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RESEARCH ARTICLE

PROCESS HAZARD SCENARIO COMPLETENESS AS A KEY RESULT INDICATOR FOR HAZOP STUDY QUALITY – THREE PHASE SEPARATOR CASE

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ABSTRACT

Scenario completeness refers to the extent to which all credible process hazard scenarios have been identified and documented. Ensuring the completeness of process hazard scenarios is foundational to the quality and credibility of a Hazard and Operability (HAZOP) study. As the cornerstone of qualitative risk assessment in the process industry, HAZOP's effectiveness depends on the systematic identification of all credible deviations and their associated hazardous consequences. This paper proposes hazard scenario completeness as a key result indicator for evaluating the quality of HAZOP studies, based on the recognition that omitted scenarios can significantly underestimate risk and compromise safeguard adequacy. A structured framework is presented for assessing scenario completeness, including benchmarking against established scenario taxonomies – such as API RP 14C – and analysing coverage through cause-consequence pairs. The approach emphasizes the role of historical data, expert knowledge, and consistency in the identification of representative and credible hazard scenarios across different process nodes. The findings suggest that incorporating scenario completeness as a quantifiable metric can enhance the reliability, traceability, and defensibility of HAZOP outputs. This approach offers a practical basis for both internal quality assurance and external regulatory validation of process hazard analyses.

Keywords: HAZOP; Key Result Indicator; Quality; Scenario; Completeness.

1.0 INTRODUCTION

Process hazard scenarios represent events that occur unexpectedly and unintentionally, typically attributed to equipment failure, human error, and/or external events (Baybutt, 2014). The lack of completeness in scenario descriptions within HAZOP reports can significantly impact the adequacy and selection of safeguards implemented to mitigate risk (Cameron et al., 2017). Furthermore, scenario incompleteness has been reported to contribute to 52.5% of incidents, encompassing cases where no Process Hazard Analysis (PHA) was conducted, previous incidents were not considered, and hazardous scenarios remained unidentified (Alshethry, 2017). Although no process hazard analysis method systematically identifies all possible scenarios (Baybutt, 2003), the number of credible scenarios in a complex process can be extremely large, and not all are subjected to further detailed analysis (Aven, 2016). As such, the selection of representative accident scenarios (RAS) remains one of the most debated issues in process risk management, given its implications for designs or assessment of appropriate safety measures (Markowski & Siuta, 2017). Furthermore, because HAZOP is designed to address both "hazards" and "operability", excluding operability-related scenarios to focus solely on hazard scenarios may not be feasible. This is particularly true since the consequences of a deviation are often not apparent until its causes have been identified and analyzed in detail (Baybutt, 2015).

Incorrect assumptions in scenario development can result in misinterpretation of risk, potentially causing a scenario to appear more effectively protected than it actually is (Eames, 2022). In defining process safety scenarios, two principal approaches are commonly adopted: the worst-case scenario and the most-credible scenario. The worst-case scenario is typically defined as the release of the maximum quantity of hazardous material with the highest potential consequences, irrespective of its likelihood of occurrence (Markowski & Siuta, 2017). This type of scenario can be further interpreted through several perspectives: as an unknown-unknown with extreme, unforeseen consequences (Aven, 2013), as an unexpected extreme event relative to the analyst's prior knowledge or beliefs (Glette-Iversen & Aven, 2021), or as a low-probability high-consequence event that defies conventional expectations (Aven, 2015). However, the identification of worst-case scenarios may be influenced by cognitive biases, including false recall of past studies or the framing effect imposed by facilitators that subtly steer the selection toward certain outcomes (Baybutt, 2017). In contrast, the most-credible scenario refers to an accident scenario deemed the most plausible, reasonable, and representative in terms of likelihood and expected consequences (Markowski & Siuta, 2017). While this approach tends to align with typical operational experience, it may overlook low-frequency, high-consequence events, as has been observed in certain facility siting studies (Graham & Thomas, 2021).

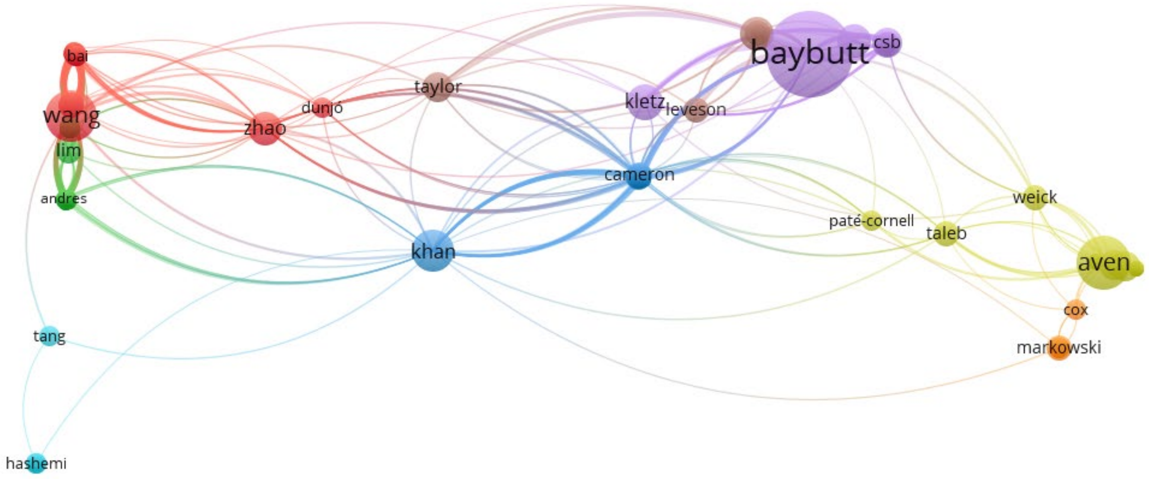

Figure 1 Bibliographic Representation of HAZOP Scenario Completeness Topic in Academic Papers

