical widely used in coal-fired power stations for water treatment. Its storage and handling pose significant risks, particularly in the event of accidental release. Such releases can result in toxic gas clouds, fire hazards, and even explosions under certain conditions. Therefore, accurate hazard assessment is critical to mitigate risks and protect personnel, infrastructure, and surrounding communities. Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA). ALOHA enables real-time estimation of threat zones associated with toxic dispersion, flammability, thermal radiation, and over pressure. Cement is one of the most widely used substances on earth. Making cement is an energy and resource intensive process with both local and global environmental, health and safety impacts.

The entire hazard from cement industry may damage the environment and health. Consequence analyses of hazardous chemical releases, as a part of risk assessment process, are very important for emergency response planning. The outcomes of the release of chemicals are influenced by the degree of turbulence in the atmosphere. In this study, consequence of CHLORINE releases of storage tank in a industries zone due attention of high flammability effects selected for modeling using ALOHA software. ALOHA models' key hazards are toxicity, flammability, thermal radiation (heat), and over pressure related to chemical releases that result in toxic gas dispersions, fires, and/or explosions. Finally, the flammable area of vapor cloud, and the threat zone of jet fire and pool fire in different stability classes were estimated. The present study aims to estimate the threat zone of flammable chemical releases and to assess the effects of different atmospheric stability classes on the consequences of hazardous liquid releases from a storage tank.



II. LITERATURE REVIEW

The Areal Location of Hazardous Atmospheres (ALOHA) model has become one of the most widely used computational tools for simulating accidental atmospheric releases of hazardous chemicals.

Tseng et al. (2012) conducted a pivotal study that systematically evaluated ALOHA's capability to model accidental releases of highly toxic industrial chemicals—including chlorine, epichlorohydrin, and phosgene—from storage tanks and industrial facilities.

Their research highlighted that ALOHA uses essential input parameters such as tank geometry, chemical properties, leak size, temperature, humidity, and wind characteristics to generate dispersion plumes that reflect realistic environmental impacts.

One of the primary strengths of ALOHA lies in its ability to simulate dynamic atmospheric interactions. For example, under stable atmospheric conditions (such as Pasquill Stability Class F), toxic plumes tend to remain concentrated and travel farther distances close to the ground. In contrast, unstable conditions (such as Class A or B) promote vertical mixing, diluting the chemical cloud more quickly. This meteorological sensitivity allows emergency response personnel to assess worst-case and most-likely scenarios with higher precision.

Tseng et al. further emphasized that ALOHA's outputs—including threat zone maps, concentration-time profiles, and toxic endpoints—directly support emergency responders by informing shelter-in-place orders, evacuation perimeters, and on-site mitigation strategies. These capabilities make ALOHA a cornerstone tool for industrial safety planning, fire departments, and government regulatory agencies (Tseng et al., 2012; U.S. EPA & NOAA, 2023). A major chemical highlighted in consequence modeling is chlorine, known for its high toxicity and density.

Its molecular weight causes it to sink and accumulate in low-lying areas, creating ground-hugging plumes with severe inhalation hazards, as supported by numerous industrial safety guidelines (Ahmed et al., 2010; Bureau of Indian Standards, 2016).

In petrochemical plants, refineries, and fuel-handling facilities, chlorine releases can quickly escalate into large-scale public health emergencies, making accurate modeling essential. Natural gas power plants present unique risks due to their reliance on pressurized pipelines and high-energy combustible gases.

Hui and Guoning (2012) conducted an advanced Quantitative Risk Assessment (QRA) to evaluate the potential consequences of pipeline leaks in natural gas infrastructure. Their study modeled three different leak sizes—100 mm, 200 mm, and 1200 mm—to examine how breach diameter influences gas dispersion, ignition probability, and thermal radiation zones. Effective evacuation planning is fundamental to minimizing injuries and fatalities during industrial chemical accidents. In their case study of Aliaga, Turkey, Onelcin et al.

Applied ALOHA to determine toxic threat zones created by a simulated chemical release. Based on chemical behavior, atmospheric conditions, and emission rate, the threat zones were mapped into three radial categories measuring 1.7 km (red zone), 2.4 km (orange zone), and 3.7 km (yellow zone).

These zones correspond to areas of immediate danger, potential injury, and long-term health concerns respectively. Ahmed et al. (2010) emphasized the importance of implementing structured risk management frameworks within Health, Safety, and Environmental Management Systems (HSEMS). Fang et al. (2023) investigated the effectiveness of carbon dioxide (CO₂) and nitrogen (N₂) in inhibiting coal oxidation—a precursor to spontaneous combustion.

Shehu & Chetehouna (2021) reviewed sprinkler systems, noting that integration with computational fire modeling tools yields more effective emergency responses by predicting flame spread and identifying optimal suppression strategies. Providing accurate insights into toxic release scenarios and supporting emergency planning across industrial sectors. Overall, the literature highlights the importance of multidisciplinary approaches—combining computational modeling, engineering.

