International Journal of Engineering Research-Online
A Peer Reviewed International Journal
Articles available online http://www.ijoer.in; editorijoer@gmail.com

Vol.5., Issue.3, 2017
May-June

RESEARCH ARTICLE

ISSN: 2321-7758

SAFETY IN ICE PLANT

KALAIRAJA.V, Dr.V.RATHINAM*, K.SHANMUGAM
The Kavery college of Engineering, Mecheri, Salem

KALAIRAJA.V

ABSTRACT

The need of ice is increasing day by day because of the population of using block ice and especially by the fishing community. Ammonia is mostly used as refrigerant for the production of block ice refrigeration which is hazardous substance and most of the workers working in ice plants are illiterate and unskilled. This study concentrates on the specific advice on the occupational safety and health issues and to eradicate the hazards and risk associated with the manufacturing process of ice. HAZOP study is conducted for the entire ice plant and the risks associated with the operation of compressor, condenser, ammonia receiver, and evaporator. Preventive measures were also suggested. An exclusive QRA (Quantitative risk Assessment) study for the release of ammonia is performed through the ALOHA software which would help the community at large. Emergency response plan was also drawn for the accidental release of ammonia.

Keywords—Guide Words, Parameter, Hazards, Qualitative risk analysis, Quantitative Risk analysis, HAZOP, ALOHA, Ice plant Safety.

1. INTRODUCTION

The need of ice is increasing day by day because of the population of using block ice is more required for the fishermen and also for the preservation of many commodities.

1.1GENERAL

Ice is water frozen into a solid state. It can appear transparent or opaque bluish-white color, depending on the presence of impurities such as soil particles or air inclusions.

It occurs naturally throughout the Solar System from as close to the Sun as Mercury to the Earth cloud and beyond as interstellar ice. Ice is abundant on Earth's surface, particularly in the Polar Regions as polar ice caps and above the snow line.

On Earth, ice is an important component of the global climate and plays an important role in the water cycle. Geologically, ice formations include glaciers, ice sheets, sea ice and icebergs. It is a common form of precipitation and deposition on Earth, falling as snowflakes and hail or occurring as frost, icicles or ice spikes.Ice is used for a wide range of applications including cooling, winter sports and the art of ice sculpting.The molecules in ice may have different geometries, or phases, depending on temperature and pressure. The hexagonal crystal form of ordinary ice is the most abundant on the Earth's surface and is denoted as ice I_h, (ice one h). The most common phase transition to ice I_h occurs when liquid water is cooled below 0°C (273.15K, 32°F) at standard atmospheric pressure. It can also deposit from vapor with no intervening liquid phase, such as in the formation of frost.

1.2 MANUFACTURING PROCESS OF ICE

Tapered rectangular metal ice cans filled with potable water are immersed in a chilling tank containing sodium chloride (brine) solution. The dimensions of the can and the temperature of the brine are usually selected to give a 24 hours production time, and batches of cans are emptied and refilled sequence during that period.

Ammonia (primary refrigerant) vapours are condensed in a condenser which may be of shell and tube type or evaporative type collected in the receiver and then expanded through the expansion valve. Due to the expansion, the pressure of the liquid ammonia is considerably reduced and then it passes through the evaporator coils surrounding the brine (secondary refrigerant) tank. The low pressure liquid ammonia absorbs the heat from the brain solution, equivalent to its latent heat of vaporisation, gets converted to vapour state and is once again fed to compressor to complete the cycle. The brain temperature is maintained by the refrigeration plant at -10oc. the tank is insulated in all the four side and from the bottom. The insulated wooden lids are provided to cover the top in the segments, to facilitate the removal of ice cans. The brain solution is kept in constant motion by agitators for increasing the heat transfer from the water in the can to the chilled brain. The ice cans are fabricated from the galvanized steel sheets and are given chromium treatment to prevent corrosion.