A review of the bibliographic landscape on HAZOP scenario completeness reveals that this issue has been substantively addressed in at least five seminal works: Baybutt (2018), Wang (2023), Khan (2002), Kletz (1999), and Aven (2016). Wang (2023) highlights that hazardous event (HaE) scenarios can be systematically explored through a novel deep learning framework, termed DLF, which utilizes multifractal analysis. In parallel, Khan (2002) demonstrates that Major Hazards Analysis offers a structured approach for the comprehensive identification of major hazard scenarios by employing a categorization scheme and systematic brainstorming of initiating events with the potential to escalate into major accidents. Nonetheless, Kletz (1999) cautions that not all hazards can be reliably identified, underscoring the inherent limitations of even the most robust hazard identification methodologies.

Through a structured brainstorming process, the HAZOP team identifies potential hazards by tracing each one back to its cause and projecting its potential effects (Jinsong, 2009). Meanwhile, Layer of Protection Analysis (LOPA), by design, restricts its evaluation to individual cause–consequence pairs, treating each as an isolated scenario (CCPS, 2001). Multiple safeguard activations initiated by a single cause, particularly when consequences manifest in equipment distant from the initiating event, are frequently overlooked in risk assessments (Roche, et.al. 2018).

The API RP 14C provides a systematic framework of validated methods for ensuring safety in offshore production operations (API, 2018). When these methods are integrated with robust design, proactive risk assessment, and diligent maintenance and operational practices, they support the realization of a safely functioning facility. Health and safety in offshore hydrocarbon operations require the deployment of effective management systems that span the entire lifecycle of installations and associated activities. A key element of these systems is the structured process of hazard identification and risk analysis, enabling evidence-based decisions on the necessity and scope of risk-reduction measures (ISO, 2019).

This case study on the three-phase separator was conducted with reference to API RP 14C, Table A.4.1: Safety Devices for Pressure Vessels. Since not all scenarios listed in Table A.4.1 of API RP 14C are applicable to every process plant or unit, the selection of credible scenarios should be established as a basis for a holistic approach to scenario completeness evaluation. The applicability of the scenarios outlined in Table A.4.1 depends on several factors, including the specific process parameters of the equipment under study, the presence and configuration of installed safeguards, and the failure modes—particularly the safe failure mode—of these safeguards. In the context of analysis and decision-making under uncertainty, it is common to encounter a lack of reliable data, hence, expert judgment often becomes a necessary and sometimes the only viable source for progressing the assessment (Pasman and Bridges, 2020). Incorporating expert judgment, synthesizing multiple opinions, and employing formal elicitation and combination techniques all function to strengthen the perceived robustness and credibility of the safety analysis (Rae and Alexander, 2017).

2.0 METHODOLOGY

A HAZOP methodology is presented where a functional plant model assists in a goal-oriented decomposition of the process unit or equipment purpose into the means of achieving the purpose. This approach leads to nodes with simple functions from which the selection of process and deviation variables follow directly. The HAZOP worksheets were developed by eight different teams, each led by a distinct facilitator.

