Generalized Hazop Analysis for Process Plant

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Abstract— The hazard and operability study (HAZOP) is a creative technique for identifying hazards and operating problems in a process plant. Advances in technology and trends to highly complex and integrated plant designs have sensitized people for systematic and sustainable methods to identify hazards of which the HAZOP study is generally recognized as the foremost solution being able to cover standard and also new complex technology. HAZOP technique assumes that the plant management is competent and that the plant or process under investigation will be operated and maintained as intended by the design team and in accordance with good management and engineering practice.

Key words: HAZOP; Process Plant; Hazard and Operability; Plant Design

I. INTRODUCTION

The primary objective of a HAZOP study is to identify potential hazards and operating problems on e.g. a process plant. Performed by a multi-disciplinary team which applies the HAZOP structured brainstorming technique all possible deviations from normal operating conditions are examined in detail and their reasons and consequences are assessed. The detailed insight into the plant is supported by dividing the plant into feasible sections, so called 'nodes'. Specific 'parameters' and 'guidewords' are used to focus the team towards likely design issues in each section of the plant. Once determined, possible 'deviations' from the standard operating or design conditions may then be discussed and assessed by the team with respect to their effect on safety. Subsequently the implemented safeguards are identified and where considered necessary recommendations for action or further consideration are recorded and presented in the form of the HAZOP Report.

A Hazard and Operability Study (HAZOP) is a systematic approach to investigating each element of a process to identify all of the ways in which parameters can deviate from the intended design conditions and create hazards or operability problems.

A Hazop Study typically involves using the piping and instrument diagrams (P&ID), or a plant model, as a guide for examining every section and component of a process. A hazop team consisting of experienced and knowledgeable people, brainstorms potentially hazardous situations that could arise in each section of pipe, each valve, and each vessel in the system.

The hazop team should be led by someone with an in-depth knowledge of the process, but they do not need to be an expert in the technology used in the process. The hazop team should include people with a variety of expertise such as operations, maintenance, instrumentation, engineering/process design, and other specialists as needed. These should not be "newbies," but be people with experience, knowledge and an understanding of their part of the system. A hazards analysis can be time consuming, be highly sophisticated, and involve a detailed in-depth analysis. If there is the potential for significant injuries or damage, then it may be essential to put an extensive on-going effort into the hazard analysis.

II. HAZOP

The success of the HAZOP study depends upon an effective system for working through the items of the study. As a first step, the definition of scope is considered with respect to the special requirements of the client before the required data are collected by the HAZOP team and/or HAZOP facilitator. The plant or process under investigation is divided into a number of suitable units, the HAZOP nodes. Each node is the topic of a HAZOP session, conducted under the supervision of a GL team leader/facilitator who is an expert in the HAZOP technique. A HAZOP on a large project may consist of a large number of nodes and respectively require several weeks to be performed.

HAZOP technique assumes that the plant management is competent and that the plant or process under investigation will be operated and maintained as intended by the design team and in accordance with good management and engineering practice. The HAZOP study starts with a systematic examination of the plant or process with a depth depending on the level of detail required. A Hazop Study may be a one-time study of limited duration, or it may be ongoing, not having a specific end date. Study results should be released as action items as they are identified. Typical actions a Hazop Study might recommend include:

- A review of existing protection system designs by a specialist
- Adding or modifying alarms that warn of deviations
- Adding or modifying relief systems
- Adding or modifying ventilation systems
- Increasing sampling and testing frequency
- Implementation of additional engineering controls

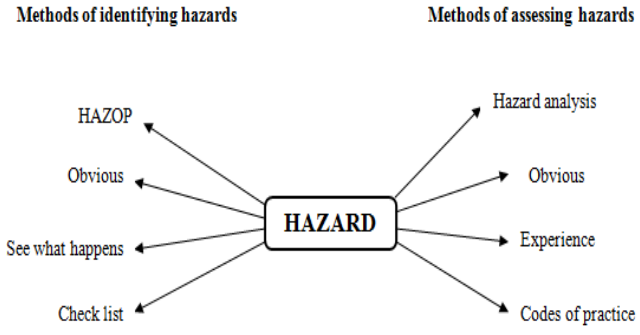

Fig. 1: Method of Identifying and Assessing Hazards

III. TECHNOLOGY USED IN HAZOP

A. *Study Node:*

Section of equipment with definite boundaries within which process parameters are investigated for deviations.

B. Intention:
Definition of how plant is expected to operate in the absence of deviations. It can be either descriptive or diagrammatic.

C. Guide Words:
Simple words that are used to qualify/quantify the design intentions and to guide and stimulate the brainstorming process.

D. Process Criterion:
Physical or chemical property associated with the process.

E. Deviations:
Departure from the design intentions that are discovered by systematically applying suitable guide words.

F. Causes:
Reasons Why Deviations Might Occur.

G. Consequences:
Results of Deviations

H. Safeguards:
Engineered systems or administrative control designed to prevent causes.

I. Recommendations:
Proposals for design alterations, procedural changes or areas of further study.

IV. GUIDE WORDS

A list of guide words is applied to each part of the plant or process, thereby generating deviations from normal operating conditions with respect to all conceivable eventualities. Apart from normal operations the following are considered and listed for all guidewords of each HAZOP: foreseeable changes to start-up and shut-down procedures, maintenance, etc. Each deviation is checked for possible causes and consequences; potential problems are identified and noted, and the need for action is decided by taking into account both the significance of the consequence(s) and the probability of the event occurring. If necessary, a team member explains the function of the item under examination, including usual process conditions and specifications if feasible, to assure that all team members have the background knowledge of the item examined. In general to search for possible deviations each HAZOP item is examined by applying the guide words

- None
- Reverse
- More Of
- Less Of
- Part Of
- More Than
- Other Than

The parameters and its guide word which can be used for the nodes are given below.

