Integrated PHA approach for an Auditable Barrier Management Regime

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Presentation agenda

- Introduction
- Objective
- Barrier Management Principles
- Facility Description
- Description of Barrier Establishment
- Description of Barrier Management in Operation
- Conclusions

Introduction

Oil and gas facilities are inherently dangerous due to the hazardous inventories involved.

The fundamental requirements for safe operation of a hazardous plant:

- Understanding the hazards to safety and environment.
- Provision of adequate equipment / facilities.
- Use of systems and procedures to safely operate equipment, with performance monitoring.
- Appropriate organisation including staffing, communication and training to maintain facilities, equipment, systems and procedures.
- Adequate measures in place to handle any foreseeable emergencies.
- Effective arrangements in place to promote a strong culture of safety.

What this paper presents?

To address these risk management issues at an existing facility:

- Integrated barrier management approach, focusing on the transition from HAZID, HAZOP, LOPA, SIL Verification, Bowtie and operational risk management.
- Aim is it ensure a sustainable operational risk management approach (termed as barrier management).
- Highlight **methodology** that was used to establish:
  - Plant risk picture by identifying hazards, their barriers, the adequacy of the barriers,
  - Required barrier performance, the calculated barrier reliability, and
  - Critical assumptions used to determine the barrier reliability.
- Outline how the critical assumptions formed the basis for a maintenance regime and the basis for monitoring potential barrier degradation at the plant, by considering a **case study example**.

Barrier Management Principles

A **Barrier** is defined as a measure intended to identify conditions that may lead to failure, hazard and accident situations, prevent an actual sequence of events occurring to limit damage or loss.

Good Barrier Management Strategy

- Organisation can understand when current operations are deviating from base assumptions for underlying studies.
- Organisation can measure and verify the performance of the barriers.
- Organisation has systems to maintain control of factors that could impact the performance of the barrier, such as weather (MOPO), temporary activities such as (SIMOPS), and manning and long-term issues such as changes in organisation, degradation of materials and modifications).
- Organisation has systems to ensure that the process is continually fit for purpose.
- Organisation has systems to ensure that personnel are competent (are aware of how their tasks impact safety).