2. DISCUSSION

2.1 HAZOP STUDY

A Hazard and Operability (HAZOP) study is a structured and systematic examination of a planned or existing process or operation in order to identify and evaluate problems that may represent risks to personnel or equipment, or prevent efficient operation. The HAZOP technique was initially developed to analyze chemical process systems, but has later been extended to other types of systems and also to complex operations and to software systems. A HAZOP is a qualitative technique based on guide-words and is carried out by a multi-disciplinary team (HAZOP team) during a set of meetings.

2.2 OBJECTIVES

At the end of this course, the attendees will have an understanding of the application of HAZOP and other identification techniques in process safety studies. Practical experience of participating in HAZOP exercises of both batch and continuous operations will have been gained. The impact of human factors and automated control systems will also be understood.

HAZOP in the process industry may be focused either to the assessment of safety or to the operability (with regards to keeping of the required quality of the product).From the experiences gained from the practical application of HAZOP in process industry is evident that the contractor very often required considering of the following factors,

- Possibility of degradation/ decomposition of raw materials
- Possibility of a failure of the human factors
- Possibility of an exothermic runaway of reaction, decomposition hazard from the raw materials, reaction mixture, intermediates and final products
- Possibility of an undesirable side reactions
- Possibility of a utility failure.

2.3 HAZOP METHODOLOGY

Essentially, the HAZOP examination procedure systematically questions every part of a process Or operation to discover qualitatively how deviations from normal operation can occur and whether further protective measures, altered operating procedures or design changes are required.The guide words ensure that the questions posed to test the integrity of each part of the design will explore every conceivable way in which operation could deviate from the design intention. Some of the causes may be so unlikely that the derived consequences will be rejected as not being meaningful. Some of the consequences may be trivial and need be considered no further. However, there may be some deviations with causes that are conceivable and consequences that arc potentially serious. The potential problems are then noted for remedial action. The immediate solution to a problem may not be obvious and could need further consideration either by a team member or perhaps a specialist. All decisions taken must be recorded.. Secretarial software may be used to assist in recording the HAZOP, but it should not be considered as a replacement for an experienced chairperson and secretary.

2.4 PARAMETER AND GUIDE WORDS FOR HAZOP STUDIES

The key feature is to select appropriate parameters which apply to the design intention.

These are general words such as Flow, Temperature, Pressure, and Composition. In the above example, it can be seen that variations in these parameters could constitute Deviations from the design Intention. In order to identify Deviations, the Study Leader applies (systematically, in order) a set of Guide Words to each parameter for each section of the process. The current standard Guide Words are as follows:

Table: 2.4 PARAMETER AND GUIDE WORDS FOR HAZOP STUDIES

Guide Words	Meaning	Remarks
NO/Not/None	Complete negation of Design intentions. The activity is not carried our or it ceases	Nothing happens. No flow in pipe, no reactant charged, no catalyst added, no cooling etc., (Apply the word to each item that is input /output).
More of	Quantitative increase	More flow, higher temperature, higher pressure, greater reaction rate, longer hold up time, etc.,
Less of	Quantitative decrease	Less of items listed above and similar other
As well as	Along with the intended activity, something more happens .	Other materials present (impurities), extra phase present, ingress of air, water, corrosion products, other reactions also
Part of	Only part of intention is achieved. Incomplete activity.	Only partial addition / removal of product / heat. Incomplete conversion / reaction. Lower concentration of material than design, etc.,
Reverse	Opposite of design intentions	Reverse flow of material, current, voltage, control signals, heat instead of cool, check valve wrongly installed, steam pressure vessel undergoes cooling and vacuum created., etc.,
Other than	Complete substitution	No part of the design intention is achieved. Something totally different happens. Different material is charged, material leaks on the way and odes not each destination, and some action during start-up results in unplanned shut-down, failsafe emergency shut-down results instead in fail –danger situation.
Early	Relative to the clock time	
Late	Relative to the clock time	
Before	Relating to order or sequence	
After	Relating to order or sequence	

(Note that the last four guide words are applied to batch or sequential operations.)

