XX MONTH 2024 / VERSION 1.0

Recognised Standard 24

Spontaneous combustion in underground coal mines

Coal Mining Safety and Health Act 1999

Resources Safety & Health Queensland

Contents

Recognised Standards may be updated from time to time. To ensure you have the latest version, check the website: https://www.business.qld.gov.au/industries/mining-energy-water/resources/safety-health/mining/legislation-standards or contact your local office.

This publication has been compiled by the Resources Safety and Health Queensland.

Interpreter statement:

The Queensland Government is committed to providing accessible services to Queenslanders from all culturally and linguistically diverse backgrounds. If you have difficulty in understanding this document, you can contact us within Australia on 13QGOV (13 74 68) and we will arrange an interpreter to effectively communicate the report to you.

Recognised standards

This document is issued in accordance with PART 5—RECOGNISED STANDARDS and section 37(3) of the *Coal Mining Safety and Health Act 1999*.

PART 5 - RECOGNISED STANDARDS

71 Purpose of recognised standards

A standard may be made for safety and health (a "recognised standard") stating ways to achieve an acceptable level of risk to persons arising out of coal mining operations.

72 Recognised standards

(1) The Minister may make recognised standards.

(2) The Minister must notify the making of a recognised standard by gazette notice.

(3) The CEO must publish on a Queensland government website each recognised standard and any document applied, adopted or incorporated by the standard.

(4) In this section—

Queensland government website means a website with a URL that contains 'qld.gov.au', other than the website of a local government

73 Use of recognised standards in proceedings

A recognised standard is admissible in evidence in a proceeding if—

(a) the proceeding relates to a contravention of a safety and health obligation imposed on a person under part 3; and

(b) it is claimed that the person contravened the obligation by failing to achieve an acceptable level of risk; and

(c) the recognised standard is about achieving an acceptable level of risk.

PART 3 - SAFETY AND HEALTH OBLIGATIONS

37 How obligation can be discharged if regulation or recognised standard made

(3) …. if a recognised standard states a way or ways of achieving an acceptable level of risk, a person discharges the person's safety and health obligation in relation to the risk only by—

(a) adopting and following a stated way; or

(b) adopting and following another way that achieves a level of risk that is equal to or better than the acceptable level.

Where a part of a recognised standard or other normative document referred to therein conflicts with the *Coal Mining Safety and Health Act 1999* or the Coal Mining Safety and Health Regulation 2017, the Act or Regulation takes precedence.

Issued under the authority of the Minister for Resources and Critical Minerals.

[*Gazetted dd month year*]

1.0 Purpose

The purpose of this recognised standard is to state ways for persons involved in underground coal mining operations to meet their safety and health obligations in relation to preparing and planning for mining (prevention), monitoring for and controlling risks associated with spontaneous combustion events in underground coal mines, to ensure risk to Coal Mine Workers (CMWs) is managed to an acceptable level.

2.0 Scope

This Recognised Standard applies to all underground coal mines in Queensland. All underground coal mines are subject to the risk of spontaneous combustion. The likelihood will vary from mine to mine.

All mines are required to have a Principal Hazard Management Plan (PHMP) for spontaneous combustion. The mine's PHMP must identify, analyse and assess the risks associated with the principal hazard of spontaneous combustion and include standard operating procedures and other measures to control the risks.

This standard prescribes ways in which an acceptable level of risk can be achieved with reference to:

- the planning and preparation, monitoring for and controlling risks associated with spontaneous combustion for underground mining activities;
- the development, implementation and review of the Spontaneous Combustion PHMP, including the development and implementation of effective standard operating procedures and control measures for spontaneous combustion events.

Technical references should be used to supplement this standard and inform risk management. This document states a way or ways of achieving an acceptable level of risk for the planning and preparation, monitoring, and control of spontaneous combustion in an underground coal mine. This standard is not intended as a technical guide. A list of documents referred to in this standard and other useful material for developing a Spontaneous Combustion PHMP at the time of writing this standard is contained in Appendix 2.

3.0 Definitions

Consider – Define, document, evaluate and assess.

Critical Controls are controls crucial to preventing the event or mitigating the consequences of a spontaneous combustion event. In addition, a control that prevents one or more unwanted event, or mitigates more than one consequence is normally classified as critical. For the purpose of this standard critical controls must be determined by the Site Senior Executive (SSE) and detailed in the Spontaneous Combustion PHMP.

Goaf (Active) is that part of a mine from which the coal is being partially or wholly extracted and then becomes inaccessible by persons or machinery.

Goaf (Sealed) is that part of a mine from which the coal has been partially or wholly extracted and then abandoned and sealed.

Heating refers to a situation where the oxidation rate is increasing in a self-sustaining manner. It may also refer to an event where the temperature of the coal is substantially elevated from ambient conditions. In the context of spontaneous combustion this is due to an increase in the rate of oxidation leading to the self-heating of the coal and may become an ignition source or mine fire.

Increased Oxidation is an increased rate of oxidation compared to background levels (cause for concern event) of the coal which may lead to a heating.

Source of Ignition refers to a heating that has progressed to a temperature that has the potential to ignite an explosive mixture of gases or cause a mine fire.

Spontaneous Combustion is the process by which materials self-heat due to environmental conditions. This process arises due to reactions of oxygen with the material producing heat faster than it can be lost to the environment. In this document, spontaneous combustion refers to various stages of the self-heating of coal, other carbonaceous or pyritic material.

Spontaneous Combustion Risk is the set of risks to people and/or asset which may arise from spontaneous combustion where the rate of oxidation is, or is likely to, be increasing in an uncontrolled manner and result in a rapid temperature increase.

