ICMM
International Council
on Mining & Metals

CRITICAL CONTROL MANAGEMENT

IMPLEMENTATION GUIDE

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FOREWORD

ICMM member companies are committed to ensuring the well-being of workers, communities and their families. While mining is an inherently hazardous activity, this does not mean that accidents are inevitable. Health and safety has to be at the heart of all operations and processes.

Fatalities and catastrophic incidents continue to occur, but our member companies acknowledge that this is unacceptable and believe a goal of zero fatalities is achievable.

ICMM is committed to providing leadership and resources for managing health and safety. We have developed an approach called critical control management (CCM) to improve managerial control over rare but potentially catastrophic events by focusing on the critical controls.

This note is a follow up to, and designed to be read in parallel with, the Health and safety critical control management guide published by ICMM in April 2015. It provides additional practical guidance on preventing the most serious types of health and safety events and uses case studies to demonstrate the CCM approach, providing actions to achieve the target outcomes within each step.

Since the launch of the first guide, we have been delighted with the high level of uptake of the CMM approach within member companies and other companies within the mining and metals industry. We would like to thank our members for the support and guidance they have provided during the development of this work.

We continue to encourage those implementing CCM to provide us with further examples of good practice which we can share in future documents or through other knowledge sharing activities.

Tom Butler
Chief Executive Officer, ICMM

PART 1
HOW TO SUPPORT CRITICAL CONTROL MANAGEMENT IMPLEMENTATION

INTRODUCTION

The International Council on Mining and Metals (ICMM) has published the Health and Safety Critical Control Management Good Practice Guide (Good Practice Guide) (2015), which outlines the approach to critical control management (CCM) for use in the mining and metals industry. This document provides guidance to implement the CCM approach in the Good Practice Guide. It also provides history and context of the approach, potential benefits and obstacles, and how an organisation can adopt CCM.

Note that there is no one right way to implement the CCM Good Practice Guide, and it will need to be tailored to suit individual companies and sites.

The document is in two parts.

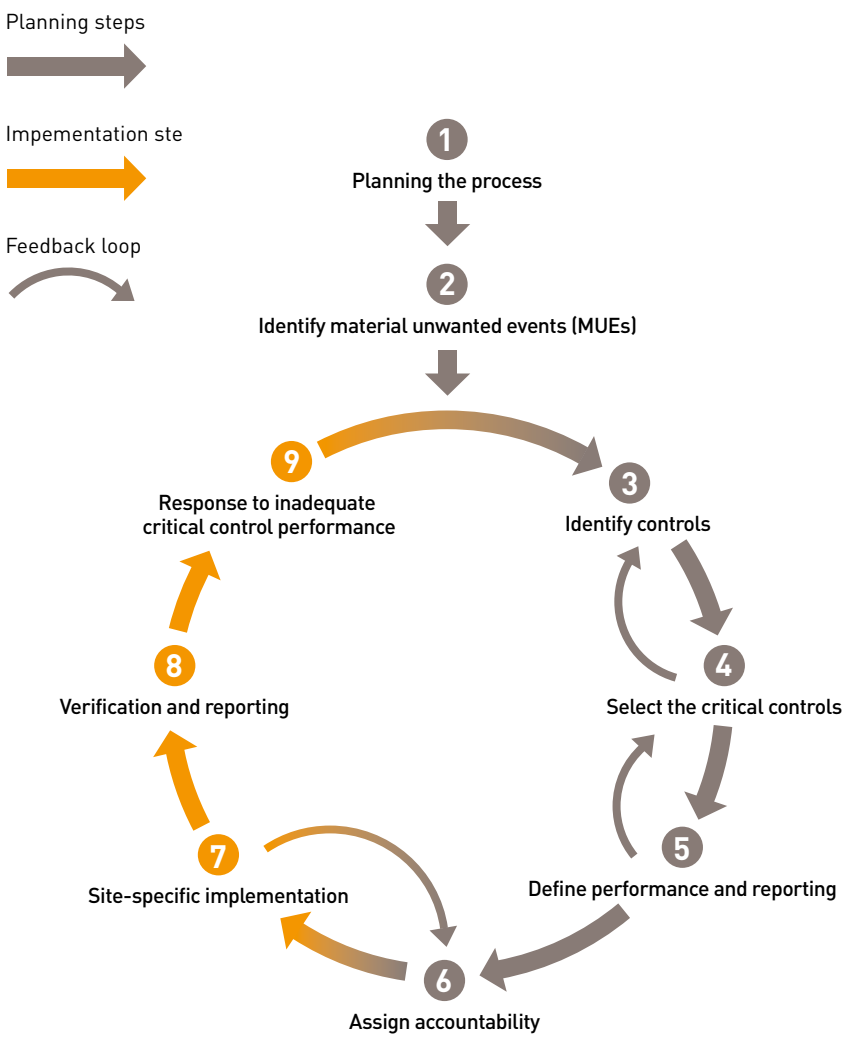
Part 1 covers:

- summary of the process
- history of the CCM approach
- benefits of the CCM approach
- challenges when implementing the CCM approach
- how to prepare and plan to implement the CCM approach.

Part 2 covers:

- A step-by-step guide that uses health and safety case studies to demonstrate the approach. The document provides actions to achieve the target outcomes within each step.

Figure 1: The critical control management process



What is the critical control management process?

The CCM process (see Figure 1) is a practical method of improving managerial control over rare but potentially catastrophic events by focusing on the critical controls. These sorts of events are called material unwanted events (MUEs). Mining industry examples of MUEs include underground fires, coal dust explosions and overexposure to diesel particulate matter. Not all MUEs though involve sudden events. For example, MUEs may also include the potential exposure of groups of workers to carcinogenic or other agent at harmful levels over a protracted period. These all have the potential to cause multiple casualties, but they can also affect the ongoing viability of a business. In other words, they represent a material risk to the business. Prevention of MUEs requires specific attention at the highest level of an organisation alongside other material business risks.

The CCM approach is based on:

- having clarity on those controls that really matter: critical controls (Step 4)
- defining the performance required of the critical controls (Step 5) – what the critical control has to do to prevent the event occurring
- deciding what needs to be checked or verified (Step 5) to ensure the critical control is working as intended
- assigning accountability for implementing the critical control – who has to make it work? (Step 6)
- reporting on the performance of the critical controls (Step 8).

Underlying assumptions of the critical control management process

The CCM process is built upon a number of assumptions.

Assumption 1
The majority of MUEs within the mining and metals industry are known, as are the controls.

Assumption 2
Most serious events including MUEs are associated with failures to effectively implement known controls rather than not knowing what the risks and controls should be.

Assumption 3
More can be less. A hazard management plan of 50 pages will often contain a large number of controls, which can be complex to understand, implement and monitor. This can lead to less robust management of critical controls. Less can be more. The fewer number of controls, the more robustly they can be monitored.

Assumption 4
Some controls are more important than others. These critical controls should be monitored more regularly.

HISTORY OF THE CRITICAL CONTROL MANAGEMENT APPROACH

Managing health, safety and environment in high-hazard industries

There is a long history of embarking on programmes to improve managerial control over major incidents in a variety of industries. Major improvement initiatives have typically followed major disasters and have involved building on pre-existing ideas and programmes that had not received sufficient support prior to the incidents. In Europe, the Seveso incident in 1976 led to European-wide regulatory change involving a type of safety case, which has influenced regulatory systems around the world. The Alexander Kielland and Piper Alpha disasters in the North Sea in the 1980s had a similar but more limited impact on upstream petroleum's emphasis on managing material events. More recently, the BP Texas City disaster in America in 2005 and the Buncefield petroleum terminal explosion in Britain in the same year have stimulated greater focus on MUEs. These incidents have driven development of a wide range of guidance and standards. Examples include:

- Center for Chemical Process Safety 20-element approach
- Energy Institute 20 elements (2010).

Typical approach to improving health, safety and environment in high-hazard industries

A traditional approach to implement a control-focused approach would typically involve selecting a reputable process safety management framework (such as the Energy Institute 20-element programme mentioned above) and conducting a "gap analysis". This task assesses the company's current situation and identifies the areas in a company's management system where further work is needed to meet the requirements of the chosen framework. A prioritisation of gap analysis results would be undertaken before developing a plan to implement the requirements to adopt the framework.

This is usually recommended and regarded as the orthodox approach. However, there is little guidance provided on how to do this as opposed to what is required. While this approach is entirely valid, it can result in relatively high-level actions with limited impact on the practices of the organisation. This includes a limited impact on managing critical controls. For example, if one determines in your company that management of operational interfaces requires more work to meet the Energy Institute guidance, then the improvement work in a company may focus on this. This is an important topic and no doubt will yield rewards in time. It is still difficult to see how this will sustain interest at the front line on critical controls, nor help to start and sustain a programme to improve critical controls.

Similar approaches

There have also been some approaches to managing major hazards that are specifically focused on "critical controls" even if this term has not been used.

For example, in Britain the Offshore Installations (Safety Case) Regulations 1992, and later the Offshore Installations (Prevention of Fire and Explosion, and Emergency Response) Regulations 1995, created after the Piper Alpha disaster in 1988, introduced the concept of safety critical elements (SCEs) (similar to the idea of critical controls in the ICMM guidance). These regulations also introduced a regulatory requirement for a process of examining the condition and performance of SCEs.

What is different about the critical control management approach?

CCM also focuses on the specific controls to prevent or minimise an MUE. This can establish a robust CCM system quicker and more efficiently than the methods outlined above. Any managerial change programme needs "quick wins" to demonstrate that the change works. The CCM approach is focused on achieving more practical and visible actions for critical controls.

This will increase the likelihood that the change in emphasis for an organisation (ie maintaining gains on personal safety while enhancing managerial control over MUEs) can be sustained.

The CCM approach focuses on:

- identifying what controls are needed (many controls will already be in place)
- identifying the critical controls
- ensuring supervisors and managers are monitoring the critical controls to check they are providing in practice what they are assumed to provide.

WHY SHOULD AN ORGANISATION UNDERTAKE THE CRITICAL CONTROL MANAGEMENT APPROACH?

Why is a focus on material unwanted events needed?

Many companies have improved their safety performance as measured by lost time injury frequency rates and similar measures. However, MUEs such as fatal accidents, rarer catastrophic events and significant health exposures can still occur. Investigations of incidents that are material (MUEs) to companies, including fatal accidents and rarer catastrophic events, typically show that known controls for known risks were not effectively implemented in practice. This is the reason for the focus on critical controls that is championed by the CCM approach.

Many of the systems and plans in place to prevent MUEs are often set out in bulky and complex safety management systems, hazard management plans, and procedures. They can be difficult to implement and can become "shelf ware". Experience also suggests that these systems and plans lack clarity as to what the really important or critical controls are. The key to the CCM approach is a focus on the critical controls, clearly described, monitored and reported upon. Much of the pre-existing detailed information in management plans, risk assessments and so on is still needed. This provides much of the background material to enable the CCM approach to be implemented.

What are the benefits of implementing the critical control management approach?

By adopting the CCM approach we can reduce the risk of an MUE. This is because the CCM approach:

- focuses on a smaller and more manageable number of risk controls – the critical controls
- uses bowties, which provide a simple and readily understood picture of the links between the MUE, how it can be caused, and the critical control to prevent it occurring and minimise the consequences if it does
- documents the critical controls in a simple format, making explicit the performance required of them, how they are to be checked and who is responsible for them
- provides a way of measuring the "health" or performance of critical controls – knowing the health of controls provides a mechanism to allow more effective governance over this category of material business risks
- gives a clear understanding of the controls needed to manage MUEs across all levels of the organisation.

Companies have also reported other benefits. These include:

- A better understanding of critical controls has led to more productive and insightful "visible leadership" interactions between managers and the workforce. This occurs because the documents produced as a result of implementing the CCM approach, for example bowties (Steps 3 and 4) and critical control information summaries (Step 5), make it easier to have meaningful discussions. Senior managers now have the detail to ask good-quality questions about critical controls even if the subject-matter is outside of their expertise.
- A focus on the controls has led to better maintenance and improved asset integrity. This has resulted in reduced downtime and lowered maintenance costs.
- Actively managing the risk of an MUE also manages the risk of reputation damage.
- A focus on controls and oversight of the MUEs allows better governance and decision-making.

