 

# COMMON PROBLEMS AND RECENT TRENDS WITH HAZOPS

Alan Munn CEnv CEng FIChemE
Aker Solutions, Rutherford House, Warrington Road, Birchwood Science Park, Warrington, WA3 6ZH;
Tel: +44 (0) 1925 666010, e-mail: alan.munn@akersolutions.com

Hazard and operability (HAZOP) analysis has a well-deserved reputation for systematic and thorough evaluation of process hazards. The technique is now widely known and is in widespread use in the chemical and hydrocarbon processing industries; so much so that in many Countries performing a HAZOP has become a legal requirement for new or modified plants.

A number of guides exist for performing HAZOPs, the most recent being the IChemE guidelines on best practice – second edition, published in 2008. In practice however, following best practice is not that easy and many compromises have to be made in order to complete the task. An added complication occurs when the HAZOP is led by an independent leader from an external company as is increasingly the case. In this situation the leader also has to satisfy the client or client's requirements which do not always correspond to best practice.

In addition there is a trend to reduce HAZOP study scope to safety and environmental concerns only and to exclude operability and reliability issues. This has resulted from a compliance mindset, possibly in an attempt to reduce liabilities. HAZOP is increasingly being seen as a compliance tool rather than as a methodology to ensure a safe, reliable and well designed plant. With the current financial climate we can expect these problems to increase as project costs come under increased pressure and the scope of many projects is reduced.

This paper discusses some of the more common problems that occur during HAZOPs and some of the possible solutions.

KEYWORDS: HAZOP, Process Safety

## INTRODUCTION

Hazard and operability studies (HAZOP) were developed in the 1960s by ICI following some major problems with new process plants. The technique is now widely known and is in widespread use in the chemical and hydrocarbon processing industries worldwide and has a well-deserved reputation for systematic and thorough evaluation and identification of process hazards and operability issues. A number of guides exist for performing HAZOPs, the most recent being guidelines on best practice – second edition, published in 2008 by IChemE [1].

In practice however, following best practice is not always easy and many compromises have to be made in order to complete the task. Sometimes HAZOP is not the best tool to use at the time the design is reviewed and other techniques are more appropriate. The term HAZOP has become ubiquitous with process hazard study and many people refer to HAZOPs when they actually mean other types of hazard studies. In some cases this can lead to HAZOPs being performed at the wrong stage of a project leading to them having to be repeated later.

There are a number of common problems that occur during HAZOPs that are not discussed in detail in the guidelines but are discussed below along with some possible solutions. In addition there is a trend to reduce HAZOP study scope to safety and environmental concerns only and to exclude operability and reliability issues. With the current financial climate we can expect this trend to increase as project costs come under increased pressure and project managers attempt to reduce costs.

A number of companies are now insisting on an independent facilitator or leader from an external company to run the HAZOP. This requirement for independence and hopefully objectivity is clearly beneficial although it does add some problems to the task that require managing.

## THE PROCESS SAFETY STUDY PROCESS

In a typical organisation, projects typically undergo several process hazard study reviews. These occur at different stages in the development of the project. According to best practice [EPSC 2008, Kletz 2006, AIChE 1992 and Nolan 1994] the process consists of eight stages; the classic six stages which are often called process hazard studies 1 to 6 and two additional stages (0 and 7). These are shown in Table 1. Ideally all eight reviews will be conducted during the lifetime of a project along with additional HAZOP reviews every few years during the operating phase. In practice many organisations fail to perform all these reviews. The classic HAZOP study is the stage 3 process hazard study applied to a design during the detailed engineering stage with firm (frozen) P&IDs and other engineering support documentation.

