Critical P&ID Reviews Using HAZOP/LOPA Methodology – Overkill or Underrated?

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Abstract

Prior to moving from define phase to execution phase on a given project, the typical project protocol is to perform a critical process and instrumentation drawing (P&ID) review as a transition from "issued for information or preliminary design" to "issued for design or HAZOP".

The objectives of a critical P&ID review are to (1) identify commercially-positive design changes early in the project lifecycle to reduce downstream implementation costs, (2) identify operational concerns to ensure optimal resolution and long-term operational effectiveness, and (3) identify safety vulnerabilities for early application of inherently safer design (ISD) principles where possible and early identification of safety integrity levels (SIL) for required safety-instrumented systems (SIS).

Companies perform critical P&ID reviews using various evaluation methods, including P&ID symbology/element checklists, process hazard analysis (e.g. Checklist, HAZID, and HAZOP), and "cold-eyes" review. Each of these approaches provides structure to a critical P&ID review; however, each also provides opportunities for commercial, operability, and safety vulnerabilities to remain in the design when applied independently.

The authors posit use of a hybrid HAZOP/LOPA process hazard analysis methodology to conduct critical P&ID reviews (1) results in a more rigorous evaluation and (2) reduces the likelihood for commercial, operability, and safety vulnerabilities to persist into the design/execution phase of projects. In this paper, the authors present the advantages and disadvantages of using a hybrid HAZOP/LOPA approach for critical P&ID reviews. They also provide recommendations to enhance the effectiveness of the HAZOP/LOPA methodology when applied to critical P&ID reviews. Specifically, the authors provide examples of commercial benefits realized, enhanced operational insight, ISD successes, and application pitfalls when applying a hybrid HAZOP/LOPA PHA methodology to a critical P&ID review.

The target audience for this paper includes project managers, project engineers, EH&S managers, PSM coordinators, and operators; however, anyone involved with small or large capital projects may also benefit from this paper's content.

1. Background and Purpose

A Process and Instrumentation Drawing (P&ID) is arguably the most important document for any given process across the oil, gas, and chemical industries. P&IDs provide piping, instrumentation, process flow, process control, process chemistry, equipment, relief/effluent system, and safety system design details. Critical operational and maintenance decisions are made every day at offshore platforms, gas terminals, refineries, and chemical plants with the aid of P&IDs. Before P&IDs are used for operational and maintenance purposes, they must be developed as effective representations of the design proposed for construction and operation.

P&IDs are typically developed during the Define phase of the project life cycle (see Figure 1.1 below). More specifically, P&IDs are usually one of the primary deliverables of the Front-End Engineering and Design (FEED) stage of a capital project. The activity used by a project team to issue a P&ID for design is called a critical P&ID review. The objectives of a critical P&ID review are to (1) identify commercially-positive design changes early in the process life cycle to reduce downstream implementation costs, (2) identify operational concerns to ensure optimal resolution and long-term operational effectiveness, and (3) identify safety vulnerabilities for early application of inherently safer design (ISD) and risk management principles, which may afford early identification of safety integrity levels (SIL) for required safety-instrumented systems (SIS).

Figure 1: Typical Project Life Cycle

Companies perform critical P&ID reviews using various traditional evaluation methods; including P&ID symbology/element checklists, process hazard analysis (PHA), and “cold-eyes” review. Each of these traditional approaches provides structure to a critical P&ID review; however, each also provides opportunities for commercial, operability, and safety vulnerabilities to remain in the design when applied independently.

When PHAs are used to facilitate a critical P&ID review, the traditional methods employed are Checklist, Hazard Identification study (HAZID), or Hazard and Operability study (HAZOP). Recently, the authors facilitated critical P&ID reviews using an emerging hybrid PHA methodology. The hybrid PHA approach combines the HAZOP methodology with the Layer of Protection Analysis (LOPA).

This paper provides a comparison between traditional approaches to conducting critical P&ID reviews and the emerging hybrid HAZOP/LOPA PHA methodology. The authors provide information from recently-facilitated critical P&ID reviews to help illustrate the (1) differences between traditional approaches and the hybrid HAZOP/LOPA PHA methodology and (2) advantages and disadvantages of various approaches. Specific to employing a hybrid HAZOP/LOPA PHA methodology to conduct critical P&ID reviews, the authors provide examples of realized commercial benefits, enhanced operational insight, ISD successes, and application pitfalls. The authors argue the use of a hybrid HAZOP/LOPA PHA results in a more rigorous critical P&ID review; and reduces the likelihood for commercial, operability, and safety vulnerabilities to persist into the Execute phase of capital projects. The authors also provide recommendations to enhance the effectiveness of the hybrid HAZOP/LOPA PHA methodology when applied to critical P&ID reviews.

