Identifying and Assessing the Process Risks of Ammonia Refrigeration Room by Using the HAZOP Technique to Provide Solutions to Control and Reduce Accidents in the Food Industry

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Abstract

Nowadays, safety and accident prevention play a vital role in all stages of a process or system life span. The discovery of hazards that lead to accidents and analysis of the process units risk can have a significant impact in reducing ammonia refrigeration accidents. In order to comprehensively plan in safety and reducing accidents, risk identification and hazards assessment should be the priority. Among the available methods, Hazard and Operability Study (HAZOP) popular technique is a powerful way to identify process risks and determine their effects on the system. In this study, the results of HAZOP and PHA-pro software have been provided as recommendations for increasing safety of this unit and reducing the risks of identified hazards.

Key words: HAZOP, ammonia, food industry, accidents

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Introduction

Development, progress and spreading of highly complex and important technology in various industries, especially “process industries” have resulted in the philosophy of safety based on risk identification and the process of incident controlling has changed from after-the-incident approach to a new approach. Growing utilization of this new approach and reducing the number of accidents in the process industries reflects this processes’ positive effect on reducing damage. Process industries are often associated with high risk chemicals and units operating under the parameters such as temperature, pressure, viscosity and so on. Therefore, the probability of incidents such as explosions, toxic spills and fires is high. Also, due to the large expansion, the high number of personnel, and a considerable amount of various chemical substances in severe operating conditions, this industrial sector has the potential to generate huge accidents in line with the number of casualties, the amount of damage and higher distance dimensions. Sometimes the occurrence of a major accident or explosion can cause irreparable damage with regard to the position of a plant and possibly the entire body of a specific industry.

A close examination of popular accidents proves that a large part of damage caused by them and their likelihood of occurrence were not only foreseeable but also they were preventable, provided that at least engineering safety analysis such as Consequence Modeling and quantitative risk assessments are done timely. Quantitative risk assessment of hazards such as releasing flammable and explosive chemicals into the environment is one of the most urgent and most important steps in increasing the level of safety in existing or designing process of units. In developed and developing countries, quantitative risk assessment is an integral part of process units design that unfortunately in our country still has not gained its place and perhaps one of the important reasons is the lack of sufficient familiarity with the basic principles of risk assessment. Risk assessment is the most widely used method for the management of effective tools in safety of process units to reduce the risk of various accidents.

Temperature plays an important role in maintaining the quality of food products. Refrigeration in the food industry is necessary and inevitable. Ammonia is a toxic substance that is used as the refrigerant in most of the food industries' refrigeration rooms. Due to the process risks of ammonia refrigeration that may be caused by human error, equipment failure or other factors, the importance of the security in different parts of the existing units or those under design will be manifold.

In order to comprehensively plan in safety and reducing accidents, hazards identification and risk assessment should be the priority. Among the available known methods Hazard and Operability Study (HAZOP) technique is a powerful way to identify process risks and determine their effects on the system. In addition to detecting and determining the effects on the system, HAZOP is able to detect operational problems, which are also involved in the efficiency process.

With regard to the risks involved in ammonia refrigeration the need for using a systematic method for identifying hazards is required. In this study, while using the HAZOP techniques and use of PHA-pro software, we aimed to evaluate and identify hazards as a component addressed in ammonia compressor units, and recommendations should be provided to prevent potential accidents in order to maintain health and safety and reduce damage to equipment and the environment. In this study, the results of HAZOP and PHA-pro software are provided as recommendations for increasing safety of this unit and reducing the risks of identified hazards. Also scenario review of ammonia leakage and its consequences by software PHAST and utilization of obtained results has contributed to casualties and the reduction of ammonia leak harmful and developing an appropriate plan with regard to the emergency response.

HAZOP (Hazardous Operability) Technique

This technique used for the first time in the 1970s based on the techniques called critical testing was introduced by the Great British monarchy chemical industry and then became legal on the recommendation of T. A. Kletz. Basically, the HAZOP technique that has a prospective and prevention nature was used as the reaction to the use of a retrospective method based on the philosophy of the checklist. Although the intended technique for the first time was introduced and used to identify and assess the process risks, today by introducing and demonstrating its capabilities, it has been extended to other systems and industries. HAZOP is a systematic and qualitative approach that is based on the use of key words. It is a creative way to solve problems with safety and operational roots, which is based on cross functional team activities.

HAZOP study goals

The following objectives can be considered:

1. Identifying all the potential reasons in the field of the study that led to important safety and operational effects.
2. Decision making about this issue regarding current designs and to ensure that risk of known hazards are acceptable or not?
3. Achieving an acceptable level of risk.
4. Maximizing the value of the company's facilities by reducing processes risk with regard to an acceptable level and improvement of operational effectiveness.