- These are therefore combined e.g. NO FLOW, MORE TEMPERATURE, and if the combination is meaningful, it is a potential deviation. In this case LESS COMPOSITION would suggest less than 96% sulphuric acid, whereas OTHER THAN COMPOSITION would suggest something else such as oil. Once the causes and effects of any potential hazards have been established, the system being studied can then be modified to improve its safety. The modified design must then be subject to another HAZOP, to ensure that no new problems have been added.

2.5 GUIDEWORDS TO CONSIDER DURING HAZOP

The record of a study is realized by a usual form of the discussion of the HAZOP team according to the scheme

Deviation – causes – effects – safety functions – action / measure.

Table 2.5 Guidewords to consider during HAZOP

Guide Word	Deviation	Example
Flow	More	Increased pumping capacity - increased suction pressure - reduced delivery head - greater fluid density - exchanger tube leaks - restriction orifice plates deleted - cross connection of systems - control faults - control valve trim changed - running two pumps - etc.
	No	Wrong routing - blockage - incorrect slip plate - incorrectly fitted check valve - burst pipe - large leak - equipment failure (isolation valve, pump vessel , etc.) - incorrect pressure differential - isolation in error - etc
	Less	Line restrictions - filter blockage - defective pumps - fouling of vessels, valves, orifice plates - density or viscosity changes - etc.
	Reverse	Defective check valve - siphon effect - incorrect pressure differential - two way flow -emergency venting - incorrect operation - in line spare equipment - etc.
	Other	
Pressure	More	Surge problems - connection to high pressure system - gas breakthrough (inadequate venting) - defective isothermal overpressure - positive displacement pumps - failed open PCV's design pressures, specifications of pipes, vessels, fittings, instruments - etc.
	No	See Less
	Less	Generation of vacuum condition - condensation - gas dissolving in liquid - restricted pump / compressor suction line - undetected leakage - vessel drainage - blockage of blanket gas reducing valve etc.

3.NODES OF HAZOP

From the P & I diagram, four major nodes are identified they are shown below:

NODE 1: COMPRESSOR
NODE 2: AMMONIA RECIVER
NODE 3: EVAPRATOR
NODE 4: CONDENSER

The generic methodology of the HAZOP as adopted for the present study is presented in the earlier in this project**.** Deviations from the standard practice or the design parameters and its values may cause an accident. The risk involved in the ice manufacturing facility is analyzed by generic methodologies of risk analysis developed specifically for the present study. The nodes of the proposed facility, process parameters, guide words and deviations are made complementary for the performance of the industry without accident. The HAZOP study analysis ended up with few possible deviations which could result in a hazard. The causes, consequences and safeguards for each deviation were listed in the HAZOP study sheet. This would help ice plant to operate accident free production.

4. QUANTITATIVE RISK ANALYSIS

Quantitative Risk Assessment (QRA) is a systematic technique that is used to estimate the cumulative likelihood of the consequences of hazards associated with a plant, facility or operation. QRAs provide numerical estimates of risk. These assist in understanding the risk profile of the system being analysed. Potential improvements can then be easily identified and ranked for risk - reduction effectiveness.The types of risk that may be considered include safety risk, environmental risk and business / operational risk. QRA is an effective tool for ranking the hazards and comparing the risk profile for various design or operational options.

4.1 ALOHA SOFTWARE

ALOHA (Areal Locations of Hazardous Atmospheres) is an atmospheric dispersion model used for evaluating releases of hazardous chemical vapours. ALOHA allows the user to estimate the downwind dispersion of a chemical cloud based on the toxicological/physical characteristics of the released chemical, atmospheric conditions, and specific circumstances of the release. ALOHA can estimate threat zones associated with several types of hazardous chemical releases, including toxic gas clouds, fires, and explosions. Threat zones can be displayed on MARPLOT maps to help users assess geospatial information, such as whether vulnerable locations (such as hospitals and schools) might be impacted by the release or whether other nearby factors (such as construction zones) might complicate the response.