2. Traditional Approaches to Critical P&ID Reviews

2.1 Traditional Non-PHA Approaches

2.1.1 Symbology/Element Checklist

Project teams often use symbology/element checklists to conduct critical P&ID reviews. Most checklists detail the P&ID symbology and elements required by a governing standard or guidance document. These standards and guidance documents may be controlled internal corporate documents. Some companies simply adopt standards and guidance documents published by professional organizations, which have achieved Recognized and Generally Accepted Good Engineering Practice (RAGAGEP) status by the company's industry (oil, gas, refining, or chemical).

Checklists vary by company and oftentimes by business units within a company. Some checklists are simple lists of required elements, such as valve types, line numbers, continuation arrows, title blocks, piping specifications, equipment blocks, instrumentation designations, and control and alarm information. Other checklists include questions for the reviewer to answer and verify, such as the following:

1. Are all valve types and sizes accurately depicted?
2. Are effective mechanisms for isolation, venting, bleeding, and de-energization readily available and accessible?
3. Are the governing design cases for pressure relief devices indicated on the drawing?
4. Are safe limits for critical process parameters indicated on the drawings?

For example, the checklist used by project teams in the upstream business unit may be different than the checklist used by the refining or chemical business units. Furthermore, the checklist used by North American operations within the upstream business unit of Company X may be different than the checklist used by European and African operations within the same upstream business unit of Company X.

Checklists may be applied by a single individual or by a team with a representative from each discipline (e.g. process, mechanical, electrical, instrumentation, controls, flow assurance, maintenance, and operations). As the project approaches the end of the Define phase or the end of the FEED stage, each person responsible for reviewing the checklist or a portion of the checklist against the P&IDs can do so independent of other persons' schedules. All changes identified by application of the checklists are made to the P&IDs before issuing them for design.

2.1.2 Cold-Eyes Review

Another traditional non-PHA approach is the cold-eyes review. This approach may incorporate a checklist (as described above) to guide the reviewer, but the primary goal of a cold-eyes review is to obtain an objective perspective and evaluation from a person or persons independent of the project. Time constraints are usually imposed on the reviewers to ensure closure of the activity and provide adequate time to update P&IDs to reflect changes identified by the cold-eyes review.

2.1.3 3-D Model Review

With the advent of effective 3-D modeling of processing units, most capital projects require a "virtual" walkthrough during the FEED stage. 3-D models show design elements unavailable on a 2-D drawing. For example, the 3-D model identifies:

1. Proposed piping routes and lengths;
2. Potential interferences between piping, equipment, and instrumentation elements;
3. Accuracy of fitting connections; and
4. Accessibility and availability of critical field elements, such as safety showers/eyewash stations, self-contained breathing apparati, and fire monitors.

Some project teams have combined the required 3-D model review with the checklist-driven critical P&ID review to ensure timely delivery of P&IDs out of the FEED stage of a capital project.

2.2 Traditional PHA Approaches

2.2.1 Checklist

The Checklist PHA methodology is similar to the symbology/element checklist approach as it also uses a prescribed element set to evaluate the P&IDs against. Checklist PHAs are normally performed by a multi-disciplined team towards the end of the FEED stage of a capital project. The team as a rule consists of personnel knowledgeable on the process from mechanical, chemical, electrical, instrumentation/controls, and operational perspectives.

The primary difference between the two checklist approaches is the prescribed element set. Checklist PHAs use prescribed element sets focused on process safety and risk management. A Checklist PHA is more focused on identifying, eliminating, or mitigating process hazards. Checklist PHAs usually employ questions similar to the following:

1. Are effective mechanisms for isolation, venting, bleeding, and de-energization readily available and accessible?
2. Are the governing design cases for pressure relief devices indicated on the drawing?
3. Are safe limits for critical process parameters indicated on the drawings?

In contrast, symbology/element checklists typically prescribe P&ID requirements with respect to symbology, drawings elements, and installation/design conventions (which may include process safety and risk management considerations).

