Evaluation of Hazard and Assessment of Toxicity Index of Potassium Fluoride in Warehouses using Aloha and Rectification by Safety Information System

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Abstract— Chemical industries can be highly dangerous for human kind as well nature.in the different stages of manufacturing different types of chemicals are used out of which some are toxic and some are non-toxic. Storage of toxic chemicals can be a risky task. This research has been done in a fluoro chemicals industry where many toxic chemical like potassium fluoride, Ammonium difluoride, Potassium fluoride, Sodium fluoride, Potassium fluoro titanate, Potassium fluoroborate and Hexafluorophosphoric acid are used and produced. By using Aloha method event tree analysis we have identified the hazard related to the leak of hazardous chemical. Next toxicity Index Calculation is used to rank the chemicals based on the data collected from checklist. After the selection of the hazardous chemical, the next step is to find out what is the next event going to happen if there is a release. For which, Event Tree Analysis (ETA) is used in this step. The next step after finding the final event from ETA is to find how it is dispersed into atmosphere and how much distance it covered if any leak happened. It can be easily found out using the ALOHA Dispersion Software. The next step is human health and safety loss calculation using the distance found out by software and compensation amount gathered from law. The final step is to make the precautionary & preventive measures to avoid the toxic dispersion into atmosphere and the emergency preparedness should be prepared for what should be done during the toxic release, we have reduced the risk by using safety information system.

Keywords: Safety Information System, Warehouse Safety, Chemical Hazard, ALOHA

I. Introduction

Navin Fluorine International Ltd (NFIL) is one of the largest and the most respected Indian manufacturers of speciality fluorochemicals. It belongs to the Padmanabh Mafatlal Group – one of India's oldest industrial houses. Established in 1967, NFIL operates one of the largest integrated fluorochemicals complexes in India with manufacturing locations at Surat and Dahej in Western India and Dewas in Central India. Our R&D Centre named as Navin Research Innovation Center (NRIC) is located at Surat, India. Main chemicals used in the industry are the fluoride products this company produce: -Ammonium bifluoride, Potassium fluoride, Sodium fluoride, Potassium fluoroborate, Hexafluorophosphoric acid, HF adducts as HF Pyridine complex and HF urea complex. Toxicity Elemental fluorine is very toxic to living being. Its effects in humans start at concentrations lower than hydrogen cyanide's 50 ppm and are similar to those of chlorine: significant irritation of the eyes and respiratory system as well as liver and kidney damage occur above 25 ppm, which is the very dangerous to life and health value for fluorine. Eyes and noses can get seriously damaged at 100 ppm, and inhalation of 1,000 ppm fluorine will cause death in minutes, compared to 270 ppm for hydrogen cyanide.

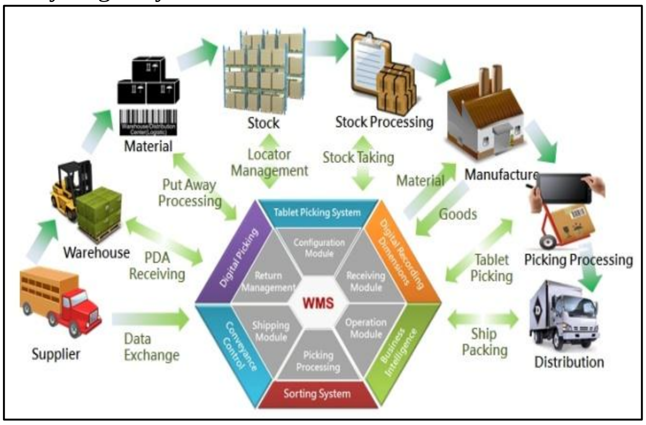

Fig. 1: Warehouse management system

II. Literature review

Hu Si (2012) et alstated that QRA model involves that probability calculations for leakage, derivative accidents to identify the likelihood and frequency of these accidents. It also calculates the influence range to identify who and how much people are involved. Loss calculations includes Personnel direct economic loss, Material direct economic loss, and total economic loss for quantitative analysis. Acceptable risk level analysis is done by comparing the standards with calculated risks by plotting graphs. By this, poisoning of toxic release pose high risks comparing than fire and explosion by using above factors. After finding this, suitable suggestion was made to revoke or reduce it to control it within an acceptable range [1].

