# Callide Power Station Unit C3 Incident Report

August 2025

# Investigation summary and actions

**Overview**

On 4 April 2025, Callide Unit C3 experienced a significant boiler pressure event following the fall of a large clinker (hardened ash) into the furnace ash system. This event disrupted flame stability, resulting in a delayed unit trip and subsequent re-ignition. While no injuries were reported, the incident caused notable equipment damage and necessitated an extended outage of approximately two months. The nature of the event carried the potential for serious harm and has prompted a thorough review of operational safeguards, response protocols and our Process Safety Improvement Program.

**Our investigation**

CS Energy initiated two complementary review processes:

1. **Root Cause Analysis (RCA):** Focused on the technical sequence of events and equipment issues that led to the incident.
2. **Incident Cause Analysis Method (ICAM):** Examined these technical issues in a broader context to identify contributing factors.

**Primary technical findings**

The primary technical findings included:

- Clinker management controls were not fully effective.
- Protection system delays prolonged fuel admission after flame loss.
- Sub-optimal combustion and equipment condition increased the tendency for clinker formation.
- Fuel quality visibility and blending constraints limited proactive control.

**Contributing factors**

Contributing factors to the incident included inadequate risk control, poor planning and scheduling, operator shortages, gaps in operator training, and insufficient progress in embedding process safety in the organisation. Flaws in the original design of the C3 unit impeded the detection of flame loss in the boiler and delayed the shutdown of the unit.

**What we have done**

CS Energy's response began immediately and included:

- A review of C4 functional safety standards, equipment condition and critical safety systems to ensure that the C4 unit was safe to operate.
- Completed all necessary repairs and safety inspections/unit testing to Unit C3 before it returned to service on 1 June 2025.
- Updated the operator clinker management tool and trained operators on the use of the tool. Implemented clinker de-load procedures and parameters that ensure correct de-loading is observed at all times.
- Upgraded the maintenance strategy upgrades for sootblowers, hydrojets and burner components.

- Reviewed and changed protection logic thresholds and acceptance criteria for burner and boundary air performance.
- Commencement of actions to prevent recurrence.

**Actions underway**

The actions underway include:

- Reprioritise the Process Safety Improvement Program.
- Embedding a structured competency program for operators, including updated clinker formation and combustion management modules.
- Ongoing review of critical safety systems (turbines, boilers and high voltage) standards and test methodologies.
- The conversion of bow ties into training material.

**Actions planned**

The actions currently planned include:

- Engineering improvements to reduce iron ingress and to minimise clinker formation in the ash system.
- Systemised end-to-end testing of the “flame loss to fuel isolation” sequence against defined performance standards.

**Our commitment**

We are committed to learning from this event and continuously improving to deliver a safer, better CS Energy for the benefit of our people, our communities, and our customers.

Since April 2025, we have made wide-ranging improvements across our systems, processes, and training to deliver safer, better operations. A detailed **Action List** overseen by CS Energy leadership, ensures every finding is linked to a specific action and is tracked to completion.

# Callide C3 Significant Pressure Event

Root Cause Analysis Investigation Report

14 July 2025

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# 1.0 Executive Summary

On 4 April 2025, Unit C3 at Callide Power Station experienced a significant pressure event following the dislodgement of a large clinker from the furnace wall. The clinker fell into the water hopper of the Submerged Chain Conveyor (SCC), triggering a rapid steam release and total flame loss across all operating mills. A delayed unit trip allowed unburnt pulverised fuel to accumulate and subsequently re-ignite, causing a pressure excursion (explosion) that exceeded the boiler's design threshold. While no injuries occurred, the incident posed a credible risk of serious harm and was classified by CS Energy as an Actual Category 3 and Potential Category 4 event.

CS Energy initiated a dual investigation: a Root Cause Analysis (RCA) focused on technical failures, and an Incident Cause Analysis Method (ICAM) facilitated by The Jonah Group to examine systemic and organisational factors. The RCA identified two immediate causes:

1. Clinker fall.
2. Total flame loss.

Two primary root causes were determined:

1. Ineffective clinker management, including compromised cleaning systems and incomplete deload procedures.
2. Latent design flaws in the flame detection system, which delayed protective trip signals.

Eight contributing factors were also identified, including:

1. Delays in fuel cut damper closure.
2. Indeterminate coal quality.
3. Operation on two lower mills.
4. Trade-offs in combustion tuning.
5. Ineffective clinker cleaning tools.
6. Subjective clinker assessment practices.
7. Unclear deload procedures.
8. SCC design vulnerabilities.

Corrective actions were implemented prior to the unit's return to service on 1 June 2025, including updates to the clinker assessment tool, flame detector calibration, and damper response optimisation. Longer-term recommendations target improvements in operator competencies, burner and clinker management equipment maintenance strategies, combustion tuning procedures, and ash handling system design.

It revealed critical gaps in system integration, performance standards, and organisational discipline.

# 2.0 Introduction

## 2.1. Incident Overview

On 4 April 2025 at 04:35 AM, a large clinker dislodged from the furnace wall of Unit C3 at Callide Power Station and fell into the water hopper of the Submerged Chain Conveyor (SCC). The resulting steam release caused total flame loss across all operating mills.

A delayed unit trip allowed unburnt pulverised fuel to accumulate within the furnace, which subsequently re-ignited. This re-ignition triggered a pressure excursion that exceeded the boiler's design threshold, resulting in significant pressure event which caused structural damage including the boiler casing, insulation, and surrounding platforms.

Although no one was physically harmed, the incident had clear potential to cause serious injury to personnel had they been in the immediate vicinity. CS Energy classified the incident as an Actual Category 3 and Potential Category 4 event, which triggered a formal Incident Cause Analysis Method (ICAM) investigation.

CS Energy led both the Root Cause Analysis (RCA) and ICAM investigation. The RCA was conducted internally and focused on the technical sequence of events and immediate failures. The ICAM, facilitated by The Jonah Group and reporting directly to a CS Energy-appointed sponsor, examined the systemic issues, failed safeguards, and deeper organisational factors that influenced decisions, behaviours and operational performance.

## 2.2. Objectives and Scope

This Root Cause Analysis (RCA) was undertaken to investigate the Unit C3 boiler incident that occurred at Callide Power Station on 4 April 2025. The primary objective of the RCA was to determine the technical causes of the event, evaluate the effectiveness of existing controls, and identify improvements to reduce the likelihood of recurrence.

The objectives of the RCA were to:

- Reconstruct the full sequence of technical events that led to significant pressure event
- Identify immediate, root, and contributing causes, using structured analysis techniques
- Assess the condition and performance of protective systems and control mechanisms
- Evaluate the adequacy of operational procedures, training, and response actions in place
- Recommend corrective and preventive actions to strengthen risk control, equipment reliability, and operational discipline
- Support compliance with regulatory requirements and drive organisational learning

The scope of the RCA included:

- Reviewing all available operational and control system data to map the incident timeline
- Examining the design, condition, and response of key equipment and safety-critical systems
- Assessing the procedures, roles and decision-making processes related to clinker management and furnace operation
- Identifying gaps in plant performance, system integrity, and frontline execution

This analysis provides a technical foundation to inform broader organisational learnings captured through the parallel ICAM investigation.

# 3.0 Methodology

## 3.1. Approach

This Root Cause Analysis (RCA) was undertaken using a structured, evidence-based methodology to identify the technical, operational, and systemic causes of the incident that occurred on Unit C3 at Callide Power Station on 4 April 2025. The investigation was guided by an established Root Cause Analysis (RCA) process. The aim was to produce findings that are accurate, defensible, and actionable, with a clear line of sight from causal pathways to preventive controls.

At the core of the analysis was a structured hierarchy of causes and contributing factors – immediate causes, root causes and contributing factors. This model enables investigators to distinguish between what triggered the event, what allowed it to happen, and what contributed to its escalation.

- Immediate Causes

The direct, observable event or condition that triggered the incident. This is typically the last link in the causal chain, such as a failure of equipment, loss of containment, or an unsafe act. In this case, the immediate causes included the fall of a large clinker, total flame loss, and a delay in isolating fuel. These are the proximate events that converted existing risks into actual consequences.

- Root Causes

The deeper systemic, procedural, or design failures that enabled the immediate cause to occur. These may involve poor engineering design, gaps in procedures, ineffective training, or the absence of appropriate monitoring and control systems. Root causes are not always visible in day-to-day operations but, if not addressed, will continue to pose an ongoing risk of recurrence.

- Contributing Factors

Conditions, behaviours, or decisions that increased the likelihood, duration, or severity of the incident but would not have caused it on their own. Contributing factors often reveal latent weaknesses in systems, tools, or human-machine interfaces that allow errors to propagate. These factors can erode the effectiveness of otherwise sound controls and compound the consequences once an initiating event has occurred.

The investigation applied a four-staged approach:

1. **Event Reconstruction**

   A verified timeline of technical and operational events was developed using control system data, logs, and operator accounts. This established a factual basis for causal analysis.

2. **Causal Analysis**

   Structured techniques including fault tree diagrams, 5-Why analysis, and bowtie evaluation were applied to trace cause-and-effect relationships and test the performance of safety controls. Contributing factors were mapped and validated against the relevant Callide C bowtie scenarios for uncontrolled combustion and furnace containment loss.

3. **Evidence Review and Testing**

   Hypotheses were tested using engineering data, site inspection findings, and input from technical subject matter experts. Findings were pressure-tested through internal workshops with engineering, operations, and safety teams.

4. **Validation and Corrective Action Planning**

   Findings and causal pathways were validated through structured multi-disciplinary workshops. Immediate and systemic corrective actions were defined and prioritised, with focus on addressing root causes and strengthening site-wide controls.

This systematic approach ensured that conclusions were not based on assumptions, isolated failures, or hindsight bias, but on verifiable facts and sound engineering judgment.

## 3.2. Investigation Team

The RCA team brought together subject matter experts from operations, engineering, and process safety disciplines. The team was led independently and supported by external specialists to ensure objectivity and is provided in Table 1.

**Table 1** - RCA Investigation Team

| Role | Area of Expertise / Position Description |
|---|---|
| Investigation Leader / Facilitator | Process Safety Improvement Program Lead |
| Team Member | Mechanical Engineer – Process Safety, Strategy & Standards |
| Team Member | Head of Process Safety, Strategy and Standards |
| Team Member | Head of Unit Plant Engineering |
| Team Member | Mechanical Engineer – Callide Power Station |
| Team Member | Mechanical Engineer – Unit Plant Engineering |
| Team Member | Control Systems Engineering Superintendent |
| Team Member | Control Systems Engineer – Electrical Engineering |
| Team Member | Shift Operator Technician – Callide Power Station |
| Team Member | Shift Operator Technician – Callide Power Station |
| Team Member | Shift Operator Technician – Callide Power Station |
| Team Member | Mechanical Engineer – Unit Plant Engineering |
| External Expert | Boiler and Coal Explosion Subject Matter Expert |
| Independent Observer | Independent ICAM Oversight |

## 3.3. Tools and Techniques

The following RCA tools were applied to develop and test causal pathways:

**Event Reconstruction:** Used to build a timestamped sequence of events using control system and plant data.

**Fault Tree Analysis:** Structured logic trees mapped how equipment, process, and human factors combined to trigger the incident.

**5 Why Analysis:** Applied to trace each immediate cause to its contributing and root causes.

**Bowtie Evaluation:** Control performance was assessed using the bowtie methodology to identify where preventive and mitigative barriers failed or were degraded.

### 3.4. Data Sourced

A wide range of data sources were used to support findings:

- Operator and supervisor interviews
- Control room logs and Integrated Control and Monitoring System (ICMS) reports
- PiVision and historian trend data
- Maintenance records and work order history
- Technical drawings and design documentation
- Physical inspections and post-incident photos
- Relevant risk bowties and furnace operation procedures

### 3.5. Constraints

Access to the affected area was limited by WorkSafe Queensland controls for one week post-incident. This did not affect digital data or the investigation timeline. Preservation of control system data and supporting evidence was ensured through standard incident protocols.

### 3.6. Validation and Corrective Actions

All root causes, contributing factors and control failures were validated through structured multi-disciplinary workshops involving operations, engineering, and process safety leaders. Corrective actions were developed with a focus on closing systemic gaps, improving protective functions, and preventing recurrence across CS Energy assets.

# 4.0 Incident Overview

## 4.1. Incident Summary

On 4 April 2025 at 04:35 AM, a large clinker dislodged from the furnace wall of Unit C3 at Callide Power Station and fell into the water hopper of the Submerged Chain Conveyor (SCC). The resulting steam release caused total flame loss across all operating mills.

A delayed unit trip allowed unburnt pulverised fuel to accumulate within the furnace, which subsequently re-ignited. This re-ignition triggered a pressure excursion that exceeded the boiler's design threshold, resulting in a significant pressure event which caused structural damage including the boiler casing, insulation, and surrounding platforms.

Although no one was physically harmed, the pressure excursion had clear potential to cause serious injury to personnel had they been in the immediate vicinity. CS Energy classified the incident as an Actual Category 3 and Potential Category 4 event, which triggered a formal Incident Cause Analysis Method (ICAM) investigation.

CS Energy led both the Root Cause Analysis (RCA) and ICAM investigation. The RCA was conducted internally and focused on the technical sequence of events and immediate failures. The ICAM, facilitated by The Jonah Group and reporting directly to a CS Energy-appointed sponsor, examined the systemic issues, failed safeguards, and deeper organisational factors that influenced decisions, behaviours and operational performance.

The incident was formally reported to WorkSafe Queensland, who provided oversight to support Return To Service (RTS) and Commissioning. Table 2 summaries the incident details.

**Table 2 -** Incident Overview

| Key Fact | Details |
|---|---|
| Date and Time | 4 April 2025, 04:35 AM |
| Unit | Callide Unit C3 |
| Asset Affected | C3 Boiler Furnace |
| Category | Actual: Category 3; Potential: Category 4 CGR #3099 |
| Immediate Impact | Operational disruption, boiler damage; no injuries but high potential for serious harm |
| Location | Callide Power Station, Queensland |
| WHSQ Involvement | Initial site control, investigation oversight and approval to Return to Service |
| Return-to-Service Date | 1st June 2025 |

## 4.2. Consequences

**Safety**

No injuries occurred. However, the incident posed a credible risk of serious injury had personnel been closer to the affected furnace area at the time.

The overpressure event caused visible damage to sections of the boiler casing, disrupted furnace insulation, and damaged nearby access platforms. Minor repairs were required to the ash handling system and furnace sealing components.

**Production**

Unit C3 was automatically shut down following the event. The forced outage resulted in just under 8 weeks downtime, with the unit offline until all safety checks, repairs, and regulatory clearances were completed.

**Safety Significance**

CS Energy classified the event as an Actual Category 3, with a credible potential severity of Category 4 under the company's incident management framework.

**Precursors or Warnings**

There were three pre-cursor events:

**1 April 2025**

At 22:32 1 April 2024 a clinker fell and caused a C3 Unit Mill Group Trip causing B and D mills to trip, there was also flame loss on both A and E mills but not enough to trip these mills. Unit C3 was running at full load with two bottom mills in service. The recorded furnace pressure was 3.5kPa. The incident was categorised as Actual Category 2, Potential Severity 2.

**20 November 2024**

At 06:30 on the 20th of November 2024 a large clinker fell and caused a C3 Unit Master Fuel Trip. Unit C3 was running at 400MW with two bottom mills in service. A hydrojet canon failed 3.5 hours before the clinker fall. The recorded furnace pressure peak was 3.7kPa. The incident was categorised as Actual Category 1, Potential Severity 1.

**21 November 2024 (C4 Unit)**

At 22:13 on the 21st of November 2024 a clinker fell and caused a C4 Mill Group Trip causing D and E mills to trip on flame loss. Unit C4 was running at 400MW with two bottom mills in service. The reduction in fuel affected steam temperature (low), and the turbine tripped, the boiler remained online and unit returned to service ~3hours later. The C4 unit had recently returned to service at the start of November. The recorded furnace pressure peak was 4.3kPa. The incident was categorised as Actual Category 1, Potential Severity 1.

### 4.3. Initial Response

Immediately following the incident and automatic shutdown, the unit was stabilised and made safe in accordance with established procedures. Site leadership at Callide was notified without delay, and internal communication protocols were activated.

WorkSafe Queensland was informed in line with statutory reporting requirements and conducted initial site inspections under controlled access conditions. CS Energy's Executive Leadership Team was briefed, and two parallel investigations were initiated: an internal Root Cause Analysis (RCA) focused on technical failure mechanisms, and an externally facilitated ICAM to examine systemic and organisational factors.

Investigation teams were mobilised within 24 hours. A CS Energy sponsor was appointed to oversee the RCA add ICAM investigation and ensure executive alignment. In the days that followed, regular management meetings were held to review emerging findings and guide early corrective actions.

## 5.0 Event Timeline

**Table 3** - Event Timeline

| Date & Time | Event | Description |
|---|---|---|
| Prior to 4 April 2025 | Elevated clinker risk conditions | Ongoing operation at or near maximum load with multiple prior red zone indications. |
| 3 April 2025, 19:00 | Shift handover | Outgoing operators' hand over Unit C3 to incoming team. Nine active red zones noted on PI Vision but not fully communicated in J5 handover notes. |
| 3 April 2025, 19:25 | Partial clinker deload attempt | Operator deloads Unit C3 to 280MW (procedure is 240MW) based on verbal instructions from Shift Supervisor. |
| 3 April 2025, 22:00 – 4 April 2025, 04:20 | Clinker Assessment Tool Updates | Operators' complete assessments using the tool at 02:50 and 04:20. Clinker Assessment Tool shows elevated clinker risk but a deload was not indicated. |
| 4 April 2025, 04:21 | Ongoing operation | Despite red zone indicators, Unit C3 continues to run at 400MW with no additional clinker deload action taken |
| 4 April 2025, 04:35:05 - 04:35:07 | Clinker dislodgement and flame loss | A large clinker dislodges falling to the wet ash hopper. Sudden steam formation causes furnace disturbance and a loss of combustion. |
| 4 April 2025, 04:35:10 | Flame loss detection first response | Flame loss from first detector. Flame loss detection fails to promptly detect full flame loss due to logic and over sensitivity. |
| 4 April 2025, 04:35:18 | Mill Group Trip (MGT) operation | MGT initiated to isolate the mills and boiler but with inherent system delays. |
| 4 April 2025, 04:35:20 | Master Fuel Trip (MFT) operation | Low Furnace. Pressure trip triggers MFT. |
| 4 April 2025, 04:35:20 | Re-ignition and overpressure | Unburnt fuel accumulates, re-ignites, resulting in furnace pressure excursion above design limit. Boiler casing, insulation are damaged. |
| 4 April 2025, ~05:00 onwards | Immediate response | Unit safely shut down and isolated. Site leadership, Executive and WHSQ notified. Preliminary controls put in place to secure the site for investigation. |

# 6.0 Root Cause Analysis Fault Tree

## 6.1. Summary

As part of the investigation, a fault tree analysis was conducted to systematically identify the immediate causes, root causes, and contributing factors. These are mapped in Section 6.0, with the fault tree diagrams presented in Section 6.2.

Table 4 below provides a consolidated summary of the findings, including references to the fault tree which is aligned with sections within this report where it is explained. In some cases, root causes are supported by multiple underlying causes, as discussed in Sections 7.0, 8.0 and 10.0.

**Table 4** - Root Cause Analysis and Fault Tree Mapping

| Type | Cause/ Factor | Section Ref # |
|---|---|---|
| Immediate Causes | Clinker Fall | 7.2.1 |
| | All Flames Out | 7.2.2 |
| | Delay in Isolating Pulverised Fuel. | 7.2.3 |
| Root Causes | Ineffective Clinker Management<br>1. Compromised Clinker Cleaning<br>2. Initial Clinker Deload Ineffective<br>3. No Subsequent Deloads at 02:50 and 04:21 | 8.2.1 |
| | Delay in Flame Loss Triggering Mill Group Trips and Master Fuel Trip<br>1. Latent Design Flaws in Flame Detector System<br>2. Flame Detectors gain increased over time, to potentially Compensate Boiler Combustion Conditions | 8.2.2 |
| Contributing Factors | Delay in Cut Damper Closure Time from Mill Group Trips & Master Fuel Trip | 9.2.1 |
| | Indeterminate Coal Quality in Real-Time Basis | 9.2.2 |
| | Operating on Two Lower Mills | 9.2.3 |
| | Combustion Trade-offs Between Emissions, Efficiency & Clinker Formation | 9.2.4 |
| | Ineffective Clinker Cleaning Tools<br>- Sootblowers<br>- Hydrojets | 9.2.5 |
| | Subjective Clinker Assessment Tool | 9.2.6 |
| | Unclear clinker deload practices | 9.2.7 |
| | Submerged Chain Conveyor (SCC) | 9.2.8 |

## 6.2. Fault Tree Diagrams

The following diagrams present a visual breakdown of the incident using a fault tree format. The fault tree identifies the immediate causes, root causes, and contributing factors that led to the event. These elements are colour coded for clarity and ease of reference, providing a structured view of how different failures and conditions combined to cause the incident.

Figure 1 provides an overview of the incident and Figure 2 to Figure 4 expand on the immediate and root causes to identify the contributing factors.

**Figure 1 -** C3 Unit Clinker Incident

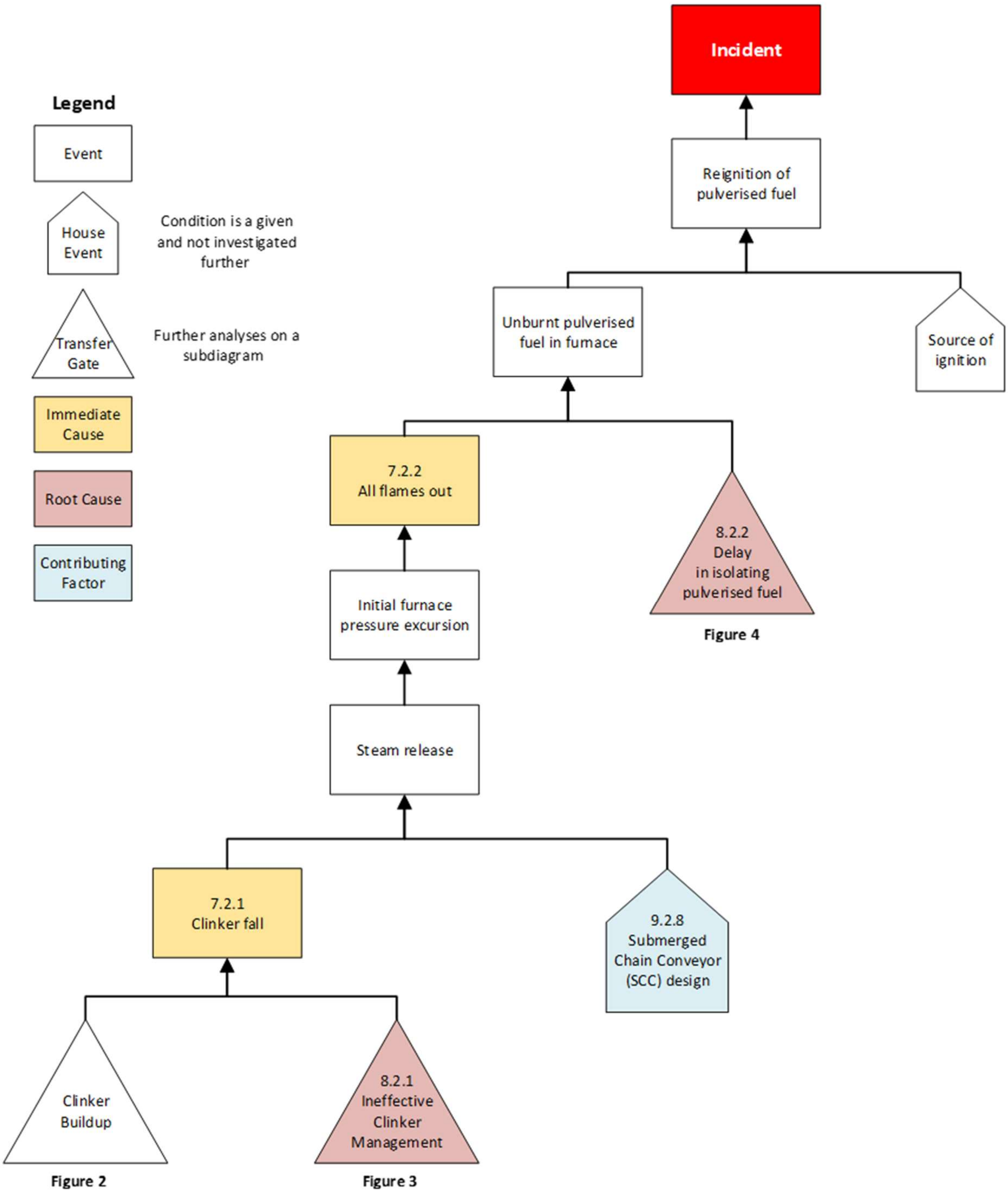


**Figure 2** - Clinker Build Up Fault Tree

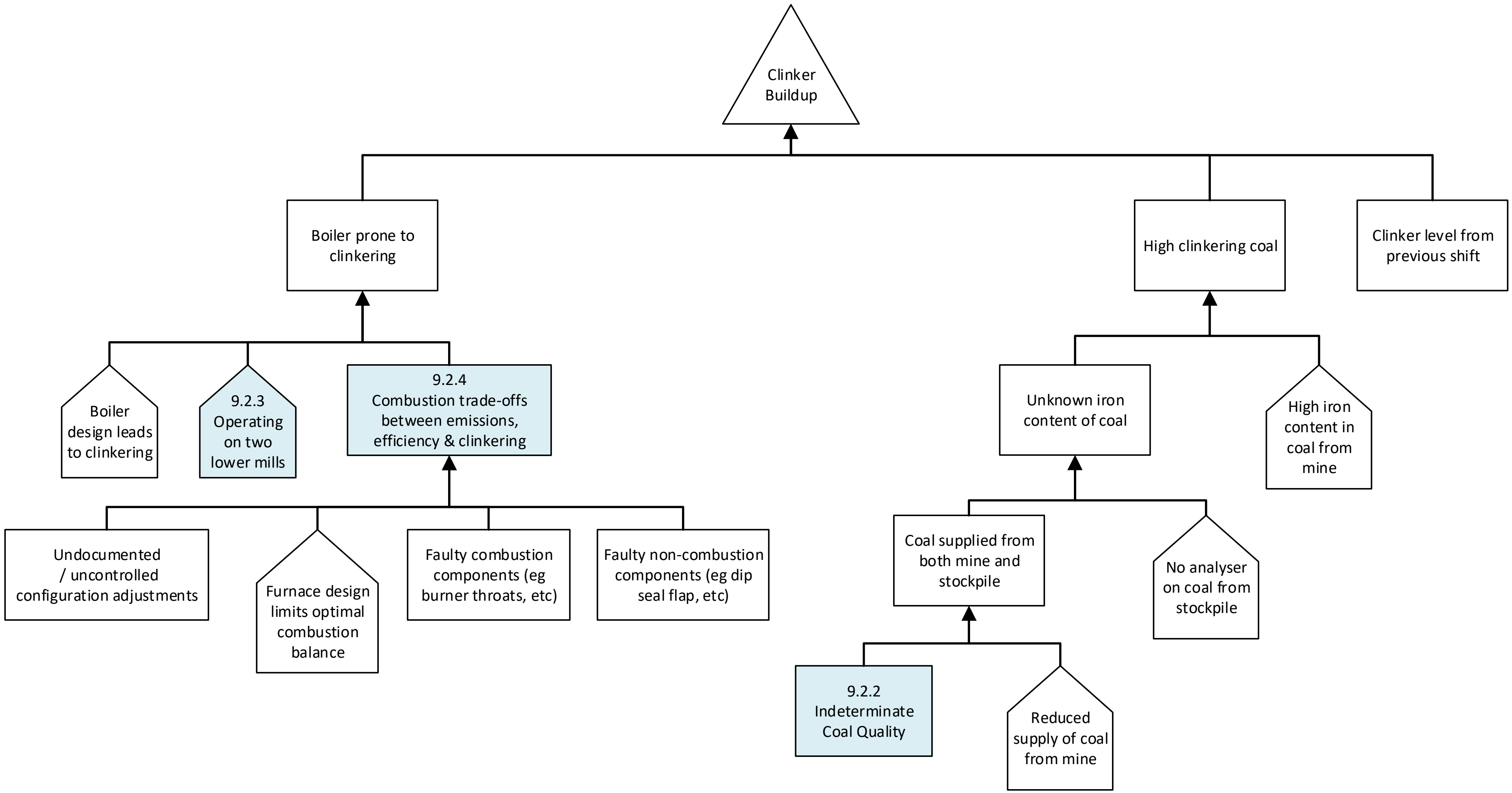


**Figure 3 -** Ineffective Clinker Management Fault Tree

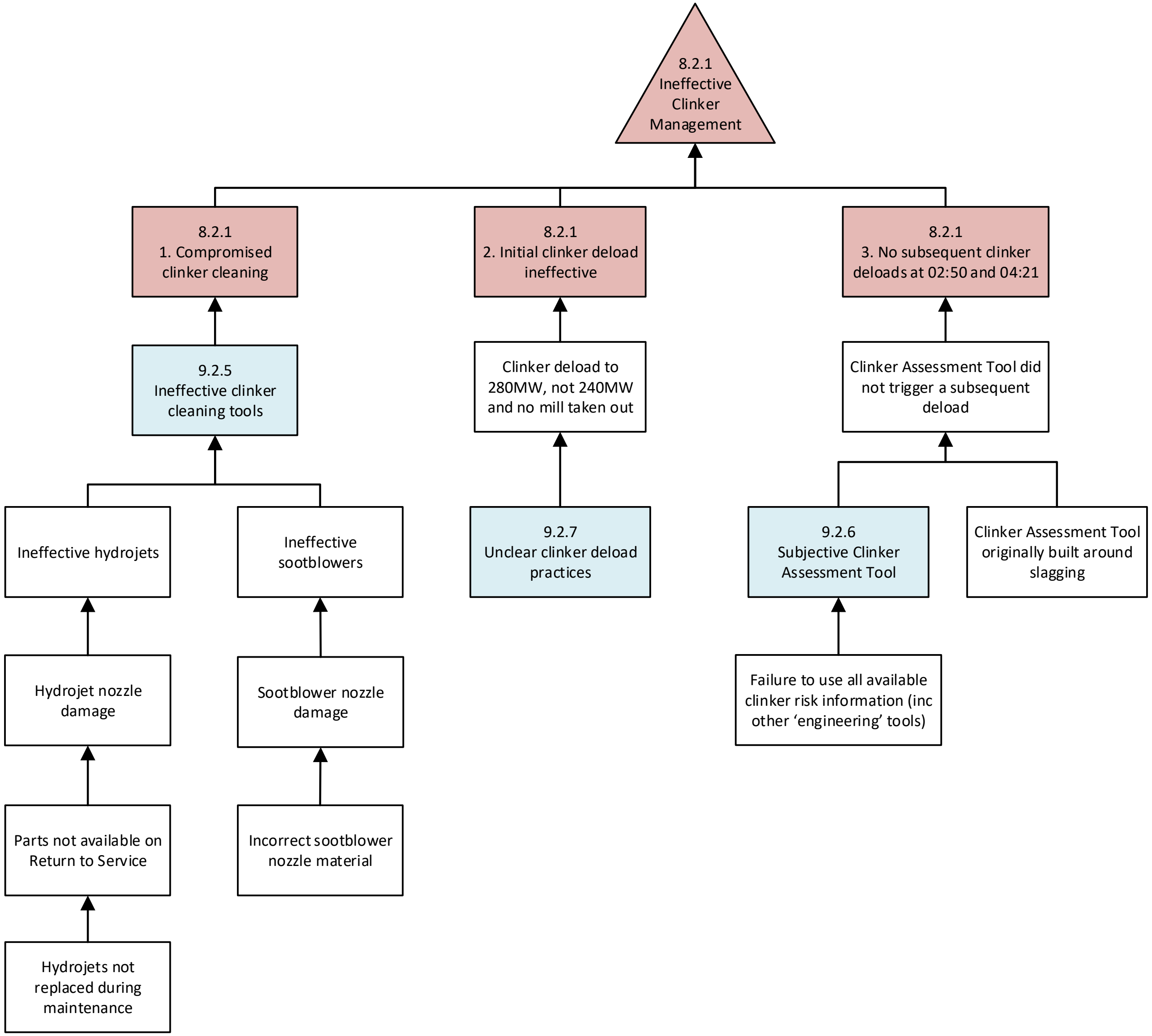
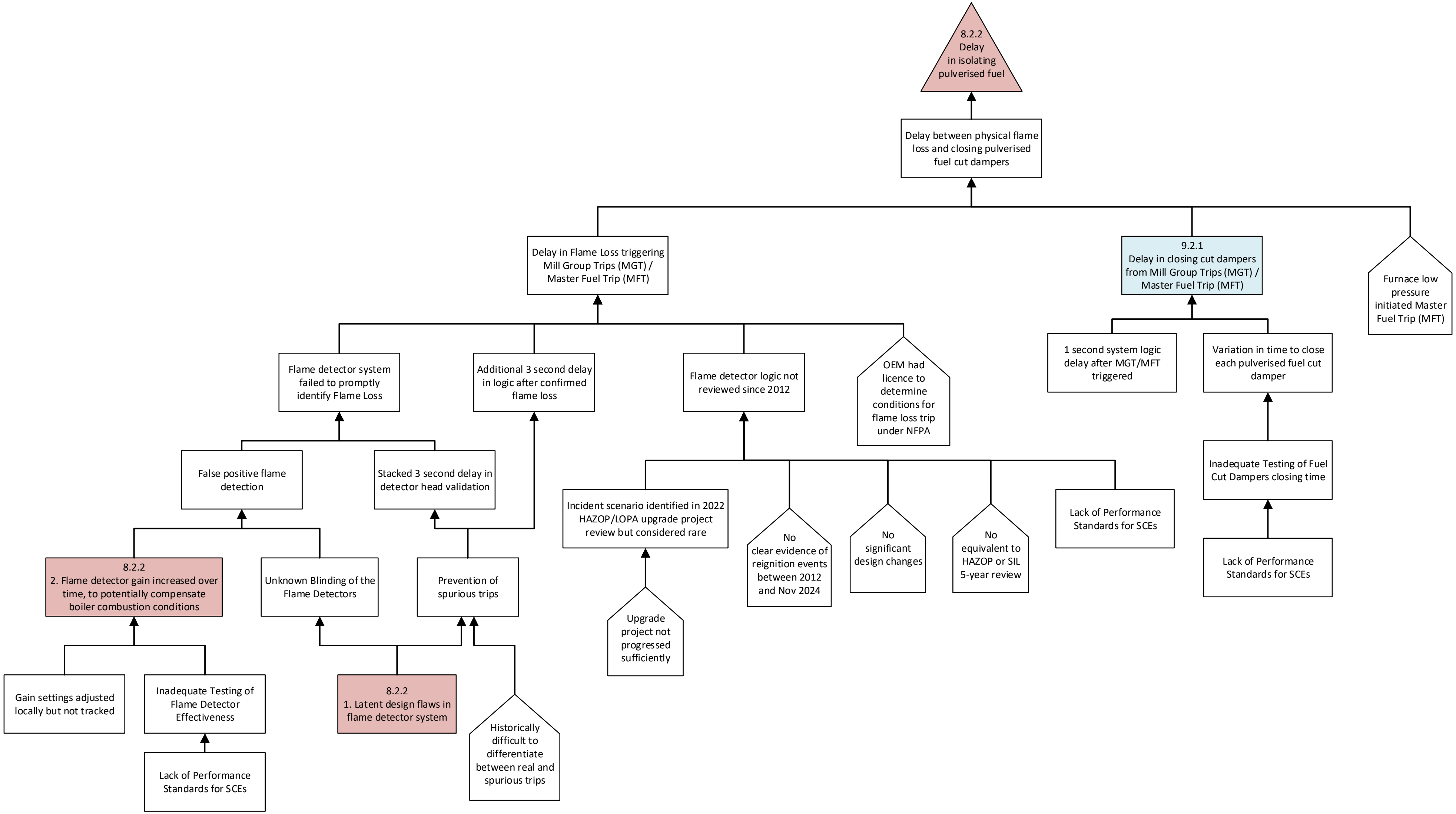


**Figure 4** - Delay in Isolating Pulverised Fuel Fault Tree



# 7.0 Immediate Causes

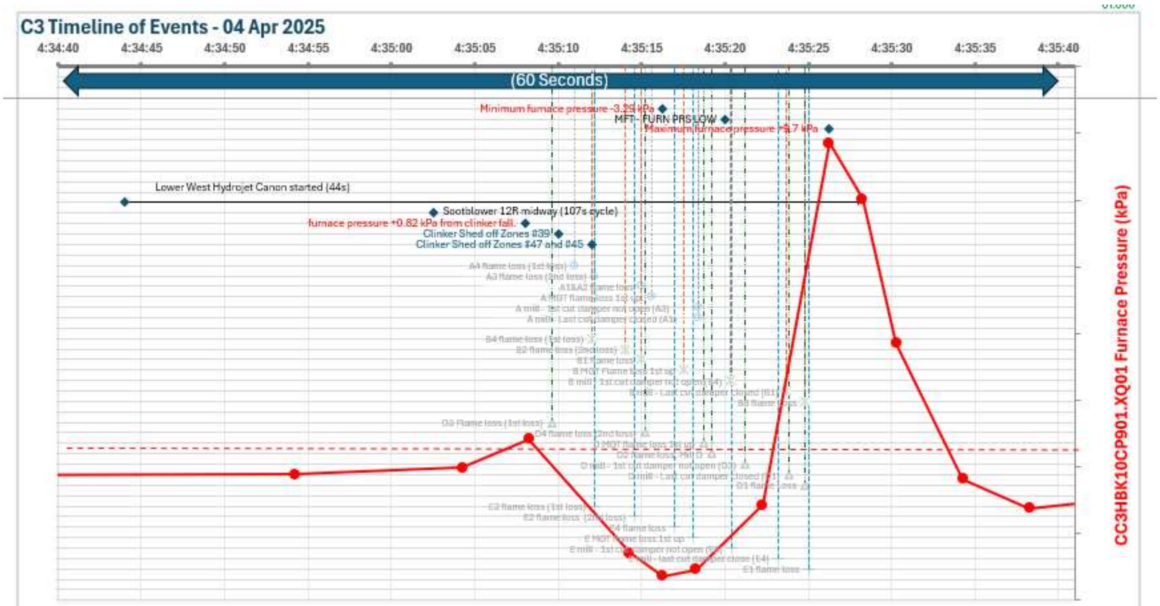
## 7.1. Definition

This section outlines the immediate causes of the incident - those direct events or conditions that triggered the furnace overpressure and subsequent boiler damage. While these causes do not explain why the conditions existed, they represent the final breakdowns in the sequence.

## 7.2. List of Immediate Causes

The timeline presented in Figure 5, is derived from control system data. It highlights the pressure in the furnace with key events superimposed onto the timeline. It shows a staggered sequence of flame loss detections across the mills over a 16-second window, beginning after the clinker fall.

**Figure 5** - Clinker Fall Timeline with Key Events Superimposed




### 7.2.1. Clinker Fall

One of the key immediate causes of the incident was the fall of an abnormally large clinker from the furnace wall of Unit C3. Clinker formation is an expected by-product of coal combustion, influenced by both the unit's design and the mineral content of the fuel. These deposits are routinely managed using established operational controls.

At 04:35:05 on 4 April 2025, a clinker significantly larger than normal dislodged and fell into the quench water in the hopper of the Submerged Chain Conveyor (SCC). The resulting rapid steam release caused a sudden combustion disturbance, leading to total flame loss across all operating mills. This initiated the pressure excursion that ultimately exceeded the boiler's design limits.

Clinker shedding events are not uncommon; however, the scale of this clinker and its interaction with the SCC water created a high-energy steam release that directly triggered the incident.

### 7.2.2. All Flames Out

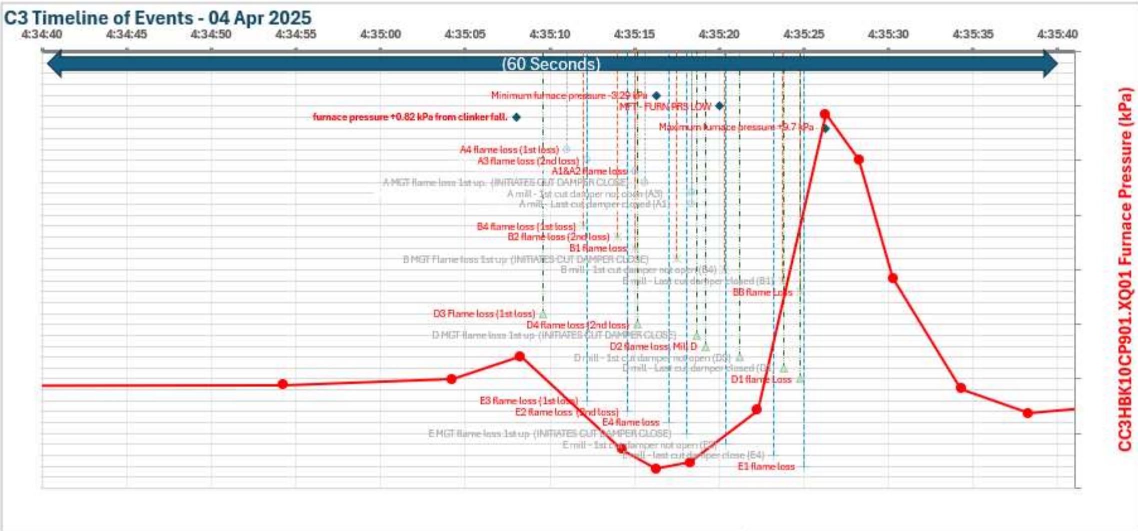
Following the clinker fall into the ash conveyor water system at the base of the furnace, a high-energy steam and dust cloud formed, generating a rapid pressure disturbance in the combustion zone. This disturbance caused flame collapse across all four mills that were in service at the time.

Control system analysis indicates that loss of flame was recorded within 3 seconds of the clinker fall. Had at least two mills maintained stable combustion, the unit protection sequence would not have progressed to a full unit trip. The loss of all flames was a critical escalation point in the incident sequence.

Figure 6 below presents a timeline generated from control system data, highlighting the pressure in the furnace with key events superimposed onto the timeline. This figure shows the clinker fall. This timeline underpins the subsequent event analysis and is referenced throughout this report

Figure 6 also highlights that three flame detectors continued to show false positive flame indications after the fuel isolation dampers had closed - despite there being no active combustion - indicating performance issues in the flame detection system.

**Figure 6** - Incident Timeline Highlighting All Flames Out




### 7.2.3. Delay in Isolating Pulverised Fuel

Following the loss of flame, the furnace experienced a sharp drop in internal pressure, creating a significant negative pressure condition. This negative pressure differential continued to draw unburnt pulverised fuel and combustion air into the furnace until the primary air (PA) dampers and fuel cut dampers fully closed to isolate the fuel supply, approximately 16 seconds after the clinker fell.

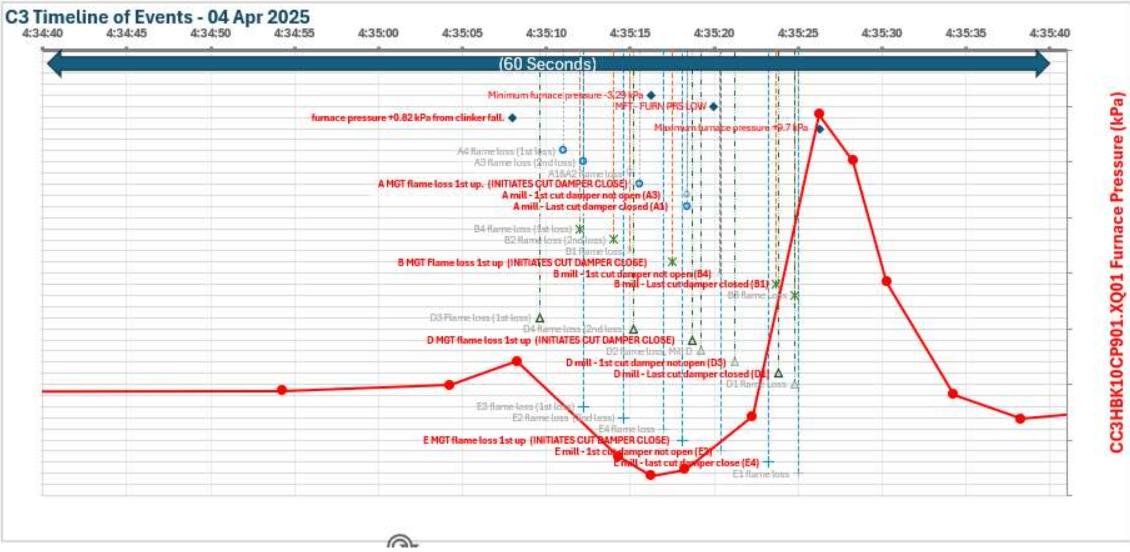
The delay in fuel isolation allowed a buildup of unburnt fuel within the furnace. When re-ignition occurred, it caused a rapid pressure surge, contributing directly to the overpressure event. Had the isolation of pulverised fuel occurred more rapidly, the scale of the incident could have been reduced or avoided altogether.