Workforce and culture

The CCM approach supports the development of an effective safety culture. CCM emphasises the importance of effective implementation of critical controls. In other words, it focuses on important practices that prevent or minimise MUEs. A focus on practices or "how we do things around here" is an accepted way of developing and sustaining an effective safety culture. As Andrew Hopkins has pointed out, an effective safety culture is necessary to make safety systems work.[1]

1 Source: A. Hopkins, Safety, Culture and Risk: The Organisational Causes of Disasters, Sydney, New South Wales, CCH Australia, 2005.

Learning from the experience of others

This guidance is based on practical experience from a number of organisations that have embarked on the process of improving their managerial focus on MUEs. The lessons learnt[2] from this experience, and from other industries that have carried out similar work, is reflected in the following guidance on how to implement the CCM approach.

The main lessons from other companies in both mining and other industries are:

- Most companies reported that they already had the information necessary to implement a CCM-type approach in the form of hazard identification and risk assessments. However, they had not distilled or summarised this information into a readily usable form.
- Companies usually cannot get this right the first time – it requires experience. But this experience is useful as it builds understanding of the MUEs, the controls and the critical controls.
- There is no one right answer to the question, which controls are the critical controls? This depends on the particular circumstances of a company and mine site.
- Implementing the CCM approach requires a project management approach and dedicated human resources.
- Wherever possible the experience of internal company personnel should be used. In particular, the involvement of subject-matter experts on technical areas will be required. However, external resources may also be needed, particularly in the early stages of a CCM project.
- Create a realistic project plan that does not underestimate the time required to thoroughly review the MUEs and develop the CCM material.

2 Lessons learnt are only really learnt when an organisation applies the lessons and changes processes and behaviours, and the results of the changes can be measured. Until this is done lessons are not effectively learnt but are still strictly speaking lessons to be learnt.

COMMON CHALLENGES

This section identifies some of the common challenges faced by companies implementing the CCM approach. Section 5 provides additional guidance on how to make the change.

Does your organisation have existing internal guidance?

Many companies already have existing guidance on safety management and/or risk management. Existing guidance is unlikely to advocate or support the CCM approach explained in the ICMM Health and Safety Critical Control Management Good Practice Guide.

As a result, it may be necessary to explicitly agree and explain within the organisation how this approach supports effective management of MUEs, including how the ICMM guidance relates to existing guidance and practices. These might require changing. Examples could include governance frameworks, existing health and safety management systems and training packages.

Human resources and investment

Often the human resourcing requirements needed to undertake the CCM approach is underestimated. This leads to organisations attempting to "job share" CCM with other (often health, safety and environment (HSE) or operational) duties. This presents a challenge as sharing human resources will result in a less effective and thorough management of the CCM process.

Ahead of regulation?

The CCM approach consists of concepts and actions that may be unfamiliar to regulators in some jurisdictions. This may require companies or sites to justify and explain CCM to regulators.

Prominence of personal safety

The mining industry has successfully reduced the number of injuries and fatalities. This has led to an understandable and broadly successful focus on reducing personal safety incidents. However, as MUEs are relatively low-probability but high-consequence in nature, they are often difficult to mobilise attention towards. Organisations therefore need to explain their focus on MUEs, in addition to a focus on personal safety, and acknowledge any similarities or differences.

PLANNING FOR CHANGE

Planning for the change is critical to the success of the CCM process. Step 1 of the process outlined in Part 2 explicitly deals with planning for the CCM approach. However, there are steps that need to be taken before you can embark on the CCM approach. This section describes those key actions, issues and themes to be taken into account prior to starting the CCM process. These key themes are:

- planning activities
- project scoping
- organisational readiness.

Planning activities

Planning activities need to be undertaken before planning the CCM project. This ensures that the organisation has the required maturity and understanding to properly scope the task. The activities include the following.

Senior leadership support
Senior leadership commitment to the process will help to realise the benefits. Ensuring senior leadership understands the CCM process and benefits is essential. External expertise may be needed.

Common language
A common and agreed set of terms to discuss the CCM process is essential to communicate key concepts. Staff will have varying levels of experience with MUEs and understanding of relevant terms (such as critical controls). A list of definitions and abbreviations is shown in Appendix A and may help to define terms; however, an organisation should decide on the best language for them.

Assurance of the process
A sense of unease and uncertainty is common in organisations undergoing change. The adoption of the CCM process may challenge existing processes and procedures, propagating these feelings. If assurance in the outcomes of the change can be clearly communicated, it can help address the unease and uncertainty. Consider using examples of successful application of the control-focused approach in the mining and metals industry (and in other high-hazard industries, such as offshore petroleum) as case studies of the success of the process.

Project scoping

The project scope will set the expectations and outcomes of completing the CCM process. It is important to have a scope tailored to your organisation. You should consider the following questions.

Do you have a clear end point?
Implementing the CCM process to a high standard requires significant organisational change, human and capital resources, and investment. Consider the end point for the project and the wider organisation. This could include the support frameworks such as governance frameworks, existing health and safety management systems and training packages. Once you have a clear vision of the end point you can identify the project outcomes. This enables progress tracking and will help encourage and motivate staff.

Do you have realistic expectations?
Organisations need a realistic expectation of the CCM process. After completing the process there will not be 100% assurance that MUE risks are controlled, but there will be oversight of the MUEs. There will be continuous review and improvement to ensure the greatest level of MUE control (as discussed in Step 9).

Do you have realistic timelines?
The complexity of the CCM approach is often larger than initially thought. It is not uncommon for a multi-year project to see the CCM approach fully implemented. Organisations should consider what a realistic timeline for implementation is and, if possible, discuss the experience with a similar organisation that has undertaken the process.

Do you have a plan for project governance?
A robust governance structure is crucial for any large project. This should not be confused with governance over control monitoring, which is part of the CCM process. Your organisation may have project governance structures already defined. If not, a robust structure should include:

- internal structures and reporting – this includes clearly identifying the roles and responsibility of staff, and it should define mechanisms for progress reporting within the governance structure (this may be integrated into current systems)
- a change management methodology or approach
- a project governance body such as a steering committee or governance board – this group ensures there is adequate oversight throughout the life of the project.

How much training do your key staff need?
The project manager, project team and senior leadership within the organisation should have a good understanding of the CCM approach. This should include an understanding of the theory, terminology, challenges and benefits of the approach. Adequate training may require engaging external expertise to deliver this.

Have you scoped your existing internal experience and expertise?
An organisation should leverage off its existing experiences in managing MUEs. For example:

- Organisations should identify internal expertise they may have, such as staff that have attended MUE risk management and risk control training.
- Some organisations have risk assessments and bowties that are able to be used in the CCM process.
- Learn from incidents within your company and from the industry as a whole.

Organisational readiness

The Good Practice Guide provides a CCM journey model and mapping tool (Appendix A, page 23), intended to assist a company, business unit or site to benchmark its current CCM maturity. This will help assess organisational readiness prior to undertaking the CCM approach. A higher maturity score suggests a higher level of capability to implement the CCM approach.

In addition to the tool, organisations should consider the following four questions to assess readiness:

- Do your proposed project managers have appropriate understanding, education and training?
- Do you have a consistent and agreed terminology?
- Do you have senior leadership buy-in?
- Do you have realistic timelines and outcomes for the project?

If you answer yes, your organisation has a base level of readiness to adopt the CCM approach.

PART 2
IMPLEMENTATION STEPS

GUIDE TO PART 2

Part 2 contains guidance on how to implement each of the nine steps summarised in the Good Practice Guide. This implementation guidance should be used in conjunction with the Good Practice Guide, not as a stand-alone document. This guidance is not prescriptive, but provides advice and suggestions to aid implementation.

Part 2 has the following main components:

- step-by-step guidance (Steps 1–9)
- a worked example for each step using a fictitious company East Coast Coal (ECC) as a vehicle to illustrate how the CCM process may be implemented (see below for the introduction)
- bowties – one for a safety MUE (underground fire and coal dust explosion) and the other a health-related MUE (diesel particulate matter overexposure) – each bowtie is presented twice: firstly with a sample of the controls presented and secondly with critical controls identified.

When implementing the CCM process, one person will not have all the knowledge required to complete the process. When necessary, conduct workshops or form a working group with personnel who have the appropriate knowledge and expertise. Consider the use of external expertise if necessary.

The CCM approach

Although the CCM approach is based on a tried and trusted approach that has been in use in other industries for over 20 years to manage major hazards, there is limited experience of applying this approach in the mining and metals industry. This implementation guidance draws on the limited practical experience that is available and on the experience gained in other industries.

This experience strongly suggests there is no one right way to implement the CCM approach. Companies will need to adapt the approach described here to suit the circumstances in which they operate.

East Coast Coal

Part 2 uses a case study to illustrate the application of each step. The case study involves a fictitious company, East Coast Coal, that is implementing the CCM approach. There are two MUEs, one a health event and the other a safety event.

CASE STUDY

INTRODUCTION TO EAST COAST COAL

East Coast Coal Ltd (ECC) is a coalmining company with operations in several countries. These operations are a combination of underground and open-pit mining. ECC has 4,000 employees in its international operations. The company has come under new leadership after the recent retirement of the CEO.

ECC wants to implement a new strategy to better control operational risks. Management has evaluated and explored other safety strategies in the past. An attempt to improve safety lacked momentum and required more resources than expected. It also focused primarily on fatal accidents and lost time injuries, which are important, but did not adequately address rarer health and safety risks such as multiple fatal accidents and even rarer catastrophic events.

Senior management are aware of rare but catastrophic risks

Management recognised a number of "weak signal" events, including some minor incidents, that could have proven disastrous, suggesting that they were still vulnerable to a major event. Having recently seen a presentation on the results of the investigation into the Upper Big Branch Mine disaster in West Virginia, America, senior management have asked what can be done to improve their focus on controlling the company's major risks.

The COO asked the HSE manager to arrange a meeting with a number of experienced and respected staff. These comprised some subject-matter experts, including the ventilation officer from one of the underground mines, the engineering manager, the HSE manager, a mine manager and a head-office risk analyst.

Internal meeting of experienced personnel to discuss MUEs

The COO met with the experienced and respected staff and explained the background to the meeting. The CEO had been briefed on the Upper Big Branch Mine disaster in America and the Pike River disaster in New Zealand. The CEO asked members of the leadership team if such an event could happen in their operations. There was a mixed response. Some members of the leadership team thought no but others were not so sure. One member of the leadership team pointed out that if the same question was asked in those companies involved in major disasters, before the incident happened, they would probably have said a disaster couldn't happen to them. The CEO asked the COO to investigate and advise what should be done. As a result, this meeting was taking place, and he wanted to hear the views of the (very experienced) staff that were present.

As with the leadership team, views were mixed. One person pointed out that they had extensive and detailed hazard management plans in place. Somebody else said that they had enjoyed a very low and industry-leading lost time injury frequency rate (LTIFR). Another said that the government regulator had visited the mine regularly and not raised any problems.

However, other views were expressed too. The near misses that could have led to serious events, which fortunately did not escalate to their full potential, were described. It was also pointed out that there was little or no connection between a low LTIFR rate and the probability of a fatal or major incident. It was discussed that an airline safety record is not judged by the occupational health and safety (OHS) of airside workers and baggage handlers but how well the aircraft are operated. A low back injury rate to the baggage handlers does not mean that their aircraft maintenance procedures are all in order. Somebody else from around the table quoted from an OHS safety magazine that said, "the implementation of safety management is largely ineffective because ... documented systems are too complex for the organisation to comprehend, implement and maintain". She said that sounds like some of our systems.

The COO asked the HSE manager to convene a working group to review the ICMM Health and Safety Critical Control Management Good Practice Guide and to prepare a project plan.

STEP 1: PLANNING THE PROCESS

Target outcome

Develop a plan that describes the scope of a project, including what needs to be done, by whom and the timeframes.

Scoping and planning the implementation of the CCM process is essential to success. This requires careful thought and forward planning for each step. This step describes the considerations for the development of a project plan to guide the implementation of the overall process.

Actions in planning the process

Action 1: Develop a project plan

A comprehensive project plan will assist in the successful implementation of the CCM process. As a minimum the project plan should cover:

- the organisational context that will determine the conduct of the project
- the project objectives – ensure they are clear and reasonable for the timeframe of the project
- the responsibilities of teams and individuals
- the business areas that will be impacted during implementation.

