Risk Engineering Guidance Paper

Hazard and Operability (HAZOP) Studies – Creating High-Value Results

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1 Introduction

This BakerRisk Best Practice document provides general guidance for performing highly effective HAZOP studies. Note that the guidance is not rigid; it is our opinion that there is no one 'best' way to perform a HAZOP, and the optimal methods will depend on what is being studied, the makeup of the study team, and many other factors. However, there are many ways to perform a HAZOP poorly, and we will discuss the history of HAZOP approaches and tools, and the pros and cons of the current methods that are in use in different circumstances to prevent poor performance.

Key aspects of a highly effective HAZOP study are presented below, in order of importance:

1. High-quality and up to date reference documents such as P&IDs
2. Knowledgeable and open-minded team members
3. Skilled HAZOP facilitator
4. Established and effective HAZOP protocols
5. Adequate time

The priorities listed above are in the eye of the beholder. A regulator, for example, might have a different view of what constitutes inputs to a ‘good’ HAZOP study. The order above reflects the primary, original intent for performing HAZOP studies which, in our view, is to identify measures that protect personnel, minimizes equipment damage, and improves operability.

We have witnessed studies performed by others where the primary goal of the HAZOP was not achieved due to a lack of one or more of these key aspects.

There are two other factors that are not exactly “convenience” issues, but they can compromise the efficiency or ease with which the study is performed.

6. Optimal meeting facilities (room, refreshments)
7. HAZOP recording software

These elements and others will be explored in the subsequent sections.
2. Is HAZOP the Right Method?

Before initiating a HAZOP study, it is worth asking the question “Is HAZOP the right way to do this study?” Given the near-universal adoption of the HAZOP method in the U.S. over the last two decades, one might be forgiven for thinking that HAZOP is a ‘one size fits all’ methodology. However, there are situations where another approach will provide superior results.

The OSHA Process Safety Management (OSHA PSM) regulation points out several Process Hazard Analysis methodologies that might be appropriate for doing a hazard review.

Each approach has advantages and disadvantages. For example, “What if” approaches can be useful for high-level conceptual evaluations where P&ID-level details are not yet available. FMEA is appropriate when the analysis depends on component-level details, such as the detailed review of a compressor or loading hose. Fault trees can be insightful when considering events involving a complex combination of initial failures and intermediate conditions or safeguard failures (for example, determining the main contributors to a reaction runaway). HAZOP is not always the best approach in these cases simply because it is difficult to develop a good list of process parameters/deviations.

There are also approaches other than those mentioned by OSHA PSM that can be fruitful. The “bow-tie” approach that originated with the offshore industry has been successfully utilized to graphically analyze other situations more effectively than HAZOP – in particular, high-level hazards, or for review of specific activities such as heavy lifts.

While PHA alternatives to HAZOP should be considered, HAZOP can be used in situations that don't initially come to mind as being suitable for HAZOP, or within the skill set of a typical HAZOP team. One striking example is the analysis of electrical distribution systems, albeit with a completely different guideword list than for a typical process HAZOP.

Ultimately, it is up to the PHA facilitator to determine the optimal methodology to use. The subject of methodology selection is covered in great detail by AIChE.
3 Whatever Happened to “OP”?

Looking back 40 or more years ago to when HAZOP was in its relative infancy and not widely used, it was common for the recommendations coming out of a study to be about evenly split between resolving hazardous conditions and improving upon the operability of the unit. In the modern world where HAZOP team members are generally over-committed to other activities, many HAZOP studies have virtually (or actually) eliminated discussion of events that are purely operability or economic in nature to reduce study time. Thus, over time, we have removed the part of HAZOP that actually helped pay the bill for the HAZOP by making the plant more efficient!

Economics aside, it should be recognized that a unit that runs smoothly is arguably one that runs safely as well.

When operators have more time available to monitor for upset conditions, the profitability of the unit allows greater resources to be available to maintain and upgrade equipment, etc. There is also the potential that a scenario that is identified by the PHA team as an economic or operational risk can lead to unrecognized health and safety hazards. By eliminating any rigor in studying these economic and operational issues, these hidden hazards remain unaddressed; when the “OP” factor is given real weight and review, actions taken to prevent economic impacts can reduce the probability of associated hazards that have not been clearly identified. For these reasons, we lament the disappearance of “OP” from HAZOP studies, while recognizing the real-life reasons as to why this occurs.
Preparing for the HAZOP

Team Members

The most important aspect of preparing for a HAZOP is to assemble an effective team. BakerRisk does not subscribe to any specific rule set on numbers or types of people involved, particularly since this will vary with the scope of the study. Ultimately, HAZOP is a conversation among subject matter experts, and the following must be in place:

- Enough people to have a conversation, but not so many that the conversation is disrupted
- People who have the expertise to discuss the issues relevant to the HAZOP
- People who ‘play well together’

In practice, this could mean a team size of anywhere from two to twenty people, excluding the facilitator/scribe.

