BEST: International Journal of Management, Information Technology and Engineering (BEST: IJMITE)
ISSN (P): 2348-0513, ISSN (E): 2454-471X,
Vol. 3, Issue 10, Oct 2015, 117-126

STUDY OF HAZARD IDENTIFICATION TECHNIQUES ADOPTED BY OIL AND GAS INDUSTRIES FOR RISK ASSESSMENT

R.TAMIL SELVAN[1], N.A SIDDQUI[2] & KANCHAN BAHUKHANDI[3]

[1]Research Scholar, University of petroleum and Energy studies, Dehradun, India

[2,3] Associate Professor, University of petroleum and Energy studies, Dehradun, India

ABSTRACT

Risk management in oil and gas industry play vital role in preventing accidents. In oil and gas industry risk assessment is carried out in conceptual stage to end of life cycle of the plant. Accidents in oil and gas industry give catastrophic result to the industry and affect the country's economy. Fire, explosion and toxic gas release from the oil and gas industry kills huge number of employees, publics and damage assets and impact the environment. Major accidents such as Bhopal, Flexibrough, Pipher Alpha, Seveso, BP Blow out, Indian Oil Terminal fire, Texas City, Deep water horizon, Macondo were results in many people died; damaged assets; impacted the environment. Over the last four decades management of risk, from the operation of hazardous facilities are being increased focus. These major accidents emphasize the importance of process safety in oil and gas industries. Risk management is used by oil and gas industry to manage the threats & risks in their operation. Risk management has many steps. The first and key step of risk assessment process is hazard identification. In this research an attempt is made to study the various techniques used by oil and gas industries to identify the hazards and their advantages and limitations. HAZID, HAZOP, SAFOP, Fire and Explosion Index, Mond Index, FMCA, LOPA, FTA are used by various companies to identify the hazards or causes of major incidents.

KEYWORDS: Hazard, HAZID, Risk, Accident, HAZOP, HACON, FMCA, LOPA etc

INTRODUCTION

Safety in the design of oil, and gas, petrochemical, and offshore plants relies on the appliance of various codes of design, which are based upon the wide experience and knowledge experts and specialists in the industry. Hazard identification is a fundamental in safety management system. Hazard means anything which has the potential that can cause harm or ill health or injury or damage to assets. C.M. Pietersen and B.F.P. van het Veld. (1992) explained that safety of a plant is determined to a large extent during design stage, so it is great importance to identify the hazards in the early design phase. Risk assessment is carried out by oil and gas industries in different stages of the plant. There are various risk assessment is followed by industries either quantitative or Qualitative in nature. Few risk assessments are involved numerical assessment up to some extent and they are called semi quantitative assessment. Hazard identification is the fundamental step in risk assessment. Many techniques adopted by industries to identify the hazard. If the hazard is not identified then risk assessment is not cover all the hazards. The unidentified hazard may strike any time which results in accidents and loss. So it is very important that the hazard identification to be carried out in comprehensive manner. Alfredo Verno and Geoff Stevens. (2008) explained that the HAZOP study is one of the hazard identification technique can be applied various phases of project development includes in front end engineering and design phase, as a part of detailed design phase and plant operation phase or any modification or alteration of the plant.

Literature Review

Micaela Demichela et al. (2004) outlined that identification and evaluation of major hazards are vital in any safety management system. New oil and gas projects and in some cases modifications to existing oil and gas plants, call for some element of change and the degree of change is often considerable The procedure has to identify the hazards systematically arising from normal and abnormal operation of the plant. It is important to recognize that experience expressed in codes etc. is limited by the extent of existing knowledge. Hazard identification was conducted through employee interview and pipeline hazard identification studies. Interviews are either one to one basis or in groups. Ray J. Davies et al. (2009)

Many techniques are available such as experience, engineering codes and standards, checklists, hazard index, what-if analysis, hazard and operability (HAZOP) study, failure modes and effect analysis (FMEA), preliminary hazard analysis (PHA), Fire and Explosion Index, Mond Index, Hazard identification (HAZID), construction hazard identification (HAZCON), SAFOP (Electrical hazard and Operability) etc. Checklist approach is used in chemical and process industries to identify the hazards in the process. But checklists are considered as a more generic approach. C.M. Pietersen and B.F.P. van het Veld. (1992)