O. Sanguino (2013) et alstated that predicting release rates is the first step, and a crucial step, in consequence analysis. The dispersion modeling of acid gas was calculated using PHAST software by applying various parameters. Effects of quantification can be done using probity functions. The author concluded that Mostly intermediate hole sizes (50mm) can cause more consequences [2].

MD Copper et al.Culture can be seen as a concept that describes the shared corporate values within an organization which influences the attitudes and behaviors of its members. Safety culture is a part of the overall culture of the organization and is seen as affecting the attitudes and beliefs of members in terms of health and safety performance. It is likely, as suggests, that the status of the safety officers is a reflection of management's commitment to safety [3].

HSE et al.Safety systems encompass aspects of the organization's safety management system, including safety committee, safety officers, safety equipment and policies. Overall, there has been little research into how the status of the safety officer and safety committee influence employee's safety behavior. The work suggests that safety advisors should have status and competence within the organization in order to advise management and employees. If a senior manager does not see the importance of safety it is unlikely that the safety officer will be given management status. The effectiveness of safety committees is also likely to be influenced by management commitment. If the senior executive sees safety as less important than other aspects of the organization e.g. production he/she is unlikely to support the committee through attending meetings and implementing suggestions for change [4].

Kathryn Mearns et al. proposed that a type of human factors training (Crew Resource Management), first developed in the aviation industry and now expanded to other domains, may play an important role in improving industrial safety by teaching relevant skills such as communication, leadership, team-working, personal limitations and decision making. CRM may help to break down the barriers that exist between subcultures, allowing personnel with different perspectives on the work situation to share information and work together as a team to resolve problems [5]

A. *Objective*

The following objectives are made in this project work.

1) To analyze the Consequences of chemical release.
2) To calculate the Safe and Threat Zone this can be used by emergency responders.
3) To take Preventive and Precautionary measures.
4) To prepare the Emergency Preparedness Plan.
5) To rectify the hazard by using safety information system.

III. METHODOLOGY

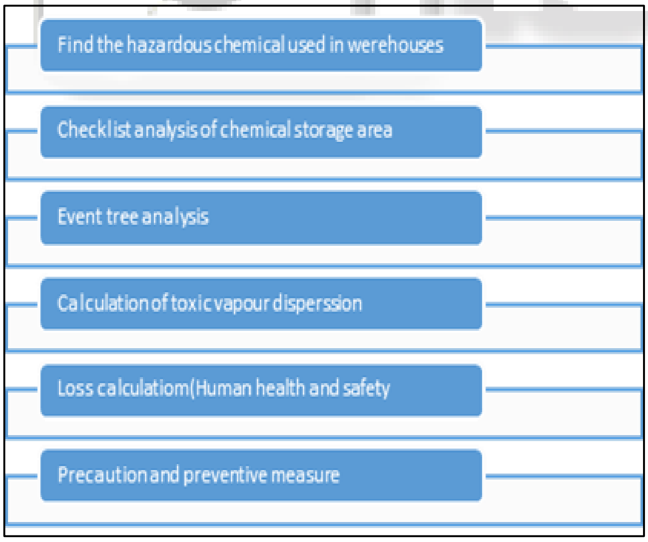

Fig. 2: Methodology flow chart

The result will be compared and rectified using safety information system.

A. *Event Tree Analysis*

After the chemical selection by using Toxicity Index numbering, what is the likelihood and possible event when there is a release of KF. It can be done by using Event tree Analysis (ETA). An event tree analysis involves the development of the consequences of an event. It starts with a particular event such as power failure or ruptures of vessels and is developed from the bottom up. It is constructed by defining an initial event and the possible consequences which flow from this.

The initial event is usually placed on the left and branches are drawn to the right. The branches should be only the safety functions. When the event goes up it results success and if down results in failure of the safety function. The event tree analysis of chlorine dioxide leak from vessel, due to rupture. It is said as loss of containment and the safety function used are leak detector, manual shutdown and DCS automatic shut off which are shown below.

From these Event tree analyses, no safety function can hold of the toxic release. So when there is a release, it will quickly forms vapor and disperse into atmosphere as toxic vapor which can be hazardous to workers nearby. If the vapors escape out of industrial area, it will definitely affect the people nearby and up to certain distances based on the different criteria.

