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Hazard and Operability (HAZOP) Study for Analyzing Disaster Risk Reduction in Hazardous Chemical Industrial Unit

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ABSTRACT

One of the accessions to get an outline for disaster risk based decision making in chemical industrial units is Hazard and Operability Analysis (HAZOP) study. HAZOP methodology will be useful as a tool in assessing elementary study to investigate the disaster risk reduction based decision making for hazardous chemical industrial units. Hazardous chemical industrial units in present international scenario acts as a major component for increasing disaster risk and vulnerability for the environment & people. Outcome of this study will explain the potential hazards as well as vulnerability and the possible consequences of incidents in industrial unit which increases the chances of disaster due to failures using HAZOP as preceding analysis.

Keywords : HAZOP Methodology, BLEVE, Vapor Explosion, Chemical Industrial Units

I. INTRODUCTION

HAZOP, or Hazard and Operability Study, is a methodical way to identify possible hazards, risk& vulnerability in any industrial unit. In this accession, the process in industrial units are broken down into steps, and every transformation in work parameters is considered for each step, to see what could go wrong and from where the probable risk can be find & analyzed. HAZOP's subtle approach is commonly used with chemical production in major industrial units and piping systems, where fairly larger number of pipes and umpteen containers on failure can become a potential source of chemical industrial disaster. The aims of HAZOP study for disaster risk reduction are as follows:

- To understand, predict and deal with hazards and locate vulnerable points that can arise due insufficient process design or any process failure to ensure preparedness for effective operations in chemical industrial units.
- To evaluate immediate compliance that will fulfill Safety Health Environment & disaster risk reduction standards.
- To develop effective analysis through which potential threats can be discovered before they result in any disaster.
- To create a detailed elaborative and analytical record of hazard identification process in hazardous chemical industrial units.

The method of HAZOP will provide real-time decisions for disaster risk reduction and will work as a tool for risk event processing in case of disaster in hazardous chemical industrial units. Hazard or Risk-based Decision Management System—correlating events, managing decision logic, embedding predictive analytics, optimizing results, and monitoring and improving decision making are some other key findings that can be predicted by HAZOP study. Key features of the HAZOP in disaster risk reduction include competence and hypothesis as shown in Table 1:

Table 1 : Hypothesis & Competence of HAZOP study in assessing disaster risk

Competence	Hypothesis
Event correlation, disaster risk reduction rules, and predictive analytics in combination by HAZOP	HAZOP can lead to real-time response solutions focus on event correlation, on disaster risk reduction measures, or on predictive analytics. With the use of HAZOP study disaster risk reduction event processing and real-time decisions can be analyzed mutually and the solution received by HAZOP balances these capabilities by maximizing the flexibility and power of the decision-making systems.
Scalability and flexible distribution study by HAZOP	Requirement of extreme scalability and deploy ability for disaster risk reduction measures can be achieved by HAZOP study. With HAZOP integrated with disaster risk reduction event processing deployed at the edge of a process through architecture, event detection and correlation is widely distributed and it will be very useful to predict the potential threat. This also improves responsiveness and contextual awareness while lowering latency.
Broad support for divergent industrial hazardous environment	It is very much required to support externally managed disaster risk reduction data, content, response & mitigation rules, and predictive analytic models with HAZOP study. A wide range of hazard sources can be handled and event handling is extensible with HAZOP technique.
Adaptability and robustness in the face of change	The overall solution is very robust in the face of ongoing change. Event processing allows new patterns and queries to be deployed to a live instance while HAZOP allows similar changes to disaster risk reduction rules and analytic models. HAZOP for disaster risk reduction provides support for analytic models that are based on risk finding & hazard mapping, while automation of the full analytic lifecycle allows professionals to use hundreds of regularly updated disaster risk reduction based analytic models in mitigating disaster affects.
Extensibility in HAZOP	The solution is extremely extensible. HAZOP-based approach to disaster risk reduction event processing means that new functions and capabilities can be made available to the pattern-matching process while the support of real time decisions made by HAZOP study for external disaster risk reduction rules and analytic models allows the decision-making to be broader than that which is embedded in the disaster risk reduction decisions environment itself.

The main purpose of the HAZOP study is to assess the plant as well a industrial units in order to prepare possible measures for ensuring plant safety and eventually mitigate disaster risk. This is done by the selected members of HAZOP team in a series of discussions &meetings. The team methodically "brainstorms" the plant design& any failure that can enhance potential risk. This brainstorming increases creativity and procreate ideas through team member interaction.

Full participation of each team member id required in the HAZOP process. During the study, team members must resist criticizing suggestions of other team members. All creative ideas even very small are openly received and considered. The team's focuses on specific points of the design and risk associated with it.

All points in discussion are explored assiduously one by one. Team usually focuses at is deviations in the process parameters that can be precursor to any potential risk.

