Integrated PHA approach for an Auditable Barrier Management Regime

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Abstract

The Oil and Gas Industry is constantly evolving and increasing in complexity. Operators are seeking new strategies to increase the auditability and connectivity between disciplines and their studies. Barrier management is a developing methodology that is utilised, to systematically establish and maintain barriers so that the risk faced at any given time can be handled. This is achieved by preventing undesirable incidents from occurring or by limiting the consequences should such accidents occur. Barrier management includes the processes, systems, solutions, measures and tools which must be in place to ensure the necessary risk reduction through its implementation. Barrier management establishes an easily communicated risk picture.

The impact of COVID 19 on operations risk management has been unexpected, substantial and therefore challenging. This has forced companies to look at streamlined methodologies to ensure effective and efficient barrier management techniques.

A holistic barrier management involves the a), the identification of hazards and their barriers, the determination of barrier performance standards, and the monitoring of barrier performance during operations and their continued applicability in an ever changing operational environment. There are various techniques and tools available to safety professionals when considering overall barrier management. However, despite some efforts in the past, there is still no standard methodology on how to practically combine these complex standalone techniques into one easily understood combined barrier model. Techniques such as HAZOP, LOPA, RBI, Bowtie, Alarm Rationalisation, Prestart-up safety audits, and human factors studies are traditionally used to address concerns due to design issues, mechanical integrity issues, process and operations issues and external events. However, these studies are performed in isolation and are rarely combined into one distilled easily understood risk picture. This results in differing competing conclusions from the various studies and a complex risk picture which is not easy for frontlines operations staff to understand and implement.

To address the potential issues of performing these studies in isolation and to ensure the safe operation of hazardous facilities, a formal, systematic and integrated system will be presented. As a sample case, an integrated HAZOP, LOPA approach was developed for a large existing onshore oil and gas facility to address process risks. This integrated approach is presented as an example to illustrate how complex studies such as HAZOP and LOPA were distilled into a pictorial and easy to use bowtie for operations. Bowtie diagrams are often used to communicate a holistic picture of barrier management efforts. They take into account all the various studies undertaken by the differing disciplines. The diagrams give a clear illustration of the relationships between the hazard, the causes of its realisation and its potential consequences. It includes easily understood pictorial descriptions of the control and recovery measures along with barrier degradation issues such as the effect that ageing has on a facility barrier management system.

Additionally, the paper will discuss examples techniques, which are being utilised or being considered for the integration of the degradation of barriers which are not deeply considered in HAZOP and LOPA, such as mechanical integrity, external event and design defects. When combined with the process risks discussed in HAZOP and LOPA a holistic unified risk picture can be presented e.g. the impact of omission of critical inspection and maintenance activities, human error during critical tasks operational activities, failure in ignition control, ineffective emergency response systems. The paper will therefore discuss the impact of deficient assurance activities, design, human factors and the overall process management system.

The paper will demonstrate how an integrated barrier management approach is currently being applied at an existing facility by focusing on integrating HAZOP, LOPA and Bowtie Studies. Potential future improvements to current practice will also be addressed. The paper will ensure that study findings, from various critical studies covering all potential failure mechanisms are clearly communicated via the pictorial bowtie, and provide a clear risk picture to practitioners, operations and management. This methodology results in a highly efficient and auditable workflow.

Hazop, Lopa, Bowtie, Barrier Management, Operation Risk Assessment

Introduction

Oil and gas facilities are inherently dangerous due to the hazardous inventories involved. Hawksley (1987) referenced by (Tweedale, 2003) describes the fundamental requirements for safe operation of a hazardous plant as,

- Understanding the hazards to safety and environment.
- Provision of adequate equipment and facilities.
- Use of systems and procedures to safely operate equipment, with routine performance monitoring, audits and improvements.
- Appropriate organisation including staffing, communication and training to maintain facilities, equipment, systems and procedures.
- Adequate measures must be in place to handle any foreseeable emergencies

- Effective arrangements must be in place to promote a strong culture of safety

All these factors allow the complex oil and gas facilities to adapt to expected (and unexpected) changes during the plant life-time.

Typically, risk management at the operate stage does not consistently link with the safety critical assumptions and requirements stated in risk assessments (conducted at both design and operate stage). This can lead to potentially contradictory risk analysis results and may, therefore, give conflicting advice when decisions are required to be made during the operation of the plant. Additionally, changes to the risk profile can occur over time due to the introduction of new hazards and/or due to the degradation of protection measures that have been put in place to protect against known hazards. These protections are termed barriers (Eltervåg, A., et al, 2017).

Lethal gaps in hazard management are very likely to exist when the performance of risk assessment studies is not aligned with risk management on the plant. This misalignment is more likely to occur if these studies are performed in an isolated manner i.e. with no interface with operations. Issues can occur such as inappropriate barriers being defined at the operate stage when compared to the findings of risk assessments. Concerns over operational risk management have been raised in the past by authors such as (Emery, 2014), (Øien, 2015), (Pitblado, 2016), and (Bucelli et al, 2017). This highlights that many companies, consultants and risk practitioners are currently seeking new sustainable strategies to increase the auditability and connectivity between risk assessment studies and risk management during plant operations. (Øien, 2015) especially stated that there is a "jungle of terms" which represents "a challenge in the communication between the blunt and the sharp end". This makes it difficult to have a coherent unified approach to barrier management within industry. This paper will therefore highlight a worked example which brings clarity on the steps taken to ensure an adequate and coherent barrier management approach at a facility. The authors of this paper agrees with statement from (Øien, 2015) that "one single common approach is probably not an achievable goal, but exchange of ideas and experience in conferences, seminars and workshops may support convergence towards a few suitable approaches". This aim of this paper is to contribute to that debate.

