

Good safety practice

HAZOP failure

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Summary

HAZOP is probably the most widely used technique for identifying hazards in the process industry and involves the line by line interrogation of a process by a team, utilising guidewords to identify deviations from the design intent. It can fail to produce the desired outcome in a number of ways that are identified in this paper, together with suggested prevention strategies. The prime responsibility of a HAZOP leader is for the quality of the review but organisational deficiencies can also compromise the outcome. The issues discussed in this paper are based on the author's own experience and are not intended to be exhaustive.

Keywords: HAZOP, hazard assessment

Introduction

It is often easier to be negative about something than to be positive. By exploring what can go wrong, then considering a mitigating strategy, a positive outcome can result.

A number of reasons why a HAZOP study may fail to produce the desired outcome are suggested, together with a prevention strategy. These are based upon the author's experience but there are undoubtedly more causes and solutions.

Background

An outline of the HAZOP process is contained in many texts and publications (Feltoe, 2011).

The desired outcome from a HAZOP study is a report identifying all hazards, be they safety, operationally or environmentally related, together with appropriate actions considered necessary by the team. This is the ideal, but we are all human and can only approach this asymptotically, minimising the chance of omission by following good practice. The prime responsibility of the HAZOP leader is for the quality of the review, and anything within his or her sphere of influence that compromises this must be addressed. A multitude of reasons can compromise the outcome – some associated with the meeting itself, some with project management or the design process and some systemic issues associated with the organisation.

What are the requirements for a good HAZOP?

- A competent leader;
- A competent, available and compatible team;
- A common language;
- A well reviewed design;
- Accurate technical information including P&IDs, cause and

Author's definition of HAZOP

"A systematic study, carried out by a team of persons experienced in aspects of the topic, using the line by line (or step by step) application of guidewords to identify all deviations from the design intent with undesirable effects for safety, operability or the environment."

- effects/functional description;
- An adequate facility and equipment to carry out the review;
- Time to complete the review;
- Absence of interruption;
- Ideally, site access.

HAZOP failure – causes, consequences and suggestions**HAZOP used as a design review**

A design review and a HAZOP are two fundamentally different activities. In the case of the former, the focus is on whether the design will work. The latter tries to break the design by studying the effects of failure from equipment, control systems or human error to determine if the design is sufficiently robust. They require two different mind sets which, in the author's opinion, cannot co-exist.

Causes:

Project procedures either do not exist or do not mandate a design review prior to HAZOP.

- Immature design – time pressure to hold HAZOP before all necessary information is available. Clues can be that the P&IDs are an early revision or the control philosophy has not been fully developed.
- Poor understanding by the team of the difference between HAZOP and design review.
- The leader does not table design issues, either because he/she is unable or has been over-ruled or because the HAZOP cannot proceed without the design issue being resolved.

Consequences:

The HAZOP will develop into a design review because the questions asked during a HAZOP force the issue. Even if the leader manages to avert a design review, the quality of the HAZOP will be compromised as causes and consequences may be based upon incorrect assumptions about how the plant will operate.

Suggestions:

- A clearly laid out project sequence showing the different reviews required (design, HAZID, HAZOP) and when they must occur will help but must be practical within the timeframe of the project.
- Every industry has different constraints, which are not always purely financial. For example, the dairy industry has many project completion dates driven by the seasons. Milk will start flowing in September (in New Zealand) regardless. The only degree of freedom is the start date.
- The same project procedure, which outlines the stages of a project, should describe the type of review required, the information required in advance of that review, how it will be carried out and the competence requirements for the attendees. This will only succeed if the project procedure is actively managed.
- The above will reduce the likelihood of an immature design being brought to HAZOP however should all else fail the final option is to reschedule the HAZOP. This can be a bold but necessary move particularly if team members have travelled to attend. If the HAZOP proceeds regardless, the leader must qualify the final report clearly identifying the limitations.

Lack of management support

Industries such as oil and gas have a long standing relationship with HAZOP and support is automatic. Others that are new to the concept have yet to appreciate the benefit.

Causes:

- A complex management structure with no assigned responsibility;
- Insufficient resources provided;
- Poor management awareness of the process, its benefits and their legal responsibilities.

Consequences:

If the HAZOP process is not perceived as important, a number of consequences may ensue including poor attendance by team members, tolerated interruptions, lack of resources for a timely design or for implementing actions. The last point relates particularly to the review of existing rather than new facilities where engineering and financial resources are harder to justify than on a new facility. HAZOP is a method of extracting information from people in the team who have the knowledge. If the right team has not been selected the knowledge will not be there to be extracted. Some interesting questions may still be raised but have all the right questions been asked? Having the right team is crucial.

Suggestions:

Managing from the bottom up is never an easy task. Management training is often offered as a solution to this problem but the author only concurs with this view to a point. It will help but not on its own. Three suggestions:

- Show management the product i.e. the report with all the identified actions, which would not exist but for the HAZOP.
- Make a senior manager responsible for the final "sign off" of the HAZOP report prior to commissioning. This will focus

their attention. The responsibility in this regard is to confirm that all actions have been cleared or formally accepted as exceptions and that the HAZOP process has been carried out according to company guidelines by competent people.