To the extent possible, the team members need to come to the table without a personal agenda. If there is an ‘alpha personality’ on the team, it is the facilitator’s job to call out opinions from the other team members to balance out the input from that personality. If there are two or more ‘alphas’ on the team, the facilitator may need to take on the role of a referee as well.

Study Facilitator

A typical HAZOP facilitator in today’s process industries is a degreed chemical engineer or chemist, or someone who is qualified in a related engineering/technical field. Sometimes a client states a preference for a facilitator who has HAZOPed the subject unit type before, or even one that has previously worked on that unit type. However, it bears remembering that in the earliest days of HAZOP, the facilitator might have little knowledge of chemical processing. They were solely the “facilitator,” all technical knowledge came from the team. While this is still possible, BakerRisk experience shows that it is useful for our facilitators to be engineers so that they can probe comments that seem questionable and ensure that wording on scenario descriptions and recommendations is both sufficient and technically accurate.

We also acknowledge that it can be hard for a facilitator to let the team provide the technical input in the case where the facilitator has prior experience that makes them as knowledgeable on the unit type as the plant staff. BakerRisk has many staff members with considerable process plant experience; however, we do not overtly promote our leaders’ prior experience in a specific technology unless it is a client requirement. Similarly, the facilitator should not be in the reporting line for the unit being studied; there is too much potential for actual or perceived bias in how the study is conducted (see personal note from the author on supervisor/manager team members).

Personal note from the author:
Regarding the last bullet, early in his career, the author was a scribe for a HAZOP that included both the unit supervisor and the degreed engineer who created the design and was responsible for the ongoing operation/profitability. Many conversations went like this:

[Supervisor] “This situation has been a mess from the very beginning and has to be fixed.”
[Degreed Engineer] “We have made do with this for the past six years, and there’s no budget to fix it anyway, so you might as well forget about it.”

Needless to say, the study was a never-ending effort to find a compromise between black and white on each issue. In practice, having a supervisor/manager on a team with their subordinates may exacerbate existing tensions or stifle ideas and conversations needed for effective team communication.
BakerRisk staff have monitored studies where a great and motivated team was assembled, the documentation available to the team was fantastic, and the facilitator was properly trained and motivated. However, the HAZOP was a complete failure because the facilitator either did not control the meeting properly or over-controlled it.

In our experience training HAZOP facilitators, we find that 1/3 of people who are otherwise qualified by education, experience, etc. actually make good HAZOP leaders. A good facilitator needs to have interpersonal skills that will allow them to control and lead rooms with many different personalities and cultures – both at an individual level and at a corporate level. A facilitator who cannot adapt their style to differing groups and corporate cultures will have limited success. Some people are just not equipped with the skills to manage a group discussion; others may feel they are more knowledgeable than the team members and thus dominate the study. Loss of control of the study is also discussed in the HAZOP Execution section (Section 5).

**Study Scribe**

In recent years, there has been an increasing tendency to have the facilitator also act as the scribe. This is a reasonable expectation with the assistance of modern software, assuming that the facilitator has decent typing skills and, particularly in the case of HAZOP revalidations, the team is operating more in ‘edit’ than ‘create’ mode. Nonetheless, a strong argument can be made for having a separate scribe, since it frees up the facilitators’ time so that the team is not waiting for him/her to update the worksheet. In addition, a scribe allows the facilitator to concentrate on team discussions while items are being documented and updated.

A separate scribe is most beneficial when:

- The HAZOP team is large – The 10-15% time saved is applied across many people.
- The HAZOP is a new design – Lots of drawing, shuffling, and editing that delays typing.
- The HAZOP is being done remotely – Managing screen switching between worksheets and drawings is much easier when another person is available to handle that task.
- The HAZOP is expected to be prolonged (more than a week) – Facilitating and scribing at the same time takes intense concentration and is very draining; managing both roles for long periods of time can have negative impacts on the facilitator’s performance in both roles.