According to Hans J. Pasman and Bruno Fabiano.(2008) the HAZOP method is immensely popular for identification of hazards in qualitatively. Fire and explosion index, Mond indexes are considered the type of materials used, quantity of material, operating conditions and the kind of operation etc. The values of indices used for prioritize or comparison only. It is not providing the actual risk. They are guide us how further risk assessment study to be carried out for the plant. Recursive Operability Analysis (ROA) was performed to identify the possible accident sequences study carried out by Micaela Demichela et al. (2004). C.M. Pietersen and B.F.P. van het Veld. (1992) pointed out that modification of plants resulting from safety studies probable have prevented an accidents. He suggested that safety audit is another tool to identify the hazards in the plant or installation including its condition of operation and maintenance. Cristina Gilardi and Mauro Gotti. (2013) study involved HAZOP study as a semi quantitative analysis which is applied to upstream oil and gas operations such as offshore drilling operations. Risk Assessment Matrix (RAM) is combined with typical HAZOP worksheet and assessed the risk level in his study.

LOPA is introduced in 1990's in U.S as a simple risk assessment tool. It is examining the functioning of safety measures in a process section given initiating event which may progressively upset the plant. Hans J. Pasman and Bruno Fabiano.(2008). Gregory Carter and Simon D.Smith. (2006) explained that unidentified hazard negate the risk assessment process; risk cannot be assessed for those hazards and control measures cannot be developed and implemented. The operators those who involved in the operation are not aware of the hazard in first place.

N.A. Siddiqui et al. (2011) suggested other techniques such as Job Safety Analysis (JSA), logic diagrams, What-if checklist techniques can be used as qualitative risk assessment techniques for assessment. JSA is method to analyse a job by, step by step process.

Objetives & Methodology

To study the various techniques adopted by the oil and gas industry to identify the hazards in their operation from conceptual stage to life cycle end of oil and gas facility. The advantages and limitations of these techniques also studied. The methodology followed is to study of various oil and gas industry guidelines or standards for quantitative risk assessment process of oil and gas major companies in Middle East and India and hazard identification (HAZID) techniques

followed by these companies. A sample real case study is taken and the HAZID technique is applied for NG transportation facility and HAZOP technique is applied for a natural gas export pipeline system.

HAZID

Hazard identification (HAZID) is to identify the hazards at an early stage of the plant and the hazards are to be removed or to be managed. Usually a multispecialty team to review the total project proposal of the oil and gas plant and its effects on environment. The study followed a systematic methodology and used a checklist with set of guide words to identify the various hazards and assess the influence on project development. The scope of the HAZID study involves present operation and if any future expansion of the plant. Gregory Carter and Simon D.Smith. (2006) pointed out that introduction of hazard identification indices that can be used as a measure of the degree of hazard identification in various projects. Broadly the indices are obtained based on the number of hazards identified and assessed in appropriate study and project.

Table 1: Shows the Typical Guidewords to be used in the HAZID Checklist

Table 1: HAZID Checklist

Sections	Category
External and Environmental Hazard	Natural environment
	Man-made
	Effect of plant to surrounding
	Infrastructure
	Environmental damage
	Control methods
Facility Hazards	Fire and explosion
	Process hazards
	Utility hazards
	Maintenance Hazards
	Construction hazards
	Existing Hazards
Health Hazards	Health hazards
Project Implementation Issues	Hazard Management methods
	Contingency Plan
	Competency
	Contracting plan

Each category of hazard further subdivided based on set of further guide words and identify the hazard in the plant. For example a typical subcategory hazards for external and environmental category are given in Figure 1.

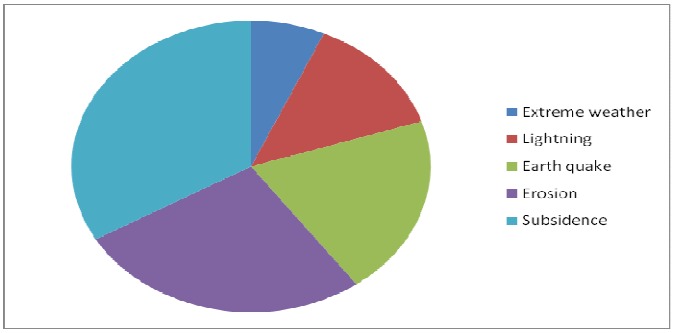

Figure 1: Indicates Guidewords Subcategory for External and Environmental Category Hazards

The following figure 2 shows the various subcategory guide words to be considered for fire and explosion hazard category.