Barrier Management Principles

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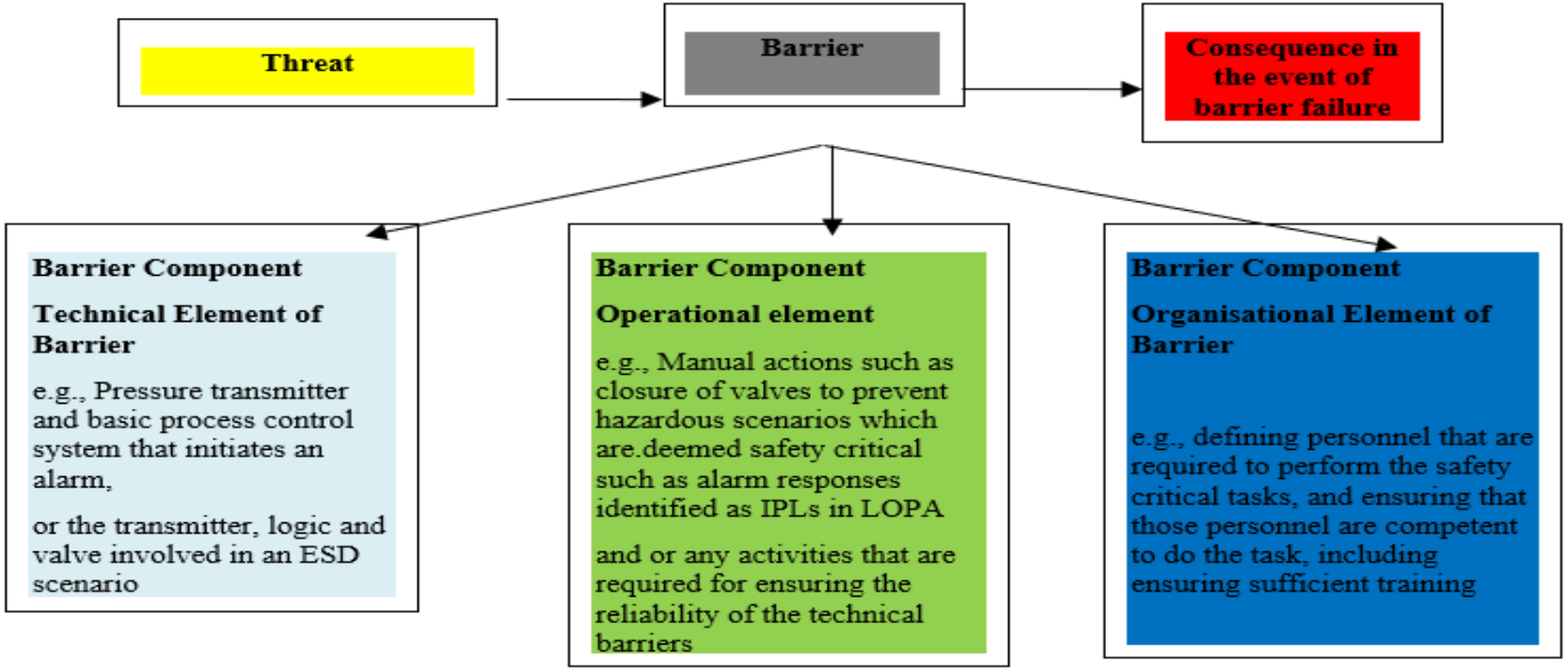
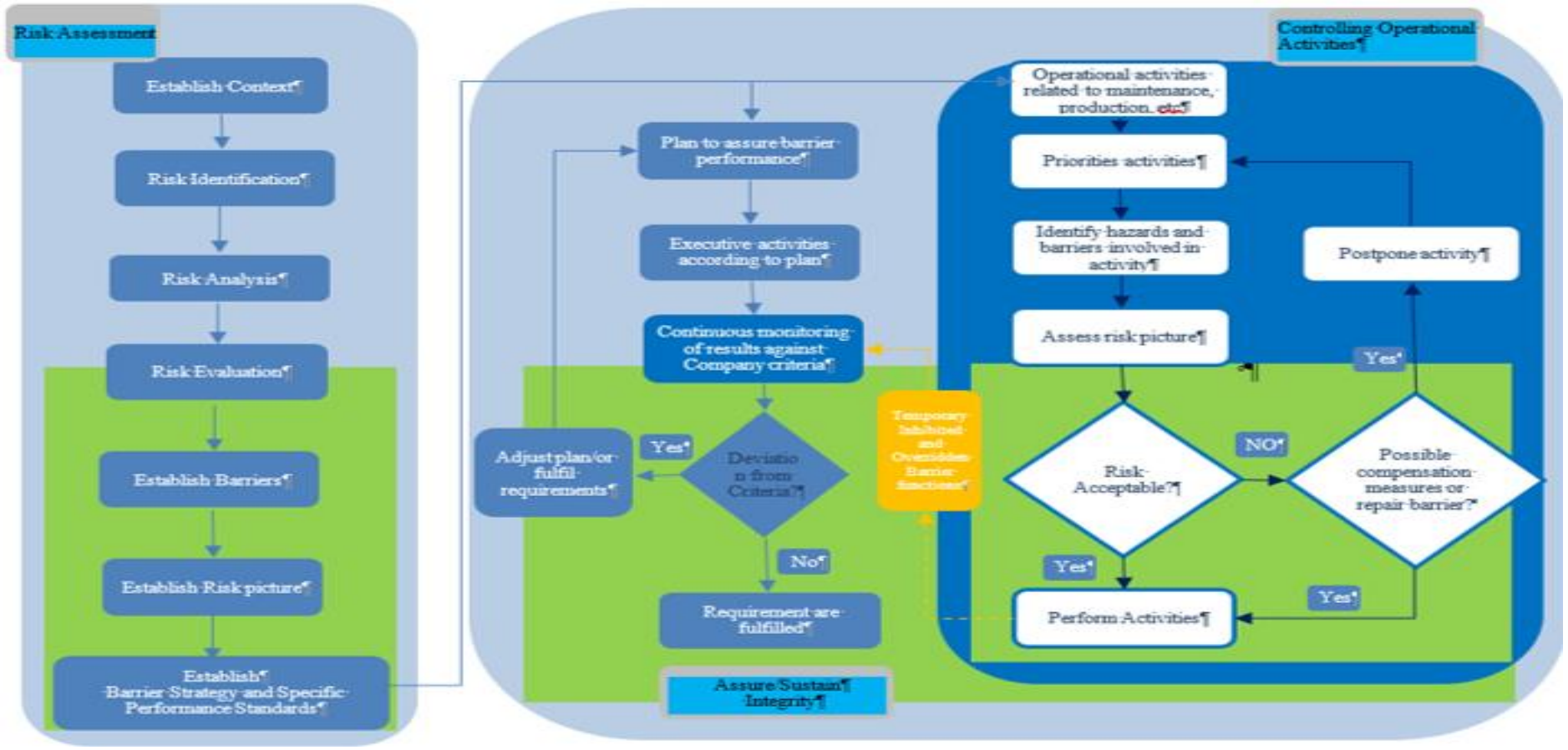