To address these operational risk management issues, a cases study is used to highlight how barrier management principles were used at an existing plant for performing risk assessment and operational risk management activities. The case study will seek to show links between differing plant specific studies and operational risk management due to the formal, systematic, and integrated barrier management approach. The aim is it ensure a sustainable operational risk management approach (termed as barrier management in this paper) which provides an auditable trail. The system facilitates the ability to make quick safety critical decisions at the operate stage, due to the existence of a thoroughly documented and researched plant risk picture.

Via the case study, this paper will specifically highlight a methodology that was used to establish the plant risk picture by identifying hazards, their barriers, the adequacy of the barriers, the required barrier performance, the calculated barrier reliability, and the critical assumptions used to determine the barrier reliability. The case study will further outlines how the critical assumptions formed the basis for a maintenance regime and the basis for monitoring potential barrier degradation at the plant. The case study specifically highlights, how the methodology aided critical operational decision making during the COVID pandemic.

Background Principles

Barrier Management Principles

A barrier is defined as follows (Eltervåg, A., et al, 2017):

"A measure intended to identify conditions that may lead to failure, hazard and accident situations, prevent an actual sequence of events occurring or developing, influence a sequence of events in a deliberate way, or limit damage and/or loss."

Barrier management is a fundamental aspect of corporate governance and facility risk management (Eltervåg, A., et al, 2017). The aim of barrier management is the establishment of barriers and maintenance of barrier functionality during the lifecycle of the plant. This is illustrated in Figure 1 which is adapted from (Øien, K et al,2015). All potential measures that can aid in plant specific risk reduction are utilised,

- including processes and systems that identify the requirement for specific barriers,
- the required barrier functionality for the specific scenarios,
- identification of factors that can degrade the effectiveness of the barriers and systems that allow remedial measures to be implemented should the barriers degrade.

Effective barrier management allows facilities to maintain facility risks at tolerable and acceptable levels. It requires that for each barrier, critical elements which enable barrier functionality are identified and managed, as follows (See Figure 2):

- Technical elements: the specific equipment and systems.
- Organisational elements: the specific personnel roles/functions and specific competence.
- Operational elements: the tasks which must be performed in order for the barrier function to work.

Management of the technical, operational and organisational elements of barriers should be planned for and monitored over time. The barrier management system should therefore aid in demonstrating to plant management and regulators that operational risks specific to the plant are being maintained to As Low as Reasonably Practicable (ALARP) and that degradation factors due to issues such as plant age as discussed in (Horrocks et al.,2010).