The complete loss of flame in three mills triggered Mill Group Trips (MGT), and a subsequent low furnace pressure condition initiated a unit trip via the Master Fuel Trip (MFT). This is shown in

Figure 7. However, fuel continued to enter the furnace until fuel flow was ceased by the closing of either the PA isolation damper or fuel cut dampers.

The control system timeline highlights the sequence of flame losses, and the corresponding fuel cut damper activations. This timing confirms the delay between initial combustion loss and full fuel isolation, a critical factor in the escalation of the event.

**Figure 7** - Incident Timeline and Confirmation of Fuel Isolation



# 8.0 Root Causes

## 8.1. Definition

A root cause is the fundamental reason an incident occurred. If this cause had been eliminated or controlled, the incident would not have happened. A root cause can be a failure in a system, process, equipment, or a critical human action (done or not done) that directly enabled the event.

## 8.2. List of Root Causes

### 8.2.1. Ineffective Clinker Management

Ineffective clinker management was a primary root cause of the incident. The purpose of clinker management is to remove ash deposits while they are still small and manageable, preventing excessive buildup that can create operational or safety risks when dislodged.

At Callide C, clinker management relies on a combination of cleaning systems - including sootblowers, hydrojets, and air knockers - supported by continuous monitoring using heat flux sensors. These tools are designed to detect and manage clinker formation as part of routine operations.

Operators also use a Clinker Assessment Tool to assess fouling severity and determine whether a unit deload is required. Deloading causes cooling of the furnace and promotes the removal of larger clinkers before they become hazardous.

There are three key underlying causes related to ineffective clinker management which are discussed below:

**1. Compromised Clinker Cleaning**
Clinker within the furnace is managed using dedicated cleaning systems, including sootblowers, hydrojets, and air knockers. These tools are strategically positioned to target key areas of clinker accumulation and work by applying high-pressure steam, water, or mechanical impact (air knockers) to dislodge ash and clinker deposits. When these systems are ineffective or degraded, clinker can remain in place, harden, and continue to grow.

**Sootblowers**
Post-incident inspection found that sootblowers located in the upper furnace had damaged nozzles, significantly reducing their cleaning effectiveness in that area. Although routine preventive maintenance had been recorded, there were no documented concerns regarding nozzle condition prior to the event. The damaged components were identified and replaced before the unit returned to service.

**Hydrojets**
Hydrojets operate in conjunction with heat flux sensors to target localised clinker growth. The post-incident review identified multiple issues, including failed sensors, blocked nozzles, alignment and calibration errors, and a failed hydrojet. These defects were addressed prior to the unit restart.

**Air Knockers**
No issues were identified with the air knockers during inspection. These systems focus primarily on clinker removal from lower furnace slopes.

It is important to note that the effectiveness of these tools cannot be fully verified during normal load operation. Functional testing of nozzles and alignment accuracy requires offline inspection; during operation, effectiveness is judged based on observed clinker removal.

Cumulative defects in clinker removal systems are one of the inputs considered by the Clinker Assessment Tool in determining the need for a deload. Prior to the incident, maintenance records indicated minor faults in cleaning equipment, but none were significant enough to trigger a deload recommendation.

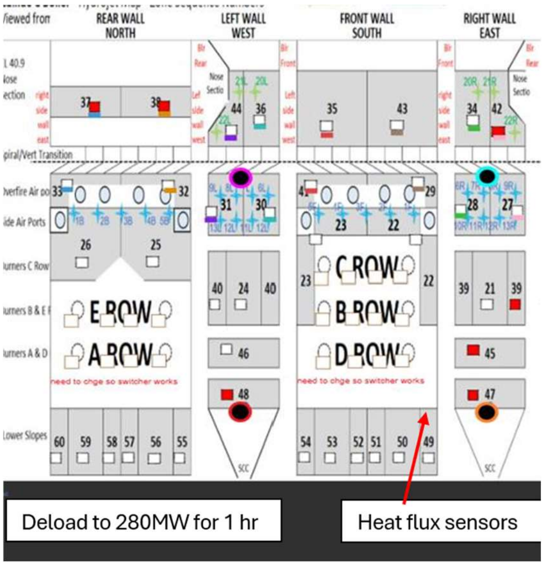
**2. Initial Clinker Deload Ineffective**

Clinker management assessments are conducted multiple times per day in accordance with the Callide C Production Advice Manual Procedure PAMC-CH20-SO4-P21 – *Deload Clinker Assessment Tool*. The aim of this tool is to provide operators with structured guidance based on real-time control system inputs to determine when a unit deload is warranted to disrupt clinker formation and to promote clinker shedding while they are still at a manageable size.

At the time of the event, the Deload procedure required a full deload to 240 MW, along with specified mill changes, to generate the thermal disturbance necessary for effective clinker removal. On 3 April, the unit was only reduced to 280 MW, falling short of the procedural target. Furthermore, all four mills remained in service, limiting the intended temperature shift across the furnace.

This incomplete execution of the Deload procedure reduced the likelihood of clinker dislodgement. A full deload, as prescribed, would have been more effective in safely removing clinker Figure 8 below shows the HMI (Human Machine Interface) screen for the boiler with the red dots showing heat flux sensors in alarm that indicate clinker accumulation.

**Figure 8** - HMI Diamond Power Screen 03 April 19:25 - Heat Flux Indicates High Clinkering



### 3. No Subsequent Clinker Deloads

Following the clinker deload conducted on 3 April, two further assessments were completed at 02:50 and 04:21 using the Clinker Assessment Tool and Hydro Jet monitoring screen. These are the primary tools available to operators for evaluating clinker formation and furnace fouling. Neither assessment indicated that a deload was required. However, at approximately 04:35, a large clinker fell from the furnace wall, directly contributing to the event.

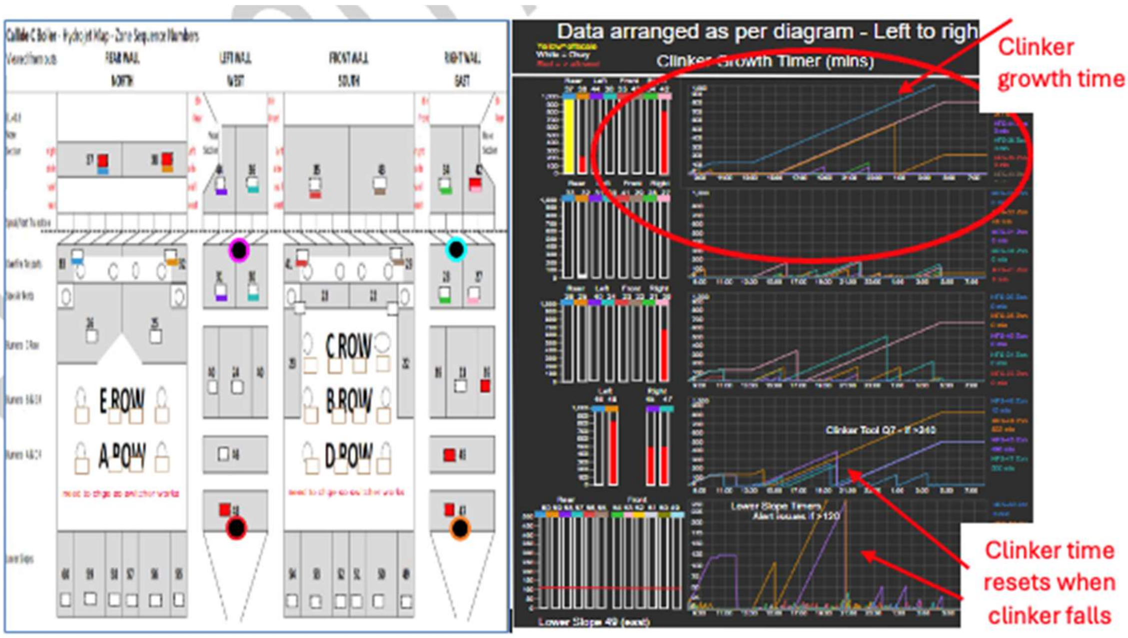
Additional clinker-related data was available through the PiVision system, including clinker growth predictions and duration indicators, but this information was not routinely used by operations. If accessed, it could have improved the accuracy of the clinker assessments. The availability and use of this data is addressed in the associated ICAM investigation and is not explored further in this RCA.

Figure 9 below shows the ICMS screen of the boiler, the numbered squares are heat flux sensors in the boiler. The red colour indicates that there is clinker accumulation and a timer is started to measure this growth. The graphs in the PiVision screens correlate to the locations in the boiler, and also the colours to sensor locations. Although PiVision data is available to operators, it is not readily visible or well understood.

The bar charts capture visually the clinker growth times. The line graphs capture the same information but as a trending upwards line. When clinker falls the heat flux sensor clears and the trend line vertically falls, creating the triangle shapes seen below. These images identify clinker accumulation time which are indicative to size of clinker, and clinker falls are shown by sharp vertical lines representing change in flux sensor readings.

**Figure 9** - Furnace Conditions at the Time of the Clinker Event

HMI Screen Pivision



### 8.2.2. Delay in Flame Loss Triggering Mill Group Trip / Master Fuel trip

The flame detection system is the primary safeguard for monitoring stable combustion in the furnace and forms a critical part of the unit protection system. The burner management system includes built-in logic designed to balance flame sensing with the need to avoid spurious trips. This logic incorporates time delays to verify actual flame loss before triggering protective actions such as a Mill Group Trip (MGT), which shuts down a single mill, or a Master Fuel Trip (MFT), which shuts down all mills and the unit.

Each mill operates with four burners, and each burner is equipped with two flame detectors. At full load, with all five mills in service, there are 20 burners and 40 flame detectors active. The control logic is configured to initiate an MFT if there is a total loss of flame across all detectors for 3 seconds. A MFT will also occur if two mills lose flame for 10 seconds while the remaining two still show flame presence.

The incident could have been prevented if the flame detectors had been correctly calibrated and the embedded delay logic in the control system had been properly optimised.

This root cause consists of two underlying causes.

**1. Latent Design Conditions in Flame Detector System**

The flame detection system includes embedded logic designed to balance the risk of spurious trips with the need for effective unit protection. The detector heads validate cumulative flame loss through a stacked 1 to 3 second time check before transmitting a signal. Once confirmed, an additional 3-second processing delay is applied in the logic to further screen out false signals before initiating the primary unit protection response - closure of the pulverised fuel cut dampers.

According to the original IHI design documentation from 2001, the system initially treated Primary Air dampers as the primary isolation mechanism, with pulverised fuel cut dampers as a secondary safeguard. These cut dampers originally had a 30-second delay before activation to prevent backflow to the mills during a trip.

However, a revision to the NFPA code in 2011 shifted the protection philosophy, designating the cut dampers as the primary protection device. Following this change, a CS Energy review in 2012 optimised the logic, reducing the cut damper delay from 30 seconds to 2 seconds. While the original source of the 30-second delay is unclear, NFPA-compliant OEMs retain discretion in defining flame loss trip conditions. At other CS Energy units (e.g. Callide B and Kogan), mill outlet cut dampers are already configured as the primary isolation safeguard.

Figure 10 shows the shutdown logic timeline for the boiler protection system, including the inherent delays. These latent delays in the C3 boiler protection logic contributed to the root cause: a delay in flame loss triggering a Mill Group Trip or Master Fuel Trip.

Figure 11a to Figure 11c shows the shutdown logic timeline for the boiler protection system, for a specific mill (Mill D), including the possible effects of over-gaining of the flame detectors. Figure 11a shows the situation at the time of the incident. Figure 11b shows the situation post incident, after the issues have been rectified – the time from flame loss detected until cut dampers closed has reduced from 17 seconds to 8 seconds. Figure 11c shows the original situation at commissioning of C3 in 2001. It should be noted that closing the primary air damper was the original method of preventing re-ignition and the original configuration was in place until 2012 at which time some improvements were made to reduce the time of the MGT.

The latent delays embedded in the C3 boiler protection logic directly contributed to the delayed initiation of the Mill Group Trip and Master Fuel Trip. These delays are a key factor in identifying the failure to promptly isolate fuel as a root cause of the event.

**Figure 10** - Shutdown Logic Timeline for the Boiler Protection System

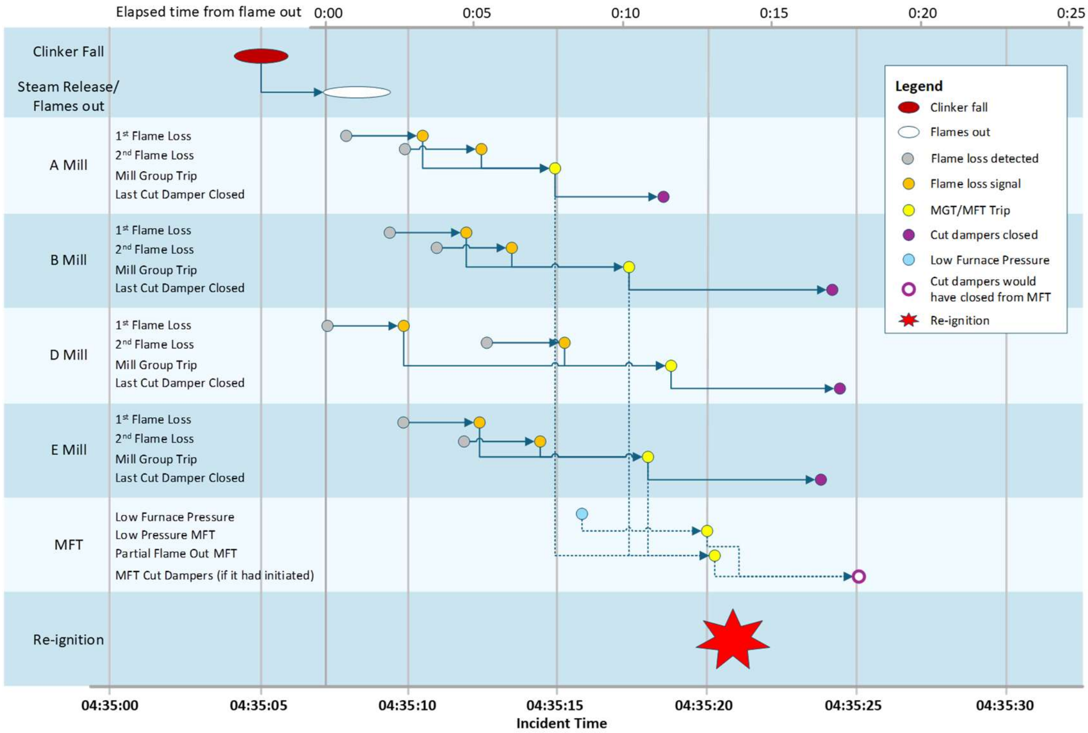



**Figure 11** - Boiler Protection Shutdown Logic Flow from Clinker Fall to Cut Damper Isolation (D Mill)

**Figure 11a** - Boiler Protection Shutdown Logic Flow at the Time of the Incident

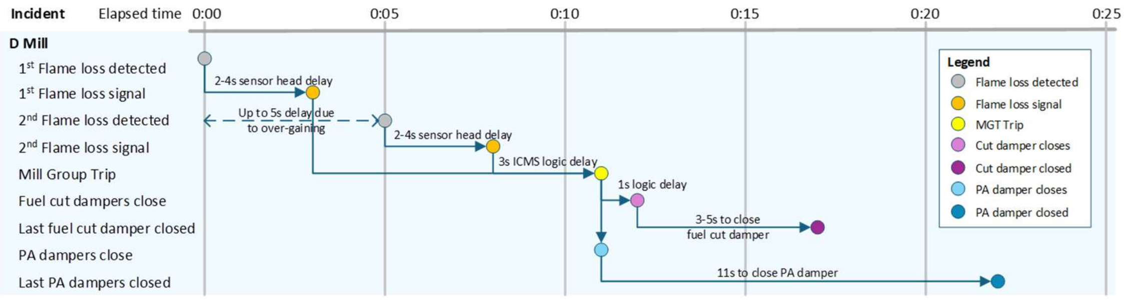


**Figure 11b** - Boiler Protection Shutdown Logic Flow – After improvements implemented

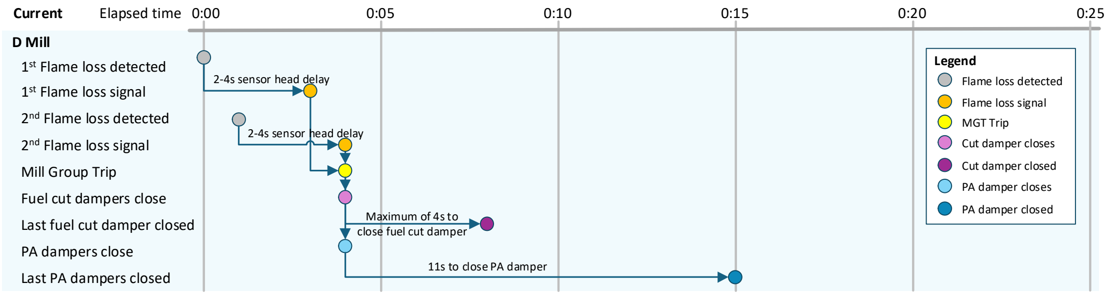
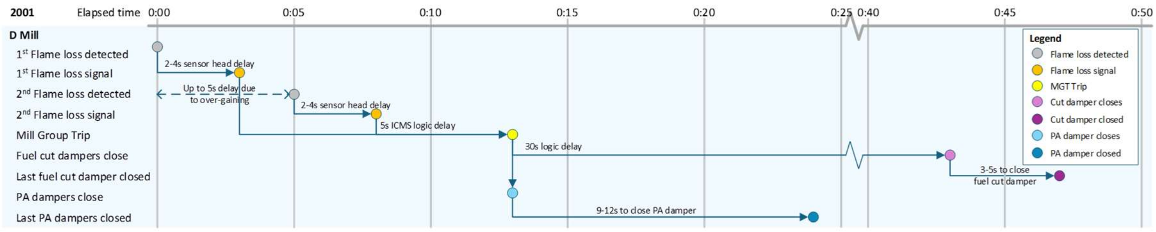



**Figure 11c** - Boiler Protection Shutdown Logic Flow – Original in 2001




## 2. Flame Detectors Gained to Compensate for Suboptimal Combustion Conditions

Flame detectors are calibrated to detect flame presence at their respective burners. Under suboptimal combustion conditions, detector gain can be manually increased at the local tuning dial to improve flame pickup. However, excessive gain introduces risk of false positives, where a detector continues to indicate flame presence despite actual flame collapse or instability. These gain adjustments are not digitally recorded, and no formal performance standards exist for flame detector configuration or calibration.

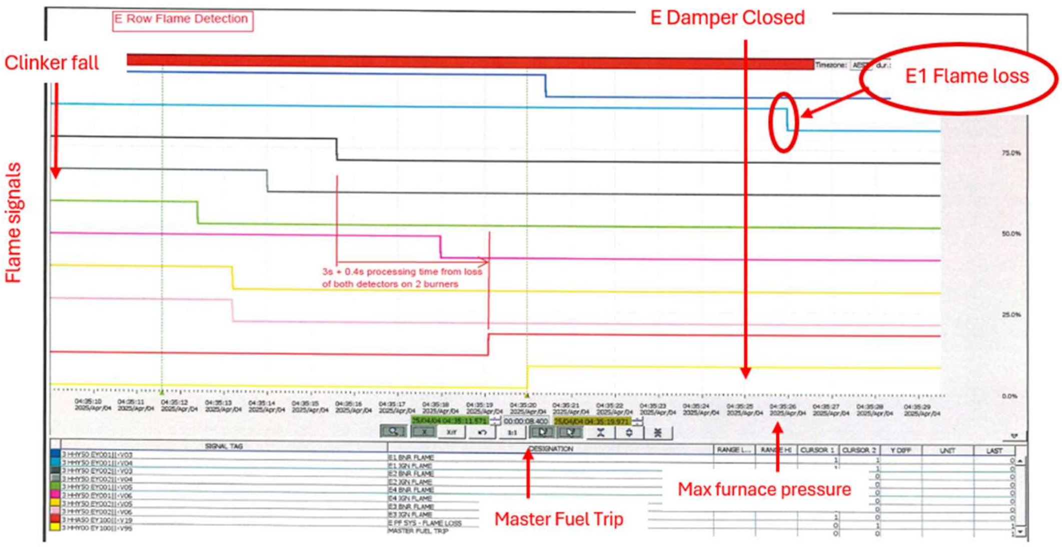
A flame blinding function is also used to prevent false flame signals from non-firing mills. This is achieved by isolating power to the flame detectors for mills with no fuel input, i.e. when they are out of service. While intended to exclude inactive burners from total flame loss calculations, this practice is inconsistent with NFPA requirements and defeats critical flame detector discrimination logic. By masking over-gained detectors, it also suppresses maintenance alarms and bypasses burner start interlocks, allowing impaired detectors to go undetected.

Although the blinding function did not directly cause the incident, it contributed to undetected degradation in flame detection integrity. Subsequent testing of the C4 flame scanner system on 12 April 2025 identified performance issues in 26 of 40 detectors, including miscalibration, poor configuration, and reduced sensitivity. Similar deficiencies were rectified on C3 prior to its return to service.

Figure 12 shows the E Mill flame detection system displaying a flame (a false positive) after pulverised fuel was eliminated through closing of the mill cut dampers. For example, because of this blinding function, E1 flame loss is acknowledged approximately 7 seconds after its Mill Group Trip is initiated.

These impairments increase the delay in initiating fuel isolation and reduce system reliability under abnormal combustion conditions.

**Figure 12** - E Mill Flame Detection Signals Through the C3 Event



# 9.0 Contributing Factors

## 9.1. Definition

A contributing factor is a condition, action, or omission that increased the likelihood or severity of the incident but, on its own, would not have caused it. Contributing factors combine to create the circumstances in which the incident could occur.

## 9.2. List of Contributing Factors

### 9.2.1. Delay in Fuel Cut Damper Closure Time from Mill Group Trips and Master Fuel Trip

Fuel Cut dampers are large mechanical isolation devices designed to stop the flow of pulverised fuel from the mills to the furnace. The Fuel Cut dampers do not slam shut, rather they operate quicky at first, but slow down just before closing to prevent mechanical damage to the damper and normally require 3 to 5 seconds to move to a closed state from full open.

The burner management system includes built-in logic to initiate closing of the fuel cut damper following a Mill Group Trip (MGT) or Master Fuel Trip (MFT). After a trip signal is initiated, a 1-second delay is applied before damper actuation begins. The subsequent damper mechanical closure takes between 3 and 5 seconds, depending on individual damper stiffness and flow conditions, resulting in a maximum total closure time of up to 6 seconds. This has been typical of their operating closure times since commissioning.  At the time of the incident, there were no defined performance standards for cut damper response.

Figure 13 shows the actual Fuel Cut damper closure times prior to the event, detailing the sequence from trip initiation to solenoid activation (“signal”), solenoid activation to valve movement, (“damper closing started”), and, to solenoid activation to valve close (“valve closed”). Figure 13 also compares pre and post event closure times of the cut dampers.

Post-event data shows a consistent reduction of 1-2 seconds in damper closing time on all mills, also illustrated in Figure 13. The current closure times now fall within the required performance standard of less than 4 seconds from initiation based on OEM specifications.

**Figure 13 -** Pulverised Fuel Cut Damper Closure Times Prior and Post Tuning (All Mills*)

| | PRIOR TO TUNING: C3 A MILL 4/04/2025 4:35:15 AM | | | | | POST TUNING: C3 A Mill 1/06/2025 8:34:06 PM | | | | | Improvement (s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Damper 1 | Damper 4 | Damper 2 | Damper 3 | Average | Damper 1 | Damper 4 | Damper 2 | Damper 3 | Average | |
| Trip to Solenoid Activation (s) | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 1.2 |
| Solenoid Activation to Valve Movement (s) | 1.7 | 1.7 | 1.6 | 1.3 | 1.6 | 1.6 | 1.7 | 1.5 | 1.4 | 1.6 | 0.0 |
| Solenoid Activation to Valve Close (s) | 3.2 | 3.1 | 2.9 | 2.5 | 2.9 | 3.1 | 3.2 | 3.0 | 2.8 | 3.0 | -0.1 |
| Trip to Valve Close (s) | 4.6 | 4.5 | 4.4 | 4.0 | 4.4 | 3.3 | 3.4 | 3.2 | 3.0 | 3.2 | 1.1 |

| | C3 B MILL 4/04/2025 4:35:15 AM | | | | | C3 B MILL 1/06/2025 6:06:20 PM | | | | | Improvement (s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Damper 1 | Damper 4 | Damper 2 | Damper 3 | Average | Damper 1 | Damper 4 | Damper 2 | Damper 3 | Average | |
| Trip to Solenoid Activation (s) | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 1.2 |
| Solenoid Activation to Valve Movement (s) | 2.4 | 1.4 | 1.7 | 1.7 | 1.8 | 2.7 | 1.3 | 1.8 | 1.3 | 1.8 | 0.0 |
| Solenoid Activation to Valve Close (s) | 4.9 | 3.0 | 3.0 | 3.6 | 3.6 | 3.5 | 2.3 | 3.2 | 2.7 | 2.9 | 0.7 |
| Trip to Valve Close (s) | 6.3 | 4.4 | 4.5 | 5.0 | 5.0 | 3.7 | 2.5 | 3.4 | 3.0 | 3.2 | 1.9 |

| | C3 C MILL 31/03/2025 10:39:05 PM | | | | | C3 C MILL 31/05/2025 6:27:52 PM | | | | | Improvement (s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Damper 1 | Damper 4 | Damper 2 | Damper 3 | Average | Damper 1 | Damper 4 | Damper 2 | Damper 3 | Average | |
| Trip to Solenoid Activation (s) | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 1.2 |
| Solenoid Activation to Valve Movement (s) | 1.8 | 1.6 | 2.4 | 1.9 | 1.9 | 1.6 | 1.5 | 2.0 | 1.2 | 1.6 | 0.3 |
| Solenoid Activation to Valve Close (s) | 3.3 | 3.0 | 3.2 | 3.2 | 3.2 | 2.9 | 3.1 | 3.2 | 2.3 | 2.9 | 0.3 |
| Trip to Valve Close (s) | 4.7 | 4.4 | 4.6 | 4.6 | 4.6 | 3.1 | 3.3 | 3.4 | 2.5 | 3.1 | 1.5 |

| | C3 D MILL 4/04/2025 4:35:15 AM | | | | | C3 D MILL 31/05/2025 6:27:52 PM | | | | | Improvement (s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Damper 1 | Damper 4 | Damper 2 | Damper 3 | Average | Damper 1 | Damper 4 | Damper 2 | Damper 3 | Average | |
| Trip to Solenoid Activation (s) | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 1.2 |
| Solenoid Activation to Valve Movement (s) | 1.7 | 1.4 | 1.4 | 1.1 | 1.4 | 1.2 | 1.6 | 2.2 | 0.9 | 1.5 | 0.0 |
| Solenoid Activation to Valve Close (s) | 3.8 | 2.7 | 2.6 | 2.6 | 2.9 | 2.4 | 2.9 | 2.5 | 2.6 | 2.6 | 0.3 |
| Trip to Valve Close (s) | 5.2 | 4.1 | 4.0 | 4.0 | 4.3 | 2.6 | 3.1 | 2.8 | 2.8 | 2.8 | 1.5 |

| | C3 E MILL 4/04/2025 4:35:15 AM | | | | | C3 E MILL 31/05/2025 4:47:13 PM | | | | | Improvement (s) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Damper 1 | Damper 4 | Damper 2 | Damper 3 | Average | Damper 1 | Damper 4 | Damper 2 | Damper 3 | Average | |
| Trip to Solenoid Activation (s) | 1.4 | 1.4 | 1.4 | 1.4 | 1.4 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 1.2 |
| Solenoid Activation to Valve Movement (s) | 1.6 | 3.0 | 0.9 | 1.5 | 1.7 | 1.4 | 2.4 | 0.9 | 1.3 | 1.5 | 0.3 |
| Solenoid Activation to Valve Close (s) | 2.5 | 3.7 | 2.1 | 2.8 | 2.8 | 2.5 | 3.3 | 2.1 | 2.6 | 2.6 | 0.2 |
| Trip to Valve Close (s) | 3.9 | 5.2 | 3.6 | 4.2 | 4.2 | 2.7 | 3.5 | 2.3 | 2.8 | 2.8 | 1.4 |

Speed of damper physically closing

Total time to close from initiation

KEY
- ≤ 3s
- 3-4s
- 4-5 s
- ≥ 5s

*C (top) mill was not in service at the time of the incident -

### 9.2.2. Indeterminate Coal Quality

Coal quality monitoring and control processes at Callide C were insufficient to detect and manage clinker risk. The Coal Stockpile Management Procedure (CWP-ES-0030, May 2013) provides guidance for maintaining coal supply continuity during interruptions but lacks detail on managing quality parameters relevant to clinker formation, such as ash content, calorific value (CV), or iron concentration.

Coal is transported via the R1 conveyor, where a single online analyser measures iron oxide ($Fe_2O_3$) levels. This data assists coal plant operators with general handling decisions but is not integrated with unit operations or combustion risk assessments. While coal delivered to units is blended, there is no real-time feedback loop linking coal chemistry with boiler performance, particularly clinkering behaviour.

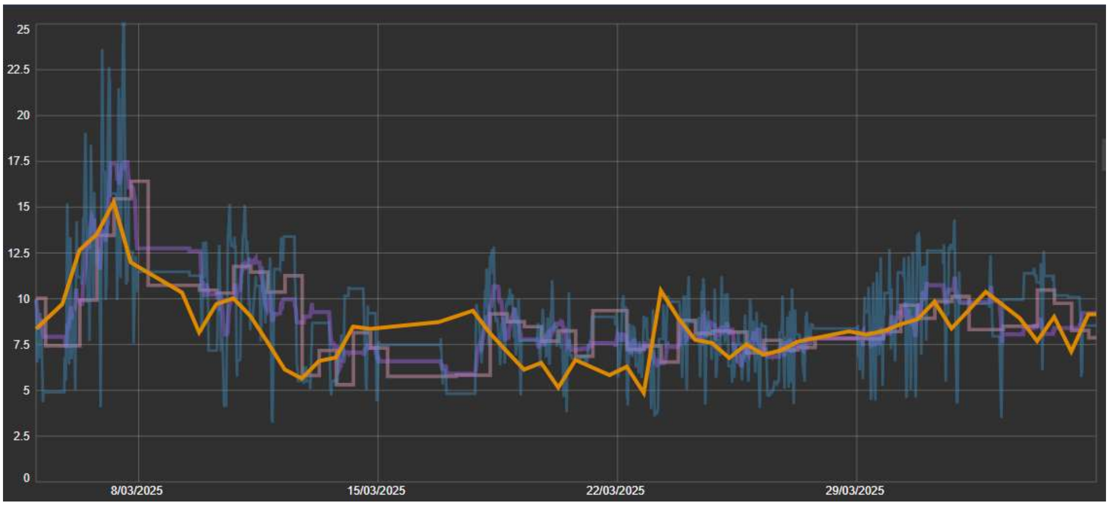
Historical observations suggest excessive clinker formation when iron content in ash exceeds 15%. Post incident analyses of the pulverised fuel from the mill belts indicate an iron content of 7% entering the boiler pre-event below that threshold. However, the inability to trace or predict variations in coal quality at the unit level, especially iron content, limits operators' ability to manage clinker risk proactively.

Coal reclaim and distribution practices, including the use of the open stockpile and slot bunker, are outlined in Appendix (Section 12.0).

Figure 14 shows $Fe_2O_3$ variation over the four weeks preceding the event. The chart shows iron oxide content over time using several data sources: Orange represents the Lab 12-hour shift average, Pink is the Analyser 12-hour shift average, Purple is the Analyser 6-hour moving average, and Blue is the Analyser 1-hour moving average. Instantaneous spikes reaching up to 15% were observed in the days prior to the event, though these are not shown here for clarity.

There is currently no real-time integration between measured iron oxide levels in incoming coal and the operation of the Callide C units. While technically feasible, the ability to use this data to actively influence unit operations is limited. This gap limits visibility of fuel risk and leaves the units exposed to variable coal quality.

**Figure 14** - Iron Oxide Levels Content in Coal Feed Supply Previous 4 Weeks Supply




### 9.2.3. Operating on Two Lower Mills

Operating on two lower mills "bottom mills" is recognised as contributing to clinkering of the slopes and forming large slabs that are difficult to remove and contribute to damage to the throat and Submerged Chain Conveyor (SCC) when they fall.  On the 31st March C mill (the top mill) was removed from service for regular preventive maintenance and required C3 to operate periodically with both bottom mills in service.

The Deload Clinker Assessment Tool procedure PAMC-CH20-S04-P-21 identifies operating with two lower mills as a key input to managing clinker. Figure 15 shows the guidance in the procedure for specific activities to be conducted for different plant operating conditions. The Clinker Assessment Tool correctly identified in the two assessments before the incident that the bottom mills had been in service for greater than 6 hours.

**Figure 15 - Clinker Assessment Tool Guidance Operating with Bottom Mills in Service**

PAMC-CH20-S04-P-21
AMD 05/2015

| Scenario | Mill Configuration | Unit Deload | Comments | Clinker Assessment Tool |
|---|---|---|---|---|
| Scenario 1 | Both Bottom Mills (A & D) -In service | 1 Deload / 12hrs | Subject to approval from Plant Manager regarding timing of deload. | Every 12 Hrs* Assessment to be carried out at 0800, 2000 Hrs |
| Scenario 2 | Both Bottom Mills (A & D) - In service | If 1 Deload / 12hrs is **NOT** approved | Deload as per assessment tool, subject to approval from Shift supervisor. | Every 4 Hrs Assessment to be carried out at 0800, 1400, 2000 and 0200 Hrs |
| Scenario 3 | Both Bottom Mills (A & D) - **NOT** in service | 1 Normal Deload / 24hrs | Subject to approval from Plant Manager regarding timing of normal deload. | Operators Daily routine checks |
| Scenario 4 | Both Bottom Mills (A & D) - **NOT** in service | If 1 Normal deload / 24hrs is **NOT** approved | Deload as per risk assessment tool, subject to approval from shift Supervisor. | Every 12 Hrs Assessment to be carried out at 0800, and 2000 Hrs |

** "Both bottom mills in service" is identified as worst scenario so in order to initiate prompt for operator to conduct Clinker assessment, a new Alarm is created –*

1) *Condition 1 – Both Bottom Mills in service for more than 8 Hrs*
2) *Condition 2 – Unit Load > 300 MW*

***Alarm** – Clinker Assessment Required.*

- *If Deload required - Shift supervisor approval required before doing unit deload, and to be recorded in assessment log.*
- *If No deload required – Continue monitoring as per above clinker Deload Guidelines.*

Mills typically provide Pulverised Fuel at the same feed rate, unless an operator specifically adjusts one of the mills to different. The panel operators were aware of the additional propensity to clinker with bottom mills in service and reduced D bottom mill throughput to be 20% lower 6 hours prior to the event. The clinker assessment tool considered the bottom mills in service.

### 9.2.4. Combustion Trade-offs between Emissions, Efficiency and Clinker Formation

Managing combustion in a Pulverised Fuel furnace is a complex multiple variable process. It is necessary to continuously manage the air and fuel flow ensuring the correct air-to-fuel ratio is maintained while balancing the requirements of efficiency, flame stability and emissions. To accomplish this Callide C has automated burner management system (BMS) which incorporates complex logic, the ability to detect flames and to cut off all fuel should it detect unhealthy flames or loss of combustion.

Maintaining the integrity of the burners and air control systems is critical to ensuring optimal low NOx burner performance. Burner distortion, as observed in C3 burner throats post incident, disrupts flow within the recirculation zone and can negatively impact combustion efficiency and emissions control. This gradual distortion and resulting poor burner condition could have led to the gaining of C3 flame detectors which were compensating for poor burner condition and masking the true condition of the burners.

The C3 burner throats were last serviced in 2019 during that year's major overhaul. At Callide burner inspection and maintenance is normally performed during planned major overhauls every 5 years since access to the burners requires significant scaffolding.

**Post Incident C3 Boiler Inspection Summary**

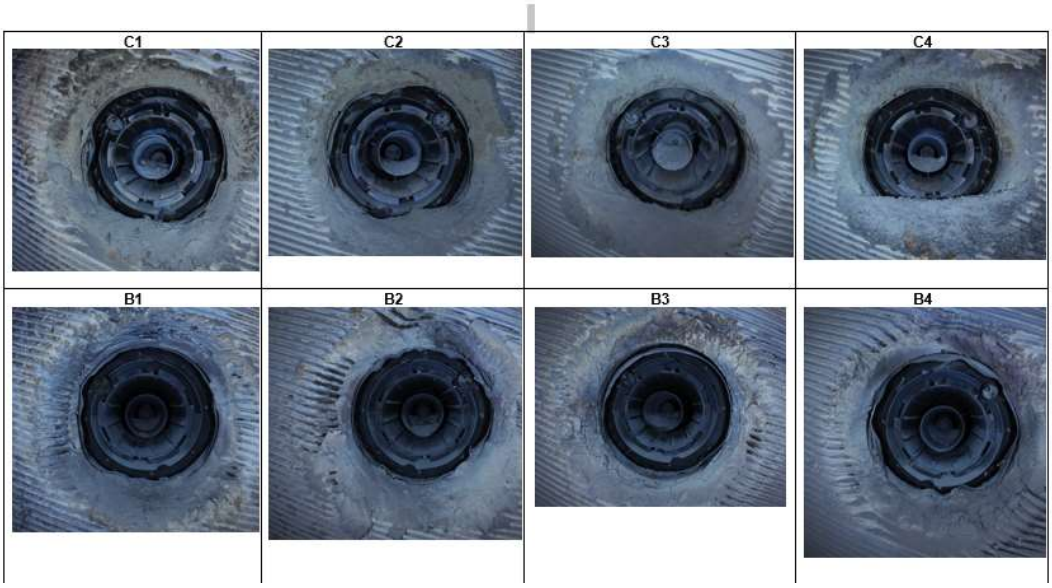
Observations from post incident C3 boiler inspections with regards to clinker formation and/or impact on flame detection performance identified the following key concerns for combustion:

- Burner Degradation: Secondary air guide rings are distorted; C3 burners show greater wear due to reduced cooling airflow (15% vs. C4's 25–30%).
- Air ports & Registers: Restricted boundary air ports affect near-wall combustion. Air register calibration issues noted on C4, E4, D4, A2, and A3.

- Uncontrolled Adjustments: Manual dampers on A-side overfire air port were changed from 80% to 20% without authorization, impacting combustion stability.
- SCC Flap Gate Damage: Removal due to clinker drops is allowing tramp air into the furnace and potentially reducing burner air supply.
- Fouling Patterns: A-side of boiler shows more fouling, likely linked to missing B-side SCC flap gate and associated airflow changes and condition of burners.

Figure 16 shows drone pictures from an internal boiler inspection post the event. Some burners are distorted in the throat external ring which impacts performance of burners through poor flame shape and some boundary air ports were blocked fostering wall clinkering.

**Figure 16** - Pulverised Fuel Burner Conditions on C and B Mills photos taken by drone




Boundary air is important in clinker management because Iron oxide is very sticky but rapidly oxidises to a less sticky form of iron oxide in the presence of any oxygen; it uses the oxygen much faster than char particle combustion dynamics. Hence boundary air helps form friable deposits rather than dense vitrified deposits. There is currently no performance standard acceptance criterion for the burners.

It was observed during the investigation that there was a general lack of knowledge of combustion management across operations.

The physical state of the burner throats, boundary air ports and general low-level knowledge of boiler combustion management makes this a contributing factor to the event. The unauthorised changes to operating parameters will be dealt with in the ICAM report.

### 9.2.5. Ineffective Clinker Cleaning Tools

Clinker within the furnace is managed using a range of clinker cleaning tools, designed to dislodge clinker through the application of high-pressure air, steam or water. These tools are positioned to target key furnace zones and minimise clinker accumulation. If ineffective, they allow clinker to harden, adhere and grow, increasing the risk of dislodgement and unplanned events.

**Sootblowers**

Sootblowers are the primary clinker cleaning devices, positioned to target the furnace's radiant and convection zones. Twenty-two clean the pendant superheaters and furnace nose, while ten clean the horizontal tube banks. They operate in opposing pairs and are maintained on bi-weekly, monthly, and three-monthly cycles. Nozzle integrity cannot be visually confirmed without removing the lance, so operators rely on audible cues to detect damage.

Review of maintenance records shows that routine pressure and flow testing was only partially completed, constrained by steam limitations when the unit operated at lower loads due to market dispatch. Inspection reports exist but supporting inspection records were not consistently attached to SAP maintenance entries.

The last maintenance, completed the day prior to the incident, indicated no issues. However, post-incident inspections found damage to the upper furnace sootblowers (refer Figure 17). The installed nozzles were of incorrect material; 303 stainless steel instead of the required 304H stainless steel suited for high-temperature zones. All nozzles were replaced with the correct material prior to the unit's return to service.

**Figure 17** - Sootblower Nozzle Damage

**Hydrojets**

The Clinker Assessment Tool had identified that hydrojet effectiveness may be compromised as at least one heat flux sensor was showing signs of clinker growth for over 6 hours in the prior three assessments. The hydrojets were not replaced prior to the units being returned to service in June 2025 as parts were unavailable, however these tools can be maintained/changed out whilst the unit is operating. A review post incident of the hydrojets has also identified multiple failed heat flux sensors, blocked nozzles, alignment / calibration and a failed hydrojet (now rectified).

The air knockers focus on lower-level clinker removal and completed maintenance in March 2025 with 2 defects found and rectified.

Cumulative corrective maintenance requirements of clinker cleaning tools above a threshold are a key input towards when a clinker deload may be indicated by the Clinker Assessment Tool. The maintenance records prior to the incident identified some minor defects on some cleaning tools but not to the extent which required inclusion in the Clinker Assessment Tool. Partial completion of maintenance activities is reviewed as part of the Work Management process.

The absence of identification of damaged clinker cleaning tools is a contributing factor to this event. The ICAM will further investigate the reasons for the maintenance failings on the clinker cleaning tools and the work management system.

### 9.2.6. Subjective Clinker Assessment Tool

Clinker assessments are completed several times per day using the Callide C Power plant Production Advice Manual PAMC-CH20-SO4-P21 Deload Clinker Assessment Tool. The Clinker Assessment Tool was built around boiler slagging and developed to assist decision making related to clinker formation and guidance on initiating clinker deloads. It is supplemented by the HMI screens and Hydrojet heat flux screens as seen earlier in Section 8.

The Clinker Assessment Tool (Figure 18) is imprecise with the operator responding to questions about the state of the unit, with no distinction made between factors that increase clinker proclivity and actual evidence of actual clinker formation. More experienced operators supplement the Clinker Assessment Tool with additional operational knowledge, such as growth time and locations of clinkers, but many do not.

**Figure 18** - Clinker Assessment Management Tool

| | C3 | C/D/18/5396 CC3 - Clinker Assessment Tool<br>Version 9 - 27 October 2017 | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Current Date/Time | ############## | Date/Time Completed | 30/03/2025 15:00 | 30/03/2025 19:16 | 30/03/2025 23:52 | 31/03/2025 03:25 | 31/03/2025 07:42 | 31/03/2025 11:29 | 31/03/2025 19:52 | 01/04/2025 03:09 | 01/04/2025 08:59 | 01/04/2025 17:59 | 01/04/2025 19:36 | 01/04/2025 23:00 | 02/04/2025 03:35 | 02/04/2025 19:15 | 02/04/2025 22:10 | 03/04/2025 04:06 | 03/04/2025 07:00 | 03/04/2025 11:00 | 03/04/2025 15:00 | 03/04/2025 19:25 | 04/04/2025 02:50 | 04/04/2025 04:21 |
| No | Description | Source | Value | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No | Yes/No |
| 1 | Observation from last deload | Observation and ICMS Trend | Furnace pressure spikes > 0.2kPa or large clinker falls in SCC since the end of prev de-load (ignore press blips when hydrojet spraying) | no | no | yes | no | no | no | no | yes | yes | no | no | no | no | no | no | no | no | no | no | no | no | no |
| 2 | Coal Cv | ICMS | CV - Greater than 105% for 4hrs in previous 24hrs | yes | yes | yes | yes | yes | yes | yes | yes | no | no | no | no | no | no | no | no | no | no | no | no | np | np |
| 3 | Furnace Pressure | ICMS | NO LONGER USED | | | | | | | | | | | | | | | | | | | | | | |
| 4 | SCC Ash Composition | Local Observation | Dense, dark, fused deposits in SCC | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no |
| 5 | Unit Load | ICMS | Load > 300MW for > 12 hours | no | no | no | no | no | no | no | no | yes | no | no | no | no | no | no | no | no | no | no | no | no | no |
| 6 | Hydrojet Operation | Hydrojet Screen | Not spraying red zones which are enabled in auto | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no |
| 7 | Hydrojet Effectiveness | Hydrojet Screen | At least one red zone with CGT > 360 mins | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | yes | yes | yes |
| 8 | Air Knockers | Local Observation | More than 3/18 knockers defective (see weekly clinker assessment) | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no |
| 9 | Furnace Sootblowers | ICMS | 6 or more out of 26 short furn blowers unavailable or any nose sootblower (21 or 22, left or right) unavailable (see weekly clinker assessment) | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no | no |
| 10 | Mill Configuration | ICMS | 2 bottom mills in service for > 6hrs | no | no | yes | no | no | no | no | no | yes | no | no | no | no | no | no | no | no | no | no | no | yes | yes |
| 11 | Slope heat flux sensors | Hydrojet Screen | At least 2 red zones on front slope or 2 red zones on rear slope with CGT >240mins | no | no | no | no | no | no | no | no | yes | no | yes | no | no | no | no | no | no | no | no | yes | no | no |
| 12 | Furnace Inspection | Local Observation | NO LONGER USED | | | | | | | | | | | | | | | | | | | | | | |
| 13 | Furnace Heat Pickup | ICMS | Furnace + Nose Heat Pickup less than Generated Load MW - See ICMS (Refer sheet "Q13") | no | yes | yes | yes | no | no | yes | no | yes | yes | yes | no | yes | no | no | no | no | no | yes | yes | yes | yes |
| 14 | AH Gas Inlet Temp | ICMS | NO LONGER USED | | | | | | | | | | | | | | | | | | | | | | |
| 15 | Furnace Upper Metal Temp | ICMS | NO LONGER USED | | | | | | | | | | | | | | | | | | | | | | |
| | If Total Yes's are 4 or More OR If #11 = Yes (only) Organise a deload within 2 hours | | | 1 | 2 | 4 | 2 | 1 | 1 | 2 | 2 | 11 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 11 | 3 | 3 |

The Clinker Assessment Tool asks 11 questions about the operation of the unit requiring a yes/no answer, if 4 yes's are obtained then a deload is scheduled to be completed within 2 hours. If there are 2 heat flux sensors on the front or rear slope for greater than 4 hrs a deload is triggered with a single yes.