**Table 1.** Process hazard studies

| | Process hazard study |
|---|---|
| 0 | Consideration of inherent safety or less polluting systems (research stage) |
| 1 | Concept stage hazard review |
| 2 | FEED or project definition hazard review |
| 3 | Detailed design HAZOP (Also performed during the operating phase) |
| 4 | Construction/design verification |
| 5 | Pre-commissioning |
| 6 | Project close out/process start-up |
| 7 | Demolition/abandonment |

## THE HAZOP PROCESS

The HAZOP process has been described in detail in various guides (refs). It is not our purpose here to discuss this in depth. For a typical review it consists of the following stages:

- Agreement of terms of reference and boundaries of the study
- Specifying the sections/nodes for the study
- Describe the node and agree on the design intent of the node
- Generate deviations by systematically applying combinations of parameters and guidewords
- Identify realistic causes of the deviations and possible consequences
- Evaluate safeguards and decide if adequate and if further changes or studies are needed
- Systematically record the findings and any recommendations
- Follow up and close out

## RECENT TRENDS

In recent years there is a trend to reduce the HAZOP study scope to identify safety and environmental concerns only and to exclude operability and reliability issues. Although cost control by project management has played a role in this, the major reason for this trend appears to have resulted from a compliance mindset. HAZOPs are considered a safety/legal requirement and any findings become legal requirements with costly implications and on-going controls. As a result, clients and especially their legal advisors want to minimise findings and action items. Eliminating findings relating to operability and reliability is one way of achieving this, although a simpler approach of categorising findings into safety, environmental and other would probably be wiser and at least one company has developed a procedure to screen out these issues prior to HAZOP based on the observation that most (something like 90%) of items have been identified before in previous HAZOPs and an extra review has been added into the project development process to identify these items and resolve them.

Another continuing trend is the use of the word HAZOP to refer to all safety studies rather than using it for its true meaning. For some companies this has created real problems and unnecessary costs as their formal procedures require them to perform a HAZOP even when a different type of review such as a process hazard study 2 or HAZID would be more appropriate.

## COMMON PROBLEMS

The following are some of the more common problems that occur during HAZOPs and some of the possible solutions. Very little guidance is given on these in the guidelines:

## HAZOP BY DIFFERENCE

HAZOP by difference is a valid technique for dealing with repetitive designs. It is commonly used on a small scale in many HAZOPs where there are parallel pieces of equipment. One piece is reviewed and the findings then applied to the others. Some discussion should also take place on any possible interactions between the parallel streams with all or only some of the units on line and how the flow distribution will be controlled.

Where HAZOP by difference can easily become a problem is where similar equipment such as vendor packages are installed in different plants. The first issue that needs resolving is determining what is different from the previously HAZOP studied case. It is easy to fall into the trap of only focussing on the hardware changes such as materials of construction or design pressures etc. and not to consider all the process conditions of the plant that the equipment is connected too. Any changes in these conditions need to be identified as these can impact on the package operation. It is rare for there not to be any significant changes. The technique we have found most successful is to consider the interfaces in turn and where differences are identified apply the appropriate parameter/guideword combinations. Care must be taken as if there are numerous previously unidentified changes, sometimes this can take longer than doing a conventional HAZOP anyway.

The other issue with HAZOP by difference is determining an acceptable number of repeats before a completely new HAZOP should be done. In the same way as operating plants should undergo a HAZOP study every few years, repetitive designs should be revisited. Various options are possible, for example, every four years or after every three HAZOP by differences. Ideally the team leader should review the previous HAZOP by difference and use his judgement to determine if it would be better to perform a fresh HAZOP.

## VENDOR AND LICENSOR PACKAGES

Vendor and Licensor packages present particular challenges. They are typically approached by using HAZOP by difference and the previously mentioned problems apply. In addition there is often reluctance by a vendor or licensor to accept that there may be problems with their design that

should be resolved. The typical argument is that the package/design has already been through a HAZOP and there have not been any accidents on their units so it is safe! As it is impossible to do a proper HAZOP without considering all the external connections and interfaces which are different in each case, this argument is wrong. One of the major challenges the HAZOP leader will face is getting positive participation from the vendor who may only be attending the HAZOP because of a contractual obligation.

Even if changes are acceptable to the vendor then it can add enormously to the cost. Re-engineering a package design is not recommended and although the re-engineering should not take place in the HAZOP, the wording of any recommendations can easily lead to re-engineering later even if other options to resolve the problem are available.