Figure 1 Barrier Management Workflow

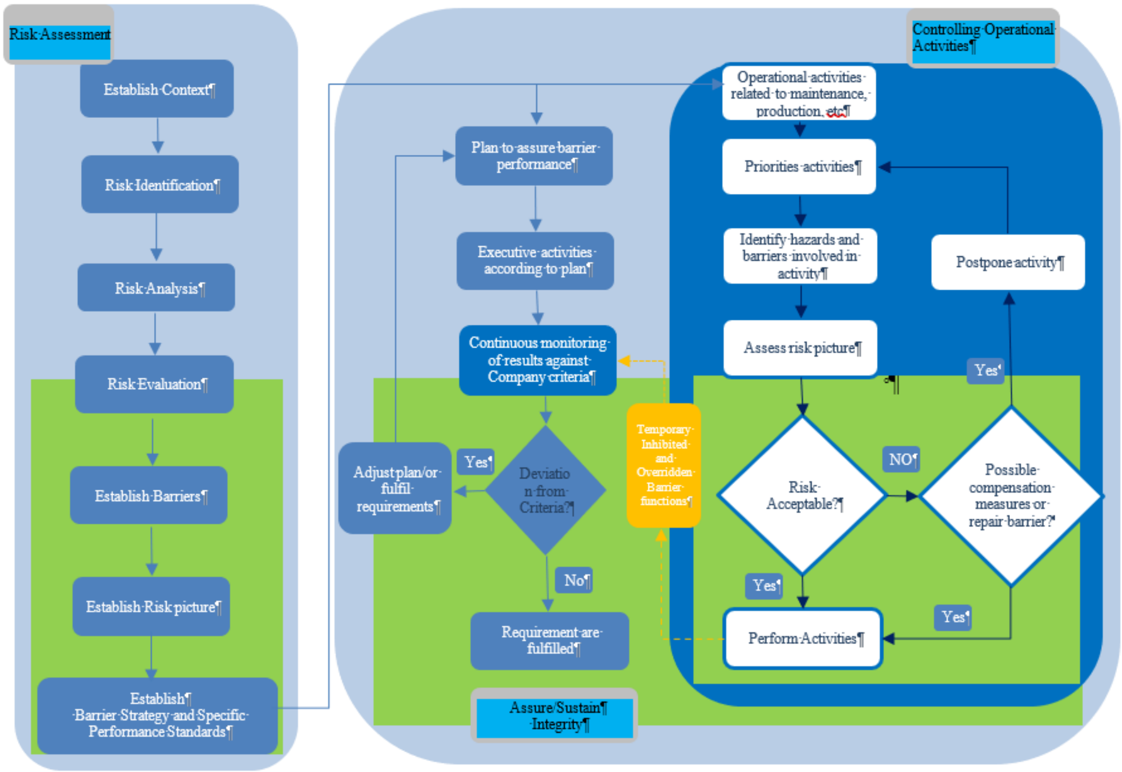
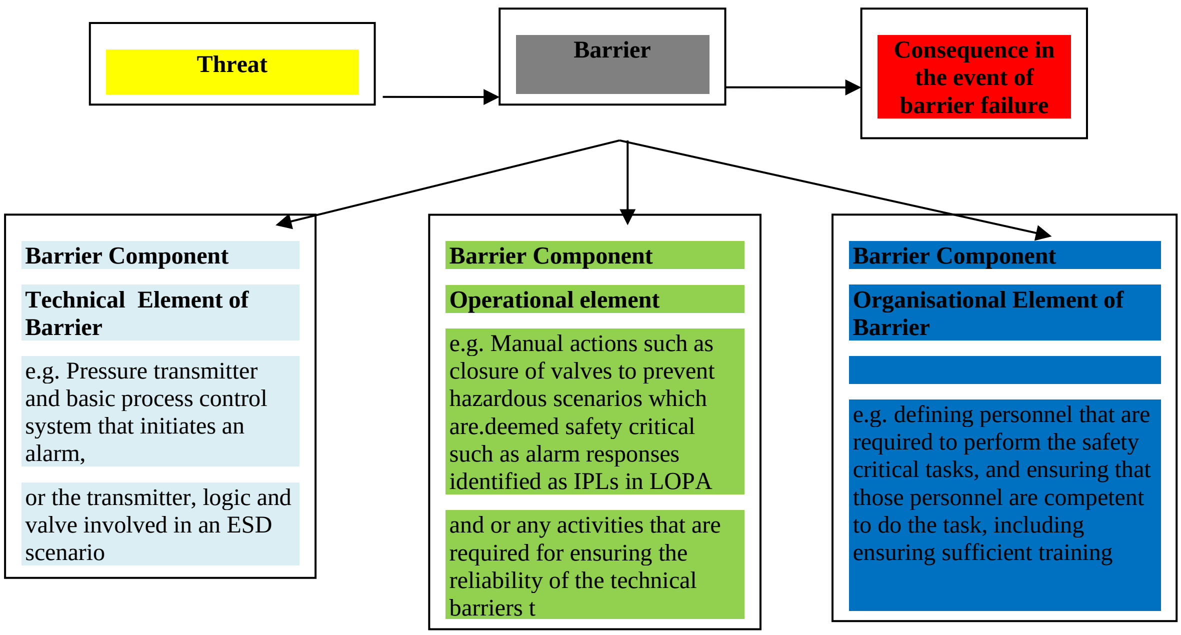


Figure 2: Major Hazard Management Process



As the O&G industry has seen in many past cases, major accidents tend to occur when one or more physical elements of barriers (technical) fail when they are required. This failure of the barriers is typically underpinned by underlying causes i.e. organisational elements barriers and operational elements of the barrier. Barrier management during operation should therefore ensure that all barrier elements are continuously effective during the life time of the plant ensuring the ongoing suitability of the barriers. A few key attributes that are essential for good barrier management are as follows (Eltervåg, A., et al, 2017):

- The barrier management strategy should ensure that the organisation has the ability to understand when current operations are deviating from base assumptions for underlying studies.

- The barrier management strategy should ensure that the organisation has the ability to measure and verify the performance of the barriers. This includes systems which will confirm that organisational and operational barriers elements of a specific barrier are fit for purpose. Systems such as accident investigations, and verification of drill performance and personnel training.
- The barrier management strategy should ensure that the organisation has systems to maintain control of factors that could impact the performance of the barrier, such as weather (e.g. Matrix Of Permitted Operations (MOPO)), temporary activities such as simultaneous operations (SIMOPS), and manning and long term issues such as changes in organisation (e.g impact of de-manning during COVID), degradation of materials and modifications).
- The barrier management strategy should ensure that the organisation has systems to identify, follow up and enhance the barrier management process itself, to ensure that the process involves and is continually fit for purpose.
- The barrier management strategy should ensure that the organisation has systems to ensure that personnel are competent and are aware of how their tasks impact safety.

The philosophy above aligns with the aims stated by Hawskley (Tweedale, 2003), however, the barrier management approach highlights a more detailed practical outline regarding how to achieve the aims.