There are specific questions on clinker cleaning tools requiring Yes/No answers.

- More than 3 of 18 air knockers needing to be defective,
- More than 6 of 26 soot blowers unavailable, or
- Any 1 nose soot blower unavailable (the ones that were subsequently found to be damaged) would trigger a yes.

Assessments completed at 02:50 and 04:21 on 4 April using the Clinker Assessment Tool determined that a clinker deload was not required despite other panel screens indicating significant boiler fouling. The subjectiveness of the Clinker Assessment Tool and its inability in this case to not prescribe a Clinker Deload despite other indications that could have be used to identify significant clinker in the furnace is a contributing factor.

Figure 19 below shows the Human Machine Interface screen, Showing Heat Flux Probes as a representation of clinker buildup, at the time of unit trip. It shows red indicators on areas of boiler impacted by clinker presence for periods greater than the prescribed limit for that area. The

Screenshot taken 5 April 2025 1:51PM (approx ~ 34 hours following event on 04 Apr 2025 4:35am) zone info frozen.

**Figure 19** - Hydrojet Screen, Showing Heat Flux Probes

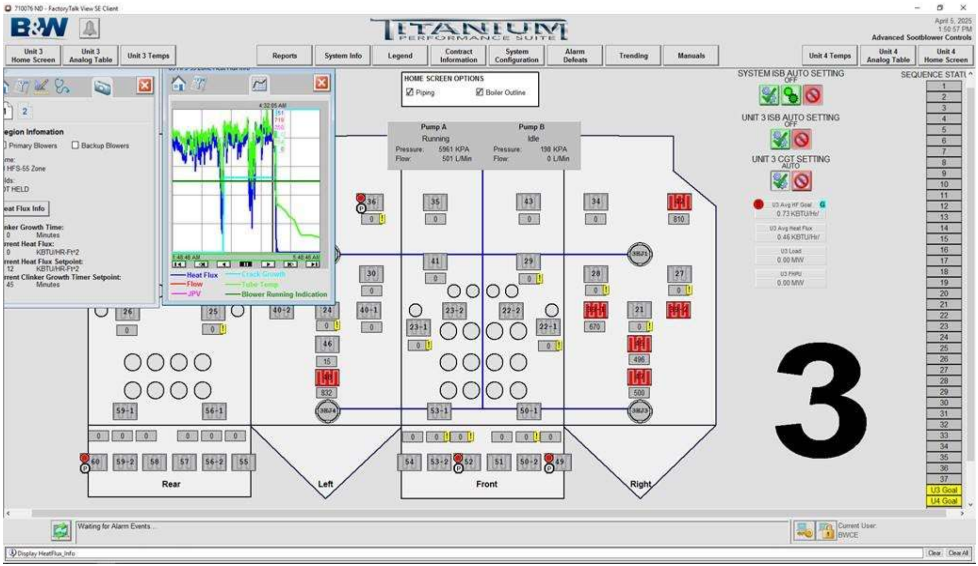
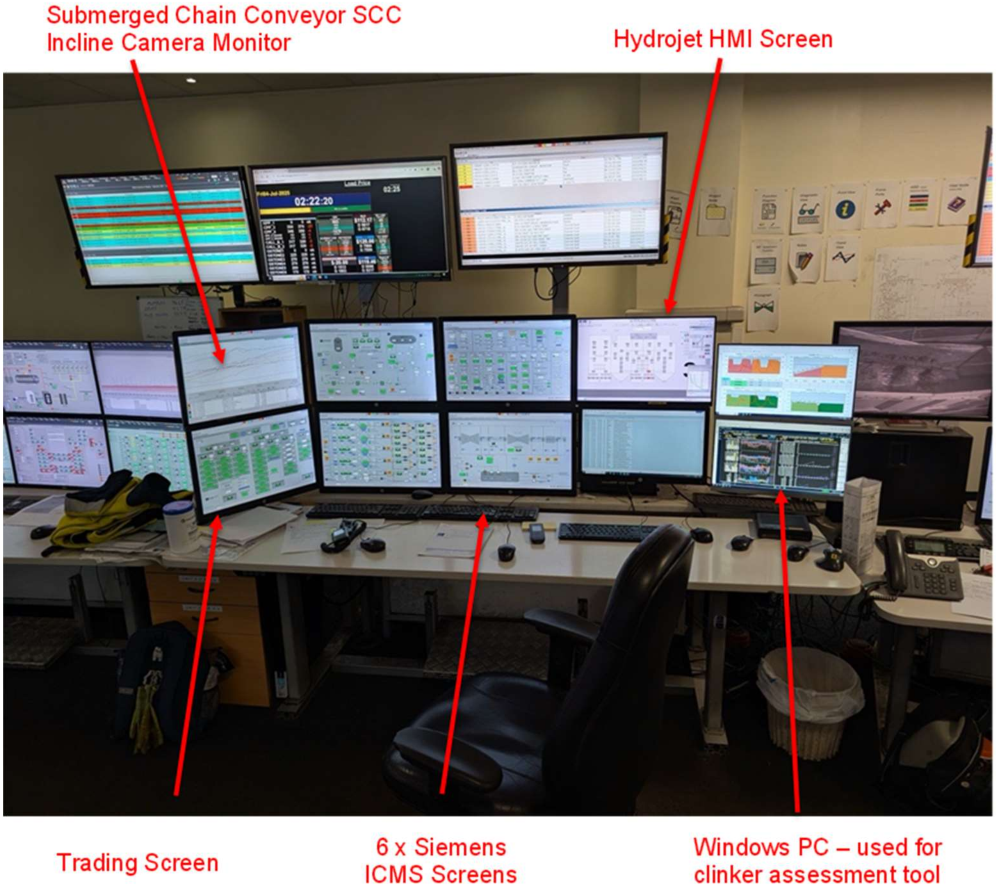



Figure 20 shows the control configuration setup for the operators, noting the clinker heat flux probes can be seen on the Hydrojet HMI Screen and the Submerged Chain Conveyor (SCC) camera monitor and access to the clinker assessment management tool through a windows pc.

Figure 20 - Control Room Desk Screen, Monitor Setup for Clinker Management




### 9.2.7. Unclear Clinker Deload Practices

The Production Advice Manual (PAMC-CH20-SO4-P21) for Callide C specifies that a Clinker Deload should be conducted at 240 MW and held for one hour. The associated Clinker Assessment Tool further advises that, if a deload is indicated, it should occur within 2 to 6 hours depending on the number of 'YES' responses.

In practice, however, a different approach known as a 'Proactive' Clinker Deload is often used. This version is agreed between Operations and Trading to take advantage of market conditions but may differ from procedural requirements. This divergence between formal procedure and actual practice has created confusion about how a Clinker Deload should be performed to be effective.

It is standard practice to remove one mill during a Clinker Deload to achieve the 240 MW target. The combination of mill removal and reduced load significantly alters furnace conditions, promoting clinker dislodgement. In contrast, a deload to 280 MW with all four mills in service, as was performed on 3 April 2025, results in a milder change that is less effective at dislodging clinker. The procedure does not specify whether a mill should be taken offline during a deload.

Failure to perform a full Clinker Deload at 240 MW, including mill removal, was a contributing factor to the incident. A review of the procedure identified key areas for clarification to improve effectiveness:

- Specify the minimum load and duration at that load
- Require removal of a mill from service during deload
- Define ramp rates for load reduction and recovery

Figure 21 and Figure 22 illustrate inconsistencies in how clinker deloads are managed across procedures,

**Figure 21** - Inconsistencies within Clinker Assessment Management Tool

| Instructions | |
|---|---|
| 1 | Assess each item against the value and note Yes or No |
| 2 | Add up the number of Yes's |
| 3 | If there are 4 or More Yes's then a deload is required within 6 hours. |
| 4 | If you have other parameters you think are relevant then advise |
| 5 | If you think the values need to adjusted then advise |

| 15 | Furnace Upper Metal Temp | ICMS | NO LONGER USED |
|---|---|---|---|
| | If Total Yes's are 4 or More OR | If #11 = Yes (only) | Organise a deload within 2 hours |

**Figure 22** - Inconsistencies within CPM / SITE / CPT Plant Co-ordination Meeting

| 2.2 Regular Activities | | | | |
|---|---|---|---|---|
| *Description* | *Freq.* | *Start* | *Finish* | *Avail* |
| Valve Stroking | Saturday | 11:00 | 13:00 | <260 Fixed |
| | | | | |
| Daily De-loads to 280MW required when 2 bottom mills in service or 250 for combustion issues. When 1 bottom mill in service de-load to 250 every second day. | | | | |

| 3.2 Regular Activities | | | | |
|---|---|---|---|---|
| *Description* | *Freq.* | *Start* | *Finish* | *Avail* |
| Clinker De-load | Alternate days | TBA | TBA | 280 |
| Valve Stroking | Saturday | TBA | TBA | <260 Fixed |
| | | | | |

### 9.2.8. Submerged Chain Conveyor (SCC) - Ash Handling System Design

The SCC is a water-filled hopper at the furnace base that collects ash, clinker, mill rejects, pyrite, and economiser hopper discharge. It transfers this material to the ash disposal system and serves multiple critical functions:

- **Water Seal:** Maintains a 1.4-meter water depth to prevent air ingress and stabilise furnace pressure.
- **Thermal Expansion:** Allows safe expansion of furnace walls.
- **Cooling:** Cools water via an external circulation loop connected to the ash dam.

Following the C3 clinker fall, a 10 cm drop in SCC water level indicated substantial steam release. Figure 23 compares typical clinker consistency with the friable material observed post-event.

When large, solid clinker enters the SCC, minimal surface contact produces limited steam. In contrast, friable clinker disperses on impact, creating widespread contact with water and significantly more steam.

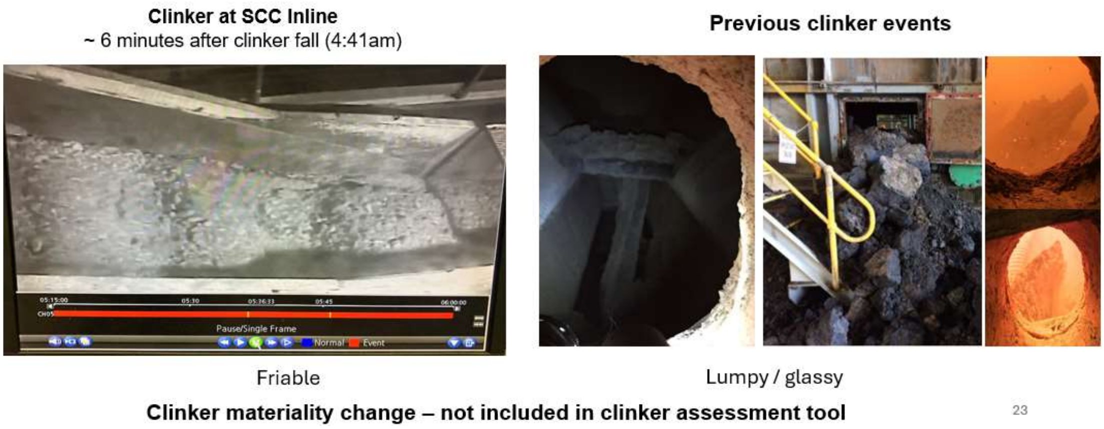
The B-side water seal flap was missing, likely damaged by an earlier clinker fall. This allowed uncontrolled air ingress, disturbing combustion conditions on that side of the boiler.

The RCA team assessed higher-order controls and considered two key options:

- Eliminate steam risk by removing water from the wet ash system.
- Reduce boiler iron content to lower the likelihood of iron-based clinker formation.

These higher order controls are under review as identified opportunities to further mitigate risk associated with furnace clinkering.

**Figure 23** - Clinker Consistency Emerging from the Submerged Chain Conveyor (SCC)



# 10.0 Recommendations

An analysis of the root causes and contributing factors identified recommendations that will bolster existing controls to address the likelihood of this event re-occurring. The actions were split into immediate actions needed for continuation of operation of unit C4 and return to service and commissioning of unit C3. They are summarised below.

## 10.1. Immediate - Return to Service Requirements

**Table 5** - Return to Service and Commissioning Action - WHSQ Requirements

| Root Cause/ Contributing Factor | Return to Service and Commissioning Immediate Actions | Action Completed |
|---|---|---|
| Ineffective clinker management | Update of operations clinker management assessment tool to be more prescriptive for effective clinker management. | Yes |
| Flame detector system failed to promptly identify flame loss | Implement set up and calibration procedures (including discrimination testing) for flame detectors and Pulverised Fuel cut dampers. Action first on C4 and then replicate on C3. | Yes |
| | Flame detection trip time to be optimised as far as possible to minimise trip time. Action first on C4 and then replicate on C3. | Yes |
| | Remove blinding function on flame detectors to eliminate control masking. Action first on C4 and then replicate on C3. | Yes |
| Cut Damper Closure Time from Mill Group Trips (MGT) & Master Fuel Trip (MFT) | Damper times to be reduced and all aligned on Pulverised Fuel cut dampers. Action first on C4 and then replicate on C3. | Yes |
| Indeterminate coal quality | Update coal blending stockpile management procedure (CWP-ES-0030) to define processes for when blending is restricted or impaired. | Yes |
| Combustion tuning trade-offs | Clinker formation and shedding and importance of combustion management focus areas to be communicated to all Callide C panel operators before Callide C3 unit restart. | Yes |

Action Closeout of the above will be found in CGR Insight associated with the incident record #3099.

## 10.2. Improvement – Longer Term

Recommendations aimed at addressing the root causes and contributing factors can be seen below. All these recommendations are in progress and associated with the CGR incident record #3099.

**Table 6 -** Improvement Recommendations and Action Plan

| Root Cause/ Contributing Factor | Improvement Recommendations | Due Date |
|---|---|---|
| Ineffective clinker management | Include clinker formation and shedding as a core competency of operators for Callide C units. | 30 January 2026 |
| Flame detector system failed to promptly identify flame loss | Review logic and minimise unit protection trip thresholds on partial and total loss of flame (including)<br>• Review trip thresholds for mill trip loss of flame (currently 2 burners)<br>• Review trip logic for partial loss of flame<br>• Review trip logic for total loss of flame | Unit C3<br>5 December 2025<br>Unit C4<br>TBA |
| Cut Damper Closure Time from Mill Group Trips (MGT) & Master Fuel Trip (MFT) | Investigate options to improve reliability and speed of closing of fuel cut dampers on both Callide C units. | 1 July 26 |
| Indeterminate coal quality | See Return to Service and Commissioning Immediate Actions | Closed |
| Operating on two lower mills | See Return to Service and Commissioning Immediate Actions - Ineffective clinker management recommendation | Closed |
| Combustion Trade-offs | Include furnace combustion management as a core competency of operators for units | 30 January 2026 |
| | Burner maintenance strategy does not match CS Energy overhaul strategy – develop appropriate planned maintenance activities for burner covers/shrouds for next overhaul | 5 December 2025 |
| | Burner design improvements, define performance acceptance criterion for stable combustion | 19 December 2025 |
| | Future combustion tuning of the units should include checks of boundary air flow on each side by briefly closing the manual isolating dampers and measuring the change in wind-box to furnace Differential Pressure (DP). A detailed procedure for this test should be developed and include checks for valid readings on Differential Pressure DP transmitters, windbox secondary air inlet pressures and furnace pressures. | 3 October 2025 |
| | A procedure will be developed to monitor changes to manual air dampers on the Callide C units to ensure all modifications are captured | 3 October 2025 |

| Root Cause/ Contributing Factor | Improvement Recommendations | Due Date |
|---|---|---|
| Ineffective clinker removal tools | Investigate water ingress into air system from hydrojets potentially compromising air actuated control devices on the burner | 5 December 2025 |
| | Investigate how to maintain hydrojet nozzles online – include in overhaul maintenance activities | 5 December 2025 |
| | It is recommended that the strategy for maintaining sootblowers in the high temperature furnace/pendant zone is reviewed and the SAP criticality associated with these sootblowers on Callide C units increased from a C to an A. | 3 October 2025 |
| Subjective Clinker Assessment Tool | See Return to Service and Commissioning Immediate Actions - Ineffective clinker management recommendation | Closed |
| Unclear clinker deload practices | See Return to Service and Commissioning Immediate actions- Ineffective clinker management recommendation | Closed |
| Ash handling system design (SCC-related) | Complete analysis of options for removing of iron through desanding – opportunity to remove 50% of iron through elimination | 3 July 2026 |
| | Complete analysis of options for removing the water in the Submerged Chain Conveyor (SCC); minimise water content + sprays / Magaldi - concept papers | 3 July 2026 |

# 11.0 Conclusions

**Incident Overview**

The event could have occurred at any time since the original commissioning of the Callide C units. While the flame scanner scenario was embedded in the system design, the associated risks were understated due to limited understanding of latent design flaws. The incident reflects a systemic failure to manage both technical and organisational risks, highlighting the critical need for integrated system reviews, clearly defined performance standards, and disciplined oversight of process safety.

**Alignment of Multiple Failures**

The incident was triggered by the concurrent failure of several independent controls. A large clinker formed and fell, leading to total flame loss in the furnace, while fuel was not isolated in time. Each failure point had an associated control mechanism; had any single control operated effectively, the event could have been averted.

**Underrated Clinker Risk**

Clinker falls were treated as routine operational events rather than serious process safety concerns. As a result, these events were not consistently reported, investigated, or escalated. This normalisation eroded oversight, diminished risk visibility, and contributed to missed opportunities for control improvements.

Operators relied on the Clinker Assessment Tool as a trigger mechanism rather than as a broader decision-support resource. The clinker deload executed prior to the incident did not meet procedural requirements—namely, reducing the load to 240 MW or removing a mill from service—thereby diminishing its effectiveness. Degraded clinker removal systems, including damaged sootblower nozzles and misaligned hydrojets, further impaired clinker management. These issues were not identified or corrected by maintenance processes. Despite clear and ongoing signs of clinker growth, no additional deloads were initiated.

**Latent Design Issues in Fuel Isolation**

Post flame loss, pulverised fuel continued feeding into the furnace longer than acceptable. Mechanical cut dampers closed within 3 to 5 seconds, but logic delays embedded in the Burner Management System added further latency. These delays, intended to prevent false trips, ultimately allowed unburned fuel to accumulate. Although logic optimisation was performed in 2012, the overall response time remained excessive. No performance standards existed to define acceptable limits, and the end-to-end sequence from flame loss to fuel isolation was neither well understood nor measured.

**Absence of Integrated System Perspective**

The Burner Management System incorporates multiple layers of logic and sequencing. However, there is no unified view of how the system behaves under critical conditions. Control logic diagrams are fragmented, and there is no accessible, documented end-to-end representation of system operation during a real-world event. This lack of transparency restricted the identification of latent risks and limited the ability to validate system performance under worst-case conditions.

# 12.0 Appendices Additional Support Reference

## 12.1. Inadequate Coal Blending

Callide Power Station gets its coal from the Callide Mine via the Receiving R1 conveyor (refer Figure 24). The mine pulls coal from different seams, each with its own quality. The Trap Gully pit seams have higher iron levels, which can lead to increased clinker forming during combustion.

The Callide coal plant has one coal analyser (for coal quality monitoring e.g. high iron content%) located on R1 conveyor from the mine. The slot bunker has a capacity of 38,000 tonnes at full capacity (approximately 2 days of coal supply). Since Callide Power Station doesn't control which seam the coal comes from, it can't prevent high-iron coal from being delivered. However, if that coal isn't blended properly with other types to reduce iron levels, the chances of clinkering increases.

The coal handling arrangement into Callide Power Station is shown in Figure 25 coal handling schematic. Coal is stockpiled and managed under procedure CWP-ES-0030 - Coal Stockpile Management (May 2013), which provides guidance for handling high-moisture coal but does not address coal quality in relation to ash, calorific value or iron content. Coal blending is achieved through the management of the stockpiles and slot bunker configuration. Effective blending relies on sufficient stock levels and operational flexibility to mix coal before it enters the furnace.

## 12.2. Constraints Leading Up to the Event

In the days prior to the incident, several factors combined to severely restrict coal deliveries relative to plant consumption. These constraints included:

- Receiving R2 conveyor belt drift trips.
- Reclaim S3 conveyor chute blockage trips.
- Batchfire supplying coal to other customers (via trains), reducing deliveries to Callide.
- Reclaim D10T2 dozer unavailable for two days.
- Slot bunker feed R3 conveyor tripper bearing replacement outage.
- Callide Mine planned maintenance down day.

There was also a period of wet weather resulting in localised stockpile reclaim to find dry coal. The Slot bunker had operated at around 30% for the 3 days prior. While none of these factors alone create a significant blending issue, together they depleted accessible coal stocks and forced the station to rely heavily on the slot bunker. The delays are shown visually in Figure 26 and Figure 27.

## 12.3. Operational Measures Taken

To conserve remaining coal stocks, shift supervisors in consultation with CS Energy traders implemented a site-wide "coal conservation" strategy at 16:37 on 2 April 2025. This required all units to operate at reduced loads for 12 hours. The conservation measure was lifted at 04:00 on 3 April 2025 - the day prior to the C3 clinker incident.

The combined impact of reduced supply, multiple plant constraints, wet weather, and the absence of blending-specific quality controls or procedural guidance directly impaired the station's ability to manage coal feed quality.  This finding is supported by the coal supply schematic (refer Figure 25).

**Figure 24** - Callide Coal handling Pant Supply Configuration Overview

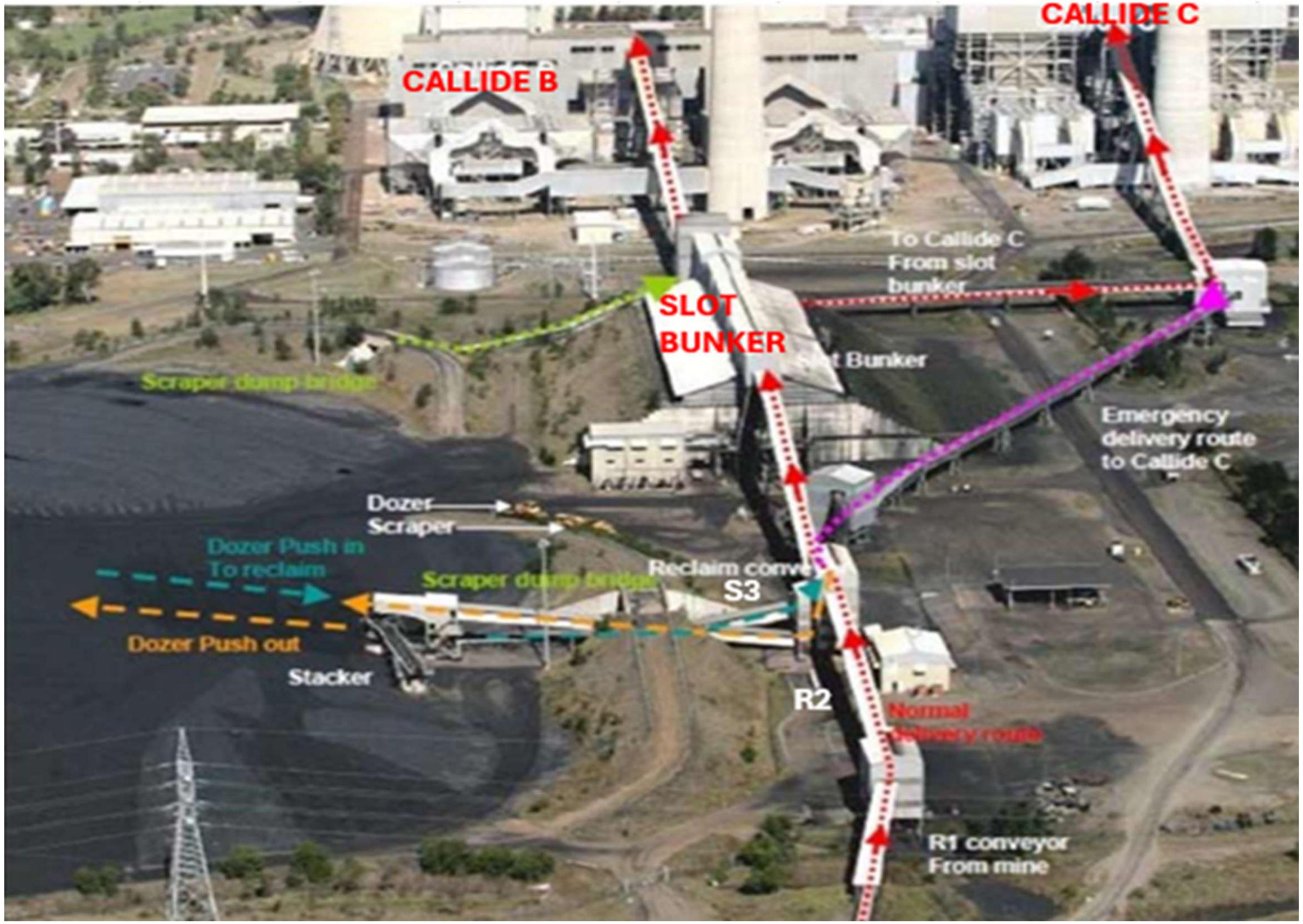


**Figure 25** - Callide Coal Handling Plant Supply Configuration Schematic

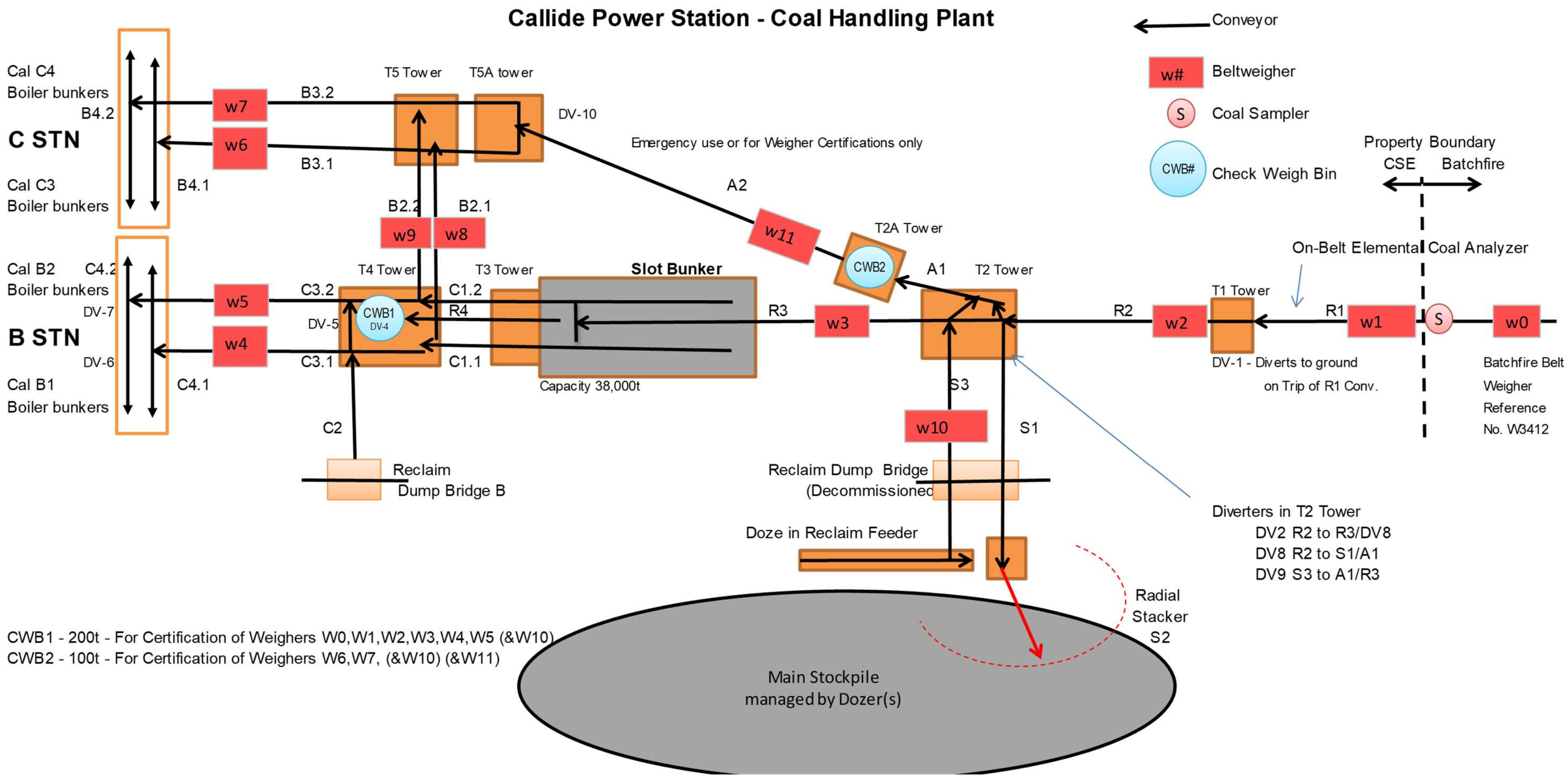
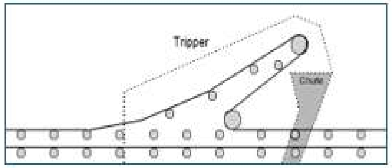


**Figure 26** - Callide Coal Slot Bunker Blending

### Slot bunker functions

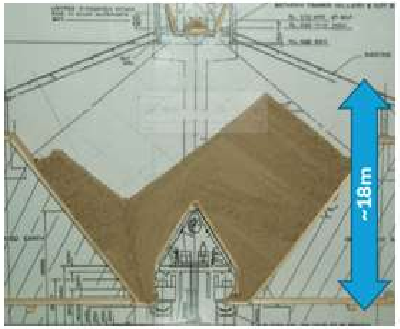
- ~ 2days of dry storage at full capacity
- Reclaim direct to boiler bunker via plough feeders
- <u>**Blending**</u> of coal into the slot bunker.

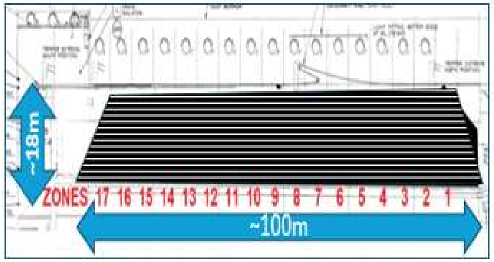



Coal Tripper on R3 Conveyor
Feeds coal into Slot bunker

### Blending details - Normal operation

- Tripper runs entire length - up & back every 20 minutes
- Ploughs runs entire length - up & back every 1.5hours
- “Layers” method selected to counter this type of feed (variability vs # layers laid down



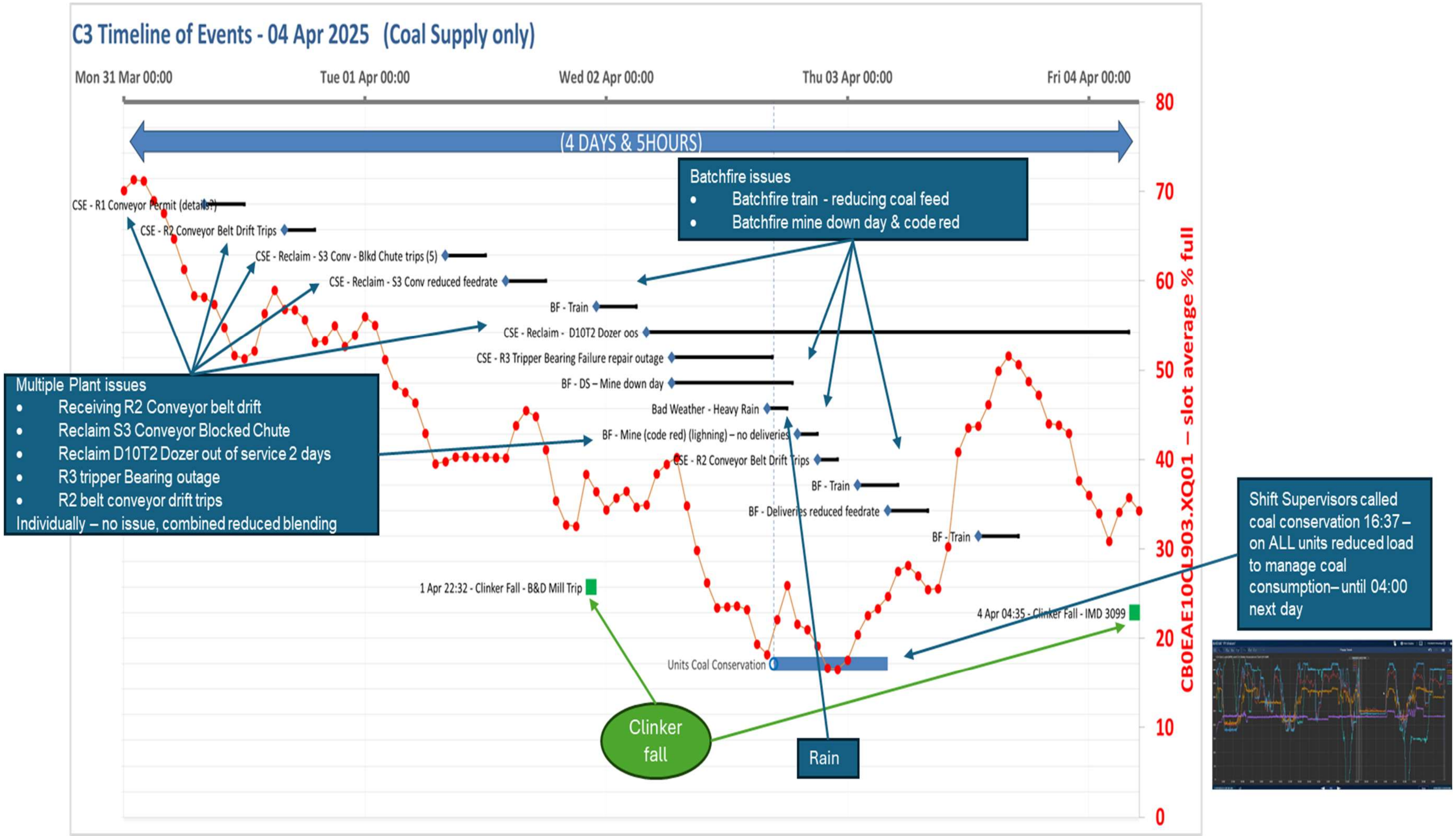


Coal Plough Feeder
Takes coal out of slot bunker
Rakes Coal off Shelf

Coal Shelf

4

**Figure 27** - Coal Supply Timeline and Slot Bunker Level



### 12.4. Coal Mill Configurations

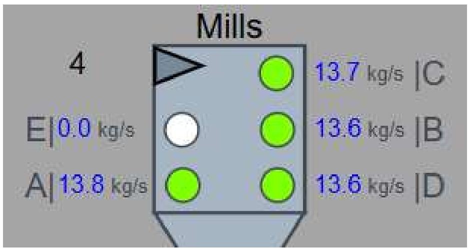
Prior to 31st March, Unit C3 operated with mills A, B, D, and C in service, while mill E was offline. Although clinkering occurred, system controls were effectively managing it, keeping overpressure events below 1 kPa. On 31st March, mill C was taken out of service for scheduled maintenance, and C3 was reconfigured to run with mills A, B, D, and E. Operating with both bottom mills (A & D) in service for long periods without rotating mill configurations tends to promote large clinker formation on the lower slopes. This mill configuration is historically proven to increase the propensity for clinker build-up. C3 was clinkering and on Tuesday 1 April 2025 a clinker fall event occurred, resulting in flame loss and tripping of 2 mills and produced an overpressure of 3.53 kPa.

Historically, most flame loss Master Fuel Trips (MFTs) have occurred under these conditions, often accompanied by clear signs of clinker growth in lower regions. Unit C3, for example, ran with bottom mills for 54 out of the previous 63 days. Being closest to the base of the boiler, A & D mills are particularly susceptible to flame disruption caused by steam and dust plumes from clinkers.

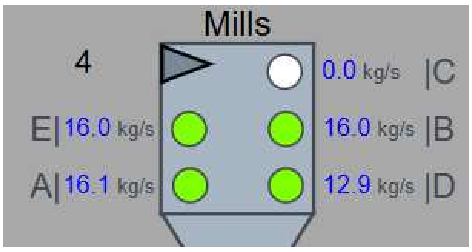
Figure 28 shows the mill operating loads (coal flow kg/s) and mill configurations for prior to the event. Mills typically deliver Pulverised Fuel at the same feed rate, unless an operator specifically adjusts one of the mills to different. Prior to 3 April 2025 Pulverised Fuel flow was 54.7 kg/s vs a small increase in flow to 61 kg/s pre-event. The D mill flow was reduced 6 hours prior to the event by an operator in an attempt to minimise clinkering.

**Figure 28** - C3 Mill Configurations Overview Pre Event

Prior to 3 Apr 22:00




3 April 22:00 to 4 April 2025



### 12.5. Combustion Tuning

Boiler combustion management involves precise control and optimization of the combustion process to ensure operational efficiency, equipment reliability, and environmental compliance. Key objectives include minimizing unburnt fuel, reducing emissions (particularly NOx), and maintaining stable thermal output.

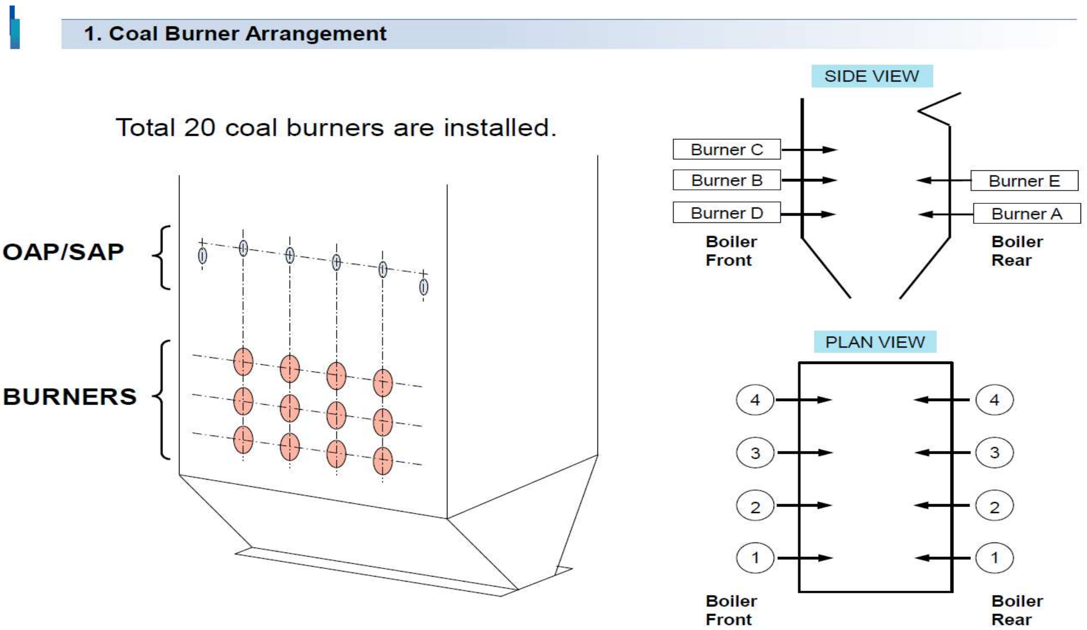
Combustion performance is governed by multiple interrelated variables, notably:

- Air-fuel ratio control: Accurate metering ensures stoichiometric balance or desired excess air conditions.
- Airflow optimization: Primary, secondary, and overfire air distribution must support staged combustion and flame stability and match fuel distribution
- Automated control systems: Integration of burner management systems (BMS) provides dynamic regulation, fault detection, and response coordination.

Figure 29 depicts the Unit C3 coal burner layout. The C unit employs low NOx burners, engineered for enhanced mixing and reduced flame temperature to suppress NOx formation. Burners are designed to run sub-stoichiometrically (more fuel than air), i.e. reducing environment, with overfire air completing combustion. Reducing environments is prone to clinkering, therefore tuning for NOx makes clinkering worst. As illustrated in Figure 30, these burners use aerodynamic stabilisation via internal geometry to establish a recirculation zone, critical for flame anchoring and complete combustion.

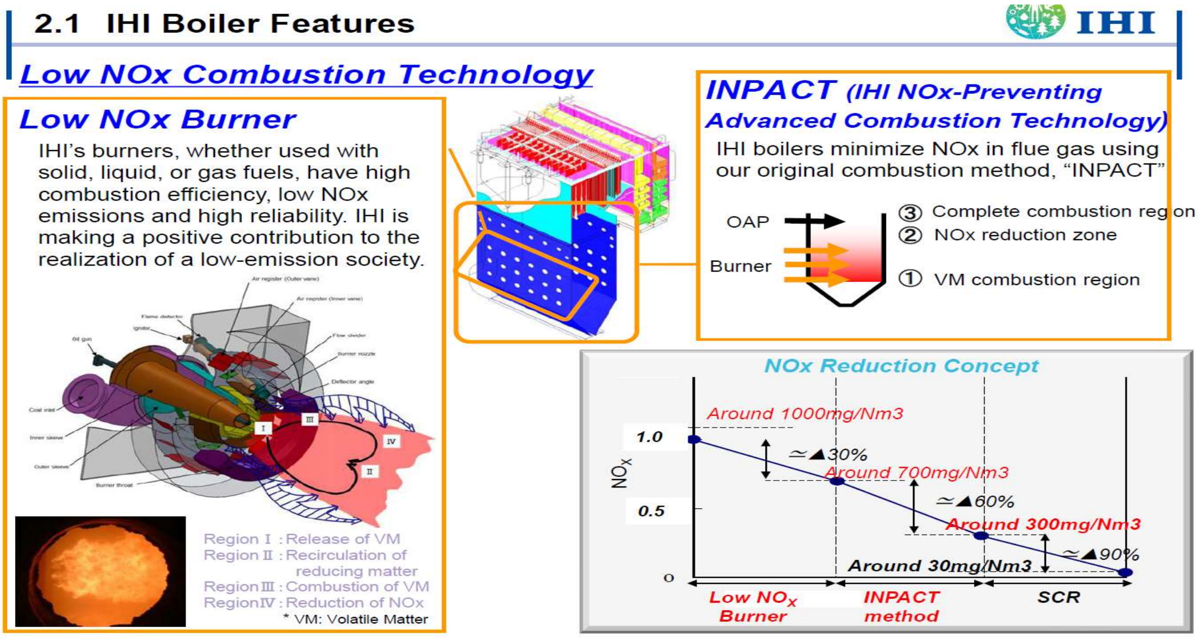
Any degradation in air or coal delivery -such as maldistribution, blockages, or feeder inconsistencies, compromises these conditions. This leads to incomplete combustion, elevated carbon-in-ash levels, and promotes clinker development due to localised slagging and fouling.

**Figure 29** - C3 Coal Burner Arrangement – illustrative only



Images from IHI Training Manual CS Energy IHI Training Material 24-Mar~29-Mar 2025. IHI is the Original Equipment Manufacturer (OEM)

**Figure 30** - C3 Low NOx Burner – Illustrative only




Maintaining the integrity of burner throats is critical to ensuring optimal low NOx burner performance. Distortion, particularly observed in C3 burner throats, disrupts flow within the recirculation zone and can negatively impact combustion efficiency and emissions control.

The C3 burner throats were last serviced in 2019 during a major overhaul that included furnace scaffolding. Current maintenance strategy include a 5-year service interval to maintain burner .

Historically, internal burner inspections were only feasible during major overhauls due to access limitations requiring scaffolding. However, with the improvement of drone technology in recent years, options exist to complete more frequent inspections, however scaffolding is required for maintenance.