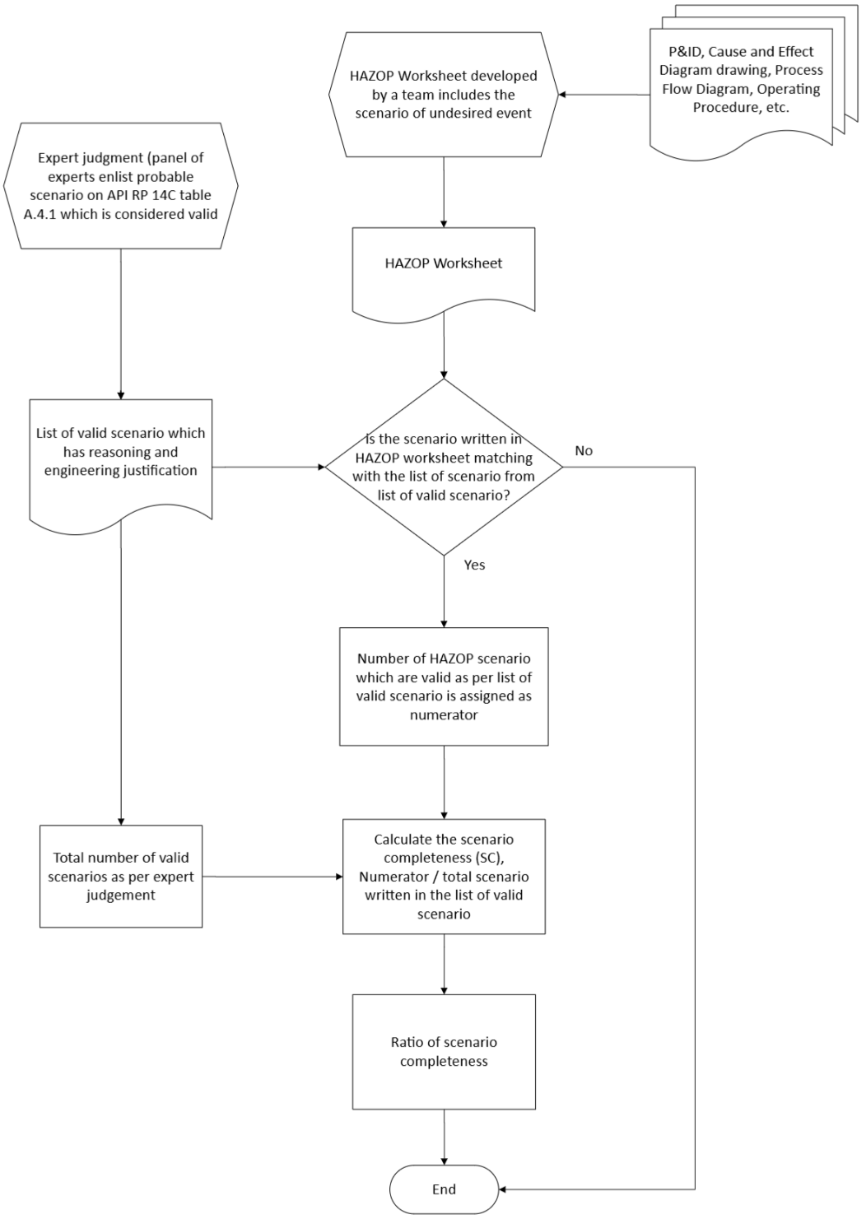

Figure 2 Flowchart of Scenario Completeness Ratio Evaluation Methodology

The HAZOP methodology applied was in accordance with the international standard IEC 61882 (IEC, 2016). Each team conducted a systematic hazards evaluation of the Piping and Instrumentation Diagram (P&ID), as shown in Figure 3, by performing the following activities: defining guidewords and possible deviations (such as more flow, no/less flow, more pressure, less pressure, higher level, or lower level), identifying potential causes associated with each deviation (for instance, misoperation involving the closure of a 3” manual valve on the suction line of Produced Water Pump P-01), evaluating all credible consequences resulting from these causes (e.g., potential overpressure that may lead to leakage, which in turn could escalate to fire and potentially result in fatalities), documenting existing safeguards that could prevent or mitigate the identified consequences (such as Pressure Safety Valve PSV-02 located on the discharge line of Produced

Water Pump P-01, which can relieve excess pressure back to the Low Pressure (LP) Separator V-01), qualitatively assessing the severity of each consequence and the likelihood of occurrence, and, where applicable, proposing recommendations to further reduce the associated risk of each scenario under review.

To ensure the thoroughness of such a HAZOP study, it is essential to benchmark identified scenarios against established references such as Table A.4.1 of API RP 14C, which outlines the full spectrum of credible causes for pressure vessels. Failure to consider the complete range of scenarios—such as blocked outlet, inflow-outflow imbalance, pressure control failure, gas blow-by, thermal expansion, excess heat input, and fire exposure—may result in gaps in hazard identification. Scenario completeness, as defined by such standards, provides a robust basis for validating whether all relevant initiating causes have been adequately considered and safeguards appropriately assigned.

Table 1 Scenario and Deviation List for Pressure Vesessel (API 14C)

No	Scenario (detectable abnormal condition)		Deviation
1	Overpressure (high pressure)		Blocked or restricted outlet
			Inflow exceeds outflow
			Gas blowby (upstream component)
			Pressure Control System Failure
			Thermal Expansion
			Excess heat input
			Fire
2	Underpressure (low pressure)		Withdrawal exceeds inflow
			Thermal contraction
			Open outlet
			Pressure Control System Failure
3	Liquid Overflow (high liquid flow)		Inflow exceeds outflow
			Liquid slug flow
			Blocked or restricted liquid outlet
			Level control system failure
4	Gas Blowby (low liquid flow)		Liquid withdrawal exceeds inflow
			Open Liquid Outlet
			Level control system failure
5	Leak (low pressure, low liquid level)		Deterioration
			Erosion
			Corrosion
			Impact Damage
			Vibration
6	Excess Temperature High (high temperature)		Temperature control system failure
			High inlet temperature
7	Excess Temperature Low (low temperature)		Temperature control system failure
			Low inlet temperature
			Low ambient temperature
			Blowdown or rapid depressurization

A Piping and Instrumentation Diagram (P&ID) was developed and distributed to eight (8) HAZOP teams to evaluate the consistency and completeness of scenario identification among teams with experience levels ranging from 4 to 19 years. This methodology aligns with the benchmark approach implemented by the Joint Research Centre (JRC) between 1988 and 1990, in which eleven (11) teams conducted major hazard analyses of a representative chemical process facility (Amendola et al., 1992). The evaluated P&ID is presented in Figure 3.