Guide words are used to ensure that the plant design& safety is investigated from each &every possible angle. The team identifies a fairly large number of divergences. Next, each is considered as a potential threat that can generate risk or effect of operations or hazards.

Effectiveness of HAZOP is largely determined by:

- The criterion and exact illustration of the study
- The competence and expertise of the HAZOP team members
- The team's caliber to work well together
- Germane questions asked by the HAZOP team
- The capability of the team to use outlined perspective for completeness and accuracy of the study
- Competence of the team to target serious hazards & vulnerability and not to get side tracked.

Usually the teams of four or five members are formed for HAZOP study and the said study is carried out by only experienced team members with enormous multi-disciplinary technical skill. Qualitative assessment aimed at drawing attention to problems is done during set of meetings which aims to draw attention to focus on potential hazards, risk and vulnerability of industrial unit.

The HAZOP teams are generally kept small and only inclusion of those members are allowed who possess relevant and multidisciplinary experience & skill in process safety, risk analysis, hazard identification, disaster risk reduction etc. The expertise in particular domain was also taken into consideration in order to maintain synchronization and balancing on competence of each and every member of HAZOP team.

Guide words play vital role in framing various parameters for process & plant safety of the HAZOP team study. Representations of standard sets are done by the help of guide words in a HAZOP study. Types of unit operation in any chemical industrial unit or plant use different sets of guide words.

The standard set of process in unite operation in chemical industries are determined by guide words. Each and every type of unit operations are framed by different types of guide words. General guide words for unit operations and their consequences includes:

No	Renunciation of the Design Aim
Less	Quantitative Decrement
More	Quantitative Increment
Part Of	Qualitative Decrement
As well as	Qualitative Increment
Reverse	Logical Opposite of the Aim
Other Than	Comprehensive Substitution

Usually guide words are helpful in analysis of HAZOP but sometimes they are not applicable in HAZOP studies. Sometimes process parameters are determined by guide words like:

Flow	Pressure	Temperature	Level
Composition	pH	Viscosity	Voltage
Speed	Frequency	Addition	Mixing
Separation	Reaction	Time	Control
Sampling	Inspection	Maintenance	Information

The gap analysis from HAZOP study generally focuses on divergence from the set patterns. Once the fluctuations from the set norms are identified, reasons

for those fluctuations are analyzed. Such fluctuations may be because of human faults or errors, material handling or procedures etc.

The HAZOP is developed in a systematic method using the guidewords and fluctuation to consider each component for disaster risk reduction in hazardous chemical industrial unit, their potential causes of failure, the consequences and the safeguard action. The HAZOP results are tabulated in Table 2. The HAZOP result recorded in this study are generally in the operational and maintainable categories. Formerly there are no significant records of potential causes that may lead to a disaster. Detailed HAZOP actions must be reviewed and recorded by the disaster professional or authority to ensure that all system are fit for purpose. The application of HAZOP can be seen in another paper namely HAZOP as one of the risk assessment method[6,7].

II. HAZOP METHODS

Identification of the potential threats and finding hazards of any industrial unit that may create accident is primary focus of any HAZOP study. The suggestions that arise from a HAZOP study can be implemented for mitigating risks and disaster. HAZOP steps for hazardous chemical industrial unit are described in Fig. 1:

The few Steps in order to carry out HAZOP are as follows:

1. Step 1: Define the System Description of Chemical Industrial Units

Identify and examine the system/activity that is going to be analyzed for disaster risk reduction in a chemical industrial unit.

2. Step 2: Define the problems statement for analysis of industrial units to mitigate the probable effects of disaster.

Define the potential hazards, threats, risks and significant impact on the system by using guideword and fluctuations parameters.

3. Step 3: Provide Application of All Guidewords Along With the Fluctuations. Any Hazard, Risk or Vulnerability

Analyze the findings that focus on the critical hazards as well as critical operational problems those results in disaster

4. Step 4: Repercussion Reporting, Finding Causes and Action Submission

To check the changing, cause and submission of actions that is required for HAZOP study to evaluate the process parameters which could lead to disaster.

5. Step 5: HAZOP reporting for the entire process

The results of HAZOP are recorded using HAZOP spreadsheets which generally include the guideword, fluctuations, possible causes, outcome, safeguards and suggestion action, etc. Sample worksheet example is shown in table 2.