Barrier Management Principles

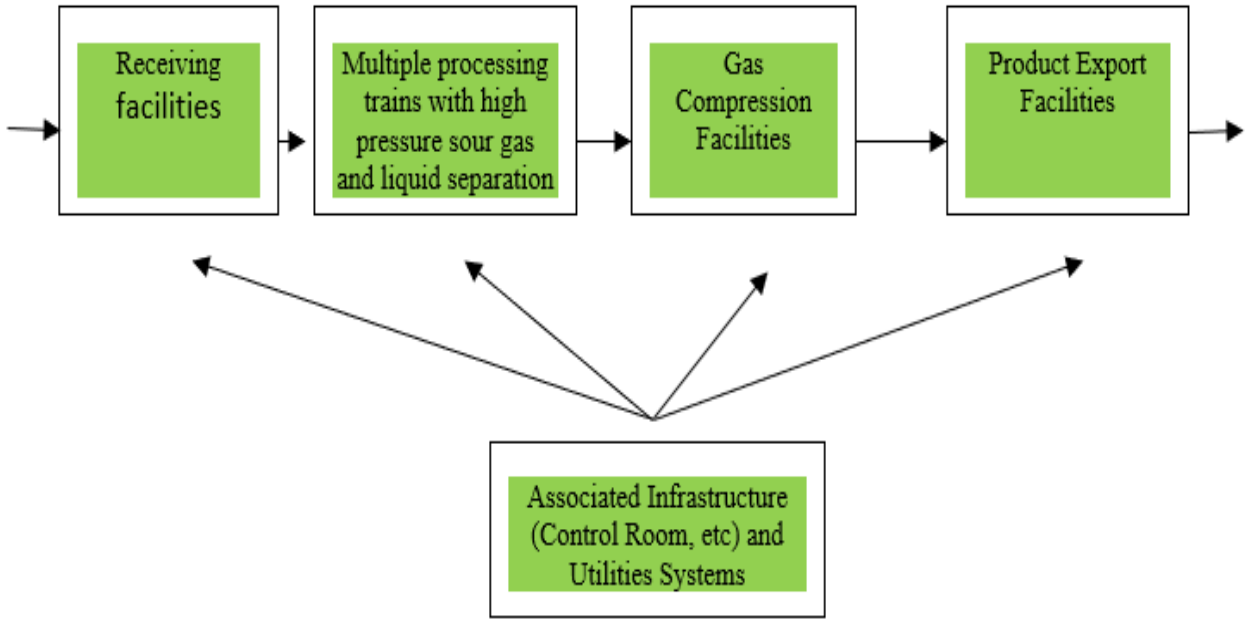
Management Workflow & Management Process



Facility Description – Case Study

Sour Gas Facility

- Facility comprised of a sour processing facility handling high pressure hydrocarbon.
- Consist of :



Description of Barrier Establishment

Risk Assessments and Risk Management

- 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 (RBI, SIMOPS, EERA and FERA). However, this study focuses on the flow from HAZID, HAZOP, LOPA, SIL verification studies.

Description of Barrier Establishment

Risk Assessments and Risk Management - Hazard Identification Study (HAZID)

- HAZID analysis formed the platform for the hazard assessments. All potential significant safety hazards that could occur at the plant were identified and considered at a high level.
- 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.
- 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 EERA and FERA were utilised to identify and establish the adequacy of the mitigative barriers.