Within the plan identify the requirements for each step in the CCM process. This provides clarity on the resources needed to achieve the expected outcomes. This includes:

- timeline for the project, and for each step of the project
- finance needed to support the project, and a mechanism to track spend throughout the project
- project approach, which depends on the size and scope of the project that an organisation deems most appropriate – this could include regional rollout, or site-specific pilot project (a pilot project should be considered to address the project challenges and barriers to implementation, as well as how to better realise the benefits of the CCM process)
- human resourcing requirements, such as who and how many people are involved at each stage of the project:
  - a dedicated project manager from startup through to completion
  - an internal project team dedicated full time to the project – the size of the team will differ between companies
  - subject-matter experts for technical matters and advice – some organisations will have internal expertise; however, others may require external expertise
  - for multi-site implementation, to maintain focus on the project, consider allocating personnel to be specifically dedicated to the CCM project full time – this will assist with site-specific implementation.

The CCM process is potentially a resource-intensive process. Ensuring that adequate resources are available is essential to the success of the project. Minimal resources will lengthen the timeline of the project and may result in further costs to get the project on track and impact on outcomes.

The project plan provides the governance framework for the process. As such the company's executive and governance bodies (including the board of directors) should review and agree to the project plan prior to the project startup.

Develop a detailed implementation plan. The detailed implementation plan is an essential to mapping the steps in the process. Use the project planning checklist (see Appendix C) to ensure the key items are included in the plan.

STEP 1 CASE STUDY

EAST COAST COAL'S PROJECT PLAN DEVELOPMENT

ECC embarked on planning the CCM process. First, ECC formed a working group to oversee the project that consisted of appropriate personnel with varying roles, expertise and levels of seniority.

The working group's first task was to define the objectives for the project. The group reflected on the company's vision and values to align the project's goals with their HSE strategy. Quantifiable targets were set to measure these goals. Benefits for the project were articulated.

It was decided early on by the working group that taking on this project all at once could be overwhelming, and so the group chose to implement the process at only one site for two MUEs to begin with before trying the CCM approach with the rest of the company.

A realistic timeline was created to reflect the significance of the task and the amount of resources required. This timeline included milestones to track progress.

Responsibilities were defined for the project. Because of the significance of the project, the CEO asked the COO to oversee the project. Appropriate staff were allocated to the project for the organisation as a whole as well as at the site-specific level. Groups within the organisation were identified to leverage specific skills or expertise. This step also involved noting areas where knowledge may be insufficient and external guidance would be required.

Overview of the project plan

Organisational context
The ECC's vision is to be a leading coal and metals mining company. The company's values include protecting the well-being of its employees and minimising its environmental impact.

Project aim
The project aim is to implement the CCM across the company.

Responsibilities
At a corporate level the CEO and board will provide oversight of the project, while the HSE manager is in charge of implementing the guidance. At the site level the site manager will be in charge of overseeing that the implementation occurs, while the site HSE manager will be in charge of implementing the controls and associated processes.

Business units Involved
At the corporate level, the business units involved will include the company CEO, board and HSE division. At the site level the site manager will ensure the implementation of the CCM framework while the site HSE manager will implement the controls and supporting activities.

Timeline
A pilot programme will seek to have a single critical control framework implemented within 36 months, and across the organisation in 48 months.

With the project plan in place, the working group began developing methods to identify and assess risks, identify controls and whether they are critical or not, and how to measure the impact of the project. The group recognised the importance of creating effective methods to identify critical controls as they would be applied later in the project. To support this, the working group engaged external expertise.

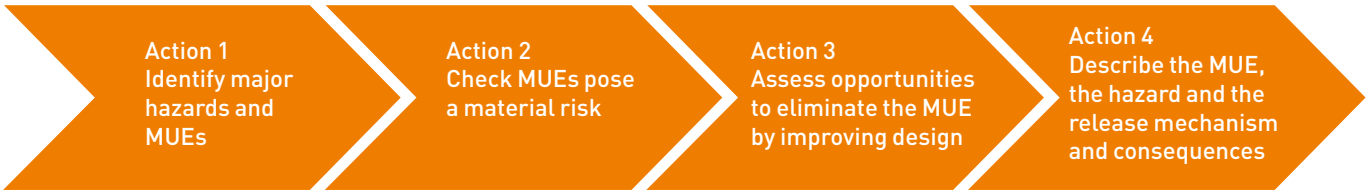
STEP 2: IDENTIFY MATERIAL UNWANTED EVENTS (MUES)

Target outcome

Identify the MUEs to be managed. Summarise the key information for each MUE.

This step will identify the major hazards and MUEs, then assess the known (and unknown) major hazards to check they are material to the company. This ensures the CCM process will target the most relevant MUEs. The step will consider if an MUE can be eliminated by improving design of the operation. The design improvements aim to reduce the likelihood of an MUE occurring, or the impact of the consequences, and thus remove the MUE as a material risk. The outcome of this step includes a "hazard description" document that summarises the key information of the MUE.

Actions to identify MUEs



Action 1: Identify major hazards and MUEs

The first step of the process is to identify the major hazards to the organisation and to identify MUEs to be controlled. In identifying the MUEs consider:

- reviewing internal documents for MUEs, such as existing risk assessments (often MUEs have already been identified but for a different purpose) – assess the relevance of these documents to the CCM process before using them
- reviewing the wider context for historical and foreseeable future events – consider reviewing recent global mining incidents for relevant MUEs, including associated companies that may have similar or relevant MUEs to your organisation, and consider reviewing industry news publications (eg Australian Mining)
- discussing different types of risks separately (eg underground risks may need to be considered separately to above-ground risks).

The major hazards and MUEs identified should be specific to your organisation but could be applicable to multiple sites.

Action 2: Check MUEs pose a material risk

The next step is to assess the identified MUEs to ensure they are a material risk. That is, if the MUE eventuates, it will impact the ability of the business to meet its core objectives. This can be done by defining materiality criteria, then applying these criteria to each of the MUEs. If the MUE meets a minimum number of criteria, it is deemed material. This action will provide assurance that the MUE should progress in the CCM process.

First, define the materiality criteria. This is the threshold that a risk must exceed before being considered a material risk. The materiality criteria will differ between organisations, so identify what your organisation considers as material to the business (eg the possibility of multiple fatalities or causing a shutdown and loss of production for more than 12 months).

Definitions of materiality may differ between companies due to the size and number of sites, operations, mine type, commodity and location of the operation. When defining the materiality criteria, consider what is the threshold a hazard needs to exceed to have a material impact on the organisation.

Second, apply the materiality criteria to each MUE. Work methodically through applying the criteria to each MUE. The MUEs that satisfy the criteria are material risks and progress to the next step. The MUEs that do not satisfy the criteria are not material and do not need to be managed by the CCM process. However, these MUEs may still need to be managed through other means. The list of MUEs should be reviewed periodically.

Action 3: Assess opportunities to eliminate the MUE by improving design

Assess each MUE for design opportunities that could eliminate it as an MUE. The aim of improving design is to reduce the likelihood of

an MUE occurring or the impact of the consequences, and thus removing it as a material risk. When assessing the opportunities for improved design consider:

- reviewing documents (such as maintenance documents, policies and procedures) to identify improvements
- reviewing the design improvement opportunities to determine if the MUEs are eliminated from the CCM – some improvements will be implemented while the process continues.

Action 4: Describe the MUE, including the relevant hazard, mechanism of release and the consequences

Summarise the information for each MUE in a document to provide context for others to understand the MUE. The development of the document should include staff that understand the MUE and the CCM process. At a minimum the description should consider:

- the background and importance of the MUE – this provides context of where it exists
- the mechanism of release of the MUE – in other words the factors that could initiate it
- the scope and boundary of the MUE – this is the systems and areas where it exists (and where it is not considered a risk)
- the potential consequences to people, environment, reputation, stakeholders, financial and any other significant impact on the organisation.

Once completed, review the document using appropriate personnel. This could be the personnel that assisted in Action 1 of this step, the CCM project manager or the prospective MUE owner (a person who will be identified in Step 6).

WHAT WERE THE MATERIALITY CRITERIA EAST COAST COAL DECIDED UPON?

The actions in Step 2 are:

- identify major hazards and material unwanted events (MUEs)
- check which MUEs were material
- assess opportunities to eliminate by design
- describe the MUE, the hazard, the release mechanism and consequences.

Of these only one proved difficult to decide upon in the working group. This was deciding what was meant by "material".

Materiality as a screening tool

The risk analyst provided some guidance, explaining that materiality was a concept used in enterprise risk management to define what events could stop a business from achieving its objectives. It was normally used to describe the most serious events. In the context of health and safety it was typically used to describe major disasters. The Pike River Mine explosions in New Zealand fell into this category whereas an individual fatality from an overturning bulldozer, while still tragic, would not normally be regarded as an MUE. Materiality is a description of a potential consequence from an event. It is used as a screening tool to decide which foreseeable health and safety events are the most important and should be included in the CCM process.

What about existing fatal risk controls and golden rules?

A member of the working group asked about the existing fatal risk controls. Why didn't these address MUEs?

The HSE manager said that this was an important question. The HSE manager agreed that there was some overlap. However, the fatal risk controls and golden rules were mainly focused on serious incidents that were unlikely to result in more than one or two fatalities at once. They were also focused on frontline worker behaviour. Prevention of MUEs such as underground fires, or health risks such as exposure to diesel particulate matter, also needed the right frontline worker behaviours but were also critically dependent on optimising the design of mine layout, equipment and systems and effectively implementing complex systems such as ventilation. Many of these sorts of controls were not easily monitored by behavioural-based systems as used to support frontline worker behaviours.

Materiality criteria

Following this discussion, the working group decided on two categories of materiality criteria:

- safety – incidents with potential consequences of three or more fatalities in any one event
- health – potential for serious impairment or death arising from repeated exposure to occupational contaminant(s) above the occupational exposure level.

STEP 2 CASE STUDIES

UNDERGROUND FIRE AND COAL DUST EXPLOSION HAZARD DEFINITION

This is a safety MUE example of the outcome from Action 4.

Background

Underground fire and coal dust explosions are a prevalent risk for all underground coalmining operations. These explosions typically occur from methane gas or from coal fines mixing with the underground atmosphere to form a combustible composition. Exposure to an ignition source can result in rapid combustion. When this combustion occurs in confined spaces, the sudden release in energy causes a shock wave to travel through the tunnels. Accumulated coal fines may become airborne from the shock waves, which leads to further explosions. Severe damage to equipment and/or personnel and death can result from the pressure wave or from shrapnel carried by the shock wave. Personnel may also experience injury or death from the radiant heat of combustion, or asphyxiation from the depletion of oxygen. Other consequences of these events include financial losses from equipment damage, litigation or process shutdown.

Scope

This hazard exists where coal fines are present – in particular, underground mining and surface operations for brown and black coal. This hazard may also exist when mining other commodities in an underground environment depending on the surrounding geology and methods.

Boundary

Underground activities, associated activities (such as maintenance) and systems that support underground operations (eg ventilation, electricity supply, water supply, etc).

Potential consequences

Immediate damage, injuries or death from the event. Secondary consequences such as mine collapses will be treated as a separate hazard (but give consideration to underground explosions as a cause). Longer-term consequences may include lost production, processing delays or shutdown.

DIESEL PARTICULATE MATTER OVEREXPOSURE HAZARD DEFINITION

This is a health MUE example of the outcome from Action 4.

Background

Diesel particulate matter (DPM) is a complex mixture that makes up diesel exhaust. Organic compounds, sulphates, nitrates, metals and other toxins form a cohesive layer on the particulate. This particulate is able to bypass the body's natural defences and become lodged in the lungs. It has been recognised as an occupational hazard to miners, particularly in underground operations. While diesel exhaust contains many known carcinogens, DPM has recently gained prominence as a particular concern. This is in response to the 2012 study by the International Agency for Research on Cancer reclassifying DPM as carcinogenic to humans (Group 1). This was reinforced by the Diesel Exhaust in Miners Study by the US government that examined over 12,000 miners and found an increased risk of lung cancer.

Scope

This hazard exists in underground environments with low or poor ventilation in which vehicles or machinery emit diesel particulate – in particular, underground workshops that undertake vehicle maintenance.

Boundary

Any confined space where operators and diesel particulate are in a confined space.