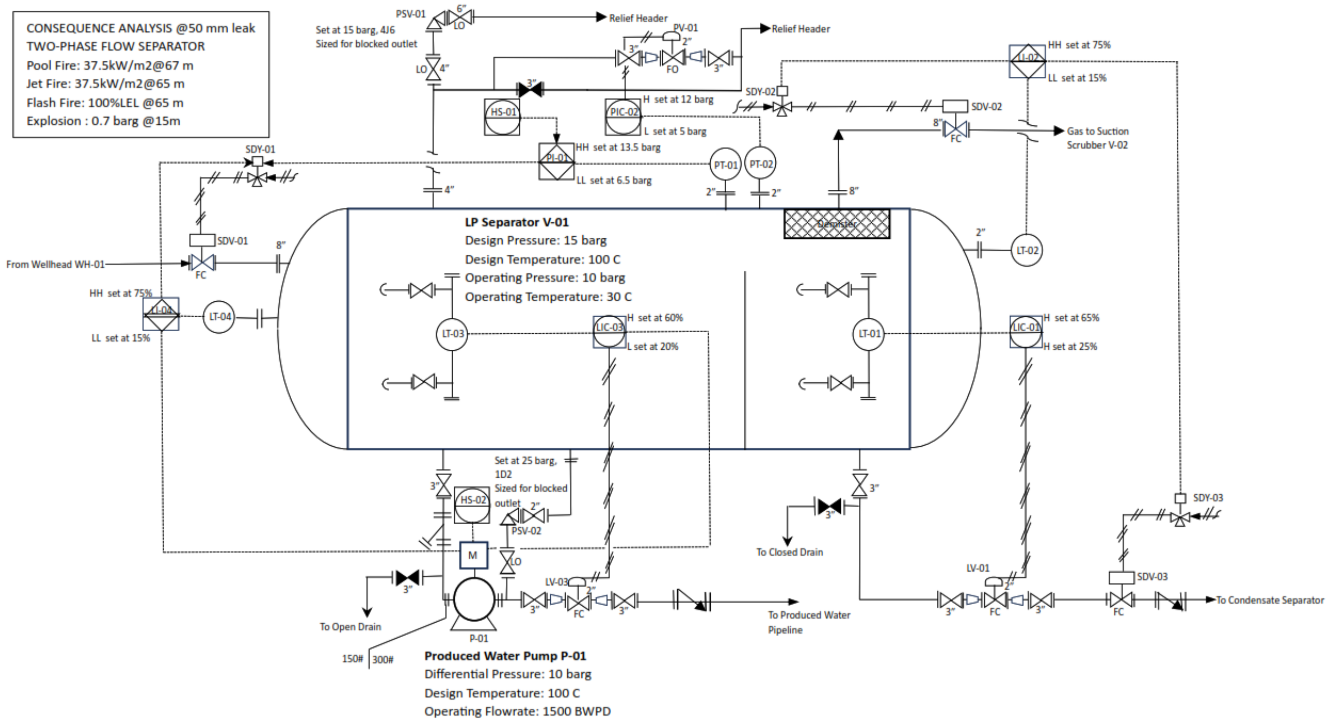

Figure 3 Piping and Instrumentation Diagram for HAZOP Worksheet Development

In parallel, three (3) process safety experts—each with over 12 years of experience in oil and gas facilities—were engaged to develop a consensus-based set of validated HAZOP worksheets following the scenario and deviation list for pressure vessel in Table 1 and refined which scenario is valid for this case. These worksheets, containing valid scenarios, encompassed the maximum number of plausible scenarios that could be derived from the aforementioned P&ID.
Analysis then conduct for each hazop worksheet generated by eight team whether or not matching the valid scenario set by consensus of process safety experts. The scenario is credited as matching if the pair of scenario and deviation is completely stated in the worksheet as a cause and consequences. For example, a pair scenario-deviation of overpressure-blocked or restricted outlet, the deviation or the cause in the HAZOP worksheet shall mention the blocked or restricted outlet, in this case, can be due to SDV-01 and SDV-02 fail closed, or demister plugging which can cause the overpressure inside the vessel.

The scenario coverage from the eight HAZOP teams was subsequently compared against this expert-validated reference set. A scenario completeness ratio was calculated for each team, from which the average, minimum, and maximum values were determined to assess the overall representativeness and variability in scenario identification. Scenario completeness is calculate using following formula:

$$Scenario\ Completeness\ (\%) = \frac{Number\ of\ Scenario\ identified\ by\ each\ team}{Total\ scenario\ identified\ by\ Process\ Safety\ Experts\ Consensus} \qquad \text{Equation 1}$$

3.0 RESULTS AND DISCUSSION

The result of process safety expert's consensus on possible scenarios were compiled and presented in Appendix A. In total, there are fifty-four (54) possible scenarios agreed by three process safety experts to be used as the basis for scenario completeness evaluation or as denominator in equation 1. Result from eight team then tabulated and assigned as numerator in equation 1, the example of HAZOP worksheet developed by one of the team is presented below:

Table 2 Example of HAZOP Worksheets by One of The Team

Deviation	Initiating cause	Scenarios	S	L	RR	Safeguards
Blocked or restricted outlet	SDV-02 at LP Separator V-01 Gas Outlet fails closed	If SDV-02 at LP Separator V-01 Gas Outlet fails closed, it can cause potential for overpressurization in LP	5	3	15	1. PAH-01 sets at 12 barg on LP Separator V-01 will alarm on DCS and alert operator to take further action accordingly 2. PSHH-02 sets at 13.5 barg on LP

Deviation	Initiating cause	Scenarios	S	L	RR	Safeguards
		Separator V-01 resulting in potential for leak/rupture followed by potential for fire/explosion which can cause potential for personnel exposure/environmental pollution/asset or production loss/reputation damage				Separator V-01 will trigger shutdown xx including closure of SDV-01 on upstream LP Separator V-01 3. PSV-01 on LP Separator V-01 is sized for blocked outlet case will relieve pressure to relief header 4. Gas Detectors is installed in LP Separator V-01 area 5. Fire Detector (Fusible plug) is installed in LP Separator V-01 will trigger ESD-1F including deluge valve
	SDV-01 at inlet LP Separator V-01 is spuriously closed	If SDV-01 at inlet LP Separator V-01 is spuriously closed, it can cause potential for overpressurization in wellhead flowline resulting in potential for leaks/rupture followed by potential for fire/explosion which can cause potential for personnel exposure/environmental pollution/asset or production loss/reputation damage	5	3	15	6. PAH well flowline will alarm on DCS operator to take further action accordingly **7.** PSHH well flowline will trigger ESD well including closure of WV, UMV, and DHSV sequencely
		If SDV-01 at inlet LP Separator V-01 is spuriously closed, it can cause potential for production loss	2	3	6	8. PAL-02 sets at 5 barg will alarm on DCS and alert operator to take further action accordingly
	Demister at LP Separator V-01 is plugged	If Demister at LP Separator V-01 is plugged, it can cause potential for overpressurization in LP Separator V-01 resulting in potential for leak/rupture followed by potential for fire/explosion which can cause potential for personnel exposure/environmental pollution/asset or production loss/reputation damage	5	1	5	9. PAH-01 sets at 12 barg on LP Separator V-01 will alarm on DCS and alert operator to take further action accordingly 10. PSHH-02 sets at 13.5 barg on LP Separator V-01 will trigger shutdown xx including closure of SDV-01 on upstream LP Separator V-01 11. PSV-01 on LP Separator V-01 is sized for blocked outlet case will relieve pressure to relief header 12. Gas Detectors is installed in LP Separator V-01 area **13.** Fire Detector (Fusible plug) is installed in LP Separator V-01 will trigger ESD-1F including deluge valve

Subsequently, all HAZOP worksheets produced by the eight teams were reviewed to identify and compile the full range of consequences identified across all teams. Valid deviations, as defined in API RP 14C Table A.4.1, for each scenario were compared against the outcomes from the eight HAZOP teams. Each identified scenario documented in the HAZOP worksheets was credited and counted. A completeness score of 100% indicates that all HAZOP teams discussed and evaluated the specific deviation.

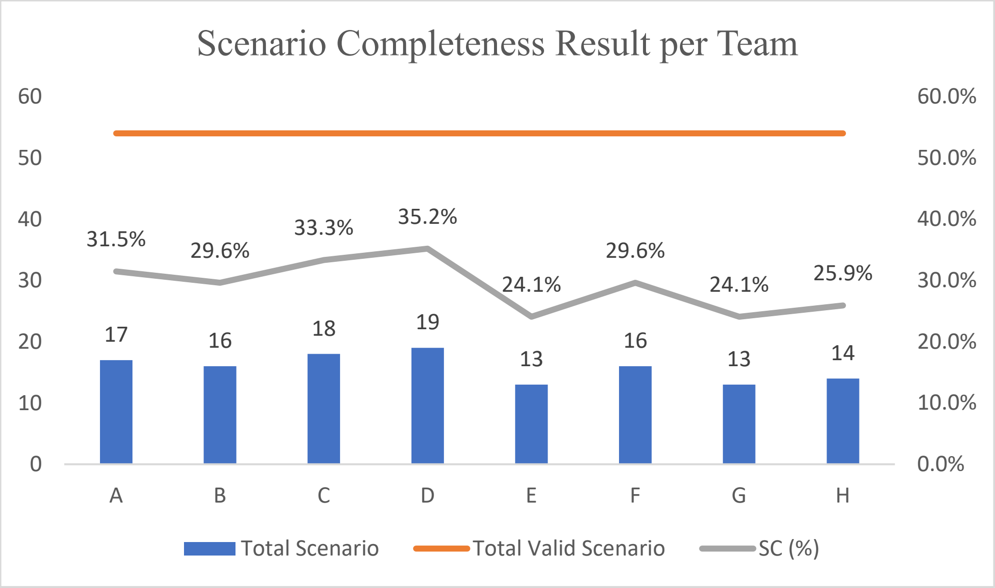

Figure 4 Scenario Completeness Result per Team

The overall scenario completeness is ranging from 24.1 % to 35.2% with average in 29.2%. This result is slightly higher compared to Taylor (1982) works on Distillation Unit, which is also pressure vessel, with only 22% of all scenarios identified in HAZOP study. Conversely, this range is slightly lower than the completeness of safeguards identified in HAZOP studies, which has been reported to vary between 11.76% and 82.79% (Mukharror et al., 2025). A fundamental principle of hazard identification is to develop a threat register that is as exhaustive as practicable, avoiding the premature dismissal of any credible hazard. However, it is important to recognise that complete coverage of all possible threats can never be fully achieved (Ale, 2002).