III. RESEARCH METHODOLOGY

A fire is a complex chain reaction where a fuel combines with oxygen to generate heat, smoke, and light. Most chemicals fires will be triggered by one of the following ignition sources: sparks, static electricity, heat, or flames from another fire. Additionally, if a chemical is above its auto ignition temperature it will spontaneously catch on fire without an external ignition source. Here we'll discuss three of these properties: volatility, flash point, and flammability limits. Volatility is a measure how easily a chemical evaporates. ALOHA (Areal Locations of Hazardous Atmospheres) is a computer program designed especially for use by people responding to chemical releases, as well as for emergency planning and training. ALOHA models key hazards toxicity, flammability, thermal radiation (heat), and overpressure (explosion blast force) related to chemical releases that result in toxic gas dispersions, fires, and/or explosions. ALOHA was developed jointly by the National Oceanic and Atmospheric Administration (NOAA) and the Environmental Protection Agency (EPA). The most basic definition of an explosion is a sudden, intense release of energy that often produces a loud noise, high temperatures, and flying debris, and generates a pressure wave.

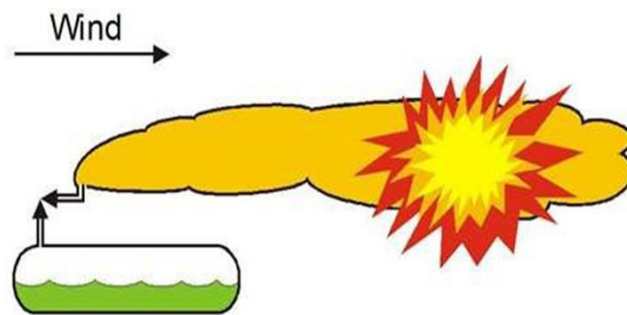


FIG 1: Vapor Cloud Explosion Model

A flash fire is a release of flammable vapor (or liquid that vaporizes) that premixes with air and expands, eventually igniting. Once ignition occurs, the burning velocity travels from the point of ignition toward the release point, potentially igniting the source as well. Potential hazards associated with a flash fire include thermal radiation, smoke, and toxic byproducts from the fire. ALOHA will predict the flammable area of the vapor cloud that is, the area where a flash fire could occur at some time after the release.

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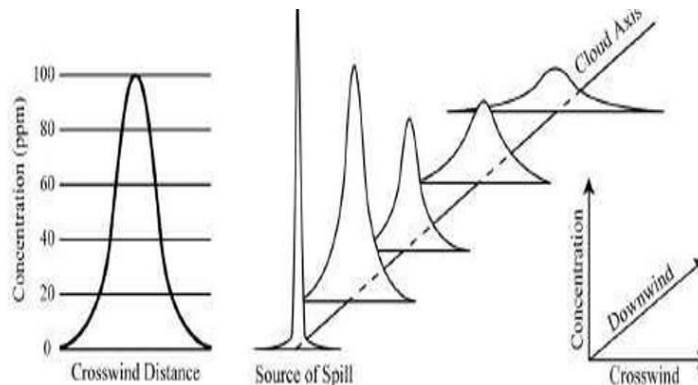


FIG 2: Gaussian and Heavy Gas



IV. RESULTS AND DISCUSSION

A Thermal Radiation Level of Concern (LOC) is a threshold level of thermal radiation, usually the level above which a hazard may exist. When you run a fire scenario, ALOHA will suggest three default LOC values. ALOHA uses three threshold values (measured in kilowatts per square meter and denoted as kW/m²) to create the default threat zones. The thermal radiation effects that people experience depend upon the length of time they are exposed to a specific thermal radiation level. Longer exposure durations, even at a lower thermal radiation level, can produce serious physiological effect Chlorine station is located at an altitude of 92 m. The chlorine station is about 360 m away.

Threat Zone	Concentration	Health Effect (60-min exposure)
Red	1100 ppm	AEGL-3: Life-threatening effects
Orange	160 ppm	AEGL-2: Irreversible effects
Yellow	User-defined (e.g., 10 ppm)	AEGL-1: Mild irritation

V. CONCLUSION

It is noticeable that chlorine is mainly used for disinfection of drinking water in this station. Since chlorine is a toxic material, thus, its dispersion can be dangerous for human health. These are referred to as source strength models. An instantaneous or continuous release of chemical vapour into the air from a single point. This is the only option that allows for an elevated release. A direct source option allows the user to directly specify the amount of chemical vapour introduced into the air from a point in space. The user can specify an instantaneous release, or a steady-state release of finite duration. This option can be used with gases that are denser than air and are affected by gravity or gases that behave as neutrally buoyant.

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