**Callide C3 Combustion Tuning Summary – August 2024**

HRL conducted combustion tuning using the Multipoint Combustion Diagnostic Analysis system. Key findings include:

- Fuel-Rich Operation: Burners are fuel rich; overfire air completes combustion and reduces NOx formation.
- Airflow Imbalance: Overfire and secondary air are skewed to the B side to balance reheater outlet temperatures, causing incomplete combustion (CO buildup) on the A side.
- Efficiency Trade-Off: Increasing boiler airflow (+0.2% $O_2$) reduces fuel richness, increasing NOx emissions.
- Air Redistribution Challenge: Shifting air to A side requires adjusting dampers/registers, currently favouring the B side.

**Fuel Distribution and Mill Balancing**

- In September–October 2024, individual mills were balanced to equalise reheater steam temperatures. Follow-up fuel distribution tests in March 2025 showed good performance, with all burners online—supporting consistent thermal output and stable emissions control. This was achieved with fixed orifices engineered for each mill. This is only valid for specific load points.

**Post C3 Boiler Inspection Summary**

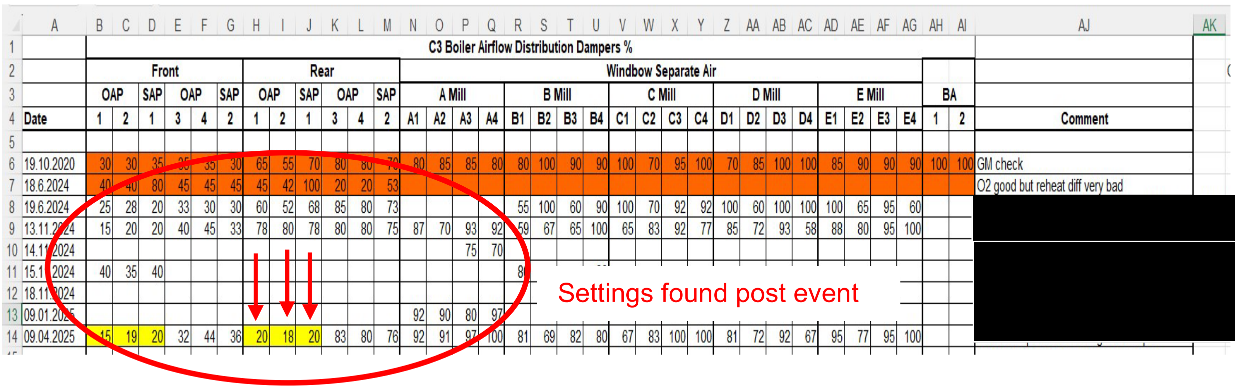
- Burner Degradation: Secondary air guide rings are distorted; C3 burners show greater wear due to reduced cooling airflow (15% vs. C4's 25–30%) as commissioned.
- Air ports & Registers: Restricted boundary air ports affect near-wall combustion. Air register calibration issues noted on C4, E4, D4, A2, and A3.
- Uncontrolled Adjustments: Manual dampers on A-side overfire air port were changed from 80% to 20% without authorization, impacting combustion stability.
- SCC Flap Gate Damage: Removal due to clinker drops allows tramp air into the furnace, reducing burner air supply.
- Fouling Patterns: A-side of boiler shows more fouling, likely linked to missing B-side SCC flap gate and associated airflow changes. This was evident in physical inspections in the boiler, showing delayed combustion, as well as O2 sensors dropping away at higher loads, showing incomplete combustion on A-side.

**Manual Damper Adjustment and Procedural Oversight – C3 Unit**

Uncontrolled manual adjustments to C3 overfire air ports were observed and not logged under record C/D/20/27883. Several air dampers, designed for static settings relative to mill configuration, had been altered outside of sanctioned tuning campaigns. These changes were made without formal procedure or clarity on ownership, undermining combustion control integrity.

Figure 31 illustrates the change, with the unauthorised air distribution changes likely contributing to reduced flame stability and increased clinker formation due to disrupted combustion dynamics.

**Figure 31** - C3 Boiler Airflow Distribution Dampers Change




C3 Boiler Airflow Distribution Dampers %

| | Front | | | | | | Rear | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | OAP | | SAP | OAP | | SAP | OAP | | SAP | OAP | | SAP |
| Date | 1 | 2 | 1 | 3 | 4 | 2 | 1 | 2 | 1 | 3 | 4 | 2 |
| 19.10.2020 | 30 | 30 | 35 | 35 | 35 | 30 | 65 | 55 | 70 | 80 | 80 | 70 |
| 18.6.2024 | 40 | 40 | 80 | 45 | 45 | 45 | 45 | 42 | 100 | 20 | 20 | 53 |
| 19.6.2024 | 25 | 28 | 20 | 33 | 30 | 30 | 60 | 52 | 68 | 85 | 80 | 73 |
| 13.11.2024 | 15 | 20 | 20 | 40 | 45 | 33 | 78 | 80 | 78 | 80 | 80 | 75 |
| 14.11.2024 | | | | | | | | | | | | |
| 15.11.2024 | 40 | 35 | 40 | | | | | | | | | |
| 18.11.2024 | | | | | | | | | | | | |
| 09.01.2025 | | | | | | | | | | | | |
| 09.04.2025 | 15 | 19 | 20 | 32 | 44 | 36 | 20 | 18 | 20 | 83 | 80 | 76 |

| | Windbow Separate Air | | | | | | | | | | | | | | | | | | | | BA | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A Mill | | | | B Mill | | | | C Mill | | | | D Mill | | | | E Mill | | | | BA | | |
| Date | A1 | A2 | A3 | A4 | B1 | B2 | B3 | B4 | C1 | C2 | C3 | C4 | D1 | D2 | D3 | D4 | E1 | E2 | E3 | E4 | 1 | 2 | Comment |
| 19.10.2020 | 80 | 85 | 85 | 80 | 80 | 100 | 90 | 90 | 100 | 70 | 95 | 100 | 70 | 85 | 100 | 100 | 85 | 90 | 90 | 90 | 100 | 100 | GM check |
| 18.6.2024 | | | | | | | | | | | | | | | | | | | | | | | O2 good but reheat diff very bad |
| 19.6.2024 | | | | | 55 | 100 | 60 | 90 | 100 | 70 | 92 | 92 | 100 | 60 | 100 | 100 | 100 | 65 | 95 | 60 | | | [redacted] |
| 13.11.2024 | 87 | 70 | 93 | 92 | 59 | 67 | 65 | 100 | 65 | 83 | 92 | 77 | 85 | 72 | 93 | 58 | 88 | 80 | 95 | 100 | | | |
| 14.11.2024 | | | 75 | 70 | | | | | | | | | | | | | | | | | | | [redacted] |
| 15.11.2024 | | | | | 80 | | | | | | | | | | | | | | | | | | |
| 18.11.2024 | | | | | | | | | | | | | | | | | | | | | | | |
| 09.01.2025 | 92 | 90 | 80 | 97 | | | | | | | | | | | | | | | | | | | |
| 09.04.2025 | 92 | 91 | 97 | 100 | 81 | 69 | 82 | 80 | 67 | 83 | 100 | 100 | 81 | 72 | 92 | 67 | 95 | 77 | 95 | 100 | | | |

Whilst there is CS Energy Combustion Tuning Training Material for its C units from IHI is available it was observed during the RCA investigation that there is a general lack of knowledge of combustion management across operations.

**Comparison of C3 & C4 burner airflows at 400 MW.**

It was notable that over the past few months prior to the event C3 has clinkered readily whenever it ran on bottom mills, but C4 did not. This is the opposite of the situation for many years before C4 shut down in 2021.

Comparing burner air flows on C3 prior to its trip on 4 April 2025 (23:00 to 04:30) with C4 on 5 May 2025 (20:35 to 22:56) at the same load of 400 MW and similar flue gas oxygen (2.14% on C3 and 2.36% on C4) and similar secondary air temperatures (350 'C on C3 and 348 'C on C4), and similar average manual distribution damper position (86% on C3, 82% on C4), similar over-fire & side-air port separate damper positions (28 & 28% front, 50 & 48% rear, with 65% control SADs on C3 and 19 & 17.5% front, 66 & 68.5% rear, with 68.2% control SADs on C4) and similar average burner separate air control damper positions (63.7+62.8+53.8*0.8+62.8)/3.8=61.1% on C3, (52.6+57.3+59.9+57.4)/4=56.8% on C4); Windbox-furnace DPs on C3 were 1.65 & 1.51 kPa compared to 1.38 & 1.33 kPa on C4.

Considering C3 was missing the SCC exit flap allowing more tramp air ingress, the higher windbox Differential Pressure (DP) on C3 suggests its boundary air flow may have been restricted. Boundary air ducts through the furnace throat above the SCC have become blocked with cemented wet ash in the past.

Restricted boundary air on A side of C3 may explain the low reading on A1 O2 measurement and the clinkering on A side of the furnace and thus could be a significant factor in C3's incident.

### 12.6. Clinker History at Callide

Unit C3 was commissioned in 2001 and has consistently seen clinkering in its operational life. Since 2001 on the Callide C station units there have been over 70 unit protection trips (Master Fuel Trips MFT) due to Flame Loss with the unit on-line with 3 or more mills in service.

Of these clinker falls, 5 events have seen generation of a positive overpressure greater than 5kPa in size, with 2 events generating an overpressure greater than 8kPa. Prior to November 2024. there had not been a notable pressure excursion greater than 3kPa for many years with the last one on unit C3 in July 2015 generating 3.18kPa. The previous maximum overpressure experienced on the Unit C3 was on the 20th June 2005 at 3:01:48 AM when a furnace pressure was recorded at 8.96 kPa (noting design boiler pressure rating of 8.7 kPa). This event occurred in the early years of the unit operation when clinkering was significant, which ultimately resulted in the burners being modified and clinkering reduced.

Unit C4 has a similar history with clinkering with the previous maximum overpressure experienced being on the 29 April 2011 at 6:27:02 PM when a furnace pressure was recorded at 5.0 kPa.

The operating history indicates that whilst clinkering occurs frequently over the previous 20 years of operations clinkers have typically provided smaller furnace pressure excursion events. The hazards of clinker falling are normalised to be smaller furnace pressure events.

### 12.7. Furnace Management - Clinkering Cleaning Tools

A proactive way to minimise clinker build up on boiler surfaces is with clinker removal tools such as air knockers, hydrojets, sootblowers and in significant clinker build up at unit deload.

Hydrojets are used in conjunction with the heat flux sensors to target contaminated regions of the furnace. These run after the heat flux drops below a set threshold for a set period. When large areas of the furnace are unable to be properly maintained by the hydrojets the risk of large clinker formations is increased.

Air knockers are used to dislodge clinker formations on the slopes (lower levels)– they are most effective when clinker is small and lose effectiveness once large slabs form. Air knockers degrade over time gradually reducing their impact force – they typically continue to cycle through and appear to work but are not effective when doing so. The present maintenance cycle confirms the knockers run on a weekly basis but does not confirm the knocker is imparting sufficient force, noting the force analysis is only done monthly and is not recorded in a central location.

Furnace soot blowers are used to remove clinker formations on the walls. Soot blower failures / outages are frequent and generally accepted to not significantly impact the management of clinker on the plant unless they are widespread or long lasting.

The loss of furnace cleaning tools has an aggregate effect on clinker growth rate, the loss of an individual sootblower / hydrojet / air knocker on its own is not significant but cumulatively the overall impact can escalate quite quickly. Currently in SAP sootblowers have a criticality rating of C – the lowest priority in SAP.

During the investigation it was observed (Attachment 2 evidence) that some of the hydrojets, air knockers and soot blowers had defects recorded against these clinker removal tools. The work order evidence showed the following

- Hydrojet canons - All four (4) were in service at time of event – historical defects were all rectified.
- Testing of Air Knockers last test occurred in March 2025 with 2 defects identified and rectified. The air knockers focus on lower-level clinker removal and would not have assisted in removing the higher up clinker in the C3 event.
- Some sootblowers were out of service at the time, but they would not have assisted in removing the higher up clinker observed in the C3 event.

On the 20th May the upper-level long lance soot blowers 21 L&R / 22 L&R /23 L&R were physically inspected and found to have damaged / missing nozzles on 5/ 6 sootblowers. The Secondary Super Heater and Tertiary Super Heater are both maintained by the affected sootblowers and no heat flux sensors are fitted here. Hence further investigation was completed on the sootblowers as they play an important part in clinker management in the high temperature furnace/pendant zone.

### 12.8. Sootblowing System Purpose

Some of the residue from combustion of Coal (including Ash and Dust) tends to deposit on the boiler heat exchanging surfaces. These deposits act as insulation on the boiler tubes as well as the Gas Air Heater elements. If the deposits are left to build up, the heat transfer characteristics of the boiler will change. This will result in a higher firing rate for a given output of steam, which creates areas of higher-than-normal heat release. Boiler tube damage can result from this action because the high heat release areas may not be evenly distributed throughout the boiler. Insulation of the tubes by dust and soot deposits creates a major economic loss because less heat transfer occurs between the fire /hot gas to the steam/ water in the boiler tubes. Extra fuel is required to obtain the design turbine steam conditions for a given Megawatt output from the generator.

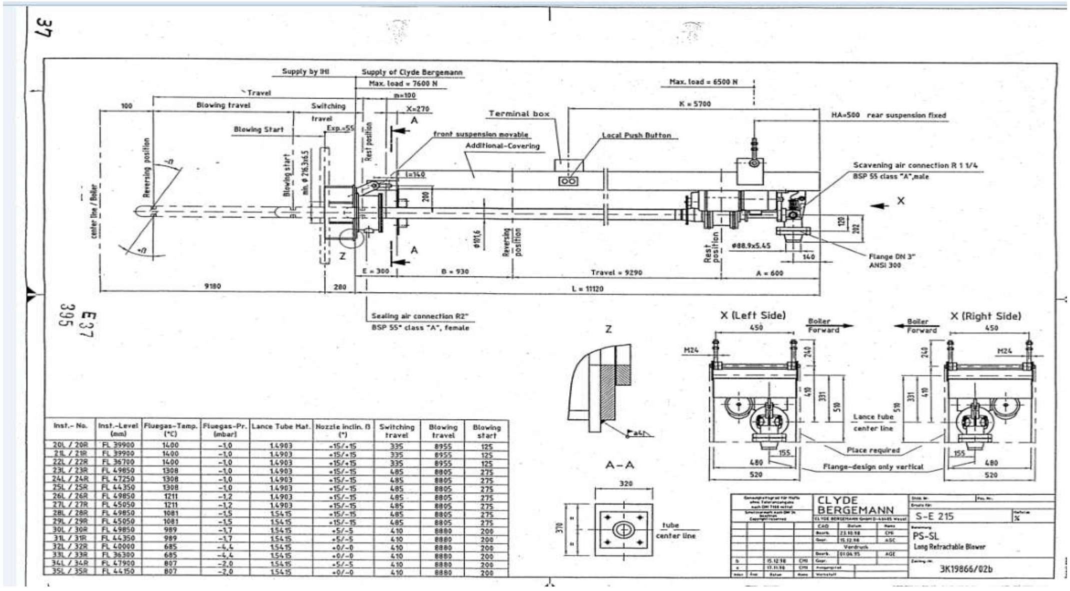
Fouling of Gas Air Heater elements is also a major problem because if the heat transfer from the flue gas to the Primary Air is reduced, the mill temperatures may not be as high as required. If the Secondary Air temperature is reduced, combustion of fuel is affected by lower combustion air temperature.

The positioning of the Sootblowers is designed to give maximum cleaning effect to the tube surfaces.

The long retractable sootblowers are placed opposite one another in the left and right-side wall of the boiler. Twenty-two sootblowers are installed in the radiant and convection area for cleaning the pendant superheaters and furnace nose and ten sootblowers are in the convection area for cleaning the horizontal tube banks. The Sootblowers operate in opposite pairs.

Sootblowing is covered in the operator training (FINAL - Operator Training - Callide C - Module - Chapter 06 – Sootblowing). Figure 32 shows a General Arrangement Drawing for a sootblower.

**Figure 32** - General Arrangement Drawing for a sootblower




Note Soot blowers are C Low Criticality in the SAP maintenance system priority.

Callide C3 - Sootblowers – are maintained under a maintenance plan and complete 2W, 4W, 12W packages of work.

Maintenance Plan numbers are - 13045 CC3 I/S 2W-3M SOOT BLOWER INSP

Maintenance Item no.   31583 CC3M 2W-3M I/S SOOT BLOWER INSP

The cycle of inspections and tasks in SAP are in Figure 33 below

**Figure 33** - Sootblower cycle of inspections and tasks in SAP

Operat. Overview Maint. Packages

| Op. | SOp | Operation Description | 1W | 2W | 3W | 4W | 6W | 8W | 12 | 13 | 16 | 24 | 26 | 30 | 48 | 1Y | 78 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0010 | | CC?M I/S 2W LONG SOOT BLOWER INSP | ☐ | ☑ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 0010 | 0010 | CC?M I/S 2W LONG SOOT BLOWER INSP | | | | | | | | | | | | | | | |
| 0020 | | CC?M I/S 1M LONG SOOT BLOWER INSP | ☐ | ☐ | ☐ | ☑ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 0020 | 0010 | CC?M I/S 1M LONG SOOT BLOWER INSP | | | | | | | | | | | | | | | |
| 0030 | | CC?M I/S 3M LONG SOOT BLOWER INSP/LUB | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | ☐ | ☐ |
| 0030 | 0010 | CC?M I/S 3M LONG SOOT BLOWER INSP/LUB | | | | | | | | | | | | | | | |
| 0040 | | CC?M I/S 2W SHORT SOOT BLOWER INSP/LUB | ☐ | ☑ | ☐ | ☑ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |
| 0040 | 0010 | CC?M I/S 2W SHORT SOOT BLOWER INSP/LUB | | | | | | | | | | | | | | | |
| 0050 | | CC?M I/S 3M SHORT SOOT BLOWER INSP/LUB | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | ☐ | ☐ |
| 0050 | 0010 | CC?M I/S 3M SHORT SOOT BLOWER INSP/LUB | | | | | | | | | | | | | | | |
| 0060 | | CC?M I/S 2W LONG/SHORT SOOT BLOWER ADJ | ☐ | ☑ | ☐ | ☑ | ☐ | ☐ | ☑ | ☐ | ☐ | ☐ | ☐ | ☐ | ☑ | ☐ | ☐ |
| 0060 | 0010 | CC?M I/S 2W ONG/SHORT SOOT BLOWER ADJ | | | | | | | | | | | | | | | |
| 0070 | | INAC CC?M 1Y I/S SOOT BLOWER ACTUATOR LU | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

The procedures called for each test are in Figure 34 below and an example of a procedure is further in this evidence pack.

**Figure 34** - Sootblower Operations

Group CCBOIL CC?M I/S 2W-3M BLR LONG STEAM SOOTBLOWER Grp.Countr 30

General Operation Overview

| Act. | SOp | Work Ctr | Plnt | Ctrl | Operation Description | LT | Work | Un. |
|---|---|---|---|---|---|---|---|---|
| 0010 | | CMM-CMU | CAL1 | PM01 | CC?M I/S 2W LONG SOOT BLOWER INSP | ☑ | 4.0 | H |
| 0010 | 0010 | CUW-CMU | CAL1 | PM01 | CC?M I/S 2W LONG SOOT BLOWER INSP | ☐ | 4.0 | H |
| 0020 | | CMM-CMU | CAL1 | PM01 | CC?M I/S 1M LONG SOOT BLOWER INSP | ☑ | 4.0 | H |
| 0020 | 0010 | CUW-CMU | CAL1 | PM01 | CC?M I/S 1M LONG SOOT BLOWER INSP | ☐ | 4.0 | H |
| 0030 | | CMM-CMU | CAL1 | PM01 | CC?M I/S 3M LONG SOOT BLOWER INSP/LUB | ☑ | 4.0 | H |
| 0030 | 0010 | CUW-CMU | CAL1 | PM01 | CC?M I/S 3M LONG SOOT BLOWER INSP/LUB | ☐ | 4.0 | H |
| 0040 | | CMM-CMU | CAL1 | PM01 | CC?M I/S 2W SHORT SOOT BLOWER INSP/LUB | ☑ | 1.5 | H |
| 0040 | 0010 | CUW-CMU | CAL1 | PM01 | CC?M I/S 2W SHORT SOOT BLOWER INSP/LUB | ☐ | 1.5 | H |
| 0050 | | CMM-CMU | CAL1 | PM01 | CC?M I/S 3M SHORT SOOT BLOWER INSP/LUB | ☑ | 1.5 | H |
| 0050 | 0010 | CUW-CMU | CAL1 | PM01 | CC?M I/S 3M SHORT SOOT BLOWER INSP/LUB | ☐ | 1.5 | H |
| 0060 | | CMM-CMU | CAL1 | PM01 | CC?M I/S 2W LONG/SHORT SOOT BLOWER ADJ | ☑ | 2.0 | H |
| 0060 | 0010 | CUW-CMU | CAL1 | PM01 | CC?M I/S 2W ONG/SHORT SOOT BLOWER ADJ | ☐ | 2.0 | H |
| 0070 | | CMM-CMU | CAL1 | PM01 | INAC CC?M 1Y I/S SOOT BLOWER ACTUATOR ... | ☑ | 2.0 | H |

Testing procedures are in SAP, an example is in Figure 35 below. A work order on a soot blower feeds into the Clinker Assessment Tool.

**Figure 35** - Sootblower Test Procedure

0010CC3M I/S 2W LONG SOOT BLOWER INSP

1. Long Soot Blower Operational Check.
Refer to the soot blowers listed below and confirm the long soot blower sequence with operators for soot blowers to be inspected, check for:-

a) Poppet Valve

- Steam supply activates as lance enters furnace.
- Gland packing not leaking.
- Linkages not jammed.
- Vent not passing, indicated by temperature of discharge pipe.
- Steam pressure is correct, see pressure chart at bottom.

b) Lance/Feed Tube

- Feed tube gland packing (acceptable leakage).
- Not bent, eroded, cracked or damaged.
- Mid span support mechanism supports lance during operation and retracted position. (Applies to blowers 20, 21 and 22 only)
- Lance tube furnace end support bearings operate correctly.
- Carriage runs freely without excessive noise or vibration
- Limit switches operate correctly.

c) Nozzle

- Listen for a "Whoosh/Whoosh" sound of alternating steam flow, this confirms the nozzle is in good condition. A loud constant steam flow noise could indicate a damaged nozzle.

(-LL Soot blower has live loaded gland)
22 L/R (Lvl 7.5-LL)
20 L/R (Lvl 8LL)
21 L/R (Lvl 8LL)
26 L/R (Lvl 10LL)
27 L/R (Lvl 9-LL)
28 L/R (Lvl 10-LL)
29 L/R (Lvl 9-LL)
34 L/R (Lvl 9.5-LL)
35 L/R (Lvl 9-LL)
Clyde Bergmann Soot Blower Set Pressure kPa)
Sootblower Pressure

| | |
|---|---|
| 20 | 1500 |
| 21 | 1600 |
| 22 | 1600 |
| 23 | 1300 |
| 24 | 1300 |
| 25 | 1300 |
| 26 | 900 |
| 27 | 900 |
| 28 | 1000 |
| 29 | 1000 |
| 34,35 | 800 |

As it is physically impossible to check the nozzle without being extracted from the furnace – only an audible check is conducted for a damaged nozzle.

The Sootblower Inspection record form identifies checks needed for a condition assessment including the required pressures to operate. The Callide C Sootblower Inspection Record Form was last updated in November 2020, but is used frequently as shown by the audit history of the document in TRIM.

Below is the summary of C3 Sootblower maintenance activities completed in 2025, with inspection responses, extracted from SAP maintenance system.

**Table 7** - C3 Sootblower maintenance activities completed in 2025

| **Date Scheduled / WO Number / Date Completed** | **Full Test Y/X** | **Actual long text (names removed XXXX)** |
|---|---|---|
| 03.01.25<br>5196822<br>Completed 02.01.25 | Y | CC3M 2W-1M I/S SOOT BLOWER INSP<br>OP-40/10 Short sootblower insp and lube complete. XXXXX 02/01/25<br>OP-20/10 Long sootblower insp complete. XXXXXX 02/02/25<br>OP-60/10 Sootblower adj complete. XXXXXX 02/01/25 |
| 17.01.25<br>5198503<br>Completed 16.01.25 | Y | CC3M 2W I/S SOOT BLOWER INSP<br>Service was modified due to unit been down on load, manually went thru and did mini service XXXXX 15/01/25<br>OP 10 Complete - Nipped up 23R and 22R -Possible leaking vent valve 24L<br>OP10/10 Complete / OP60 Complete / OP60/10 Complete<br>OP40 and 40/10 3F not seeing front limit W/O in already 5211811 XXXXX 16/11/25 |
| 31.01.2025<br>5200057<br>Partially Completed<br>24.01.25 | X | C3M 2W-3M I/S SOOT BLOWER INSP<br>Full inspection not complete due to unit/market conditions basic inspection has been carried out. XXXXX 24/1/25 |
| 14.02.2025<br>5202301<br>Partially Completed<br>07.02.25 | X | CC3M 2W I/S SOOT BLOWER INSP<br>Unit on low load and ops won't run sootblowers closing job out. XXXXX 07/02/25 |
| 28.02.2025<br>5204128<br>Completed 25.02.25 | Y | CC3M 2W-3M I/S SOOT BLOWER INSP<br>Complete XXXXX 25/2/25 |
| By 14.03.2025<br>5206094<br><br>Completed 08.03.25 | Y | CC3M 2W-3M I/S SOOT BLOWER INSP<br>op 40 & 40/10 XXXXX, XXXXX completed inspection 6/3/25.NOTIFICATION 10693156 PUT IN ON 5F SHORT SOOTY, OP'S HAVE DESELECTED 5F UNTIL REPAIRED. ......................................................................<br>OP 10 & 10/10 XXXXX AND XXXXX COMPLETED LONG SOOTBLOWER INSPECTION NO ISSUES 8/3/25. ...................................................................... |
| 28.03.2025<br>5207931<br><br>Completed 20.03.25 | X | CC3M 2W-3M I/S SOOT BLOWER INSP<br>Op #40, #40/10 Incomplete. Contacted operations staff and were told sootblowers couldn't be run due to reduced load. Visual checks were carried out & and the lubrication of short sootblowers completed, including application of chain spray. Notifications were raised.<br>XXXXX and XXXXX 20.03.2025<br>Op #60, #60/10 Complete. XXXXX, XXXXX 20.03.2025 |

| Date Scheduled / WO Number / Date Completed | Full Test Y/X | Actual long text (names removed XXXX) |
|---|---|---|
| | | Op #20, #20/10 Incomplete, same issue of unit down on load not be able to operate sootblower. Visual inspection carried out all grease points & chains lubricated on long sootblowers carried out.<br>XXXXX, XXXXX 20.03.2025 |
| 11.04.25<br>5209841<br>Completed 03.04.25 | Y | CC3M 2W-3M I/S SOOT BLOWER INSP<br>op 10 40 60 complete XXXXX 03/04/25<br>op 10/10.40/10.60/10. complete XXXXX 03/04/25 |

A review of the sootblower maintenance activities shows that testing through the year has been partially completed, with pressure tests not completed due to steam availability at low loads. The last maintenance activity completed the day before the C3 clinker event the maintenance records indicate completed activities with no issues identified. It should be noted that whilst there is a soot blower inspection report, the inspection checks are not attached to SAP maintenance records.

### 12.9. Detection of Flame Loss

C4 scanner testing on 12 April 2025 identified 26 impairments out of 40 (now rectified), including ineffective flame loss detection that would cause reduced sensitivity, trip delays and prolonged fuel admission. Table 8 shows the results of the investigation on the unit flame detectors.

Operational logic showed that that the time from loss of flame to cut dampers closing and stopping Pulverised Fuel was between 9-13 seconds and it varied for all mills.

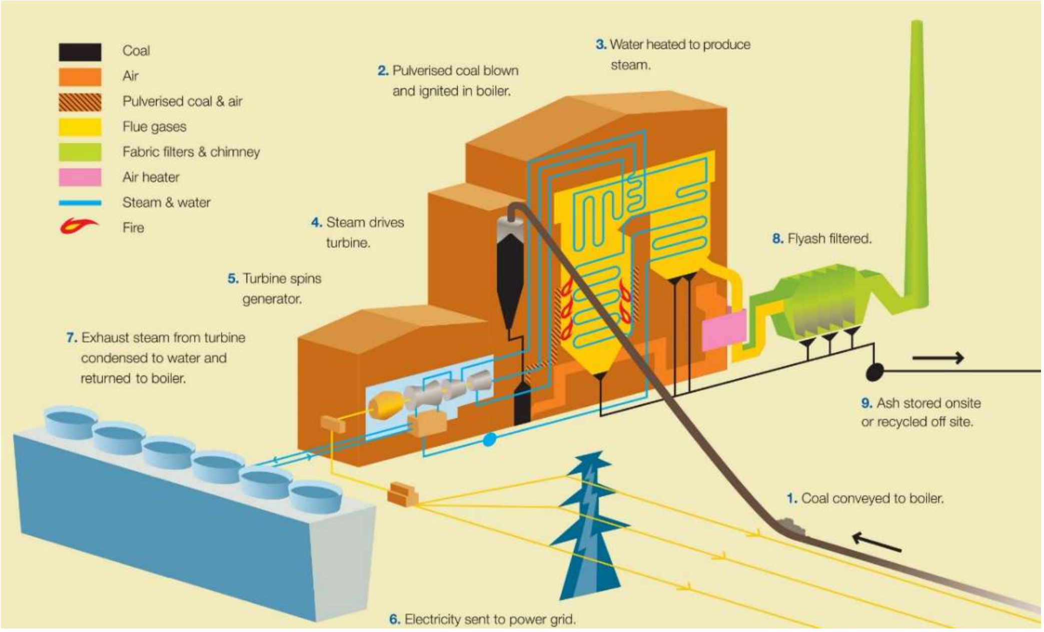
**Table 8 -** C4 Flame detectors as found position (now all rectified)

| Mill | As found condition | Current condition |
|---|---|---|
| A mill | 1x strong false positive<br>1x intermittent false positive<br>2x detectors on A2 burner partially obstructed by throat plate | 8x scanner sight tubes cleared and inspected.<br>8x scanners read 0 when physically blinded<br>8x scanners do not indicate flame when mill & ignitors OOS.<br>A1/2 main scanners have poor discrimination against ignition flame.<br>A2 ignition flame detection is weak<br>8x scanners read strong at 20tph with ignitor support<br>8x scanners read strong at 20tph<br>8x scanners read strong at 50tph |
| B Mill | 8x intermittent false positives | 8x scanner sight tubes cleared and inspected.<br>8x scanners read 0 when physically blinded<br>8x scanners do not indicate flame when mill & ignitors OOS.<br>4x ignitor scanners read strong on ignitor only<br>4x main scanners do not read on ignitor only *<br>8x scanners read strong at 20tph with ignitor support<br>8x scanners read strong at 20tph.<br>8x scanners read strong at 50tph with no opposing mill. |
| C Mill | 3x strong false positives<br>3x intermittent false positives | 8x scanner sight tubes cleared and inspected.<br>8x scanners read 0 when physically blinded<br>8x scanners do not indicate flame when mill & ignitors OOS.<br>4x ignitor scanners read strong on ignitor only<br>4x main scanners do not read on ignitor only *<br>8x scanners read strong at 20tph with ignitor support<br>8x scanners read strong at 20tph.<br>8x scanners read strong at 50tph with no opposing mill. |
| D Mill | 3x intermittent false positives<br>D3 burner compromised<br>1x scanner on D3 ignitor cable physically cut and taped | 6x scanner sight tubes cleared and inspected.<br>2x D3 scanner sight tubes obstructed by burner issues<br>7x scanners read 0 when physically blinded<br>7x scanners do not indicate flame when mill & ignitors OOS.<br>D3 ignitor scanner physically disconnected and reading no flame. |
| E Mill | 2x detectors incorrectly configured as UV type.<br><br>1 detector failed and over gained to compensate. Reading strong false positive.<br><br>E1 ignitor sight tube partially obstructed. | 8x scanner sight tubes cleared and inspected.<br>8x scanners read 0 when physically blinded<br>8x scanners do not indicate flame when mill & ignitors OOS.<br>4x ignitor scanners read strong on ignitor only<br>4x main scanners do not read on ignitor only *<br>7x scanners read strong at 20tph with ignitor support<br>7x scanners read strong at 20tph.<br>7x scanners read strong at 50tph with no opposing mill.<br>E1 ignitor scanner reading weak.<br><br>E2 main scanner replaced. E mill removed from service again and scanner proven to discriminate against opposing mill and in service ignitor. |

## 12.10. Power Station Operating Principles

Figure 36 shows the basic operating principles of a power station. Coal is crushed into a fine powder in a mill and mixed with hot air and is then burned in a boiler. The boiler provides energy through heat which turns high-pressure water in steel tubes into steam, which drives a turbine connected to a generator to produce electricity sent to the grid via power transmission lines. The steam is then cooled, condensed and cycled back through the boiler. The cooling tower circuit circulates raw water in separate circuit to cool the steam in condenser.

**Figure 36** - Power Generation Schematic



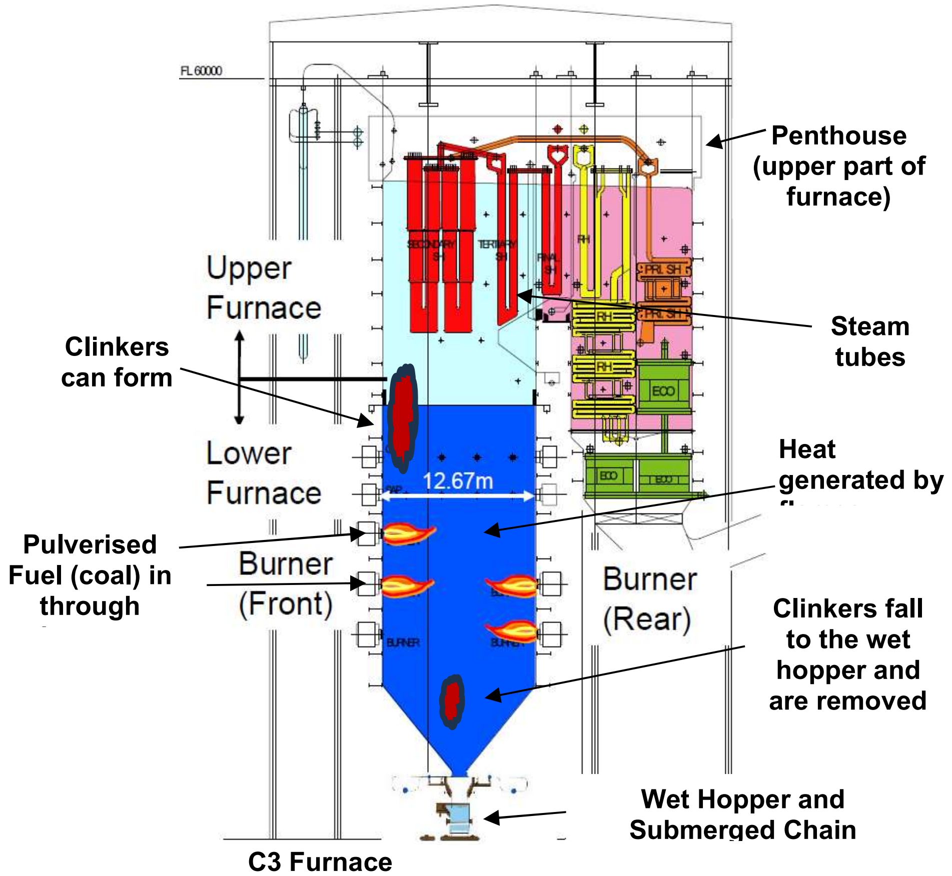

## 12.11. Furnace Operating Principles

Figure 37 shows further detail on the Callide C Furnace. Coal is fed to the boiler as pulverised fuel through mills at the bottom of the furnace, the hot combustion gases rise up the furnace and transfer thermal energy to the waterwall tubes, economiser and the superheater and reheater sections to create high temperature and pressure steam. The flue gases contain a mixture of combustion gases such as NOx and ash particulate that is removed in either the form of "bottom" ash or "fly" ash. Approximately 75% of the ash is collected as fly ash and removed by the Fabric Filter baghouse. The other 25% is bottom ash that drops to the bottom of the furnace into wet hopper that quenches the bottom ash which is then removed via the Submerged Chain Conveyor to the ash handling system.

Clinker formation (hardened ash) is a common issue on coal fired power boilers and is a topic of considerable industry concern. Clinker formation in boilers is largely governed by the coal quality, combustion conditions and boiler design. The ashing characteristics of the coal are a key contributor to how the clinker (slag) forms and its ability to be removed.

Clinker deposits reduce thermal efficiency by building deposits on furnace internals, they can build up in the furnace on the walls of a furnace or heat transfer tubes. Sootblowers, air knockers, hydro jets and clinker deload procedures are methods used to manage minimise clinker buildups.

**Figure 37** - Callide C Furnace




The Callide C units are of a supercritical boiler design for better thermal efficiency and reduced emissions, a function of this design is longer heat transfer tubes in the boiler and helical tube water wall panels. The downside to this design is that the furnace is prone to clinkering as the helical tubes provide ledges for clinker to gather and grow. This phenomenon has been present on the Callide C boiler since it was commissioned, with clinkers found attached to the boiler nose, superheater pendants and furnace wall tubes.

## 12.12. Clinker Formation

Coal clinkers form when the inorganic elements contained in coal such as iron, calcium, and other elements interact through combustion at high temperatures. Clinker formation is a complex series of chemical reactions and phase changes that occur as coal burns that forms hardened ash; commonly called clinker or slag. Small ash deposits can fuse together forming larger clinkers and if not managed can achieve a mass to cause physical damage in a boiler when they fall. Clinker formation and the ongoing management of them is a normal part of the combustion process in all coal-fired boilers.

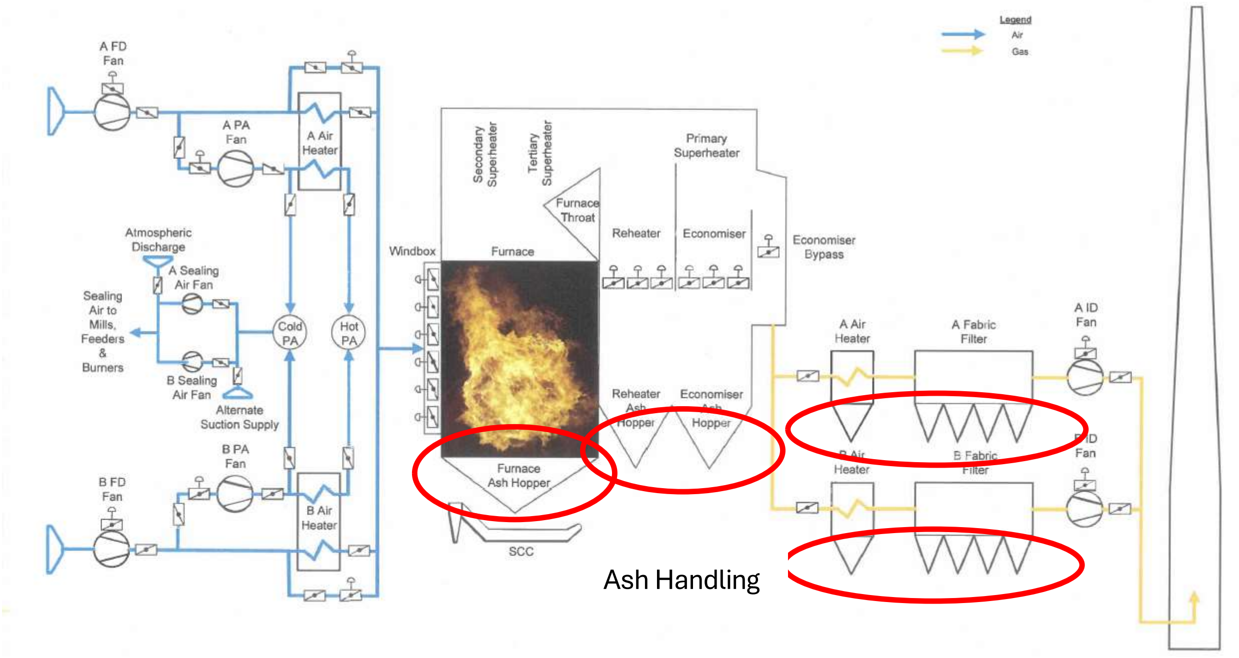
## 12.13. Ash And Dust Plant

The Ash & Dust Plant provides a conveying process for removal of solid byproducts of the furnace. Fly Ash is a fine dust entrained in the boiler flue gas that leaves out of the top of the furnace is removed at the Fabric Filter Plant and transported to the Fly Ash Silo via chain conveyors. The second byproduct is the heavier ash also known as bottom ash. This ash is collected from the Furnace, Economisers, Air heaters, and together with Mill rejects (pyrites) is transported to the Furnace Ash Bin via the Submerged Chain Conveyor (SCC). The Furnace Ash Handling Plant collects crushes and transports Ash from the furnace to the Furnace Ash Bin (refer Figure 38).

Ash is collected from the Economisers, Air heaters and Mills by using High Pressure Motive Water. The Furnace ash is transported to the Wet Ash Hopper where it is removed along with furnace bottom ash by the Submerged Chain Conveyor. All the ash is then de-watered, crushed and deposited into the Furnace Ash Bin being removed by way of truck.

The Callide C units were designed to have a wet bottom ash removal system to the furnace ash silo (emptied via truck) and a dry fly ash removal system to the fly ash silo (emptied via high concentration slurry disposal pumping system)

**Figure 38** - Callide C Unit Ash Handling Locations




## 12.14. Submerged Chain Conveyor

For furnace ash removal a Submerged Chain Conveyor is located under each boiler. A refractory lined chute is connected directly to the base of the Boiler Water Wall Furnace Tubes and acts as boiler dip seal, allowing the boiler to expand or contract. The chute is partially immersed into the water, which is maintained in the Submerged Chain Conveyor. The Submerged Chain Conveyor is designed to be in operation whenever the boiler is in service. Its chain speed is variable to encompass varying unit loads as well as a variety of coal quality. It is shown in Figure 39.

**Figure 39** - Submerged Chain Conveyor

CS ENERGY

# Callide C3 Significant Pressure Event

Incident Investigation Report

26 August 2025

Final Report

# Executive Summary

## Introduction

On 4 April 2025, a large clinker dislodged from the furnace wall of Callide Unit C3, causing total flame loss and a delayed unit trip. Unburnt fuel accumulated in the furnace and later re-ignited, resulting in a significant pressure excursion that exceeded boiler design limits and caused significant structural damage. While no one was injured, the event had credible potential for serious harm or fatality and was classified by CS Energy as an Actual Category 3, Potential Category 4 incident.

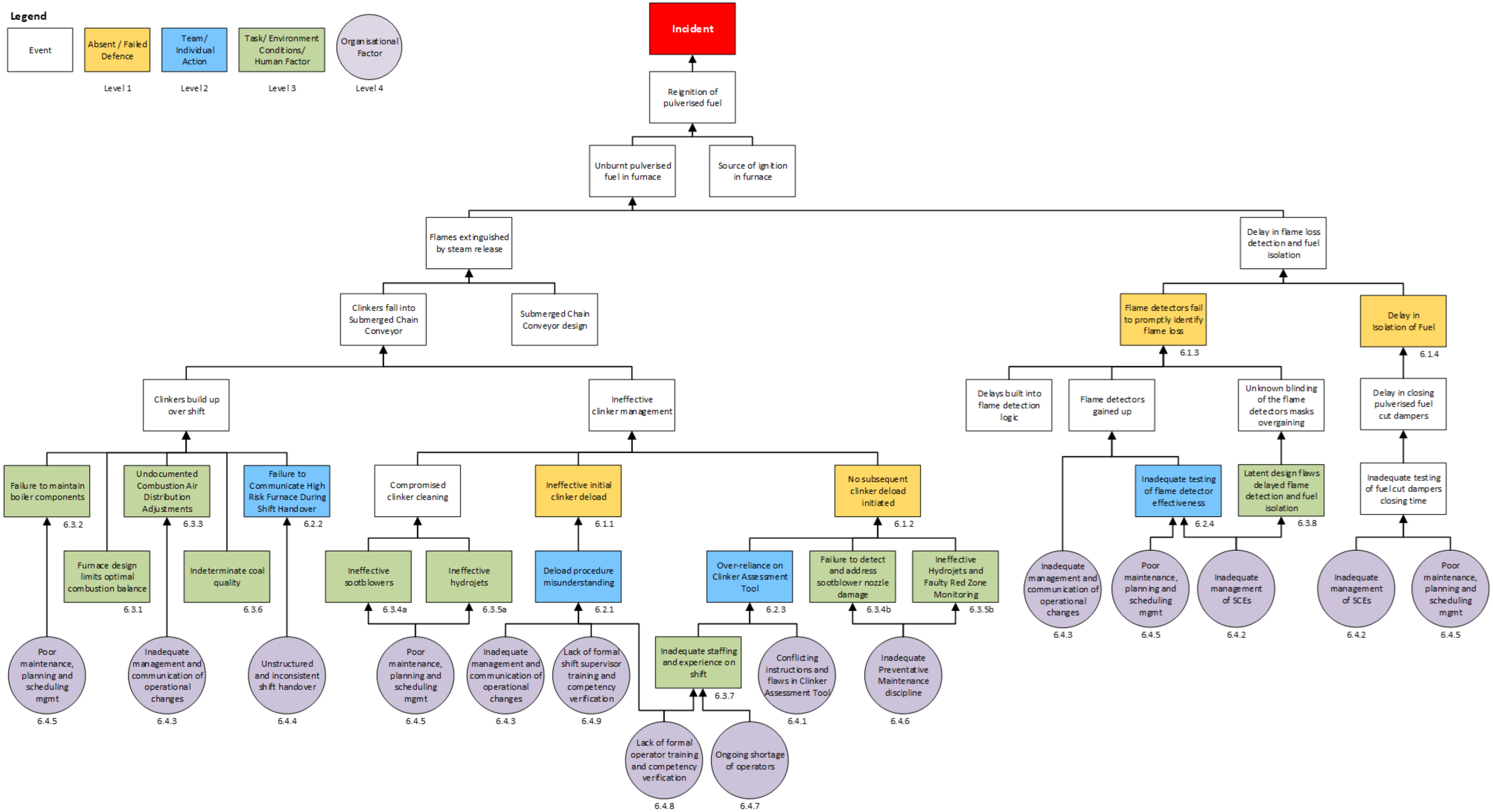
CS Energy conducted an internal Root Cause Analysis (RCA) to examine the technical sequence of events and immediate equipment failures. In parallel, The Jonah Group was commissioned to facilitate the ICAM investigation, reporting to a CS Energy-appointed sponsor.