Further breakdown analysis then conducted on scenario completeness per scenario-deviation pair. 100% value means that the scenario-deviation pair is discussed and written in all HAZOP worksheet by eight teams, while 50% indicate only four teams discuss about this scenario-deviation on their worksheet. On average, the overpressure scenario exhibited the highest completeness at 37.5%, followed by liquid overflow (28.1%), gas blowby (20.8%), leak (12.5%), and underpressure (8.3%). Scenarios related to temperature deviations, both high and low, were not addressed in any of the HAZOP discussions. The detailed results scenario – deviation pairs and its completeness are presented in Table 3:

Table 3 Scenario Completeness on Average

Scenario	Deviation	Completeness (%)	Average (%)
Overpressure	Blocked or restricted outlet	100.0%	37.5%
	Inflow exceeds outflow	12.5%	
	Thermal Expansion	0.0%	
Liquid Overflow	Inflow exceeds outflow	12.5%	28.1%
	Liquid slug flow	0.0%	
	Blocked or restricted liquid outlet	62.5%	
	Level control system failure	37.5%	
Gas Blowby	Liquid withdrawal exceeds inflow	0.0%	20.8%
	Open Liquid Outlet	12.5%	
	Level control system failure	50.0%	
Leak	Erosion	0.0%	12.5%
	Corrosion	0.0%	
	Vibration	37.5%	
Underpressure	Withdrawal exceeds inflow	12.5%	8.3%
	Open outlet	0.0%	
	Pressure Control System Failure	12.5%	
Excess Temp (H)	High inlet temperature	0.0%	0.0%
Excess Temp (L)	Temperature control system failure	0.0%	0.0%

The evaluation of scenario–deviation pairs revealed that overpressure resulting from a blocked or restricted outlet achieved the highest completeness, having been addressed by all HAZOP teams. Conversely, several scenarios–deviation combinations were not discussed by any team, including overpressure–thermal expansion, underpressure–open outlet, liquid overflow–liquid slug flow, gas blowby–liquid withdrawal exceeding inflow, leak–corrosion, leak–erosion, excess high temperature–high inlet temperature, and excess low temperature–temperature control system failure.