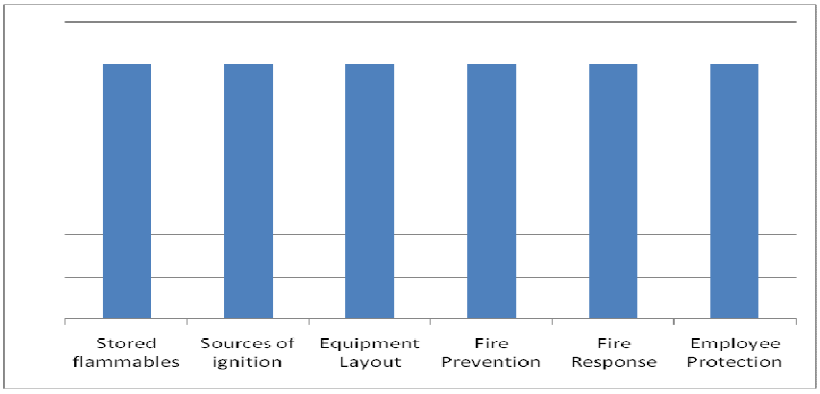

Figure 2: Indicates Guidewords Subcategory for External and Environmental Category Hazards

HAZOP

HAZOP study means Hazard and Operability study. In this study the analysis of process plant undergone in through rigorous process. Miguel Angel de la O Herrera et al. (2015) ICI in UK is developed this standardized approach to analysis the process hazards associated with basic operations of the plant. It is defined as

"The application of a formal systematic critical examination to the process and engineering intentions of new or modified facilities to assess the hazard potential or mal operation or malfunction of individual items of equipment and the consequential effects on the facility as a whole".

It is used to identify deviations from the design intent that could lead to hazards or operability problems, and to define any actions necessary to eliminate or mitigate these. M. Perez-Martin and M.A. Rodriquez Toral. (2013) is pointed out that the HAZOP studies include from original ICI method with required action and now a day's computerized method of HAZOP study wok sheets are employed for analysis.

The main objectives of the HAZOP study is

Identifies potential hazards related to the system;

- Identify deviations from the design intent.
- Determines the operability of each facility as designed;
- Suggests recommendations to eliminate or mitigate the hazards.
- Appropriately simplify or improve design and the operations.

For this HAZOP study, a combination of guidewords and process parameters has been used to review the process and instrumentation diagram of the selected plant. The selected plant is divided into nodes as per the process flow diagram. Each node the intended function is defined and with the set of guidewords and process parameters are to be applied and deviation and consequences is assessed. If the existing protection system have taken care of the consequences or any additional measures to be provided is established. According to Miguel Angel de la O Herrera et al. (2015) process data, technical information, process and instrumentation diagram, material balance sheets, process parameters, instrumentation diagram, site plans, line arrangement, list of safety valves are to be kept ready before start the study.

HAZOP Pre-Concessions

- The following are the pre concessions are followed during this study.
- All equipment are well designed, manufactured and properly inspected
- Only single failure results in hazard – no double jeopardy
- Inadvertent closure/opening of manual valves are generally not considered
- Natural Calamity, falling of items from space is not considered
- Plant is well maintained and operated in accordance with acceptable standards
- Failure of instrument gauges and valves are not considered i.e. fail closed valve will not fail open
- Catastrophic of equipment or pipe is generally not considered

HAZOP Team

A multidisciplinary team is essential for this brainstorming HAZOP study. Because the system is analysed for various types of deviation and how the safety and fire protection, instrumentation and mechanical and electrical system operates and functions to manage the hazardous situation or condition. The following are the disciplinary team members are participated in the case study. The team comprised of 13 members from the relevant disciplines. The members had experience and understanding in their respective engineering field such as process design, instrumentation and control, mechanical, project and operation.