Effective factors in success of HAZOP study

In general, the success of studying HAZOP depends on several factors, some of which are:

- Team suitable composition.
- Experienced and participatory members.
- The existence of appropriate instructions that at least by job analysis will be provided and will be stated clearly and audibly.
- Team members' technical skills, knowledge and insight.
- Team members' ability to ally closer the team's thinking to distortions; receiving and understanding and strengthening the group imagination.

Findings

For response plans preparation in emergencies, at first, data must be collected and organized. This information may include the needed elements to control and reduce the consequences of an accident and identifying them is important in terms of available power to control events and provide a proper design. These items are as follows:

- List of employees, contractors and visitors present in different parts of the workplace
- Required specifications to communicate with employees' families
- Available potential in place such as geology status and seismic imaging, the probability of floods and extreme weather changes, along with all the climate information that is reported by meteorologists.
- The epidemic cases, etc.

Response Team in emergencies and related duties

Emergency Response Team has been considered for planning and performing specific actions in emergency situations and in emergency conditions. Everything depends on this team's performance, therefore, its organization and the type of functions are very important. In general, this collection of people and teams are:

1. Team management that can be the senior management of the organization, For better results it is also better to assign three successors for the management team who are responsible for planning and management in emergency situations.
2. The publicity team that includes people in different units and central offices, and activating the warning equipment, providing information for public and informing the firefighters and rescue teams and other operational units are the responsibility of this team.

3. The Operational Team which is responsible for the Emergency shutdown, rescuing people at risk and bringing them out from the environment, Search and Emergency rescue and monitoring the evacuation of all people with regard to the planning.
4. The technical team that is aware of system status, insurance, laws, security systems etc. and in this regard can provide the necessary information.

Response program in emergency situation is determined and driven through an office or central room (ERC); the tasks of this central unit are as follows:
• Establishing an ongoing relationship with the relevant operating unit, organizing and coordinating of all required support operations, for example evacuation and management of injured and dead bodies.
• Developing strategies and actions based on analysis of existing technological problems and the overall condition of the unit and spreading and worsening emergency situation.
• Gathering the necessary documentation that may later be interrogated, followed and claimed.

The process of emergency response
To prepare emergency response, at first the process of reaction must be specified. This process is usually a systematic process and its general process is described as follows:
1. Activating the warning systems and informing
2. Informing the fire department (that is done through transferring the warning signals to fire stations by alarm systems that are installed in place and which in a fire or emergency phones that are connected directly to the fire department.)
3. The separation of the incident location (e.g. fire)
4. Evacuating the incident location
5. Gathering of people in a secure position and doing census
6. Rescue operations for injured people and search operations for missing persons
7. Harness the incident (e.g. fire extinguishing)

Training and performing a variety of maneuvers
The last stage of the fire escape, is staff readiness in line with the accident; although a separate team is considered in the emergency response plan for each stage of work, but everyone in the team must have necessary training that this training is as follows:

1. How to use the informing and warning equipment
2. Types of first aid, especially artificial respiration
3. System emergency discharge procedures (ESD)
4. Evacuation procedures
5. Using personal protective equipment and supplies
6. The search and rescue methods in all circumstances
7. The method of inhibiting the incident (e.g. fire suppression methods on fire incident)

And ultimately the obligation and necessity for any person at particular places, especially eventful places such as places where process industries are present, is familiarity with emergency evacuation procedures, functions related to emergencies and paying attention to the signs, alarms and warning systems.

Typically training can be done through the following levels:
1. Training in the early stages of system design
2. Training newcomers
3. Training during the new equipment installation and processes operation and working with new materials
4. Periodic training (e.g. once a year)
5. Advanced training

Discussion

Risk assessment is a tool for a risk analyst manager whereby based on this tool a manager can prioritize the risk to identify the suitable areas in order to lower the risk. In order to identify the risks of a process and ensure the absence of some of the risks identification, HAZOP can be a good choice. Response planning in emergencies for each process or non-process system is a basic requirement but the prepared plan varies with the system size and the cost allocation. A suitable program can reduce the severity of accident damage, and minimize incident-related costs and support the organization's credibility but the main feature of a good plan, is not the complexity and the different trends in that decision is simplicity and practicality so here the maneuvers and testing the plan to ensure it works are very important. On the other hand in the development of emergency response plans the risk scenarios should be limited to enhance efficiency.

Operational points in designing, manufacturing and elements of cooling systems (6985-1)
All parts of the refrigerant circuit must be designed and constructed in such a way that they are able to maintain no leakage state and resist pressure that can occur during the operation and in stoppage time and system transporting it should resist heat, and physical and chemical stresses. Safety and control devices should not be operated by unauthorized and irresponsible persons and should have been saved from intentional or unintentional use. Piping in the cooling system must be designed and installed in such a way that liquid knock (water hammering) cannot damage the system.

Operational points in line with the cooling systems installation and launching
Discharge of the refrigerant to the atmosphere must be minimized. The discharge of refrigerant that is inevitable should be to that extent that cannot endanger human health. Guards, plumbing network and connections as far as possible should protect the cooling system against the harmful effects of atmospheric conditions and dust and junk.