2.2.2 HAZID

The HAZID PHA methodology is a structured brainstorming exercise designed to identify hazard scenarios early in the process life cycle. A HAZID can use guidewords and parameters along with nodes (system sections or procedural tasks) to focus the team's discussion and scrutiny. A HAZID does not incorporate risk assessment as it is usually performed before the completion of technical risk characterization calculations and analyses. Most actions from HAZID reviews involve further risk assessment to better understand identified hazard scenarios. Similar to other PHA efforts, HAZIDs are performed by a multi-disciplined team.

2.2.3 HAZOP

The HAZOP PHA methodology is another structured brainstorming exercise performed by a multi-disciplined team. Unlike the HAZID PHA methodology, a HAZOP uses risk assessments to detail out the cause and consequence of identified hazard scenarios. Risk acceptance criteria is applied to determine Likelihood and Consequence rankings within a given risk matrix. Safeguards are not accounted for in assigning the Consequence value; however, safeguards are taken into account when determining the Likelihood value. Where the qualitative risk-ranking recognizes a process safety or risk management vulnerability, the team crafts a recommendation to resolve the gaps.

Due to the information required to perform a HAZOP, it is often deemed impractical to employ this PHA methodology for critical P&ID reviews. It is uncommon for all of the risk assessment information required to fully characterize the hazard scenario in a HAZOP to be complete in time to execute the critical P&ID review during Define or FEED.

3. Emerging HAZOP/LOPA PHA Approach to Critical P&ID Reviews

The authors recently performed critical P&ID reviews using a hybrid HAZOP/LOPA PHA methodology. From conversations with (1) other consultants serving the oil, gas, and chemical industries and (2) colleagues employed by a company within the oil, gas, or chemical industry, the authors have determined a hybrid HAZOP/LOPA PHA approach to critical P&ID reviews is not common. Nonetheless, the use of the hybrid PHA approach is emerging as a comparable, perhaps enhanced, alternative to the already-mentioned traditional approaches to critical P&ID reviews.

By adding the LOPA methodology, the hybrid PHA approach also evaluates proposed Independent Protection Layers (IPLs) for adequacy to eliminate and/or mitigate the identified hazard scenario. HAZOPs and LOPAs are typically not used for design purposes; however, they can be valuable tools to assess the adequacy of proposed IPLs by quantifying the required risk reduction factors (RRFs) of proposed safety-instrumented functions (SIFs).

3.1 Example 1 of Critical P&ID Review Facilitated By HAZOP/LOPA PHA

One of the critical P&ID reviews facilitated by the authors using the hybrid HAZOP/LOPA PHA methodology involved an upstream subsea asset. There were approximately 22 unique nodes and the effort was completed in approximately seven days. The average number of persons in attendance each day was approximately 12. The approximate cost of the effort to the project was estimated by the authors at $150,000, which incorporates time to prepare, attend, and document the critical P&ID review.

Approximately 60 actions were generated using the HAZOP/LOPA PHA methodology. Several significant design changes were identified as being necessary to eliminate and/or safeguard against high-risk hazard scenarios. One action specified adding a completely redundant hydraulic line with separate pumps. The cost to implement this one design change was minimal as the critical P&ID review was performed towards the end of Define. It is unlikely traditional approaches would have uncovered the required change. The cost to implement the design change had it been uncovered during the formal HAZOP/LOPA PHA of the Execute phase would have eclipsed the total cost of the critical P&ID review estimated at $150,000.

3.2 Example 2 of Critical P&ID Review Facilitated By HAZOP/LOPA PHA

A second critical P&ID review facilitated by the authors using the hybrid HAZOP/LOPA PHA methodology involved another upstream asset. The scope included both the subsea and topsides designs. There were approximately 65 unique nodes and the effort was completed in approximately two months. The average number of persons in attendance each day was approximately 15. The approximate cost of the effort to the project was estimated by the authors at $850,000, which incorporates time to prepare, attend, and document the critical P&ID review.