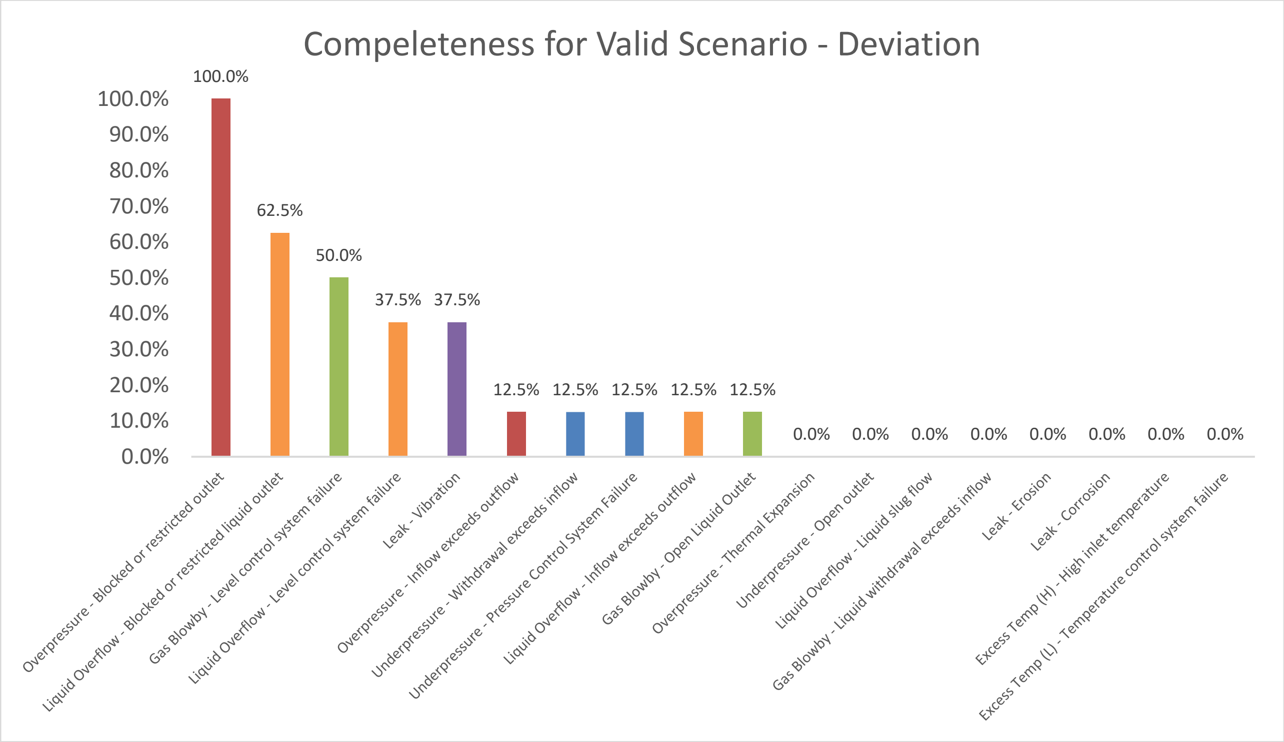

Figure 5 Completeness for Pair of Scenario - Deviation

The results from the eight HAZOP teams were consistent with the distribution of direct causes of pressure vessel failure reported by Bellamy (1994) which overpressure as main cause amounted to 45.2%. Specifically, the tendency of the HAZOP teams to prioritize overpressure events as the most credible hazards for pressure vessels aligns with Bellamy's findings, which identified overpressure as the most frequent hazard associated with pressure vessel failures.

Despite of limitation of this case study on pressure vessel, the finding can be elaborated in wider perspective, not only a single equipment but also a whole plan. The resuls is align with the previous study from 118 accidents in Dutch Seveso Plants which revealed that overpressure as the most frequent loss of control event (Bellamy, 2013).

The results also demonstrated a positive and strong correlation ($R^2 = 0.676$) between HAZOP team operational experience and scenario completeness. Eight facilitators with experience ranging from 4 to 19 years has different result in term of scenario completenesss, but the more experience the facilitator, tend to provide higher scenario completeness. This finding indicates that team operational experience plays a critical role in enhancing the quality of HAZOP studies. The observed relationship is consistent with the observations of Kletz (2006), who noted that the combination of knowledge and experience enables teams to identify the causes of accidents and determine the actions necessary to prevent recurrence. The study also demonstrated a similar correlation between the experience of the HAZOP facilitator or HAZOP team and the quality of the study, as measured by scenario completeness, consistent with the findings of Mukharror et al. (2025), who evaluated the impact of facilitator operational experience on HAZOP outcomes.

4.0 CONCLUSION

The study demonstrated that scenario completeness in HAZOP evaluations ranged from 24.1% to 35.2%, with overpressure scenarios showing the highest completeness and several critical scenarios–deviation combinations receiving no attention from any team. These results highlight that, while overpressure is consistently recognized as a primary hazard in line with historical accident data, substantial gaps remain in identifying other credible threats, reinforcing the inherent limitations of achieving full hazard identification. Addressing these gaps through improved methodology, broader expertise, and systematic completeness assessment is essential for enhancing the effectiveness of HAZOP studies and overall process safety performance. The effectiveness of HAZOP studies is strongly influenced by the experience of the facilitators. This capability stems from their familiarity with real-world process behavior, equipment limitations, and operational anomalies, enabling more accurate hazard outcome assessments. In contrast, facilitators without such experience may find it challenging to recognize subtle but critical hazards, potentially reducing the overall completeness of the study. Consequently, integrating operational experience as a fundamental criterion in facilitator selection is an evidence-based strategy to improve the robustness, credibility, and overall effectiveness of HAZOP analyses. To improve the statistical reliability and applicability of findings, future research should incorporate a broader range of HAZOP reports from diverse facilities and industries. Additionally, establishing a standardized, simplified method for evaluating safeguard completeness may offer an effective means of assessing HAZOP quality and supporting continuous process safety improvement

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Appendix – A Complete Scenario Developed by Process Safety Expert Consensus