- HAZOP chairman
- HAZOP Secretary
- Project concept Engineer
- Process Engineer
- Production Engineer
- Control and Automation Engineer
- Commissioning Engineer
- Construction Engineer
- Piping Engineer
- HSE Engineer

The process parameter guide word used for this HAZOP study of natural gas pipeline system is listed in Table 2.

Table 2: Process parameter Guide word

S.No	Description
1	Pressure
2	Temperature
3	Flow
4	Level
5	Composition
6	Phase
7	Operability

The guide word deviations are mentioned in Table 3 for this study is adopted.

Table 3: Process Parameter Guide word

Word	Meaning
None	No flow at all
More of	More of flow, temp, pressure etc
Less of	Less of flow, temp, pressure etc
Part of	System composition different
More than	More thing present
Other	other than normal operation
Reverse	Opposite of what is to be

The typical worksheet used for HAZOP study is enclosed in Appendix 1 with Table 4

Brief Description-Case Study

The natural gas (associated gas from well and flash gas from compressor) produced at the production station is compressed by compressor and pumped into the export gas pipeline. During the process the gas is dehydrated by dehydration unit and dew pointed in refrigeration unit. One soar gas pipeline is exporting this gas from pumping station to gathering station. The figure-3 shows the typical process flow diagram of natural gas compression and production system.

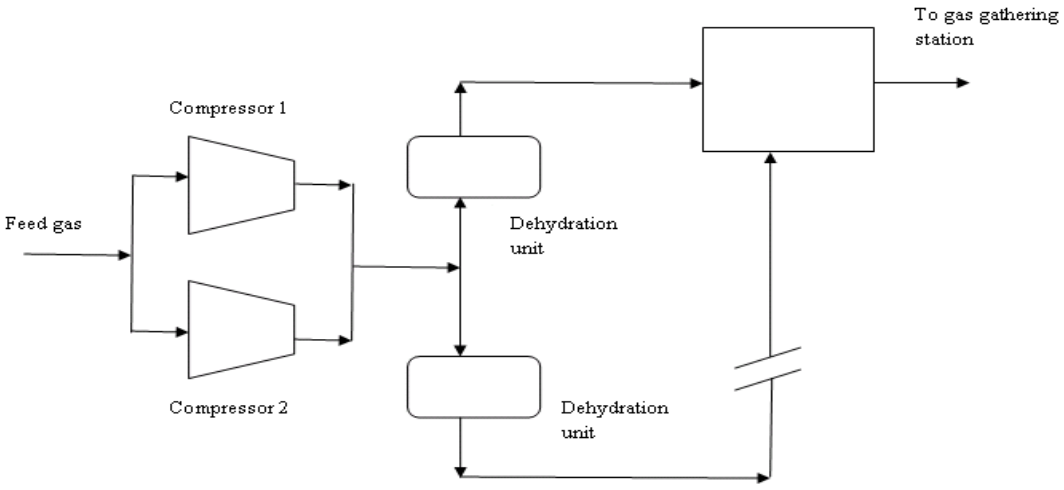

Figure 3: Typical Flow Diagram of Natural Gas production and Pipeline System

RESULTS AND DISCUSSIONS

The HAZOP study was conducted based on the drawings provided for the natural gas compression and pipeline system. The findings were based on the design intent of each node. A number of changes have been identified for the

improvement of the system and these needs to be incorporated. The safe operation of the natural gas station and export pipeline will depend on the final design and a review of the revised system would be required in order to ascertain the changes are in order. The HAZOP study review is resulted in action items and recommendations are shall listed out in the report.

Table 4: Typical HAZOP Recommendation Worksheet

HAZOP Node /Action No	Action Description	Action Party	Priority Level
2A	Valve tag number to be provided for 3" and above sizes.	Consultant	3
3A 04	Ensure that the MOC is adequate for high sour service (3500 ppm)	Consultant	2

Advantages & Limitations of Hazid / Hazop Techniques

HAZID process is an important part of risk management. The team may discard some scenarios because they are extremely unlikely and low consequence. Incomplete and inaccurate facility description may lead to many mistakes either fail or generate many actions and lose credibility. G.Viswanathan. (2013)

Paul Baybutt. (2015) explained that the HAZOP study has numerous inherent weaknesses in the system. But understanding and having knowledge about the weakness enable the study team to compensate to the extent possible. Miguel Angel de la O Herrera (2015) pointed out that this study can be easily followed by people who are willing to use this technique improve the performance of the plant and comply with the legal requirement.