> **Note:** Fire or an ignition of explosive gases can result from an uncontrolled spontaneous combustion.

Ventilation Change is any change to the ventilation system, including for the purpose of gas and spontaneous combustion management, that alters ventilation flows, directions and pressures.

4.0 Principal Hazard Management Plan

The SSE must develop a Spontaneous Combustion PHMP through a risk management process, considering this Recognised Standard. The Spontaneous Combustion PHMP must contain critical controls for spontaneous combustion. These must be approved by the Ventilation Officer (VO) and the Underground Mine Manager (UMM).

The SSE must nominate the owner of the Spontaneous Combustion PHMP.

Prior to conducting the spontaneous combustion risk assessment, the SSE must organise systems and resources for the timely collection of appropriate information related to spontaneous combustion risk and critical controls.

5.0 Critical Controls

Every underground coal mine must have critical controls for spontaneous combustion management. Whilst every mine will have its own unique circumstances to manage, the following critical controls must be considered:

- Reduction of working and adjacent seam gas by pre-drainage to minimise air/oxygen ingress to the active goaf dug post-drainage.
- The ventilation system is designed and maintained to incorporate spontaneous combustion reduction principles.
- Design and implementation of the gas sampling, analysis and monitoring system to detect increased oxidation, heatings and sources of ignition.
- Proactive inertisation to manage oxygen levels less than 5% in active goaf and unsealed goaf areas.
    - Where oxygen levels are greater than 5% effective continuous monitoring to detect for products of combustion or oxidation to be in place.
- Management of stowage underground and broken coal/spillage is managed to minimise the risk of spontaneous combustion.
- Management system for the use of products with exothermic reactions (such as polymeric chemicals and other cementitious grouts).
- Other sources of heat such as transformers, conveyor belt drives, major electrical installations and battery-operated plant.
- Triggers are identified for the safe withdrawal of persons from the mine following a spontaneous combustion event.
- Remote monitoring is established from the surface (a place of safety) to allow effective monitoring post a withdrawal.
- Remote sealing capability is established from the surface.

6.0 Risk Assessment

The risk assessment team developing or reviewing the Spontaneous Combustion PHMP must include a cross section of affected CMWs. The team must have ventilation engineering experience, experience in spontaneous combustion management with relevant industry experience and competency. The risk assessment should include the planning, monitoring and control of spontaneous combustion. The VO and UMM should be active participants in the risk assessment. Information to be considered in the risk assessment should include, but not be limited, to the following:

6.1 Planning

6.1.1 Characterisation

- Evaluating the spontaneous combustion related history of both the mine and any adjacent mines or prior operations in the same seams and/or coal measures.
- Natural and mining specific factors must be considered. These include, but are not limited, to the following:
    - Coal quality and variations including pyrites.
    - Geology.
    - Caving characteristics/bulking factors.
    - Roof coal that ends up in goaf.
    - Multiple seam extraction.
    - Overlaying and underlaying seams.
    - Geothermal gradient and working depth.
    - Faulting/Dykes - geological structures.
    - Proposed working methods.
    - Mine ventilation system pressures.
    - Mine cooling systems.
    - External heat sources including polymeric chemicals, explosives, and friction.
- Evaluating propensity testing in locations relevant to current and proposed workings. Test the relevant sections of the seam for spontaneous combustion propensity.
- Evaluate gas evolution. Testing in locations relevant to current and proposed workings. Identify the relevant sections of the seam and conduct testing.

Note: Gas evolution results, whilst they provide useful information and describe the sequence of gas release, should not be solely relied upon for setting TARP values as temperature of release may vary between testing and real incidents.

Note: Many seams that test low propensity (based on R70 testing) to spontaneously combust have a history of spontaneous combustion, such as the Goonyella Middle Seam and Moura D Seam. History is more representative of a coal seam's likelihood to spontaneously combust as many site-specific factors are not represented in the laboratory testing.

6.1.2 Mine Design

Mine design factors to consider must include, but are not limited to, the following:

- Adequate and appropriate resources (system, people, and infrastructure) to establish and support the mine design process.
- The mine operator must ensure adequate and timely pre-drainage of all relevant seams as a primary gas management control to reach the target gas content (m3/t) to be specified in the Spontaneous Combustion PHMP.

Note: Demonstrated effective pre-drainage reduces the reliance on post-drainage and ventilation engineering dilution controls, thereby reducing the ventilation velocities and pressure differentials which impact on oxidation and spontaneous combustion. Inadequate pre-drainage of working, lower and upper seams would later contribute to the gas management practice and impacting spontaneous combustion risks.

Note: Pre drainage will reduce the water content in the drained coal seam; this must be considered in managing spontaneous combustion risks.

- Mine design, sequencing and scheduling should avoid overloading sections of the ventilation system. Any change to the ventilation design that increases the spontaneous combustion risk, such as the delaying or cancelling of ventilation shafts, new access drifts or reducing the number of intake/return roadways, must trigger a review of the relevant parts of the Safety and Health Management System, including change management, and a potential review of the Spontaneous Combustion PHMP.
- Major ventilation changes, as defined in the Ventilation PHMP, must consider the impact on spontaneous combustion risk and include a review of its impact on high-risk areas of the mine.
- Potential areas of fluctuating pressures and resulting lower velocities, created by multiple shafts.
- The UMM must review any changes to the longwall face width. The width impacts on geological conditions that reduces retreat rates and increases potential for stoppages. Wider longwalls also increase the pressure differential across the longwall face and increase the size of the gas reservoir which increases goaf well drainage requirements as well as the risk of spontaneous combustion within the goaf. The review must trigger an impact assessment and additional controls to ensure the spontaneous combustion risk is as low as reasonably achievable.
- Ventilation arrangements for longwall companion roadways, particularly where shafts are used whether up cast or down cast and the resultant pressure differentials applied to the maingate seals.
- Pillar size and potential for pillar fracture and spall.
- The SSE must have a documented mine plan change procedure which assesses the impact of mine design changes on the spontaneous combustion risk. This documented change procedure must be approved by the SSE.
- The mine design (including gas drainage designs) must consider minimising potential sources for oxygen ingress such as the design of barrier pillars, assessment of caving, subsidence and borehole leakage paths.

