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Comparing of HAZOP and ETBA Techniques in Safety Risk Assessment at Gasoline Refinery Industry

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Abstract: Incidents prevention is very important in process industries, which requires detecting the hazard and risk assessment. The aim of this cross-sectional study was to compare the HAZOP and ETBA techniques for safety risk assessment in a gasoline refinery industry. Data was collected by PFD, P and ID, Walking-Talking and direct observations. The worksheets of both HAZOP and ETBA techniques were filled based on MIL-STD-882E. HAZOP method detected 44 deviations were detected that 47.73% of them were unacceptable and undesirable, also 118 causes of deviations detected that the most important (46.1%) of those were related to failure of equipment. ETBA method detected 10 types (24 sub-types) of energy so that the most important risks were chemical and potential energies. ETBA detected 33 hazards that 37.79% of them were unacceptable and undesirable. Although HAZOP was more powerful than ETBA to predict and detect the hazards, but implementation of ETBA is easier than HAZOP and it needs a short period of time. Also ETBA was able to reveal some hazards which couldn't be considered by HAZOP. Therefore, combining of two methods is better selection compared to either of them alone for risk assessment in process industries.

Key words: Process Industry · Gasoline Refinery · Safety Risk Assessment · HAZOP · ETBA

INTRODUCTION

Complexity and expanding of chemical and process industries leads to high safety risk and disaster in world. Some of these tragic events were Feyzin, Mexico City, Bhopal (India), Piper Alpha (UK), explosion of liquid fuel (North Sea) or Chernobyl (Russia) [1].

Gasoline refinery industry is one of the most important units in process plants and each deviation from desirable situation can result in a hazard. Each year, the incidents deliver so many irreparable damages to personnel and equipments that almost all of them are predictable and preventable by risk assessment and control strategies [2]. Risk is the harm or injury from a hazard that will occur to specific individuals or groups exposed to a hazard for every system or process [3]. Analysis of incidents points to different factors such as human errors, too much reliance on the safety of machinery, problems in design of the plant, unprepared to face and cope with critical situations and lack of HSE rules [4].

To prevent incidents, the safety experts must recognize, assess and reduce or control the potentially small, big, visible and invisible hazards by using risk assessment and management techniques. The importance of risk assessment is to help the decision making for choosing the good solutions and for convincing the managers to spend resources for safety solution.

Several methods with some advantages and disadvantages for risk assessment of hazard is including of the PHA, FMEA, LOPA, FTA, HAZOP and ETBA [5-6]. Moreover, because of the multifaceted nature of workplaces, the use of single-oriented methods, such as AEA (man oriented), FMEA (system oriented), or HAZOP

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(process oriented), is not satisfactory [7] and no single one will always be the best [8]. Different techniques have been introduced for analysis of process systems with their own capabilities and limitations namely HAZOP and ETBA [9].

HAZOP was developed since 1960 for analysis of safety risk factors and can be considered as one of the most accurate methods for identifying hazards in the various industries, especially chemical plants [10] and it's a widely used process hazard analysis (PHA) approach [11]. But HAZOP study is expensive due to highly time consumption [10] and also requires the key personnel away from their daily jobs to attend the HAZOP meetings which might last for weeks [12]. On the other hand, in attention to existence of different energies in process plants including of chemical, electrical, mechanical and thermal, some of researchers apply the ETBA for safety risk assessment. For example; Isomax unit in refinery [2], chlorination unit in treatment plants [9], foundry industry [13] and corn processing industry [14].

Gasoline refinery has high risk of potential hazards, therefore the aim of this study was to investigate the safety risk in one of the Iranian gasoline refinery (nearing the residential area) by applying two methods of HAZOP and ETBA and also the results of two techniques were compared.

MATERIALS AND METHODS

At first, the primary method of risk assessment called "what if..?" has been used to recognize all of the potentially hazard in process. The basis of this method is to pose some questions like "what will happen if…?" and then find the right answer for these questions. Before that, we separated the process to smaller sections and then the questions for each section are posed [15].

Data were gathered using the direct observation, process flow diagram (PFD), piping and instrument diagram (P and ID), interview with key persons and walking-talking through Methods [9]. Finally the HAZOP and ETBA worksheets are accomplished. To perform these methods, the experts group should be formed [4]. In this study, a 7-member team was formed that consist of: the process, chemical, electrical, mechanical and safety engineers in refinery unit and two safety experts (researchers). In following both of HAZOP and ETBA method have been explained:

HAZOP Technique: HAZOP is a qualitative, systematic, creative and group method that is so easy to learn and is an effective method to detect hazard and system operability problem by determination of their affects.