The red, orange, and yellow zones indicate areas where specific Level of Concern thresholds were exceeded

4.2 MORE INFORMATION ABOUT ALOHA

- ALOHA Fact Sheet [PDF, 660 KB]: Learn more about program features and updates by reading this ALOHA fact sheet.
- Ask Dr. ALOHA: Get to know ALOHA better by reading this series of informational articles that discuss key program features and walk through sample ALOHA scenarios.
- ALOHA Arc Tools: Learn about tools for displaying ALOHA threat zones in ArcMap and ArcView.
- Met Station Vendor List: Look through a list of vendors of portable meteorological stations designed to work with ALOHA and find out how to design a met station for ALOHA.
- ALOHA Technical Resources: Review these documents if you are interested in developing a program or tool to work with ALOHA or if you want to learn about the equations ALOHA uses.
- ALOHA Development History: Review a list of the most significant modifications in each release of the program.
- CAMEO News Service: Join the CAMEO News Service e-mail list on the EPA CAMEO site to receive news and other helpful information from the development team. CAMEO Software Suite: Access additional information, like training opportunities for first responders and emergency planners.
- MARPLOT is a mapping application. The program comes with several global background base map options, with maps in both street and satellite view.

4.3ALOHA's Limitations

ALOHA's accuracy depends on the quality of the information you give it to work with. But even when you provide the best input values possible, ALOHA (like any model) can be unreliable in certain situations, and it cannot model some types of releases at all.

4.4ALOHA Doesn't Account for Some Effects

When using ALOHA, keep in mind that the program doesn't account for the effects of by products from fires, explosions, or chemical reactions. ALOHA doesn't account for the by products of combustion (such as smoke) or chemical reactions. The smoke from a fire, because it is has been heated, rises before it moves downwind. ALOHA doesn't account for this initial rise. ALOHA assumes that a dispersing cloud does not react with the gases that make up the atmosphere, such as oxygen and water vapor. However, many chemicals react with dry or humid air, water, other chemicals, or even themselves. Because of these chemical reactions, the chemical that disperses downwind might be very different from the chemical that originally escaped from containment. In some cases, this difference may be enough to make ALOHA's dispersion predictions inaccurate.

- **Particulates.** ALOHA does not account for the processes that affect dispersion of particulates (including radioactive particles).
- **Chemical mixtures.** ALOHA is designed to model the release and dispersion of pure chemicals and a few select solutions; the property information in its chemical library is not valid for mixtures of chemicals.

5 QRA STUDY

The results of the QRA study for the accidental release of ammonia obtained from the software is given in Fig : 10.2Threat zone simulated from ALOHA

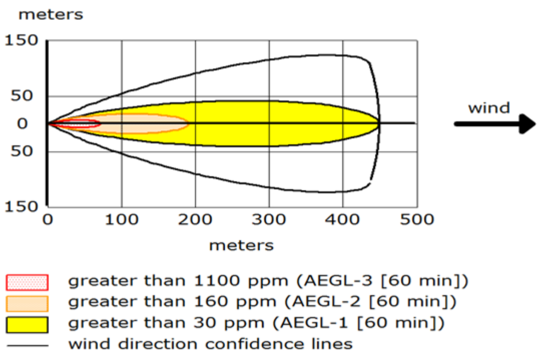

Fig. 5 Threat zone simulated from ALOHA

The threat zone prediction with respect to the concentration of ammonia obtained from the software is presented in this table 10.2

Table: 5 various AEGL for Ammonia and duration

	AMMONIA (values in ppm)				
	10 min	20 min	60 min	4 hours	8 hours
AEGL-1	30	30	30	30	30
AEGL-2	220	220	160	110	110
AEGL-3	2700	1600	1100	550	390

6 .IMPACT OF AMMONIA WITH RESPECT TO AEGL

The impact of various ammonia exposure levels are classified and is given in the table 10.3.

Table: 6 Impact of ammonia with respect to AEGL

S.No	AEGL VALUE	IMPACT
1	AEGL-1	The airborne concentration (expressed as ppm/m30 of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non s-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure.
2	AEGL-2	The airborne concentration (expressed as ppm/m30 of a substance above which it is predicted that the general population, including susceptible individuals, could experience Irreversible or other serious, long-lasting adverse health effects or an impaired ability to escape.
3	AEGL-3	The airborne concentration (expressed as ppm/m30 of a substance above which it is predicted that the general population, including susceptible individuals, could experience life threatening health effects

7.RECOMMENDATIONS FOR SAFE OPERATION OF ICE PLANT

7.1SAFETY SYSTEMS

The following safety systems must be ensured during commissioning, operation and maintenance of the plant.