As to the qualifications of the scribe, we typically provide a junior degreed engineer, but have also had success with conventional administrative assistants – the difference being the degree to which they require dictation. It was more problematic to utilize a university professor who was working at the plant as part of a community-industry interaction program. Not only was it necessary to dictate the findings, it was also necessary to explain why the discussion ended up the way it did, thus resulting in a double-inefficiency.

**Study “Infrastructure”**

Since the PHAs rarely take place at a BakerRisk facility, our experience with HAZOP meeting locations has been varied. In the extremes, HAZOP meeting locations have included a plant meeting room, a hotel, or congregating pool-side (when a hotel fire forced the team outdoors). The important thing to note is that, regardless of the location, the HAZOP teams made use of the locations successfully. The main characteristics of a good meeting place include:

- Minimal background noise and opportunity for interruptions or distractions (e.g., mobile phones)
- Table arrangement that allows all the team to make eye contact with everyone else
- Refreshments that keep the team happy and alert
One comment about projector screens – The use of screens/TVs to project the contents of the worksheets has become almost universal. We have observed HAZOP studies that failed miserably because the projections were not managed properly by the study facilitator. Aside from the tendency of some people (like this author) to gravitate toward typographical errors that would be more effectively fixed outside the team meeting, the presence of the projection draws many people to focus on the screen rather than the P&IDs.

During one study (see “Personal note”), the team was literally looking at the projector screen more than 95% of the time. Observations:
1. How many hazards have ever been identified in a HAZOP by looking at a worksheet projection on a screen/TV?
2. Would you want to be part of this study?

This author, who was an observer to the study, quickly concluded that the study was going nowhere, and decided to HAZOP the drawings independently. This resulted in discovering a myriad of discussions and findings that the team missed because they were so focused on getting everything right on the screen; over 80% of what should have been discussed was missed. The study also took more than twice as long as it should have.

It is the facilitator’s job to monitor the team’s use of the projection and curtail it if necessary. This tendency can be managed by calling out P&ID numbers individually when looking for new causes to prompt the team to look at them and, in severe cases, the projector can be disabled when the team is supposed to be brainstorming. Don’t do a zombie HAZOP!

Defining Nodes/Node Markups
There are opposing views on the degree to which the nodes should be defined on the P&IDs prior to the study. Pre-defining the nodes has several advantages in terms of documentation preparation, saving time during the study, and more. Some feel that the facilitator should do just a modicum of pre-study node planning – that it would be presumptuous of the facilitator (particularly an external one like BakerRisk) to think we know enough about the process and its operation that we can pre-define the node breakdown. Ultimately, it is something that can be agreed upon between the facilitator and the main client contact.

Personal note from the author:
In one case, we observed the following conversation:

[Facilitator] “OK, we had 14 causes for No Flow. Which of these apply to “Less Flow?”
[Team] “Causes 1, 2, 3, 5, 8, 9, 12 and 13.”
[Facilitator] “OK. For cause 1, which of the consequences above apply?”
[Team] “Consequences 1, 2, 3 and 5.”
[Facilitator] “For consequence 1, which of the earlier safeguards apply?”
[Team] “Safeguards 1, 2, 3, 4, 7 and 9.”
5  HAZOP Execution

HAZOP Methodology Enhancements

It has become popular in recent years to integrate elements of Layers of Protection Analysis (LOPA) methodology into HAZOP. This is present in the form of providing specific rule sets for the initiating event frequency and the credits to give safeguards. Some of these rule sets are very helpful in assuring consistency for tasks such as risk-ranking, and there are some companies that provide many pages of guidance on how to categorize the severity and likelihood of a hazard. That is a positive development, since HAZOP facilitators have heard teams ask for years questions such as “How are we supposed to know whether this is a one-in-one thousand or one-in-ten thousand-year event?”

BakerRisk supports efforts to bring coherence to these risk-ranking discussions. However, we have also seen a slippery slope toward convoluting the HAZOP and LOPA approaches, so that it becomes unclear as to what the “frequency” of an event is – is it the frequency of an initiating event, or the frequency of a specific outcome before or after mitigation measures? This is particularly confusing for a team member who is not a frequent participant in HAZOP studies. We also lament the recent tendency to discount any safeguard unless it has a proven “layer of credit” that can be assigned. Does that mean that we should no longer use check valves on pump discharges? In some methodologies, there would be no basis for specifying a check valve because it would be considered without value. HAZOP and LOPA are both great methodologies, and rule sets can be very helpful in promoting accuracy and consistency, but let HAZOP be HAZOP and let LOPA be LOPA.