- The benefits of leaving a barrier pillar between groups of panels that would improve gas management as well as minimising oxidation risks.
- Changes to mining equipment that may change pressure differentials in ventilation splits.

6.1.3 Operations

Mine operational factors to consider must include, but are not limited to, the following:

- Rate of retreat and spontaneous combustion controls during planned and unplanned stoppages.
    - Slow retreat, stoppage, or shutdown/breakdown on an active longwall face.
    - Minimising air ingress into the goaf in the maingate behind the shields (including shield design).
    - Strata – Managing goaf hang up and falls (flush).
    - Ventilation Control Device (VCD) (temporary) to be installed immediately after the longwall has passed the cut through.
    - No more than two (one is leading practice) temporary VCDs to be installed at seal sites behind the longwall before permanent seals are in place.

Note: Exception when managing windblast at panel start up.

- Avoid the stowage of carbonaceous material underground.
- Ventilation leakage, created by pressure differential (intake to return air circuit) increases the risk of spontaneous combustion. Increased inspections and monitoring must be conducted in these areas.
- Geotechnical conditions (e.g. faulting / mining direction and gradient / potential for flooding).
- Strata control methodologies.
- Impact of first goafing, barrier pillars and goaf flush.
- Risk of spontaneous combustion in multi seam mining operations operating simultaneously.
- Risk of spontaneous combustion in longwalls operating side-by-side.
- Evaluating external information on spontaneous combustion, regularly where available, including reviews of other mines experience, and emerging technology.

6.1.4 Supporting procedures

The SSE must develop, document, and implement procedures to support the Spontaneous Combustion PHMP. Procedures must be backed by risk assessment and include a cross section of affected workers and content experts. Procedures must include the following:

<u>Stowage Management</u>

- In the first instance, take every reasonable step to avoid stowage of carbonaceous material underground.
- If stowage cannot be avoided, develop a stowage management procedure that covers:
    - a maximum time for stowage.
    - each stowage location has a permit to authorise stowage.
    - design of stowage, height and size, material, position.
    - stowage rules and permits and adherence to these.

        - Consideration of Job Safety Analysis including location of high-tension cables, communication cables, services, stoppings, seals.
    - stowage mapped/surveyed and included on the mine plan.
    - stone dusting/use of capping material for temporary stowage.
    - stowage inspection and confirmed removal.
    - monitoring and inspection of stowage.
    - actions for removal to be entered into the mines action database.

Pillar Design and Spall Management

- Pillar design and design compliance.
- Mine design variations must flag a review of the Spontaneous Combustion PHMP.
- First goaf – weighting on barrier pillars.
- Age of pillars/ management of spall.
- Fractures in pillars post shot-firing.
- Trigger for ventilation pressure across pillars to identify additional monitoring requirements.
- Other coal spillage.
- Preventing and managing belt spillage/coffin seal spillage and fines.

Note: Belt shavings have been identified as spillage that can be a source for spontaneous combustion.

Sealed areas

- Seal standards & maintenance:
    - Sealing to be completed as soon as practicable.
    - VCDs – surrounding strata, certified, follow design criteria, maintenance.
    - Protection of seals from strata movement, stowage, vehicles, water ingress and damage.
- Leakage paths into sealed and other areas:
    - Air pathways into sealed underground workings to be eliminated.
    - Sealing of boreholes/goaf well/shafts and leakage around.
    - Borehole intersection practices/design of boreholes relative to workings.
    - Multiple seam interaction.
    - Subsidence causing an airpath into a sealed area.

Ventilation and pressure differentials

- The following must be included in the Ventilation PHMP and supporting procedures to minimise spontaneous combustion risk:
    - Ventilation and ventilation pressure design, monitoring and management.
        - Design, operate and maintain the ventilation system.
        - Manage ingress of air in the goaf. Air wash zones.
        - Areas of higher-pressure differentials.
        - If booster fans are used, the risk of spontaneous combustion needs to be considered.
        - Ventilation pressure design and regulator location.
        - Auxiliary fan installations, especially when ventilating through VCDs, creating higher pressure differential and air paths.

Note: Highwall fan installations. High pressure and potential opencut highwall blast cracks creating air paths.

Note: Maingate back regulator – regulator for managing methane – this introduces an increased risk of spontaneous combustion.

Note: Any ventilation changes (e.g accessibility to tailgate), including to manage gas in an active longwall and goaf drainage changes, which impacts the oxygen content in the goaf, must consider an increase in spontaneous combustion risk and monitoring.

Gas drainage

The essentials of pre-drainage for spontaneous combustion risk management must be considered:

- Pre-drainage, through Surface In Seam (SIS) and Underground In Seam (UIS) holes, reduces gas content prior to and during mining and is a proactive preventative gas management control. Lower gas content leads to reduced post-drainage and a reduced risk of oxygen ingress into areas being post-drained. This results in a reduced risk of spontaneous combustion.

Note: Less than adequate pre-drainage leads to higher volumes of post-drainage during production and increases the risk of spontaneous combustion.