Potential consequences

Immediate and long-term health effects from DPM exposure (such as cancer). Because of its carcinogenic properties, the consequences of the exposure may take years to develop.

STEP 3: IDENTIFY CONTROLS

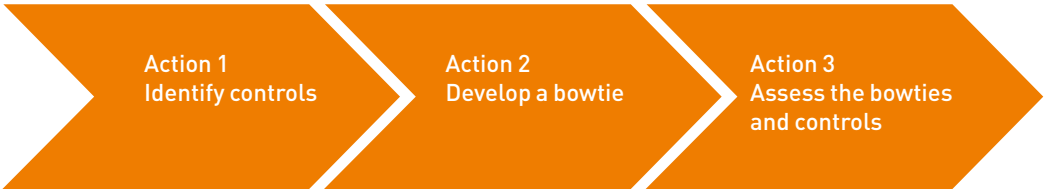
Target outcome

Identify controls for each MUE, both existing controls and possible new controls, including the preparation of a bowtie diagram.

Step 3 identifies all the controls (existing and possible) for each MUE, and then Step 4 identifies the critical controls. A control is defined as an act, object (engineered) or system (combination of act and object) intended to prevent or mitigate an unwanted event. The tools provided within the Good Practice Guide can help identify the known and possible controls.

Once identified, controls are then used to develop a bowtie diagram for each MUE. A bowtie diagram is a method to illustrate the linkages between the potential cause of an incident, or risk, and the relevant controls (more information on the bowtie can be found in the Good Practice Guide Appendix B).

Actions to identify controls



Action 1: Identify controls

In Action 1 identify the controls for each MUE, in particular the controls that will prevent the event from occurring or mitigate the consequences. Controls can be administrative or engineering based. However, some engineering controls have a human or administrative element to ensure that they are working correctly. When identifying controls consider the following.

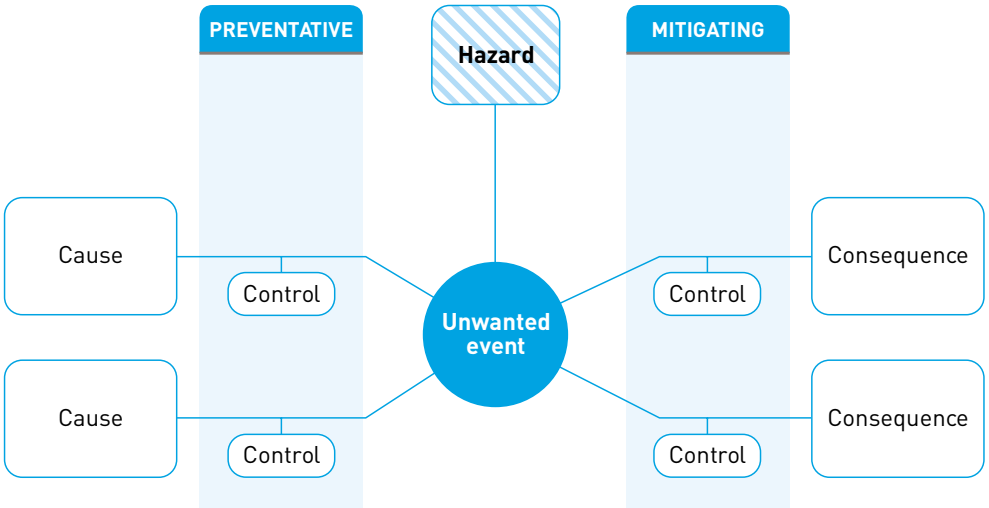
Identify existing controls
Often controls are already identified within existing company documents. Seek guidance from staff that have MUE or control knowledge as they will be most familiar with the company's internal documents. As a starting point it is useful to review:

- internal risk assessments and bowties
- internal maintenance procedures and standard operating procedures
- legislation that may contain general control advice – legislation may have associated guidance or standards (eg environmental standards) containing controls; controls should not be copied from standards as they need to be critically assessed for relevance to the MUE
- risk assessments from associated companies or industries with similar operations and MUEs – for example, there may be common risks and controls between solvent extraction plants.

Tools to help identify controls
Use the decision tree (see Figure 3) and following questions to help decide on what is or is not a control. It is common to identify many controls, some that will not be suitable for the CCM process. Consider the following:

- Is the control specific to preventing an MUE or minimising its consequences?
- Can you specify the required performance of the control?
- Can the control's performance be verified?

Figure 2: **A simple bowtie diagram**



Action 2: Develop a bowtie

Once all the controls are identified, develop a bowtie (see Figure 2). A bowtie summarises the main controls that companies should have in place to prevent unwanted events. Bowties are a popular method to illustrate the linkages between the potential cause of an incident, or risk, and the controls that can be put in place. These controls can either prevent the initial incident and/or mitigate the consequences once it has occurred.

There is no one right way to develop a bowtie. However, this is a critical stage and the bowtie should be prepared by careful reference to the definitions in Appendix A. The Good Practice Guide contains information on bowties in Appendix B. The important steps in completing the bowtie are starting with the MUE, and considering the following:

- What are the possible causes that could lead to the MUE?
- What controls are in place (or could be put in place) to prevent the cause leading to the MUE?
- What are the maximum foreseeable consequences of the MUE?
- What controls are in place or could be introduced to reduce the possibility of the consequences occurring?

The use of software can be helpful to develop bowties (such as BowTieXP, BowTie Pro or Microsoft Visio).

When developing the bowtie and selecting critical controls (Step 4), it may be useful to undertake this as an iterative process. This is because the selection of critical controls will assist in refining the bowtie.

Action 3: Assess the bowties and controls

Assess the bowties and controls to ensure they are appropriate and relevant for each cause and/or consequence, and against the hierarchy of controls. This assessment should check that there is not an overdependence on one type of control (for example people, engineering, etc).

STEP 3 CASE STUDY

HOW DID THE ECC IDENTIFY CONTROLS?

The ECC working group set out to identify the controls needed to prevent the MUE from occurring or to mitigate its consequences. The working group gathered a range of technical, operational and project knowledge, including HSE staff and asset management and maintenance staff to identify the controls for each MUE. A workshop was held to bring this information together.

For the underground fire and coal dust explosion MUE, the working group consulted internal experts for ventilation, technical services team, subject-matter experts, underground electrical engineers and the HSE manager. Before the meeting each individual reviewed internal documents for potential controls within their area, which consisted of existing risk assessments, safety documents and safety standards to identify actions, systems, processes or equipment that could control the MUE.

For the diesel particulate matter overexposure MUE, the working group consulted the vehicle's manufacturer, HSE staff in particular occupational hygiene expertise, manager for safety, the vehicle maintenance team and the ventilation officer.

The causes and consequences of the MUEs were identified and all the controls that could be implemented to prevent and mitigate the MUEs. The control identification decision tree from the Good Practice Guide (see Figure 3 below) was used to help identify what is a control.

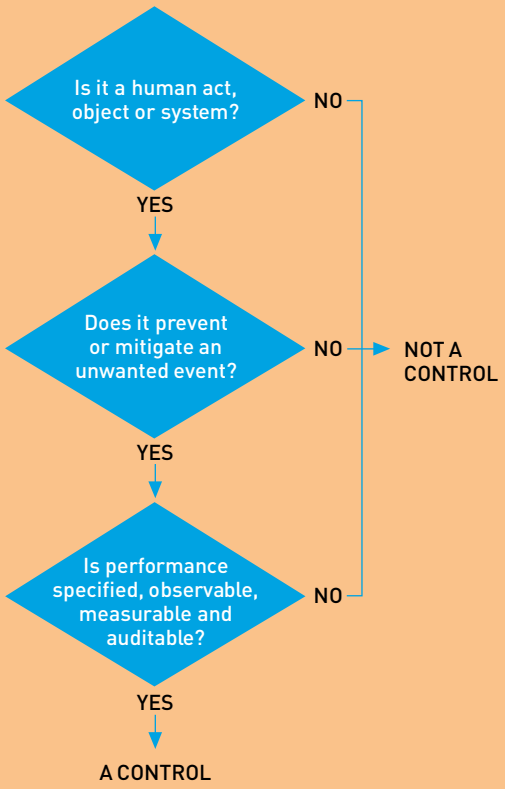
The group developed a bowtie diagram for each MUE (see Figures 4 and 5).

The working group identified a very large number of possible controls (over 60 controls), especially for the underground fire and coal dust explosion MUE. This is normal, and as the bowtie (see Figure 2) shows, there is a wide variety of types of controls (or potential controls). These ranged from very specific controls such as "water sprays on shearer head" to wide-ranging systems (eg "ventilation system") or checking or monitoring processes such as "inspections".

This is a normal and necessary step in the CCM process. However, managing a large number of controls, not all of which are clearly defined in terms of their importance or criticality, is very difficult to do in practice – hence the importance of the CCM process. The next step (Step 4) explains the process to determine which of the controls are critical controls.

Note that the bowties only show a sample of the controls and potential controls identified. These are commonly identified controls and have all been taken from bowties kindly supplied by ICMM member companies. As the bowties only contain a sample of controls, blank spaces have been left to signify other threats, consequences and controls. A "quick guide" to reducing the number of controls has been included in Step 4.

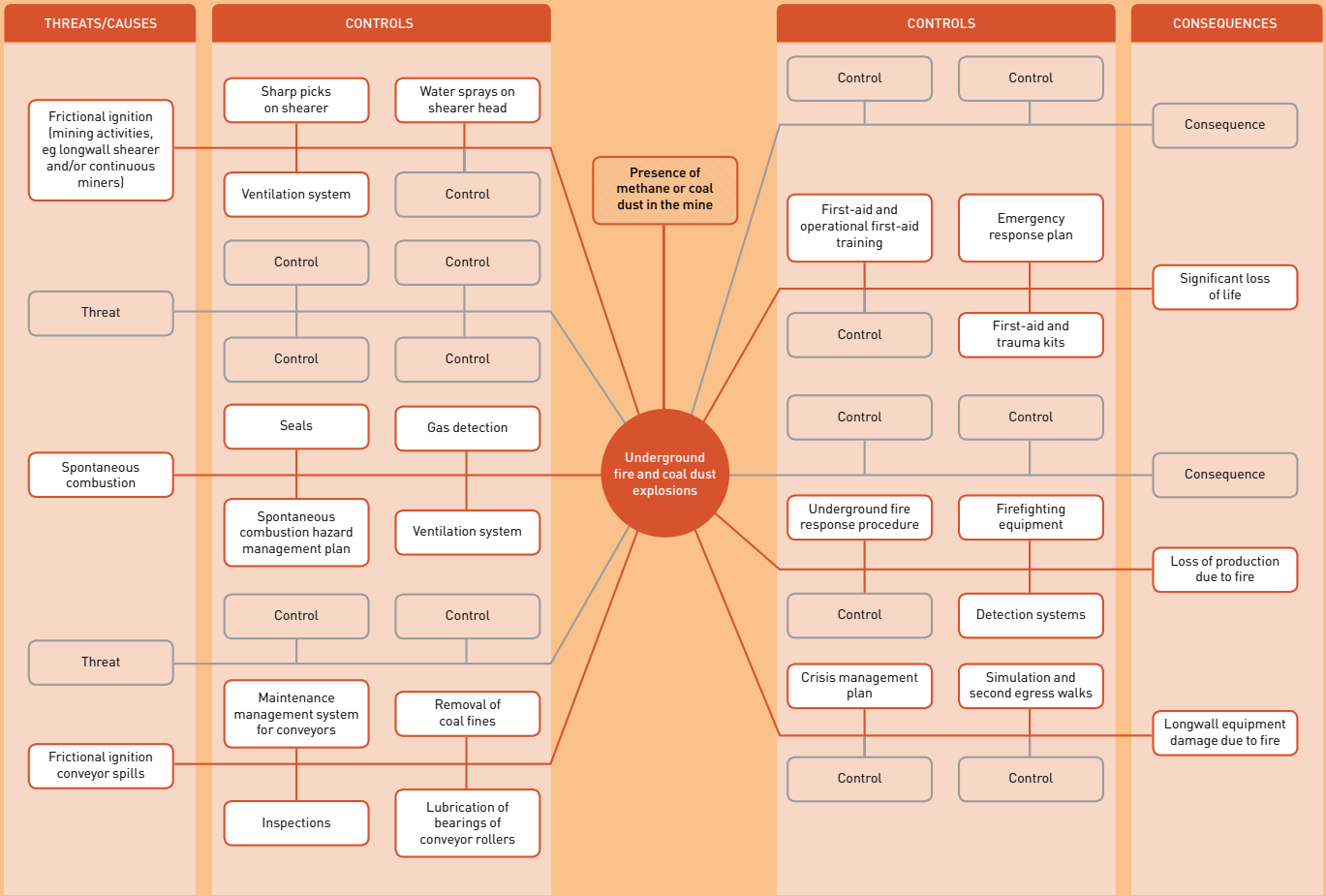
Figure 3: Control identification decision tree
(Figure 2 in the Good Practice Guide page 10)



Source: M. Hassall, J. Joy, C. Doran and M. Punch, Selection and Optimisation of Risk Controls. ACARP report no C23007, 2015. Available at www.acarp.com.au/reports.aspx.