Node Size

One of the great controversies among HAZOP facilitators is what the optimal size of a HAZOP node should be. Having seen nodes that ranged in complexity from: (a) multiple complex P&IDs, to (b) the discharge line from a relief valve, we know that the answer is neither of those extremes. There is a balance to be drawn. This balance will shift depending on the organizational skills of the facilitator, the knowledge of the team, their alertness at that point in the day, whether the study is in its first day, and more.

A large node has the advantage of providing ‘context’ – it is easier to appreciate how different equipment interacts with each other when something goes wrong. However, an overly large node also provides more opportunities to miss something (e.g., there are 43 causes of “No Flow”), and it may exhaust the team.

Conversely, a too-small node creates a record with a lot of empty space and does not provide enough context for the team to fully appreciate the interactions between the current and surrounding nodes.
Setting the boundaries of a node can be challenging at the interfaces between the scope of one HAZOP and the OSBL connections, or for a HAZOP being conducted as part of a Management of Change review. Generally, the node should include not only the equipment that is “in scope,” but also the immediate surrounding equipment that affects that node. One alternative check is to assume that any deviation can be applied to the node from outside the node, and then determine if the node can handle the situation.

Lastly, we would like to add that we know that the term ‘node’ in HAZOP is a misnomer; technically speaking, a “node” is a point, not an area, but we can live with that!

**Guideword/Deviation Lists**

Putting aside the semantics associated with the terms “parameter,” “deviation,” “guideword,” and more that are in common and inconsistent usage, the HAZOP method relies on a series of prompts that are intended to inspire creative team thought. These include deviations from normal operation (e.g., “No Flow”, “High Level”); some companies add a battery of special topics such as “Instrumentation” or “Relief” or “Startup” to make sure that specific topics get discussed that might otherwise be missed using a purely deviation-based list.

There is merit to each of the systems that we have seen, and BakerRisk does not advocate for a specific list of HAZOP prompts. In our view, the quality of the study depends far more in how the facilitator initiates discussion of topics than on the specific prompts that are used. Indeed, in the very early days of HAZOPing, facilitators commonly used prompts that were as limited as “More,” “Less,” “Reverse,” “Other Than,” and “In Addition To” – it was the facilitator’s job to determine the parameters (e.g., flow, temperature, pressure, composition) in which to apply those deviations.

Fast forward 40 or so years, and HAZOP prompt lists have generally become much lengthier, with as many as 40 or 50 items required by some companies’ PHA standards. This is a positive in the sense that it allows relatively inexperienced facilitators to lead a study with a lesser chance of missing a worthwhile discussion. The danger from a study quality view is that there is the potential for a “HAZOP” study to inadvertently become a “Checklist” study. Both study types have their merits, but there is a distinction in participant behavior and creativity between the two. As always, it is the facilitator’s job to take whatever list is mandated and present it to the team in a manner that inspires the creative process, which is the hallmark of HAZOP studies.

As an aside, there is a similar issue associated with the solicitation of discussion at the start of a given node; this also relates to the earlier node size discussion. There is a natural tendency to jump into the node discussion and start documenting the details of how this control valve, or that control valve, or a manual valve in the same line could be closed unintentionally (in this case, “No Flow” is the first discussion prompt). In doing so, there is potential for the team to “miss the forest for the trees,” which may result in the team not recognizing high-level hazards that may be present. Therefore, at the start of a node, the facilitator should ask for an overview of the high-level hazards and how they are being managed, and only proceed with more detailed discussions once any high-level issues have been addressed.
Length of Study

HAZOP is a focused mental effort. The scheduling for multi-week studies needs to recognize the long-term fatigue that can result (not to mention the difficulty of the team in keeping up with their normal duties) and consider the need for scheduled breaks. During any lengthy study breaks, the facilitator should take the opportunity to compare the initial discussions with the later ones to determine if there has been any 'drift' in terms of the team's performance or perception of risk. A midstream 'recalibration' may be necessary to ensure consistency from beginning to end.

The same is true for planning each workday. In practice, the duration of an effective HAZOP study session will depend on factors such as team motivation, fatigue, distractions, etc. In the 'old days' of HAZOP, it was common to limit the sessions to 4 hours per day, which is luxurious compared to the most common modern approach of running from 7-8 hours per day. Ultimately, the facilitator must continuously gauge the performance of the team and provide breaks of sufficient number and duration to keep the team engaged throughout the day.

