The Nuts and Bolts of Process Safety Management

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This paper provides an insight into efficient operational management of Process Safety at a Top Tier COMAH onshore gas processing plant. Presenting an effective process safety rhythm, it describes how conducting regular meetings and reviews orchestrates the comprehensive management of process safety at the site.

The aim is to promote continuous improvement, by presenting a complete process, with the hope that the reader can cherry pick those aspects that could improve or inspire their own systems. In presenting at Hazards 30 the authors hope to engage in dialogue that will challenge our own process, ultimately building on the strength of the current foundations and making an even more robust process.

Introduction

The Central Area Transmission System (CATS) comprises a fixed offshore riser platform linked to the Everest gas platform in the UK Continental Shelf, a 404km long subsea pipeline connecting 34 producing fields and an onshore gas processing terminal at Teesside in the North of England. Gas is transported from the Central North Sea areas to the terminal, where it is then processed on behalf of major North Sea gas producers before being exported to the national grid.

Since 2015, 99% of the CATS business has been owned by Kellas Midstream Ltd (hereinafter the owner) and operated in partnership with Wood to operate the terminal and pipeline. Wood (hereinafter the operator) are the Operator and Duty Holder.

The aim of this paper is to provide an insight into how process safety is managed at an onshore gas processing plant. CATS is very proud of the behaviours, processes and systems in place. Whilst recognising the fragility of such records, it is worth noting that CATS has 16 years of operation without a lost time injury (LTI) and 15 years without a Notifiable Dangerous Occurrence. The focus of process safety management at CATS is prediction: picking up the weak signals, the minor events that are the precursors to major events. These are analysed to identify common causes or trends and actions required to improve equipment, system, procedural inadequacies and behavioural barriers to major accident hazards.

Having a management process is not on its own sufficient to deliver good performance. There are key elements which contribute to a positive process safety culture: the performance and attitude of people, the environment they work in, the standard of equipment on site and the specific management policies. By no means comprehensive, the following is a list of other elements which the authors believe work in CATS' favour:

- Being a small (approximately 90 core staff), self-contained site with a single team approach.
- Considerable investment in fabric maintenance, by both the original and current owners. This started very early in the life of the Terminal and continues to this day. Care of the asset by the owners translates into pride taken by the work force in housekeeping and maintenance.
- High equipment reliability that allows schedule stability and less firefighting, therefore more time to be proactive with managing process safety.
- A policy of having zero safety critical overdue work orders.
- Realistic scheduling and expectation of 'wrench time'.
- A culture of looking out for each other, able to challenge and stop the job when required (19 recorded 'stop the job' events in 2018).

Process safety management at CATS is orchestrated by a series of regular meetings and reviews. Whilst far from unique, the combination of inputs, frequency of review, action creation and follow up is successful at CATS and in presenting it here, the authors hope that there will be interest in the process as a whole and specific aspects that could add value to similar processes elsewhere. We also hope to initiate a conversation to learn and improve from others.

The process relies on:

- Making it easy for the whole site population to report events, incidents, observations and good practice. This requires a healthy reporting culture, accessible tools and appropriate expectations of how often personnel should be reporting.
- Holding the appropriate breadth and depth of review with the appropriate personnel. This will range from a daily morning meeting to determine immediate corrective action, to an annual review to identify common causes and trends. The process tries to ensure immediate concerns are addressed without losing sight of cumulative effects.
- Identifying appropriate actions, recording them and following up to ensure appropriate completion.
- Ensuring that lessons learned are captured and shared appropriately.
- Creating a formal process to give understanding to senior personnel in both owner and operator organisations of the risks and process safety issues at site and securing their endorsement.

Organisational structure

To aid understanding of the descriptions that follow it is necessary to describe some of the details of the CATS organisation. There is a core of individuals (the site leadership team) who have a role to play in most of the meetings and reviews. Other functions and roles which support the CATS organisation which are not significantly involved in the process safety management process are not described.

The operator organisation for CATS provides an on-site core team with various functions providing remote support from offices elsewhere in the UK. It is shown in Figure 1 below.

The CATS Manager, with overall responsibility for the terminal and the pipeline is based on site, leading a small but experienced local leadership team, consisting of the Operations & Maintenance Manager, Projects & Engineering Manager, Technical Manager and HSSE Advisor.

To a degree, the owner organisation mirrors that of the operator team. There are direct counterparts for the CATS Manager, Operations and Maintenance Manager and Technical Manager. There are multiple interface points between the two teams, direct communication is encouraged and facilitated by regular formal and informal contact. This underpins the long-term partnership between owner and operator, which is far removed from a traditional client / contractor relationship.

The Operations & Maintenance Manager is supported by the Maintenance Team Leader, the shift-based Operations Team Leaders and the Operations Engineer (process engineer supporting day to day operations).

Overall responsibility for Risk Management and Process Safety lies with the Technical Manager, which ensures continual focus on process safety during leadership team meetings.