Implementation of HAZOP is as follows [9, 15-16]:

- Break the process down into functional nodes: In this research, the nodes were consist of; 1) from FRC-301 to ending of gasoline entrance pipelines, 2) tower-301 and floater, 3) from control valve-305 to caustic entrance pipelines into tower, 4) gasoline exit pipeline on top of the tower
- Identifying the deviations in every node using keywords:

- Primary Keywords: pressure, temperature, flow, etc.
- Secondary keywords: no, more than, less than, as well as, etc.
- Estimating the possible causes and consequence of deviations
- Identifying the existed safeguards and their effectiveness
- Determination of the hazards risk level
- Define controls to reduce the risk
- Re-determination of the hazards risk level

ETBA (Energy Trace and Barrier Analysis) Technique: ETBA is a system-based analysis developed to identification of hazards by focusing on the existence of different energies in system. First, the system was defined in a way that enabled the analyst to identify and trace energies from the time they enter the system until exiting the system. The next step was to use the ETBA checklist, which included the energy types that might be in the system. Then one energy type was selected at a time and traced through the system. Wherever a potential unintended energy release or exchange was discovered, the people and/or objects that are likely to be affected by the scenario were identified. [17]

Implementation of ETBA is as follows [2, 9, 13, 14 and 17]:

- Identifying the energy types (15 types and 68 subtypes of energy).
- Determination of barriers in the energy pathways
- Determination of vulnerable targets including personnel, equipment, etc.
- Determination of hazards risk level and effectiveness of controls
- Definition of controls to reduce the risk
- Re-determination of hazards risk level

Risk Level Analysis: The objective of risk level analysis is to quantify the relative importance of each failure, so that priorities for action to reduce the probability or severity of incidents [15]. Risk level is a combination of severity of an effect (4 groups from catastrophic to marginal) and the probability of occurrence (5 groups from frequent to rare). Determination of Hazard's risk level has been done based on Mil-Std-882E matrix in both HAZOP and ETBA methods [13, 14, 18-20].

RESULTS AND DISCUSSION

At first, 60 types of hazard and their consequences has been detected by use of "what if..?" method, which used as basic information for risk assessment. Result of risk assessment by using of HAZOP and ETBA methods have been separately shown.

HAZOP: 44 deviations were identified, so that 11.37% of deviations were not acceptable, 36.36% were undesirable, 29.55% were acceptable but needed reconsideration and 22.72% were acceptable and didn't need any correction act. Also 126 possible causes of hazard are detected that 46.03%, 40.47%, 7.95% and 5.55% of them were related to failure in equipment, failure in process function and controlling systems, human errors and condition of weather and the natural disasters respectively.

The main causes of hazard were consisting of: 1) opening of bypass pathways, 2) dirty and obstruction of pump's filter, 3) corrosion of the gasoline transmitter pipelines and the trays in tower, 4) rotation of gasket, 5) outage of electrical power, 6) failure in alarms, 7) closure of control valves, 8) failure in check valves, 9) increasing pressure in plant air and 10) failure in welding of pipelines. HAZOP worksheets have been filled for all of the 44 diagnosed deviations in nods. For instance, one of these worksheets shows in Table 1.

In this study, 47.73% of deviations were unacceptable and undesirable and the most important causes of deviations (46.1%) were related to failure of equipment but the human errors weren't so important.

One study in chlorination unit showed that 32.5% of deviations had intolerable and moderate risk levels, so that increasing the volume, pressure and temperature of liquid chlorine in the cylinder had the highest risk levels [9]. In other study at chemical unit, 46.1% of deviations were unacceptable and undesirable, so that the main causes of hazard were equipment's' failure (43.5%) and human error (35.8%) [18]. The main causes of deviations were failure of equipment and human error [21].

The results of studies have shown that the HAZOP method differently detects the hazards based on process-style and it probably couldn't be gained the same results using this method even in the approximately same process.

ETBA: 10 types and 24 subtypes of energy were detected that had a potential to damage the goals (man, equipment and products). The main energies were chemical (20.83%), potential (12.5%) and electrical (12.5%) energies. 33 hazards were detected so that they were 10.52% unacceptable, 27.27% undesirable, 27.27% acceptable but needed reconsideration and 39.39% acceptable and didn't need any correction act. ETBA worksheets have been filled for all of the 33 diagnosed deviations in process. For instance; one of these worksheets shows in Table 2.