Breaks

Signs that a HAZOP team needs a break:

- Loss of focus, increased level of side discussions not related to the current topic
- Fidgeting, visible restlessness on part of attendees
- Multiple team members stand up, walk around, or go to use a restroom.
- The team is listless; not developing creative ideas

In a well-run study, a team can typically perform well for about 1 – 1.5 hours without losing focus or heeding “the call of nature.” Beyond that, a break is usually needed to get re-energized.

Note that a “break” does not necessarily mean that the team members disperse for some period, although most breaks are like that. Sometimes, a team just needs to ‘vent’ – have a conversation about something completely irrelevant that snaps them out of their non-productive mood, or share ‘war stories’ that may be off-topic from the HAZOP but are still informative. Obviously, breaks of any form need to be controlled by the facilitator – this is another aspect of the facilitator’s continuous monitoring of the team to do whatever it takes to optimize performance.

Hidden Agendas

On occasion one or more team members will try to use the HAZOP study as a tool for achieving a hidden agenda; in rare cases the facilitator may even be solicited to perform such a role. We know of cases where a facilitator and the site PSM lead essentially dictated the HAZOP results; team member help not needed! We also know of cases where HAZOP team members intentionally overstated the risks of scenarios so that the HAZOP would compel capital expenditures that the team members could not get approved through other channels. A good HAZOP facilitator will be savvy enough to perceive when these games are being played.
Too fast is not good, but slow may not be better

For the facilitator, a HAZOP study is a never-ending and constant exercise in deciding whether enough discussion of a topic has occurred. Rushing through a study provides a great opportunity to miss issues or demotivate the study team by cutting them off. On the other end of the spectrum, a facilitator who sits back and calls out deviations and expects the team to do the rest of the work is asking for a study where the team is disengaged and the study takes too long.

It needs to be accepted that the results of a HAZOP will NOT be perfect. Some issues will be missed for various reasons – the unknown, a hazard that is not completely understood, a mistaken view of the likelihood or severity of an event, temporary team member loss of focus, etc. The most experienced HAZOP facilitators are of the opinion that a given HAZOP may capture about 80% of the issues that are present, even with engaged, experienced team members. This is one of the reasons for doing a revalidation on a regular cycle such as is required under OSHA PSM, and to periodically conduct a complete redo from scratch. A properly conducted revalidation/redo study will identify issues not addressed in the original PHA: changes to team membership, experience levels, and plant history over the interval between studies will change the perspective of the PHA team and can lead to beneficial differences in the results.

A study that is being facilitated at a pace that keeps the team engaged is inevitably a study where that pace will result in the occasional issue being missed. The facilitator’s job is to optimize the HAZOP, given human and knowledge limitations.

When to stop a study in progress

Situation – You are in the middle of a study, and one of the participants has an unavoidable meeting, or there is an upset on the unit that requires the team member’s involvement. When someone must leave temporarily, do you shut down the study or not? Ultimately, this is a question of whether the study integrity will be compromised by their absence, which is in part a facilitator decision, but may also depend on regulatory requirements. Consider:

- **OSHA PSM** – A HAZOP team in the U.S. covered by the regulation requires that “the team should include at least one employee who has experience with, and knowledge of, the process being evaluated. Also, one member of the team must be knowledgeable in the specific analysis methods being used.” At a complete minimum, the team must retain a member with “knowledge of the process.”

- **Interaction** – As mentioned earlier, an important success factor for a HAZOP is to have enough people to have a meaningful exchange of ideas. If the person leaving the team results in a discussion that is no longer insightful, or challenged by other team members, the study of that equipment should be suspended.

- **Alternatives** – While the absence of a specific team member may be critical to the quality of the review of most of the unit, there may be ways of using the absence time productively with the remainder of the team. For example, it may be fine to study a relatively simple utility in the team member’s absence without compromising the study quality. Because an unexpected ‘outage’ during an on-site study is hardly uncommon, the facilitator should always have a utility or similar node backup plan to use time productively when a team member unexpectedly disappears.

The discussion above illustrates the problems that can occur if a team member is pulled away for other purposes. It is for exactly this reason that some companies have chosen to conduct their studies off-site, sometimes even without allowing team members to communicate with the outside world.

Another HAZOP show-stopper is when, during the middle of a study, you discover that there is a batch of documentation that is obviously incorrect, and the necessary corrections are either unclear or are numerous. It may be necessary to temporarily bypass that area of the study, or to suspend the study altogether. Guessing at what the corrections should be is not an option, because the main point of HAZOP is in discovering the subtleties in design that can lead to problems.
How bad is ‘bad’?