The case study in this paper will therefore highlight a practical way to meet risk management aims for the plant as per Hawskley (Tweedale, 2003), using the barrier management philosophies stated in (Eltervåg, A., et al, 2017). The case study will highlight how the philosophies were used in practice, and specifically how the systems were used during the COVID period when there was a governmentally mandated need to work with a significantly reduced number of personnel. The case study shows, how due to the auditable barrier management procedure, a decision could be made relatively easily regarding the impact on safety due to a proposed de-manning philosophy. The auditable barrier management process was therefore used to aid in identifying the impact of changes e.g. manning, on plant operations and therefore help in facilitating easy, quick and auditable decision making.

Worked Example Study

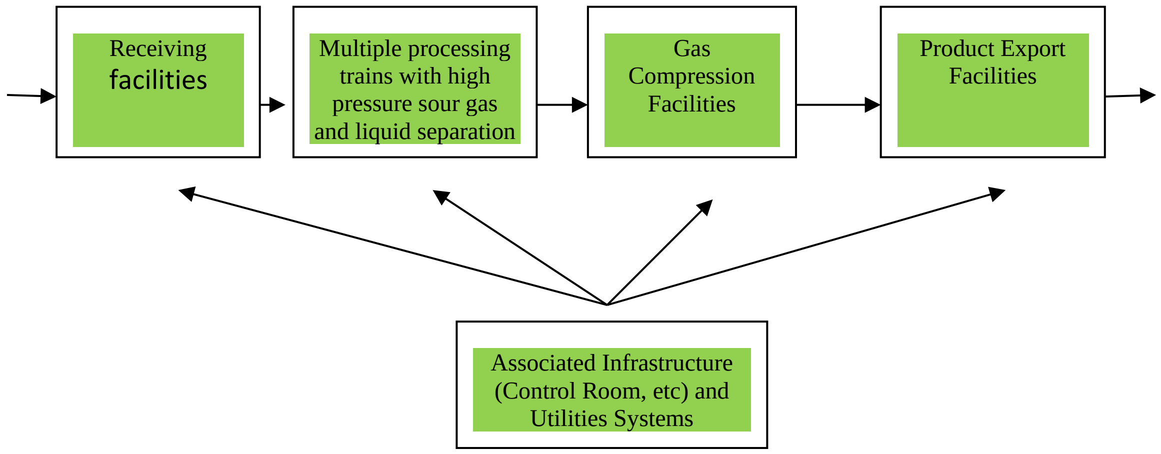
The following section illustrates how an integrated barrier management approach was utilised at the operation stage of a large hydrocarbon facility to demonstrate that the risks on the facility would remain ALARP at the start of the COVID pandemic, considering operation with a reduced number of workers.

The following sections give a brief description of the facility, the system used for establishing barriers at the facility, the systems used for operational barrier management., and an example of how a quick auditable decision could be made during the COVID pandemic.

Facility Description

The facility comprised of a sour processing facilities handling high pressure hydrocarbon (See Figure 3). It consisted of a central hydrocarbon handling units, which were fed by multiple flowlines from upstream onshore sour wells and a gathering system.

Figure 3: Sour Gas Facility



Description of Barrier Establishment at the Facility

The following section describes the systems used for establishment of barriers at the facility. As per the philosophy at site, barrier establishment is a sub-component of the overall barrier management. The aim is to identify hazards, potential safeguards, establish the performance requirements for those identified barriers with respect to the hazard, and specify the barrier management strategy. The defined steps adopted by the facility are inline with the industry standard (ISO31000, 2018) and are as follows:

- Establish Context.
- Risk Assessment.
    - Identify failure, hazard, and accident scenarios.
    - Establish barrier functions, elements and performance requirements.
    - Perform risk analysis.
    - Assess and evaluate risk. Establish a risk picture.
- Risk Management.
    - Establish the need for reducing risk i.e. better or more barriers.
    - Establish specific barrier requirements and performance requirements.
- Monitor and review all the above steps.
- Communicate and involve personnel in all aspects of risk assessment.

Barrier establishment was a key management tool by which the operator managed risks to an acceptable level. The process was also utilised by the facility operator as a basis to demonstrate to stakeholders that risks are being managed appropriately.

Establishing Context

The facility barrier establishment regime included systems that described the context for recognising potential scenarios where significant risks may arise. Systems such as the management of change (MOC) were used as the basis to identify any significant changes (temporary or permanent) that could impact technical, operational or organisational aspects of operation such as changes to the following:

- Technical aspects e.g. physical plant hardware and systems, emergency response philosophies and procedures, critical software.
- Organisation changes e.g. patterns of work, changes to key personnel, that have the potential to affect safety or plant integrity (including the transition between current and future arrangements);
- Operational changes e.g. changes in procedures and systems such as permit to work.

Additionally, the regime required the performance of a cyclical update of key studies, to ensure that new knowledge and understanding was incorporated into the risk management system and that any previous studies are reviewed and updated in line with current conditions and current best practice.

This paper focuses on how the requirement to perform cyclical updates of the Hazard Identification (HAZID), Hazard and Operability Studies (HAZOP), Layer of Protection Analysis (LOPA) and Sil Verification led to establishing an auditable trail to enable effective barrier management based on new understanding of barrier management techniques (Eltervåg, 2017). The findings of these studies were transferred to a bowtie to enable easy communication of the findings to all the stakeholders e.g. operations staff at the “sharp end”.