- Are the project and HAZOP procedures approved as company documents. These state how things will be done and establish the expected standard.

If senior managers are asking questions about HAZOP, it is a good indicator.

Not enough time

This is a real and frequently encountered problem. Ideally, the HAZOP leader should have viewed the P&IDs, agreed the scope and priorities, then made an estimate of the number of nodes involved and hence the time required allowing for breaks. In reality, the leader is often told how much time has been allocated and if attending engineers are flying in (and out) from overseas, there is additional pressure to make the HAZOP fit the available time.

Causes:

- Project time pressures;
- Leader fails to keep the team focused and drive the study along;
- A poor estimation of the required time, early in the project, which then becomes "cast in stone";
- Budget constraints.

Suggestions:

- Involve the leader in estimating the required time early.
- If the allowed duration is patently inadequate, the leader must prioritise e.g. main process, hot oil systems, steam systems, condensate system, cooling water, instrument air etc. Everything studied must be reviewed properly. There are no shortcuts, no quick and dirty 'mini' HAZOPs. Missing out functionally identical duplicates such as identical storages can speed things up and it can be agreed at the outset that certain failures are of such a low likelihood as to be considered non-credible – for example, a leak between the service and the process side of a duo plate heat exchanger. What isn't done must be tabled and a decision is then required to reschedule. The author has faced this situation on numerous occasions.

Poor leader**What makes a good leader?**

- Formal HAZOP training.
- Good facilitator skills.
- Having enough engineering nous to understand and drive the review. They are experts in the HAZOP process, not in the design being reviewed, that is the function of the team.
- A broad enough knowledge of other techniques so they may be applied where appropriate e.g. FMEA, LOPA, HAZID, batch or sequential methodology.
- A liking for attention to detail.
- Enough stamina to give the last guideword the same loving care and attention as the first.
- Be independent of the project, not the design engineer

who is defensive about his/her design, and not the project manager who is defensive about the budget.

This is quite a tall order and it would be unrealistic to believe all leaders have all the above qualities but they should aspire to them.

Causes:

- Poor or no training. It is assumed that because a person has sat in on a few HAZOPs they are competent.
- No competency standard established.
- Insufficient experience for the scale of the review.

Consequences:

The most obvious consequence is a poor quality HAZOP.

Suggestion:

- Develop a competency standard that includes training and an audit.
- The audit should not only aid improvement but weed out those who are not suited to the leader's role irrespective of their training or qualifications.
- Require the leader to be independent of the project. Not necessarily of the company unless either the company does not have the internal resources or independence between the company and contractor is required.

Dominant personality in team

This can be a problem for the leader, particularly if that person is the leaders' boss and has specifically requested to attend.

Consequences:

- Other members of the team may feel intimidated and withdraw their participation. The situation is a facilitation challenge that must be addressed by the leader. It is easy to say that he or she must have the courage of his or her convictions and deal with the situation, regardless of career limiting implications.

Suggestions:

- Directing questions to specific people in the team.
- Give the dominant person a job like scribing.
- It is rare that the person would have to be removed from the meeting and this should be done subtly, possibly involving a third party requesting the person's presence elsewhere.
- Use an independent facilitator.

Team tiredness

The first indication that the team is tiring is a lack of response. A tired team will not produce a quality product and lateral thinking will be limited. A similar effect to tiredness can be caused by analysis fatigue.

Causes:

- Sessions too long;
- Sessions too many in succession;
- Insufficient breaks;
- Poor working environment;
- A HAZOP where the team members have travelled and have their return arrangements in place can put pressure to work long hours in order to complete the study in the available time (see "Not enough time" above).

Suggestions:

- Start early finish early. Ideally start 8am, finish 3pm.
- Initial session 1.5 hrs thereafter break every hour.
- If possible, schedule a five day study to cross a weekend.
- Everyone need not be involved in the review for the whole time. This is not the same as saying a person is available on request. In the former, a deliberate decision is made that a person's skills are not applicable. In the latter, the person will only be able to answer questions which someone else has raised and will not be contributing to the identification of deviations.
- Encourage humour. HAZOP is a paradox. On one hand a rigid methodology is being followed while on the other we desire lateral thinking. It is a serious business but its success is not helped by being too serious. It is the author's opinion that humour "lubricates the brain" and encourages lateral thinking. An off-the-cuff silly remark may spark a train of thought in another direction. Even if not, it will lighten the day.
- Regular and good quality refreshments lift the spirits.

The defensive design engineer

It is only natural that a design engineer will want to defend his or her design. If the answer to every deviation is "that can't happen because, because, because!!" then the engineer is in the wrong frame of mind for a HAZOP. The desired attitude for the design engineer is for him or her to make their contribution not only by answering the questions of others but by pushing the bounds of credibility by assuming safeguards have failed, then once the hazards have been identified stepping back and by assessing the safeguards.