An issue that frequently confronts a HAZOP team early in the study is how to rank the severity of an event within a company’s risk matrix – do you assume “worst case,” “worst credible case,” and/or “most likely outcome?” In principle, many events can lead to a catastrophic outcome if all layers of protection fail. However, the implication of taking a “worst case” approach is that all hazards may be elevated to the same “very high consequence/very low frequency” cell in the risk matrix, at which point the risk matrix has lost its utility in providing guidance and setting priorities.

An analogous issue arises on the frequency side of the risk matrix when teams decide whether to document “double jeopardy” or even “triple jeopardy” events. It is presumptuous to exclude multiple-jeopardy events, given that there are many memorable industry accidents of that type. A more measured approach is for the facilitator to probe the team on whether: (a) the outcome is catastrophic (in which case a multiple jeopardy discussion may be justified), and (b) is this truly a multiple-jeopardy event? As an example of the latter, we recall several HAZOP discussions that went something like this:

[Facilitator] “So there is the potential for a loss of level in the tower to cause a bottoms pump seal failure that would release [nasty chemical X].”
[Board Operator] “Yes, but people are in that area probably less than 1% of the time, so the bad outcome is almost impossible.”
[Facilitator] “So how do you confirm whether there is really a level in the tower or not, if you are suspicious of the level instrument?”
[Board Operator] “I would call out on the radio and ask the field operator to check the level glass on the tower.”
[Facilitator] “Is the level glass anywhere near the pump?”
[Board Operator] “Hmmm, I see your point.”

Not all “double jeopardy” events are truly “double jeopardy,” and some “double jeopardy” events are less “double jeopardy” than others (e.g., pump trip followed by failure of a check valve that is never functionally tested). Another responsibility of the facilitator is to probe the team on “double jeopardy” events without exhausting them.
6 Documentation

Don’t Confuse Documentation Quality with Study Quality

An earlier example illustrated a situation where a fantastically well-documented HAZOP study was almost a complete failure. At the other end of the spectrum, this author reviewed the worksheets from a HAZOP study that, by almost all appearances, followed no method at all – there was no consistency in the application of deviations (guidewords), and sometimes the conclusions seemed divorced from the start of the conversation. And yet – the recommendations were surprisingly thoughtful and numerous.

So, what is “study quality”? Assuming the intent of the study is to identify hazards, the first study failed and the second study was a success; however, an auditor who only considered the ‘look’ of the worksheets would reach a different conclusion. While BakerRisk supports having coherent worksheets, “nice-looking” worksheets should not be the measure by which a HAZOP is judged. Study recommendations need to be documented well enough that someone who was not in the HAZOP can understand the reasoning behind the recommendation being made and implement a solution that solves the identified problem. Poorly documented scenarios may cause difficulties with revalidations and future studies, but poorly written recommendations will waste time and money and may leave identified risks unaddressed.

Software

There are a few common HAZOP software packages available that are likely familiar to the readers of this document. There are pros and cons to each, and each has its advocates. However, each of the most common software packages has shortcomings that irritate its users, which has led to BakerRisk developing its own software (PHA-Tool®) for recording PHAs. A good software package can save time in conducting a study and compiling results, but it is not necessary to produce a quality PHA. Regardless, the software is near the bottom of the list of key HAZOP success factors, and we adopt the software preferred by the client.

7 HAZOP Revalidation or Redo

For practical reasons discussed earlier, it is useful to periodically update a HAZOP study; in the U.S., the OSHA PSM rules require this to be done on a 5-year cycle. This update may take the form of a “revalidation” (update to the prior study record) or a “redo” (start the study from scratch without referring to the prior HAZOP record). There are many aspects to revalidation studies that have been discussed in other forums; in this document, we consider whether the prior study should be used as a template for the current study. Many prior PHA studies do not match current standards either in terms of technical merit or documentation. OSHA has clarified, and in some cases expanded, the scope and level of detail expected from PHA studies. Older studies may be suspect, especially in the areas of human factors and facility siting. Because the foundation of revalidation is the original PHA study, the quality and resolution of the original study must first be evaluated.
The figure below provides a roadmap for determining when to use the results from a prior study as the template for the update. A qualified PHA reviewer – preferably not a member of the original PHA team – should examine the original PHA’s documentation and consider interviewing an original PHA team member. If the prior study fails on any count, a complete redo from scratch may be warranted.

Deciding Whether to Use an Old Study Record for a HAZOP Revalidation
One person could be capable of determining the original study's effectiveness and determining if remedial measures are needed, assuming the person is knowledgeable in the PHA methodology used and understands the revalidation criteria. This person can either be inside or outside of the organization, provided he or she has access to the original documentation and at least one of the original PHA team members.