- Operations must consider the control of air/oxygen ingress when implementing pre-drainage systems.
- Operations must consider the control of air/oxygen ingress into the goaf when implementing post-drainage systems.
    - Leakage through surrounding structure due to negative pressure.
    - Monitoring gases in gas drainage wells. Minimise the oxygen percentage in goaf by managing goaf well drainage.
    - The oxygen concentration level in the goaf hole flow must be less than 5% in goaf holes beyond 100 metres from the face line to reduce spontaneous combustion risk. Individual goaf wells are to be continuously monitored for oxygen levels and accumulated gas make.
    - Design, specification, operation and changes to the goaf drainage system (including automated systems) to be authorised and countersigned by the VO and the UMM.
    - Changes to the goaf drainage system should be treated as a ventilation change by requiring approval by the VO. The VO may set parameters where changes can be made without individual approvals for each change under certain conditions (example operating in no cause for concern spontaneous combustion risk).

Note: No changes to goaf drainage systems without the authorisation of the VO. Changes to be treated the same as a ventilation change. Ventilation changes should be avoided during an oxidation event.

Goaf drainage and inertisation

For guidance on goaf gas and spontaneous combustion management (including monitoring) using proactive inertisation refer to additional information published by the regulator.

Note: No operation shall conduit the methane gas drainage below 30% limit.

7.0 Gas Monitoring

An underground coal mine must develop, document, and implement procedures that support the gas and physical indicator control mechanisms associated with monitoring for spontaneous combustion. The gas monitoring system should be a stand-alone system, not sharing other non-ventilation underground information.

The SSE must ensure that procedures are able to provide timely review and response to the data at the operation. These procedures must make the following considerations.

7.1 Resourcing (People)

SSEs must ensure personnel are available to assist the VO to manage the spontaneous combustion risks at their site.

SSEs must consider whether a specific mine-based spontaneous combustion engineer or specialist needs to be appointed to assist the VO with the purpose of reviewing, trending, and analysing all spontaneous combustion monitoring gas data. This shall include, but not be limited to, goaf drainage, active goaf, underground gas drainage system, surface gas drainage system, developing, implementing, monitoring and maintaining a proactive inertisation system, panel intake and return gas data and trending, stowage management and high intake to return pressure areas.

7.2 Resourcing (Equipment)

The following equipment must be available to implement the Spontaneous Combustion PHMP:

- Gas monitoring equipment:
  - Continuous telemetric (real time) monitoring system.
  - Continuous tube bundle monitoring system.
  - Gas bag sampling equipment (type of handheld pump, type and size of bags and covers).
  - Gas chromatograph (GC).
  - Personal / handheld gas detectors.
  - Collar static pressure measurement measuring in real time at all major return shafts.
  - Longwall, tailgate and maingate seals differential pressure monitors.
- Thermal imaging cameras.
- Ventilation pressure measuring devices (any of or a combination of the below):
  - Water manometer.
  - Digital manometer.
  - Magnahelic gauge.
  - Flow monitors on inertisation injection points (real time monitoring is leading practice).
  - Fixed underground continuous pressure monitors that forms part of telemetric monitoring system.

Collar static pressure measurement measuring in real time at all major surface to seam intake airways should be considered.

7.3 Physical Inspections

The following inspections must be developed to address the spontaneous combustion risks identified in the Spontaneous Combustion PHMP:

- Explosion Risk Zone (ERZ) Controller inspections.
- VO/spontaneous combustion engineer/specialist inspections of gas monitoring equipment to ensure it is in the correct location for spontaneous combustion management.
- Inspection of inertisation points and flows.
- Physical indicator observation and reporting.

Note: CMWs play an important role in reporting abnormal conditions by identifying physical indicators such as smell, smoke, heat, haze, sweating and fire.

7.4 Gas Monitoring Systems

The following section is based on well-established, current technology at the time of publication and should not limit the implementation of new and improved technology or techniques.

Multiple systems are required for the monitoring of spontaneous combustion.

For each technique and sensor, users must understand and apply the requirements of the relevant sections of the Australian standards.

The table below details the gases to be analysed. Real time monitoring must be applied as per the legislative requirements.

Gases measured for each analytical technique (minimum)

Component	Hand Held (General body)	Hand Held (Goaf well analysis)	Tube Bundle	Goaf skid continuous monitoring	GC
Carbon Monoxide	X	X	X	X	X
Oxygen	X	X	X	X	X
Methane	X	X	X	X	X
Carbon Dioxide	X	X	X	X	X
Hydrogen					X
Nitrogen			Calculated	Calculated	X
Ethylene					X
Ethane					X

7.5 Gas Monitoring Locations, Techniques and Triggers

The VO must identify areas of higher risk potential for spontaneous combustion through risk assessment. Once the higher risk areas have been identified the VO must determine the monitoring strategy and frequency to manage the risk of spontaneous combustion. This must be authorised by the UMM and captured in the work management process.

Note: Triggers are minimum parameters to consider for relevant TARP.

Note: Frequency is minimum frequency to be considered for routine sampling.

Note: Tube bundle sampling time must be set to avoid the carryover of gases from previous sample.

Note: Trending is more indicative of coal oxidation than spot readings.

Monitoring locations as a minimum (but not limited to) are detailed below.

7.5.1 Reference Tube (fresh air from surface)

This location is to provide a reference for fresh air and a reference for initial conditions for Graham's Ratio (GR) calculated by tube bundle analysis. At least one reference tube per tube bundle system is required.

Technique	Frequency	Trigger*
Tube Bundle Analysis	As per sampling sequence	• Low and high oxygen • Negative or excessive methane, CO_2 and CO

*Alarms set to identify analyser drift to prompt troubleshooting/calibration

7.5.2 Longwall Return

- Outbye tube to capture influence from leakage from adjacent seals.
- Inbye tube, located close to the Tailgate 150 metre (243A) sensor, to monitor the mixed airflow from goaf and longwall face.