Risk Assessments and Risk Management

The facility utilised, risk assessment studies such as HAZID, HAZOP, LOPA, as input for barrier establishment. The studies were utilised to form a base picture of current facility risks, by identifying hazards, and specifying the requirements for any plant and scenario specific risk reduction measures. Other studies were conducted e.g. Risk Based Inspection studies (RBI), Simultaneous Operations Studies (SIMOPS), Escape Evacuation and Rescue Analysis (EERA) and Fire and Explosion Analysis (FERA), however, this paper does not cover these aspects, and instead focuses on the flow from HAZID, HAZOP, LOPA, SIL verification studies upto the live facility operational risk management activities.

As the facility was in the operation stage, the risk assessments had already been performed as part of the design stage and, therefore the focus during operation was to ensure that, any proposed changes from the original design premise with the impact to affect safety or any proposed adhoc activities not addressed during design are identified and analysed.

Bowtie diagrams were used as an easy means to communicate barrier management requirement and efforts to all stakeholders. The diagrams gave a clear illustration of the relationships between the hazard, the causes of its realisation and its potential consequences.

To give a holistic picture reflecting the plant conditions, the bowtie diagram for the facility took into account all the various studies undertaken, and ensured that an auditable trail to the necessary studies is given.

An example is given below highlighting the flow and links between HAZID, HAZOP, LOPA and SIL verification to the bowtie diagram. The studies are used to identify the hazards and the adequacy of their barriers, whilst the bowtie is utilised to communicate the findings of those studies to the stakeholders, and further define any additional barriers, focusing on clearly defining responsibilities for operational and organisational barriers.

Hazard Identification Study (HAZID)

A cyclical HAZID analysis was undertaken, it formed the platform for the hazard assessments within the plant. All potential significant safety hazards that could occur at the plant were identified and considered at a high level. If there was a potential for a major accident hazard, defined at this plant as scenarios which can cause a more than 3 fatalities, further more detailed studies were mandated. In this example, the HAZID identified that process hazards leading to loss of containment of sour and flammable inventory could lead to 3 or more fatalities if personnel are exposed to the toxic gases or the effects from ignited releases. This triggered the requirement for further analysis of these risks to ensure that risk reduction can be demonstrated to be ALARP in an auditable manner. HAZOP, LOPA and SIL verification were used as part of the demonstration.

Additionally, the HAZID identified barriers such as emergency response and fire protection measures which can mitigate the impact of the loss of containment scenarios and handle emergencies. For these barriers, studies such as escape evacuation and rescue analysis and fire and explosion risk analysis were utilised to identify and establish the adequacy of the facility mitigative barriers.

Hazard and Operability Study (HAZOP)

HAZOP is typically used to identify specific failure, accident and hazard scenarios caused by deviations from expected process conditions. It is used to generate specific scenarios that can be used to determine specific barriers elements, and their specific functions in relation to the identified scenario.

An example major hazard accident scenario that was identified in the HAZOP is shown in Table 1. The scenario identified that manual error could lead to the potential overpressurisation of a column which could lead to more than 3 fatalities. A qualitative risk assessment was then performed to determine whether there is need for further risk reduction. Recommendations stating the requirement for further risk reduction via the provision of additional barrier or improvement of existing barriers was then generated, as per assessment findings.

Layer of Protection Analysis (LOPA)

To have additional assurance on the adequacy of risk reduction measures for scenarios with which could cause fatalities, the semi-quantitative LOPA approach was utilised. This resulted in all scenarios identified in HAZOP as potentially leading to a fatality being transferred from the HAZOP approach to the LOPA. Further assurance was required for these scenarios, as the qualitative HAZOP review process which is utilised to determine the adequacy of risk reduction measures was not deemed as sufficient assurance for these high consequence events. Note: For higher consequence scenarios e.g. a high number of fatalities, a more quantitative approach than LOPA was typically undertaken for additional assurance.

The LOPA technique was also used to semi-quantitatively specify the barrier requirement for the identified hazards and also set the performance requirements (See Table 2). The technique compares hazard event frequencies and compares them against a company specified tolerable target frequency. It uses, industry standard failure frequencies to determine the potential likelihood of a scenario, uses standard probability of failure on demand values for the barriers identified as valid within the HAZOP, and compares the calculated event frequency, taking into account the barriers reliability.

A Probability of Failure on Demand (PFD) of 0.01 for the Pressure Safety Valves (PSVs) and 0.01 for the Safety Instrumented Function (SIF) PAHH-003 was used. These are deemed the target reliabilities for these barriers. HAZOP identified these barriers for the given scenarios as they were defined as able to prevent the scenario by being effective (big enough, strong enough, and independent of the cause) e.g.to barrier has appropriate set points, and are able to react in time (especially important when considering human actions related to an alarm), and are sized adequately for the scenario.

An additional property of a barrier is the ability for the barrier to be auditable i.e. The barrier can be evaluated to verify that it can operate correctly when it is called upon. This is defined, by its reliability and any documentation which can be utilised to prove its effectiveness, independence and reliability. When assuming or claiming a reliability i.e. PFD for a barrier, a certain testing frequency is required to be achieved to ensure that the reliability values used with the LOPA are correct. These have to be achieved and documented during operation. The following paragraphs gives an example of how a SIF barrier targets can be set, including the barrier management strategy.