8 Knowledge-Based/Pre-Populated HAZOP

One approach to improving consistency among HAZOPs is to employ a “knowledge-based” approach in which standard questions are asked and, in some cases, much or most of the HAZOP log sheets are pre-populated with completed discussions. Consistency is a virtue – to a point. The benefits are obvious – reaching the same conclusions in the same situations from one HAZOP team to the next, saving study team time, etc. The 'moral hazard' in having pre-populated discussions is that it allows the team to become lazy and just agree with what is already entered on the log sheets rather than think creatively, if they are so inclined (the same is true for HAZOP revalidation studies).

It is therefore incumbent on the facilitator to observe the team's behavior and assess whether the team is actually thinking, or just using the pre-populated record as a crutch to avoid thinking. It should be remembered that no HAZOP team (or developer of the knowledge-based system) is perfect, and two units that are identical schematically may pose different hazards once layout, personnel experience, local modification, etc. from one location to the next are taken into account. It is also true that many problems identified in HAZOP studies are not related to the main process flow, but to details such as interconnected startup piping, isometrics, instrumentation type and connections, and more. Potential problems associated with these 'extraneous' issues are likely to be missed if the team falls into an “I agree”, “Sounds good”, “Should be the same here” mindset.

There are various techniques the facilitator can use to maintain the team's creative energy if they seem to be falling into a rote agreement mode of operation. One approach is to hide the log sheet temporarily and ask the team to identify the causes of a particular guideword, then allow them to view the pre-populated record. This should help ensure that no unique or previously-missed events remain undiscovered. In this mode of operation, a kind of hybrid PHA approach occurs – HAZOP-based scenario identification fused with checklist-based scenario development that ensures consistency. Whatever approach is taken to manage the process, the goals remain the same – to optimize the combination of brainstorming, thoroughness, consistency, and time consumption.

9 HAZOP of Capital Projects

Capital projects present a host of challenges beyond those in HAZOPs of existing facilities, and for that reason, facilitation of such projects is probably not for the inexperienced or faint of heart. Issues frequently include very large study teams, changes to P&IDs or process details in real time, and ulterior motives. While there are other challenges, this paper focuses on this paper focuses on those frequently identified issues.
Very Large Study Teams

Whereas a typical team studying an existing unit consists of four to seven team members, it is common for new capital project HAZOPs to have 10 to upwards of 30 participants. Let us reconsider the dynamics of a HAZOP; ultimately, it is a conversation among people on a given topic at any particular point in time. Have you ever had a ‘conversation’ with 10, or 20, or even 30 people?

Answer – No. What you have is a core conversation among 6-8 people, then a number of side conversations, each of which includes 2-3 people. In a typical capital project HAZOP, that primary team will often change as different portions of the project are discussed, with different design engineers and technicians moving to the lead of the study as their designs become focused. Obviously, this cacophony of conversations is distracting and detrimental to the overall HAZOP effort. In this case, the facilitator must lay down the ground rules for behavior at the start of the study, which include the following:

- If you want to have a side conversation – fine, but don’t make the conversation loud enough that the core team is distracted by it. Leave the room if necessary.
- If you have an idea that is important to the current HAZOP discussion, please share it with the core team; we don’t want to lose it.

Real-Time Changes to the Process Safety Information (PSI)

It is typical for project HAZOPs to take place while the design is in a considerable state of flux, so that the team is frequently making edits to the P&IDs in real time during the study. The conundrum for the facilitator is to determine whether a given edit is: (a) a change to the input (PSI) to the study, or (b) a “recommendation.”

There is no blanket answer to the question, but at minimum, if the change is handled as a change to the PSI rather than being a “recommendation,” then that change must be made clear to everyone else participating on the team. There must also be a designated master of the marked-up P&IDs who is responsible for making the drawing edits, communicating the edits to the drafting group, and ensuring that the marked-up set is documented as being the basis for the official HAZOP record.