This report presents the findings of the ICAM investigation, which builds on the RCA's technical findings to examine how multiple safeguard failures, human decisions, and organisational and systemic failures combined to cause the incident. The investigation identified critical gaps in process safety, control effectiveness and leadership oversight, and makes recommendations to reduce risk and prevent recurrence. The ICAM followed a structured, transparent, and blame-free approach that encouraged open participation across all.

## Fault Tree Analysis

To support the investigation, findings, two structured tools were applied to map what failed and why. The Fault Tree Analysis traces the technical sequence of events, while the ICAM Chart organises the findings across each level of the ICAM framework. Together, they show how multiple weaknesses combined to allow the incident to occur. Figure 1 shows a high-level summary of the Fault Tree Analysis diagrams that are shown in more detail in Section 5.0.

**Figure 1** – Summary Fault Tree Analysis Diagram



## Key Findings

The incident was not the result of one failure but the convergence of long-standing weaknesses across systems, practices and leadership.

The investigation identified 37 failed defences, contributing and systemic factors (Section 6.0), which group into nine key findings. These findings highlight breakdowns in critical controls, frontline execution, maintenance, governance and culture that increased the risk of a significant event. They are outlined in Section 7.0 and summarised below.

1. **Critical Risk Control Failures**
   Key safety systems did not perform as intended. Flame detection was unreliable, fuel isolation was delayed and known equipment issues had not been addressed. Design limitations and weak maintenance of Safety Critical Equipment left the plant exposed to process safety failure.

2. **Repeated Failure to Operationalise Process Safety**
   Process safety was not embedded into frontline operations. Operators lacked formal training in process safety, critical signals were missed or normalised, and process safety events were not recognised. Governance was fragmented, ownership unclear, and improvement efforts lacked operational impact.

3. **Inadequate Governance of Operational Training**
   CS Energy lacks a central, risk-based framework to oversee operator and supervisor training. Roles and accountabilities for governance were fragmented, with no single point of ownership or oversight. As a result, there was no assurance of frontline capability.

4. **Gaps in Operator Staffing Levels, Training and Competency Verification**
   Staffing shortages, high overtime use and limited supervision reduced operational resilience. Resourcing risks were not assessed, and critical tasks like clinker management lacked formal training and oversight. Supervisors had no structured program to build or verify technical and leadership capability.

5. **Leadership and Governance Failures to Act and Assure**
   Known risks in maintenance, operations and process safety were not effectively managed. Early warnings were missed, accountability was diluted, and assurance efforts prioritised volume over substance. Weak governance allowed issues to persist without intervention.

6. **Inadequate Management and Communication of Operational Change**
   Changes to procedures, controls and settings were not formally reviewed, authorised or communicated. Operators acted on informal instructions, shift handovers were inconsistent, and undocumented changes were made to critical systems without oversight.

7. **Failure to Learn and Improve from Precursor Events**
   Precursor clinker incidents were misclassified and not escalated, preventing deeper investigation and corrective action. Weak incident classification and low psychological safety negatively impacted reporting and allowed risks to persist unchallenged.

8. **Production as a Priority and Weak Psychological Safety**
   A mindset of production as a priority led to compromised decisions, reduced risk escalation, and reluctance to speak up due to fear of blame or inaction. Operational Risk Assessments

were used to justify continued operation, while Critical Control Verifications prioritised target completion over testing control effectiveness.

9. **Maintenance Failures Undermine Asset Integrity**
   Maintenance was reactive, fragmented and poorly governed. Preventative tasks were missed, overhauls poorly scoped, planned and executed, and known defects carried forward. Misaligned functional priorities, weak planning and low system trust undermined asset integrity and plant safety.

### Recommendations Overview

The investigation identified 22 recommendations to address the key findings. These recommendations focus on operationalising process safety, driving maintenance discipline, strengthening leadership accountability and governance across CS Energy.

Key themes include:

- **Operationalise Process Safety:** Refocus the Process Safety Improvement Program to deliver practical frontline tools, improve process safety weak signal awareness, reporting, critical control execution, and embed process safety as a core operational priority.
- **Operator Training, Competency and Staffing:** Establish clear governance for operator and supervisor training, implement structured competency frameworks, and address ongoing staffing shortfalls to build frontline capability and resilience.
- **Maintenance and Overhaul Discipline:** Improve the integrity of maintenance workflows, execution and verification. Treat overhauls as a risk control, not a task, with stronger scoping, planning and delivery governance.
- **Management of Operational Change:** Address weak shift handovers, poor control of operational changes, and replace high-risk tools like the Clinker Assessment Tool with more robust, user-centred platforms.
- **Leadership and Culture:** Shift from compliance-based activity to meaningful leadership oversight. Build safety leadership capability, embed psychological safety, and define a clear vision for safety that is emotionally engaging, owned and modelled from the top down.
- **Health and Safety Management Framework and Incident Learning:** Develop and implement an integrated Health and Safety Management Framework that defines how all health and personal, process and psychological safety risks are identified, controlled and continuously improved across the business. Rebuild and embed the Learning from Incidents procedure to ensure accurate classification, investigation, and embedding lessons learned.
- **Enterprise Alignment and Risk Management:** Align functions under a single risk-based strategic plan, standardise risk matrices, and ensure consistent prioritisation, escalation and governance across the business.

### Conclusion and Next Steps

This investigation confirmed that the incident was not isolated or unforeseeable, but the result of long-standing and systemic weaknesses in technical safeguards, operational controls, leadership oversight and safety governance at CS Energy. While immediate fixes have been actioned through the Root Cause Analysis and Return to Service plans, these address only part of the problem.

The 22 recommendations outlined in this report target deeper organisational and cultural issues that must be resolved to restore safe, reliable operations. The next step is to translate these recommendations into a clear, time-bound action plan. This must include defined priorities, accountable owners, measurable milestones, and robust governance to ensure delivery is not only tracked but reinforced at all levels.

CS Energy must now shift decisively from a reactive posture to one of disciplined, proactive execution. This will require strong leadership alignment, consistent messaging, and operational discipline. Safe execution must become a visible, non-negotiable standard across the business - not just an aspiration.

Sustained Board oversight is essential to drive this transformation. The Board should endorse the action plan, monitor delivery against key milestones, and hold Executives accountable for achieving measurable outcomes. This includes ensuring that actions are properly resourced, strategically aligned across all functions, and independently verified to deliver their intended

Failure to fully address these issues exposes the organisation to further operational disruption, potential regulatory scrutiny and reputational damage. For this reason, progress on the implementation of these recommendations should remain a standing item on Board and Executive agendas until all actions are fully embedded and their effectiveness independently verified.

## Table of Contents

# 1.0 Introduction

## 1.1. Incident Overview

On 4 April 2025 at 04:35 AM, a large clinker dislodged from the furnace wall of Unit C3 at Callide Power Station and fell into the water hopper of the Submerged Chain Conveyor (SCC). The resulting steam release caused total flame loss across all operating mills.

A delayed unit trip allowed unburnt pulverised fuel to accumulate within the furnace, which subsequently re-ignited. This re-ignition triggered a significant pressure excursion that exceeded the boiler's design threshold. The event caused structural damage including the boiler casing, insulation, and surrounding platforms.

Although no one was physically harmed, the incident had clear potential to cause serious injury or fatality to personnel had they been in the immediate vicinity. CS Energy classified the incident as an Actual Category 3 and Potential Category 4 event, which triggered a formal Incident Cause Analysis Method (ICAM) investigation.

CS Energy led both the Root Cause Analysis (RCA) and ICAM investigation. The RCA was conducted internally and focused on the technical sequence of events and immediate failures. The ICAM, facilitated by The Jonah Group and reporting directly to a CS Energy-appointed sponsor, examined the systemic issues, failed safeguards, and deeper organisational factors that influenced decisions, behaviours and operational performance.

## 1.2. Purpose

The purpose of the investigation was to determine how failed defences as well as organisational and systemic factors contributed to the incident. The investigation identified both strengths and vulnerabilities, uncovering critical gaps to proactively prevent recurrence and enhance process safety performance.

Importantly, the investigation reflected management's commitment to a blame-free investigation, emphasising transparency, rigorous analysis and accountability.

## 1.3. Scope

The scope of the investigation covered three areas of focus:

1. **C3 Clinker Incident**
   A detailed review of the pressure excursion in Unit C3 on 4 April 2025, including the conditions leading up to the event, clinker build-up, combustion disruption, and how the system responded.

2. **Related Process Safety Events**
   An examination of similar process safety events at Callide Power Station and Kogan Creek to identify recurring failures, shared vulnerabilities, or broader patterns relevant to the incident.

3. **Process Safety Management**
   A review of how process safety is structured, implemented and governed across CS Energy. This included assessing the progress and effectiveness of the Process Safety Improvement Plan (PSIP), the use of the bow tie methodology, and the oversight of Safety Critical Equipment (SCE) and Critical Control Verifications (CCVs).

## 1.4. Confidentiality and De-Identification

To preserve confidentiality and privacy for participants who supported this investigation, as requested by CS Energy, all direct quotations and any details that could reasonably enable a reader to identify an individual (including role descriptors, unique time/place references, or distinctive phrasing) have been removed or contextualised.

Consistent with the agreed methodology, interviews were conducted on a strictly non attributable basis and records were maintained using de-identified identifiers rather than names or positions. The analysis and findings are supported by de-identified evidence sourced from interviews, contemporaneous documents and operational data.

This approach protects participants and upholds our legal and ethical obligations without diminishing the probative value of the report. Underlying de-identified evidentiary material has been managed securely and available for assurance purposes in accordance with confidentiality commitments until the end of this process.

# 2.0 Methodology

## 2.1. Integrated Investigation Approach

The Root Cause Analysis (RCA) was facilitated internally by CS Energy to establish what happened, focusing on the technical sequence of failures. Building on this, the Incident Cause Analysis Method (ICAM) was facilitated by The Jonah Group to examine why it happened by exploring contributing and systemic factors.

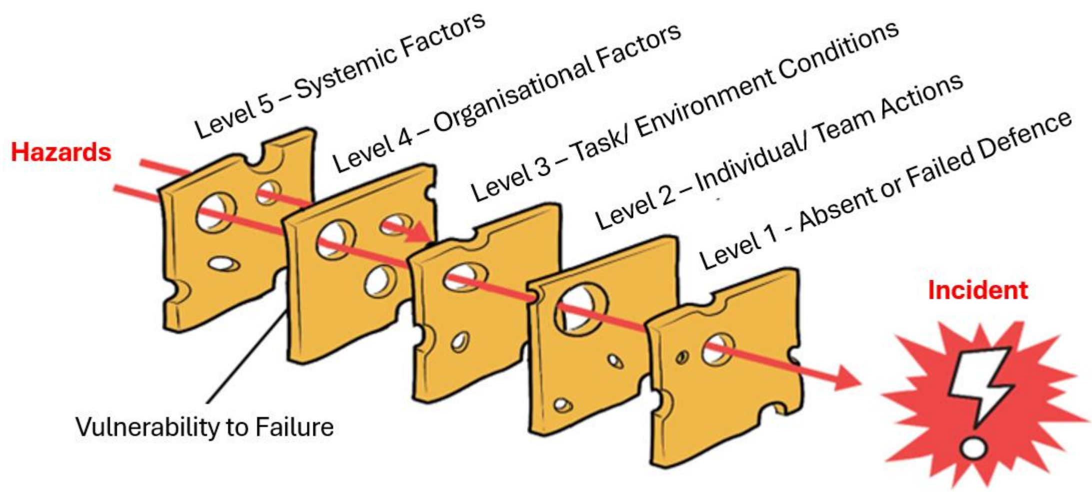
To strengthen the identification of deeper organisational conditions, the Global Weave® Model (see Appendix A1) was applied as an additional diagnostic lens. This model tests how failures often stem from interconnected weaknesses in governance, systems, leadership and decision-making.

This combined approach ensured the investigation did not stop at surface causes but uncovered the underlying conditions that allowed multiple failures to develop and persist.

## 2.2. Understanding the ICAM Process

ICAM is a structured framework designed to explain not only immediate technical failures but how multiple safeguards broke down in sequence. It is based on the Swiss Cheese Model (Figure 2): each defence layer in a complex system has inherent weaknesses or holes. An incident happens when these holes align, allowing hazards to pass through all barriers unchecked.

**Figure 2** - ICAM Swiss Cheese Model




ICAM separates these layers into five levels:

**Level 1 - Absent or Failed Defences:** Immediate safeguards that did not perform as intended, such as a safety system that failed to detect or isolate a hazard.

**Level 2 - Team or Individual Actions:** Actions by individuals or teams that deviated from procedure due to error, misunderstanding or lack of supervision.

**Level 3 - Task, Environment or Human Factors:** Conditions that shaped those actions, such as unclear tasks, poor tools or challenging work environments.

**Level 4 - Organisational Factors:** Weaknesses in systems, processes or communications that allowed local failures to go uncorrected.

**Level 5 - Systemic Factors:** Persistent organisational or cultural gaps, such as unclear accountability, weak governance or failure to learn from past events.

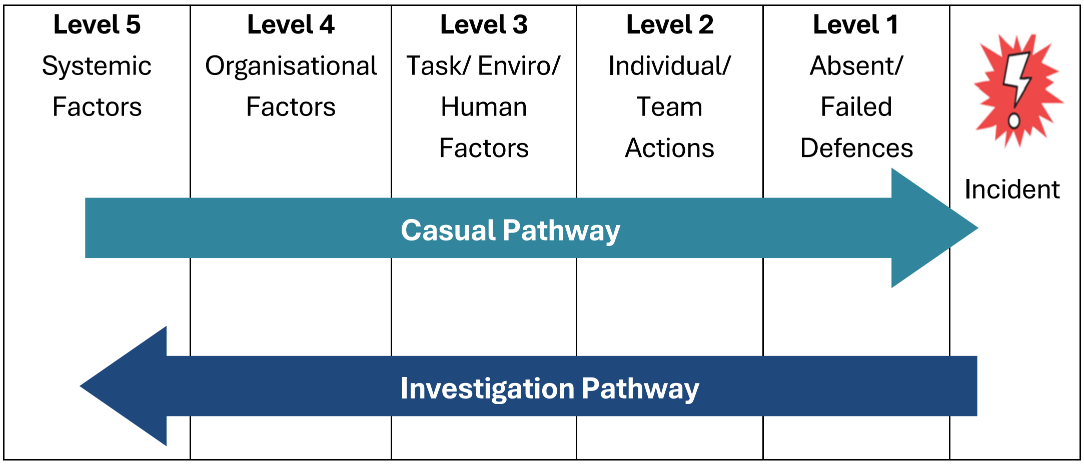
By tracing each level, ICAM shows how a hazard can pass through multiple lines of defence – aligning failures like holes in Swiss cheese to reveal the chain of contributing factors behind it.

## 2.3. How the Investigation Pathway Works

While an incident's **causal pathway** begins with systemic weaknesses and flows forward through each level until an immediate safeguard fails, the investigation works in reverse. The **investigation pathway** starts at Level 1 by asking what safeguard failed, then works backwards through Levels 2 to 5 to uncover why each layer allowed the failure to happen (Figure 3).

For example: If a flame detector did not trigger a shutdown, the investigation asked: Did the hardware fail (Level 1)? Was it configured or tested correctly (Level 2)? Were the right tasks or tools in place (Level 3)? Did the organisation have strong design assurance (Level 4)? And what deeper cultural or governance gaps allowed that weakness to persist (Level 5)?

**Figure 3** - Casual and Investigation Pathways




## 2.4. Data Gathering

The investigation used the PEEPO model: People, Environment, Equipment, Procedures and Organisation - to guide data collection. This ensured that all factors before, during and after the incident were reviewed to separate contributing from non-contributing details.

Appendix A2 lists the main PEEPO elements reviewed as part of this investigation.

## 2.5. Applying the Analysis Tools

To support this process, two tools were used together:

- The Fault Tree Analysis (Section 5.1, Figure 10) maps the technical sequence of failures.
- The ICAM Chart (Section 5.2, Table 1) shows how each finding fits across all five ICAM levels.

These tools demonstrate that the incident was not due to a single issue but to multiple weaknesses in design, practice and governance aligning at once. Together, they form the evidence base for the contributing factors in Section 6.0 and the recommendations that follow.

### 2.6. Risk Control Hierarchy and Control Effectiveness

Effective risk management relies on strong engineering controls. As a higher order of control, they provide the strongest defence against critical risk. When they are absent, misclassified, or poorly maintained, the risk of failure increases significantly.

Organisational factors including procedures, training, supervision and culture cannot replace engineering controls. They either strengthen the effectiveness of these technical controls or if inadequate, allow weaknesses to persist.

# 3.0 Incident Description

This section outlines the events related to the C3 Clinker incident that occurred on 4 April 2025. It outlines the background and sequence of key events prior to the incident, leading up to the incident, the incident itself and the actions taken during recovery.

## 3.1. Timeline of Events

Figure 4 provides a summary of the key events with a detailed breakdown illustrated in Figure 5.

**Figure 4** – Event Timeline

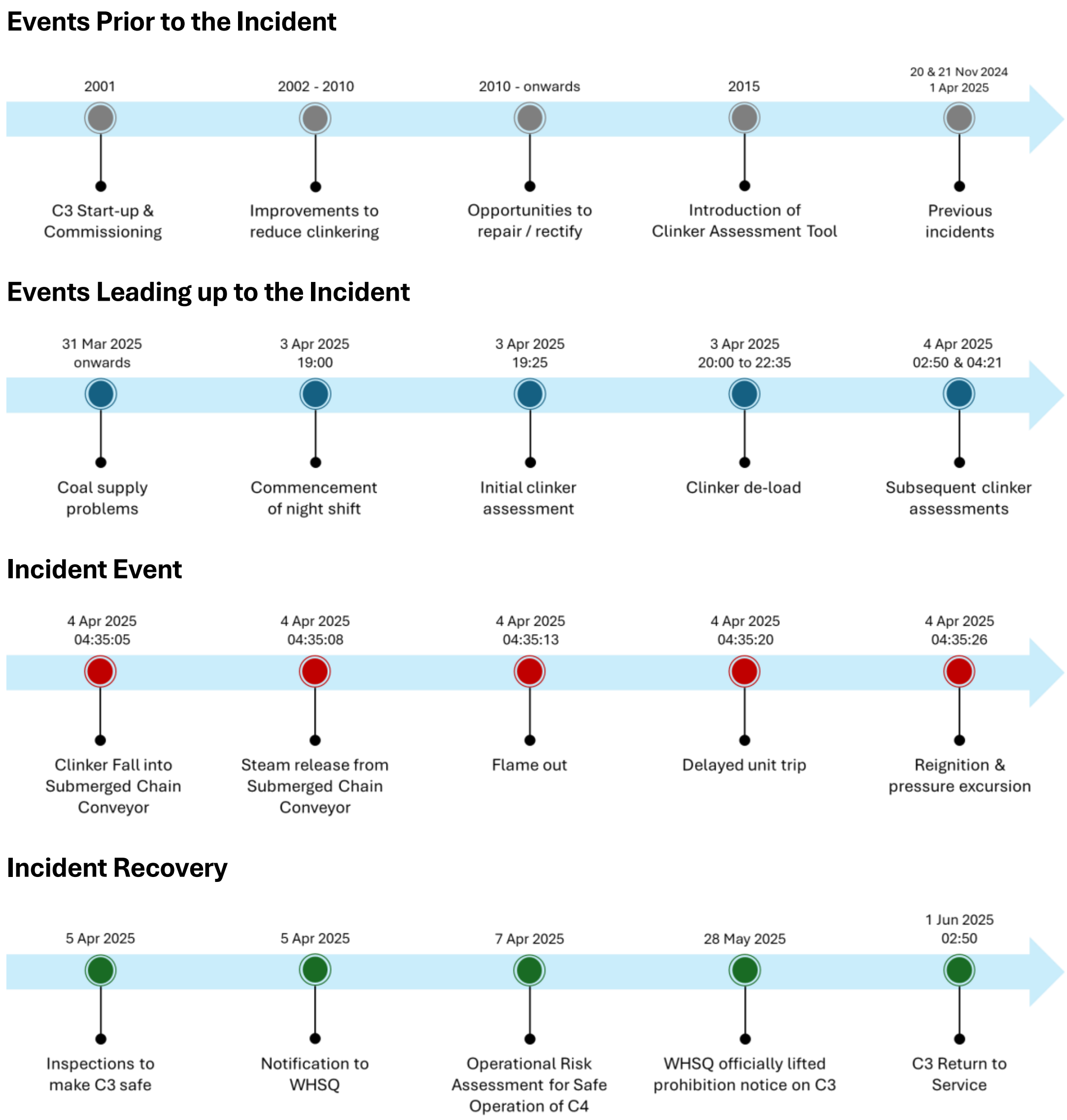
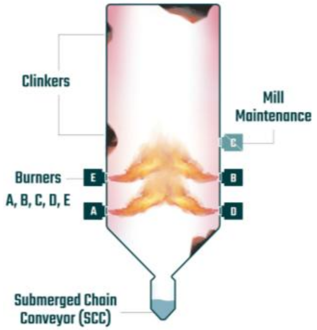
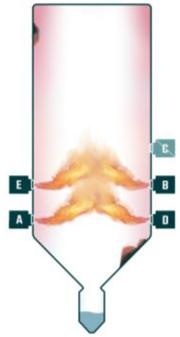


**Figure 5** - Clinker Incident Graphical Representation

**3 April 2025 15:00**
Clinkers form during day and night shift

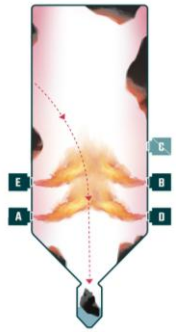



**3 April 2025 19:25**
Operator conducts a Clinker Assessment and deload to remove clinkers

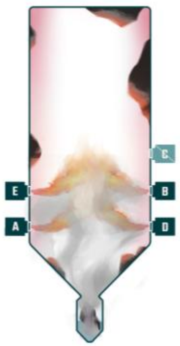


**4 April 2025 2:50 & 04:21**
Clinkers continue to build up. Subsequent Assessments done - no deloads required

**4 April 2025 04:35:05**
Clinker falls into Submerged Chain Conveyor (SCC)



**4 April 2025 04:35:05**
Steam released from SCC



**4 April 2025 04:35:07**
All mill flames go out

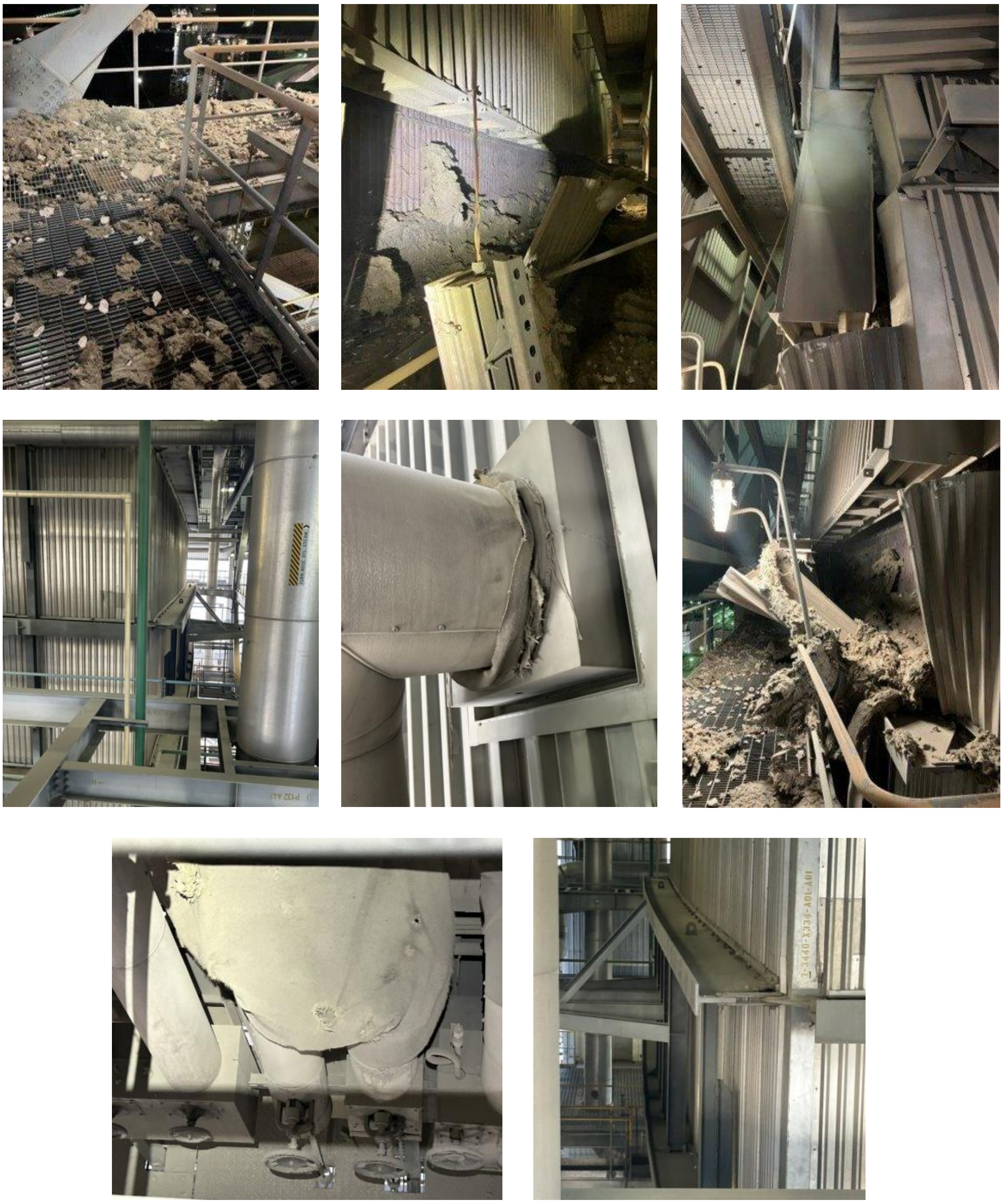
**4 April 2025 04:35:10**
Pulverised fuel continues to enter the furnace

**4 April 2025 04:35:20**
Pulverised fuel finds ignition source and creates pressure surge

### 3.2. Photos of Damage Caused by the Incident

Photos taken after the event (Figure 6) show visible damage to the penthouse area, structural deformation, and missing or damaged sootblower components. These images illustrate the physical consequences of the pressure event.

**Figure 6** - Damage Caused by the Incident



# 4.0 Callide Power Station Background

This section provides key visual references to support understanding of the incident location and boiler layout.

## 4.1. About Callide Power Station

Callide Power Station is located near Biloela in Central Queensland, is a major power generation facility comprising of four generating units. These units are arranged in two distinct plants: Callide B (Units B1 and B2), operational since 1988 and Callide C (Units C3 and C4), commissioned in 2001.

The station uses black coal from the local mine as its primary fuel source. Callide B and Callide C operate independently. Each with dedicated infrastructure including separate cooling towers and ash handling systems. Specifically, Units B1 and B2 share infrastructure as do Units C3 and C4.

Figure 7 provides an aerial view of the site, identifying each generating unit.

**Figure 7** - Aerial of Callide Power Station


Reference: Google Maps

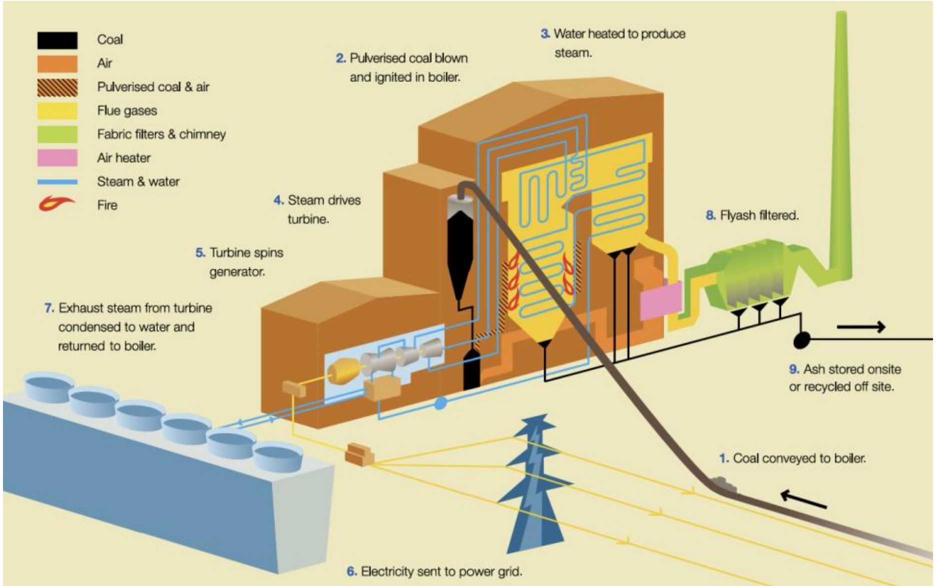
## 4.2. Electricity Generation at Callide C

Coal is crushed into a fine powder and mixed with hot air and is then burned in a boiler. The heat turns high-pressure water in steel tubes into steam, which drives a turbine connected to a generator to produce electricity. The steam is then cooled, condensed and cycled back through the boiler.

The operation of the plant, including steam generation and turbine operation, and NOx emissions from flue gases are shown in

Figure 8. Clinker, a hardened ash deposit, can build up on the walls of a furnace and block some of the heat from reaching its intended destination. Sootblowers, air knockers, hydrojets and clinker deload help to manage this risk and maintain safe boiler performance.

**Figure 8** - Electricity Generation Schematic




## 4.3. Callide Unit C3

Unit C3 was commissioned in 2001 as a low NOx boiler and has a known history of clinkering. In the early stages of operation, sootblowers, air knockers and hydrojets were installed to support clinker removal and reduce the risk of ash build up. These systems form part of the ongoing effort to manage clinker accumulation. Figure 9 provides an external image of Unit C3

**Figure 9** - Unit C3 External Image Boiler at Callide

# 5.0 Incident Cause Analysis Method (ICAM) Analysis

To support the investigation's findings, two structured tools were applied to map what failed and why. The Fault Tree Analysis traces the sequence of events, while the ICAM Chart organises the contributing factors across each level of the ICAM framework. Together, they show how multiple weaknesses combined to allow the incident to occur and provide the foundation for the contributing factors Section 6.0.

## 5.1. Fault Tree Analysis

**Figure 10** - Fault Tree Analysis Diagram

**Figure 10.1** - Top Level

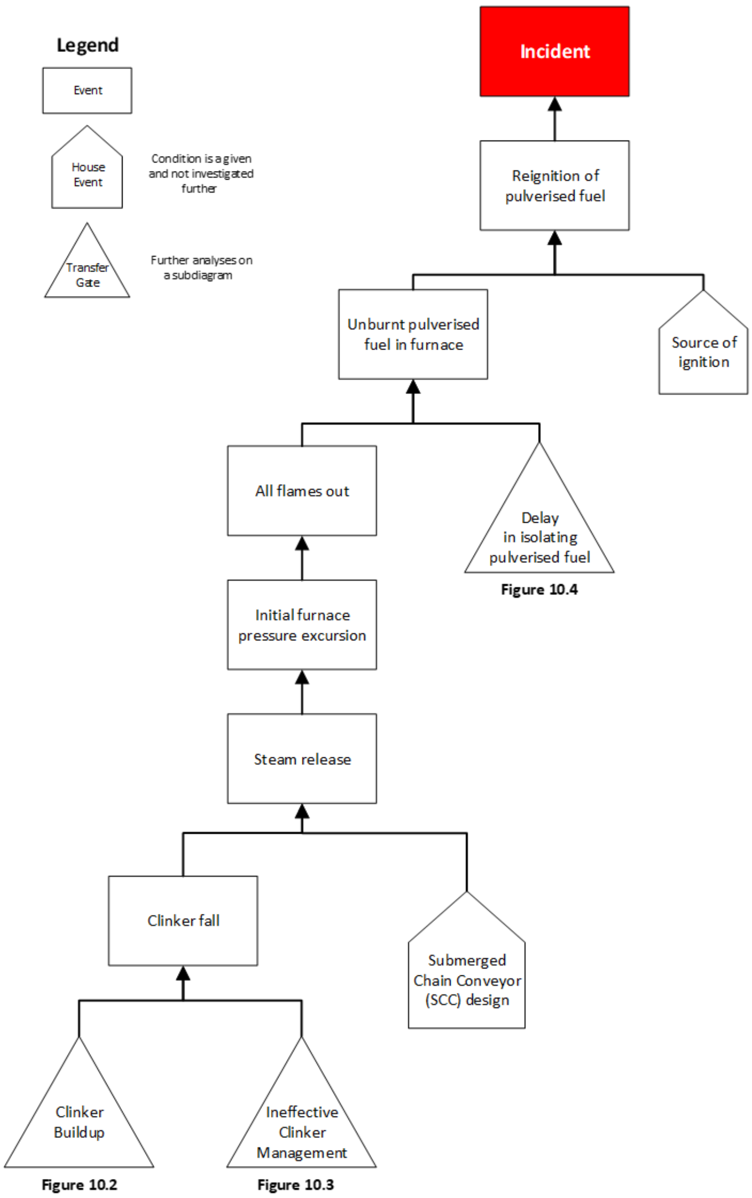


**Figure 10.2** - Clinker Buildup

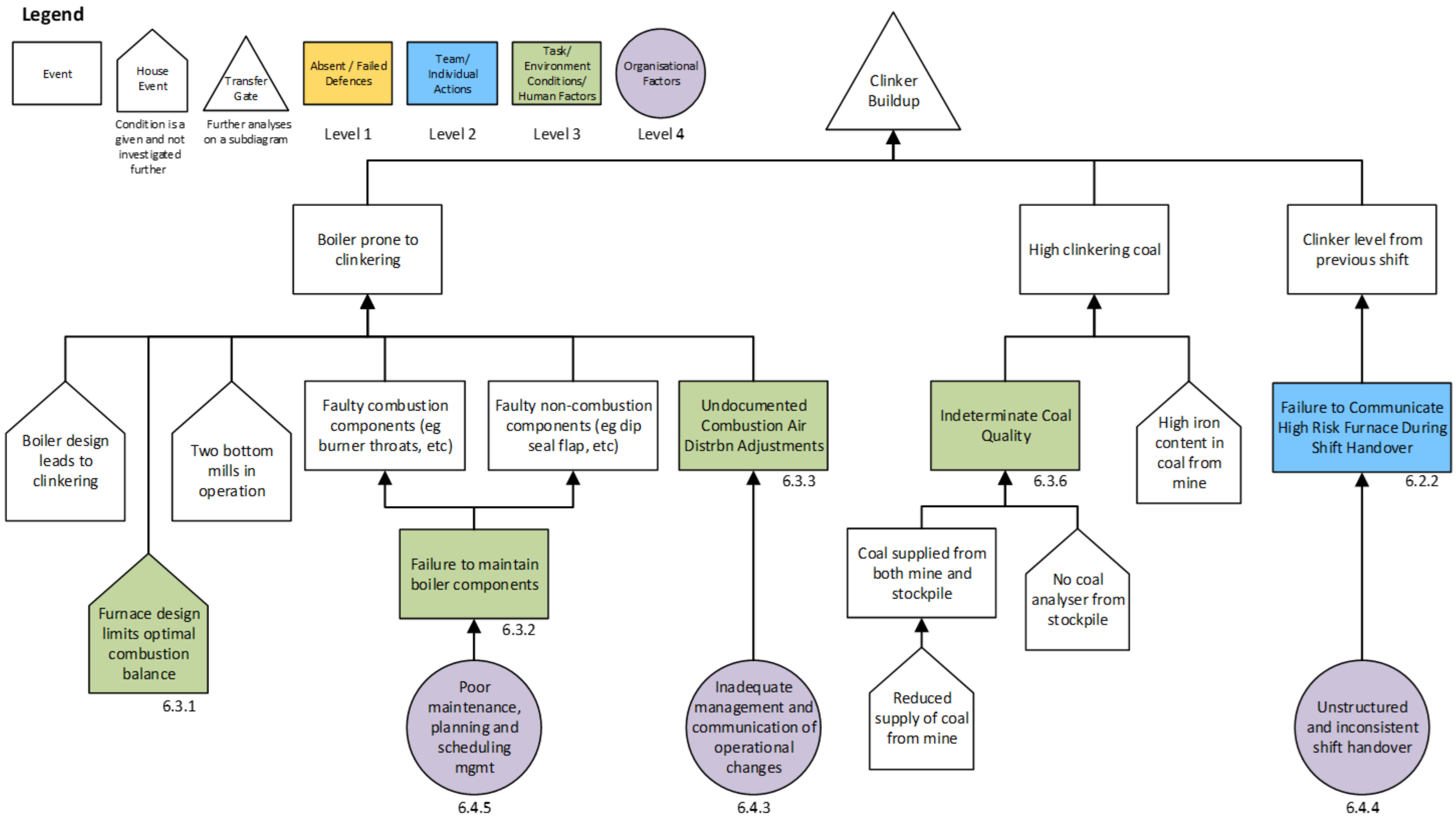


**Figure 10.3** - Ineffective Clinker Management

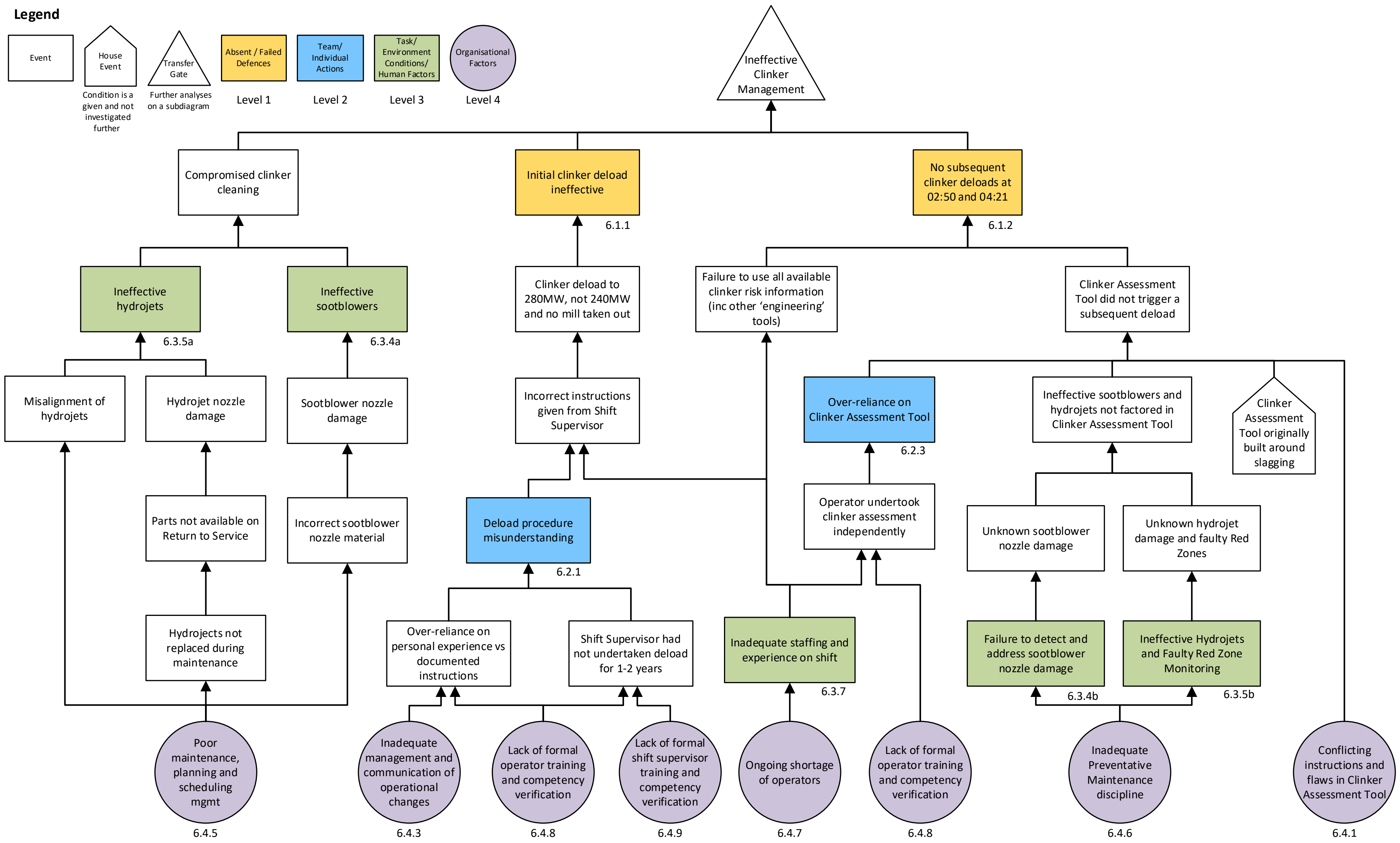
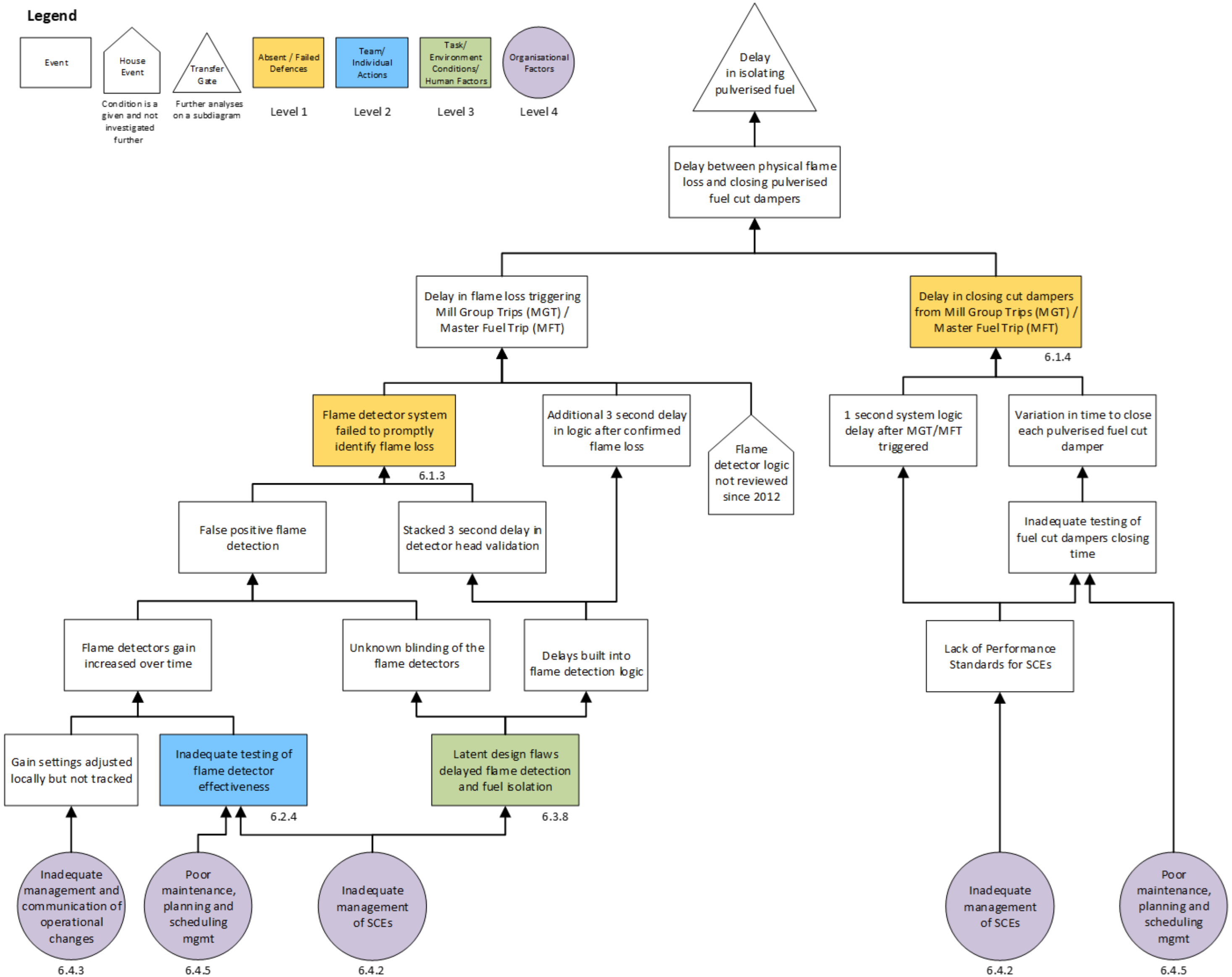


**Figure 10.4** - Delay in Isolating Pulverised Fuel



## 5.2. ICAM Chart Analysis

The ICAM Chart (Table 1) traces each failure step by step. Each factor may connect to multiple outcomes.