The technique enhances to stimulate the imaginations of designers, engineers and operators in a systematic way so that they can identify the potential hazards in a design or modification. HAZOP methodology is a powerful tools for identifying hazards and improvement suggestion intended to reduce the risk level in the plant. The feature of HAZOP studies is the "Examination Session" during which a multi-disciplinary team using a structured approach systematically examines all relevant parts of a design.C.M. Pietersen and B.F.P. van het Veld. (1992) outlined that continuous emphasis on safety consciousness and awareness among employer and employee is vital for an organisation. Leadership and commitment from top management in a company is important to prevent accidents**.**

M. Perez-Martin and M.A. Rodriquez –Toral. (2013) suggested that HAZOP study is not a simple application that assures safe plant on its own. It is necessary before carry out the study establish scope, risk acceptance criteria, and expected results. Paul Baybutt. (2015) Heuristic approarch, team brainstorming (asking feedback about previous sessions), structure provide false sense of security (not all important deviations are identified), complexity of study are limitations related to people. HAZOP study takes more times than any other PHA studies. Team members may be fatigued.

HAZOP study may theoretically be a sound tool but unfortunately by practical it is having many weaknesses. Paul Baybutt. (2015). Weakness may be from human limitations, meaning of design intent, or parameter, generation of deviation, limitation of guidewords etc. HAZOP study is fully dependant on the knowledge, experience of the team participants. Some of the causes of a deviation may be unrealistic and derived consequences insignificant, and would therefore not be considered further.

Miguel Angel de la O Herrera (2015) pointed out any person can able to follow HAZOP methodology, however only through experience multidisciplinary team to understand events responsible for deviations and validate the study.

Hans J. Pasman and Bruno Fabiano.(2008) according to them the HAZOP study identifies hazardous situation and initiating events hence provide opportunity for improvement but this study is not conceptual structure. In some cases it will be necessary to obtain further information and/or carry out detailed studies/analysis.

HAZOP / HAZID study log to be properly recorded all the discussion related to HAZOP which has relevant. Some time wrong assignment of credit to existing safeguards leads to ambiguity. All the actions / recommendations identified in the HAZOP study to be closed out in an appropriate timescale and feed this information through Hazards log.

CONCLUSIONS

The objectives of the Hazard identification study only shall be achieved only by proper close out of actions and recommendations. HAZOP is considered as a qualitative study. HAZAN is considered as a quantitative study. But now a day's these techniques are combined together for assessing the risk. HAZOP study with Fault tree and Event Tree, HAZOP study with LOPA studies are carried out to assess the risk level in the oil and gas facility and to make a decision based on the results.

The following are the key HAZOP actions for this case study.

- Permanent access platforms shall be provided for the early tie-in valves wherever required.
- An additional isolation valve with a spectacle blind shall be provided (for high sour service) for demolishing the redundant lines.
- Appropriate Piping material specification shall be identified for all early tie-in provisions including high sour service.
- Valve tag numbers shall be provided for all newly added early tie-in isolation valves which are of greater than 5" sizes.

By implementing these actions and recommendation suggested in HAZOP hazard log action sheets the risk of natural gas compression and pumping system to be reduce considerably. Jeffrey D. Marx and John B. Cornwell. (2001) pointed out that quantitative risk analysis for a process plant involves complex and extensive study. Acute hazards in the form of toxic vapour, flammable material leaks results in different kind of fire and explosion are to be identified as potential scenarios in hazard identification step. HAZID, HAZOP studies are predominately used by oil and gas industries for identification of hazards. LOPA, SIL studies are being carried out by oil and gas industries in recent past.

But this study not analysed the software used for various hazard identification techniques used by oil industry. A future research work shall be attempted to application of information technology in hazard identification and advantages and limitations.

ACKNOWLEDGEMENTS

The author thanks to University of Petroleum Energy Studies and present organization to utilize procedure and records to use in this study for research work.