Approximately 400 actions were generated using the HAZOP/LOPA PHA methodology. Once again, several significant design changes were identified as being necessary to eliminate and/or safeguard against high-risk hazard scenarios. Significant ISD opportunities were identified to safeguard against gas blow-by scenarios, which require pipe design modifications. Additional ISD opportunities were identified regarding chemical injection pressures and vendor skid specification requirements. Once again, the cost to implement these design changes was minimal as the critical P&ID review was performed towards the end of Define. It is unlikely traditional approaches would have uncovered the required ISD changes as the effort required complex, in-depth analysis of multi-system interactions. As before, the cost to implement the design changes had they been uncovered during the formal HAZOP/LOPA PHA of the Execute phase would have eclipsed the total cost of the critical P&ID review.

4. Comparison of Traditional and Emerging HAZOP/LOPA Approaches

The authors present the observed intrinsic advantages and disadvantages of the various approaches in the following tables. The approach comparisons have been grouped by the following three criteria:

- Implementation – factors evaluated include speed to implementation, ease of implementation, and information required for implementation;
- Quality – factors evaluated include expertise demanded by approach, diversity of personnel demanded by approach, breadth and depth of scope demanded by approach, and potential for early identification of inherently safer design opportunities;
- Financial Impact – factors evaluated include potential for early identification of significant cost-impacting (either positive or negative) changes and overall cost to complete the critical P&ID review.

Table 1. Implementation Advantages and Disadvantages

Approach	Advantages	Disadvantages
Symbology/Element Checklist	• Ability to implement quickly as implementation is not dependent on coordinating multiple schedules • Prescriptive nature affords execution by lesser experienced personnel	• Requires controlled checklist to already be developed against all applicable standards and guidance documents (i.e. all applicable RAGAGEP)
Cold-Eyes Review	• Utilizing resource pool independent of project; hence, project resources can continue to work on project deliverables	• Requires controlled checklist/procedure to already be developed against all applicable standards and guidance documents (i.e. all applicable RAGAGEP) • Time to complete is contingent on availability of resources not assigned to project
3-D Model Review	• 3-D perspective can accelerate visualization and understanding of piping, equipment, and instrumentation design and layout	• Requires group meeting rather than individuals working at their workspace with flexibility to work around other commitments • Review pace dependent on efficiency of virtual walkthrough
Checklist PHA	• Faster than other PHA methodologies • Prescriptive nature affords execution by lesser experienced personnel	• Requires group meeting rather than individuals working at their workspace with flexibility to work around other commitments • Requires controlled checklist to already be developed against all applicable standards and guidance documents (i.e. all applicable RAGAGEP)
HAZID PHA	• Faster than other HAZOP PHA methodologies	• Requires group meeting rather than individuals working at their workspace with flexibility to work around other commitments • Brainstorming nature not as prescriptive or efficient as checklist-driven approaches

HAZOP PHA	• Accelerates focus and delivery of critical process safety information, which is sometimes not generated until Execute	• Requires group meeting rather than individuals working at their workspace with flexibility to work around other commitments • Brainstorming nature not as prescriptive or efficient as checklist-driven approaches • Effective implementation dependent on availability and technical accuracy of process safety information, including thorough risk assessments
HAZOP/LOPA PHA	• Accelerates focus and delivery of critical process safety information and SIL determination for critical IPLs, which is sometimes not generated until Execute	• Requires group meeting rather than individuals working at their workspace with flexibility to work around other commitments • Brainstorming nature not as prescriptive or efficient as checklist-driven approaches making it the slowest of PHA methodologies

Table 2. Quality Advantages and Disadvantages

Approach	**Advantages**	**Disadvantages**
Symbology/Element Checklist	• Checklists can be tailored to accommodate varying degree of depth and breadth • Prescriptive nature drives consistent quality	• Not specifically focused on hazard identification and risk assessment • Prescriptive review only as comprehensive as standards and guidance documents (i.e. not a brainstorming exercise) • Prescriptive nature affords lesser experienced personnel to perform review • Does not provide insight to SIL requirements of critical IPLs • Requires further risk analysis to fully define risk envelope and subsequent safeguarding/mitigation measures
Cold-Eyes Review	• More people involved; hence, more eyes reviewing design • Objective evaluation from person(s) independent of project and design • Potentially greater depth of expertise reviewing the design	• Generally not focused on hazard identification and risk assessment • Personnel not familiar with project history and design considerations • Does not provide insight to SIL requirements of critical IPLs • Requires further risk analysis to fully define risk envelope and subsequent safeguarding/mitigation measures