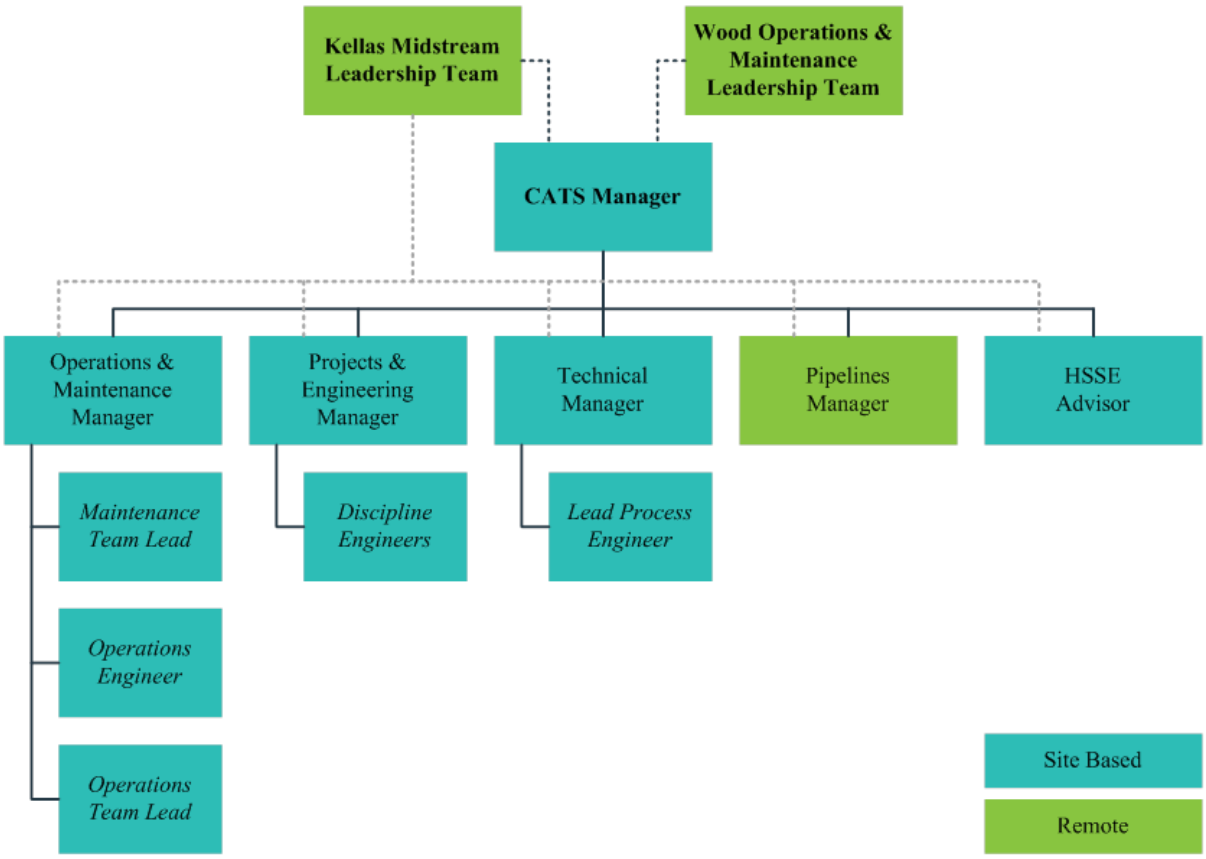

Figure 1: CATS Organisation for Process Safety Management

CATS Process Safety & Risk Rhythm Description

The CATS Process Safety Management System can be described through the rhythm of its regular meetings and reviews. These combine to give an appropriate level of action, review, oversight and endorsement. Figure 2 below summarises the rhythm, displaying typical inputs and outputs and the frequency of each meeting. These are described in more detail in the subsequent sections.