Operational points in the exploitation, maintenance, and personal protective equipment in cooling systems
In cooling systems exploitation guidelines, processes should be considered in the operation and providing service

for the system and for cases where there is a failure or leakage in the system warnings should be included that are installed in visible locations. Those responsible for the design, construction, installation, inspection, operation, maintenance, evaluating and disposal of all components, must be trained and have the technical knowledge required to be qualified for the duties.

Protection of people in cold rooms (6985-1)
To reduce the risks for the people locked inside the room, we must ensure that no person would be locked in cold storage at the end of the working day. In some cases it is possible that due to strong flow of outside cold air the door of the room will not be opened. According to operating conditions, these equipment and facilities for cold storage shall be provided with size greater than 10 cubic meters:
a) A warning switch should be activated by a luminous push-button or a hanging chain near the floor of the cold storage room.
b) Warning devices must be connected to a 12 volts electrical circuit.
c) Light bulbs switch circuit in the refrigeration room should be parallel with the light switches outside the refrigeration room.
d) Fan switch circuit or other devices that are used for this purpose in the refrigeration room should be in series with outside switches.
e) Light bulbs switches must constantly have luminous buttons.
f) In the case of a malfunction or failure of light bulbs, the paths that lead to emergency exits must be indicated by the independent light bulbs or by other approved means.
g) Permanent emergency light bulbs.

Cooling systems should be equipped with all the necessary parts for repair, maintenance and testing.

Pressure requirements and pressure vessels (6985-2)
All parts of the cooling circuit according to the possible thermal, physical and chemical stress should be designed and produced for remaining leakage proof state and withstand the pressure that may occur during operation, interruption and displacement. Additional tension can arise due to gas beat. Pressure vessels must comply with the relevant national standards. Technical requirements for pressure equipment are provided in Iran National Standard EN10204. Abutments and pillars of pressure vessels should be designed and placed in a way that can resist static and dynamic forces. These forces may be shaped due to the tanks' mass, content and equipment' mass, snow load, wind load, support mass, braces and connecting pipes and displacement of pipes and components.

Pipes
All the cooling circuit pipes should comply with the relevant design, manufacture and installation standards that with respect to expected chemical, physical and thermal tensions remain leakage proof and resist against the pressures and temperatures that occur during the performance and handling of interruptions. Protective equipment, pipes and fittings should be kept off as much as possible the negative impacts of the environment. Flexible tubular components should obey Iran National Standard EN173. These components should be protected against mechanical damage, tensional stress and other tensions. These components should be checked regularly and periodically. Misuse of pipes as a means of access should be prevented.

Corrosion protection
Pipes and steel components must be protected against corrosion by a stainless steel cover. This protection is essential, especially before operating any insulation. Corrosion protection can be performed according to standards associated with corrosion. Tubes and pipes that are used for connecting for measurement, control, safety devices should have suitable resistance proportional to the pressure and be installed in such a way to minimize vibration and corrosion.

Valves and protective equipment
Cooling systems should have suitable separator valves that minimize the risk of loss of refrigerant, particularly during repair or maintenance. Manual valves that are necessarily used in some circumstances should be equipped with a hand wheel or lever. Valves should not be used while the machine is working; they have to be designed to prevent operation by unauthorized persons. In case of emergency valves, these devices must be located near them and should be protected against improper use. Warhead Valves must be designed in a way that any refrigerant pressure that emerges under the cap can be discharged once the cap is open. The use of warheads valves always is preferable, except in places where the faucets are frequently used or should be used quickly because of an emergency condition.

Protection of system components
Protection of positive displacement compressors
Positive displacement compressors with swept volume greater than 25 liters per second must be protected by means of pressure breaker in place of discharge. Non-positive displacement compressors do not need a pressure breaker, on the condition that the crossing is not possible for the maximum allowed pressure. Evacuating the pressuring to the lower pressure part leads to overheating of the compressor. Positive displacement compressors should have an output cut off device and compressors with swept volume more than 25 liters per second must be protected by a safety key for limiting the pressure.

Materials used in the cooling system
The suitability of all materials that are in contact with the fluid must be proved by long-term practical tests and experiments. Copper in contact with refrigerants must be oxygen-free or deoxygenated. Copper and its alloys that have a high percentage of copper should not be used as part of an ammonia carrier. Aluminum and its alloys can be used everywhere in cooling circuit, provided that they have appropriate resistance and compatibility with refrigerants and lubricants. Magnesium and its alloys should not be used, unless they have already been proven to be compatible with the refrigerant. The outer layer of the

components can be covered by zinc. Zinc plating the parts is possible with the help of electricity. Soft alloys should not be used for soldering except for internal purposes. Brass alloys should not be used for welding. Tin and tin alloys will be abraded by halogenated refrigerants and they should not be used. Antimony and lead-free tin-copper alloys can be used for valve seat. Lead can be used for washers.

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