Description of Barrier Establishment

Risk Assessments and Risk Management - Hazard and Operability Study (HAZOP)

- HAZOP identifies specific failure, accident and hazard scenarios caused by deviations from expected process conditions and determines specific barriers elements and their specific functions.

An example major hazard accident scenario that was identified:

- Manual error could lead to overpressurisation of a column leading 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 / improvement of barriers was then generated.

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

Description of Barrier Establishment

Risk Assessments and Risk Management - Layer of Protection Analysis (LOPA)

- Additional assurance on adequacy of risk reduction measures for scenarios which could cause fatalities (higher consequence scenarios - HAZOP to LOPA) - **Semi-Quantitative LOPA approach.**
- The technique compares hazard event frequencies with company specified tolerable target frequency. It uses standard probability of failure on demand values for the barriers identified as valid within the HAZOP, and compares the calculated event frequency, considering the barriers reliability.

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	

Description of Barrier Establishment

Risk Assessments and Risk Management - Layer of Protection Analysis (LOPA)

- 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 e.g. barrier has appropriate set points and can 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.
- 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.

Description of Barrier Establishment

Risk Assessments and Risk Management - 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).

Tables show an example highlighting the assumptions used within the SIL verification process to calculate reliability .

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

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%

Description of Barrier Establishment

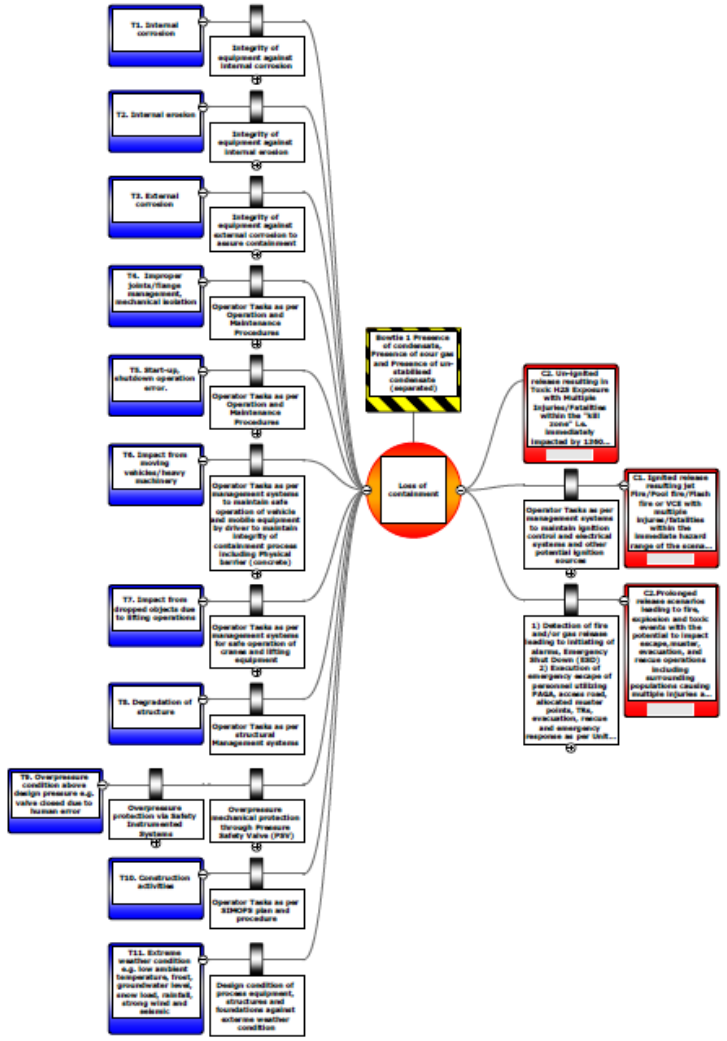
Risk Assessments and Risk Management - SIL Verification

- **The previous tables 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.
- Together with data in the **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).