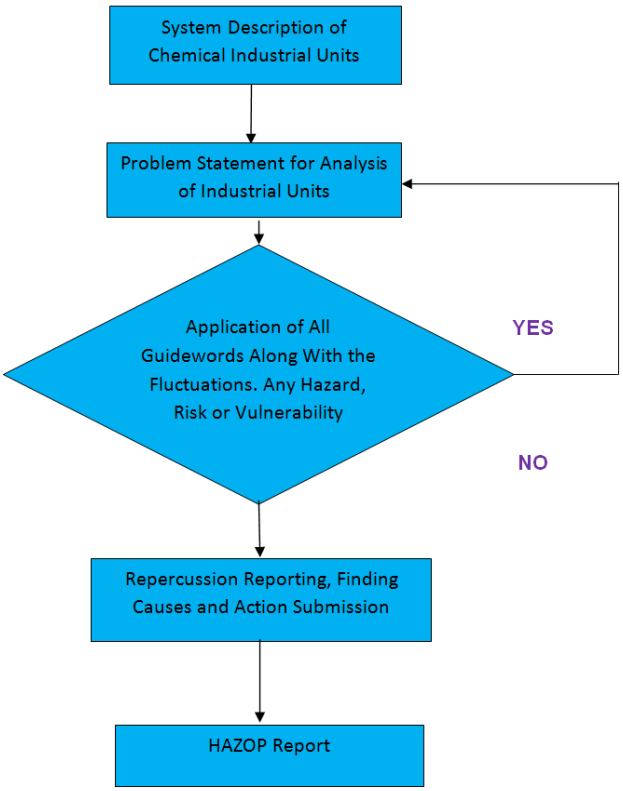

Figure 1: HAZOP Procedure

Table 2 : HAZOP Worksheet Example

System/Process Identification					
Activity : Description of System Activity for Assessing Disaster Risk					
GUIDEWORDS	FLUCTUATIONS	POSSIBLE CAUSES	POSSIBLE CONSEQUENCES	SAFEGAURD	ACTION
FLOW	Minimum	Corrosion	Blockage	Clear the blockages	HAZOP Study
TEMPERATURE	Moderate	Collision Abrasion Rupture	Fire , Explosion	Temperature Maintenance ,Fire fighting	Proper equipment
PRESSURE	Maximum	Rupture , Leakage	BLEVE , Fire	Firefighting , Monitoring	HAZOP
CONTROL	Moderate	Accident	Fire , BLEVE , Explosion	Monitoring	HAZOP
COMPOSITION	Moderate	Collision Accident	Fire, Toxic Release	Monitoring	Proper Material Balance
INFORMATION	Minimum	Major Accident	Fire , BLEVE , Explosion, Toxic Release	Monitoring Planning	Mock drill, Planning

III. Results and Discussion

HAZOP analysis matrix tabulates the results into systematic worksheets. The HAZOP worksheet consists of the components under hazard & their effect, severity, probability, risk, minimization of risk &disaster risk suggested actions in order to minimize the failure. Table 3 shows the HAZOP result of a chemical industrial unit.

Table 3 : Hazard & Vulnerability Analysis Matrix by HAZOP Analysis

Hazard and Operability Analysis Matrix							
Sr. No	HAZARD	HAZARD EFFECT	SEVERITY	PROBABILITY	RISK	MINIMISE RISK BY	DISASTER RISK
1	Fire	Skin Burn, Choking	H	H	H	Minimizing thermal radiation and oxygen depletion	Frequent
2	Explosion	Smoke inhalation, Trauma and burns due to the force and heat of the blast, Flying debris	H	L	H	Collective control measures like avoidance of effective ignition sources	Rare
3	Boiling Liquid Expanding Vapor Explosion(BLEVE)	Flame Impingement & Physical damage	H	L	H	Collective control measures like avoidance of	Rare

						effective ignition sources	
4	Toxic Release	Respiratory Track & Lung choking	M	L	M	Proper PPEs & open ventilation	Occasionally
Final Assessment				**Overall Risk**			**High Risk Disaster Unit**

- ⇨ Remark: Severity–L=Low (Minor injuries, first aid); M=Medium(Hospitalization, medical leave); H=High(Serious injuries, fatality)
- ⇨ Probability–L=Low (Unlikely); M=Medium (Possible); H=High (Very Likely)
- ⇨ Note: Severity x Probability = Risk [eg. LxL=L; LxM=M;LxH=H; HxM=H; the product follows the higher severity or probability]
- ⇨ Higher Risk requires extensive risk minimization procedures

HAZOP template provides some important and essential points to assess the hazards, severity, and probability, hence the risk associated in and near chemical industrial units which if not assessed properly will result in potential disaster. HAZOP matrix will help to evaluate disaster risk which in turn guides to get proper solutions for mitigating hazardous effects of chemical industries.

IV. CONCLUSION

Hazardous chemical industrial units are always at high disaster risk .The main reason for such pre disaster scenario is primarily due to the use of highly toxic chemicals and the properties of these chemicals. Fire, explosion, boiling liquid expanding vapor explosion and toxic release are the main hazards in any chemical industrial unit .In any type of hazard the risk maximizes to a great level and the unit can be rated as

high disaster unit. The objective of this study was to use HAZOP study in determining the disaster perspective for chemical industrial units .The critical hazard & overall risk as per the matrix is that chemical industries falls under high risk disaster unit.

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