Technique	Frequency	Trigger
Tube Bundle analysis	As per tube sequence	• CO Make • GR • CO/CO_2
Continuous monitoring **(real time)**	Continuous	• CO • CO Make

7.5.3 Goaf Stream – Active Longwall Goaf

Technique	Frequency	Trigger
GC analysis	Sample taken daily at barometer low Day shift preferred (2pm – 5pm)	• CO • CO/CO_2 • Ethylene • GR • Hydrogen
Handheld monitor	Readings taken at time of GC bag sample and recorded on bag tag	• CO • Temperature

7.5.4 Active Longwall Goaf Seals

Tube bundle monitoring locations must be determined by risk assessment. The following factors must be considered when determining the location of tube bundle monitoring points for the active goaf (not limited to):

- High risk areas
- Fault zones
- Stress notches
- Proximity to active face
- UIS holes
- Squaring off
- Validation of proactive inertisation
- Longwall recovery
- One tube to be located no further than two seals back from the face on the maingate side to monitor the air-wash zone.
- The spacing and number of maingate tubes must be based on risk assessment, re-entry monitoring requirements and industry leading practice.
- Where companion roadways are able to be accessed in the first longwall, tailgate seal tube bundle monitoring should be conducted.

Note: Tube bundle locations must be identified for remote monitoring requirements for mine re-entry following an event.

Technique	Frequency	Trigger
GC Bag sample	Each active longwall seal sampled fortnightly at barometric low – Day shift preferred. (Increased sampling regime in slow retreat)	• CO • Ethylene • GR
Tube Bundle analysis	As per tube sequence	• CO • GR • CO/CO_2

7.5.5 Longwall post-drainage goaf well / UIS riser in active goaf

- Automated monitoring must include sample conditioning to remove moisture.
- Handheld monitoring to be taken daily until confidence in the monitoring system is achieved.
- GC bag samples to be taken as per the second workings risk assessment.

- Sensor installation and maintenance must comply with the relevant Australian standard.

Technique	Frequency	Trigger
Handheld confirmation	Daily at barometer low	• CO • Oxygen • Methane
Continuous real-time monitoring*	Continuous	• CO • Oxygen • Methane • Combined CO make for tailgate and goaf drainage
GC Bag sample	Daily **(sampled and analysed)**	• CO • Oxygen • Methane • Ethylene • Hydrogen
Tube Bundle analysis / analyser at the skid* **(leading practice)**	As per tube sequence. Eliminates the need for handheld confirmation checks.	• CO • Oxygen • Methane • GR

*Where available

7.5.6 Newly identified areas of interest

The **goaf stream TARP and sampling schedule** will be applied to any unspecified location within an active goaf where it is deemed sampling is required. For example, samples taken from between or behind longwall shields.

7.5.7 Sealed goaf

Technique	Frequency	Trigger
GC Bag sample	As per mine's risk assessment or Recognised Standard 9	• Oxygen or explosibility • CO • Ethylene
Tube Bundle analysis *for selected panels based on risk assessment*	As per tube sequence	• Oxygen or explosibility • CO

7.5.8 Place change panel / Working panel main return

- Monitor CO make in the return side of the panel and the return side of inaccessible, unsealed areas.

Technique	Frequency	Trigger
Tube Bundle analysis *for selected panels based on risk assessment*	As per tube sequence	• CO • CO Make • GR • CO/CO_2
Continuous monitoring	Continuous	• CO • CO Make
GC analysis	As per TARP	• CO • Ethylene • Hydrogen • GR • CO/CO_2

8.0 Control

An underground coal mine must develop, document, and implement procedures to control a known or suspected cause for concern event relating to spontaneous combustion.

The mine's controls need to include measures that can be managed from the surface.

8.1 Response

The mine must have in place response plans for the mitigation and control for the effects of spontaneous combustion, including means for the protection of personnel and the mine.

8.2 TARPs

The mine must determine indicators for the earliest detection of spontaneous combustion, including gaseous & physical indicators (such as smell, smoke, heat, haze, sweating and fire).

TARPs must be developed with responses to indicators with levels ranging from early detection through to withdrawal and identifying re-entry limits for the mine.

In the development of TARPs, TARP development forms (see example in Appendix 1) must be kept recording the TARP development process and data used to develop the TARP. To develop the response to TARPs the following information must be considered:

- Gas data analysis (includes the analysing of gas trends).
    - Internal mine-based expertise undertaking gas analysis, trending and interpretation.
    - Access to external experts with relevant skills and experience to assist with gas analysis.
- Access to external experts with relevant skills and experience to assist with mining and ventilation analysis.
- Use of historical data from the mine, mines operating in the same seam and from real events (where available).
- Mine site to document and review technical reports used for the development of the TARP.
    - Not to be taken at face value
    - What has been adopted and why?
    - What has not been adopted and why?

TARP actions and trigger values should be evaluated and validated to ensure they are sustainable, achievable and effective.

8.2.1 TARP response levels

The following is to be considered when setting response levels.

No Cause for Concern

No indication of elevated / accelerated oxidation activity

- Represents background conditions which are not at a substantially elevated temperature from ambient/ground (virgin rock) temperature.
- This must be determined by examining the gas profile of the monitoring locations over an extended timeframe. For example, at periods when the longwall / bord and pillar panel is operating successfully (not stood or prolonged slow retreat rate) and are not preceded or followed by a suspected elevated temperature or heating event.