STEP 3 CASE STUDY

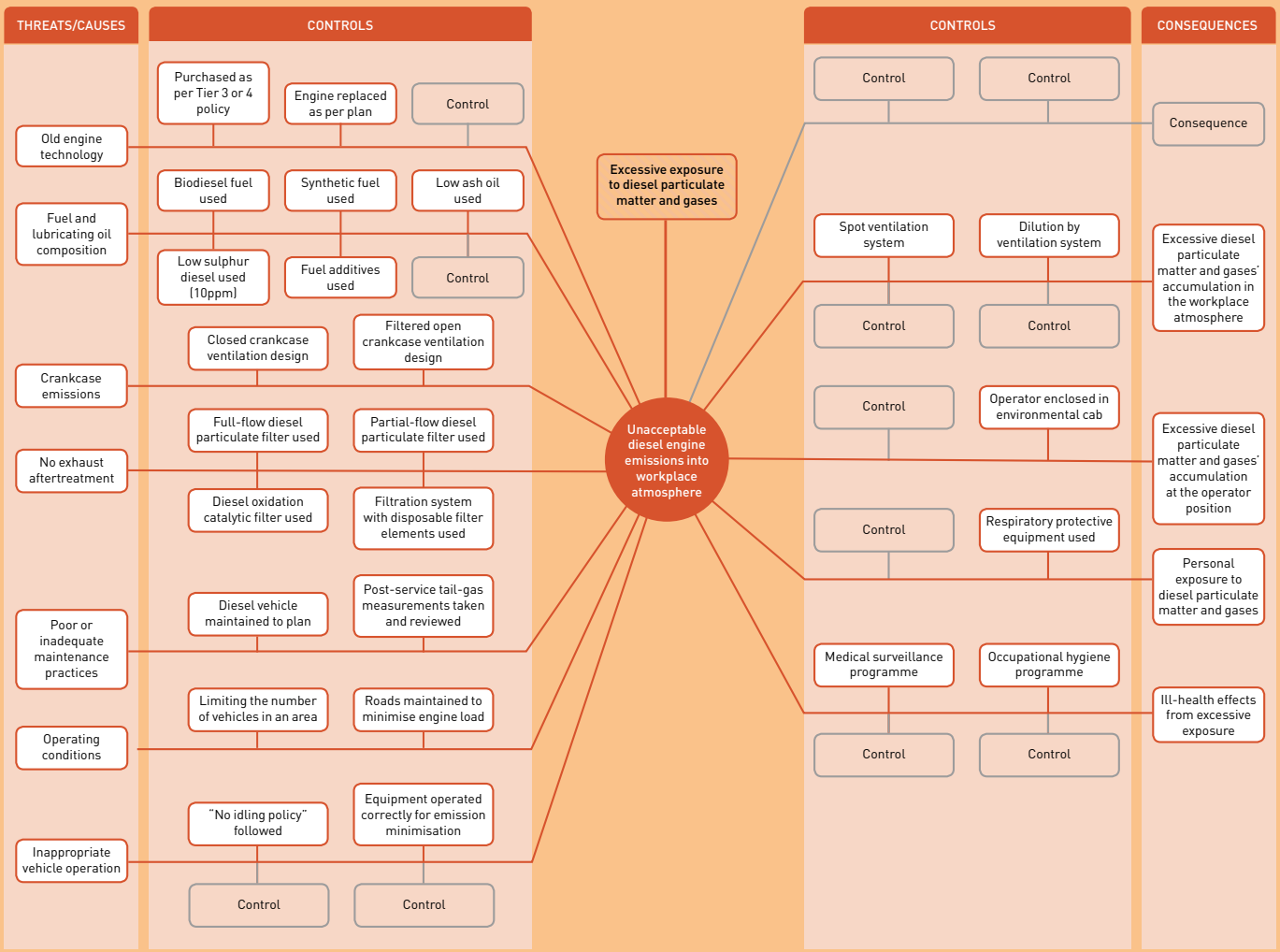
Figure 4: Underground fire and coal dust explosion bowtie*



Note: *Controls in this bowtie have not been assessed for validity (ie bowtie includes some non-controls)

STEP 3 CASE STUDY

Figure 5: Diesel particulate matter overexposure bowtie*



Note: *Controls in this bowtie have not been assessed for validity (ie bowtie includes some non-controls)

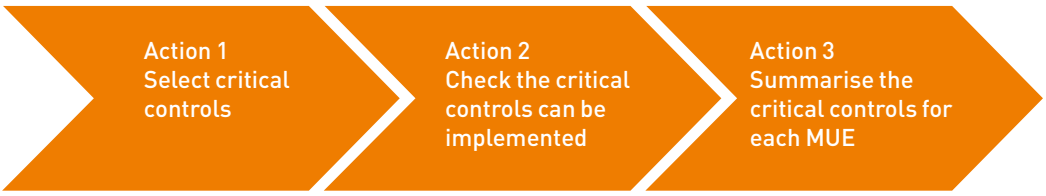
STEP 4: SELECT THE CRITICAL CONTROLS

Target outcome

Select the critical controls for the MUE. Summarise key critical control information.

Step 4 selects the critical controls from the controls identified in Step 3. Critical controls are controls that are crucial to preventing, or mitigating the consequences of, an MUE. The absence or failure of a critical control will significantly increase the risk of an MUE occurring, despite the existence of the other controls. The tools provided in the Good Practice Guide help select critical controls and identify activities to verify the control, and the performance requirements of the control.

Actions for selecting critical controls



Action 1: Select critical controls

Selecting the critical controls involves assessing all the controls on an MUE bowtie to identify if they are critical. The CCM process is a control-focused approach. Selecting the critical controls is an important step. When selecting the critical controls consider how you identify them.

The BHP Billiton decision tree (see Appendix D) can help assess if a control is a critical control. It can also be useful to consider the following questions:

- Is the control crucial to preventing the event or minimising the consequences of the event?
- Is it the only control, or is it backed up by another control in the event that the first fails?
- Would its absence or failure significantly increase the risk despite the existence of the other controls?
- Does it address multiple causes or mitigate multiple consequences of the MUE? In other words, if it appears in a number of places on the bowtie or on a number of bowties, this may indicate that it is critical.

Action 2: Check the critical controls can be implemented

Check if the critical controls can be implemented by asking if they can be actively monitored (see Step 8). Active monitoring refers to the process of checking the extent to which the performance requirements, set for a critical control (identified in Step 5), are being met in practice. In other words, can the critical controls be checked that they are working as intended, and how can this be done? To assess whether the critical controls are implementable, consider the following:

- What are the performance requirements of the critical control? If unsure, is it easy to find out what the performance requirements should be?
- How is the critical control going to be verified? What activities will support verification?

If you cannot clearly answer these questions, this control might not be implementable and therefore not a critical control.

Action 3: Summarise the critical controls for each MUE

Collate a list of critical controls for each MUE. These critical controls will be used to manage the MUE risk and will progress through the CCM process. Summarise the key information for each critical control. At a minimum consider:

- the hazard
- the threats
- the critical control name.

STEP 4 CASE STUDY

HOW DID EAST COAST COAL DECIDE WHAT CONTROLS WERE CRITICAL?

The ECC working group found that they had a large number of equipment, procedures and systems that could potentially be regarded as controls. They had to identify which of these were critical to justify the extra rigour to define and monitor the controls and report on how well they are working in practice, as required by the CCM process.

Good Practice Guide questions

The working group worked through the Good Practice Guide guidance, including asking:

- Is the control crucial to preventing the event or minimising the consequences of the event?
- Is it the only control, or is it backed up by another control in the event the first fails?
- Would its absence or failure significantly increase the risk despite the existence of the other controls?
- Does it address multiple causes or mitigate multiple consequences of the MUE?

Using the critical control decision tree – independence of controls

The working group also used the decision tree from the Good Practice Guide, reproduced here in Appendix D. The working group found that this was useful in helping to decide whether or not a control was critical. However, there was a vigorous debate in the working group over the meaning of "independence". The final question in the decision tree asks, is control independent? What does this mean?

One member of the working group said that none of the controls at a site or within the same company could be regarded as totally independent as they all operated within the same management system. In this sense they could be said to be interdependent. Although this view had merit, after discussion it was decided for the purposes of deciding on critical controls independence would be interpreted in a narrower sense. For example, the water sprays on the shearer head (to minimise risk of ignition of flammable gas) was a control that operated independently of ensuring the picks of the shearer were maintained at a defined level of sharpness to minimise sparks.

East Coast Coal's short cut

The working group also found they could develop some questions to help them filter the controls. They appear below but require care in their use. They found asking these questions prompted productive discussion on whether or not something was a control or not.

These are the questions they used:

- Is the control described as a monitoring, verification, quality assurance or inspection activity? Is the monitoring or inspection activity really the control or is it the thing or process being inspected? For example, if inspection of a pressure relief valve is described as a control, is it the inspection activity or the valve itself that is the control?
- Is the control about training or competence? If so, consider removing all controls that refer to competent operators or training. Nearly all controls require competent people to operate, inspect or maintain them. Training and competence is of course important and often a legal requirement. However, if all training and competence requirements are added to bowties, they can become very complex as nearly all controls require a degree of training and/or competence. Most companies have systems and processes to manage competence. A note can be added to the bowtie to explain this topic is not included on the bowtie.
- Is the control described as a system? For example, ECC found that the maintenance management system or ventilation system often appeared as a control. However, these proved to be too general a description for a critical control. For example, there were many thousands of items in the maintenance management system. Applying this question led to a productive discussion that focused on identifying the equipment and the maintenance activity that was critical to preventing or mitigating the MUE.
- Is the control described as a plan? Trigger action response plans and hazard management plans were also treated in the same way as systems. They may be controls or have specific aspects that should be regarded as critical. Asking the question helped to decide this.

STEP 4 CASE STUDY

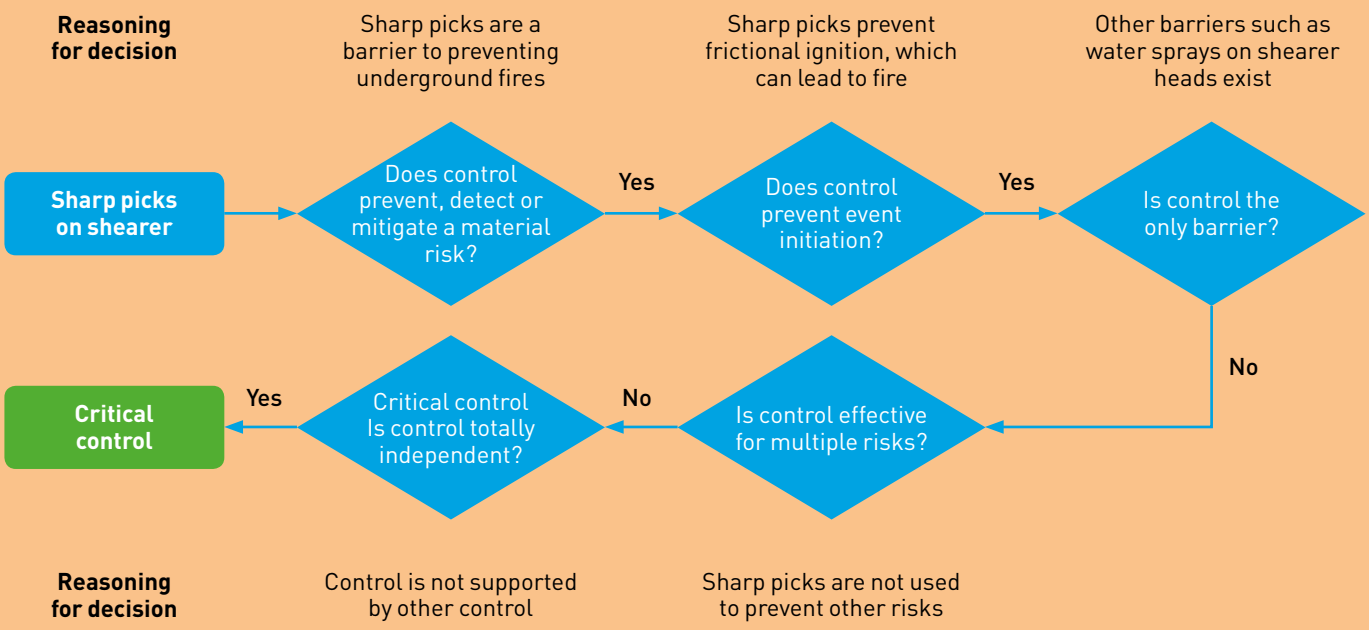
Critical control selection assessment for "sharp picks on shearer"

The control "sharp picks on shearer" was analysed with the BHP Billiton decision tree tool (see Appendix D) to help assess if it was a critical control. Figure 6 shows the reasoning. This control is related to the MUE for underground fire and explosion.