Another common problem is the vendor's reluctance to share information about their design for competitive reasons. This is typically resolved by having numerous confirmation-of-detail type action items; although the HAZOP leader needs to ensure that in situations with a particularly high risk, the action is followed through more than just by receiving a confirmation type response from the vendor.

Sometimes a HAZOP of a complete plant is called for but the vendor packages are not as well defined as the rest of the plant and are therefore not suitable for HAZOP. In this case the best move is often to perform a process hazard study 2 or HAZID on the package/interfaces or a What-if type of study. This can provide valuable feedback into the design allowing changes to be made relatively easier than would be the case if the package is ignored until a HAZOP is possible. It is important that the minutes show this clearly and that an action to do a HAZOP on the package when possible is included.

## INADEQUATE INFORMATION/DETAILS AVAILABLE

This is always a problem. Ideally, the HAZOP should be performed on firm P&IDs, frozen for the HAZOP and all support documentation (Specifications, drawings, calculations etc.) should be available. In practice it is rare that this occurs, the HAZOP dates are a fixed deadline, often set months in advance; and the engineering often hits problems causing delays. So the only flexibility available is the quality of the information provided. The other common reason for this problem is the attempt to perform a HAZOP too early in the project development when a different study such as a process hazard study 2 or HAZID would be more appropriate. The reasons for this were discussed earlier.

When this type of problem occurs, it is up to the HAZOP leader on how to handle the situation. In some cases, if the information can be made available within a few hours or days it is best to move on to another parameter or node and then come back. Sometimes it is best to proceed based on an assumption which can be confirmed later or added as an action item. If a particular section of the plant is completely lacking in details or the team knows that it has recently undergone major changes which are not yet shown on the drawings, it is often best to leave it out and move on with an action to ensure it is HAZOPd later.

Often the decision as to the best approach is determined by the logistics and the availability of the participants. If people have travelled to the HAZOP from around the world as is often the case, then it is important that they are utilised as best as possible. Organising a second HAZOP will probably be out of the question.

## COMBINING DIFFERENT STUDIES (SIL ASSESSMENTS ETC) WITH THE HAZOP

This is a recent development and is typically an attempt to reduce schedule and costs. When a request to do this occurs, it shows a lack of understanding of the process safety review process.

Ideally the SIL assessment follows the process hazard study 2 or HAZID with a gap of at least several weeks so that changes resulting from the HAZID can be followed up first. The HAZOP should be performed on the design once the findings of the SIL assessment, especially instrument details, have been included in the design.

It is possible to do a SIL assessment following a HAZOP, but any resulting changes identified in the SIL assessment will have to be reviewed in a later HAZOP. If the decision is made to do a SIL assessment immediately after a HAZOP, ensure that adequate time is budgeted to do both, trying to squeeze a SIL assessment into the time originally allocated for a HAZOP will simply not work!

## USE OF HAZOP AS AN EDUCATION EXERCISE

This is nothing new; the HAZOP process provides an ideal opportunity for participants to learn about the process. The HAZOP typically occurs at a stage when operating personnel are allocated to the project and it common for team members to have no experience of the particular process apart from two or three weeks of preparation.

Sometimes two or three such members are on the team. In my opinion this should be encouraged as the more the people running the plant understand about the process, the better input they will have into the design and the safer the plant will be. However it is important that too much time is not taken up in explaining the details of the process rather than doing the HAZOP.

Someone who has actually operated a similar plant should always be on the team. In many cases this turns out to be the licensor or an outside consultant (often retired) as the operating company may not have any such people available.

## INSUFFICIENT TIME

There is always pressure on a team leader to reduce the time taken to do the HAZOP for schedule and cost reasons. A thorough HAZOP takes time to be performed properly and short cuts should not be taken.

Based on experience, the leader will be able to estimate the time requirements by reviewing the drawings. The estimate is likely to be different to that in the project schedule and the leader must agree the time requirements with the project manager whilst finalising the terms of reference. If insufficient time is allocated, then it is better to miss areas out of the review rather than compromise on the quality. If quality is compromised there are numerous implications and this could result in the whole HAZOP having to be redone. It is possible to speed things up a little through selecting larger nodes and working extra hours but there are limits to this.