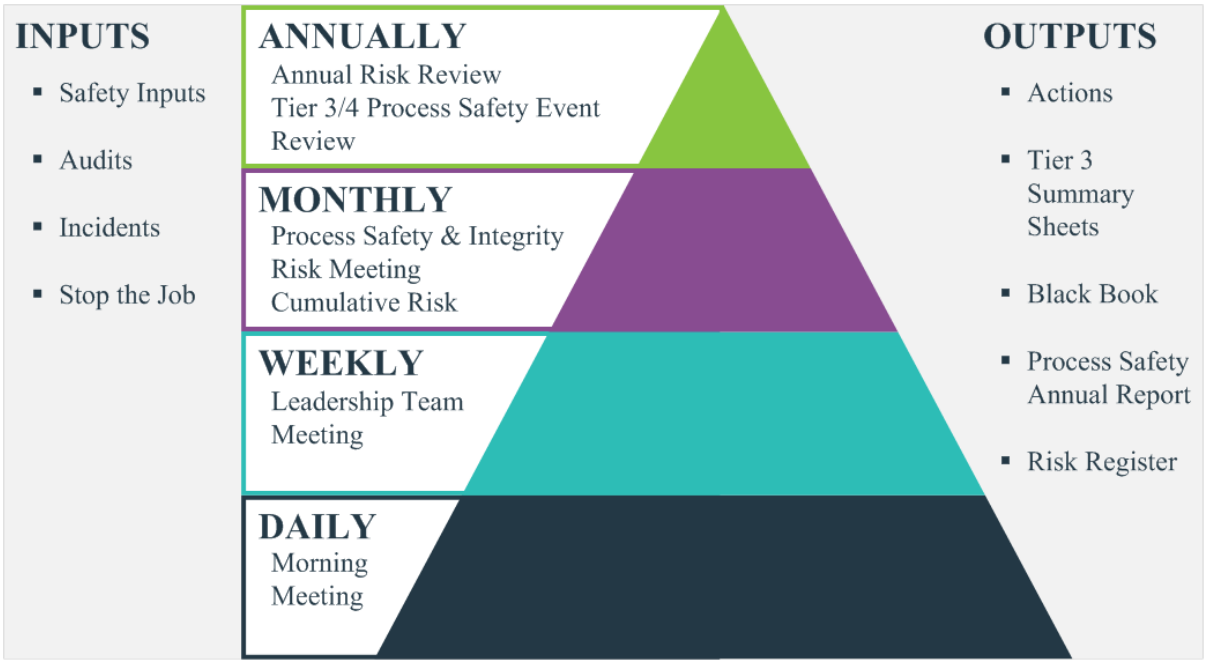

Figure 2: CATS Process Safety Meeting Rhythm

Morning Meeting

Title: **Morning Meeting**
Frequency: **Daily**

Key Inputs:

- Safety Inputs
- Daily Operations & Production Summary
- Work Orders & Planned Activity Summary

Key Aims:

- Review safety inputs raised since previous morning meeting
- Review safety and production issues relating to the operation of the plant
- Prioritise work orders raised since previous meeting
- Consider key activities planned that day
- Determine if there are any immediate process safety concerns

Chair

Operations Manager

Attendees

On-site Leadership Team
CATS Operations Team
CATS Engineering Team
HSSE Advisor
Planning & Scheduling

Figure 3: Morning Meeting Summary

Safety Inputs are records of events, incidents, observations and good practice across a wide range of HSE, Process Safety and Risk topics such as isolation and permit audits, safety conversations, stop the job incidents, documentation errors, general housekeeping issues, etc. Each month there is an expectation for all onsite personnel to contribute a minimum of two Safety Inputs.

Personnel submit Safety Inputs into a centralised spreadsheet. Safety Inputs from the previous day are reviewed by the HSSE Advisor before discussion in the meeting. This discussion may result in further actions, e.g. simple checking activities, plant changes requiring a work order, document or procedure changes or detailed investigation.

For relatively minor and short timescale issues, the follow up will take place during subsequent Morning Meetings. Significant issues will escalate to follow on meetings and reviews. Where a safety related barrier has been downgraded or disabled, an Operational Risk Assessment (ORA) will be conducted that day to determine if continued operation is tolerable and if additional risk mitigation measures are required.

The Morning Meeting also includes a summary of key production issues, a review of any new work orders and a summary of key activities planned for the day ahead. Any process safety or risk-based concerns are discussed, and actions raised as appropriate.

Leadership Team Meeting

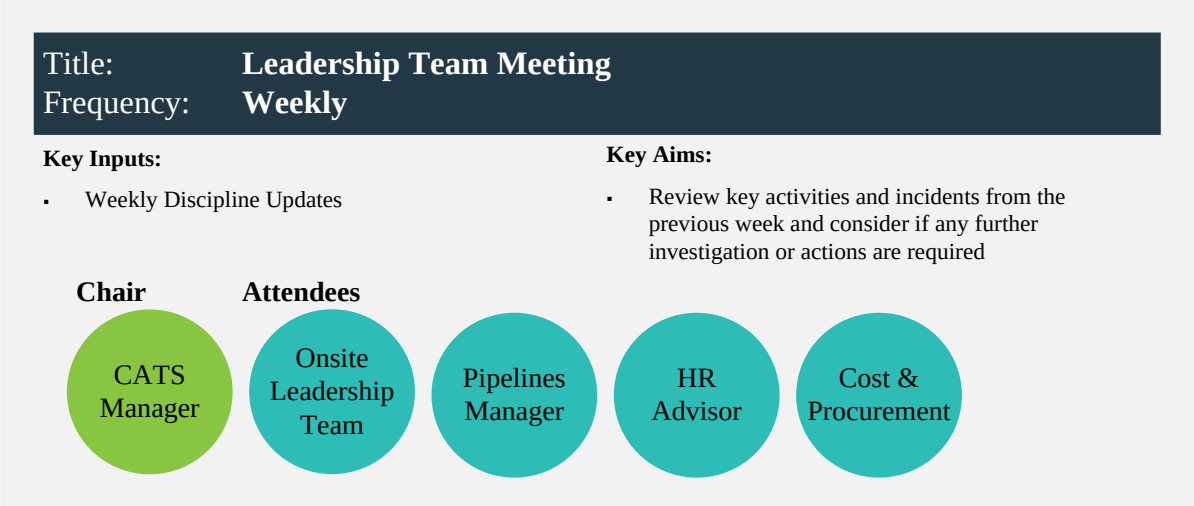

Figure 4: Leadership Team Meeting Summary

The weekly Leadership Team Meeting is an opportunity for the onsite leadership team to review all aspects of the operation and management of the site. This includes any significant process safety or risk event that has occurred in the previous week and updates on progress of any ongoing process safety related investigations or longer-term issues.

The meeting also acts as an additional forum to identify possible future risks that may need development. Any such risk would be noted and actioned as required – ranging from an immediate response to being discussed in the subsequent Monthly Risk Meeting, depending on priority.