This logic should be applied to the remaining controls that had been identified in Step 3.

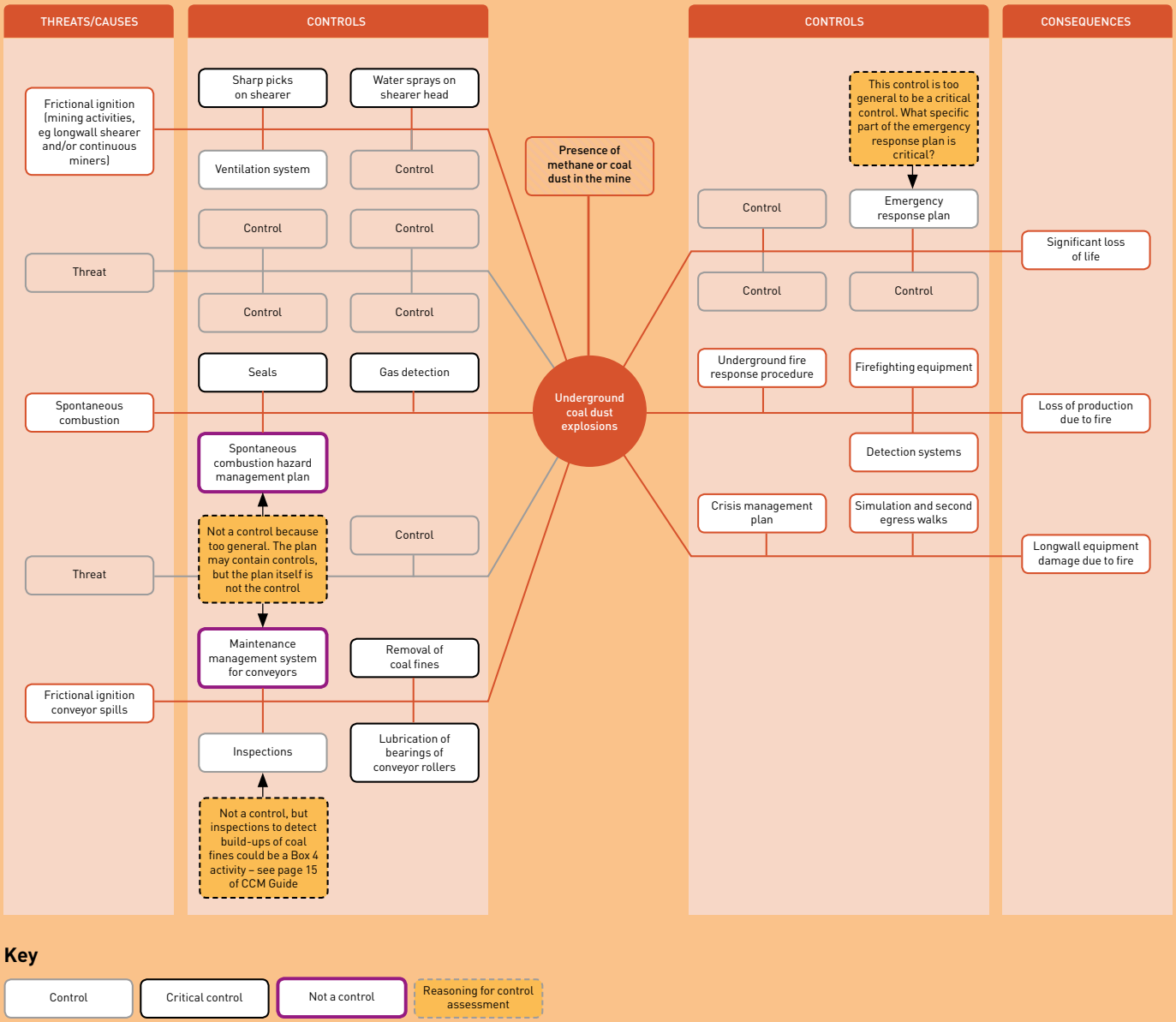
An example of a bowtie for MUE for underground fire and explosion that contains the reasoning behind the critical control assessment is shown in Figure 7.

Figure 6: Assessment of the control "sharp picks on shearer" using the BHP Billiton critical control decision tree tool and reasoning for each decision point



STEP 4 CASE STUDY

Figure 7: Underground fire and coal dust explosion bowtie



STEP 4 CASE STUDY

Critical control selection assessment for "diesel particulate filter" and "'no idling policy' followed"

The examples shown in Figures 8 and 9 demonstrate the reasoning to determine the controls are critical. Again, this was using the BHP Billiton decision tree (see Appendix D) for critical control selection.

These controls relate to the MUE for diesel particulate matter overexposure.

This logic was applied to the remaining controls that had been identified in Step 3.

An example of a bowtie for MUE for diesel particulate matter overexposure that contains the reasoning behind the critical control assessment is shown in Figure 10.

Figure 8: Assessment of the control "diesel particulate filter" using the BHP Billiton critical control decision tree tool and reasoning for each decision point

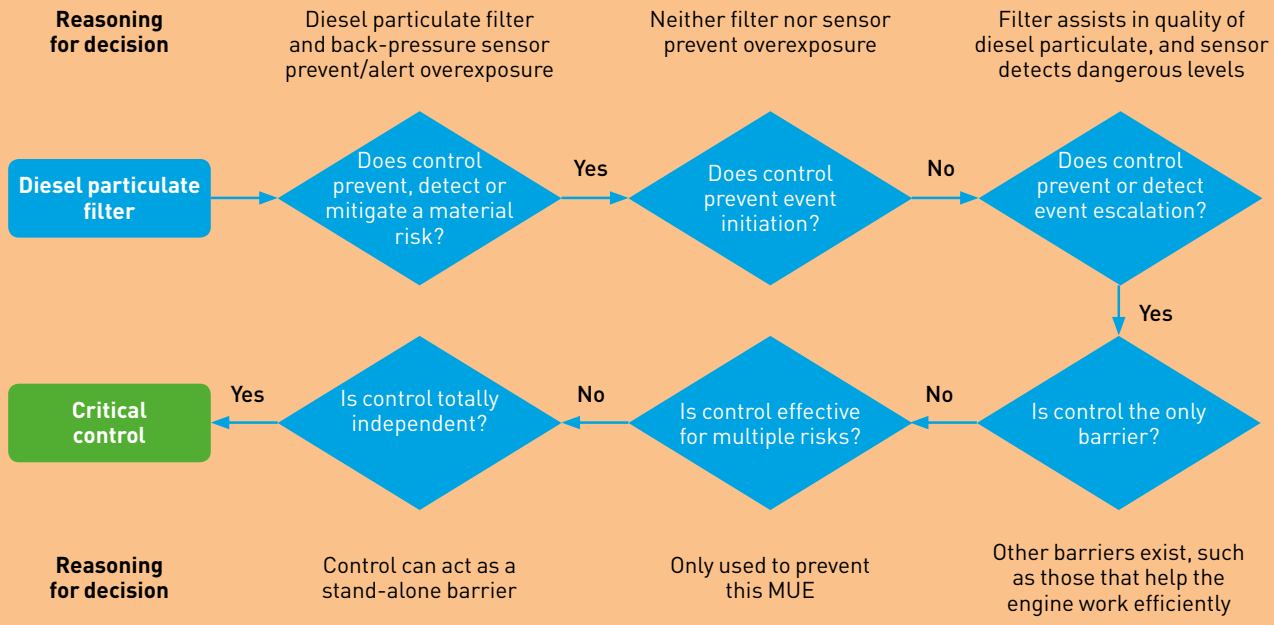
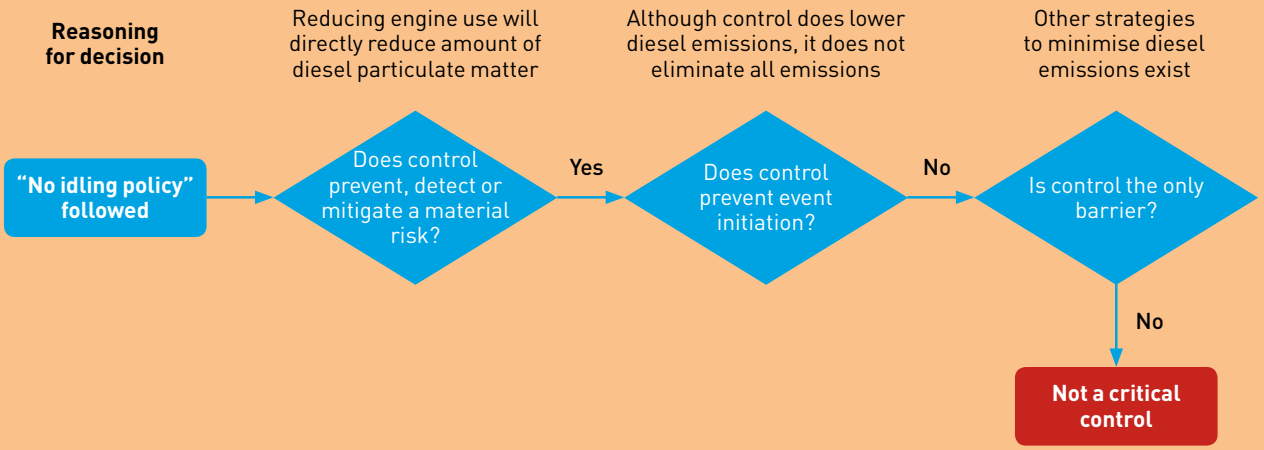
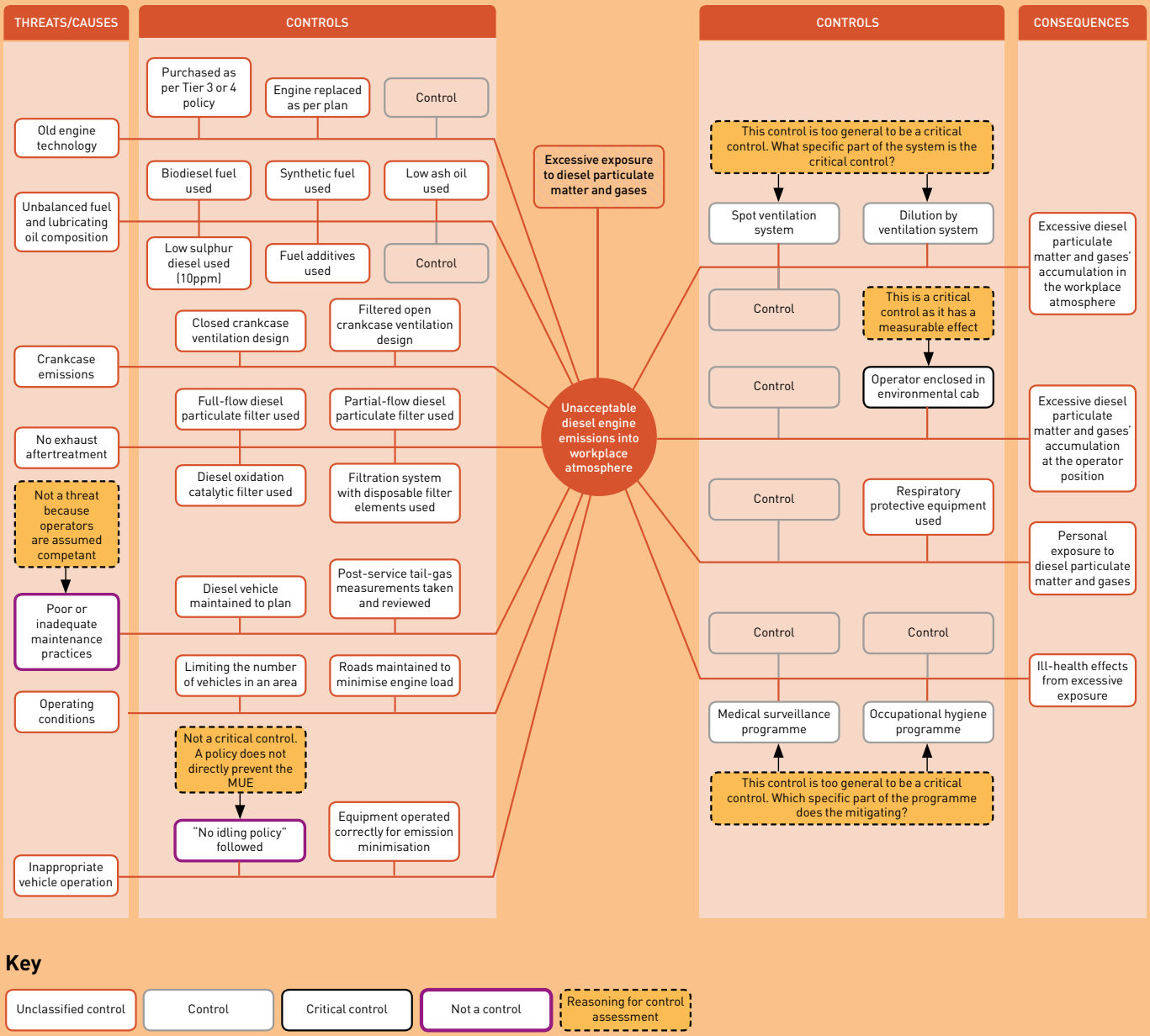