In this study, 37.79% of risks were unacceptable and undesirable. In other studies; 57.6% of hazards in chlorination unit [9], 70% of hazards in foundry industry [13] and 68% of hazards in petrochemical plant [22] had unacceptable and undesirable risk levels.

In present study, the most important risks were chemical, potential and electrical energies. The highest risk levels in different study using ETBA were related to "The reaction and involvement of individuals" [9], "Potential energy" [13-14], "Rotational and linear kinetic energies" [17] and "scaffolding and excavating" [22]. These studies shows that ETBA method has expanded application in process industries and in attention to process-style detect the existing hazards.

Table 1: HAZOP Worksheet: Operational node description; Desulphurization process at Tower-301

No.	Guide Word	Element	Deviation	Possible causes	Consequences	Safeguards	Risk Level	Required Actions	Risk Level
1	Increase	Flow	Increase of feed flow	-Opening of bypass trace	-Corrosion result in increased velocity -Reduce of Desulphurization	-Installation of S.V	A3	-pressure control system -Inspection of bypass pipeline	C4

Table 2: ETBA Worksheet: Entrance pipelines to tower-301

NO.	Type of Energy	Description of Risk	Exposure to potential targets	Protection of the flow of energy	Risk Level	Regulatory actions and proposed	Risk Level
1	Corrosive (Caustic and gasoline)	Fire due to leakage of flammable materials	People, equipment and product	-Thickness Measurement by gamma rays	3C	-Cathodic protection of the pipelines -anti-corrosion materials	4D

In this study, the main corrective actions was improvement of equipment, also in other studies were improvement and regular maintenance of equipment and using of correct operational methods [6, 17].

The main detected hazards were consisting of:

- Corrosion of the pipelines, tower's body and trays due to gasoline and caustic.
- Gasoline leakage due to rotation of gasket and loosening of flange
- Fire result in cranes' or hammer mechanical beats and static electricity
- Reaction between water and spilled caustic that led to induce of hydrogen's explosive vapor.
- Damage to dermal, ocular and respiration result in gasoline and caustic.
- Electrical shock result in connecting of bare wire to the tower's body.
- Tripping and Falling due to slippery surface.
- Pipeline explosion result in high pressure.
- Hearing loss because of pump and generator sound.

The main existing obstacles for reducing or preventing from release of unwanted energies:

- Metallic cover for electrical cable.
- Fuse, earth system and lightning arrester.
- Reticulated metallic guard in stairway.
- Pressure indicator.
- Ear protection equipment.
- Determination of the liquid thickness by gamma ray.
- Application of caustic as furnace fuel after the primary use of that.

Comparing of HAZOP and ETBA Techniques: HAZOP method detected the existing risks both more number and more severity than ETBA method. This depicts that HAZOP is more precise than ETBA in identifying the risks at gasoline refinery process. Applying of ETBA is easier than HAZOP. Also studies showed that ETBA had expanded application and acceptable sensitivity in hazard detecting at process industries.

The HAZOP and ETBA techniques identified the different hazards in same process and it seems that these two techniques can be used as complement methods for risk assessment especially in process industries.

Some corrective suggestions to decrease the risk level of hazard were:

- Regularly maintenance of the equipment, like: FRC, Check valves, etc.
- Pressure control system in tower-301.
- Installation of PC (regulator) in feed transmission pipelines.
- Cathode preservation or injection of the anticorrosive in tower and pipelines.
- Gas detector for detect of Hydrogen concentration.
- Safety alarms to prevention from crushing of vehicles to pipelines.
- Ambulant guard on the control valves to protect from stroke.
- Educational programs according to needs for all of operators periodically.
- Anti-spark rails in crane.
- Compensative pump for prevention of water pressure loss, if the existing pump be destroyed.
- Cooling system for prevention of rising temperature.
- Transmission of the refinery unit to a safe place (Far from the residential area).

CONCLUSION

HAZOP is a more appropriate than ETBA to predict and detect the hazards. But applying of ETBA is easier than HAZOP. These techniques can recognize a special hazard, then because of high complexity and hazardous of chemical processes, it's better to use the combination of these two methods to precisely detect the hazards.

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REFERENCES

1. Bartolozzi, L., A. Castiglione and M. Picciotto, 2000. Qualitative models of equipment units and their use in automatic HAZOP analysis. Reliab Eng Syst Saf., 70: 49-57.
2. Shirali, G. and J. Adl, 2006. How to perform the Energy Trace and Barrier Analysis (ETBA) in industries? A case study in Isomax unit of Tehran refinery. Iran occupational health Journal, 3: 43-49.
3. Zakia, A.M. Ahmed, Mai I. Dosoki and Shaimaa Abo A. Nasr, 2012. Review Article; Occupational Hazards in Fish Industry. World Journal of Fish and Marine Sciences, 4(2): 201-210.