Table 1:Sample HAZOP findings

Item #	Parameter	Guideword	Deviation	Causes	Consequences	Existing Safeguards	Bowtie
1	Flow	No	No flow of process gas	Manual Valve inadvertently closed	Loss of Train production Blocked vapour outlet of column Potential overpressure of Column, potential LoC, toxic release, fires and three or more fatalities Design pressure of system is 15 barg	TAH-001 FAL-002 PAHH-003 PSV-004	Bowtie 1 Threat 2

Table 2:Sample LOPA findings

Consequence Category		Initiating Cause	Failure frequency per year	Frequency Modifier	Probability	IPL	Probability of Failure on Demand	Results
Safety	E Potential for 3 or more fatalities due to toxic release, fires	Human error during a task that is performed between once per month and once per week:	0.1	No modifier is applied as the operation is continuous i.e. 100% probability of operation	1	TAH-001 and FAL-002 Alarm was not taken as an IPL as there is sufficient safeguards in place.	1	**Target frequency** 1E-5 **Mitigated Event Frequency** 1E-5
						PAHH-003 shuts ESD via logic at 12 barg	0.01	
						P SV-004 lifts at 15 barg	0.01	

SIL Verification

Safety integrity level (SIL) verification is a process which verifies that safety instrumented functions can indeed meet the target reliability which was claimed within LOPA. The target in the LOPA is stated in the form of PFD, which can also be expressed as a safety integrity level (SIL), or risk reduction factor (RRF).

Table 3 and Table 4 show an example highlighting the assumptions used within the SIL verification process to calculate the reliability of PAHH-003 ESD function. The table highlights that for the SIF to meet the required target, a SIF component such as the actuator/valve is required to have offline overhaul testing performed at a minimum rate of once per year, partial stroke testing is required to be performed at a minimum rate of 6 months per year, and any repairs or bypassing of the valve should not exceed a duration of 72 hours. This information, together with other data which is shown in a document known as the safety requirement specification (SRS - performance standard for SIFs) will form the basis of the barrier strategy for the PAHH, and any tasks required to ensure that the testing requirements are met will be recorded as safety critical (operational aspects of the barrier).

Table 3:SIL Verification findings

	Function	SIL Classification	SIL Verification Results
PAHH-003	To detect high high pressure within the Column	SIL 2	Meets SIL 2 requirement

Table 4: Assumptions Crucial in Assuaring SIF Reliability

PAHH-003 Components	Node Category	DU Failure Rate(Per Year)	Test Interval (month)	Partial Stroke Test Interval (Month)	Annual Frequency or Probability	Assumed Repair Time and Test Time (Hrs)	Diagnostic Coverage (%)	Proof Test Coverage	Partial Stroke Test Coverage
Pressure Transmitter (Generic)	Un-revealed	1.1E-03	12	N/A	N/A	24	90%	95%	N/A
Pressure Impulse Line	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Signal Splitter/Isolator (Generic)	Un-revealed	1.3E-03	12	N/A	N/A	24	90%	95%	N/A
PLC 1oo2D	Un-revealed	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Unidirectional flow regulator	Un-revealed	1.0E-02	6	N/A	N/A	4	0	100%	0
Generic 2-Way Solenoid	Un-revealed	5.1E-03	12	6	N/A	72	0	90%	60%
Valve - Regulator Pilot Valve	Un-revealed	9.7E-02	12	6	N/A	72	0	90%	60%
Actuator/Valve - Ball (FC) - Hard Seat - Pneumatic (ESD)	Un-revealed	1.8E-2	12	6	N/A	72	0%	90%	60%

The HAZID, HAZOP, LOPA, and SIL verification processes are example studies that provide an auditable trail from hazard identification, barrier identification and barrier performance assurance.

The aim of this approach was to ensure that the risks to persons are evaluated and managed in accordance with company risk and asset management procedures to demonstrate that all risks are ALARP.

Bowtie Analysis

A Bowtie diagram illustrates the relationships between the hazard, the causes of its realization and its potential consequences. It also includes control and recovery measures in place to prevent the realization of a hazard as well as to mitigate its consequences.

The bowtie was constructed using the findings of the studies to demonstrate to stakeholders that there is adequate diversity and redundancy in the control measures (appropriate to the specific plant risks) as per the studies conducted for the plant.