Risk Meeting

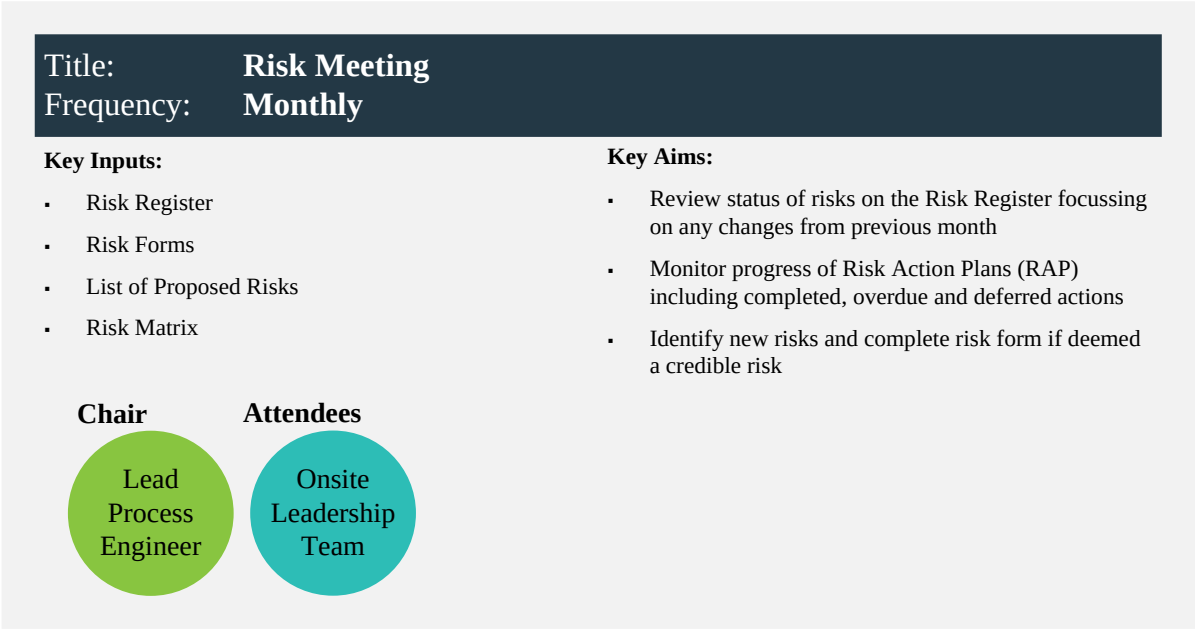

Figure 5: Risk Meeting Summary

CATS maintains a risk register, which contains risks relating to major accident hazards (MAH), activities that are a fundamental change to the business or operation and perceived threats to the business, particularly from third party activities. The register excludes risks that will be fully mitigated by the established processes and procedures.

Risks can be identified at any level in the organisation and at any time, not just in dedicated sessions such as Hazard Identification (HAZID) or Hazard and Operability (HAZOP) studies. The monthly Risk Meeting is a dedicated multi discipline session and serves to identify new risks and review potential risks that have been identified through other routes.

The Risk Register includes three types of risk:

- Enduring Risks

  Risks that are inherent to the operation and cannot be removed entirely. Existing risk controls and mitigations are judged to be as low as reasonably practicable (ALARP). Prevention and mitigation barriers in place are documented. Regular barrier audits test the robustness of each barrier.

- Active Risks

  A risk that is present due to a gap or deficiency in the protective barriers. Active risks have a Risk Action Plan (RAP) to close the gap and reduce the risk. Once a RAP is complete, active risks may be closed out or transferred to enduring risks depending on the level of residual risk.

- Project Risks

  A risk that is associated with a specific 3rd party project affecting CATS assets (typically the onshore and offshore pipelines). CATS owned projects are managed by the established process so will not be on the register unless there are exceptional circumstances. Project risks list existing prevention & mitigation barriers and have a RAP which is completed prior to the activity being executed.

Each risk has a Risk Form which contains the full details of the Risk, its assessment and RAP. The Risk Register and Risk Forms are live documents. Any changes are reviewed in the Risk Meeting. Subsequently the revised Risk Register is issued to the owner's leadership team along with a brief summary of changes and action status for that month.

Formal notification and endorsement of risks is required. The level of review and endorsement is determined by its position on the Risk Matrix. Risk endorsement ranges from the onsite leadership team for minor risks up to owner leadership and operator Business Unit leadership for major risks.

Certain Enduring risk barriers will be subject to internal assurance activities through Control of Work audits (e.g. permit audits and isolation audits). An internal program of enduring risk barrier audits is also implemented, such that all the prevention and mitigation barriers associated with individual risks are examined to confirm they are being implemented robustly.

Process Safety & Integrity Meeting (PSIM)