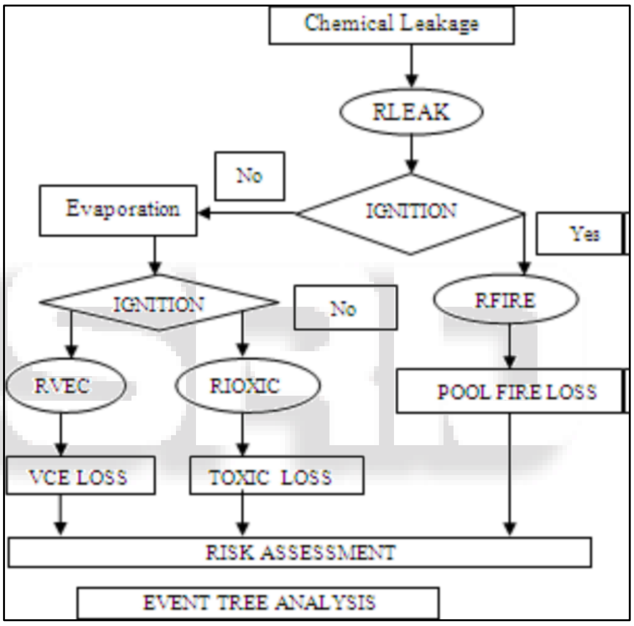

Fig. 3: Flow chart of event tree analysis

B. *Safety Information System*

The following figure contain the flow chart of safety information system which we have applied in the research work for the rectification of human or environment hazard.

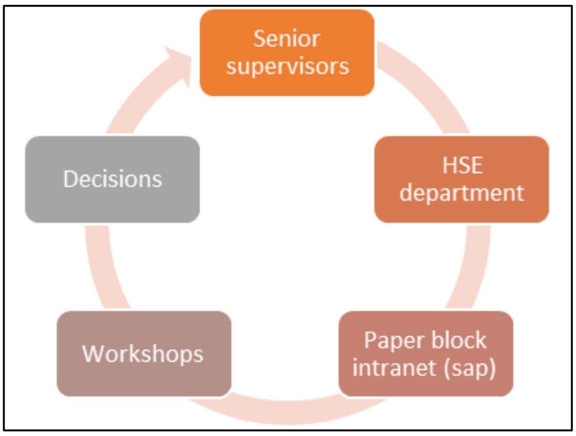

Fig. 4: Flow chart of safety information system

IV. RESULT AND DISCUSSION

DATA FOR WORST CASE	VALUES DURING DAY TIME	VALUES DURING NIGHT TIME
	ATMOSPHERIC DATA	
Wind speed	3.5 m/s	2.5 m/s
Wind direction	NE	NE
Cloud cover	0	0
Air temperature	32^{0}C	28^{0}C
Stability Class	E	F
Relative humidity	57%	61%
	Source strength	
Leak type	Hole	Hole
Tank volume	150 m^3	150 m^3
Internal temperature	18.3^{0}C	18.3^{0}C
Chemical mass in tank	80%	80%
Hole diameter	50 mm	50 mm
Hole at a height in tank	10%	10%
Ground type	Concrete	Concrete
Ground temperature	Equivalent to Ambient temp.	Equivalent to Ambient temp.

Table 1: Data collected during day and night

A. *Results of Aloha Simulation:*

The result from ALOHA showed that the release duration is 1 hour and then release rate of chemical is estimated around 1560 kgs/min. The ALOHA result showed that the results for all three threat zone, the dispersion is over 10.45 kms (6 miles) which are shown in the below figure and truncated to 10.45 kms in graphical representation. The above result is also same for during night time release.