Level 1 – Investigate and prepare for mitigative action

Level 1 TARP trigger – Indications of elevated / accelerated oxidation activity

- Investigate TARP level represents a deviation from expected background conditions which must be investigated for the potential of increased oxidation activity. Review TARP Triggers against oxidation activity (e.g. elevated trends).
- Implement suitable control strategies.
- Monitor the effectiveness of the control strategies.
- Review prevention infrastructure.
    - Additional inertisation points.
    - Additional monitoring points.
    - Additional resources.

Level 2 – Take action and prepare for withdrawal

Level 2 TARP Trigger – Indications of substantial heating requiring immediate action

- Review TARP Triggers against oxidation activity (e.g. elevated trends).
- Review effectiveness of the prevention strategies.
- Implement the control strategies.
- Monitor the effectiveness of the control strategies.
- Deploy appropriate resources to assist with the implementation.
- Prepare for withdrawal from the mine to manage the incident from the surface.
- Ensure infrastructure is in place that can be managed from the surface.
- Document and record all gas trends, actions taken and the impact of the actions taken.

Level 3 – Withdraw

Level 3 TARP Trigger – Indications of advanced heating requiring withdrawal

- Review TARP Triggers against oxidation activity.
- Review effectiveness of the control strategies.
- Develop and implement the extinguishing strategies.
- Monitor the effectiveness of the extinguishing strategies.
- Remove CMWs from risk of uncontrolled fire/explosion.
- Document and record all gas trends, actions taken and the impact of the actions taken.

The SSE must ensure there is effective remote monitoring and sealing capability established from the surface (a place of safety) to allow timely sealing and effective monitoring post a withdrawal.

Note: Preparation allowing rapid sealing, sufficient data and re-entry process to facilitate a re-entry. This aims to avoid a potential reluctance to withdraw personnel to a place of safety.

8.2.2 Actions to be considered for re-entry following a withdrawal

The UMM must have protocols in place for the re-entry decision following a withdrawal from the mine or part of the mine. Re-entry should:

- Only be considered when conditions are in TARP Level 2, trending towards conditions giving no cause for concern, with adequate and effective monitoring, determined by risk assessment, in place.
- Identify whether there is a risk of an explosive mixture of gas.
- Identify whether there is a risk of an ignition source.

8.2.3 Considerations for triggers

- TARP Creation – Must ensure that the TARPs are reviewed periodically by a review team with the VO and approved by the UMM. The aim is to ensure that the data they are based on is still relevant.
- Deeper coal operations with higher seam temperatures must have a quicker response to triggers.
- 'And' statements or qualifying statements can only apply to a single sample from the same technique.
- 'And' statements must only be used when conditions give no cause for concern or the Level 3 withdrawal TARP.
- 'But' statements must not be used.
- It is reasonable and encouraged for GC samples to be immediately reanalysed (same sample) for confirmation of an unexpected trigger.

Note: It is appropriate to use a trigger of hydrogen and carbon monoxide, if both readings are taken from the exact same sample and analysis.

Note: Trigger values in TARPS are intended to be inherent, non-emotional guides for mine workers.

Considerations for ethylene (C_2H_4) triggers

- A standalone measured ethylene response at any location underground, set to a threshold no higher than 0.3 ppm (this value may be lower based on instrument response and historic data), must trigger an investigate (level 1) TARP level by the VO.
- Samples containing unexpected ethylene should be immediately re-analysed for confirmation (using the same bag and GC).
- It is appropriate to include a conservative (100:1) carbon monoxide / ethylene ratio (from the same bag sample as the ethylene) as a qualifying condition for ethylene samples at withdrawal (level 3) TARP.
- Laboratory testing demonstrates that ethylene at 1ppm or higher combined with elevated carbon monoxide indicates an increased likelihood of a coal heating existing at a temperature of over 100 degrees Celsius. A measured response for ethylene no higher than 1ppm must be considered for a withdrawal (level 3) TARP.

Typical GC response for ethylene (C_2H_4) in the Queensland mining industry

- 0.1 ppm – 0.2 ppm: Response may be inconsistent and variable due to noise/ interpretation of baseline.
- 0.3 ppm – 0.5 ppm: Peaks are typically integrated more reliably at these measured concentrations and more consistency with trending is possible.

- 0.5 ppm – 1ppm: It is unusual to measure a response of 0.5 ppm which has been incorrectly integrated, it is often associated with a problem or other substantially elevated indictors.
- 1 ppm. This is a high concentration of ethylene, often associated with a serious event when combined with elevated carbon monoxide.
- Carbon Dioxide over 5% will reduce ethylene sensitivity.

Considerations for hydrogen (H_2) triggers

- The evolution of hydrogen from coal heating exponentially increases above 250 degrees.
- Doubling of the normal goaf stream hydrogen value associated with increase CO and detection of ethylene indicates the commencement of increased oxidation activity.
- Substantially elevated levels of hydrogen combined with elevated carbon monoxide and ethylene may indicate an advanced heating or fire.
- Elevated hydrogen combined with carbon monoxide where there is substantial movement of atmosphere i.e., the goaf stream or tailgate is of particular concern.
- TARP actions should consider the hydrogen concentration to be included in interpretation if they are not used as triggers.
- The Queensland Industry GC (Agilent 490/990) can easily detect hydrogen sub ppm levels.
- Fresh air may contain small amounts of hydrogen (1-2 ppm) but elevated levels must raise concerns.
- Hydrogen is a flammable gas and a comprehensive analysis of hydrogen, carbon monoxide and methane is to be conducted for the complete assessment of explosibility in the case of advanced heating or fire.