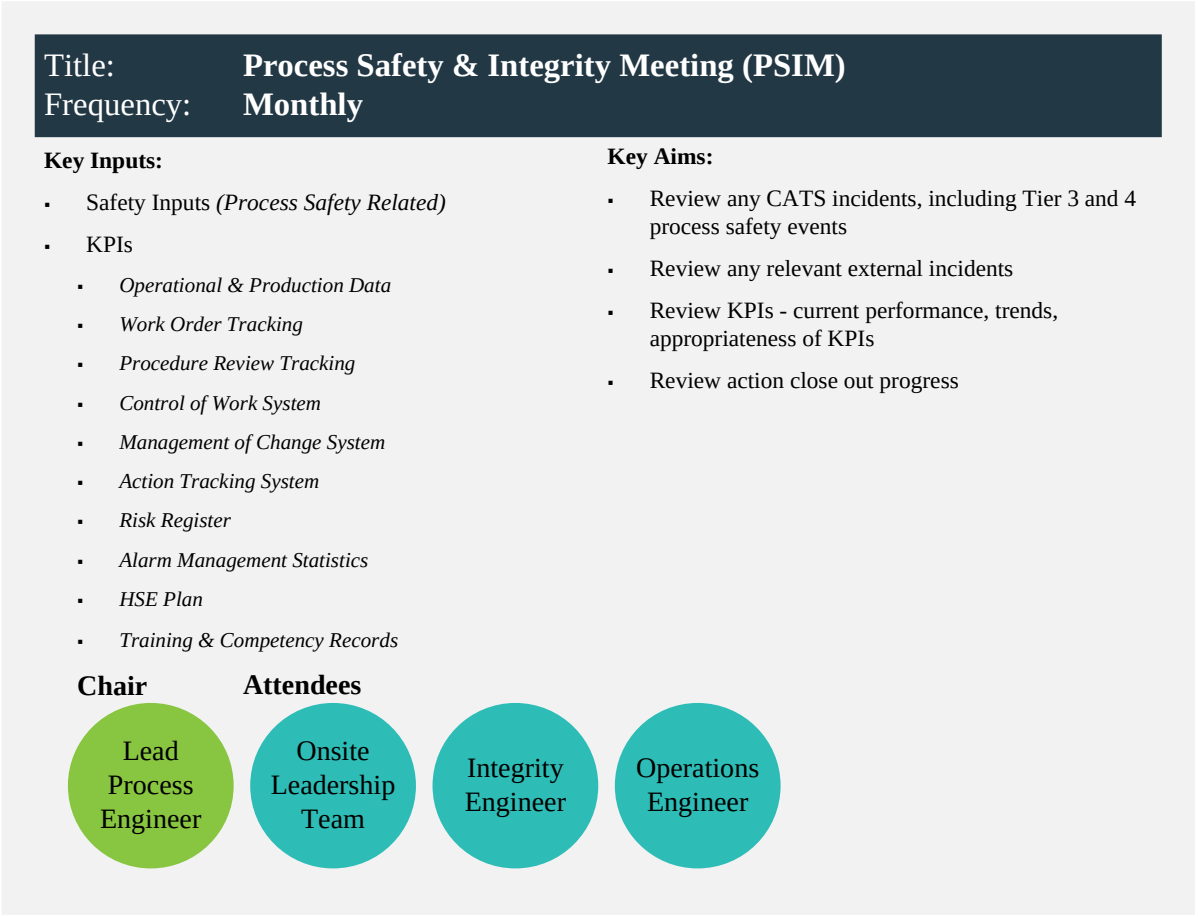

Figure 6: Process Safety and Integrity Meeting (PSIM) Summary

The PSIM is held monthly to review process safety Key Performance Indicators (KPIs) and events that have occurred at the Terminal or Pipeline in the previous month. Relevant events from elsewhere in industry are reviewed for any lessons learned for CATS.

The KPIs indicate the health of critical systems and processes across the Terminal and the Pipelines. The KPIs were initially derived following the methodology in HSG 254 'Developing Process Safety Indicators'. Since then, the KPIs have been modified based on experience from the PSIM and learning from other companies.

Multiple stakeholders input data into a KPI tracker prior to the meeting. The system allows easy data inputting, analysis and review of trends. KPIs are assessed on a traffic light basis (Red/Amber/Green) against agreed targets. The tool also displays the KPIs in a bowtie, which groups together related KPIs. If there are a number of deficiencies in in a single area, such that a process safety barrier may be weakened, this is easily spotted, and remedial actions identified.

Process safety events are categorised using the four Tier system based on API 754 guidance. The definition of a Tier 4 event has been modified to allow capture of events where there was a breakdown of an internal process or procedure. This captures more events and helps to identify 'weak signals' of issues with a process safety critical system or process. A description of the tier system used at CATS and the extent of investigation for each tier is summarised in Table 1 below.

Table 1: Process Safety Tier 1 to 4 Events Summary

Tier	Description	Investigation Summary
1	LOPC of Greater Consequence	Full detailed investigation
2	LOPC of Lesser Consequence	Full detailed investigation
3	Challenges to Safety Systems, operating limit excursions, inspection findings resulting in repair, minor leaks under 50kg	Review at PSIM Incident summary form completed and distributed to all relevant personnel and added to the Black Book
4	Incidents/Near Misses and identified improvements to Safety Processes, Procedures & Documentation	Review at PSIM No formal investigation Tracked actions may be raised

Since the Tier system was implemented, there have been no Tier 1 or 2 incidents at CATS. Typically, there are around one Tier 3 and three to four Tier 4 incidents per month; this is regarded as a positive indication that there is a culture of open and honest reporting and allows improvements to be made to the processes and systems.

The Black Book is a collation of CATS incidents to capture the lessons learnt from each one. It is part of the required reading matrix for engineering and operations roles and requires signed acknowledgement that an individual has read and understood the content.

Every 6 months the PSIM conducts a 'watermelon review' following ABB guidance. Any KPIs that have remained green during the previous 6 months are critically examined to determine their suitability and identify alternative KPIs that may be a better test of the robustness of the process.