**Table 1** - ICAM Chart Contributing Factors Summary

<table>
<tr><th>6.5 Level 5 – Systemic Factors</th><th>6.4 Level 4 – Organisational Factors</th><th>6.3 Level 3 – Task / Environment Conditions / Human Factors</th><th>6.2 Level 2 – Team / Individual Actions</th><th>6.1 Level 1 – Absent / Failed Defences</th><th>Key Outcome</th><th>Incident</th></tr>
<tr><td rowspan="5">6.5.1 Failure to Learn from Previous Clinker Events<br>6.5.2 Repeated Failures to Operationalise Process Safety<br>6.5.3 Strategic Misalignment and Leadership Instability Undermine Critical Risk Control<br>6.5.4 Organisational Silos and Leadership Inaction<br>6.5.5 Misaligned and Conflicting Risk Prioritisation Systems<br>6.5.6 Superficial Critical Control Verification and Weak Leadership Oversight<br>6.5.7 Normalisation of Process Safety Deviation<br>6.5.8 Absence of Operator Training and Competency Governance<br>6.5.9 Production-Driven Culture Undermining Safety<br>6.5.10 Enterprise Agreement Impacts on Competency and Performance<br>6.5.11 Significant Gaps in Overhaul Management<br>6.5.12 Culture of Poor Psychological Safety, Blame and Risk Aversion</td><td rowspan="5">6.4.1 Conflicting Instructions and Design Flaws in Clinker Assessment Tool<br>6.4.2 Inadequate Management of Safety Critical Equipment (SCE)<br>6.4.3 Inadequate Management and Communication of Operational Changes<br>6.4.4 Unstructured and Inconsistent Shift Handover<br>6.4.5 Poor Maintenance, Planning and Scheduling Management<br>6.4.6 Inadequate Preventative Maintenance Discipline<br>6.4.7 Ongoing Shortage of Operators<br>6.4.8 Lack of Formal Operator Training and Competency Verification<br>6.4.9 Lack of Formal Shift Supervisor Training and Competency Verification</td><td>6.3.1 Furnace Design Limits Optimal Combustion Tuning Balance<br>6.3.2 Failure to Maintain Boiler Components<br>6.3.3 Undocumented Combustion Air Distribution Adjustments<br>6.3.4a Failure to Detect and Address Sootblower Nozzle Damage<br>6.3.5a Ineffective Hydrojets and Faulty Red Zone<br>6.3.6 Indeterminate Coal Quality</td><td></td><td></td><td>Clinker Buildup</td><td rowspan="5">Boiler Explosion</td></tr>
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# 6.0 Contributing Factors

A contributing factor is any condition, action, organisational weakness, or systemic gap that increases the likelihood of an incident or reduces the effectiveness of controls.

As discussed in Section 2.3 contributing factors exist at multiple levels and the investigation pathway works from right to left - starting with the immediate absent or failed defences, then tracing back through contributing factors to identify deeper organisational and systemic causes.

## 6.1. Level 1 - Absent or Failed Defences

### 6.1.1. Initial Clinker Deload Ineffective

**Intended Defence:** The Deload Clinker Assessment Tool procedure (PAMC-CH20-S04-P21) requires reducing boiler load to 240MW for one hour to effectively shed clinkers from the furnace wall and minimise clinker build-up.

**Failed Defence:** The procedure did not function as an effective safeguard. On 3 April 2025, the unit was only reduced to 280MW instead of the specified 240MW (Figure 11). This decision was based on outdated verbal advice rather than the documented procedure. The C3 Panel Operator, newly qualified and unfamiliar with clinker deloads, followed the verbal instructions by the Shift Supervisor instead of referring to the formal procedure and the load reduction failed to shed sufficient clinker.

This was not an isolated lapse. Interviews confirmed that operators applied various deload practices, with most relying on 'tribal knowledge' rather than a documented procedure which reflects a broader failure to embed process safety to deliver front line impact.

**Figure 11** - Evidence from Logbook 3 April 2025 - Deloaded to 280MW and not 240MW

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 2025-04-04 5:05:00 | CC | CC3 | | LOA | | CARS Derate Event_Unit 3_2025-04-04_05:05:00 | Closed |
| 2025-04-04 5:04:50 | CC | CC3 | Unit Operation | Operations | | Clinker fall at 4:35am which gave a furnace pressure spike 8.44kpa, ID fan limit and unit tipped off. Commenced restart at 4:52. depressurizing Main steam, SS went to check the boiler when he discovered damage on Level 10, Run up aborted. Area Danger taped off from ground floor to level 10. | Closed |
| 2025-04-03 22:35:35 | CC | CC3 | Boiler Firing | Operations | | Biased D mill back to 0.8 to try and help with Clinkers. | Closed |
| 2025-04-03 21:12:37 | CC | CC3 | Unit Operation | Operations | | 1 hr continuous air knockers started. | Closed |
| 2025-04-03 20:05:00 | CC | CC3 | | LOA | | CARS Derate Event_Unit 3_2025-04-03_20:05:00 | Closed |
| 2025-04-03 19:54:27 | CC | CC3 | Unit Operation | Operations | | Informed trading the need to reduce load to 280mw for a clinker de load. [redacted] | |
| 2025-04-03 8:35:00 | CC | CC3 | | LOA | | CARS Derate Event_Unit 3_2025-04-03_08:35:00 | Closed |
| 2025-04-03 8:13:08 | CC | CC3 | | Operations | | Unit 3 load 390mw 186mvars tap 5 Commenced shutdown on D mill load to 180mw 11.54 A mil tripped on flame loss on clinker fall back i/s 12.03 | Closed |

**This shows how the failure to operationalise process safety and inconsistent operating guidelines allowed a critical safeguard to drift into informal practice, leaving risks unchallenged and repeating.**

### 6.1.2. No Subsequent Clinker Deload Initiated

**Intended Defence:** The Clinker Assessment Tool is intended to support operator decision-making by identifying when boiler conditions warrant a deload to reduce clinker risk. Its purpose is to guide judgement, not replace it, and its reliability depends on accurate operator inputs and sound operator understanding.

**Failed Defence:** Clinker assessments were completed at 02:50 and 04:21 on 4 April 2025, prior to the incident. However, no subsequent deload was initiated. Instead of being used as one source of information to support judgment, the tool was used as the sole basis for decisions to initiate a deload or not. Although red zone indicators were present, the operator relied on the absence of a tool-generated prompt and continued normal operation. Weaknesses associated with the clinker assessment tool are discussed in Section 6.2.3.

As noted in Section 6.3.4 and Section 6.3.5, the tool logic did not account for the ineffective sootblowers and hydrojets at the time. Its output depended on operators correctly identifying and entering degraded conditions.

**This failure contributed to the incident by allowing clinker build up despite clear warning signs, as incorrect inputs and overreliance on the tool prevented a necessary deload. It reflects a broader failure to embed process safety discipline in daily operations and ensure frontline teams have the knowledge and capability to use critical safeguards effectively.**

### 6.1.3. Flame Detectors System Failed to Promptly Identify Flame Loss

**Intended Defence:** Flame Detectors are designed to monitor the presence of flames at each of the burners. If flames are lost on a mill, the system should automatically trigger a Mill Group Trip (MGT), and subsequently a Master Fuel Trip (MFT), to shut off the pulverised fuel supply and reduce the amount of unburnt fuel from accumulating in the furnace and potentially reigniting.

**Failed Defence**: During the incident, at least three of the four mills suffered a flame loss, yet the MGTs and MFTs were not triggered as intended. System logs showed that multiple flame loss was only registered after the MFT had already been activated by a separate low furnace pressure condition. By this time, all mills had already tripped from the MGT. Operators noted that the flames had disappeared, yet no immediate trip occurred, and the system intervention was delayed.

The technical failure was restrictive conditions built into the logic including an unrecognised blinding function that masked signals indicating flame loss. Based on interviews, the issue lay in the logic rather than the scanners. The conditions for declaring a loss were too restrictive, which prevented the system from recognising the flame loss.

**This failure highlights how inadequate oversight, unclear performance standards and weak assurance for safety critical equipment left flawed flame detection logic hidden for years - undermining the system's intended role as a reliable last line of defence to promptly isolate fuel and prevent re-ignition.**

### 6.1.4. Delay in Isolation of Fuel

**Intended Defence:** The Mill Group Trip (MGT) and the Master Fuel Trip (MFT) are designed as the final safeguards in the combustion shutdown sequence. The MGT isolates individual mill fuel supplies when unsafe conditions are detected within a mill group, while the MFT provides full-system shutdown by rapidly closing all fuel cut dampers to every mill. Together, these trips are intended to prevent unburnt pulverised fuel from accumulating in the furnace and re-igniting under unstable conditions.

**Failure Defence**: During the incident, the MFT did eventually activate, but only due to a separate low-pressure signal and not due to the flame loss itself. Even then, its ability to prevent re-ignition was limited by a built-in time delay in the trip logic and the variable mechanical closure speed of the fuel cut dampers.

There was no requirement for the MFT logic to be reviewed or risk-tested under realistic fault scenarios after installation. Treated as an unlikely backstop, its timing assumptions went unchallenged, and no clear performance standard defined how quickly it should isolate fuel.

Without this assurance or testing, the slow response remained a hidden risk - allowing unburnt fuel to flow, accumulate and re-ignite.

**This shows how a lack of robust standards and assurance allowed hidden flaws in trip timing to persist for years, undermining fuel isolation when it mattered.**

## 6.2. Level 2 - Team/ Individual Actions

### 6.2.1. Deload Procedure Misunderstanding

**Intended Defence:** A deload is a critical control to shed clinkers. The Deload Clinker Assessment Tool procedure (PAMC-CH20-S04-P21) requires reducing the boiler load to 240MW for one hour, resulting in the shedding of clinkers from the furnace wall.

**Failed Defence:** On 3 April 2025, at 19:25 the operator reduced the unit load to only 280MW based on verbal instructions from the Shift Supervisor, who believed this matched a Standing Order. However, this conflicted with the documented procedure, which specified a deload of 240MW.

No Standing Order existed. The only written reference to 280MW came from minutes of a weekly coordination meeting between Trading and Callide, noting Daily de-loads to 280MW required when 2 bottom mills in service or 250 for combustion issues. Figure 12 provides an extract from these minutes dated on 2 April 2025.

**Figure 12** - Minutes of Meeting Between Trading & Callide Providing Deload Instructions

CPM / SITE / CPT Plant Co-ordination Meeting

***TeleConference***

Week 14 Wednesday 2nd April 2025 – 09:00am

| **2.2 Regular Activities** | | | | |
|---|---|---|---|---|
| ***Description*** | ***Freq.*** | ***Start*** | ***Finish*** | ***Avail*** |
| Valve Stroking | Saturday | 11:00 | 13:00 | <260 Fixed |
| | | | | |
| Daily De-loads to 280MW required when 2 bottom mills in service or 250 for combustion issues. When 1 bottom mill in service de-load to 250 every second day. | | | | |

The Shift Supervisor misinterpreted these meeting notes as a Standing Order and used them instead of the formal procedure to guide the deload. The instructions are also outdated and incorrect – there is no procedural requirement for daily deloads, as the Clinker Assessment Tool already accounts for the impact of operating with two bottom mills.

**The Supervisors misunderstanding of procedural requirements combined with management's failure to clearly document and enforce a single source of truth led to incorrect deload execution and contributed to clinker build-up that caused the incident.**

### 6.2.2. Failure to Communicate High Risk Furnace During Shift Handover

**Intended Defence:** The shift handover process is meant to ensure safe, informed continuity between shifts. This is done through the J5 system, where key operational conditions should be recorded. Operators are expected to flag abnormal conditions, such as red zones.

**Failed Defence:** At shift change, the C3 unit was handed over with nine active red zones indicating significant clinker risk (Figure 13). This is well above what operators consider typical.

**Figure 13** - 9 Red Zones Indicating Clinker Growth from PI Vision on 3 April 2025, 19:00 Handover


However, there was no record of the red zones or clinker risk documented in the 19:00 J5 shift handover notes on 3 April. Refer to Section 6.2.2 which highlights shift handover as a contributing factor.

**Without clear handover, incoming operators were not adequately informed of the true furnace condition, allowing clinker build up to continue. This underlines management system failure to enforce shift handover as a formalised critical risk control with clear standards and active oversight.**

### 6.2.3. Over-Reliance on Clinker Assessment Tool

**Intended Defence:** The Clinker Assessment Tool is intended to guide operator decisions by helping assess clinker risk, but not as a standalone trigger. Its effectiveness depends on using available data and operational insights to inform decisions, such as deloading or activating clinker cleaning systems.

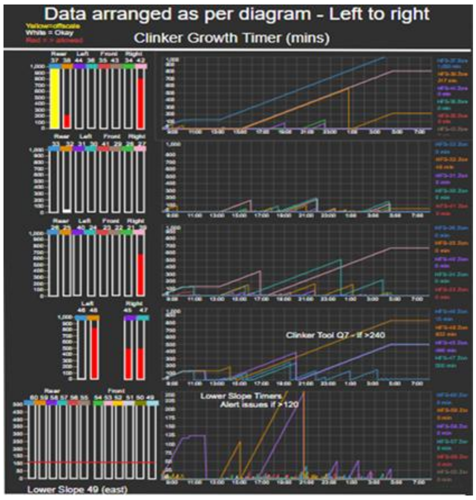
**Failure:** The operator treated the tool as a standalone directive rather than a decision support guide. At the time of the event, there were seven red zones (Figure 14.1), several of which had persisted for over 500 minutes. Whilst PI Vision screens were available to visualise this clinker growth build up (Figure 14.2), they were not directly and immediately accessible to panel operators.

Although a deload was undertaken on 3 April at 20:00, the subsequent clinker assessments at 02:50 and 04:21 only returned three 'yeses', which did not trigger a deload - four 'yeses' are required. This occurred despite degraded conditions, including multiple inoperable sootblowers and hydrojets, which were not known to the operator, and therefore not factored into the decision making.

**Figure 14** - Clinker Growth Diagrams from PI Vision at time of incident – 4 April 2025, 04:30

**Figure 14.1** - Seven Red Zones from Pi Vision


**Figure 14.2** - Clinker Growth Build Up




**This overreliance on the tool as the sole trigger, combined with failure to use available monitoring systems, allowed clinker build-up to continue unchecked. It highlights the operator's inexperience, gaps in training and competency for clinker management and the operator shortage that diverted the Shift Supervisor's oversight.**

### 6.2.4. Inadequate Testing of Flame Detector Effectiveness

**Intended Defence:** Flame detectors are critical controls designed to detect burner flame loss and trigger fuel isolation through the Mill Group Trips (MGTs) and Master Fuel Trip (MFT).

**Failed Defence:** Flame detector testing was limited to basic functional checks and did not assess the system's ability to discriminate flame loss or respond under live flame-out conditions. Tests were conducted; however they were not performed at a depth that would have revealed this problem. No defined performance standard existed to ensure testing could detect signal blinding or logic failures.

As a result, a latent flaw in the flame detection head logic went unnoticed from design and original commissioning. The unknown built-in blinding masked flame loss and delayed the MGTs and MFT, allowing unburnt fuel to accumulate during flame out. Unlike C3, Callide B used a more rigorous, informal test method that might have revealed this vulnerability. However, this practice was neither standardised nor shared across teams.

**This failure allowed an unknown flawed detection system to remain in operation. This exposes weak Safety Critical Equipment (SCE) governance - no consistent performance checks and no clear accountability to detect hidden faults.**

## 6.3. Level 3 - Task/ Environment Conditions/ Human Factors

### 6.3.1. Furnace Design Limits Optimal Combustion Tuning Balance

**Intended Defence**: The furnace is designed to support flexible mill configurations and adjustable combustion settings to maintain safe and efficient operation. Unit C boilers are fitted with low NOx combustion burners. The furnace requires online combustion tuning to balance load demands, NOx production and clinker formation, while ensuring the boiler life is not compromised.

**Failed Defence**: The unit was operating with both bottom mills, a setup known to increase clinker formation.

This risk was compounded by the underlying design limitations of the C3 furnace, which lacks combustion flexibility. The furnace cannot be tuned to simultaneously meet NOx compliance, load demands, and reduce clinker formation.

**This inherent boiler condition contributed to the incident by increasing clinker formation. This highlights the need to clearly identify the triggers such as changes to coal quality and equipment including burner components, wind boxes, air distribution system, etc. and required response to actively manage combustion tuning parameters.**

### 6.3.2. Failure to Maintain Boiler Components

**Intended Defence:** Boiler combustion components such as burner throats, vents, ducts, and air inlets are designed to support stable combustion, maintain proper airflow, and allow operators to manage NOx emissions and clinker risk effectively. These components are expected to be inspected and maintained during scheduled outages to ensure they remain in safe operating condition.

**Failed Defence**: Over the past decade, Callide C experienced issues with distorted burner throats and related components. These issues have directly compromised the ability to manage NOx emissions, forcing operators to adjust combustion settings more aggressively and increasing the likelihood of clinker formation. Several people noted that damage to the burner equipment made it more difficult to control NOx levels without elevating clinker formation.

Inspection and maintenance during overhauls have been inconsistent, with reports of partial or inadequate assessments such as reflected in *Boiler and Pressure Parts - Overhaul Final Report - C3 Major Overhaul 2019* (TRIM Ref: C/D/19/31960).

The integrity of critical components such as air inlets and ducting has deteriorated over time, reducing the system's ability to achieve combustion balance.

In addition, the dip seal flap on the Submerged Chain Conveyor (SCC) had been damaged from a clinker fall in early in 2025 and was removed on 12 January 2025. This had the effect of allowing more tramp air into the boiler, disrupting boundary air, affecting combustion tuning and likely increasing clinker formation.

**This demonstrates a site-level failure in maintenance discipline, with work not done to standard. The absence of a robust maintenance regime, poor overhaul planning and failure to fix known issues during outages, left Safety Critical Equipment (SCE) unfit for purpose, highlighting a broader management system failure.**

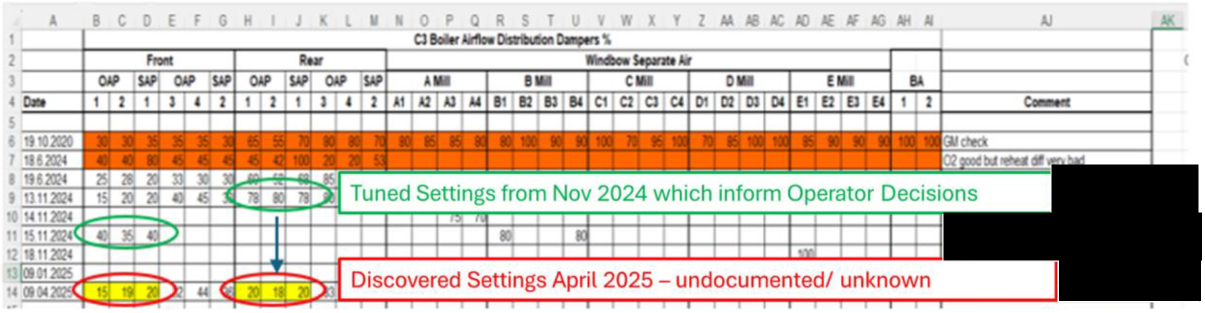
### 6.3.3. Undocumented Combustion Air Distribution Adjustments

**Intended Defence:** Air distribution within the furnace directly influences how fuel burns, where heat is concentrated, and how stable combustion is maintained. Adjusting these settings affects the balance of the flame across different parts of the furnace and can significantly affect NOx production and clinker formation.

**Failed Defence:** Between November 2024 and April 2025, undocumented changes were made to air damper settings that likely increased clinker formation. The settings had been altered without a corresponding J5 entry, and the timing and rational for the changes were unclear. Any changes must be documented in the configuration change log and shared through J5.

Data confirms these changes occurred sometime in the months before the incident (Figure 15) likely aimed at reducing NOx emissions. No entry was found in the J5 log, and the change was only discovered during combustion retuning of the boiler after the incident.

**Figure 15** - Data to confirm changes made




Interviewees confirmed this was not the first time undocumented adjustments had occurred.

**The failure to record the adjustment meant others were unaware that furnace conditions had been altered exposing poor change control and fragmented, unclear accountability. This allowed undocumented changes to critical settings to occur without oversight.**

### 6.3.4. Failure to Detect and Address Sootblower Nozzle Damage

**Intended Defence:** Sootblowers are designed to remove ash and clinker buildup from boiler surfaces by directing high-pressure steam through the nozzle ports. The system depends on rotating nozzles that redirect steam through side ports. Figure 16.1 is a photo of a new sootblower with the nozzle head intact. Effectiveness is reliant on Preventative Maintenance (PM) fortnightly inspections. When deemed ineffective, this would result in an additional ‘yes’ in the Clinker Assessment Tool and potentially trigger a deload.

**Failed Defence:** Post-incident inspection revealed six sootblower nozzles were damaged, with the nozzle heads blown out (Refer to Figure 16.2).

Although the control system indicated the sootblowers were active, the steam was not being directed correctly, which made them ineffective. Operators were unaware of this issue at the time, which meant the Clinker Assessment tool was used under the assumption that cleaning had been effective, rather than adapting the approach to address the problem.

**Figure 16** - Damaged Sootblower Nozzle

**Figure 16.1** - New Sootblower Nozzle


**Figure 16.2** - Damaged Sootblower Nozzle


The nozzle damage occurred sometime between C3 Unit Return to Service (RTS) in April 2024 and the time of the incident, as the nozzles had been replaced during the previous outage. Although visually similar, the replacements were confirmed to be the wrong material. The correct nozzles are made from 304H stainless steel, suitable for high-temperature use, while the installed ones were 303 stainless steel.

This incorrect material issue was first identified in 2018 and documented in the Equipment Strategy for Furnace Cleaning Systems (Steam, Air Knockers & Hydrojet) CC-PAS-04-EQ30 (Ref TRIM C/D/13/23139). However, the change was not implemented or systematised, as the incorrect nozzles are still held in stock at Callide and appear to likely have been installed as part of the recent C4 outage.

PM inspection routines, if conducted effectively, should have identified that the sootblowers were damaged and therefore ineffective. The extent of the problem was only discovered once the equipment was dismantled following the trip.

The inspection (Ref SAP Ref: CC3M 2W Long Soot Blower INSP) requires technicians to listen for a whoosh/whoosh sound of the nozzles during operation (Refer to extract Figure 17). This instruction was reliant on sootblowers being in operation and is somewhat subjective.

**Figure 17** - Long Sootblowers PM Work Instruction

```
c) Nozzle
- Listen for a "Whoosh/Whoosh" sound of alternating steam flow,
this confirms the nozzle is in good condition.  A loud constant
steam flow noise could indicate a damaged nozzle.
```

Prior to the incident, inspections were marked as complete, yet the nozzle damage was not identified. Inspection records did not document any issues (Figure 18). In practice, the quality and consistency of inspections varied, possibly due to subjective nature of the inspection instructions and methods used.

**Figure 18** - C3 Maintenance Inspection Record Prior to C3 Clinker Incident

```
CC3M 2W-3M I/S SOOT BLOWER INSP

op 10 40 60 complete [redacted] 03/04/25
op 10/10.40/10.60/10. complete [redacted] 03/04/25
```

After the incident and discovery of the ineffective sootblowers during the outage, there was an uplift in inspection records (see Figure 19) which provided more detail.

**Figure 19** - C4 Maintenance Inspection Record Post C3 Clinker Incident

```
CC4M I/S 2W-3M SOOT BLOWER INSP
Op #40, $40/10 Complete. Inspected sootblowers and lubricated.
Pressure guage on 1F short sootblower is damaged and not seviceable.
Will raise a notification to have a new item fitted, Notification raised
#10698148.
Some minor & moderate gland leaks, will adjust. Pressures are in range,
4F has no pressure guage fitted. 8R did not operate. 4F & 8R Chains had
not been lubricated at all since refurbs, will source some chain lube
and lubricate. [redacted], [redacted] 23.05.2025
Op #60, #60/10 Complete. Adjusted short sootblowers, 12R seemed to run
out of adjustment. Will raise a notification to be repacked.
Notification raised #10698158. *See Attachment
[redacted], [redacted], [redacted] 23.05.2025
Long sootblower service complete Nip ups completed on R25,R26,R28
Gut fill is nozzles on 20R,21R and possibles 20L,22L,22R to confirm
easiest way would be to pull poppet valve off and look down tube see if
there's a big orange glowie thing at the end
29R needs a new live loaded it appears the spring is not doing its thing
[redacted] 25/05/25
```

The failure to detect and address sootblower nozzle damage resulted in two issues that contributed to the incident. These are noted as 6.3.4a and 6.3.4b on the Fault Tree (Figure 10.3) and ICAM chart (Table 1).

6.3.4a The undetected nozzle failure and poor maintenance practices reduced the effectiveness of the sootblowers at removing clinkers.

6.3.4b If the sootblower nozzle failure had been identified, this would have triggered an additional 'yes' in the Clinker Assessment Tool and prompted further deloading before the incident as discussed in Section 6.2.3.

**At site level, there was a clear failure to detect and address the fault. At management level, there was a system failure to remove the incorrect sootblower nozzles from warehousing and update records, and a lack of follow-through to ensure the engineering change was fully implemented.**

### 6.3.5. Ineffective Hydrojets and Faulty Red Zone Monitoring

**Intended Defence:** Hydrojets and red zone thermocouples are intended to work together to enable prevention of clinker build-up. Hydrojets remove slag from furnace walls, while thermocouples detect heat loss on the wall of the furnace and trigger Red Zone indicators to guide operator response through the Clinker Assessment Tool.

**Failed Defence:** Before the incident, several hydrojets were not functioning due to blocked nozzles and misalignment. These issues went undetected due to poor inspection and maintenance practices. At the same time, the red zone monitoring system was unreliable. Some thermocouples flagged red zones incorrectly, showing high clinker risk where there was none, while others failed to indicate real risk. The hydrojet panel presented a misleading view of furnace conditions.

As a result, operators entered inaccurate information into the Clinker Assessment Tool, which did not trigger the required deload. The failure to maintain and verify both the hydrojets and red zone monitoring systems removed two critical clinker controls and reduced operator visibility of deteriorating furnace conditions.

The failure to detect and address ineffective hydrojets resulted in two issues that contributed to the incident. These are noted as 6.3.5a and 6.3.5b on the Fault Tree (Figure 10.3) and ICAM chart (Table 1).

6.3.5a The ineffective hydrojets reduced the operator's ability to remove clinkers.

6.3.5b If the ineffective hydrojets had been identified, this would have triggered an additional 'yes' in the Clinker Assessment Tool and prompted further deloading before the incident as discussed in Section 6.2.3.

**This failure disabled two key controls that should have triggered a deload. At site level, hydrojets and sensors were not properly maintained or checked. At management level, there was no oversight to ensure these systems were functional and reliable.**

### 6.3.6. Indeterminate Coal Quality

**Intended Defence:** Coal quality, particularly iron content has a direct impact on clinker formation. The intended control relies on reliable stockpile and slot blending, real-time quality monitoring, and clear communication between operators to support timely operational changes when poor quality coal is in use.

**Failed Defence**: Leading up to the incident, supply of coal from the mine was reduced, requiring the station to supplement approximately 50% of the coal supply using the stockpile. Heavy rainfall meant coal plant operators had to excavate deeper into the stockpile to access dry coal. This recovery method bypassed normal blending processes, increasing the risk of poor-quality content entering the furnace.

The specific iron content entering the system is not confirmed with real-time data as the analyser only measures coal quality from the mine and not the stockpile. With no real-time analysis at the point of use, operators had reduced visibility of iron levels or friable coal entering the furnace, increasing the potential for clinker formation to be unknown.

Despite clear loss of control over coal quality, there was no formal operational response. No heightened monitoring or mitigation measures were put in place to manage the increased clinker risk.

**This demonstrates a local failure to recognise and respond to the loss of coal quality control, and a management failure to ensure robust monitoring systems, clear contingency plans, and accountability for maintaining fuel quality during supply disruptions.**

### 6.3.7. Inadequate Staffing and Experience on Shift

**Intended Defence:** Shift teams are designed to ensure all critical roles are staffed by competent operators. A full roster of 11, including panel and outside operators, a shift supervisor, and support roles, is essential for safe operations, consistent procedures, and support for less experienced operators. The shift supervisor is responsible for oversight, decision validation, and escalation during abnormal conditions.

**Failed Defence:** On the night of 3 April 2025, only 8 of the 11 rostered roles were filled. The C3 panel operator was operating the unit for the first time, having been signed off just three days earlier, with no prior experience managing clinker deloads. The shift supervisor, covering both B and C Units, had not personally done a deload in over a year and was also mentoring a trainee on C4. Competing demands meant the supervisor could not return to oversee C3 after an earlier deload, leaving the newly qualified C3 Panel Operator to manage alone. No other qualified C Unit Panel Operator was available to support him.

Table 2 shows the roles filled at the time of the incident on C3 and each operators experience in the role.

**Table 2** - A Shift Roster at Time of the Incident

| Position | Operator Experience | Notes |
|---|---|---|
| Shift Supervisor | 12 years as panel operator | Acting Shift Supervisor - relieving from B Shift |
| B1 Panel Operator | 13 years as B panel operator | |
| B2 Panel Operator | 4 years as B panel operator | Relieving from E Shift |
| B Station Outside Operator | 36 years as outside operator | Relieving from E Shift |
| B Station Outside Operator | Vacant | Covered by Shift Supervisor |
| C3 Panel Operator | Recently qualified as C panel operator | |
| C4 Panel Operator | Trainee panel operator | Trainee panel operator |
| C Station Outside Operator | 14 years as outside operator | |
| C Station Outside Operator | Vacant | |
| Coal Plant Operator | 29 years as coal plant operator | |
| Chem Plant Operator | 18 years as chem plant operator | |

**The incident demonstrates that safe operation depends on fully staffed, competent shift teams to respond to emerging issues. Running below minimum staffing is an accepted norm. It is not recognised or managed as a critical risk.**

### 6.3.8. Latent Design Flaws Delayed Flame Detection and Fuel Isolation

**Intended Defence:** The C3 unit, commissioned in 2001, was designed with protection systems to detect flame loss and isolate fuel supply through the Mill Group Trip (MGT) and/or Master Fuel Trip (MFT).

**Failed Defence:** Two latent design flaws in the C3 unit delayed critical protection responses which existed since commissioning in 2001.

A blinding function in the flame detector logic masked flame loss, preventing a valid signal to trigger a MGT and the MFT. The flame detector logic also included built-in delays, such as permissive timers and signal averaging, some intended to avoid nuisance trips. These flaws were never detected due to the absence of performance standards, inadequate Return to Service testing and poor documentation from the design and original commissioning.

**These latent conditions were undetected allowing unburnt pulverised fuel to accumulate in the furnace, which significantly increased the severity of the incident.**

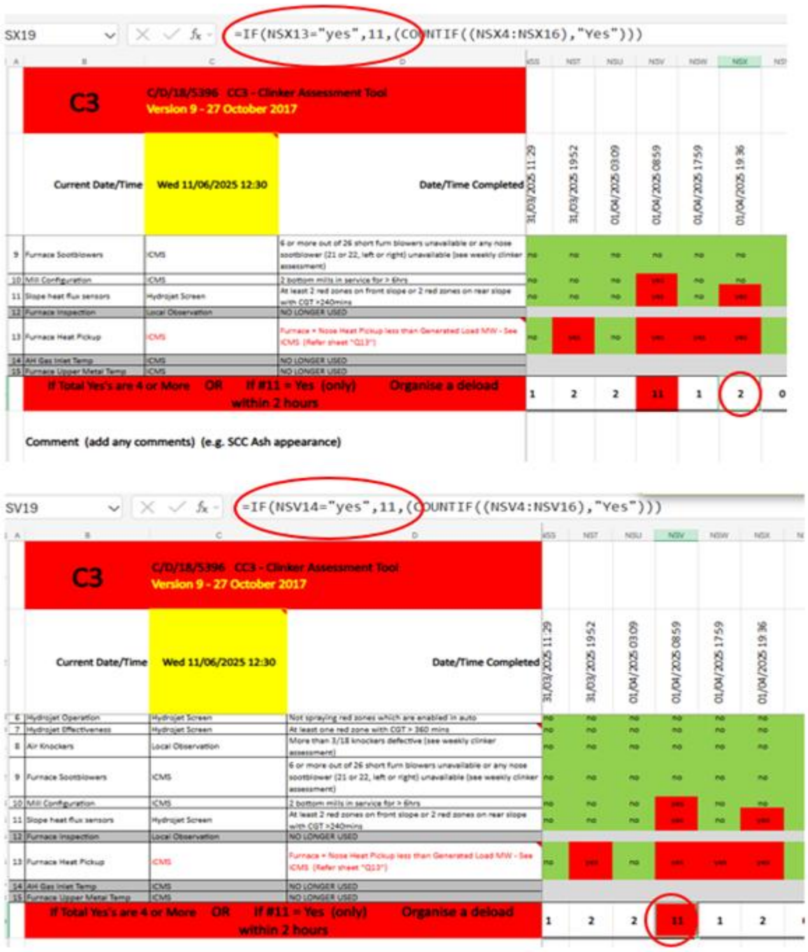
## 6.4. Level 4 - Organisational Factors

### 6.4.1. Conflicting Instructions and Design Flaws in Clinker Assessment Tool

**Intended Defence:** The Clinker Assessment Tool is intended to support consistent, risk-based decision-making by guiding operators through a structured set of inputs. It is designed to prompt a deload when four or more clinker risk conditions are met, or when a critical override is triggered. To function effectively, the tool depends on a sound underlying design and clear, unambiguous instructions that align with operating procedures and user expectations.

**Failed Defence:** The investigation revealed critical flaws in both the design and use of the Clinker Assessment Tool. Although password-protected, the Excel-based tool allowed manual input through typing, copying, or cut-and-paste. Using cut-and-paste overwrote embedded formulas, compromising the tool's logic and suppressing deload prompts. This error occurred during the 1 April 2025 precursor event, which should have triggered a deload, but went undetected. The issue was only uncovered during the RCA/ ICAM investigation into the C3 Clinker incident. Figure 20 shows evidence of the altered formula.

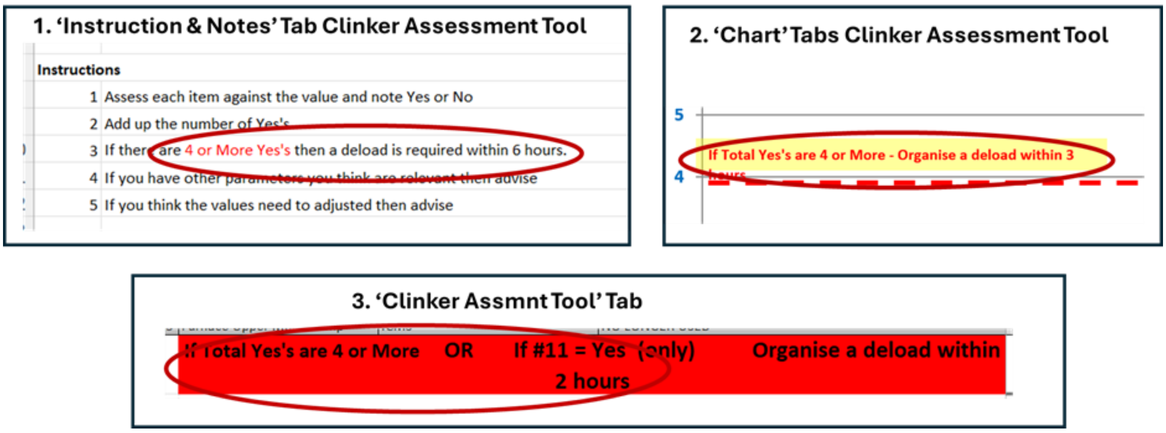
**Figure 20** - Changed Formula Due to Human Error




Additionally, the tool contained multiple tabs with conflicting instructions on when to deload, creating ambiguity at critical decision points (Figure 21).

Also, there was no review of how this tool contributed to the precursor incidents on 20 and 21 Nov 2024 as discussed in Section 6.5.1. Those investigations focused on equipment failures and inspections and did not consider wider contributing factors such as the role of the Clinker Assessment Tool.

**Figure 21** - Inconsistent instructions on deload in the tool - increasing likelihood of human error




**This highlights that a poorly controlled tool had become a key instrument for managing clinker risk. Its design relied heavily on fragile manual steps which increased the likelihood of human error. There was no robust version control, no safeguards to prevent manual errors from disabling critical logic, and no clear accountability for maintaining or reviewing the tool's use.**

### 6.4.2. Inadequate Management of Safety Critical Equipment (SCE)

**Objective:** All Safety Critical Equipment must be clearly identified, risk-ranked, maintained, and integrated into daily operations to ensure it performs reliably under all operating conditions. This requires accurate asset classification, clear functional ownership and responsibility, maintenance strategies aligned to risk, and inspection standards with clear escalation triggers.

**Weaknesses:** At Callide, the current SCE register remains incomplete and misaligned with actual operational risks. Despite reviewing over 5,500 items in 2024 under the Process Safety Improvement Program (PSIP), the register remains focused on individual parts rather than functional equipment and is not robustly connected to bowtie controls that define how risks are practically managed.

This gap has been compounded by misplaced confidence that the register is 'complete', when critical safeguards - such as sootblowers and interlock logic - is not consistently risk-ranked, verified or integrated into daily risk oversight. The PSIP was intended to address this and is discussed in Section 6.5.2, impact has been limited.

**Without a clear, risk-based SCE framework, backed by strong governance and practical site-level ownership, key safeguards were left unverified and mis-prioritised - reducing the site's ability to detect, respond and contain developing hazards effectively.**

### 6.4.3. Inadequate Management and Communication of Operational Changes

**Intended Defence:** Operational changes must be formally reviewed, authorised, documented and clearly communicated to ensure all staff work from a consistent understanding. This includes procedure updates, temporary instructions via Standing Orders, Operational Risk Assessments (ORAs), and instructions provided from other departments such as engineering, trading or maintenance.

**Failed Defence:** There were widespread inconsistencies across procedures, tools, Standing Orders and ORAs and informal instructions communicated through meeting minutes, emails and verbal directions. This left operators with multiple, sometimes conflicting sources of guidance.

- **Clinker Assessment Tool References & Inconsistencies with Clinker Deload Procedure**

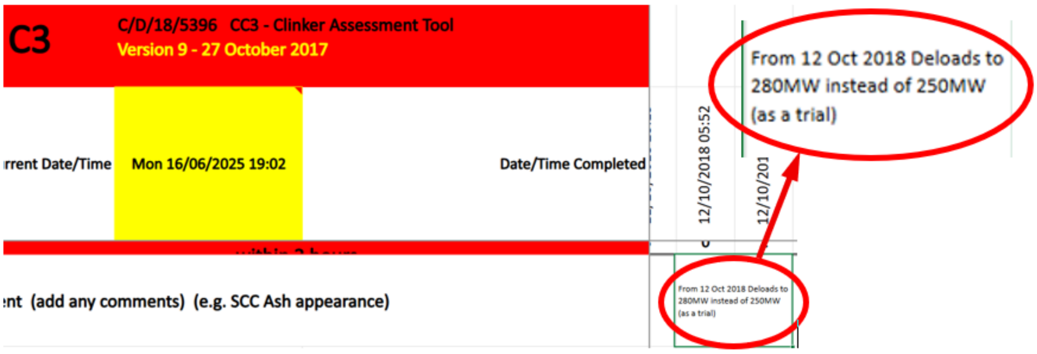
For example, the Deload Clinker Assessment Tool Procedure (Ref: TRIM C/D/14/23117 – PAMC-CH20-S04-P21) specifies a deload to 240MW for one hour (Figure 22).

However, the Clinker Assessment Tool includes outdated references to trial thresholds of 280MW and 250MW from 2018 (Figure 23). Despite this conflict, the procedure was never updated, and no structured review ensured the tool matched the latest operational standard. Interviews revealed inconsistent operator practices, with varying load and duration preferences for deloads. As noted in Section 6.4.1, flaws in the tool's design further increased the risk of user error.

**Figure 22** - Deload Procedure Extract

| Term | Definition |
|---|---|
| Deload | Load to 240MW and hold at 240 for 1 hour |

**Figure 23** - Deload Instructions from Clinker Assessment Tool




- **Standing Orders**

Standing Orders, which are designed to provide temporary changes to operations, were inconsistently managed. There was no structured process for drafting, approving, or communicating them, and no reliable systems to confirm operators read and understood them. Data showed only 20% of operators had formally acknowledged any current active Standing Orders. In interviews, people confirmed that acknowledgment rates were unreliable and there was no assurance that instructions were understood or followed.

- **Operational Risk Assessments (ORAs)**

Many ORAs were incomplete, and some were left open long after their purpose has expired. Critically, the quality of ORAs was poor, with evidence they were often treated as a tick-box step to justify continued operation than a genuine risk evaluation tool, undermining their use as a method for controlling operational risk.

- **Informal Instructions via Minutes, Emails & Verbal**

Operators noted there had been a past practice of conducting routine deloads to 280MW when operating on two bottom mills, which was in fact documented in the current weekly meeting minutes as discussed in Section 6.2.1. Many also expressed frustrations with inconsistent informal operating instructions.

**This demonstrates a lack of leadership accountability for managing operational changes and ensuring risk tools such as ORAs were properly applied to assess and control risks. There**

**was no clear ownership or sign-off for critical changes such as Standing Orders. This lack of structured governance, critical review and accountability normalised informal workarounds.**

### 6.4.4. Unstructured and Inconsistent Shift Handover

**Objective:** The shift handover process must ensure clear, consistent and complete transfer of critical plant status, operational risks, equipment condition and standing instructions between shifts to maintain safe, stable operations.

**Weaknesses:** Shift handovers lacked structure and standardisation, leading to inconsistent and incomplete transfer of information. Practices varied between operators, with some recording information in handwritten logs, others typing entries, and in some cases relying only on verbal exchanges. Although a new Operations Instruction and draft procedure were developed in 2022 (Ref: TRIM K/D/22/26568324), most operators interviewed did not recall receiving formal training, and no implementation records exist in the Learning Management System.

An internal review recognised this weakness, and a shift handover improvement blitz was launched in March 2025 but had yet to deliver meaningful operational impact.

**Without leaders actively driving and enforcing disciplined shift handover standards, critical operational information is too often missed or miscommunicated, delaying the detection of deteriorating conditions and undermining safe, stable operations across shifts.**

### 6.4.5. Poor Maintenance, Planning and Scheduling Management

**Intended Defence:** CS Energy's maintenance, planning and scheduling process is intended to ensure consistent execution of preventative and corrective maintenance across the business. It should align plant performance delivery with Asset Management Plans and the Business Strategic Plan, using approved workflows and risk-informed prioritisation.

**Failed Defence:** In practice, the system operated in silos with slow workflows, misaligned priorities and workarounds that undermine risk-based decision making.

Low priority work (P3-P5) faced delays of up to six weeks due to handovers between Maintenance and Planning, leading to frequent reclassification of jobs to higher priorities (P0-P2) just to get them done. This inflated priority coding and distorted operational risk visibility.

Engineering used the CS Energy Enterprise Risk Management (ERM) Matrix, while Planning referred to the SAP priority codes (see Section 6.5.5). The misalignment in risk ranking creates conflict with prioritisation of maintenance activities.

Trust in SAP was low across multiple roles. Asset master data was often inaccurate, and both planners and technicians reported lacking confidence in system-generated priorities. As a result, work was frequently driven by perceived operational needs rather than by the system.

These gaps were evident at the operational level. Routine maintenance tasks were sometimes missed, which contributed to larger problems emerging during outages. Maintenance was often described as rushed, with limited time available to follow through on quality checks or verification.

Beyond these workflow failures, the investigation found that CS Energy's overall Preventative Maintenance (PM) strategies were weak. While some tasks were in SAP, routine safety-critical work – like verifying the timings of the boiler protection system and fuel cut-offs – was not formally covered by any PM. This left important checks to informal knowledge and workarounds, without a structured process to ensure they were done consistently or properly recorded.

**The result was a fragmented and reactive maintenance and planning that contributed to equipment degradation and undermined plant reliability. This demonstrates a systemic**

**management failure and weak leadership accountability for ensuring maintenance strategies were complete, risk-based and consistently applied. The lack of clear oversight and structured planning meant critical maintenance activities were not appropriately prioritised and undertaken.**

### 6.4.6. Inadequate Preventative Maintenance Discipline

**Intended Defence:** Preventative Maintenance (PM) is intended to ensure equipment functions reliably under normal and abnormal conditions. For components like sootblowers, flame detectors and hydrojets, PM should confirm integrity and escalate critical issues.

**Failed Defence:** This protection failed due to poor inspection execution and incomplete inspections and documentation discipline.

- **Poor Inspection Execution**

Inspection records often contained generic comments confirming that an inspection was done, without details of what was done or observed such as long sootblower inspections which were found to have been faulty following the clinker incident (Section 6.3.4).