Description of Barrier Establishment

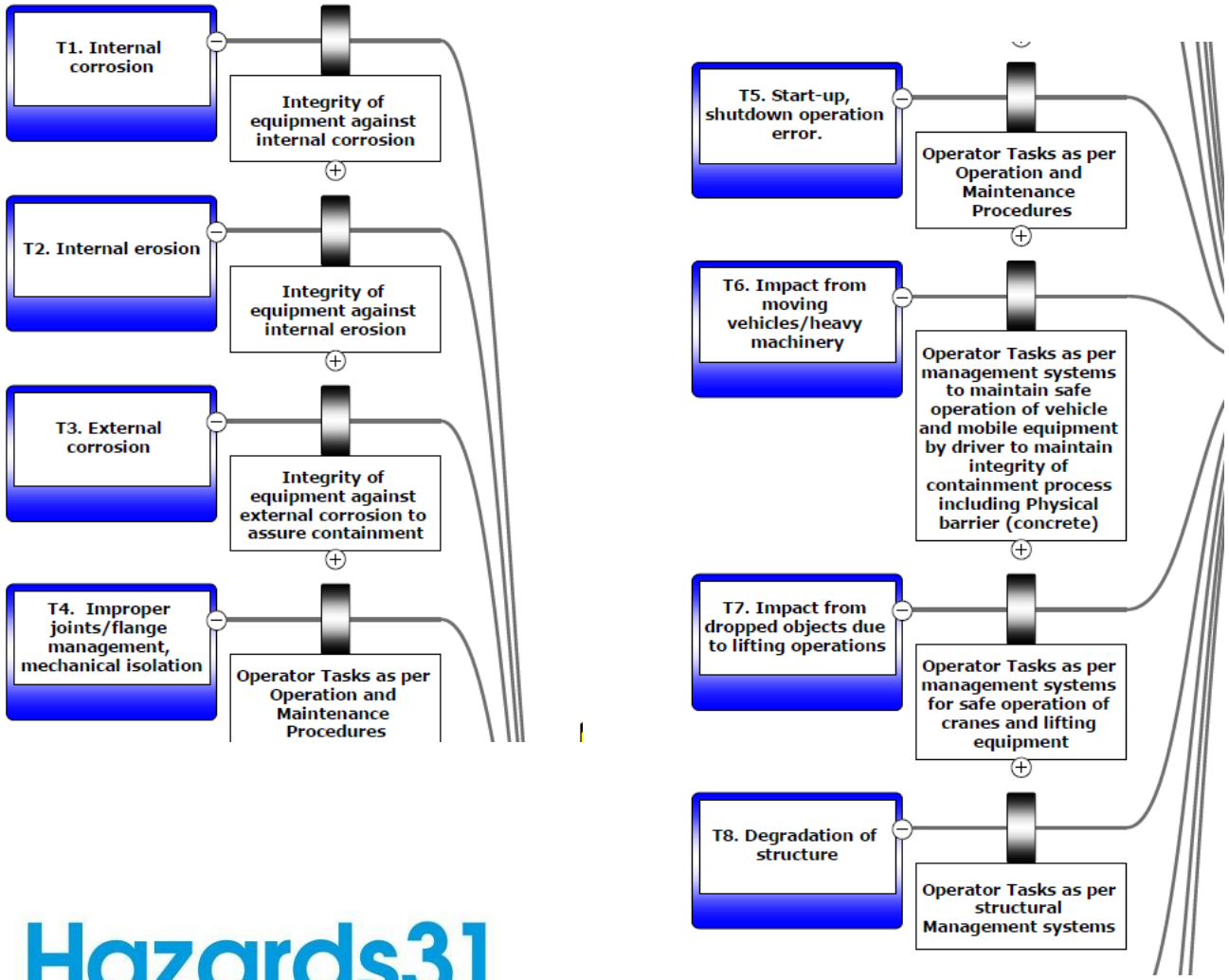
Risk Assessments and Risk Management - Bowtie

- A Bowtie diagram illustrates the relationships between the hazard, the causes of its realization and its potential consequences. It includes control and recovery measures
- The top event represents the release of the hazard.
- Barriers that prevent the cause releasing a hazard (top event) are shown in black between the threats and the top event.
- All barriers were required to have at least one safety critical activity associated with it.
- Degradation factors for barriers and their controls can also be highlighted on bowties.