General parameters	– No – More – Part of – Less – Reverse
Time parameters	– Sooner – Later
Position & Source parameters	– Where else – Other than
Temperature, Pressure parameters	– Higher – Lower – More – Less
Other parameters	– Where else – Before/After – Early/Late – Faster/Lower

Table 1:

V. HAZOP METHODOLOGY

The existing and newly planned facilities were sectioned into logical units and follow the HAZOP technique. The procedure for HAZOP technique is given below.

1) Select the appropriate node
2) Apply the first or next parameter
3) Apply the first or next guideword, which in sequence with the parameter gives the deviation
4) Determine deviation
5) Identify all potential causes of the deviation
6) Appraise the consequences of the deviation
7) Appraise the safeguards preventing or mitigating the
8) deviation and its consequences
   Agree a recommendation for action or further consideration of the trouble where needed
9) Once all causes and consequences for a given deviation have been determined and the need for action discussed, the procedure back to step 3. This process repeats until all guidewords have been mingled with a selected parameter.
10) Once all guidewords have been considered the next the next parameter will be selected (step 2) and the process will be repeated until all specifications have been applied
11) Then the discussion moves to the next node and the procedure will be repeated until all sections are applied.

As specified above the HAZOP also carries the division of the plant into sections/nodes. In a Hazop Study the hazop team works through the P&IDs examining the impact of potential changes to parameters such as flow, temperature, pressure and time. Using their experience they determine the effects of deviations from design conditions. This means that a Hazop Study is a systematic, step-by-step approach to brainstorming possible deviations; determining the likelihood of the deviation (is there a realistic cause); evaluating existing protections; and estimating the resulting impact and potential catastrophic result of the deviation.
The process system is evaluated as designed and noting the potential for deviations. All potential causes of failure are identified. Existing safeguards and protection systems are identified and their ability to handle the deviations evaluated. An assessment is written weighing the potential deviations, their consequences, their causes, and the protection requirements. When a hazard condition is identified, recommendations may be made for process or system modifications, or further study by a specialist may be required.

VI. HAZOP WORK SHEET

HAZOP always targets on eliminating the root of the consequences rather than applying mitigation measures, for that we have record the hazop proceedings in the worksheet.

Company : Node No. :				HAZOP Date : Leader :	
Parameter	Deviation/ guide words	Causes	Consequences	Existing safe guards &comments	Recommendation action
Flow	More				
	Less				
	No				
	Reverse				
Pressure	High				
	Low				
Tempera-ture	High				
	Low				
Level	High				
	Low				
Time	Sooner				
	Later				

Fig. 2: Sample Hazop Worksheet

VII. HAZOP TEAM

The HAZOP study team shall neither be over-nor undersized. Ideally the study is carried out by a team of 4 to 6 people plus a facilitator and scribe. The team should be composed of the following participants:

- The design engineer in control for the respective facility
- The project manager (for new installations)
- The plant engineer in charge
- The maintenance engineer
- The HSE representative
- The foreman/ technician
- The facilitator and scribe

VIII. FINAL STATEMENT

When the HAZOP study is finished, an ultimate report will be prepared.

The minimal needs for the report are as follows:

- Characterization of applied procedures and HAZOP technique
- Summary and description of approved HAZOP recommendations
- Summary of operational recommendations and limitations
- List and characterization of drawings and relevant documents studies
- Finalized HAZOP study work sheets together with reports from each study session including a list of participants
- commentate copies of drawings combined with supporting documentation which were used during the examination
- Recommended revisions of drawings and documents (or part thereof if more convenient) which show alterations, determined as necessary as a result of the HAZOP study
- Changes proposed by the HAZOP team, but not accepted, and the reasons why the proposed changes were rejected

IX. STRENGTH AND WEAKNESS OF HAZOP

A. *Strength of HAZOP:*

- HAZOP is a standardized, reasonably complete and flexible.
- It is suitable mainly for team use whereby it is possible to organize the general experience available.
- It gives good recognition of cause and excellent identification of critical variations.
- The use of keywords is adequate and the whole group is able to engage.
- HAZOP is a magnificent well-proven method for studying large plant in a certain manner.
- HAZOP determines virtually all significant variations on the plant; all major accidents should be identified but not necessarily their causes.

B. *Weakness:*

- It takes little account of the probabilities of events or consequences, although quantitative assessments are sometime added. The group mostly let their mutual experiences decide whether deviations are meaningful.
- HAZOP is poor where various-combination events can have severe effects.
- It tends to assume defects or degradation of materials of construction will not arise.
- When identifying residue, HAZOP tends to strengthen listing these as resulting in action by emergency control measures without considering that such action might fail. It tends to ignore the contribution which can be made by operator interventions

X. CONCLUSION

This paper focuses on preventing the accident in process industry by using HAZOP study through periodic inspection. In that, hazards will be identified and minimized. Study is carried out by visiting various work process in titanium dioxide industry, hazardous present in work through HAZOP study. Possibility for prioritizing scenarios is supplementing HAZOP study with qualitative risk analysis. This approach allows identifying the most important issues of assessed technology and assists to design an appropriate technical/organizational measure to minimize the identified risks.

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