6 Feet Under: How to Dig Yourself Out of a Recommendations Graveyard

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Prepared for Presentation at
American Institute of Chemical Engineers
2026 Spring Meeting and 22nd Global Congress on Process Safety
Houston, TX
April 12-16, 2026

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Keywords: Process Safety, Process Safety Management (PSM), Hazard Analysis, HAZID, PHA, LOPA, Recommendations, Risk Gap Closure, Risk Assessment, Safety Instrumented Systems, Safety Integrity Level, Risk Reduction Factor

Abstract

Have you felt buried under six feet of safety study recommendations that must be closed? Does it feel impossible to follow Recognized and Generally Accepted Good Engineering Practices (RAGAGEPs) to convert recommendations into engineered design reality? You are not alone.

To improve Process Safety, Capital Project and Operating teams must move recommendations from the hazard analysis stage through to a capital funding request, detailed design, construction execution, commissioning, startup, and operation. These steps are all part of the familiar Capital Projects process, but for Process Safety recommendations, they are also part of the Safety Life Cycle (SLC) journey based in ISA standards. Having an internal resource or external partner who is versed in both the Capital Projects process and the SLC process can alleviate recommendation closure challenges.

This whitepaper discusses key lessons learned across multiple projects between an end-user and an SLC partner to ensure recommendations move to closure based on the intent of the risk assessment. It will also demonstrate how to go from being an owner-operator in a graveyard full of recommendations to living the high-life of PSM, Capital Projects, and SLC by identifying risk gaps and closing them in a timely, cost-effective, and safety-conscious framework.

1 Introduction

Depending on the size and complexity of a facility, there may be copious Process Hazard Analysis and Layer of Protection Analysis (PHA and LOPA) studies starting or going into revalidation each year. This is of course on top of the day-to-day ongoing operations that challenge facility team members with constant fires (figuratively, and sometimes literally) to put out. PHA and LOPA studies typically produce recommendations to ensure corporate-defined tolerable risk can be met on each of the hazard scenarios reviewed. These recommendations can range from fairly simple such as revising an existing standard operating procedure (SOP), to extremely complicated - such as requiring implementation of a gas detection system in the field.

How do employees of facilities keep up with all the PSM requirements to close out these recommendations as well as a day job? It can be overwhelming to determine which recommendations to focus on closing before others. Not to mention that different process equipment might be covered by additional dedicated standards (such as fired equipment, dust explosion hazard process equipment, and machinery safety equipment). It's understandable that most facility employees can't be experts in all these areas related to risk assessment combined. A resource, either internal or external to the facility, who has expertise and availability to focus on these recommendations and the standards requirements surrounding them is an effective way to move them towards closure.

2 Recommendations Assessment Tools and Dedicated SLC Resources

OSHA 29 CFR 1910.119(e)(5) mandates that end-users have a system to track and progress PHA team findings and recommendations to closure[1]. However, OSHA doesn't mandate an exact method by which end-users must track recommendations to closure. Some end-users have adopted right-sized options for their own tracking needs. This can mean recommendations are kept front of mind for the team members at the plant and they get progressed appropriately.

Even an effective recommendation tracking system can be undermined by excessive turnover through a facility. This turnover could result in new team members constantly onboarding to a process unit or project and getting up to speed on what recommendations must be addressed rather than managing to move those recommendations through the project lifecycle. Having an internal SLC competent resource or an external SLC partner to guide you along the journey of progressing these recommendations through to closure is one way to prevent project team turnover from taking the focus off recommendations which require action.

Smaller facility teams may not yet have established a recommendation tracking system that works well for them. In these cases, a dedicated SLC resource can help bridge that gap to ensure recommendations don't get lost as time goes on. By ensuring that the recommendations produced in PHA and LOPA studies are passed along to team members that can develop a plan for closure, the SLC internal resource or external partner can propose plans for recommendation design and implementation. This could be as simple as resizing a PSV to ensure it can handle relief for multiple hazard initiating causes, or it could be as complex as designing and implementing a new Safety Instrumented System (SIS) loop.

A dedicated internal SLC resource or external SLC partner can help ensure plant project teams have clarity on which recommendations constitute risk gap closure requirements versus just "nice to have" improvements as well. This can be accomplished by focusing on the high-severity risk scenarios and the recommendations associated with them. Tools can take the input of a plant PHA and LOPA study and produce an output product that plots each recommendation against all the factors discussed above. This activity to map an output of the recommendations takes the guesswork out of looking through the different sections of your PHA and LOPA study file or report to understand how much risk reduction each singular recommendation can achieve.

Progressing recommendations to capital funding approval typically requires justification of mitigated risk and benefit to the facility and / or the surrounding community to be granted funding. This justification must account for all required SLC activities to be included in the capital project budget. An internal resource or external SLC partner can work to ensure the project team is knowledgeable of the lifecycle tasks that ISA-61511[2] mandates. Assessing recommendations against several factors can shed light on which recommendations produce the most benefit to the end-user. These factors include but are not limited to: total mitigated risk provided by implementing a recommendation, number of risk scenarios impacted by each recommendation, and the estimated cost required to implement each recommendation. Knowing these key factors, there is a much clearer picture of how much benefit a single recommendation can provide for a facility.