Quality control process for processing and reviewing gas results

TARPs checklist and signoff

- Operators must check for triggers at time of analysis / alarm and record.
- Develop a process for testing bag samples and tube bundles and goaf well analysis to allow for comparative testing and trending.
- Bag samples must be reviewed daily by the VO or a mine-based representative.
- Alarms must be flagged for review by the UMM daily for triggers.
- The daily alarm log must be signed by the Control Room Operator (CRO), undermanager, oncoming CRO, oncoming undermanager, VO and UMM.

8.3 Incident Management Team

If the mine needs to respond to an event, where TARP triggers have been activated, the mine forms the IMT to manage the response. The response must be managed by mine-based personnel.

The TARPs must define the trigger which will invoke the operation of the IMT to respond to spontaneous combustion triggers. The IMT must include persons with sufficient authority to implement decisions, together with appropriate knowledge and experience.

The control measures implemented must be risk-based.

The IMT must maintain an event log to record issues, decisions, actions and resulting events. The IMT must not be disbanded until a controlled and stable condition exists at the mine.

Any IMT formed from other principal hazard triggers and/or incidents must consider spontaneous combustion risk.

8.4 Emergency Sealing

The mine must develop and implement a process for the rapid sealing of specific areas of risk in response to TARPs supported by sealing procedures and seal design together with a minimum inventory of materials to be maintained on-site, or to have guaranteed ready availability, at all times.

Preparatory seals should be considered at the start of each extraction panel (to seal off panels) and in selected areas in the mains (to seal off areas inbye and keep the outbye areas of the mains open).

Other areas that must be considered include but are not limited to:

- remote sealing of the mine or parts of the mine.
- inertisation isolation and activation.
- borehole setup at panel entrances for the use of Inertisation.
- continued operation of the real time gas monitoring system (underground).
- real time gas monitoring from the surface.
- continued operation of the tube bundle gas monitoring system.
- borehole tube bundle monitoring.
- develop exclusion zones from the portals, shafts and boreholes.
- operation of the mine from the surface outside of the exclusion zones from portals.
- conduct emergency exercises to demonstrate effectiveness of the system.
- closing seals is a major ventilation change and its impact must be considered.

Note: Where there is a risk of an explosive mixture of gas and an ignition source, sealing must be done from a place of safety (on the surface).

9.0 Document and Data Control

The Spontaneous Combustion PHMP and related documents must be managed by the mine's document control system and be in a form which is easily accessible, easy to use and understand and able to be updated. All obsolete documents are to be removed from circulation.

Records related to the Spontaneous Combustion PHMP that must be retained include, but not limited to:

- Spontaneous combustion events.
- Ventilation and gas monitoring and spontaneous combustion control data.
- Mine specific spontaneous combustion characteristics.
- TARPs.
- Non-conformances - corrective action.
- Spontaneous combustion training.

10.0 Training and Competency

Persons with responsibilities under the Spontaneous Combustion PHMP must have the following competencies.

- The senior person in the organisation structure, with the relevant competency, to establish and maintain the Spontaneous Combustion PHMP.
- GC operators must be deemed competent to operate the GC (Certificate of attendance from suppliers).
- CROs must have a demonstrated competency in using the automated gas monitoring system and acknowledging alarms.
- A mine managers representative must; be appointed as per section 60(8) of the *Coal Mining Safety and Health Act 1999*; and
    - have AQF 5 qualifications or higher in spontaneous combustion, ventilation and gas management or a second-class certificate of competency.
- Persons with responsibilities under the Spontaneous Combustion PHMP must undergo training including:
    - the relevant sections of the Spontaneous Combustion PHMP and the importance of adherence.
    - the roles and responsibilities of persons in relation to the operation of the Spontaneous Combustion PHMP.
    - spontaneous combustion indicators.
    - reporting and recording the observation of spontaneous combustion indicators.
    - relevant standards and procedures associated with the Spontaneous Combustion PHMP.

11.0 Roles and Responsibilities

The Spontaneous Combustion PHMP must define the authorities and duties of all persons who have responsibilities under the plan. In fulfilling these requirements such devices as organisation charts, job, or position descriptions in relation to the spontaneous combustion management plan, or statements of duties with respect to the spontaneous combustion management plan will assist.

The VO must be involved, and appropriate dedicated resources should be assigned to assist in the prevention management and control of spontaneous combustion. Additional resources must be assigned when the workload increases i.e. increasing bag sampling, conducting inertisation, installing additional tube bundle, during an event.

All operational changes to design and process with potential to have an impact on the risk of spontaneous combustion should be counter signed and approved by the UMM and VO.

12.0 Audit

Effective and timely audits and reviews are a valuable means to give management and CMWs assurance that requirements of the spontaneous combustion principal management plan are being adhered to in practice.

Spontaneous combustion critical controls must be established by risk assessment and form part of the critical control auditing process.

A schedule of both internal reviews and external audits must be prepared to ensure the verification of the Spontaneous Combustion PHMP operation.

Internal reviews must be conducted by persons independent of those with direct responsibility for the Spontaneous Combustion PHMP.

External audits must be conducted by persons independent of the mine's operations and must be done by persons that have knowledge, relevant ventilation competencies and experience in prevention, monitoring and control of spontaneous combustion.

Records of all audits and reviews must be entered in the mine record. Audit and review actions must be communicated to the senior person responsible for the Spontaneous Combustion PHMP. All actions must be considered for implementation.

13.0 Review

The timely and effective review of the content and operation of the Spontaneous Combustion PHMP will assess its continued suitability and effectiveness in managing spontaneous combustion related risks at the mine.

The mine must prepare a review protocol conforming to the following requirements:

- Define time based and event-based review triggers.
    - Event based review triggers must include, as a minimum requirement:
        - a spontaneous combustion event level 2 or above.
        - significant change in mining systems.
        - coal seam characteristics significantly change.
        - when information of an event at another mine becomes available.
- A re-evaluation of the spontaneous combustion related risks and all aspects of the Spontaneous Combustion PHMP.
- Identification of persons to participate in reviews (indicate who should decide if significant change has occurred, and to what criteria that decision is to be made).