REFERENCES

1. Ray J. Davies, Tony D.Alfano, Farrukh Waheed and Tinna Komulainen. (2009). A Root Cause Analysis Approach To Risk Assessment Of a Pipeline Network for Kuwait Oil Company, Rio Pipeline 2009 Conference & Exposition. 1-8.
2. M. Perez-Martin and M.A. Rodriquez –Toral. (2013). HAZOP – Local Approach In The Mexican Oil & Gas Industry. Journal of Loss Prevention in the Process Industries. 936-940.
3. Micaela Demichela, Norberto Piccinini and Alfredo Romano. (2004). Risk Analysis as a Basis for Safety Management System. Journal of Loss Prevention in the Process Industries. 179-185.
4. C.M. Pietersen and B.F.P. van het Veld. (1992). Risk Assessment and Risk Contour mapping. Short Communication. 60-63.
5. Paul Baybutt. (2015) A Critique Of The Hazard and Operability (HAZOP) study.. Journal of Loss Prevention In The Process Industries. 52-58.
6. Hans J. Pasman and Bruno Fabiano.(2008). Trends, Problems and Outlook in Risk Assessment: Are We Making Progress? Chemical Engineering Transactions. 9-16.
7. Miguel Angel de la O Herrera, Aderval Severino Luna, Antonio Carlos Augusto da Costa and Elezer Blanco Lemes. (2015). A Structural Approach to the HAZOP – Hazard and Operability Technique In The Biopharmaceutical Industry. Journal of Loss Prevention In The Process Industries. 1-11
8. Nic Cavanagh and Colin Hickey. (2012). A “Triple Botton Line” approach to QRA. The Italian Association of Chemical Engineering. 165-170.
9. Gregory Carter and Simon D.Smith. (2006). Safety Hazard Identification on Construction Projects. Journal of Construction Engineering and Management. 197-205.
10. Cristina Gilardi and Mauro Gotti. (2013). Semi-Quantitative HAZOP Methodology Applied to Upstream Oil & Gas Activities. The Italian Association of Chemical Engineering. 229-233.
11. Paul Baybutt. (2015) A Critique of the Hazard and Operability (HAZOP) Study. Journal of Loss Prevention in the Process Industries. 52-58.
12. Alfredo Verno and Geoff Stevens. (2008). Is Hazop Always the Method of Choice for Identification of Major Process Plant Hazards?. Symposium Series.154.
13. Jeffrey D. Marx and John B. Cornwell. (2001). What is a QRA and what can it tell you?. Annual symposium at Mary Kay O’Conner Process safety Center 1-7
14. N.A. Siddiqui, R.T.Selvan and Akbar Ziauddin. (2011). Risk Assessment – Tool to Minimize the Accidents. 77-82.
15. G.Viswanathan. (2013). Common Mistakes in HAZID, HAZOP, SIL Studies, Process Safety Symposium, IIT Gandhi Nagar.

16. BIS-Indian Standard, (2006), Hazard Identification and Risk Analysis-Code of Practice, Bureau of Indian Standards, 1-25

17. HAZOP Procedure, PR-1686, Petroleum Development of Oman, Sultanate of Oman.

APPENDICES

- **HAZOP Work Sheet-Typical**

Table 5: Typical HAZOP Worksheet Followed in this Case Study

<table>
<tr><td rowspan="3">Project Name</td><td>Process Data</td><td colspan="3"></td><td rowspan="3">Drawing No</td><td colspan="3" rowspan="3">Line No</td></tr>
<tr><td>Product</td><td colspan="3"></td></tr>
<tr><td>Operating Pressure & Temp.</td><td colspan="3"></td></tr>
<tr><td rowspan="2">Job No</td><td>Design Pressure and Temp.</td><td colspan="3"></td></tr>
<tr><td colspan="4">Node Description:</td><td></td><td>Date</td><td colspan="2">Node: 1 of 8</td></tr>
<tr><td colspan="2">Deviation</td><td rowspan="2">Causes</td><td rowspan="2">Consequences</td><td rowspan="2">Protection</td><td rowspan="2">Recommendation</td><td colspan="3">Action</td></tr>
<tr><td>Parameter</td><td>Guideword</td><td>By whom</td><td>Priority</td><td>S.No</td></tr>
</table>