- **Incomplete Inspection and Test Plans (ITPs) and Documentation**

ITPs were de-prioritised under time pressure, with evidence of blank and incomplete records (Ref: TRIM C/D/22/2509 - Plant Area Technical Report). A full inspection of the throat burners was not completed, which meant the need for replacement was missed and temporary welding was carried out instead to extend service until the next overhaul.

**This failure allowed critical equipment faults to persist, removing an essential line of defence. It reflects a systemic management failure and weak leadership accountability for enforcing complete, accurate PM and inspection standards. A production-driven culture prioritised cost and time over safety (Section 6.5.9), resulting in inspections and ITPs to be deprioritised.**

### 6.4.7. Ongoing Shortage of Operators

**Intended Defence:** Shift rosters are structured to provide continuous 24-hour coverage across five rotating teams, with each team working two days and two nights in a 10-day cycle. Adequate staffing is essential for safe operations – it enables effective handovers, fatigue management, peer checking, supervision and ongoing on-the-job training.

**Failed Defence:** The operator shortage was a known and escalating risk well before the incident. Roster analysis over a 12-month period (Jan 2024 to Dec 2024) shows only 20% of shifts were staffed at planned levels, a further 54% met the requirement only by using overtime, and 26% of shifts fell short altogether (See Figure 24 and Figure 25). This gap was compounded by two further pressures:

- Retirement risk: 28% of current panel operators are due to retire within five years (Figure 27)
- Operator 'unavailability': 28% of qualified panel operators were unavailable due to secondments, training or extended leave (Figure 26)

These factors reduced the available pool of competent operators and increased reliance on overtime to fill critical roles. While new trainees have been recruited, staffing remains below minimum required levels.

Despite repeated recognition of this shortage in internal meetings, management did not formally recognise or treat it as an operational risk. It was not recorded in the risk register or referenced in

CGR, and no coordinated, actionable plan was developed to close the gap. There was no clear ownership, defined controls or structured reporting. By failing to treat this as a risk to safe operation, management effectively normalised the operator shortage and its impacts.

As a result, the site continued to run shifts understaffed and reliant on overtime and newly qualified operators, undermining the shift supervisor's capacity, peer checking, on-the-job training and timely response to abnormal conditions.

**Figure 24** - Overtime Coverage and Gaps in Target Operator Numbers

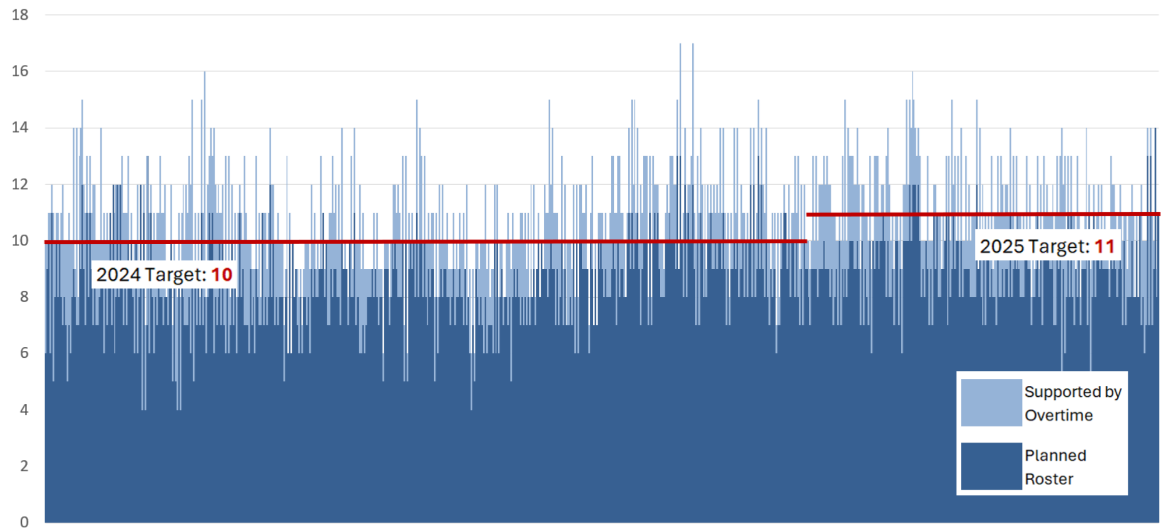



**Figure 25** - Percentage Shifts that Achieved Target Operator Numbers

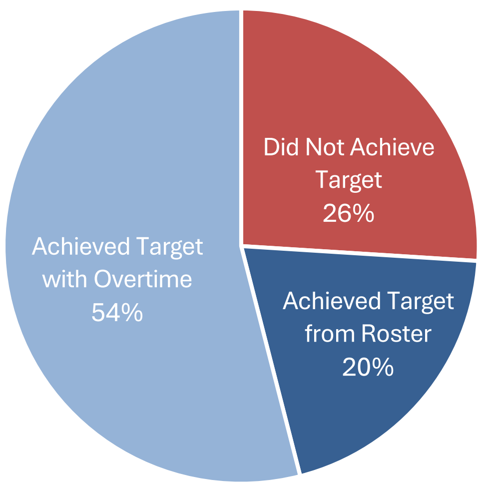
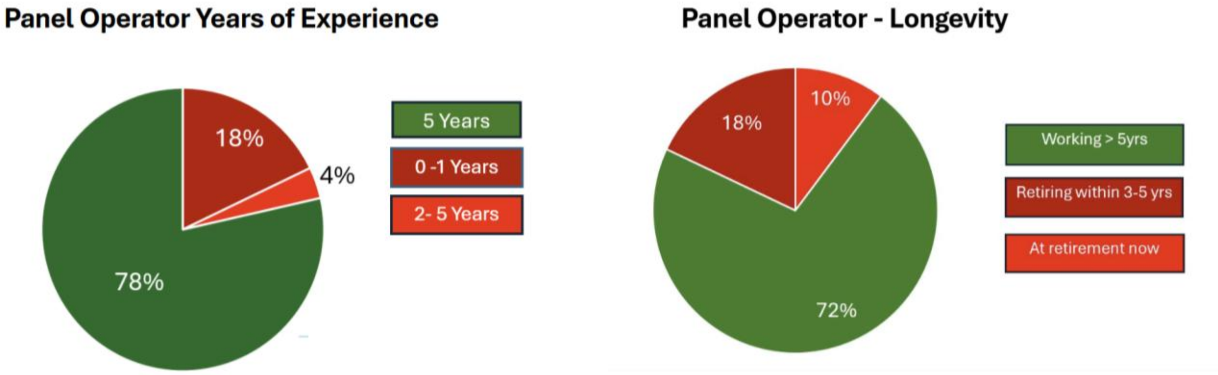


**Figure 26** - Compounding Shortage due to 'Unavailability' (Secondments, Leave, Training)


**Figure 27** - Compounding Shortage Due to Retirement




**This demonstrates a clear failure to staff and supervise shifts to safe minimum standards, and a management failure to recognise, escalate and resource this as a critical operational risk. This normalised running with insufficient and inexperienced operators, directly undermining safe, reliable operations.**

### 6.4.8. Lack of Formal Operator Training and Competency Verification

**Intended Defence:** Clinker risk should be managed through structured training and verified competency, ensuring operators can identify early warning signs and take appropriate action, including initiating a deload when required.

**Failed Defence:** There is a lack of formal training and competency verification for clinker management. Operator knowledge is gained informally, based on shift exposure and personal initiative. Simulator training focused on a defined list of scenarios which did not include clinker scenarios or deload execution.

There was no independent review of the competency framework to test whether it met good industry practice - a governance failure at senior leadership level. Management acknowledged the problem in meetings but failed to translate this into a formal plan with clear actions, ownership, and trend monitoring. Additionally, there was no independent review or third-party testing of the competency framework to confirm it met good industry practice, which was a governance failure at senior leadership level.

Cultural attitudes further downplayed the risk, with clinkers often regarded as a routine part of operations rather than a potential hazard. This reflected a lack of awareness among personnel about the possibility of an explosion resulting from ineffective clinker control.

**This highlights a failure to recognise clinker management as a process safety critical task and how a lack of formal training, verified competency and effective governance left operators reliant on informal knowledge.**

### 6.4.9. Lack of Formal Shift Supervisor Training and Competency Verification

**Objective:** Safety-critical roles, especially frontline leadership positions like Shift Supervisors, require robust, role-specific training and verified competencies to ensure they can manage plant risks, make sound decisions and lead teams during normal and abnormal conditions.

**Weaknesses:** The Shift Supervisor role lacked a formal training program or structured competency framework, including non-technical skills. Appointments were typically based on time served or general experience rather than a defined pathway with preparation, assessment, and peer review. Employees described the process as informal, with individuals moving into the role without structured training or clear development steps.

In 2018, the Role Purpose Statement (RPS) was revised, lowering the experience requirements for Shift Supervisors. The original 2014 RPS version required at least ten years of experience in a modern coal-fired boiler plant and formal technical qualifications. The updated version reduced this to five years of generic processing plant experience and removed the requirement for technical qualifications or Panel Operator certification. As a result, some Supervisors could no longer backfill as Panel Operators during shortages, creating operational risk. These changes were made to ease recruitment but significantly lowered the technical capability baseline.

**The absence of formal training, and reduced experience requirements have weakened the capability of Shift Supervisors to lead effectively, manage plant risk, and support operational teams during critical events and staff shortages.**

## 6.5. Level 5 - Systemic Factors

Systemic factors are underlying organisational weaknesses that go beyond a single or cluster of related events. They reflect failures in management systems, governance, culture or structure that allow risks to persist across time. Unlike contributing factors, which relate to specific circumstances, systemic factors point to conditions that repeatedly erode controls, reduce oversight, and impair decision-making.

To reflect their broader organisational nature, each systemic factor is presented with:

- Objective – what the system is intended to achieve
- Weakness – how the system failed to operate as intended

This framing shifts the focus from isolated breakdowns to persistent vulnerabilities that require structural change. It is not just about preventing the recurrence of similar incidents; it's also about preventing incidents more broadly.

### 6.5.1. Failure to Learn from Previous Clinker Events

**Intended Defence:** Significant operational incidents, particularly those with process safety implications, should be escalated, classified, and investigated under established frameworks such as ICAM to ensure lessons are identified, actions are tracked, and risks are addressed.

Proper classification drives appropriate levels of oversight, investigation depth, and organisational learning.

**Failed Defence:** There were two precursor clinker events that occurred in November 2024, one on C3 on the 20 November (Ref: CGR https://csenergy.cgrfoundation.com/incidents/2868) and the other on 21 November on C4 (Ref: CGR https://csenergy.cgrfoundation.com/incidents/2873). Both involved combustion disturbances linked to clinker buildup. However, these incidents were not classified as process safety events and were instead logged as operational issues, resulting in a Category 1 classification.

The lower classification limited scrutiny, investigation rigour, and management oversight. As a result, critical aspects of clinker risk - including furnace condition, risk thresholds, and deload response - were not thoroughly examined. If the event had been classified at a higher category, it would have triggered an ICAM investigation and engage executive oversight.

This was further complicated by the double reporting of the incident on C4 (Ref: CGR https://csenergy.cgrfoundation.com/incidents/2883). Whilst it occurred on the 21 November, it was first reported by Operations on 22 November and then subsequently reported again on 26 November when damage was noticed to the penthouse by engineers. This was due to confusion between the two similar incidents that occurred on the 20 and 21 November. The double reporting on C4 incident triggered two separate 5 Whys investigations which were later merged, creating further ambiguity around findings and ownership of corrective actions.

There was an additional clinker incident which occurred on 1 April 2025; however, this was not reported at the time of occurrence as it was considered a normal operating upset. It was not formally reported until 13 April (Ref: CGR https://csenergy.cgrfoundation.com/incidents/3113) and site management were unaware of this precursor event until it was later reported.

There had been no significant fuel reignition incidents caused by clinker falls between 2012 and November 2024. This long gap contributed to organisational blind spots around clinker-related process safety risks and reduced opportunities to learn from precursor events.

**This failure to escalate and properly investigate the November 2024 clinker events shows a clear gap at site level in recognising process safety events, and a broader management failure to ensure robust classification, oversight and organisational learning. As a result, key risks were normalised, lessons were lost, and opportunities to prevent repeat events were missed.**

### 6.5.2. Repeated Failures to Operationalise Process Safety

**Objective:** Establish process safety as a daily, practical discipline that consistently delivers measurable risk reduction and operational results. This requires clear structures, strong operational ownership, robust capability and leaders who ensure process safety principles translate into tangible frontline impact.

**Weaknesses:** CS Energy has made multiple attempts to strengthen process safety over the years but has failed to deliver operational impact due to shifting priorities, inconsistent funding and weak leadership follow-through. Organisational structures and capability have not supported delivery to impact frontline operations.

The current Process Safety Improvement Program (PSIP) is the fourth attempt; nine months in and 25% complete at the time of the incident, its rollout at Callide was delayed by competing return-to-service demands, with key activities like bow tie development only finalised shortly before the clinker event.

- **Process Safety Not Embedded or Understood**

Despite the existence of a formal framework, process safety is not well understood, communicated, or embedded in daily work. Many staff view it as abstract rather than essential, with minimal practical impact. Weak signals that should trigger early intervention are often rationalised away instead of escalated.

- **Widespread Process Safety Competency Gaps**

Operator and supervisor training does not consistently cover critical process safety risks. Training remains informal, inconsistent, and dependent on the capability of individual mentors, which has led to uneven skill development. This approach has created cascading gaps in process safety knowledge and practical capability across the workforce.

- **Fragmented Roles and Poor Governance**

Accountability for process safety is fragmented and often defaults to engineering teams rather than being embedded with frontline operations where risk is most immediate. The process safety team is frequently excluded from critical reviews and investigations, reducing its ability to influence operational risk control.

- **Overloaded and Under-Resourced Teams**

Engineers and technical teams are stretched thin, taking on scoping, planning, and delivery for projects and overhauls that would normally sit with a dedicated project function. This workload is compounded by competing demands such as performance standard development, KPI reporting, board requirements, and external commitments. Managing multiple priorities simultaneously under significant time pressure has limited their ability to focus on critical process safety work, leaving insufficient capacity to drive improvements effectively.

- **Superficial Improvement Efforts**

The current Process Safety Improvement Plan is spread across six concurrent workstreams, which dilutes focus and results in minor incremental changes rather than significant, targeted improvements at the frontline. Frontline teams struggle to connect these initiatives with their daily tasks, and performance standards remain poorly understood.

- **Normalisation of Process Safety Events as Routine Operations**

Unit trips and process safety events are often treated as routine operational issues rather than critical safety concerns. Operators frequently lack the awareness and capability to identify weak signals and process safety hazards, which leads to serious risks being downgraded as minor incidents. Known issues, such as clinker build-up, have become normalised and are not consistently recognised as critical events requiring escalation.

- **Failure to Prioritise the Safety-Critical Risks**

Leadership has allowed multiple reviews, action registers and tactical fixes to multiply instead of targeting the highest-priority risks that drive genuine safety improvement. This scattered effort produces noise but does not translate to sustained operational change.

**Without clear structures, practical frontline ownership, strong project delivery and leaders who enforce discipline and drive real change, process safety remains a policy, not practice.**

**Engineers stay overloaded, known hazards cycle through registers instead of being addressed, and the business stays reactive and exposed to repeat failures.**

### 6.5.3. Strategic Misalignment and Leadership Instability Undermine Critical Risk Control

**Objective:** A stable, clearly aligned strategy and consistent, accountable leadership at the board and executive level are essential to maintain focus on critical safety risks, ensure initiatives deliver measurable risk reduction, embed lessons learned and improvements to build trust and capability across all levels of the organisation.

**Weaknesses:** The organisation has been operating in an environment shaped by frequent leadership turnover, shifting priorities, external pressures, and a high volume of reactive governance interventions. This instability has divided leadership attention across multiple action registers and overlapping initiatives, often without clear prioritisation or alignment around critical risk. Leaders acknowledged that constant change has made it difficult to sustain focus or embed improvements before new demands arise.

Numerous external reviews, advisory groups, shifting public policy and asset closure timelines, have added further noise and further fragmented leadership focus. The result is a culture where actions from reviews accumulate faster than they can be closed, and operational teams struggle to see the tangible value of these efforts.

This environment has diluted ownership for long-term improvement, and made it difficult to sustain a clear, practical focus on reducing critical safety risk. The absence of a single, prioritised critical risk register and action plan has led to sub-optimal closure of issues and limited the organisation's ability to track and address critical safety exposures.

Leadership instability contributed to poor learning from incidents. Executive challenge sessions failed to identify high order controls, organisational or systemic factors. Agreed changes to categorisations did not translate to CGR and there was a failure to learn from incidents – there was no process, no oversight and no accountability.

This challenge is compounded by leadership churn at Callide. Over the last decade there have been six site General Managers, eleven Maintenance Managers and six Production Managers, making it even harder to drive and embed a critical risk-focused strategy where leaders are held to account.

**The absence of a stable, risk-focused strategy and the lack of leadership continuity have scattered effort and allowed external noise to distract from a critical risk focus. Without clear stakeholder alignment and leaders who drive accountability, critical risks stay unresolved and known hazards cycle through registers instead of being fixed.**

### 6.5.4. Organisational Silos and Leadership Inaction

**Objective:** Effective coordination between Scheduling, Planning, Engineering, Production (Operations) and Maintenance is essential for safe, reliable plant operation. Leaders must ensure these functions work as an integrated team with clear roles, aligned priorities and strong communication, driving shared ownership of operational risks and overall plant performance.

**Weaknesses:** Persistent silos and split reporting lines has fragmented risk ownership, diluted accountability and delayed responses to emerging hazards. CS Energy's organisational structure divided key functions between site and Brisbane, which contributed to this fragmentation. Reporting and accountability were split between site-based teams such as Production and Maintenance and Brisbane-based groups including Engineering, Planning and Scheduling, Facilities and Warehousing.

Engineering was not embedded on site and was repeatedly pulled between urgent plant issues, overhauls, and longer-term asset strategies. Operators described the environment as fragmented, with teams working in silos and no single function owning the full picture.

A legacy of self-managed teams contributed to these silos, with functions working in isolation and leaders failing to challenge or break down these known and persisting barriers. Key performance indicators remained misaligned across groups, creating conflicting priorities and reinforcing an ‘us versus them’ dynamic.

**This fragmented structure, and leaders’ inaction in addressing it, continues to create blind spots, dilute day-to-day accountability and prevent single-point accountability for site performance.**

### 6.5.5. Misaligned and Conflicting Risk Prioritisation Systems

**Objective:** A single, enterprise-wide risk matrix should provide a clear standard for assessing and prioritising risk so that Engineering, Planning and Scheduling, and Maintenance can make consistent, aligned decisions.

**Weaknesses:** At Callide, different teams used different risk matrices for the same types of decisions. Engineering applied the CS Energy Enterprise Risk Matrix, which classifies a catastrophic consequence with possible likelihood as a *high risk* (Figure 28*)*  - meaning it is unacceptable and must be addressed immediately. In contrast, Planning and Scheduling used a separate SAP matrix that ranks tasks by timeframes (P0 to P5) rather than by consequence and likelihood. For example, the same issue rated *high* by Engineering would be categorised as a ‘P2’, requiring completion within seven days instead of immediate action (Figure 29).

Engineering staff noted that during weekly work order meetings, serious notifications were often reprioritised. Differences in how teams assessed risk created tension, with disagreements about what should take priority. Staff felt that some issues were downgraded because planning and scheduling functions did not share the same risk perspective as those closer to the work.

Risk ratings were sometimes inflated just to push critical work through, highlighting how unclear standards and conflicting frameworks allowed significant risks to slip through unchecked.

**Figure 28** - Enterprise Risk Matrix

| Likelihood Level | | Consequence Scale | 1. Minor | 2. Low | 3. Moderate | 4. Major | 5. Severe | 6. Catastrophic |
|---|---|---|---|---|---|---|---|---|
| | A | Highly Likely | Low | Moderate | Moderate | Significant | Extreme | Extreme |
| | B | Likely | Low | Moderate | Moderate | Significant | Extreme | Extreme |
| | C | Possible | Low | Low | Moderate | Moderate | Significant | Extreme |
| | D | Unlikely | Low | Low | Moderate | Moderate | Significant | Significant |
| | E | Rare | Low | Low | Low | Moderate | Moderate | Significant |

**Figure 29** - Scheduling Risk Matrix

| Notification Priority Matrix | Consequence Levels: Minor | Low | Medium | Major | Severe | Catastrophic |
|---|---|---|---|---|---|---|
| **Likelihood Level:** Highly Likely | P5 | P4 | P3 | P2 | P1 | P1 |
| Likely | P5 | P4 | P3 | P3 | P2 | P1 |
| Possible | P5 | P4 | P3 | P3 | P2 | P2 |
| Unlikely | P5 | P5 | P4 | P3 | P3 | P2 |
| Rare | P5 | P5 | P5 | P4 | P3 | P3 |

| P0 | - A priority value used to manage Notification Escalation/De-Escalation via the daily validation meeting.<br>- It will also provide an audit measure on the health of the Notification Prioritisation tool. |
|---|---|

**The use of conflicting risk matrices leads to misaligned priorities, tension between teams and inconsistent action on critical issues.**

### 6.5.6. Superficial Critical Control Verification and Weak Leadership Oversight

**Objective:** Critical Control Verifications (CCVs) exist to confirm that high-risk controls are in place and effective. Effective leadership must set the expectation that all identified critical controls are verified as part of the CCV program, not just on meeting a numerical target.

**Weakness:** CS Energy has 19 CCV types defined in CGR and managed as forms in TRIM (for example, TRIM B/D/22/2164 - Operations Work Standards). Table 3 shows that by the end of May 2025, Callide had completed 508 CCVs for the 2024/2025 financial year, which was above target (Ref: TRIM B/D/25/8324 CCV Compliance FY25).

Despite this, the breakdown (Figure 30) shows the majority focused on lower risk checks like Permits to Work, which made up 44% of the total. No CCVs were done for Operations Work Standards, which include critical processes like Shift Handovers. The last CCV for shift handovers was completed in April 2022.

A contributing factor was the unrealistic CCV volume targets set to meet maintenance guarantee commitments. This prioritised a focus on quantity at the expense of quality, creating a ‘box-ticking’ culture rather than genuine risk assurance.

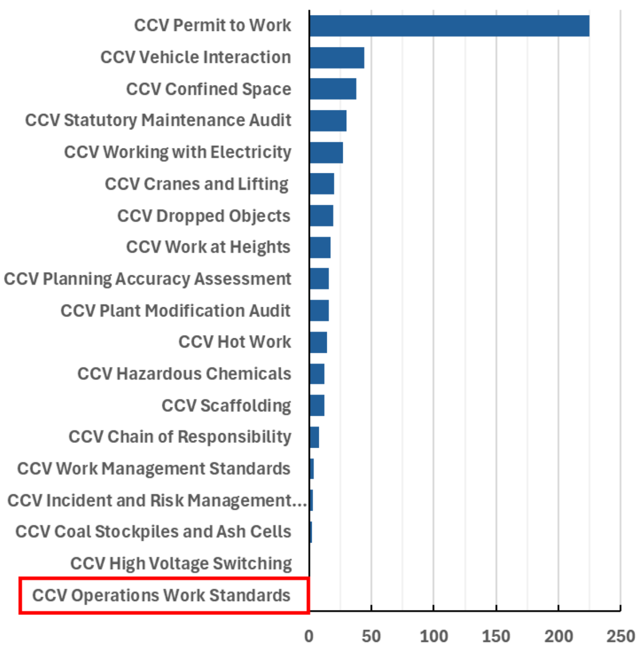
Leadership did not challenge this approach or ensure that CCVs were used to verify controls. As a result, critical safeguards were assumed rather than confirmed.

This reflects a broader leadership gap. CCVs were treated as routine compliance rather than a genuine risk assurance tool. By focusing on quantity over quality, leaders allowed critical controls to go unchecked and unverified.

**Table 3** - Callide Monthly CCV Calculations Financial Year 2024/2025

| **CCV Calculations** | | | |
|---|---|---|---|
| **Callide** | | | |
| Month | Target | Actual | % |
| Jul | 27 | 33 | 122% |
| Aug | 27 | 34 | 126% |
| Sep | 27 | 29 | 107% |
| Oct | 27 | 47 | 174% |
| Nov | 27 | 26 | 96% |
| Dec | 27 | 20 | 74% |
| Jan | 26 | 33 | 127% |
| Feb | 26 | 36 | 138% |
| Mar | 26 | 75 | 288% |
| Apr | 25 | 90 | 360% |
| May | 25 | 85 | 340% |
| Jun | 26 | 0 | 0% |
| **Total** | **316** | **508** | **161%** |

**Figure 30** - CCVs by Type Completed at Callide for Financial Year 2024/2025




**Without clear leadership accountability and a realistic, leader-driven, risk-focused CCV program, the system rewarded quantity over effectiveness, leaving key safeguards unverified when they were needed most.**

### 6.5.7. Normalisation of Process Safety Deviation

**Objective:** Unit trips and combustion upsets must be treated as potential process safety events, not just operational interruptions. The classification and reporting system should ensure these incidents are correctly risk-ranked, formally investigated and escalated where appropriate.

**Weaknesses:** Unit trips were often treated as routine and low risk rather than recognised as early warnings of serious process safety issues. Operators and supervisors described them as frequent, low-impact events, with the focus placed on quickly restarting the unit rather than investigating the underlying causes. Over time, this normalisation meant trips were viewed as just another task to reset, rather than as indicators of deeper problems.

This perception directly influenced how incidents were classified. For example, the clinker events on 20 and 21 November 2024 were both marked as Level 1 operational issues. One was recorded twice, and they were investigated using both 5 Whys and RCA, but the categorisation level was never upgraded. Neither incident triggered an ICAM or an executive review, despite internal discussions about reclassifying them. Similarly, the 1 April 2025 event was also initially treated as an operational matter and only reported on 13 April, after the major clinker incident on 4 April 2025 – a missed opportunity to intervene earlier.

**By prioritising quick return to service over root cause resolution these repeated decisions normalised unit trips and combustion instability, eroded site controls and stifled learning. Known hazards were left unaddressed, emerging risks went undetected, and process safety deviations became accepted as business as usual.**

### 6.5.8. Absence of Operator Training and Competency Governance

**Objective:** Operator training and competency must be governed under a single, centralised framework with clear standards, defined accountabilities and strong leadership oversight to ensure all qualifications and role-specific competencies are developed, verified and maintained to a consistent, reliable standard.

**Weaknesses:** Operator training and competency management lacked clear governance. No single owner was accountable for setting training standards, verifying delivery, or ensuring consistent assessment. Instead, responsibilities were fragmented: Shift Supervisors planned and signed off training at site level, Operations Training provided partial support, and the People & Culture Enterprise Training team owned the Learning Management System (LMS). This disjointed approach created critical gaps in oversight and accountability, effectively leaving Callide to assess its own performance without independent assurance.

Training records before 2019 were scattered across paper archives, TRIM files and local site folders. Only with the LMS rollout in 2019 did digital tracking begin - but even this remains incomplete:

- Only 50% of operators have full, verified training and competency documentation
- 37% have completed simulator training
- 13% have completed classroom modules but lack practical simulator experience

There was no single framework defining what competence looked like for each critical role, nor any robust system for third-party validation. The lack of a central, risk-based workforce plan and independent testing left the business exposed, with no clear line of sight to minimum standards or gaps that needed closing.

**Without centralised governance, clear standards and independent assurance, CS Energy could not verify that operators are fully competent for high-risk tasks – leaving critical gaps in frontline capability and exposing the business to preventable safety risks.**

### 6.5.9. Production-Driven Culture Undermining Safety

**Objective:** A strong safety culture must ensure that safe work practices, effective risk escalation, and early intervention are valued above production targets. Risks should be identified, openly challenged, and escalated without fear, and no production goal should override the integrity of critical risk controls.

**Weaknesses:** A persistent culture of putting production first was evident at Callide. Decisions routinely prioritised megawatts over risk management, with output treated as the overriding objective. ORAs were commonly applied as a justification tool to keep units online rather than as a safeguard to critically test operating conditions. Safety processes were often reduced to compliance exercises that enabled continued operation rather than driving risk reduction.

This mindset fostered reluctance to escalate issues, particularly when shutdowns could affect production targets. Operators felt discouraged from raising concerns for fear of blame if production was lost, which reinforced tolerance of risk.

This ingrained 'keep running' mentality normalised risk tolerance, discouraged early intervention, and shifted frontline decisions away from a precautionary safety-first mindset. Organisational priorities and KPIs further reinforced this, placing more weight on production, cost, and short-term financial performance than on asset integrity or process safety. External shareholder expectations and government policy settings added further pressure, entrenching a focus on output at the expense of long-term risk management.

**This production-first mindset meant risks were superficially managed rather than properly assessed. By normalising continued operation unless failure was certain, it discouraged early intervention, undermined risk management needed to maintain safe, reliable operations.**

### 6.5.10. Enterprise Agreement Impacts on Competency and Performance

**Objective:** The Enterprise Agreement (EA) and roster structure are intended to provide fair conditions, stable employment, and predictable shift patterns while supporting clear performance standards, accountability, and continuous workforce capability development for high-risk operations.

**Weaknesses:** Operator competency is based on formal sign-off rather than demonstrated competency in real operating conditions. This created a gap between being deemed competent and being genuinely prepared for high-risk tasks.

The EA supports a hybrid model of time-based progression and completion of basic training milestones. In practice, this has allowed operators to be signed off as competent after meeting minimum requirements without robust checks on judgement, risk management, or decision-making under pressure. Newly signed-off operators were inexperienced, requiring more support than was provided. Limited resource constraints made it difficult to provide consistent support.

Changes to the bonus structure further weakened the link between development and reward. While operators continue to receive bonuses, these are no longer tied to demonstrated capability or performance, which has eroded incentives to strive for higher standards. What was originally intended as a performance driver is now treated as a guaranteed entitlement.

This has made effective performance management difficult. The current EA does not define performance standards clearly or link progression and rewards to capability. Leaders are left without the tools or authority to address underperformance, which has contributed to a culture of tolerance for poor standards and reluctance to engage in performance-based conversations.

The two-day, two-night, six-days-off roster also undermines operational continuity, creating gaps in supervision and knowledge transfer. Extended time off between shifts means staff often return to significant operational changes, making it harder to maintain situational awareness.

Additionally, the EA includes a requirement that operator resourcing levels be set through an externally facilitated risk assessment (EA Clause 5.1.3). This has not been done, leaving the business without a clear, evidence-based view of how many operators are needed to safely and reliably staff all shifts.

The absence of clear performance standards, the decoupling of reward from capability, and time-based progression diluted accountability for maintaining competence.

**The lack of clear links between the EA obligations, operator competency, resourcing levels and performance management weakens accountability and impacts workforce development, impacting efforts to maintain safe and reliable operations.**

### 6.5.11. Significant Gaps in Overhaul Management

**Objective:** Overhaul scoping, planning and risk controls such as Operational Risk Assessments (ORAs) and Inspection and Test Plans (ITPs) must ensure all safety-critical systems are identified, addressed and verified before plant restart. This safeguards plant reliability and ensures known defects are not carried forward.

**Weaknesses:** Interviews and document reviews showed that critical maintenance and engineering issues were repeatedly raised but not fully integrated into overhaul scopes. Known defects were sometimes left unresolved for years, and jobs viewed as essential were often deferred, diluted, or incompletely done due to late changes, time pressure, or resource constraints.

Overhaul scopes were initially set with the ideal plan but then cut back significantly as planning progressed. Critical tasks were not always properly scoped or resourced, leaving gaps in execution. Issues discovered during outages were not adequately planned or resourced, resulting in either deferral or temporary fixes. This pattern meant that equipment was often patched between outages, with underlying problems persisting across multiple cycles.

A clear example was the failure to replace the Submerged Chain Conveyor (SCC) flap door during the C3 forced outage, despite a work order raised months before (12 January 2025). The missing flap was not identified in Return to Service (RTS) checks, showing a gap in execution and assurance.

Operators reported that burner maintenance and control system upgrades were sometimes only partially completed or not reflected in control room displays, which created gaps in operator awareness. In addition, basic risk controls such as ORAs and ITPs were not consistently closed out or documented. Some ORAs remained open after work was completed, and ITPs often lacked clear evidence of completion or handover.

**This weakness allowed known technical and operational vulnerabilities to persist beyond overhaul completion, undermining the intent of planned maintenance and exposing the site to preventable risks when the plant returned to service.**

### 6.5.12. Culture of Poor Psychological Safety, Blame and Risk Aversion

**Objective:** Psychological safety must underpin a workplace culture where people feel genuinely safe and expected to raise concerns, report hazards, and constructively challenge the status quo. This requires an environment free from blame, where speaking up leads to action and is valued as part of proactive risk management.

**Weaknesses:**

#### Blame and Self-Preservation Culture

A persistent blame culture has fostered self-preservation behaviours. Staff described a workplace where speaking up often leads to personal consequences, so people stay silent or ‘keep their heads down’ to avoid being singled out. This fear suppresses early warnings and drives ‘watermelon reporting’, where risks are presented as green on the surface while serious underlying issues remain unaddressed.

### Repeatedly Ignored Concerns

Concerns have been raised repeatedly without resolution, creating a strong sense of futility. Many employees described raising the same issues multiple times, only to see no action taken. This pattern has eroded trust in the reporting process and undermined the belief that speaking up makes any difference.

### Futility and Disconnect Between Reporting and Action

Many employees see reporting as generating paperwork rather than meaningful. They provided examples of how issues end up in reports but rarely translate into improvements on the ground. Weak follow-through, risk signals being softened or downgraded, and limited feedback loops have discouraged people from surfacing uncomfortable truths. Some admitted to deliberately not reporting incidents, or only reporting them after the fact, to avoid reprimand.

### Risk Aversion and Reluctance to Challenge

Fear of blame and lack of trust in follow-through discourage staff from challenging accepted ways of working - even when existing controls are clearly inadequate. This normalises the persistence of known hazards, downplays risk signals or accepts them as ‘normal' and blocks proactive improvements.

### Erosion of Ownership and Accountability

Instead of driving collective ownership to fix problems, the culture too often triggers blame-shifting and deflection. Employees pointed out that the organisation has lost sight of fundamentals - accountability is weak, people are reluctant to act, and problems are too often pushed into yet another review or handed off to external advisers rather than owned and resolved internally. This cycle has undermined operational discipline and left critical risks unaddressed.

**Low psychological safety, sustained by a deep-rooted blame culture, has normalised silence, concealed risk, and stifled learning. This prevents early escalation of issues, allows critical hazards to persist unchecked, and leaves the business exposed to repeating the same failures repeatedly.**

# 7.0 Key Findings

This section presents the nine key findings that summarise the core issues identified in the investigation. Each finding reflects a convergence of multiple failed defences, systemic gaps and contributing factors, clearly mapped in Section 7.10. These findings provide the foundation for recommendations outlined in Section 8.0.

## 7.1. Critical Risk Controls Failure

Fundamental safety systems failed to function as intended. Flame detection systems did not reliably identify flame loss, and fuel isolation was delayed. Design limitations in the furnace and combustion systems reduced the effectiveness of control responses. Testing and maintenance of flame detection and fuel isolation systems were inadequate, and earlier lessons from similar events had not been embedded. These failures reflected broader weaknesses in the management and oversight of Safety Critical Equipment.

## 7.2. Repeated Failure to Operationalise Process Safety

CS Energy repeatedly failed to embed process safety as a core operational discipline. Despite multiple improvement efforts, including the current Process Safety Improvement Program, impact to the frontline was limited due to weak ownership, fragmented governance, underdeveloped capability, and shifting priorities.

Process safety was not well understood by operators, training remains inconsistent, and safety-critical signals were often missed or rationalised. Safety Critical Equipment was not reliably identified, risk-ranked, or maintained, with key safeguards poorly integrated into daily operations. Unit trips and combustion upsets were routinely treated as operational issues rather than process safety events, leading to under-classification, weak escalation, and missed opportunities to intervene.

## 7.3. Inadequate Governance of Operator Training

CS Energy lacked a centralised, risk-based framework to govern operator and supervisor training. Roles, responsibilities, and oversight were fragmented across site teams and corporate functions, with no single point of accountability. As a result, critical frontline competencies were inconsistently developed, informally assessed, and not independently verified.

These gaps reflected a governance failure. Without clear ownership, standardised training, and external assurance, CS Energy could not reliably confirm that frontline teams were competent to manage process safety risks, exposing the business to avoidable operational failures.

## 7.4. Gaps in Operator Staffing Levels, Training and Competency Verification

Ongoing operator shortages, high reliance on overtime, and a lack of experienced staff reduced frontline effectiveness and supervision. Despite being a known issue, resourcing shortfalls were not treated as operational risks and no formal risk assessments were carried out. Training and competency frameworks were fragmented, with no structured coverage of critical tasks, such as clinker management. Operators used the Clinker Assessment Tool as a directive rather than a decision aid, resulting in ineffective deloads and missed warning signs. In addition, there was no specific training for Shift Supervisors to enable technical and leadership capability.

## 7.5. Leadership and Governance Failures to Act and Assure

Leadership did not provide effective oversight and drive meaningful assurance on process safety risks. Known issues in maintenance, operator resourcing, and clinker-related process safety hazards were not managed. Early warning signs from prior clinker events were downplayed and misclassified, bypassing executive scrutiny and missing opportunities for intervention.

Strategic misalignment, leadership instability, and fragmented organisational structures undermined risk ownership and diluted accountability. Critical control verifications focused on volume over value, leaving safeguards untested. Misaligned risk matrices across departments led to inconsistent prioritisation of safety-critical work. Shift handovers remained inconsistent despite known weaknesses.

### 7.6. Inadequate Management and Communication of Operational Changes

Operational changes lacked structured review, control and communication. Procedures, tools, Standing Orders and Operational Risk Assessments contained conflicting or outdated guidance, with no clear ownership to maintain accuracy or enforce a single source of truth. In clinker management, the operator acted on verbal instructions based on an assumed Standing Order which in fact did not exist. These weaknesses were reinforced by poor shift handovers that failed to communicate key risks such as red zone build-up.

Undocumented changes to combustion air settings and inconsistent response to changes in coal quality are additional examples of inadequate management and communication of operational changes.

### 7.7. Failure to Learn and Improve from Precursor Incidents

The organisation did not recognise and therefore respond to multiple clinker-related precursor events. Incidents in November 2024 were misclassified as low-level operational issues, bypassing a more thorough investigation and management oversight. As a result, key risks such as furnace condition, deload response and early warning signs were not addressed. A further clinker event on 1 April 2025 was not reported until after the major incident. These repeated failures showed a lack of process-safety weak signal awareness, effective incident classification, weak escalation, and poor learning from operational warnings.

Process safety events were treated as routine, and reporting culture was shaped by blame and risk aversion. Without clear accountability, structured follow-through or a culture that values learning, the organisation missed clear opportunities to prevent learning from incidents and missing the opportunity to potentially prevent this incident.

### 7.8. Production as a Priority and Weak Psychological Safety

A persistent culture of putting production first led to compromised decision-making and weakened execution of critical controls. Pressure to maintain output discouraged risk escalation, and people were reluctant to speak up or challenge unsafe conditions.

This mindset was reinforced by a blame culture - staff did not feel safe to raise concerns for fear of blame or being ignored. Reporting was widely seen as ineffective, with repeated issues ignored or reframed to avoid disruption. Known risks were tolerated, and weak signals were dismissed rather than addressed.

Leaders failed to challenge this environment or verify that critical safeguards were functioning as intended. Operational Risk Assessments became a tool to justify continued operation rather than question how safety risk could be reduced. Critical Control Verification targets were met on paper, but control effectiveness was not tested.

### 7.9. Maintenance Failures Undermine Asset Integrity

Key maintenance work was delayed, incomplete or poorly executed, allowing known defects to persist and reducing the integrity of safety-critical systems. Preventative maintenance lacked rigour. Inspection records were often generic or missing key observations, and essential checks were not consistently performed or documented.

Overhaul planning and execution were poorly managed. Critical work was deferred, scope changes not clearly defined or documented, and key risks were not addressed before Return to Service. Inspection and Test Plans (ITPs) were incomplete and known defects carried forward.

Maintenance planning and scheduling were fragmented, with siloed workflows, misaligned priorities and routine reclassification of lower-priority work to force task completion. Risk-based decision-making was undermined by inconsistent use of risk matrices and low trust in SAP master data.

## 7.10. Mapping Key Findings to Contributing Factors

The table below (Table 4) maps each key finding to its associated contributing factors. Several contributing factors appear across multiple findings, reflecting their broader impact on the incident and the interconnected nature of the underlying issues.

**Table 4** – Mapping Key Findings to Contributing Factors

| Key Finding | Mapping to Contributing Factors |
|---|---|
| 1. Critical Risk Controls Failure | 6.1.3 Flame Detectors System Failed to Promptly Identify Flame Loss<br>6.1.4 Delay in Isolation of Fuel<br>6.2.4 Inadequate Testing of Flame Detector Effectiveness<br>6.3.1 Furnace Design Limits Optimal Combustion Tuning Balance<br>6.3.8 Latent Design Flaws Delayed Flame Detection and Fuel Isolation<br>6.4.2 Inadequate Management of Safety Critical Equipment (SCE)<br>6.5.1 Failure to Learn from Previous Clinker Events |
| 2. Repeated Failure to Operationalise Process Safety | 6.4.2 Inadequate Management of Safety Critical Equipment (SCE)<br>6.5.2 Repeated Failures to Operationalise Process Safety<br>6.5.7 Normalisation of Process Safety Deviation |
| 3. Inadequate Governance of Operator Training | 6.5.8 Absence of Operator Training and Competency Governance |
| 4. Gaps in Operator Staffing Levels, Training and Competency Verification | 6.1.1 Initial Clinker Deload Ineffective<br>6.1.2 No Subsequent Clinker Deload Initiated<br>6.2.3 Over-Reliance on Clinker Assessment Tool<br>6.3.7 Inadequate Staffing and Experience on Shift<br>6.4.7 Ongoing Shortage of Operators<br>6.4.8 Lack of Formal Operator Training and Competency Verification<br>6.4.9 Lack of Formal Shift Supervisor Training and Competency Verification<br>6.5.10 Enterprise Agreement Impacts on Competency and Performance |
| 5. Leadership and Governance Failures to Act and Assure | 6.4.5 Poor Maintenance, Planning and Scheduling Management<br>6.5.1 Failure to Learn from Previous Clinker Events<br>6.5.3 Strategic Misalignment and Leadership Instability Undermine Critical Risk Control<br>6.5.4 Organisational Silos and Leadership Inaction<br>6.5.5 Misaligned and Conflicting Risk Prioritisation Systems<br>6.5.6 Superficial Critical Control Verification and Weak Leadership Oversight |

| Key Finding | Mapping to Contributing Factors |
|---|---|
| 6. Inadequate Management and Communication of Operational Changes | 6.2.1 Deload Procedure Misunderstanding<br>6.2.2 Failure to Communicate High-Risk Furnace During Shift Handover<br>6.3.3 Undocumented Combustion Air Distribution Adjustments<br>6.3.6 Indeterminate Coal Quality<br>6.4.1 Conflicting Instructions and Design Flaws in Clinker Assessment Tool<br>6.4.3 Inadequate Management and Communication of Operational Changes<br>6.4.4 Unstructured and Inconsistent Shift Handover |
| 7. Failure to Learn and Improve from Precursor Incidents | 6.5.1 Failure to Learn from Previous Clinker Events<br>6.5.3 Strategic Misalignment and Leadership Instability<br>6.5.7 Normalisation of Process Safety Deviation<br>6.5.12 Poor Psychological Safety, Culture of Blame and Risk Aversion |
| 8. Production as a Priority and Weak Psychological Safety | 6.5.6 Superficial Critical Control Verification and Weak Leadership Oversight<br>6.5.9 Production-Driven Culture Undermining Safety<br>6.5.12 Culture of Poor Psychological Safety, Blame and Risk Aversion |
| 9. Maintenance Failure Undermine Asset Integrity | 6.3.2 Failure to Maintain Boiler Components<br>6.3.4 Failure to Detect and Address Sootblower Nozzle Damage<br>6.3.5 Ineffective Hydrojets and Faulty Red Zone Monitoring<br>6.4.2 Inadequate Management of Safety Critical Equipment (SCE)<br>6.4.5 Poor Maintenance, Planning and Scheduling Management<br>6.4.6 Inadequate Preventative Maintenance Discipline<br>6.5.4 Organisational Silos and Leadership Inaction<br>6.5.5 Misaligned and Conflicting Risk Prioritisation Systems<br>6.5.11 Significant Gaps in Overhaul Management |

## 8.0 Recommendations

The following recommendations aim to address the key findings. Priority should be given to higher-order controls that follow the hierarchy of controls. Engineering and system-level solutions must take precedence over administrative measures to ensure sustainable and effective risk reduction.