Competing Agendas

There are frequent underlying agendas in a project HAZOP that are driven by the presence of groups of people with different vested interests. While everyone wants to protect workers, what is “required” vs. what is “desired” is in the eye of the beholder. The engineering contractor may be more or less enamored of additional protections depending on whether their contract is fixed price, or if changes resulting from the HAZOP are billed on a “cost plus” basis. Fortunately for the facilitator, these biases are generally not very well disguised. In such a case, the facilitator’s job is to mediate between the team members’ corporate motivations and steer through a fair and consistently applied standard for deciding on the degree of safeguards required. This is a case where a very experienced facilitator with unquestioned credibility and perceived absence of bias is required.
10 Remote HAZOPing

The COVID-19 pandemic has changed HAZOPing remotely from being a rare occurrence to being common almost overnight. One wonders whether this might become more common in the future, either for health reasons or to avoid the costs/time associated with traveling to a HAZOP on the other side of the country or planet. While remote HAZOPs have been more successful than we initially expected, based on our limited prior experience, there are some different preparations that contributed to their success. These included the following:

**Doing a Pre-HAZOP Test of the Meeting Software**

About a week before the start of the HAZOP, an invitation to pre-test meeting software was sent to all participants to log in exactly as they intended to during the HAZOP. In the course of the test run, software issues were resolved, and the team learned all of the software functions such as muting and sharing, etc.

**Benefit of Scribe**

We discovered that a remote HAZOP benefited a bit more than an in-person HAZOP by having a separate scribe. This was particularly true for a new design HAZOP, where time was saved by having the scribe shuffle between worksheets and drawings, rather than leaving the facilitator with that task, along with the rest of the facilitator duties.

**On-line Courtesy**

We discovered, somewhat to our surprise, that team members did not need to be reminded to mute to avoid background noise, or talk over each other, etc. One could say that the online studies suffered less interruptions than a normal study, such as people walking by the study room, entering the room to say hello, or calling someone to come out of the room for an ‘emergency’ conversation. We did have one occasion where a team member left temporarily to help her daughter with a math problem for school. We could forgive her for that during her temporary home-schooling gig!
11 Conclusions

Some HAZOP providers have given presentations that purport to save X % of team time by doing this, and Y % of time by doing that, and Z % of time by doing something else. While we support some of the individual concepts, the presentations leave one with the feeling that it might be possible to do the HAZOP in less than zero time if all measures were implemented!

While there are efficient ways of performing HAZOPs, there are no shortcuts, and efforts to make the study go too fast will inevitably lead to issues being missed – there is simply some gestational time required for a good idea to be formed in a team member's head, and a rush to completion through purported “efficiencies” greatly increases the potential for the most insightful ideas to never see the light of day. The optimal way of performing a study will depend on individual circumstances, such as the material being covered and the people participating in the study.

And finally, we'd like to remind the reader of the operational benefits and efficiencies that can be recognized when the OP in HAZOP is not neglected!

Ultimately, there is no “right” way to perform a HAZOP, but there are plenty of wrong ways to perform one.
12 References


13 Old and New References

There are several reference works that discuss how to perform HAZOPs. The following publications from IChemE also discuss optimization of approaches and can be considered complementary to the discussions above:

About BakerRisk

BakerRisk’s HAZOP facilitators have a combined 200 years’ experience performing Process Hazards Analyses, and have trained almost 1,000 client facilitators.

In addition, our facilitators have a combined 100 years of process industry plant experience prior to becoming HAZOP facilitators, and hundreds of additional years working with clients on related process risk management activities such as facility siting, insurance risk, fire protection, area classification, and more.

It is this combination of expertise and supplemental analytical tools that are available to our facilitators that make us uniquely qualified to address your HAZOP needs.
What is PHA-Tool©?
BakerRisk’s PHA-Tool© software suite is a comprehensive tool that helps facilitators easily conduct a PHA using any one of a variety of methodologies, including:

- HAZOP
- LOPA
- What-If
- HAZID
- Checklists
- Other formats, as desired

Why PHA-Tool©?
PHA-Tool© is built on extensive experience from BakerRisk experts in PHA facilitation. The tool captures many user-friendly features desired by facilitators while meeting specific corporate requirements and regulations.

Key features of PHA-Tool© include the following:

- Spreadsheet structure with drag-and-drop functionality as well as other enhanced data editing features
- Highly customizable worksheets enable studies to be performed according to unique corporate standards and guidelines
- Clean Graphical User Interface (GUI) to efficiently perform revalidations
- Ability to easily transfer from HAZID to HAZOP or What-If studies without changing files
- Easy transition of information from HAZOP/What-If study to a LOPA study
- Ability to store all the related Process Safety Information (PSI) in the same file
- Secure data management with password protection of studies to allow limited access for different personnel
- Pre-populated databases of guidewords and deviations for HAZOP, HAZID, and Structured What-If studies to jump-start studies

Learn more at www.BakerRisk.com/pha-tool