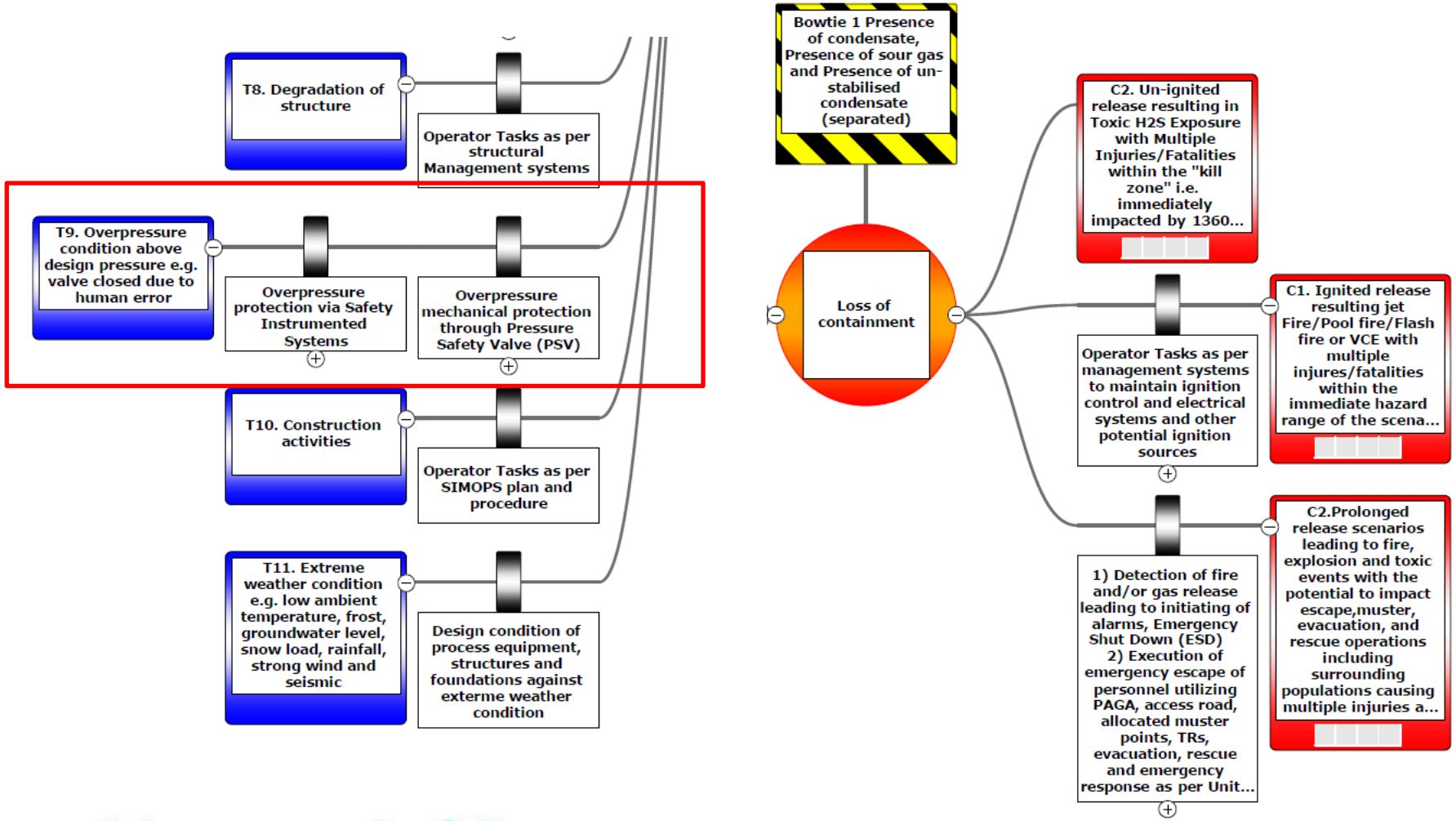
Description of Barrier Establishment

Risk Assessments and Risk Management - Bowtie



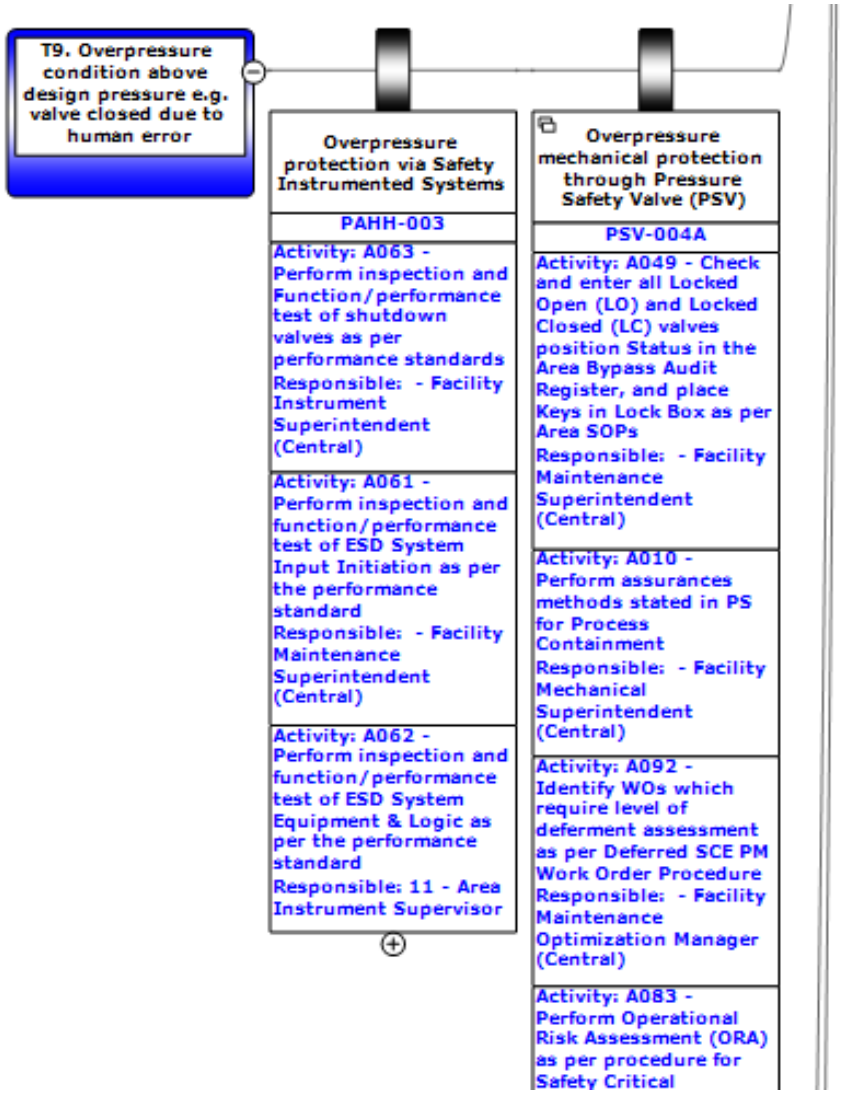
Description of Barrier Establishment

Risk Assessments and Risk Management - Bowtie



Description of Barrier Establishment

Risk Assessments and Risk Management - Bowtie



Hazards31

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Description of Barrier Establishment