Cumulative Risk Meeting

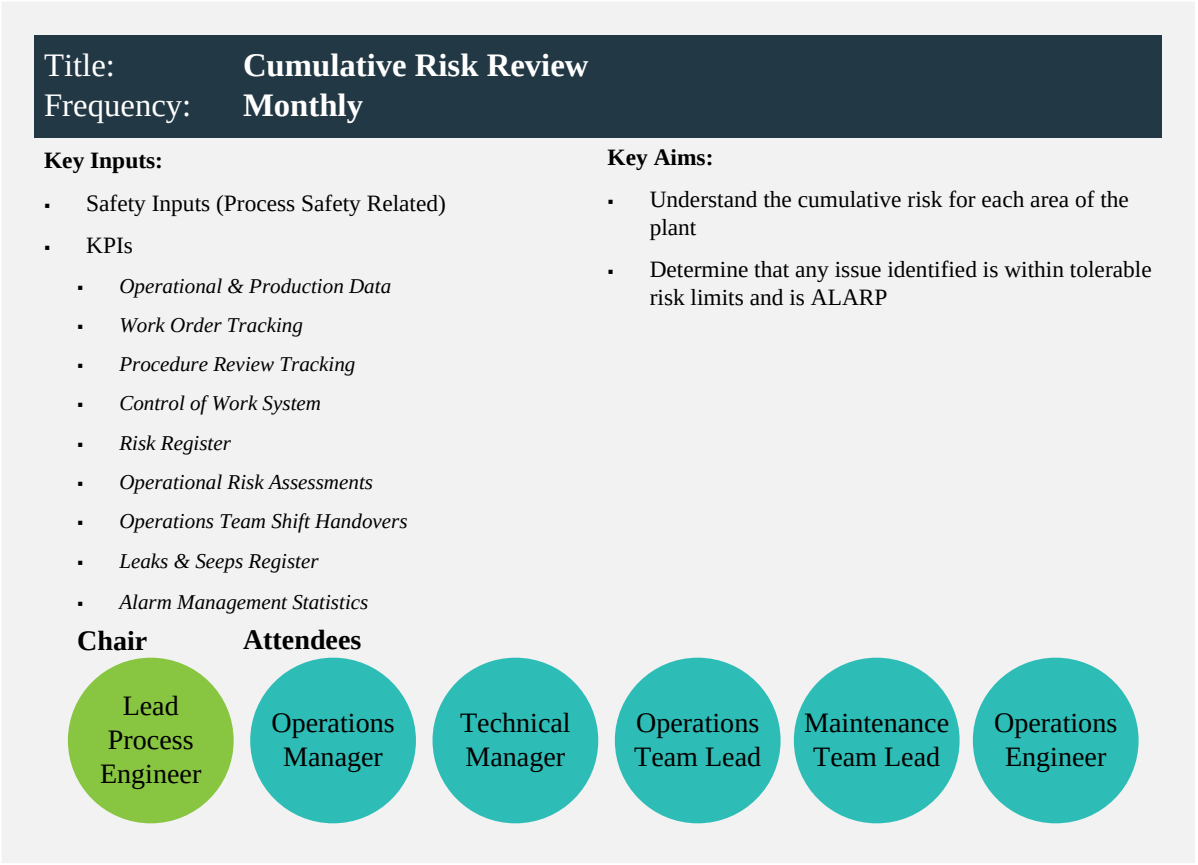

Figure 7: Cumulative Risk Meeting Summary

The Cumulative Risk Review considers a wider view of operational risk than the Risk Meeting. The process looks for interactions between specific deviations and influencing factors which may create an increased risk of a major accident occurring. The process is based on the Oil & Gas UK Cumulative Risk Guidelines. The guidelines were originally developed to help offshore installations manage the safety implications of a backlog of safety critical maintenance. CATS does not allow safety critical maintenance to go overdue, but has found significant value in the process.

Deviations are known deficiencies e.g. active risks, ORAs, overdue non-safety critical work orders, gaps in competency, etc.

Influencing factors are any factors associated with workload, the local plant area or personnel that could make an incident more likely. These include workload, type of work, leaks and seeps, standing or supressed alarms, staff morale, fatigue and the potential for risk normalisation.

The Cumulative Risk process splits the plant into processing areas and for each area qualitatively assesses whether the risks are understood and adequately controlled, by reviewing a suite of KPIs. The potential outcomes are shown in Table 2 below.

Table 2: Cumulative Risk Review Outcomes

Description	Outcome
GREEN - Zero or minimal deviations with no interactions.	No additional risk reduction measures required - cumulative risk understood and under control, risk is ALARP. Mitigations in place to manage individual deviations
AMBER - Some deviations, no immediately concerning interactions, but potential exists for risk level to be increased substantially on the addition of any more deviations.	Reprioritisation of existing tasks required - Operations continue, but reprioritisation required to remain in control of cumulative risk
RED - Considerable deviations or clear interactions that substantially increase risk level. Remedial action is required.	Additional Risk Reduction required - Operations can continue, but certain deviations must be resolved immediately, e.g. stopping certain tasks

The cumulative risk process has many benefits. By categorising the different elements of process safety and risk into the different areas, it can highlight common themes and reveal issues that were not initially apparent looking at the individual data. An overview of the different areas that have been amber or red in any month is also reviewed during the Annual Risk Review; this allows further analysis to identify longer-term themes.