- The ammonia receiver must be provided with Safety Relief valve to avoid rupture due to high pressure and hence avoiding sudden release of containment.
- The ammonia receiver must be fitted with a level indicator to know the quantity of ammonia in the containment.
- A High and Low pressure Switch must be provided in the compressor to overcome the pressure related incidents.
- Ensure all Personal Protective Equipment (PPEs) viz., hand gloves, face shields, goggles, self-contained breathing apparatus are available at work site.
- Two Fire extinguishers of DCP/CO_2 type must be available in the working area.
- A safety shower/eye wash station must be available at the work place to wash body/face/eye if any exposure to acid or caustic splashes or to gases.

- Pressure gauges with safety valves (as per P & I) must be available with the compressor.
- Provision for the compressor to be started only after the condensing water pump is switched on must be available to overcome the buildup of excess pressure in the ammonia receiver.
- Ensure all fire extinguishers are right in position in fire prone areas such as ammonia handling and compressor oil storage areas.
- Develop awareness to employees by display of all safety rules and MSDS on the work place.
- Valves fitted to gas cylinders shall comply in all respects of Gas Cylinder Rules.
- A wind sock needs to be provided in the top of the building to recognize the down wind direction.

8. CONCLUSION

A detailed study is made on the ice plant for its hazards through HAZOP and QRA studies. HAZOP study on the four major operations namely compression, condensation, ammonia receiver, evaporation and ammonia storage were done and the worksheet is presented with the possible hazard producing situation and its prevention techniques.

A QRA study is also done for the accidental release of ammonia for a quantity of 25 Kg ALOHA software was used and the predicted threat zone is given Fig 6.An emergency response procedure was established for the fire and spill management. On the thorough investigation many of the safety systems required for the plant is also identified and presented.

REFERENCES

1. AlchE, Guidelines for Hazard Evaluation procedures' New York (1985).
2. Biswas, S.K., HAZOP & HAZAN, Lecture delivered during a short course on Hazard Analysis in Chemical Engineering IIT Kanpur
3. Chudleigh, Mores, F., Hazard Analysis of a Computer Based Medical Diagnostic System, Computer Methods and Programs in Biomedicine, 44(1), 45-54 (July 1994)
4. Coulson, J.M. and Richardson, J.F., Chemical Engineering, 3rd ed., Vol 6, Oxford : Pergamum Press (1983)
5. Coyle, Wendy, HAZOP Studies, Non-destructive Testing and evaluation, 11(1) 28-29 (1994)
6. Crowl, D.A. and Louvar J.F., Chemcial Process Safety : Fundamentals with Applications', Englewood Cliffs ; Prentice Hall (1990)
7. WWW.NEER.COM for details about components of ice plant.
8. Chudleigh, Morres, F., Hazard Analysis of a Computer Based Medical Diagnostic System, Computer Methods and Porgrams in Biomedicine, 44(1), 45-54 (July 1994)
9. Coulson, J.M. and Richardson, J.F., Chemical Engineering, 3rd ed., Vol 6, Oxford : Pergamon Press (1983)
10. Kletz, Trevor. Hazop and Hazan. Taylor & Francis, 1996.
11. Shafaghi A, Cook FB. Application of a hazard & operability study to hazard evaluation of an absorption heat pump, IEEE Trans Rel 1988; 37:159-166.
12. Ozog H, Bendixen LM. Hazard identification and quantification: the most effective way to identify, quantify, and control risks is to combine hazard and operability study with fault tree analysis. ChemEngProg 1987; 83:55-64.
13. IEC 61882:2001 Hazard and Operability Studies (HAZOP Studies) - Application Guide.
14. Swain AD, Guttmann HE. Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications. Nureg/CR – 1273. Albuquerque, 1983.