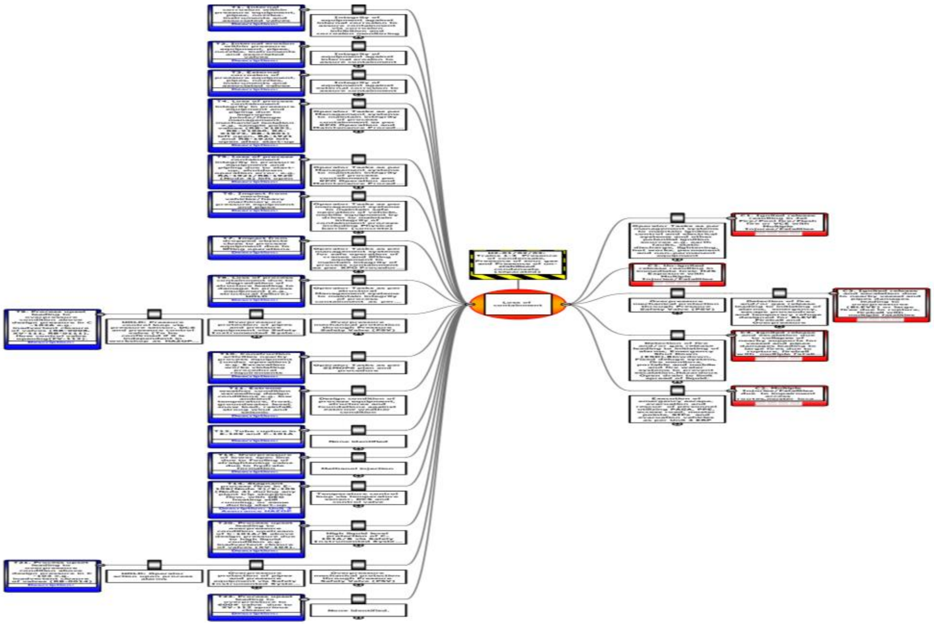
Figure 4 shows a sample bowtie diagram. At the centre of the diagram are the hazard (yellow circle in the centre) e.g. flammable toxic gas, and top event (black and yellow chequered box above the circle) e.g. loss of containment of toxic and flammable gas. The top event represents the release of the hazard. On the left hand side, there are the identified potential causes/threats (blue boxes) which if not stopped could lead to the top event. On the right hand side the potential consequences (red boxes) is shon e.g. ignition of flammable gas with 3 or more fatalities.

Barriers that prevent the cause/threat releasing a hazard (top event) are shown in black between the threats and the top event. Whilst, barriers that prevent the top event from developing further into a consequences are termed mitigative barriers.

All barriers were required to have at least one safety critical activity associated with it for which highlighted the task required to ensure the reliability of the barrier during operation.

Although not shown in the below, degradation factors for barriers and their controls can also be highlighted on bowties. These controls are typically organisational systems that are in place to handle potential changes in plant conditions.

Figure 4: Sample Bowtie



Technical, operational and organisational barriers identified within the risk assessment studies were further scrutinised to verify their validity. To satisfy the operational and organisational the bowtie exercise involved ensuring that the safety critical tasks and processes identified in the risk assessment studies are all clearly documented in the bowtie. The bowtie exercise ensured that all personnel positions related to the safety critical activities are identified and shown, to highlight those responsible for the design, implementation, operation and maintenance of identified barriers, and any organisation processes and personnel in place to handle identification and control of any potential barrier degradations is clearly defined.

The diagram is also a visual communication tool for all levels of personnel and further demonstrates that operational safety depends on both safety equipment and also the actions of individual persons.

Table 3 Safety Critical Activities and Positions

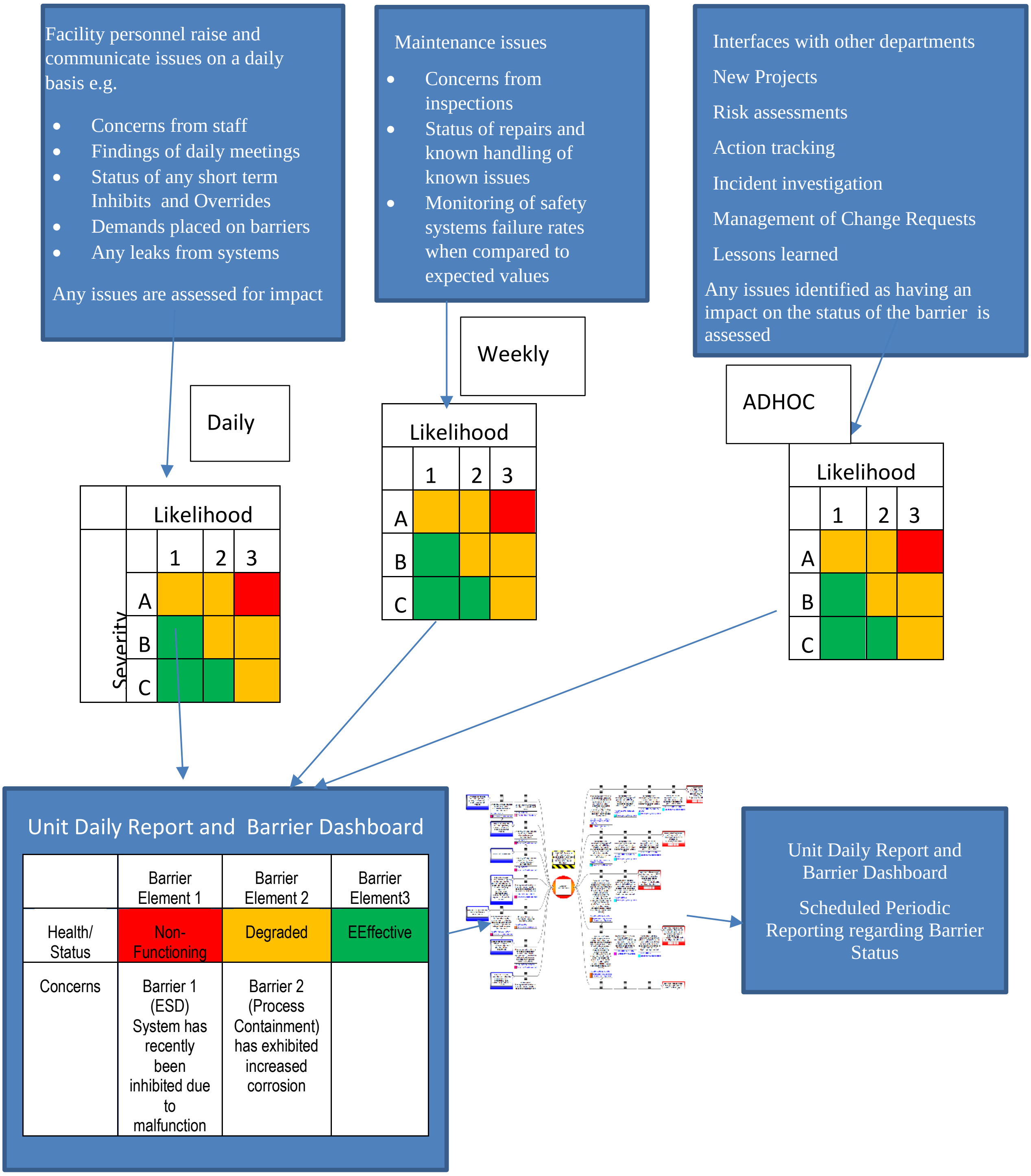
Act. Ref.	**Bow-Ties**	**Critical Activity**	**Activity Description**	**Responsible**	**Documentation**	**Verification**
A001	1	Perform inspection and function test of ESD System Equipment & Logic as per the performance standard	Perform function test, maintenance, control room monitoring, testing of ESD System Equipment & Logic.	Control and Instrumentation	Operational Performance Standards for,ESD System Equipment	Maintenance Manager to check the status of maintenance of safety critical elements weekly