Annual Risk Review

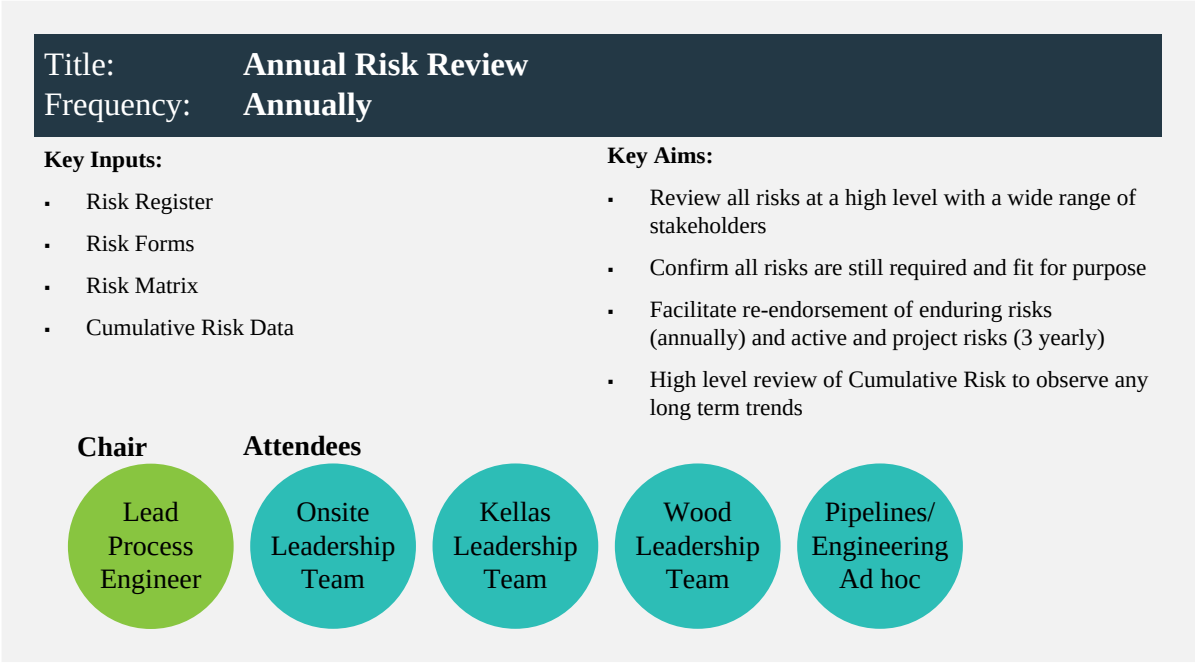

Figure 8: Annual Risk Review Summary

The Annual Risk Reviews consider each entry on the Risk Register in depth with a larger team than the monthly Risk Meetings. Two separate sessions consider Terminal risks and Pipeline risks, so a focused team reviews a manageable amount of risks each time.

Although owner and operator leadership are updated throughout the year of any significant changes or progression, the Annual Risk Reviews provide an opportunity for them to review the full set of risks.

Each risk is individually reviewed to determine if risks are still valid, new risks are required and if further work is required due to changes and updates against RAP progress.

The main goal of the meeting is to ensure all risks are up to date and ready for required re-endorsements. High-ranking Enduring Risks are re-endorsed annually, and all other risks are re-endorsed on a 3-year cycle, keeping the risks relevant and senior management informed.

Tier 3/4 Process Safety Event Review

Figure 9: Annual Tier 3/4 Process Safety Event Review Summary

The annual Tier 3 and Tier 4 event review is first conducted with the CATS Leadership Team, before being shared with the owner's Leadership team in a second review.

All Tier 3 and Tier 4 events from the year are reviewed to identify any common themes or negative trends in performance and generate corrective actions. Comparison with historical themes is also made to ensure that lessons have been learned and changes implemented.

Individual events have already been considered during the monthly PSIM and the annual review allows similarities and themes to be identified. Events could be linked by common areas of the site, common failure modes, similar types of equipment, etc. These connections would not necessarily be easily identified from the normal monthly process due to the events being spread out over several months or even years.

The review also provides the opportunity to open the discussion up to a wider audience than the monthly sessions, allowing a fresh view, initiating new and different actions. It also gives an opportunity to review these events again, which in some cases allows further information to be added that was not available during the initial monthly meeting, for example, this could include findings from a detailed investigation.

Case Studies

To best illustrate the function of the meetings and the connectedness of the process, two case studies are presented below. The first concerns the response to a faulty blowdown (emergency de-pressuring) valve, the second considers a staffing issue. The trigger event is summarised and then the study follows the progression through the meeting structure.