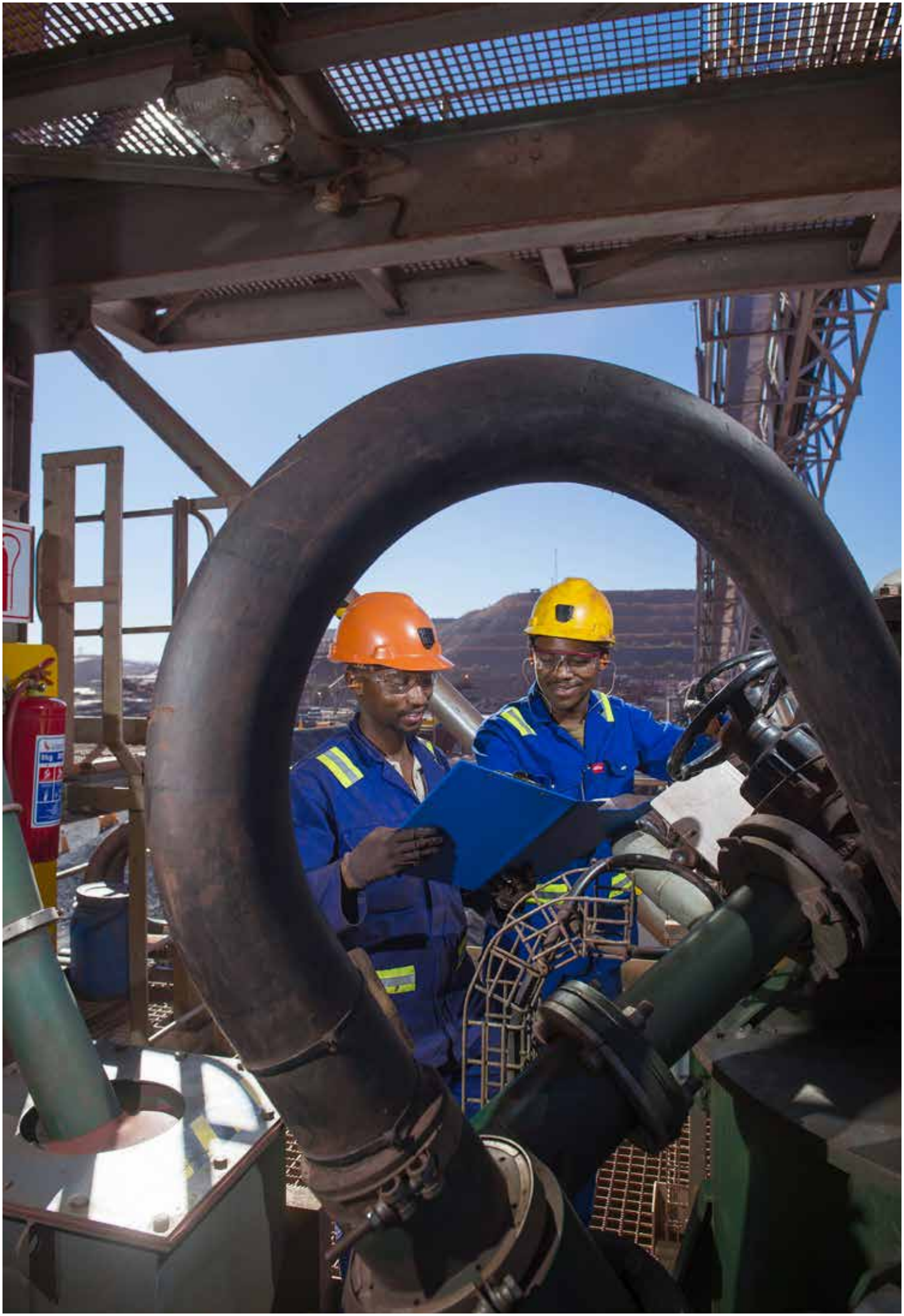
Figure 9: Assessment of the control "'no idling policy' followed" using the BHP Billiton critical control decision tree tool and reasoning for each decision point



STEP 4 CASE STUDY

Figure 10: Diesel particulate matter overexposure bowtie





STEP 5: DEFINE PERFORMANCE AND REPORTING

Target outcome

Define the critical controls' objectives, performance requirements, and how performance is checked in practice. Summarise this information.

Step 5 defines the critical control objectives and the performance requirements for each critical control. This is the minimum performance required from the critical control to ensure its effectiveness in mitigating an MUE risk. This step identifies activities that will impact critical control performance. These activities provide an understanding of how a critical control can be verified in practice and a mechanism to monitor the health of a critical control.

Actions for defining performance and reporting

Action 1: Define the critical control objective

Defining the objective of the critical control will help understand the role, expectations and outcomes of the control. The critical control objective is a specific description of what the control is required to do. For example, for the critical control titled "probe calibration", the critical control objective is the calibration of the pH and EC probes. To help define a critical control's objective, consider:

- What is the outcome you are trying to achieve by implementing this critical control?
- How will the critical control prevent the MUE?

Action 2: Define performance requirements for the critical controls

The performance requirements are the standards to which a control has to perform. A control's performance requirement should consist of an action (such as to prevent, to maintain, etc) and a value (such as 0.1mL above the critical level, 50% of capacity, etc). A performance requirement needs to consider the context of the control, meaning that a tank holding diesel may have different integrity performance standards to an identical tank holding acidic slurry. An example of a performance standard for the control of a bunded area around a tank could be to hold 90,000 litres, which is 110% of the volume of the tank.

Performance requirements for a control may already exist within company documents. This can be determined by reviewing the relevant processes, procedures, maintenance manuals and other support documents. Industry standards may also help to determine performance requirements. However, caution should be applied as industry-wide standards may not be specific or relate directly to the context of the control. When no performance requirements exist for a critical control, they must be developed. If this is the case, the performance requirements should consider being:

- specific – requirements should be clearly defined and not vague
- measurable – performance requirements should be quantifiable wherever possible
- appropriate – the performance requirements should align with the critical control objective (as defined in Action 1)
- realistic – requirements should be achievable in the operating context.

The final component of this action is to define a critical control's level of performance that would initiate immediate action to shut down or change an operation, or signal that improvements to the critical control are required. The process for defining these performance levels is the same as the process for identifying performance requirements above.

Action 3: Identify activities that impact critical control performance

To maintain the health of a critical control, identify what activities impact its performance, and support or enable the critical control. When looking for information to review these activities consider:

- reviewing existing processes, procedures and maintenance manuals for day-to-day activities and tasks – speak with personnel that work closely with the control and are involved in supporting activities (they will have knowledge on how these activities are conducted and their relevance to critical control performance)
- list the activities that support, improve and impact the performance of the critical control – by knowing what reduces its performance allows the management of the activities.

Action 4: Define verification or "checking" activities

Verification is the act of checking, or "actively monitoring", that the activities that support and improve critical controls are completed to an acceptable level. For each critical control, identify what is required from verification.

This provides high-level guidance for later steps that will identify how the verification is done in practice and on-site (Step 7), then carrying out the verification activity on-site (Step 8). It can be useful to identify these verification requirements while reviewing the documents and speaking with personnel involved in Actions 1–3 of this step. In addition, consider:

- what checking is needed to verify the critical control is meeting its required performance
- how frequently does checking need to occur
- what type of checking is needed (ie inspection, review logs, review monitoring system, etc).

The outcomes of the verification activities should be reported up the ownership chain on a regular basis. The detailed reporting structure is defined in Step 6. At the end of Step 5 complete a control information summary for each critical control. The control information summary is a guide only and can be adapted to suit individual organisation needs.

STEP 5 CASE STUDY

HOW DID EAST COST COAL DEFINE ITS PERFORMANCE?

The working group decided the most effective way to complete this step was through a workshop that included those personnel who knew about the critical controls in practice such as first-line supervisors. The objective of the workshop was to determine the level of performance required for each critical control.

The group also worked out how to assess the performance of the critical control. The group summarised this information in a table – a critical control information summary.

Below are examples of the critical control information summaries for a critical control for the:

- underground fire and coal dust explosion MUE (see Table 1)
- diesel particulate matter overexposure MUE (see Table 2).

Table 1: "Sharp picks on shearer" critical control information summary

1 What is the name of the critical control for underground fire and coal dust explosions?		
Sharp picks on shearer		
2 What are its specific objectives related to the MUE?		
To reduce the risk of ignition of flammable mixture by reducing the friction between the shearer and rock		
3 What are the critical control performance requirements to meet the objectives?	**4 What are the activities that support or enable the critical control?**	**5 What activities can be checked to verify the critical control performance?**
Picks are sufficiently sharp to reduce the risk to prevent sparking	A template of acceptable pick profile is developed	Picks inspected against the template
	Shearer picks are visually inspected pre-shift to assess their condition	Review of inspection records weekly
	Regular maintenance is carried out on shearers	Review of maintenance and replacement records monthly
6 What is the target performance for critical control?		
Picks meet the acceptable pick profile template, between markers 3 and 5. Picks outside this range are replaced.		
6 What is the critical control performance trigger for shutdown, critical control review or investigation?		
5 per cent of inspections indicate that the picks are beyond threshold condition for use.		