These pieces of information will allow teams to discern which recommendations should be prioritized to improve safety of personnel and the surrounding community. For example, a recommended alarm protection layer that can reduce risk on five hazard scenarios for a given cost of implementation may provide more value to a site than a recommended automatic explosion suppression system protection layer which only reduces risk on two scenarios for a similar cost of implementation. This may seem obvious when picked out as one example of direct comparison. However, when your risk assessments could result in hundreds of recommendations, having a tool to make these comparisons through automated assessment of various factors described above can drastically simplify making decisions around which recommendations to prioritize and fund.

3 Case Study 1

Case Study #1 involves a pyrolysis process unit which experienced several incidents during its operating life. The end-user was looking for opportunities to improve the process. It is common for facility teams to develop an unconscious bias toward existing designs and operating practices. Plant teams routinely conduct PHA and LOPA studies ensuring risk tolerance guidelines are met. However, facility team members may not think outside the box if they’re so accustomed to the process they have now and a certain level of risk tolerance. An internal SLC resource independent of the team participating in the PHA and LOPA or an external SLC partner can help provide an outside perspective that makes it clear what inherently safer design choices are attainable and how to get the most risk reduction within the bounds of the existing process.

The end-user worked with an external SLC partner to conduct a preliminary or pre-Front End Engineering Design (FEED) PHA around the pyrolysis process. The focus of the preliminary PHA study was to generate recommendations which ensured the evaluated system was meeting company criteria and considered inherently safer design options for the pyrolysis system. This enabled the project team to make process modifications to eliminate or reduce hazards rather than requiring independent protection layers (IPLs) to mitigate higher risk scenarios later. Starting with a preliminary PHA and following into the Final PHA established continuity in the study itself resulted in a list of recommendations that aren’t nebulous. The final process design PHA then contained a more clearly defined set of recommendations for the facility team to act upon.

The pre-FEED study resulted in twenty-three (23) recommendations mainly around ensuring detailed design changes considered to be high hazard risks and opportunities for improvement. Some recommendations discussed considering potential hazard scenarios with safety consequences such that they could be protected against in the design of the system ahead of the final PHA. Other recommendations were covered considering possible hazard scenarios to determine if they were still credible given the preliminary design. This opportunity to investigate the potential scenarios ahead of a final PHA, outside the constraints of a formal PHA session, improved confidence in the team's conclusions and risk rankings.

The preliminary study recommendations were then considered to improve the design of the pyrolysis process. A Final Design PHA was conducted resulting in only ten (10) HAZOP recommendations and two (2) LOPA recommendations. The consideration for inherently safer design is one way to minimize the number of recommendations resulting from your official PHA study on the process which will be implemented in the field.

4 Case Study 2

Case study #2 covers a rotating kiln fired equipment process. The end-user's risk tolerance criteria resulted in process safety gap closure recommendations to implement Safety Instrumented Functions (SIFs). There was a secondary complication of having to be compliant with National Fire Protection Association (NFPA) code for the fired equipment in question. When there are multiple spheres of requirements to assess it's no wonder plant team members may feel like they're unable to dig themselves out of a hole. A dedicated SLC resource that has expertise in all these spheres can take on the additional burden of ensuring requirements from all angles are met to move forward safely and in compliance. It's not always clear which standard or multiple standards may apply to a project. Should the kiln burner management system (BMS) be a code compliance only BMS design? Should it be a safety system plus code compliant BMS, also known as a safety instrumented BMS (SI-BMS) design? These nuances can be difficult to decipher without a subject matter expert (SME) providing the necessary background information on the standards requirements.

One way to ensure NFPA compliance is to conduct a code gap assessment on the fired equipment process prior to a PHA and LOPA study. A SME in BMSs and NFPA codes was able to visit the facility and walk down all existing kiln equipment and the existing BMS to determine code compliance gaps that must be addressed by any subsequent study recommendations. This early involvement of an NFPA SME provides NFPA specific recommendations as an input to the PHA and LOPA study which the study facilitator can take into consideration during scenario assessments. This ensures that no NFPA requirements are missed in the final safety BMS design as well as that PHA and LOPA study recommendations don't double up on NFPA requirements. One recommendation may close a safety gap in the PHA and LOPA study as well as comply with an NFPA requirement - accomplishing multiple objectives at once.

Another way to assess NFPA compliance through PHA and LOPA recommendations without a gap assessment is to have the BMS or NFPA SME participate in the study to provide input on NFPA requirements. Once all risk gaps and NFPA requirements are addressed in the final PHA and LOPA study recommendations, both the end-user and the facilitator of the study can feel confident that the future designed BMS will accomplish all PSM and industry code compliance goals.