Where the conduct of any review indicates that the Spontaneous Combustion PHMP is no longer suitable and effective in managing spontaneous combustion related risks then management should implement corrective action to amend the Spontaneous Combustion PHMP.

Appendix 1: Example of TARP Development Form

TARP DEVELOPMENT - TRIGGER LEVELS			
Name of Reviewer		**Date**	Date
TARP NAME		**Signature**	Signed
NORMAL CONDITIONS	Legislative Requirement.		
	Circumstance or Condition.		
	Historical Data.		
	Best Practice.		
	Supporting RA or documentation.		
	Consider any conflict or interaction between next trigger point.		
	Consider logical progression of the trigger response relative to supporting information used to determine trigger level.		
LEVEL 1 INVESTIGATION REQUIRED	Legislative Requirement.		
	Circumstance or Condition.		
	Historical Data.		
	Best Practice.		
	Supporting RA or documentation.		
	Consider any conflict or interaction between next trigger point.		
	Consider logical progression of the trigger response relative to supporting information used to determine trigger level.		
LEVEL 2 ACTION REQUIRED	Legislative Requirement.		
	Circumstance or Condition.		
	Historical Data.		
	Best Practice.		
	Supporting RA or documentation.		
	Consider any conflict or interaction between next trigger point.		
	Consider logical progression of the trigger response relative to supporting information being used to determine trigger level.		
LEVEL 3 URGENT ACTION REQUIRED	Legislative Requirement.		
	Circumstance or Condition.		
	Historical Data.		
	Best Practice.		
	Supporting RA or documentation.		
	Consider any conflict or interaction between next trigger point.		

Appendix 2: Reference Documents

List of documents referred to in this standard and other useful material for developing a Spontaneous Combustion PHMP:

ACARP

- 19010 Emergency Response: Mine Entry Data Management July 2015
- C29024 Contamination – Ethylene from Timber Supports March 2023
- ACARP web site for spontaneous combustion research reports ACARP Search

Australian/New Zealand Standard – *Electrical equipment for coal mines – Introduction, inspection and maintenance*. Part 3: Gas detecting and monitoring equipment (AS/NZS 2290.3:2018).

Balusu, R, Deguchi G, Holland, R, Moreby, R, Xue, S, Wendt, M and Mallett, C 2001. *Goaf Gas Flow Mechanics and Development of Gas and Sponcom Control Strategies At A Highly Gassy Coal Mine.* Australia-Japan Technology Exchange Workshop 2001, 2nd – 4th December, Hunter Valley, Australia.

Balusu, R, Tuffs, N, White, D, Harvey, T and Xue, S 2006. *Surface Goaf Gas Drainage Strategies for Highly Gassy Longwall Mines*. Journal of The Mine Ventilation Society of South Africa, Volume 59, Number 3, Jul/Sep 2006, pp 78 – 84.

Belle, B., Cliff, D., Improved TARP development based upon mine specific data, International Journal of Mining Science and Technology, Volume 28, Issue 3, May 2018, Pages 477-481.

Caley, D. 2023. *Broadmeadow Mine Solid Coal Oxidation Event 18-19ct, South Mains* ERZ forums and ventilation officers workshop March 2023.

Cliff, D, Beamish, B and Cuddihy, P, 2009. Explosions, fires and spontaneous combustion.in *Monograph 12, Australasian Coal Mining Practice – Third Edition*, pp 800-814 (The Australasian Institute of Mining and Metallurgy: Melbourne).

Cliff, D, Brady, D & Watkinson, M 2018 2nd ed, *Spontaneous combustion in Australian coal mines*, referred to as 'The Green Book', Simtars, Redbank, Australia.

Coal Mining Safety and Health Regulation 2017 (Queensland, Australia).

ICMM: Health and Safety Critical Control Management: Good Practice Guide

Muller, S, Bartrop, L and Dhyon, S. 2023 *Detection of ethylene by micro gas chromatograph and associated evolution temperatures for gas evolution testing*. World Mining Congress Brisbane Qld Australia 26-29 June 2023.

National Coal Board 1977, *The Tube Bundle Technique for the Continuous Monitoring of Mine Air*, National Coal Board, London.

NSW Resources Regulator

- *MDG 1006 Spontaneous Combustion Management Guideline*
- *MDG 1006 Technical Reference for Spontaneous Combustion Management Guideline*

Queensland Coal Mining Board of Inquiry Part II Report – May 2021

Resources Safety and Health Queensland (RSHQ)

- *Recognised Standard 09: The monitoring of Sealed Areas*
- *Recognised Standard 16: The use and control of polymeric chemicals at underground coal mines*
- *Safety Bulletin 204: Spontaneous combustion monitoring and response systems*

Simtars, Redbank, Australia:

- 1999, Interpretation of Mine Atmospheres referred to as the “Grey book”.
- 1997, Spontaneous Combustion in Underground Coal Mines “Red book” (for CMWs).
- 1997, Spontaneous Combustion in Underground Coal Mines “Blue book” (for coal mine officials).

Task Group 4 report 1998. Moura No2 Inquiry. *Developments in Self Escape and Aided Rescue Arising from The Moura No. 2 Wardens Inquiry*

Windridge, F. W., Parkin, R.J., Neilson, P.J., Roxborough, F.F. & Ellicott, C.W. 1996, *Report on an Accident at Moura No. 2 Underground Mine* on Saturday, 7 August 1994: Wardens Inquiry, Queensland Government, and Brisbane, Australia.