### 8.1. Summary of Recommendations Mapped to Key Findings

**Table 5** - Recommendations Mapped to Key Findings

| Key Finding | Recommendations |
|---|---|
| 1. Critical Risk Controls Failure | 8.2.1 Verify Implementation of RCA Primary Immediate Actions |
| 2. Repeated Failure to Operationalise Process Safety | 8.2.2 Refocus the Process Safety Improvement Program (PSIP) to Optimise Operational Impact |
| 3. Inadequate Governance of Operator Training | 8.2.3 Strengthen Operator Training and Competency Assurance<br>8.2.4 Implement Shift Supervisor Training and Competency Standards<br>8.2.5 Establish Governance of Operational Training and Competency Oversight |
| 4. Gaps in Operator Staffing Levels and Experience | 8.2.6 Strengthen Operator Staffing Levels and Succession Management |
| 5. Leadership and Governance Failures to Act and Assure | 8.2.7 Strength Functional Integration - Operations, Engineering, Maintenance, Planning<br>8.2.8 Deliver Operational Excellence Through a Risk-Based Enterprise Plan<br>8.2.9 Align Risk Matrices Across Enterprise and SAP<br>8.2.10 Ensure Critical Control Verification Clarity and Drive Leadership Ownership |
| 6. Inadequate Management and Communication of Operational Changes | 8.2.11 Strengthen Shift Handovers to Improve Risk Visibility and Continuity<br>8.2.12 Improve Control of Operational Changes<br>8.2.13 Move the Clinker Assessment Tool to a Robust Platform<br>8.2.14 Improve Response to Variations in Coal Quality |
| 7. Failure to Learn and Improve from Precursor Incidents | 8.2.15 Develop a Health and Safety Management Framework to Drive Operational Excellence<br>8.2.16 Develop and Implement a Robust End-to-End Learning from Incidents Procedure |
| 8. Production as a Priority and Weak Psychological Safety | 8.2.17 Define and Embed a High-Performing Safety Vision<br>8.2.18 Strengthen Safety Leadership Capability to Optimise Human Reliability<br>8.2.19 Develop Psychological Safety Capability |
| 9. Maintenance Failure Undermine Asset Integrity | 8.2.20 Deliver Successful Overhauls Through Improved Scoping and Planning<br>8.2.21 Improve Maintenance Workflow Integrity<br>8.2.22 Enforce Maintenance Execution Discipline |

### 8.2. List of Recommendations

#### 8.2.1. Verify Implementation of RCA Primary Immediate Actions

The RCA identified actions required to meet Work Health and Safety Queensland (WHSQ) requirements for continued operation of C4 and RTS of C3 (Table 6). These actions have been implemented. Verify these actions effectively, address the root causes and contributing factors as intended to prevent similar incidents in future. The RCA actions are tracked in CGR Insight (Ref: CGR 3099).

**Table 6** - Return to Service and Commissioning Action – WHSQ Requirements

| Return to Service and Commissioning Immediate Actions |
|---|
| Update of operations clinker management assessment tool to be more prescriptive for effective clinker management. |
| Implement set up and calibration procedures (including discrimination testing) for flame detectors and Pulverised Fuel cut dampers. Action first on C4 and then replicate on C3. |
| Flame detection trip time to be optimised as far as possible to minimise trip time. Action first on C4 and then replicate on C3. |
| Remove blinding function on flame detectors to eliminate control masking. Action first on C4 and then replicate on C3. |
| Damper times to be reduced and all aligned on Pulverised Fuel cut dampers. Action first on C4 and then replicate on C3. |
| Update coal blending stockpile management procedure (CWP-ES-0030) to define processes for when blending is restricted or impaired. |
| Clinker formation and shedding and importance of combustion management focus areas to be communicated to all Callide C panel operators before Callide C3 unit restart. |

Effectiveness will be demonstrated through verified evidence that all corrective actions are fully implemented, operationally embedded, and performing as intended, with improved control of clinker-related process safety issues under similar conditions.

### 8.2.2. Refocus the Process Safety Improvement Program (PSIP) to Optimise Operational Impact

The Process Safety Improvement Program at Callide had been implemented with broad scope but had not led to improvements in how process safety risks are identified, managed or escalated.

Refocus the PSIP to deliver targeted, practical actions that directly improve frontline management of process safety risks. Define clear process safety indicators and build operator capability to detect and act on early warning signs. Finalise the Safety Critical Equipment (SCE) register and fully integrate it into routine operations and maintenance.

Ensure leaders are accountable for making process safety a daily operational priority while recognising the risk of initiative overload. Effective delivery depends on clear ownership and practical frontline application.

Position the PSIP as a program that helps provide practical tools to support day-to-day decisions, builds operator confidence and ensures consistent use of safety controls. The PSIP must deliver visible benefits to operations and maintenance teams, not remain solely an engineering initiative.

Success is measured by consistent execution of safety-critical tasks, timely escalation of risk, improved operator decision-making and evidence of reduced risk from process safety incidents.

### 8.2.3. Strengthen Operator Training and Competency Assurance

The operator training program did not treat clinker management as a process safety critical task. Operators relied primarily on on-the-job learning, with no formal structure to verify competence.

As the Process Safety Improvement Program identifies additional process safety critical tasks, ensure these are incorporated into the training program and regularly updated.

Establish a structured competency assurance framework that includes periodic reassessment, refresher training, targeted simulator sessions for high-risk scenarios, and independent validation where appropriate. Define clear accountability for sign-off and routine monitoring.

Assess existing operator capability to identify gaps and deliver targeted training for critical scenarios such as clinker management, furnace instability and emergency procedures.

The program should go beyond compliance by supporting a learning culture and building deep technical understanding, enabling operators to apply required standards and controls with consistency and discipline.

Indicators of effective implementation include a comprehensive competency framework which focuses on process safety critical tasks, with operators consistently demonstrating capability in managing defined scenarios.

#### 8.2.4. Implement Shift Supervisor Training and Competency Standards

There was no structured training program for shift supervisors that built both technical and leadership capability. In its absence, the business relied on individual experience and informal knowledge transfer, resulting in inconsistent leadership at the frontline.

Define clear expectations for the shift supervisor role, including technical competence, process safety responsibilities, leadership behaviours, team development and performance management. Develop targeted training aligned to these expectations to build consistent capability.

Update the Role and Purpose Statement to reflect the defined standards, training requirements and competency expectations. Establish a structured assessment process to verify capability before appointment and through ongoing performance reviews.

Effective implementation will be evident when shift supervisors have clear and consistent understanding of their responsibilities and demonstrate the ability to lead teams confidently and effectively in dynamic environments.

#### 8.2.5. Establish Governance of Operational Training and Competency Oversight

There was no formal governance model in place for operational training and competency. Without access to accurate, up-to-date competency records, the business did not have oversight and was exposed to legal, safety and operational risk.

Establish a governance framework with defined roles, responsibilities and reporting lines for overseeing training and competency management. Work with site teams to ensure training records are centralised, securely maintained, consistently updated and accessible to relevant leaders.

Ensure governance includes routine compliance reviews, escalation pathways for training and competency gaps, and regular reporting to senior leadership. Assign clear ownership for sign-off, audit and independent assurance of training effectiveness.

When effectively implemented, leaders will have clear visibility of workforce training and competency records, governance will drive accountability and risk control, and the business will be protected from compliance failures and undue exposure.

#### 8.2.6. Strengthen Operator Staffing Levels and Succession Management

Callide had experienced an ongoing operator shortage, leading to understaffed shifts, heavy reliance on overtime and trainees, and senior operators and shift supervisors being pulled into multiple roles, limiting their ability to support and train other operators or trainees.

Conduct a risk-based review of operator numbers, as required under Enterprise Agreement clause 5.1.3 (2) and (3), to establish the staffing levels needed per shift to maintain safe and reliable operations.

Recruit additional operators to meet baseline requirements, reduce overreliance on overtime, trainees or newly signed-off staff and enable senior operators and shift supervisors to provide the required support and training especially during critical activities.

Align roster planning with these staffing levels to ensure each shift has the right mix of experienced and developing operators in place. Actively manage rosters to maintain this balance, monitor overtime use and avoid heavy reliance on trainees, keeping experience mix as a key operational risk control.

In parallel, establish a robust succession plan to develop and maintain a pipeline of skilled operators and future supervisors. The plan should identify critical roles, define competency requirements, map internal candidates and provide targeted development, hands-on experience and formal assessments. Integrate succession planning with broader workforce planning and rostering to ensure continuity.

Effective implementation will be evident through consistent shift coverage with the right skill mix, reduced reliance on overtime and trainees, visible succession pipelines, and improved operational stability and resilience in managing critical scenarios.

### 8.2.7. Strengthen Functional Integration - Operations, Engineering, Maintenance, Planning

There was a disconnect between critical functions, resulting in delayed maintenance, limited engineering input into operations, poor scheduling, poor overhauls and critical work missed or deprioritised.

Define clear roles, responsibilities and reporting lines for Operations, Engineering, Maintenance and Planning, supported by shared functional KPIs and aligned individual performance expectations.

Ensure onsite engineers are embedded to support immediate operational needs, while technical teams focus on medium and long-term asset strategy including overhauls and outages.

Embed integrated planning processes, shared accountability and formal feedback loops to support risk-based prioritisation, execution and continuous improvement.

When implemented effectively, all functions will operate as one team with clear accountabilities, aligned planning and full visibility of critical work, leading to consistent delivery of high-priority tasks, improved overhaul outcomes and safer, more reliable plant operation.

### 8.2.8. Deliver Operational Excellence Through a Risk-Based Enterprise Plan

CS Energy was managing a high volume of disconnected and competing initiatives, resulting in noise, initiative fatigue and reduced ability to deliver meaningful, coordinated impact at the frontline.

Develop and implement a single, enterprise-level strategic plan that defines the critical few objectives required to achieve safe, reliable and efficient operations.

All functional strategies and improvement plans should align to this enterprise plan, with a clear line of sight from board priorities to frontline execution. Conduct a structured review of existing programs and action registers to eliminate duplication, low-value activity and misaligned efforts.

Strengthen governance to ensure all new initiatives are tested through a consistent risk lens, prioritised by operational impact, and subject to senior-level challenge.

Define and cascade clear KPIs aligned to enterprise objectives, with regular reporting to track progress, manage performance and reinforce accountability.

Indicators of success include a clear strategic focus on critical risk, aligned leadership, coordinated functional delivery and frontline teams achieve safer, more reliable performance through clear priorities and better resourcing.

### 8.2.9. Align Risk Matrices Across Enterprise and SAP

Different functions used inconsistent risk matrices, definitions and language, leading to misaligned priorities, confusion and conflicting decisions, particularly across planning, maintenance and engineering.

Align all risk matrices to the Enterprise Risk Management (ERM) Matrix as the single source of truth for assessing and communicating risk. This includes updating the SAP Risk Matrix, which is currently out of step, to ensure consistent risk ratings, definitions and priorities across all operational areas.

Support this alignment with clear guidance, practical training and visible leadership to build a shared understanding and reinforce consistent day-to-day decision making. Define clear ownership for governance, maintenance and periodic review of all risk matrices.

The ERM matrix should also be updated to explicitly incorporate psychological safety as a core risk category, alongside operational and process safety.

The intent is to ensure all functions use a common risk language, decisions are clearly prioritised and understood across teams, conflicting assessments are eliminated, and critical risks are escalated and addressed consistently and without delay.

### 8.2.10. Ensure Critical Control Verification Clarity and Drive Leadership Ownership

Critical Control Verifications (CCVs) were often treated as a box-ticking exercise instead of being used as critical, active risk control.

The business should clearly define what a critical control is and ensure a common understanding of the term and separate CCVs from Critical Control Audits (CCAs), Safety Interactions (SIs), verification of Safety Critical Equipment (SCE) to ensure clarity, define expectations and hold people accountable. CCVs should cover both SCEs and non-physical critical controls to verify that all key risk barriers perform as required.

Each critical control should have two levels of verification:

1. **Frontline Critical Control Verification (CCVs):** A practical check in the field, carried out by any qualified person to confirm that controls are working at the point of task. These checks should be used to drive safe behaviours, support active safety leadership and serve as an early warning for emerging risks or improvement opportunities.

2. **Critical Control Audit (CCA):** A deeper, more structured review conducted by the Critical Control Owner or senior leader. CCAs look at the effectiveness of controls over time, check for signs of erosion and use clusters of CCV results to find trends, underlying causes and opportunities for stronger prevention. CCAs should be detailed enough to build confidence that critical controls will hold when needed.

All CCVs should have clear owners to make sure every required verification is done, not just the convenient ones. CCVs and CCAs should be used as real opportunities for leaders and supervisors to engage with teams, reinforce standards and build accountability through practical safety interactions.

Leaders should be trained to complete effective CCVs and CCAs, know when to escalate issues and use results to drive learning and corrective actions. CCVs and CCAs should be built into daily operations, performance reviews and leadership KPIs to keep ownership visible and consistent.

By clearly defining CCVs and CCAs, covering all critical controls, assigning clear ownership and using insights to strengthen leadership accountability and early risk detection, the business will protect the integrity of its risk controls and embed stronger operational discipline.

#### 8.2.11. Strengthen Shift Handovers to Improve Risk Visibility and Continuity

Shift handovers were inconsistently executed and poorly governed, often omitting critical risk information despite being classified as a critical control. This weakened operational continuity, reduced risk visibility and increased the likelihood of missed or repeated issues across shifts.

Establish shift handover as a critical operational control, with standardised content and accountable ownership for delivery and quality.

CS Energy's Improvement Blitz 4, launched in March 2025, included a review of shift handover processes. Confirm that the Blitz scope includes a comprehensive review and update of the Shift Handover CCV – Operations Work Standards, with a focus on consistent content, defined roles and responsibilities and clear governance.

Minimum handover requirements should include plant status, abnormal conditions, isolation status, red zones, outstanding work permits, incomplete tasks, active Standing Orders, Operational Risk Assessments (ORAs), safety-critical issues and required escalations.

Ensure structured training, practical templates, peer checks and visible supervisor reinforcement to embed discipline and consistency at the shift level.

Effective shift handovers will ensure accurate transfer of accurate risk information between shifts, stronger operational continuity and reduced recurrence of missed or unresolved issues in high-risk conditions.

#### 8.2.12. Improve Control of Management of Operational Changes

Uncoordinated and undocumented operational changes caused confusion, inconsistent practices and poor situational awareness. Changes to combustion tuning, standing orders and other instructions were often shared informally by email, meeting notes or verbal directions, with little tracking or oversight.

Implement a centralised process to manage all operational changes. Define clear triggers for when a change is required, who reviews and approves it, and how it is formally recorded. All changes should be documented, time-stamped and logged in one location that is accessible for reference and audit.

Assign clear accountability for reviewing, approving and distributing changes. Ensure all updates are communicated with plain language that explains what changed, why it changed, what it impacts and what actions are required. Feed changes directly into shift handovers, pre-start meetings and other operational communication channels.

Require supervisors to confirm that critical changes have been briefed and understood. Build in regular checks to ensure changes are applied as intended and conflicting or outdated instructions are closed out.

A clear process with strong governance and simple communication will improve control of operational changes, strengthen situational awareness and support safe, reliable operations.

### 8.2.13. Move the Clinker Assessment Tool to a Robust Platform

The Clinker Risk Assessment Tool was built in Excel, which left it exposed to errors, uncontrolled inputs and inconsistent use. Operators are the last line of defence, so the tools they rely on must be clear, reliable and easy to use under pressure.

Replace the current spreadsheet with a secure, fit-for-purpose platform that controls data entry, uses clear guidance prompts and has built-in logic to flag errors or missing information. The tool should be intuitive and accessible, with clear instructions so that operators can complete assessments quickly and accurately every time.

Where possible, automate the population of inputs by linking to live plant data to reduce manual entry, improve accuracy and minimise cognitive load during dynamic situations.

Ensure the platform can capture and track risk data in real time, support version control and make audit trails clear so there is integrity in how clinker risks are identified and acted on.

A robust, human-centric tool will strengthen risk visibility, reduce the chance of error, and help operators make sound decisions.

### 8.2.14. Improve Response to Variations in Coal Quality

Coal quality directly affects combustion stability, clinker formation and boiler performance. Operators had limited real-time visibility of coal quality and lacked clear guidance on how to adjust operations when quality varied.

Develop a clear process to monitor, communicate and respond to variations in coal quality. Ensure coal quality data is reliable, up to date and easily accessible to operators when reclaiming from stockpiles.

Establish clear roles and accountabilities for who monitors coal quality and how changes are communicated across shifts. Include these requirements in shift handovers and standing orders to ensure any actions are consistently applied and understood.

A structured response plan with clear controls, reliable data and consistent communication will help operators to manage variable or unknown quality proactively, reduce clinker formation and maintain safe, efficient operations even when coal quality fluctuates.

### 8.2.15. Develop a Health and Safety Management Framework to Drive Operational Excellence

CS Energy did not have an integrated Health and Safety Management Framework. Instead, it relied on a health and safety handbook that provided high level information and broad guidelines.

Develop and implement a robust Health and Safety Management framework that drives operational excellence by setting out how health and safety risks are identified, managed and continuously improved. This includes personal, process and psychological safety.

The framework should define how all functions, disciplines and risk controls fit together in a single, integrated system that supports safe, reliable and consistent operations across all sites.

Define key elements within the framework that reflect CS Energy's critical operational risks and priorities. For each element set objectives, standards, roles and responsibilities and ownership so expectations are clear, transparent and enable accountability governance.

Conduct a structured gap analysis to identify where current systems and practices meet requirements, where gaps exist, and where overlaps or inefficiencies can be removed. Prioritise improvements based on risk exposure and operational impact to focus effort where it matters most.

Establishing this framework will help embed strong leadership accountability, drive disciplined execution and provide greater assurance that health and safety risks are controlled - reducing the likelihood of repeat incidents.

### 8.2.16. Develop and Implement a Robust End-to-End Learning from Incidents Procedure

CS Energy's Learning from Incidents (LFI) procedure was weak, lacked rigour and did not reflect a critical safety risk approach. It was discretionary, poorly structured and failed to embed process safety principles, resulting in precursor events often being treated as routine operational issues. There was no process in place to embed lessons learned.

Ensure existing incident data is reviewed to confirm accuracy and integrity, and identify any misclassified or missed events, particularly those involving process safety. Assign clear ownership for data integrity to ensure ongoing reliability.

Develop an end-to-end procedure that sets out clear roles, responsibilities, steps and timeframes, supported by simple templates and tools that make it practical to use on site.

Establish a central control point to review, triage and categorise all reported events, ensuring the appropriate level of investigation and management oversight.

Embed the procedure into broader business systems through management of change, targeted training for operational teams, and routine quality checks to confirm consistent use.

Lessons learned should be formally documented, communicated and translated into tangible actions. These actions should be tracked through to completion and verified locally to ensure changes are understood, adopted and sustained in practice.

Define lead and lag metrics to track reporting, investigation quality, closure and learning transfer. Use trend reporting to highlight repeat risks and guide decision-making at both site and enterprise levels.

A clear, embedded Learning from Incidents procedure with strong governance, reliable data and consistent follow-through will strengthen organisational learning, improve risk visibility and reduce the likelihood of repeat events.

### 8.2.17. Define and Embed a High-Performing Safety Vision

The culture often prioritised production over safe execution, leading to rushed decisions, weak handovers and shortcuts that reduced safety to a tick-the-box exercise rather than a true core value.

Develop and embed a clear, practical vision for safety that defines what good looks like and sets clear measures and behaviours for everyone. The vision should describe a workplace culture that prioritises safe execution, critical risk, encourages people to speak up, supports a blame-free environment and promotes visible, genuine leadership commitment and psychological safety at all levels.

**Key Activities:**

1. **Develop a Safety Vision in Collaboration with Key Stakeholders**
   Co-create the safety vision with frontline teams, leaders and site-based stakeholders to ensure it is grounded, relevant and owned by those who need to live it. The vision should describe what good looks like across all levels - characterised by open communication, trust, accountability for critical controls and a culture of continuous learning.

2. **Develop Leaders to Champion and Reinforce the Vision**
   Equip leaders to communicate the vision authentically and consistently. Provide practical tools to help them reinforce expectations, model safe behaviours and hold teams accountable.

3. **Define and Cascade Clear Behaviours and Measures**
   Translate the vision into clear, observable behaviours for each level. Develop lead and lag indicators to track visible safety leadership. Embed these into regular practices and reporting.

4. **Align Vision and Measures to Functional Strategies**
   Ensure functional and site plans clearly link to the safety vision and define how each area supports and tracks cultural goals.

10. **Conduct Integrated Safety Culture Diagnostics**
    Conduct safety culture diagnoses every 12 to 18 months to provide a baseline to measure change and initiative impact. This should evaluate perceptions and inter-dependency with health and safety systems and assets through surveys, interviews and field checks.

A clear, embedded safety vision with strong leadership, clear behaviours and visible measures will make safe execution part of daily work, helping teams own safety because they choose to, not because they have to.

### 8.2.18. Strengthen Safety Leadership Capability to Optimise Human Reliability

CS Energy lacked a clear, consistent standard for safety leadership, which undermined human reliability, increased the risk of human error and resulted in inconsistent oversight of critical risks. Without defined and embedded expectations, safety leadership is driven by individual discretion rather than embedded as a systematic organisational practice.

Identify key safety leadership behaviours for each level of the organisation and map them to typical daily and shift routines for critical roles. Integrate these behaviours into Role Purpose Statements, performance management, and site leadership routines to ensure a consistent, systematised approach. Safety leadership must be treated as a core responsibility, not left to individual style or preference.

Develop targeted capability programs that equip leaders with the skills to lead risk conversations, challenge unsafe behaviours and visibly model the standards expected of others.

By defining and embedding safety leadership expectations, CS Energy will strengthen its ability to manage operational risk, reduce human error and build a culture where safe execution is led with clarity, consistency and credibility.

### 8.2.19. Develop Psychological Safety Capability

A culture of blame discouraged employees from speaking up, reporting concerns, or challenging decisions. This reduced the organisation's ability to detect emerging risks, undermined learning from incidents, and limited proactive safety management. In addition, the business had not met its obligations under WHS Regulation 55D related to psychosocial risk.

Undertake a formal psychosocial risk assessment to ensure compliance with WHS Regulation 55D. This includes identifying stressors, organisational factors and cultural barriers that undermine trust, risk reporting and open discussion.

Build leadership capability to foster psychological safety. Respond constructively to concerns, bad news or raised issues, recognising these as valuable signals for learning rather than reasons for blame. Include targeted training to recognise early signs of low psychological safety and take timely, appropriate action.

Set clear expectations for team behaviour. Reinforce that all employees are encouraged to raise issues, challenge assumptions and contribute to ideas for improvement. Support this through visible leadership, open forums, and consistent follow-through and feedback on raised concerns.

Success will be measured by increased hazard and near miss reporting, early escalation of concerns or psychological safety issues, and improved workforce engagement. These outcomes will support a shift to a blame-free culture and help embed a safety vision where speaking up is expected, valued, and acted on.

### 8.2.20. Deliver Successful Overhauls Through Improved Scoping and Planning

The ability to deliver safe, effective overhauls had been compromised by short-term pressures, incomplete planning, and reactive decision-making. Critical work scopes were frequently undefined, diluted, or deferred, limiting the organisation's ability to address key risks and sustain plant performance.

To strengthen overhaul outcomes, scoping and planning must be treated as a proactive risk control, not just an administrative process. Apply the Overhaul Management Framework (OMF) thoroughly, using the master scope as a baseline only. Do not assume existing records are complete. Validate against maintenance histories, outstanding inspections, test reports, and undocumented items that may be buried in emails or informal communication.

Engage all relevant stakeholders early to ensure critical scope is identified, reviewed, and confirmed. If any work is proposed for removal from scope, it must be formally assessed for risk and reassigned to preventative or corrective maintenance to prevent unmanaged deferral.

Establish a rolling medium- and long-term planning process that defines priorities and identifies critical scope well ahead of each outage. Integrate this planning across engineering, operations, and asset management to ensure alignment and a shared focus on safety and risk.

A successful overhaul is marked by zero safety incidents, full scope delivery, on-time Return To Service (RTS), and on-budget execution. Quality is reflected in minimal rework, full documentation, regulatory compliance, and completion of Inspection and Test Plans (ITPs). Importantly, lessons learned must be captured throughout and applied to future planning to reduce risk, improve reliability, and strengthen performance over time.

### 8.2.21. Improve Maintenance Workflow Integrity

The maintenance workflow process was fragmented. Notifications were sometimes downgraded, deferred or missed altogether, leaving known safety-critical risks unaddressed. There was also limited tracking, verification and oversight to ensure maintenance work was completed as planned and escalated when it is not.

Establish a structured, risk-driven maintenance workflow that clearly connects notifications, risk ranking, planning, scheduling, execution, close-out and feedback. Assign clear roles and responsibilities at each stage and ensure safety-critical work is visible, prioritised and protected from unplanned deferrals or scope changes, especially during major outages or overhauls.

Strengthen governance by requiring formal tracking and field verification of completed work. Build in routine checks and oversight to confirm that maintenance activities are fully executed and that gaps are identified and addressed promptly. Improve SAP data quality and master data to reduce reliance on generating work orders from scratch and ensure maintenance plans are consistent and reliable.

A disciplined, risk-based maintenance workflow with clear tracking, field verification, and oversight ensures safety gaps are closed, critical work is completed, risks are controlled, and plant reliability is strengthened.

### 8.2.22. Enforce Maintenance Execution Discipline

Maintenance practices lacked rigour and discipline to consistently identify equipment degradation and ensure changes were properly executed and verified as complete. Inconsistent inspections, poor documentation, and weak follow-through resulted in safety-critical issues being missed or left unresolved.

Lift the standard of maintenance discipline by improving inspection quality, enforcing complete and accurate record-keeping, and requiring engineering oversight for all safety-critical equipment changes. This includes ensuring maintenance of boiler burner components, the integrity of Management of Change, with clear assessment and verification processes to ensure equipment integrity and performance standards are met.

A more disciplined maintenance approach will reduce the risk of undetected faults, improve equipment reliability, support successful overhauls, ensure safety-critical work is effectively executed and field verified prior to work orders are closed.

# 9.0 Next Steps and Conclusion

The C3 clinker incident was a high-risk event that exposed significant weaknesses in CS Energy's technical controls, operational systems, and leadership oversight. While immediate engineering improvements are being actioned, the investigation found that many of the underlying conditions that enabled the incident to remain present. These include unclear accountability across functions, inconsistent application of risk processes, gaps in operator competency, maintenance discipline, and a safety culture that has not been fully embedded.

CS Energy has demonstrated a constructive and transparent response to this investigation. Leaders and staff actively contributed to the review, supported open conversations, and began implementing immediate corrective actions before the final report was completed. This sets a strong foundation for change.

However, ensuring operational safety and integrity will require more than technical fixes. It will require strong executive leadership, aligned strategic priorities which aim to deliver operational impact, commitment to address the systemic and cultural gaps identified and governance to track, close out and verify the close out and effectiveness of actions.

The recommendations provided in this report focus on critical safety risk-based decision-making, functional integration, improved operator staffing and training and a culture of safe execution and psychological safety.

Recommended next steps:

- Review the recommendations in this report and develop a structured action plan that addresses both the contributing and systemic factors identified.
- Engage all key stakeholders in the development and validation of the plan to ensure shared ownership and accountability.
- Define clear completion criteria for each action that confirm the recommendation's intent has been met, not just the task completed.
- Assign clear responsibility for implementation and establish governance mechanisms to track delivery, unblock issues, and provide assurance to executive and board-level sponsors.
- Monitor progress through regular reviews and ensure that implementation remains focused on outcomes, not just activity.

To prevent recurrence and build long-term resilience, CS Energy must now shift from a reactive response to sustained operational discipline and leadership alignment. This will require continued attention from both the Executive and the Board to ensure safety remains a non-negotiable value across all levels of the business.

# 10.0 Appendices

## Appendix 1 - Global Weave Model®

## Appendix 2 - Data Gathering PEEPO

# A1 Global Weave Model®

The Global Weave Model®, developed by The Jonah Group in 2010, is a diagnostic tool used to manage major hazard risks by strengthening both technical and non-technical controls. It supports high-reliability operations by helping organisations prevent catastrophic events through a focus on systemic conditions.

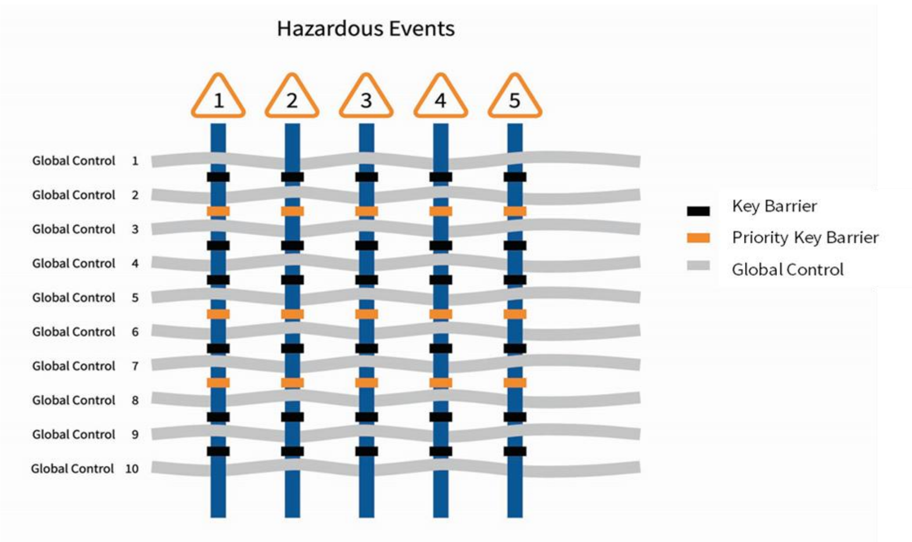
The model recognises that while engineering controls are essential, their reliability depends on the organisational context that surrounds them. Systems, behaviours, and governance can either support or erode these critical barriers.

Used in investigations and proactive risk reviews, the model goes beyond identifying what failed to uncover why the failure occurred. It examines leadership, culture, decision-making, and system integrity as they relate to safety-critical performance.

Applied across high-hazard industries including oil, gas, mining, chemicals, and explosives, the Global Weave® Model offers a structured way to identify and address systemic weaknesses using a critical risk lens (See Figure 31).

- The **vertical blue lines** represent major hazards, potential catastrophic or fatal events.
- The **black and orange rectangles** indicate technical controls such as flame detectors, interlocks, fuel trip systems and pressure relief values.
- **Grey waves** represent non-technical controls known as Global Controls which weave across all hazards. These include operating model, leadership, culture, procedures, training.

**Figure 31** - The Jonah Group's Global Weave® Model




This model is based on several leading practices, including alignment with the Energy Institute Process Safety Framework. By combining technical and organisational insights, the model helps organisations focus improvement efforts where they matter most: reinforcing the controls that protect people, plant, and environment.

Eighteen key global controls or organisational factors are identified (Table 7)

**Table 7** - Global Controls

| # | Global Control | Description |
|---|---|---|
| 1 | Operating Model: Structure, Accountability & Resources | Clear structures, defined roles, and accountable governance ensure the right people, tools, and systems are in place to manage risk effectively. |

| | | |
|---|---|---|
| 2 | Organisational Priority & Senior Safety Leadership | Senior leaders model safety as a core value, making risk-based decisions and holding themselves and others accountable for performance. |
| 3 | HSE Management System – Centralised & Disciplined | A single source of truth, practical system sets expectations, language, and processes, reinforced through training, access, and governance. |
| 4 | Data Analysis and Safety Metrics | Balanced safety metrics enable trend analysis, decision-making, and learning across all levels, supported by clear dashboards and follow-up. |
| 5 | Reporting, Tracking, Investigation & Close Out | Reporting systems define expectations for incident classification, investigation, action tracking, and verification of close-out. |
| 6 | Process Safety Competence & Risk Management | Role-specific safety competencies are trained, assessed, and verified, with site-level accountability for delivery and oversight. |
| 7 | Asset Integrity – Safety Critical Equipment | Safety-critical assets are identified and maintained through risk-based programs, with strong controls for failure detection and response. |
| 8 | General Asset Maintenance | Defined maintenance activities are executed by qualified staff, with backlogs, trends, and completions monitored for reliability. |
| 9 | Critical Process Safety Documentation | Key documents must be accurate, controlled, and accessible. Failures to access or inaccuracies, are treated as safety events. |
| 10 | Operating No-Go Zones | Safe operating limits are defined and enforced below critical thresholds, with breaches treated as reportable incidents. |
| 11 | Management of Change – Physical | All physical changes undergo a formal MoC process with risk assessment, SME sign-off, and review after implementation. |
| 12 | Management of Change – Non-Physical | Organisational and procedural changes are risk-assessed, clearly communicated, and monitored for unintended consequences. |
| 13 | Safety Culture, Human Factors & Intervention | A culture of speaking up is reinforced through training and leadership, with no penalties for stopping work or raising concerns. |
| 14 | Weak Signal Awareness & Reporting | Operators must identify and report early risk signals, with systems in place to differentiate personal and process safety. |
| 15 | Operational Beliefs & Behaviour | Ownership, fairness, and trust are core to culture, supporting learning and shared responsibility for safety outcomes. |
| 16 | Fascination with Failure & Risk Management | Critical risk lens applied, failures are actively studied, with a bias for higher-order risk controls and focus on worst-case scenario planning. |
| 17 | Risk Competence & Respect for Standards | Operators consistently apply safety standards and conduct risk assessments, supported by strong training and reinforcement. |
| 18 | Operational Safety Leadership | Site leaders lead by example, are visible in the field, and build trust through consistent, values-driven safety leadership. |

# A2 Data Gathering PEEPO

## A2.1 People

The personnel associated with the incident and/or activities and processes impacting on the incident occurring on 4 April 2025 were interviewed. The number of people interviewed by department are listed in Table 8.

**Table 8** - Number of people interviewed by role

| Department/Team | Number interviewed |
|---|---|
| Engineering | 15 |
| HSE | 3 |
| Management | 14 |
| Maintenance | 5 |
| Operations | 24 |
| Process Safety | 3 |
| Training | 4 |
| Union delegates/Reps | 6 |
| Total | 74 |

## A2.2 Environment

The following environmental conditions at the time of the C3 clinker incident on 4 April 2025 played a role in contributing to the event:

- Wet Weather Leading to Coal Stockpile Issues
- Recent rainfall had saturated sections of the coal stockpile.
- Operators were forced to reclaim coal from specific areas of the stockpile to find drier coal suitable for combustion.

This reduced flexibility for coal blending, as only limited sections of the pile were usable, leading to feed inconsistencies.

**Impaired Coal Blending and Quality Control**

Because of the wet conditions, around 58 percent of the coal fed into the unit came from a reclaimed stockpile that was not analysed or blended.

Low bunker levels (around 30%) meant that homogenisation of the coal feed was poor, increasing the risk of introducing poor-quality or high-iron-content coal into the boiler.

These pockets of unblended, potentially high-clinker-producing coal are a likely contributor to the large clinker formation.

**High Load Operation**

The plant had been operating at or near maximum load almost continuously in 2025, with only one week of reprieve.

Higher boiler loads are directly associated with increased clinker formation due to higher combustion intensity and greater ash fusion risks.

## A2.3 Equipment

The following equipment is relevant to the investigation:

**Flame Detectors**

Flame detectors are responsible for identifying flame loss and initiating fuel trip logic. During the incident, calibration and configuration issues delayed detection, allowing fuel to continue flowing after flameout.

**C3 Boiler**

The C3 boiler is a high-pressure steam generator with a design pressure of 8.7 kPa. It is configured for coal-fired operation and features upper and lower furnace zones where ash and clinker can accumulate. The boiler's geometry and fuel characteristics require active clinker management and effective cleaning systems to maintain safe operation.

**Mill Group Trip (MGT)**

The Mill Group Trip is a safety interlock designed to isolate fuel supply to a group of burners associated with a single mill when flame loss is detected. The system includes a time delay function intended to avoid false trips and is integrated with the flame detection and combustion control systems.

**Master Fuel Trip (MFT)**

The Master Fuel Trip is a safety interlock designed to isolate all fuel supply to the furnace when flame loss is detected. The system includes a time delay function intended to avoid false trips and is integrated with the flame detection and combustion control systems.

**Sootblowers**

Sootblowers are mechanical devices that remove ash deposits from boiler surfaces using high-pressure steam or air. They consist of a lance or rotating arm with a nozzle that targets heat transfer areas to prevent clinker buildup. The system includes multiple sootblowers across different furnace levels and is monitored through control room interfaces.

**Hydrojets**

Hydrojets are water-based cleaning systems designed to remove larger clinkers from furnace walls. They operate through high-pressure water jets aimed at strategic furnace locations and are activated via control systems accessible to operators during shifts.

**Hydrojet Panel**

The hydrojet panel is the operator interface for monitoring and controlling hydrojet functionality. It displays real-time system status, including which jets are operational, in fault, or offline, and enables local or remote activation. The Hydrojet Panel also includes thermocouples that measure heat loss on the wall of the furnace, indicating Red Zones of clinker buildup.

**Submerged Chain Conveyor (SCC)**

The SCC is located beneath the boiler and is designed to collect ash and clinker that fall from the furnace. It transports this material via a water bath to reduce dust and manage heat before disposal. The system is a key part of the boiler's ash handling infrastructure.

**Fuel Jets and Dampers**

Fuel jets and dampers regulate the flow of pulverised coal into the burners. The dampers adjust the volume and distribution of coal-air mixture to support stable combustion. These components are integrated with the burner management and fuel delivery systems.

### A2.4 Procedures

The CS Energy processes and procedures relating to the pressure excursion event were reviewed to establish any aspects that may have contributed to the incident. The documents reviewed are listed in Table 9.

**Table 9** - Documents Reviewed

| Area | Procedure |
|---|---|
| Operations | Panel Screen Shots<br>Clinker Management Procedure<br>Clinker Assessment Tool and Guidance<br>Clinker Deload Instructions<br>Flame Scanner Calibration and Functional Testing Procedure<br>Master Fuel Trip (MFT) Logic and Protection Settings<br>Sootblower and Hydrojets Operating Instructions<br>Shift Handover Logs and Protocols<br>Shift Roster and Leave<br>Operational Risk Assessments<br>Standard Operating Procedures<br>Safety Critical Equipment List<br>Critical Control Verifications |
| Training | Operator and Trainer Competency Framework and Checklists<br>Operator Training Modules and Assessment Checklists<br>Simulator Training Checklists<br>Operator Qualifications and Training Log<br>LMS and TRIM training records |
| Maintenance | Work Orders & Maintenance Logs (12–24 months)<br>Preventive Maintenance (PM) Task List<br>Maintenance Backlog Reports<br>Reactive vs. Proactive Maintenance Ratios<br>Safety Critical Equipment List<br>Critical Control Verifications<br>Reliability Reports / RCAs<br>Shift Logs (last 3–6 months)<br>Operator Rounds / Daily Checks<br>Fault Reporting Logs / Notifications<br>Maintenance Strategy Document<br>Asset Integrity Policy / Governance Framework |
| Engineering | C3 Clinker Incident Root Cause Analysis Report<br>Overhaul and Outage Scopes and RTS reports<br>Inspection Technical Reports<br>Return to Service Logs |
| Corporate | Past External Reports – Morrison, Advisian, IAG<br>Role and Purpose Statements<br>Performance management procedures – EA and Non-EA<br>Organisation Charts<br>Minutes of Meeting between trading and Callide<br>Management of Change Procedure and triggers |

| Area | Procedure |
|---|---|
| | Jonah Group Leadership Retention and Engagement Board Paper and Interview Notes. |
| Safety | Learning from Incident Procedures<br>Safety Management Handbook<br>Incident definitions and classification<br>Jonah Group Cat 3/4 Incident Investigation Assurance Report<br>Jonah Group Overhaul Safety data and trend report<br>CS Energy Safety data and trend reports<br>Incident reports for pre-cursor events and investigation reports<br>Operational Risk Assessments |
| Coal Management | Coal Blending Guidelines and Operating Procedures<br>Coal Quality Sampling and Testing Procedures<br>Coal Stockpile Management Procedures<br>Slot Bunker Level Logs and Feed Records |

### A2.5 Organisation Systems

The relevant organisational systems and processes impacted at the time of the incident are included in the following:

**Clinker Management**

The investigation reviewed CS Energy's clinker management systems, including the Clinker Assessment Tool, associated procedures, and deload guidance. Historical records of how deloads were applied in response to clinker risk were also examined. These systems govern how clinker-related risks are monitored, interpreted, and actioned in operations.

**Safety Management**

Documentation reviewed included CS Energy's Health and Safety Handbook, and the classification framework used to categorise events. These documents outline the structure and expectations for how safety is managed, reported, and managed across the business.

**Process Safety Improvement Program**

CS Energy had a three-year Process Safety Improvement Program (PSIP) in place, which was reviewed as part of the investigation. The evaluation focused on key elements of the plan, including initiatives to strengthen weak signal awareness, build process safety competency, improve incident reporting, define and implement performance standards, and apply bow tie analysis to Major Incident Hazards.

**Critical Control Risk Management**

Critical controls associated with combustion and pressure excursion were reviewed, including risk bow ties, control documentation, and monitoring practices. The investigation looked at how well these controls were defined, understood by frontline teams, and tracked over time for performance. In general CS Energy has two types of critical controls, Safety Critical Equipment (SCEs) and critical tasks & systems (e.g. Permit to Work).

**Maintenance and Asset Management**

A range of asset and maintenance management data was examined, including preventive and corrective maintenance schedules, work orders, fault logs, and backlog reports. Operating instructions and performance records for sootblowers and hydrojets were included, alongside asset governance documents that define safety-critical systems and maintenance prioritisation.

**Shift Management and Handover**

Shift rosters, allocation records, and handover protocols were reviewed to understand how operational knowledge is transferred across shifts. The review also looked at plant monitoring tools and documentation guiding stability during load changes and abnormal conditions.

**Training and Competency**

The investigation reviewed training records, competency frameworks, and qualification logs for operators and engineers. Training modules, simulation practices, and refresher checklists were considered to assess how capability is developed and maintained across safety-critical roles.

**Document Management System**

The investigation sourced a range of documents from various corporate document management systems including TRIM, the Corporate Governance Risk (CGR) system, SAP, J5, and various local Archives. Many of these systems are the corporate repository of key documents referenced above. These ranged from role purpose statements and training records, to shift handover notes, CCV completion data and work order information.

**Management of Change (MoC)**

The investigation reviewed Management of Change (MoC) procedures, including the thresholds for triggering MoC, approval workflows, and documentation of recent changes. Particular attention was given to records involving the air distribution system. Instances where changes may have occurred without formal MoC processes were also identified for further examination.

**Engineering Reporting and Governance**

Engineering governance structures were reviewed to understand how responsibilities are defined, and oversight is maintained. This included Return to Service (RTS) documentation, overhaul scopes, technical inspection reports, and the formal reporting lines for engineering staff. The aim was to assess how engineering activities are planned, executed, and integrated into operational decisions.

**Learning Management System**

Operator training and competency data stored in the Learning Management System (LMS) was reviewed, including how competency status is managed, verified, and linked to performance review or remuneration systems.

**Leadership, Accountability and Performance Management**

Documents related to role clarity, job descriptions, and leadership oversight responsibilities were reviewed. This included evidence of how management monitored training status, made operational decisions, and ensured accountability. Organisational charts, reporting lines, and performance systems for both EA and non-EA employees were included.

**Cross-Functional Coordination**

The investigation reviewed meeting minutes and communication records between trading, operations, and engineering teams. These sources provided insight into how decisions were made around unit loading, mill availability, and clinker risk, and how information flowed across functions.

**Coal Quality and Fuel Management**

Procedures and records related to coal sampling, analysis, and blending strategies were reviewed. The investigation also examined how real-time coal quality data was used in operations and whether variation in coal characteristics was actively monitored or acted upon.

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# CS Energy Callide Unit C3 Investigation
# Key Findings and Action Plan

| Key findings | Status |
|---|---|
| **1. Critical risk control failure** | |
| **Action** | |
| All technical root causes (clinker management, boiler protection systems, combustion systems and coal quality) have been rectified. Specifically, the timing delays that were built into flame scanner control logic have been removed. | Complete |
| **2. Repeated failure to operationalise Process Safety** | |
| **Action** | |
| Reprioritise the Process Safety Improvement Program | In progress |
| **3. Inadequate governance of operator training** | |
| **Actions** | |
| Strengthen operator and shift supervisor training and competency assurance | In progress |
| Establish governance of operational training and competency training oversight | In planning |
| **4. Gaps in operator staffing levels and experience** | |
| **Action** | |
| Develop workforce plan to strengthen operator staffing levels and succession management | In progress |

## 5. Leadership and governance failures to act and assure

| Actions | |
|---|---|
| Strengthen functional integration – Operations, Engineering, Maintenance, Planning | In progress |
| Deliver operational excellence through a risk-based enterprise plan | In progress |
| Align risk matrices | In progress |
| Ensure CCV clarity and drive leadership ownership | In progress |

## 6. Inadequate management and communication of operational changes

| Actions | |
|---|---|
| Strengthen shift handovers to improve risk visibility and continuity | In planning |
| Improve control of operational changes | In progress |
| Move the clinker assessment tool to a robust platform | In progress |
| Improve response to variation in coal quality | In progress |

## 7. Failure to learn and improve from precursor incidents

| Actions | |
|---|---|
| Develop a Health and Safety Management framework to drive operational excellence | In progress |
| Implement a robust end-to-end Learning from Incidents Procedure | In progress |

## 8. Production prioritised over speak up culture

| Action | |
| --- | --- |
| Strengthen workplace practices that encourage speaking up | In progress |

## 9. Maintenance failures undermine asset integrity

| Actions | |
| --- | --- |
| Deliver successful overhauls through improved scoping and planning | In progress |
| Improve maintenance workflow integrity | In progress |
| Enforce maintenance execution discipline | In planning |