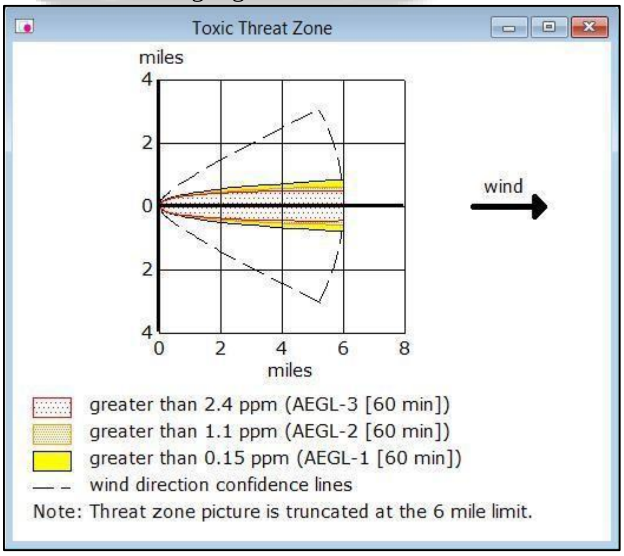

Fig. 5: Release during day time

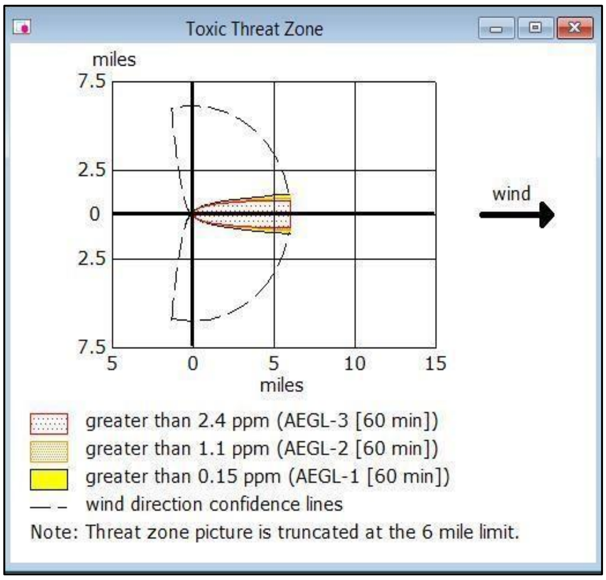

Fig. 6: Release during night time.

B. *Preventive Measures:*

FRP type tank is one of the safer storage systems for potassium fluoride (KF). As it does not corrode like ordinary MS tanks. Even though, it is safer storage but there is still a chance offailure occurrence. These failures can be simply averted by regular monitoring and periodical testing of the storage tanks. The main cause for failure of rupture is due to improper removal of pressure created inside the tank due to decomposition of POTASSIUM FLOURIDE (KF) which is by failure of pressure relief valve. By this, the pressure developed inside the tank and cause the rupture leads to loss of containment.

C. *Emergency Preparedness:*

In this section, what should be done and what should not be done when there is a POTASSIUM FLOURIDE (KF) release (After installing the spray barrier). They are listed below,

1) First thing when there is a leak means, there is a chance of explosion when there is a vapor concentration greater than 10% if it is initiated by light, shock, and electrical discharge including static electricity, hot surfaces and open flames. The above initiating things around the POTASSIUM FLOURIDE (KF) plant should be immediately cut off. Because when it decomposes it produces oxygen and Chlorine (which is very hazardous when compared to POTASSIUM FLOURIDE (KF)).
2) The tools going to use during the emergency situations should be non-sparking type to avoid spark creation.
3) The fire produced by POTASSIUM FLOURIDE (KF) should be extinguished only by water medium and do not use Chemical type extinguisher because it may cause explosion.
4) No person should be approach to the storage yard without wearing the following PPE such as cartridge or canister type gas mask (max. usage 10 mins. at least), full body suite with hood, nitrite or rubber gloves, slip resistant or anti-static shoe and goggles.
5) The electrical equipment used around the area during spill time should be explosion proof.

6) When using spray barrier, the dyke is filled with both POTASSIUM FLOURIDE (KF) and water, it can overflow and spill on the ground. To avoid it, a pump can be used to suck it from the dyke and store it in another container.
7) As it should not be released into the environment directly, it should be treated with sodium sulphide or bisulphate solution to decompose the POTASSIUM FLOURIDE (KF) and then dispose it safely.
8) The POTASSIUM FLOURIDE (KF) vapor is highly reactive in nature, so the combustible materials nearer to it should be cleared off.
9) The firefighting personals should be readily available at site to fight fire incase ignited.

V. FUTURE SCOPE

This study has used empirical findings from qualitative and quantitative result to analyze safety culture's role. An alternative approach in future research could be methodological triangulation. For instance, sending out questionnaires to most employees within a similar facility to identify a broader set of attitudes. Therefore, get a more holistic evaluation of facilitating and inhibiting factors to a SIS' performance. Another suggestion would be to examine flexible and learning culture to a larger degree than this study, and see if any additional factors influence the SIS. A formal assessment study of an implemented SIS' effectiveness in the oil and gas industry can also provide new knowledge. At last, it could be interesting to conduct comparative studies of both onshore and offshore safety cultures within the same organization and examine their effects on an implemented SIS.

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