3-D Model Review	• More in-depth with respect to mechanical, structural, ergonomic, and layout aspects of process design • More people involved; hence, more eyes reviewing design • Greater depth of expertise and team diversity affords more in-depth review of process design	• Generally not focused on hazard identification and risk assessment • Process tends to narrow focus of review on specific elements rather than systems and interactions between equipment • Does not provide insight to SIL requirements of critical IPLs • Requires further risk analysis to fully define risk envelope and subsequent safeguarding/mitigation measures
Checklist PHA	• Checklists can be tailored to accommodate varying degree of depth and breadth • Prescriptive nature drives consistent quality • Focused on hazard identification • More people involved; hence, more eyes reviewing design • Greater depth of expertise and team diversity affords more in-depth review of process design	• Generally not focused on risk assessment • Prescriptive review only as comprehensive as standards and guidance documents (i.e. not a brainstorming exercise) • Does not provide insight to SIL requirements of critical IPLs • Requires further risk analysis to fully define risk envelope and subsequent safeguarding/mitigation measures
HAZID PHA	• Structured brainstorming focuses on identification of hazard scenario for further risk analysis • Brainstorming nature affords more creative and in-depth review of process design • More people involved; hence, more eyes reviewing design • Greater depth of expertise and team diversity affords more in-depth review of process design	• Not as in-depth a review as HAZOP PHA approach • Requires further risk analysis to fully define risk envelope and subsequent safeguarding/mitigation measures • Does not provide insight to SIL requirements of critical IPLs

HAZOP PHA	• Structured brainstorming focuses on identification of hazard scenario along with comprehensive characterization of hazard scenarios via input from completed risk assessments • Brainstorming nature affords more creative and in-depth review of process design • HAZOP methodology affords systems-based review along with facility siting and human factors checklist and 3-D model reviews • More people involved; hence, more eyes reviewing design • Greater depth of expertise and team diversity affords more in-depth review of process design	• Does not provide insight to SIL requirements of critical IPLs • Quality of analysis is dependent on quality of information inputs
HAZOP/LOPA PHA	• Structured brainstorming focuses on identification of hazard scenario along with comprehensive characterization of hazard scenarios via input from completed risk assessments • Brainstorming nature affords more creative and in-depth review of process design • HAZOP methodology affords systems-based review along with facility siting and human factors checklist and 3-D model reviews • More people involved; hence, more eyes reviewing design • HAZOP/LOPA methodologies look at facility siting, human factors, and SILs of IPLs • Greater depth of expertise and team diversity affords more in-depth review of process design	• Quality of analysis is dependent on quality of information inputs

Table 3. Financial Impact Advantages and Disadvantages

Approach	**Advantages**	**Disadvantages**
Symbology/Element Checklist	• Not as labor and time intensive as other approaches making it most cost-effective approach	• Does not afford early identification of process safety and risk vulnerabilities
Cold-Eyes Review	• Not as labor and time intensive as PHA approaches making it more cost-effective	• Does not afford early identification of process safety and risk vulnerabilities

3-D Model Review	• Affords early identification of layout modifications, which can be costly if not identified until later project stage	• Labor and time intensive making it less cost-effective than non-PHA checklist and cold eyes review
Checklist PHA	• Affords early identification of non-compliant process safety elements of the design, which are usually not identified until final HAZOP/LOPA of P&IDs at the end of Execute phase	• Labor and time intensive making it less cost-effective than non-PHA approaches, but more cost-effective than other PHA approaches
HAZID PHA	• Affords early identification of hazard scenarios, which are usually not identified until final HAZOP/LOPA of P&IDs at the end of Execute phase	• Labor and time intensive making it less cost-effective than non-PHA and checklist PHA approaches, but more cost-effective than HAZOP and hybrid HAZOP/LOPA PHA approaches
HAZOP PHA	• Affords early identification of process safety and risk vulnerabilities as well as safeguarding requirements, which are usually not identified until final HAZOP/LOPA of P&IDs at the end of Execute phase	• Labor and time intensive making it less cost-effective than non-PHA and other PHA approaches, but more cost-effective than hybrid HAZOP/LOPA PHA approach
HAZOP/LOPA PHA	• Provides greatest opportunity to (1) identify commercially-advantageous design changes early in the project lifecycle to reduce downstream implementation costs, (2) identify operational concerns to ensure optimal resolution and long-term operational effectiveness, and (3) identify safety vulnerabilities for early application of inherently safer design (ISD) principles where possible and early identification of safety integrity levels (SIL) for required safety-instrumented systems (SIS).	• Labor and time intensive making it most costly approach

5. Recommendations for More Effective Critical P&ID Reviews

As presented, each approach has its advantages and disadvantages. Based on experience and observation, the authors recommend using multiple approaches to conduct critical P&ID reviews on all projects, not just large capital projects.