Causes:

- Lack of appreciation of the purpose of a HAZOP by the design engineer.
- A natural personality trait.

Consequences:

- The study may degenerate into a dialogue between the design engineer and the leader.
- Hazards are not identified and documented.
- Questions are viewed as a direct challenge to the engineer's competence.

Suggestions:

- The leader can ascertain if the design engineer is familiar with HAZOP prior to the meeting starting and if not can provide a few words of wisdom.
- As part of the leader's introduction, a few words such as: "Our going-in position is that the design is perfect in performing its desired function. Now we are going to try to break it to see how robust it is and we need your help" will help.

The author's experience has been that those engineers new to the process soon warm to it but those whose personality makes them naturally defensive are hard work.

Problem solving

This is a common problem.

Causes:

- Engineers are problem solvers.
- The team do not get together very often, if ever, and they are the ideal group to solve the problem.
- Inaction by the leader.

Consequences:

- A time blowout.

A discussion that clarifies or defines the problem is necessary. This can easily develop into a problem solving discussion. If the solution is obvious and agreed by the team then this should be recorded. It is the leader's job to recognise when problem solving is happening and to put the breaks on.

Incomplete or inaccurate information

Much has been written about the information needs and wants for a HAZOP (Kletz, 1999). A HAZOP study is typically carried out at the end of "Front End Engineering" at which time much detailed design and specification has yet to be carried out. Isometric drawings or 3-D models are not usually available at the time of HAZOP so spatial factors cannot be assessed. The P&IDs together with the control system and operating philosophy are what is being HAZOPed and should be accurately defined. If the information is inaccurate or changes are made post-HAZOP without control, then the HAZOP of those areas becomes meaningless.

Causes:

- HAZOP carried out too early – project pressure.
- No control of change system post HAZOP.

Suggestions:

- Formalise a layout review between the design team, maintenance and operations personnel when the detailed design is sufficiently developed. This can be supplemented by a Process Hazard Review (PHR) as described by Ellis et al (2004) which takes a high level view using guidewords such as "Impact, Coincident Activities, Loss via Opening".
- The HAZOP leader should be asking questions about the information available, accuracy of the P&IDs, cause and effects, functional description, hazardous area classification etc prior to the review. A few minor mark ups can be red lined but if the drawings have not been "as built" in recent history, the alarm bells should be ringing.

Budget pressures

If pressure is applied not to make recommendations or not to review because the budget is insufficient to fix any issues, this is not the problem of the HAZOP team and should be resisted by the leader. If the issue is purely financial, the acceptance of risk is a management decision. If there are safety or environmental implications then moral and legal issues arise. To quote Trevor Kletz "It is unacceptable not to look for problems simply because we may not like what we find".

Poor facility

The HAZOP team cannot be expected to perform if the room is in a noisy location or subject to disturbances. When HAZOPing an existing plant, carrying out the HAZOP on site means the team can visit the plant to clarify issues, take a break from the confines of a study and site information, such as DCS

information, is accessible. On the negative side, it also means that team members can easily be accessed. The ideal location, in the author's view, is:

- An on-site room large enough to house say ten attendees seated horseshoe fashion;
- Enough wall space for several A1 P&IDs;
- A data projector and screen for minutes to be displayed as they are generated;
- A management protocol inhibiting interruptions.

Poor minutes

No matter how good and meaningful the discussion is, it will all be forgotten soon after the meeting if not captured in the minutes. This does not require every spoken word to be documented. The normal HAZOP worksheet serves the purpose and all the hazards identified must be recorded together with the safeguards, either full or partial, together with actions. It should be stated in the report that those identified hazards that do not incur an action, are manageable with existing controls.

A good scribe should:

- Understand the discussion and not be an admin person;
- Be reasonably quick on the keyboard;
- Be prepared to slow the meeting down to their speed;
- Understand their first responsibility is to keep the record and to participate in the review only as scribing duties allow;

It is the responsibility of each team member to ensure the record is accurate. In the author's experience, a young engineer meets the requirements but should be rotated for a large HAZOP.

This can be a touchy subject, but if not all attendees in the review speak the same language fluently then it is likely that misunderstandings will arise. Additionally some cultures are reluctant to offer perceived criticism. There is no simple answer.

Suggestions:

- Use of interpreters where necessary.
- The leader should take additional time and cross check by paraphrasing.
- Using the author's method of applying failure effects (Feltoe, (2011)) prior to the application of guidewords will mean that the leader can ask direct questions, relieving the team members of what can be abstract thinking.

There are undoubtedly more causes and alternative solutions for HAZOP failure. Most of the issues discussed above do not happen frequently but two, in the author's experience, are common: Insufficient time and poor or no design review prior to HAZOP. Addressing these would produce a significant improvement.

References

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