In this project, there were enough NFPA code gaps around the fuel supply skid design that it was necessary to completely re-engineer the entire fuel skid. The SLC partner's BMS SME had the necessary expertise to assist the end-user by working with a fuel skid vendor to design, test, and commission a new code compliant fuel skid.

Additionally, one of the LOPA recommendations to install a mechanical stop on a fuel supply valve wasn't implemented in the field by the facility team. It was discovered by the SLC partner when investigating another IPL's capable risk reduction on the same scenario. How did the implementation of this recommendation get overlooked? Hindsight reveals the end-user did not perform an IPL Verification effort to confirm that *all* IPLs credited in the LOPA were implemented as described, rather than just verifying the SIF recommendations were implemented.

It is likely more obvious to most end-users that project teams must validate and verify installation of SIF IPLs as this is a key step in the ISA-61511 safety lifecycle. It may not be as obvious that project teams must ensure all other non-SIF IPLs are verified for installation and risk reduction as well. When any of the credited IPLs on a LOPA scenario are not implemented as assumed in the study, there is unmitigated risk burden existing for that hazard scenario. That risk burden must then be mitigated by either another credited IPL taking on more of the risk burden for the scenario, or by an entirely new IPL being credited to mitigate the remaining burden, assuming all other scenario factors remain unchanged.

5 Case Study 3

Case study #3 involves an ethylene oxide (EO) and propylene oxide (PO) plant. As this was the first ever SIS to be installed at the site, the end-user chose to partner with an external SLC consultant through the entirety of the project. The initial PHA and LOPA studies were conducted by the SLC partner and there were IPLs identified which required safety integrity level (SIL) 1, 2, and 3 functions to close the various scenario risk gaps.

A key constraint was brought up by the end-user after the studies were completed. The end-user required minimal additions of new process leak points introduced by EO & PO process instruments per state regulatory requirements. The SLC partner conducted an IPL Select effort after the initial PHA and LOPA to reassess SIFs which assumed new devices would be installed in the process piping. Some cases were resolved by deciding that a Basic Process Control System (BPCS) device would be replaced with a SIL certified device and further engineering design would be done in the project to ensure independent signals were sent from the device to the SIS and the BPCS for indication only. This allowed the plant operator to continue toward mitigating risks by installing SIFs while also staying in compliance with regulatory requirements.

This plant team runs their facility extremely lean, therefore they had little time to dedicate to full scale engineering of a new SIS to tackle their study recommendations. The SLC partner continued to collaborate with the end-user team through the safety project lifecycle so that the recommendations could be progressed after years of sitting on the shelf. The SLC partner supported the end-user in developing an FEL2: Concept Stage cost estimate for the SIS to secure capital funding from their corporate projects group. Once capital funding was granted for the project, the SLC partner took on conceptual design tasks to continue progressing the SIS project at the request of the end-user. The SLC partner performed SIL Verification calculations, wrote Safety Requirement Specifications (SRSs) and proof test procedures (PTP) for each SIF. They also conducted Functional Safety Assessments (FSAs) per ISA-61511 requirements.

This EO/PO SIS was the first safety system the end-user installed on site. The SLC partner gave guidance on how the SIS must be designed to be in compliance as an independent layer of protection from the BPCS. This included hardware design for the SIS panel and segregation from the BPCS. It also included best practices for how to configure safety logic in a safety programmable logic controller (PLC). The end-user participated in a factory acceptance test (FAT) led by the SLC partner to validate the SIS logic was programmed and performed as per the SRS design.

During the detailed design phase of the project, the end-user requested that the SLC partner support them by specifying safety instruments for sensors and final elements in their SIFs. This end-user plant didn't have any instrumentation engineers on staff capable of completing this task. The SLC partner was able to provide the necessary expertise to specify third-party SIL certified instrumentation for use in the project. Once installed and commissioned, the end-user now has an SIS which addresses their open recommendations and closes their high severity risk gaps in their PHA and LOPA.

6 Conclusion

While it can be overwhelming to tackle large numbers of PHA and LOPA recommendations as an end-user or plant operator, there are many ways to find or achieve resolutions. By assessing specific details of the recommendations such as risk reduction achieved, number of risk scenarios mitigated by the recommendation, and relative cost of an implemented solution, teams can assign prioritization to a large group of recommendations. An internal SLC resource or external SLC partner can help provide guidance for how to appropriately comply when the resolution for closing recommendations spans across multiple applicable codes and standards. SLC resources can also remove the burden from site operations teams with minimal bandwidth to execute capital projects and assist in executing safety lifecycle tasks to move towards resolution on these recommendations. When we use all these tools in our toolbelt, we can dig ourselves out of the recommendations grave and move back to safer, resilient operations.

7 References

[1] OSHA 29 CFR 1910.119, Process Safety Management of Highly Hazardous Chemicals. OSHA; 2024; 333 p.

[2] IEC 61511-1, Functional Safety: Safety Instrumented Systems for the Process Industry Sector - Part 1: Framework, Definitions, System, Hardware and Application Programming Requirements. IEC; 2016.