4. Dunjo, J., V. Fthenakis, J.A. Vílchez and J. Arnaldos, 2010. Hazard and operability (HAZOP) analysis. A literature review. J. Hazard Mater, 173: 19-32.
5. Mohammadfam, I., A. Sajedi, S. Mahmoudi and F. Mohammadfam, 2012. Application of Hazard and Operability Study (HAZOP) in Evaluation of Health, Safety and Environmental (HSE) Hazards. IJOH., 4: 69-72.
6. Mohammadfam, I. and A. Kianfar, 2010. Application of Hazard and Operability study (HAZOP) in evaluation of health, safety and Environmental (HSE) hazards (Case Study: Oil Storage of National Iranian Oil Products Distribution Company), Journal of Environmental Science and Technology (JEST), 1: 39-49.
7. Vernez, D., D.R. Buchs, G.E. Pierrehumbert and A. Besrour, 2004. MORM-A Petri net based model for assessing OH and S risks in industrial processes: modeling qualitative aspects. Risk Anal., 24: 1719-35.
8. Gressel, M.G. and J.A. Gideon, 1991. An overview of process hazard evaluation techniques. Am Ind. Hyg. Assoc J., 52: 158-63.
9. Mohammadfam, I., S. Mahmoudi and A. Kianfar, 2012. Comparative safety assessment of chlorination unit in Tehran treatment plants with HAZOP and ETBA techniques. Procedia Engineering, 45: 27-30.
10. Khan, F.I. and S.A. Abbasi, 1997. TOPHAZOP: a knowledge-based software tool for conducting HAZOP in a rapid, efficient yet inexpensive manner. J. Loss Prev Process Ind., 10: 333-43.
11. Swann, C.D. and M.L. Preston, 1995. Twenty-five years of HAZOPs. Journal of Loss Prevention in the Process Industries, 8: 349-353.
12. Cui, L., J. Zhao and R. Zhang, 2010. The integration of HAZOP expert system and piping and instrumentation diagrams. Process Safety and Environmental Protection, 88: 327-334.
13. Zaroushani, V., A. Safari Varriani, S. Ayati and A. Nikpey, 2010. Risk assessment in a foundry unit by energy trace and barrier analysis method (ETBA). Iran Occupational Health Journal, 6: 7-14.
14. Booya, M., S. Arghami, H. Asilian and S. Mortazavi, 2007. Safety analysis of a corn processing industry by energy trace and barrier analysis method: a case study. Iran Occupational Health Journal, 4: 27-34.
15. Duising, L.P.M., S.V. Til, A.J. Magielsen, D.M.S. Ronden, B.S.Q. Elzendoorn and C.J.M. Heemsker, 2013. Applying HAZOP analysis in assessing remote handling compatibility of ITER port plugs. Fusion Engineering and Design, 88: 2688-2693.
16. Ericson, C.A., 2005. Hazard Analysis Techniques for System Safety. John Wiley and Sons, pp: 365-81.
17. Habibi, E., M. Zare, A. Barkhordari, A. Yousefi and M. Morowatisharifabad, 2011. The comparison of ETBA and HAZOPS Techniques. Process Safety Progress, 30: 356-359.
18. Habibi, E., M. Zare, A. Barkhordari, S.J. Mirmohammadi and Gh.H. Halvani, 2008. Application of a Hazard and Operability Study Method to Hazard Evaluation of a Chemical Unit of the Power Station. J Res Health Sci., 8: 13-20.
19. Mata, J.L. and M. Rodriguez, 2012. HAZOP studies using a functional modeling framework. COMP AID CH., 30: 1038-1042.
20. Labovsky, J., P. Lassak, J. Markos and L. Jelemensky, 2007. Design, optimization and safety analysis of a heterogeneous tubular reactor by using the HAZOP methodology. COMP AID CH., 24: 1241-1246.
21. Spencer, A.B. and M.G. Gressel, 1993. A hazard and operability study of anhydrous ammonia application in agriculture. Am Ind Hyg Assoc J., 54: 671-7.
22. Mortazavi, B., A. Zaranezhad, A. Khavanin and H. Asilian, 2007. Safety identification and evaluation of hazards nodes in one of petrochemical designs. Journal of Babol University of Medical Sciences, 4: 39-46.