Scenario as per safety analysis table of API 14C	**Development of scenario by process safety expert consensus as per API 14C**			
	Common Cause	**Initiating cause**	**Scenarios (with Consequences)**	**Locus delicti**
Overpressure	Blocked or restricted outlet	SDV-01 on LP Separator Gas Inlet fails closed	Potential for leaks with fire	Wellhead Flowline
		Demister on LP Separator is plugging	Potential for leaks with fire	LP Separator V-01
		SDV-02 on LP Separator Gas Outlet fails closed	Potential for leaks with fire	LP Separator V-01
	Inflow exceeds outflow	3" Manual Valve on PW Pump Suction is inadevertently closed	Potential for leaks with fire	LP Separator V-01
		Strainer on PW Pump Suction is plugging	Potential for leaks with fire	LP Separator V-01
		PW Pump P-02 stops / failure	Potential for leaks with fire	LP Separator V-01
		LV-03 on PW Pump Discharge fails closed	Potential for leaks with fire	LP Separator V-01
		3" Manual Valve on PW Pump Discharge is inadevertently closed	Potential for leaks with fire	LP Separator V-01
		3" Manual Valve on Condensate Outlet is inadevertently closed	Potential for leaks with fire	LP Separator V-01
		LV-01 on Condensate Outlet fails closed	Potential for leaks with fire	LP Separator V-01
		SDV-03 on Condensate Outlet fails closed	Potential for leaks with fire	LP Separator V-01
		Check valve in condensate line fails in closed position	Potential for leaks with fire	LP Separator V-01
		LV-03 on PW Pump Discharge fails closed	Potential for leaks with missiles	PW Pump
		Check valve in PW Pump Discharge fails in closed position	Potential for leaks with missiles	PW Pump
		3" Manual Valve on PW Pump Discharge is inadevertently closed	Potential for leaks with missiles	PW Pump
	Gas blowby from upstream	N/A	N/A	N/A
	Pressure control system failure	N/A	N/A	N/A
	Thermal expansion	3" Manual Valve on Condensate Outlet is inadevertently closed	Potential for leaks with fire	Condensate Line
		LV-01 on Condensate Outlet fails closed	Potential for leaks with fire	Condensate Line
		SDV-03 on Condensate Outlet fails closed	Potential for leaks with fire	Condensate Line
		Check valve on Condensate Line fails in closed position	Potential for leaks with fire	Condensate Line
	Excess heat input	N/A	N/A	N/A
	Fire	N/A	N/A	N/A
Underpressure	Withdrawal exceeds inflow	PV-01 on LP Separator fails open	Potential for surging with leaks	Compressor
		3" Manual Valve on LP Separator (bypass PSV-01) is inadvertently open	Potential for surging with leaks	Compressor
		SDV-01 on LP Separator Inlet fails closed	Potential for surging with leaks	Compressor
	Thermal contraction	N/A		
	Open outlet	3" Manual Valve on LP Separator (to Open Drain) PW outlet is inadvertently open	Potential for cavitation with leak	PW Pump
	Pressure Control System Failure	PIC-01 on LP Separator open bigger than requirement	Potential for cavitation with leak	PW Pump
Liquid overflow	Inflow exceeds outflow	PV-01 on LP Separator fails open	Potential for liquid carryover with leaks	Compressor
		3" Manual Valve on LP Separator (bypass PSV-01) is inadvertently open	Potential for liquid carryover with leaks	Compressor
	Liquid slug flow	PV-01 on LP Separator fails open	Potential for leaks with fire	LP Separator V-01
		3" Manual Valve on LP Separator (bypass PSV-01) is inadvertently open	Potential for leaks with fire	LP Separator V-01
	Blocked or restricted liquid outlet	3" Manual Valve on PW Pump Suction is inadevertently closed	Potential for liquid carryover with leaks	Compressor
		Strainer on PW Pump Suction is plugging	Potential for liquid carryover with leaks	Compressor
		PW Pump P-02 stops / failure	Potential for liquid carryover with leaks	Compressor

Scenario as per safety analysis table of API 14C	**Development of scenario by process safety expert consensus as per API 14C**			
	Common Cause	**Initiating cause**	**Scenarios (with Consequences)**	**Locus delicti**
		LV-03 on PW Pump Discharge fails closed	Potential for liquid carryover with leaks	Compressor
		3" Manual Valve on PW Pump Discharge is inadevertently closed	Potential for liquid carryover with leaks	Compressor
		3" Manual Valve on Condensate Outlet is inadevertently closed	Potential for liquid carryover with leaks	Compressor
		LV-01 on Condensate Outlet fails closed	Potential for liquid carryover with leaks	Compressor
		SDV-03 on Condensate Outlet fails closed	Potential for liquid carryover with leaks	Compressor
		Check valve fails in closed position	Potential for liquid carryover with leaks	Compressor
	Level control system failure	LIC-01 on LP Separator open smaller than requirement	Potential for liquid carryover with leaks	Compressor
		LIC-02 on LP Separator open smaller than requirement	Potential for liquid carryover with leaks	Compressor
Gas Blowby	Liquid withdrawal exceeds inflow	3" Manual Valve on LP Separator (to Open Drain) Condensate Outlet is inadvertently open	Potential for gas dispersion with fire	Open Drain
		PW Pump P-02 continuously running	Potential for leaks with fire	PW Pipeline
	Open liquid outlet	3" Manual Valve on LP Separator (to Open Drain) PW outlet is inadvertently open	Potential for gas dispersion with fire	Open Drain
	Level control system failure	LIC-01 on LP Separator open bigger than requirement	Potential for leaks with fire	Condensate Separator
		LIC-02 on LP Separator open bigger than requirement	Potential for leaks with fire	PW Pipeline
Leak	Deterioration	N/A	N/A	
	Erosion	LV-03 on PW Pump Discharge is driven open	Potential for leaks	PW Pipeline
		LV-01 on Condensate Outlet is driven open	Potential for leaks with fire	Condensate Line
	Corrosion	3" Manual Valve on PW Pump Suction is inadevertently closed	Potential for leaks with fire	Condensate Line
		Strainer on PW Pump Suction is plugging	Potential for leaks with fire	Condensate Line
		PW Pump P-02 stops / failure	Potential for leaks with fire	Condensate Line
		LV-03 on PW Pump Discharge fails closed	Potential for leaks with fire	Condensate Line
		3" Manual Valve on PW Pump Discharge is inadevertently closed	Potential for leaks with fire	Condensate Line
	Impact Damage	N/A		
	Vibration	PW Pump P-02 continuously running	Potential for leaks with missiles	PW Pump
Excess Temperature High	Temperature control system failure	N/A	N/A	
	High inlet temperature	SDV-02 on LP Separator Gas Outlet fails closed	Potential for leaks with fire	LP Separator V-01
Excess Temperature Low	Temperature control system failure	PV-01 on LP Separator fails open	Potential for leaks with fire	Flare Header
	Low inlet temperature	N/A	N/A	N/A
	Low ambient temperature	N/A	N/A	N/A
	Blowdown or rapid depressurization	N/A	N/A	N/A