Prior to reviewing the P&IDs using a hybrid HAZOP/LOPA PHA methodology, the project team should subject the P&IDs to a checklist-driven review to ensure compliance with corporate and regulatory standards and guidance documents. This review should verify whether the proposed design meets the requirements of specific mechanical, metallurgical, structural, electrical, instrumentation, process control, and process safety standards and guidance documents. Actions to ensure compliance with all applicable standards and guidance documents should be resolved prior to the next phase of the critical P&ID review – the HAZOP/LOPA PHA.

Once the checklist review has been performed and all compliance and risk assessment actions have been resolved, then a HAZOP/LOPA PHA should be performed. A 3-D model review should be incorporated into the Facility Siting and Human Factors nodes required by the HAZOP methodology. Special care should be taken to ensure evaluation of the 3-D model against the electrical area classification drawings.

The phased approach described in this section requires special information considerations. More specifically, the proposed fusion of critical P&ID review approaches requires greater technical accuracy and scope of information. Significant ***preliminary*** process design, operational insight, and risk analyses are required to properly employ the HAZOP and LOPA methodologies. The following ***preliminary*** documents and models are a sampling of the envisioned inputs to the proposed phased approach to critical P&ID reviews:

1. Material safety data sheets;
2. Fire and explosion models;
3. Dispersion models of potential release scenarios;
4. Chemical/Material reactivity matrices;
5. Mass and energy balances;
6. Safe upper and lower limits for critical process parameters;
7. Operating philosophies;
8. Materials of construction;
9. Electrical area classification drawings;
10. Relief and effluent system design bases;
11. Ventilation system design basis;
12. List of design codes and standards applicable to the process;
13. Cause and effect matrices for safety controls, alarms, and interlocks (SCAI);
14. Equipment specifications;
15. Sparing philosophies (primarily used in upstream subsea asset development);
16. Electrical one-line diagrams;
17. Plot plans;
18. Safety shower/eyewash location drawings; and
19. Vendor-provided skid package information.

The authors acknowledge and appreciate the resources and time required to produce the information required to facilitate the proposed phased approach. The authors recognize the challenge associated with balancing (1) business excellence against (2) operational risk management; hence, the authors propose the allowance of practical flexibility when defining the scope and level of detail for all inputs to the proposed phased critical P&ID review. The design is not supposed to be final coming out of the Define or FEED stage of a project; however, ***preliminary*** calculations and models can provide valuable insight at this phase of the project.

6. Conclusion

Hazard identification and risk analysis (HIRA) are not activities exclusive to formal tasks. Such as vapor cloud explosion modeling, facility siting studies, human factors assessments, HAZOPs, and LOPAs. HIRA must be inherent to each activity and deliverable of each phase of a project's life cycle. Although more costly and more difficult to implement on the front-end, multiple approaches should be utilized to conduct critical P&ID reviews on all projects – not just large capital projects. Using multiple approaches provides greater structure, detail, and certainty to a critical P&ID review; thereby affording identification of more commercial, operability, and safety opportunities earlier in the project life cycle. Using multiple approaches amplifies the ISD opportunities afforded by simple, surface checklist-driven reviews and complex, in-depth PHA-driven reviews.

More specifically, the authors recommend (1) subjecting the P&IDs to a checklist-driven review to ensure compliance with corporate and regulatory standards and guidance documents; (2) reviewing the P&IDs using a hybrid HAZOP/LOPA PHA methodology; (3) incorporating a 3-D model review into the Facility Siting and Human Factors nodes required by the HAZOP methodology. By adding the LOPA methodology, the hybrid PHA approach also evaluates proposed Independent Protection Layers (IPLs) for adequacy to eliminate and/or mitigate identified hazard scenarios. The authors recognize HAZOPs and LOPAs are typically not used for design purposes; however, these methodologies can be valuable tools to assess the adequacy of proposed IPLs by quantifying the required risk reduction factors (RRFs) of proposed safety-instrumented functions (SIFs).

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