Ideally an extra day will be built into the schedule to allow for contingencies, this is especially important when people have to travel to the HAZOP from around the world as is often the case. Letting them leave early is always easier than extending their stay.

As the HAZOP progresses, it will become clear if there is going to be an overrun. It is important for the leader to discuss this with the project manager as soon as possible and agree on how it will be handled.

## LANGUAGE PROBLEMS

In multinational companies and large contractors, it is not uncommon for HAZOPs to be conducted in a language that is not the first language of some of the participants. This can be a difficult situation to handle and the leader needs to be careful to ensure that all members of the HAZOP team can fully take part and contribute to the session.

Sometimes it is necessary to use an interpreter. The leader and interpreter must develop a good working relationship for it to be successful. The interpreter must also have a good understanding of the technical details of the process and have participated in HAZOPs before. The use of an interpreter often results in multiple discussions taking place at the same time, something that is considered contrary to good practice. Generally it is better to allow the conversations to take place independently and then feed back the results to the leader. Trying to have one-to-one discussions via an interpreter doesn't work.

Allow significant extra time if an interpreter is required.

## CULTURAL ATTITUDES TO SAFETY

In many parts of the world a risk-based approach to safety is not used or understood and either a compliance mindset is present or in some cases a more casual attitude to safety is present. In extreme cases the two approaches result in either minimal actions, only those absolutely necessary by law; or alternatively a refusal to believe that operators will make mistakes and will always successfully follow detailed procedures so that no other safeguards are necessary.

Different people in the same HAZOP team are likely to have these different attitudes and part of the leader's job is to overcome these differences and get the team to work together. These differences should not affect the findings of the HAZOP in terms of concerns or hazards identified, but are likely to affect the recommended actions.

The leader should never compromise his integrity and accept lower standards. The Institution of Chemical Engineer's *Rules of Professional Conduct and Disciplinary Regulations*, Issue 3, 7 December 2001, state:

> 3. Members when discharging their professional duties shall act with integrity, in the public interest, and to exercise all reasonable professional skill and care to:
> (a) Prevent avoidable damage to health and safety.

Clearly local ways of doing things should be acceptable to the team, but this may not always be the case. At the end of the day the leader's role is to run the HAZOP and identify potential safety and other problems for the client to take action on. The operating company is responsible for operating the plant safely and responding to the actions. Couching the actions in such a way as to enable flexibility in the response is one way of handling this situation, but care must be taken not to dilute the importance of the situation.

## FOLLOW UP OF HAZOP ACTIONS

This is a very common problem. Often the recommendations are not dealt with or not dealt with appropriately.

It is important that there is a single point of responsibility for this and an auditing activity takes place to ensure follow up. Approval/rejection of the actions also requires an experienced engineer at a senior level in the organisation who has the authority to make decisions.

Some companies follow the practise to make the HAZOP leader responsible for the close out of the actions, although with the use of independent or external HAZOP leaders this is not usually feasible.

## CONCLUSION

Hazard and operability studies (HAZOP) have a well-deserved reputation for systematic and thorough evaluation and identification of process hazards. A number of guides for performing HAZOPs exist but these do not cover many of the problems involved in performing the HAZOPs.

This paper has discussed some of the common problems that occur during HAZOPs along with some possible solutions in the hope that such open discussion will lead to improved quality of HAZOP studies and resultant improved plant safety and performance.

## REFERENCES AND BIBLIOGRAPHY

EPSC, 2008. Hazop guide to best practice, 2nd edition, *IChemE*.

Kletz, T., 2006, HAZOP and HAZAN, 4th edition, *IChemE*.

AIChE, 1992, Guidelines for hazard evaluation procedures, *AIChE*.

Nolan, D.P., 1994, Application of hazop and what-if safety review to the petroleum, petrochemical and chemical industries, *Noyes publications*.