The following section discusses, how the findings of the risk assessments and bowties were used during operation to make decisions during the COVID pandemic.

Description of Barrier Management in Operation

The facility utilised the risk assessment and risk management studies undertaken during barrier establishment to formulate an operational barrier management strategy. The strategy involved systems to monitor barrier performance during the operation of the plant. The system was a structured approach to support the delivery of safe and sustainable operation, taking into account any ageing concerns, and ensured that identified barriers were functioning as per the performance standards specified during the risk assessments. Figure 5 highlights the approach taken at the plant to identify operational issues, maintenance issues or organisational changes that can impact the current barrier arrangements. The change in manning requirements during COVID triggered a requirement for further investigation via management of change mechanism. This is discussed in the following paragraphs.

Figure 5 :Operational Integration



COVID de-manning requirements sample Case

At the onset of the COVID pandemic, management were required to minimizing the number of personnel onsite and align with COVID spacing requirements set by the government. A set of roles were identified as being impacted by the potential de-manning requirements. It was identified that this could have a significant impact on the safety of the plant via the management of change process.

As per Figure 5, the impact required further risk assessment to determine how reducing the manning would impact safety. The roles to be considered were discussed in a workshop, and compared against the safety critical positions identified during risk assessments and highlighted in the bowtie. One of the roles that was identified was the control and instrumentation engineer, his role was identified as safety critical in the safety studies and bowtie. This highlighted, that there was a potential to impact safety on the plant if the measures were rolled out.

A further assessment was conducted to ensure that there were adequate resources available within the maintenance team to perform the tasks allocated to the role, additionally the personnel in those roles would be required to be of adequate competence. The findings of the assessment were incorporated to ensure that any changes to manning would not compromise performance tests for the ESD systems. With the implementation of the recommendations, it was concluded that there would be no compromise on safety critical tasks and activities due to changes in manning levels.

Conclusion

The Oil and Gas Industry is constantly evolving and increasing in complexity. Operators are seeking new strategies to increase the auditability and connectivity between disciplines and their studies. Barrier management is a developing methodology that is utilised, to systematically establish and maintain barriers so that the risk faced at any given time can be handled. This is achieved by preventing undesirable incidents from occurring or by limiting the consequences should such accidents occur. Barrier management includes the processes, systems, solutions, measures and tools which must be in place to ensure the necessary risk reduction through its implementation. Barrier management establishes an easily communicated risk picture.

The paper demonstrate how an integrated barrier management approach is currently being applied at an existing facility. The focus of the paper was on the transition from HAZID, HAZOP, LOPA, Sil Verification, Bowtie and operational risk management.

All the fundamental requirements for safe operation of a hazardous plant such as understanding the hazards to safety and environment, provision of adequate equipment and facilities, use of systems and procedures to safely operate equipment, with routine performance monitoring, audits and improvements, appropriate organisation including staffing, communication and training to maintain facilities, equipment, systems and procedures, adequate measures must be in place to handle any foreseeable emergencies are covered within the approach. The efficient approach and the ability to define a non contradictory risk picture also aids in promoting a strong culture of safety within the facility.

This paper highlighted how such robust practice can be utilised in practise to aid in quick decision making such as the COVID crisis.

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