Case Study 1: Train 1 Gas Dehydration Reduction in Blowdown System Redundancy

Event	
Train 1 Gas Drying System is depressurised in an emergency via two blowdown valves, V-001 and V-002, which open simultaneously. Flow through each valve is controlled by restriction orifice (RO). V-002 fails to open during a routine test. Initial investigation finds that the valve is effectively seized and must be removed for repair or replacement.	
Effect on Process Safety & Risk Rhythm	
Morning Meeting	Following immediate discussions between the Operations Team Leader and the Operations and Maintenance Manager, the failed test is discussed in the next Morning Meeting. The issue is raised as a Safety Input and as part of the Operations Team Daily Update. Following discussions, an operational risk assessment (ORA) is raised to allow the plant to continue operation relying only on depressurising via V-001. To repair or replace V-002 the processing train would require to be shut down and depressurised. The ORA concludes that the risks associated with shutting the train down, depressurising, carrying out the work and starting the train back up again are greater than the risks of continuing to operate the plant with only V-001, which are loss of redundancy and a tolerable extended blowdown duration. ORAs have a limited timeframe based on risk tolerability therefore, initiate investigation of longer-term solution to allow operation of Train 1 to continue until the next planned shutdown.
Leadership Team Meeting	The incident is discussed during the following week's Leadership Team Meeting and progress with the investigation is reviewed. It is identified that any proposed change would likely require approval from the Process Technical Authority (TA) and a management of change (MOC) to be completed. An action is raised to begin engaging the TA to ensure the proposed solution can be implemented prior to expiration of the ORA.
PSIM	The incident is raised as a Tier 3 Process Safety Event on the basis that it is a safety system not operating correctly on demand (during a test). An incident summary sheet is produced summarising the incident. Once complete, this will be distributed to relevant personnel to ensure they are aware of the incident and any lessons learned are shared both onsite and beyond.
Cumulative Risk Review	Failure of V-002 influences several Cumulative Risk KPIs in Train 1 including open ORAs, unapproved deviations from technical standards and Tier 3/4 events. This is also combined with increased work activity and several overdue procedure reviews in the area. Hence Train 1 is categorised as 'amber' until the MOC and TA approval is completed. Therefore, reprioritisation of existing tasks is required but operations continue. Limitations relating to vehicle movement and lifting in the area are put in place to reduce the likelihood of an event occurring in the area that would require the system to be blown down in an emergency.
Annual T3/T4 Event Review	During the Annual Tier 3/4 Event Review, it is noted that V-002 has a history of similar failures due to actuator failures. The previous solution had been to increase trip test frequency prior to overhauling the valve as part of a train TAR. The subsequent failure considered in this case study means that the overhaul had not adequately resolved the issue. Based on the history of this failure, when the original design is reinstated, a new valve will be installed rather than overhaul the existing valve for a second time.
Implemented Solution	
The solution for allowing continued long-term operation of the system until the next Train TAR is to replace the RO downstream of V-001 with a new RO that has an area equal to the total area of the two existing ROs downstream of V-001 and V-002. At the next Train TAR, the original design will be reinstated. The solution restores the design blowdown time. The loss of redundancy is a deviation from original design which is reviewed and approved by the TA. Full implications of the change are assessed via the MOC process. Implementation of the solution results in the ORA being closed and the Cumulative Risk category for Train 1 returning to green and the restrictions on vehicles and lifting being removed.	

Case Study 2: Gas Administration Role Staffing Issues

Event	
The Gas Administrator at CATS is responsible for managing the gas pipeline. It is a production and safety critical role that is covered 24 hours a day, 7 days a week by five members of staff on a rotational shift basis and one on day hours. When one of the five shift Administrators is unable to fulfil their duties, this results in an increased workload for the remaining four by having to cover the shifts of the absent staff member. This is not uncommon and has happened previously. However, on this occasion during the period of absence a second Administrator is also unable to complete their duties. Concerns are raised regarding fatigue of the remaining three staff members.	
Effect on Process Safety & Risk Rhythm	
Morning Meeting	The on-shift Gas Administrator attends the Morning Meeting to provide an update on the status of the pipeline. The issue of shift cover is discussed when problems are foreseen and short-term solutions put in place to ensure all shifts are covered. This includes the Gas Administrator day role covering shifts rather than fulfilling their normal role.
Leadership Team Meeting	The issue is discussed during the next leadership team meeting, which the site HR advisor also attends. Additional measures are identified, including creation of an emergency cover role, a short-term solution to cover critical aspects of the role, when no other cover is available. This solution allows additional cover to be put in place without the lengthy timescale required to fully train someone to cover all aspects of the role. The vulnerability of this role to lack of cover is also recognised, concluding that an Active Risk should be created to implement a longer-term plan to mitigate the risk in future.
Monthly Risk Meeting	During the monthly risk meeting, an active risk form is completed for the reduced availability of the Gas Administrator role. The risk is added to the risk register and actions assigned to ensure long-term cover is provided and to train a second member of each shift team to provide the critical aspects of the role.
Cumulative Risk Review	The issue is flagged during the next cumulative risk review. There are also ongoing inlet gas specification issues which increase the Gas Administrator workload, raising a fatigue concern. As a result, the area is scored as amber and an action is raised to stop non-essential additional Gas Administrator work and move essential additional duties to the day role or the operations engineer.
Annual T3/T4 Event Review	The Gas Administrator issues are raised in the next annual risk review, through the cumulative risk trend analysis and review of the individual active risk. It is identified that there are other critical roles on site that could lead to similar production or safety critical gaps if the roles could not be filled for any reason. An action is raised to consider a new risk to cover loss of staff in critical roles.
Implemented Solution	
The short-term issue is resolved when all 5 members of the Gas Administrator team return to their normal shift patterns. The active risk remains open until all actions are complete to prevent the issue being repeated in future.	

Summary

Process safety management at CATS is effectively orchestrated by a series of regular meetings and reviews. The key elements are considered to be: facilitating a healthy reporting culture; holding the appropriate breadth and depth of review with the appropriate personnel; ensuring a core of key personnel are involved in the majority of those reviews; active management of actions; communication of lessons learned and ensuring buy-in from senior personnel. CATS is keen to continuously improve its process, which is the key driver for sharing and engaging in conversation with other operators.

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