Risk Assessments and Risk Management - Bowtie

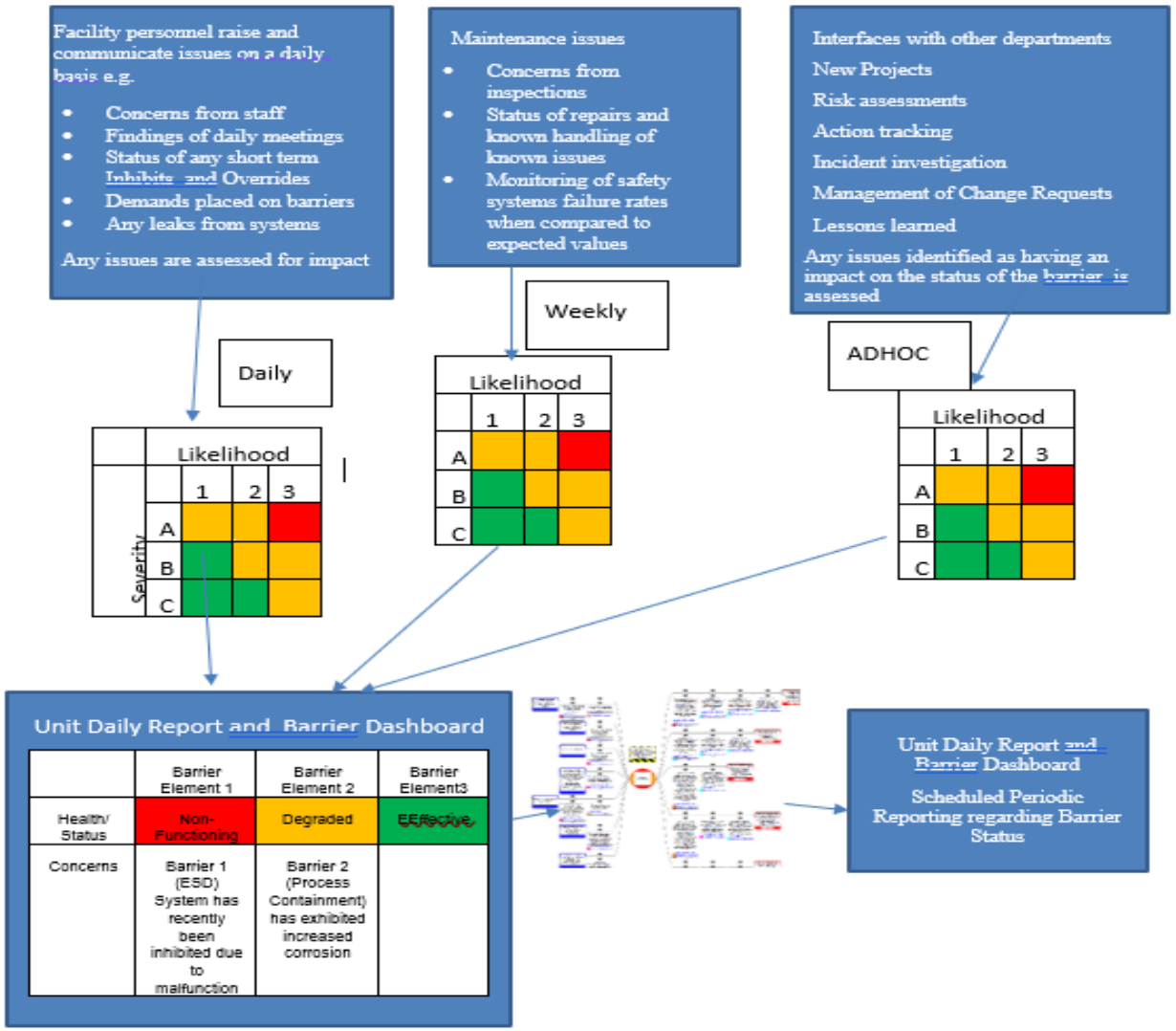
- The bowtie ensured that all personnel positions related to the safety critical activities are identified: responsible for the design, implementation, operation and maintenance of identified barriers, and any organisation processes and personnel in place
- Handle identification and control of any potential barrier degradations is clearly defined.
- The diagram demonstrates that operational safety depends on both safety equipment and 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

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.
- Systems to monitor barrier performance during the operation of the plant. Taking into account any ageing concerns and ensured that identified barriers were functioning as per the performance standards specified during the risk assessments.
- The Figure (to the Right) highlights the approach taken at the plant to identify operational issues, maintenance issues or organizational changes.



Description of Barrier Management in Operation

COVID de-manning requirements

- **A set of roles were identified** as being impacted by the potential de-manning requirements.
- The roles to be considered were discussed in a workshop and compared against the safety critical positions.
- 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.
- Further assessment was conducted to ensure that there were adequate resources available within the maintenance team to perform the tasks allocated to the role.
- 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

- 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.
- Paper demonstrate how an **integrated barrier management approach** was applied at an existing facility and focuses on the transition from HAZID, HAZOP, LOPA, Sil Verification, Bowtie and Operational Risk Management
- Paper highlighted how such robust practice can be utilised in practise to aid in quick decision making such as the COVID crisis.