Table 2: "Diesel particulate filters" critical control information summary

1 What is the name of the critical control for diesel particulate matter overexposure? Diesel particulate filter		
2 What are its specific objectives related to the MUE? Reduce diesel particulate levels in the workplace atmosphere to below the occupational exposure limit.		
3 What are the critical control performance requirements to meet the objectives?	**4 What are the activities that support or enable the critical control?**	**5 What activities can be checked to verify the critical control performance?**
Filter housing/ductwork maintained so that particulates are collected and not allowed to bypass	Pre-shift filter housing/ducting inspected for damage at pre-start, and maintenance conducted if required	Review pre-start inspection records and confirm maintenance conducted when required.
Back-pressure sensor alarms when back pressure on filter exceeds critical level	Diesel exhaust back-pressure sensor is calibrated to ensure it detects back-pressure at the correct set-point	Review calibration records to ensure that the back-pressure sensor is working within tolerance limits.
Engines maintained to maximise filter life	Electronic fuel engine management systems (EMS) – EMS is monitored by operations and maintenance personnel Maintenance is conducted following detection of below-standard performance by EMS	Sample x% of EMS reports identifying faults, and check that maintenance was conducted and in accordance with original equipment manufacturer (OEM) specifications.
	Manual fuel injection systems – opacity testing of exhaust emission conducted every 28 days. If opacity test fails (exceeds set-point of xmg/m3), carry out required maintenance – clean/replace engine air inlet filter; clean flame trap, check valve clearance, replace injector(s), compression test, replace diesel pump, clean/replace diesel particulate filter	Sample x% of opacity test reports exceeding set-point, and check that maintenance was conducted and in accordance with OEM specifications.
6 What is the target performance for critical control? Maintenance requirements identified are conducted 100% of the time, and back-pressure sensor calibration is within tolerance for 100% of tests		
7 What is the critical control performance trigger for shutdown, critical control review or investigation? Diesel particulate filter housing/ductwork damaged, or back-pressure sensor alarm triggered		

STEP 6: ASSIGN ACCOUNTABILITY

Target outcome

Develop a list of the owners for each MUE, critical control and verification activity. Develop a verification and reporting plan to verify and report on the health of each critical control.

Step 6 assigns accountability or "ownership" for each MUE, critical control and verification activity, from the site level to the company board. This includes outlining the responsibilities of each owner, including reporting responsibilities.

Actions to assign accountability

Action 1: Assign ownership and reporting accountabilities

Ownership for each MUE, critical control and verification activity should be assigned to specific roles or positions within the organisation. These "owners" are responsible for ongoing assurance in managing their allocated task. They also form the basis of CCM governance through the line of reporting. Identifying owners will depend on an internal company structure and the tasks being assigned. Suggested owner responsibilities are outlined in Table 3, which indicates the role within CCM, an indicative title this owner may hold within the company and the responsibilities of the owner.

The line of accountability is also outlined in Table 3, from the verification owners to the leadership team and board of a company. Each tier within the line of accountability includes additional governance responsibilities for CCM than the tier below it. This provides a robust governance structure that includes all levels of ownership.

The high-level reporting requirements are also outlined in Table 3. The products of each report, and the frequency of each review period, are outlined as part of each tier's responsibilities. This can be used to define a verification and reporting plan as outlined in the Good Practice Guide.

Table 3: Ownership and reporting responsibilities

	Role in CCM	Title		Responsibilities
Corporate level		Board		Receive reports from leadership team biannually
		Company leadership team	Chief executive officer	Discuss MUE health and critical controls on a quarterly basis
			Chief operating officer	Receive and collate MUE and critical control reports from all company sites, and produce corporate reports
Site level	MUE owner	Site/mine manager		Monitor and review monthly reports on MUE and critical control health, and feed up to company leadership team
	Critical control owner	Line manager		Report on critical control health to MUE owner weekly
	Verification activity owner	Supervisor		Undertake or oversee verification activities, and provide regular reports of activity to the critical control owner

STEP 6 CASE STUDY

REPORTING ON CRITICAL CONTROLS AND MUES WITHIN EAST COAST COAL

The working group decided to define reporting from the mine site all the way to the board. This included:

- who would report on critical controls and MUEs
- what would be reported
- to whom
- the frequencies for doing this.

There was some discussion about whether the working group should do this amid concern that they could be seen to be overstepping the mark by telling the leadership team and board what to do. The project sponsor, the COO, was asked for advice. The COO said that neither the leadership team nor the board knew what they needed to do, but would appreciate the working group identifying what they thought was appropriate.

The working group worked on the basis that MUEs should not receive any less prominence in reporting within the organisation than material enterprise risks or other types of health and safety. Table 3 illustrates who reports on what, to whom and the frequencies for doing this.

This proposal was accepted by both the leadership team and board with the proviso it would be reviewed after 12 months' experience.

STEP 7: SITE-SPECIFIC IMPLEMENTATION

Target outcome

For each MUE define a verification and reporting plan. Develop a strategy to implement the CCM at the site level.

Step 7 describes how the CCM process can be implemented on the site level. This involves tailoring the previously completed CCM process steps (Steps 2–6) to include site-specific detail. This requires adapting the MUE hazard descriptions (Step 2), control and critical control identification (Steps 3 and 4), critical control information summaries and verification and reporting plans (Step 5), and assigned "owners" to the site level (Step 6).

Actions for site-specific implementation

Step 7 should be implemented by a site-specific team with oversight from a corporate level (eg the CCM process manager). Consider training the site manager and leadership team early in the CCM process and involving them in as many actions in this step. Consider allocating one full-time staff member at each site to aid implementation.

Action 1: Tailor the CCM process to the site level

Tailoring the documents from the previous CCM process steps ensures the process can be implemented at a site level. This considers site-specific context, processes and assets.

Sites should review the key documents developed in the CCM process so far. To tailor these at the site level, consider engaging site-based personnel that work in the areas relevant to the MUE, controls or verification activities. This may include line managers, supervisors and operators. Feedback from these positions will ensure the process is implementable on-site.

The critical control information summary (Step 5) is the key document to be tailored and will ensure site-specific concerns are included. The control information summary for each critical control should be reviewed. Particular attention should be focused on the:

- critical control objective
- critical control performance information
- verification activities.

A full list of documents developed through the process that could be reviewed and tailored is listed in Table 4.

Once this action is complete, this set of documents is the "site-specific MUE control strategy".

Action 2: Review the site-level CCM strategy

The documents tailored in Action 1 should be reviewed by the CCM manager at the corporate level. This ensures consistency in the application of the CCM process between sites. Sites should adjust the material as necessary based on feedback.

Table 4: Site-specific tailored documents

Step	Action 1: Items to be tailored to site level
Step 2: Identify MUEs	Review the hazard description document for each MUE. Check the MUE is relevant to this site
Step 3: Identify controls, develop a bowtie	Review the bowtie diagram for each MUE. Assess the bowtie and its applicability to the site. Tailor the threats and consequences as necessary
Step 4: Select the critical controls	Review and tailor the critical controls. Ensure the critical controls are site specific and appropriate for the site-specific MUE
Step 5: Define performance and reporting	Review and tailor the control information summaries for each critical control. Consider the site-specific requirements for the: • control objectives • performance requirements • activities that affect critical control performance • activities to verify performance (verification activities) • reporting requirements
Step 6: Assign accountability	Review and tailor the assigned "owners" and the lines of reporting. Match them to positions at the site level

Action 3: Develop a plan to implement the CCM strategy on-site

The plan should establish a foundation for an effective CCM approach on-site. The plan should support CCM leadership, develop appropriate knowledge, identify how to communicate CCM and identify site-specific standards for the critical controls.

Communicating the change is important to the success of implementation. This may include CCM material in internal newsletters, on-site intranet pages and through site safety alerts. The goal of communication is to bring MUEs to the attention of the workforce.

Develop and implement an education-training package for current staff, and training modules for new employees, at all levels of the site organisational structure. This should include detailed CCM training for the senior personnel on the site. Developing a training package involves the following:

- Assess site personnel training needs. For example, senior leaders, operational personnel and support staff have different training requirements. Training should provide the context and knowledge to support staff to carry out their duties. Use the site-specific CCM documents from Action 1 to support training for operational and support staff.
- Use an agreed common language to discuss MUEs. The language should be aligned with company terms and agreed on before starting the CCM process.
- Introduce and explain company documents, such as site-specific standards and policies related to the CCM.

Action 4: Implement the plan

As a site implements its site-specific MUE control strategy, ensure there is regular communication between the corporate CCM manager and the site-level project leader. As sites implement, they may require external assistance in the process, for example in developing and delivering training. At the corporate level, companies should assess their internal capability to assist sites, and decide on a whole-of-organisation approach to engaging external assistance. For example, if an organisation does not possess the required capability to deliver training, it should engage an external partner to deliver training across all sites to ensure consistency.

STEP 7 CASE STUDY

HOW DID EAST COAST COAL TAILOR THE CCM APPROACH FOR A SPECIFIC SITE?

As decided during Step 1, ECC began the implementation phase of the process with just one site. This approach was chosen so ECC could gather experience and learn lessons to assist when implementing the CCM approach across other sites. The site chosen was an underground mine that produces thermal and coking coal. The site has been producing for 15 years.

The site has a strong safety record, as measured by lost time injuries, but the ventilation system is at its maximum capacity. This increases the concentration of diesel particulate matter (an identified potential MUE). The rock formation above the seam has a high content of quartz, which has been noted as causing significant sparking with the longwall shearer.

A site-specific working group was formed that included members of the CCM project team and personnel from the site. The knowledge from the site personnel would be used to determine if the MUEs, controls and the verification activities that had been identified would be appropriate. This step also involved assigning accountabilities to the appropriate positions on-site (see tables 5 and 6).

Governance over changes at site level

An important question raised by one of the site team was if the site personnel thought that an MUE or control was not appropriate or needed, how would this be dealt with? A concern raised by a member of the working group was that an individual site might decide that a particular MUE or control might not be needed without reference to more senior management, weakening senior management's ability to have proper governance processes.

As a result, it was agreed that any significant changes proposed at site level from the MUEs decided by ECC in the earlier steps of the process must be done formally using the company's management of change system, including senior managers' sign-off.

Table 5: Underground fire and coal dust explosion site-specific critical control information summary

			Assigned owner
MUE: Underground fire and coal dust explosion			Underground mine manager
1 What is the name of the critical control? Sharp picks on shearer			Line manager
2 What are the specific objectives related to the MUE? To reduce the risk of ignition of flammable mixture by reducing the friction between the shearer and rock			
3 What are the critical control performance requirements to meet the objectives?	**4 What are the activities that support or enable the critical control?**	**5 What activities can be checked to verify the critical control performance?**	
Picks are sufficiently sharp to reduce the risk to prevent sparking	A template of acceptble pick profile is developed Shearer picks are visually inspected pre-shift [set as new point	Picks inspected against the template	Shift supervisor
	Regular maintenance is carried out on shearers	Review of inspection records weekly	Maintenance supervisor
	Regular assessment of the quartz content of the layer above the coal seam. Samples are taken at every 50m to determine the quartz content is above 30%	Review of quartz content inspection record weekly	Head geologist
6 What is the target performance for critical control? Picks meet the acceptable pick profile template, between markers 3 and 5. Picks outside this range are replaced			
7 What is the critical performance trigger for shutdown, critical control review or investigation? 5 per cent of inspections indicate that the picks are beyond threshold condition for use			

Note: The critical control information summary has been tailored to the site-level context shown in the red text. The summary contains the assigned MUE, critical control owners and verification owners.

Table 6: Diesel particulate matter overexposure site-specific critical control information summary

			Assigned owner
MUE: Overexposure to diesel particulate matter			Mine manager
1 What is the name of the critical control? Diesel particulate filter			Maintenance supervisor
2 What are its specific objectives related to the MUE? Reduce diesel particulate levels in the workplace atmosphere to below the occupational exposure limit			
3 What are the critical control performance requirements to meet the objectives?	**4 What are the activities that support or enable the critical control?**	**5 What activities can be checked to verify the critical control performance?**	
Filter housing/ducting maintained so that particulates are collected and not allowed to bypass	Pre-shift housing/ducting inspected for damage at pre-start, and maintenance conducted if required	Review pre-start inspection records, and confirm maintenance conducted when required	Maintenance manager
Back-pressure sensor alarms when back pressure on filter exceeds critical level	Diesel exhaust back-pressure sensor is calibrated to ensure it detects back-pressure at the correct set-point	Review calibration records to ensure that the back-pressure sensor is working within tolerance limits	Maintenance manager
Engines maintained to maximise filter life	Electronic fuel engine management systems (EMS) – EMS is monitored by operations and maintenance personnel. Maintenance is conducted following detection of below-standard performance by EMS	Sample x% of EMS reports identifying faults, and check that maintenance was conducted and in accordance with original equipment manufacturer (OEM) specifications	Maintenance manager
	Manual fuel injection systems – opacity testing of exhaust emission conducted every 28 days. If opacity test fails (exceeds set-point of xmg/m^3), carry out required maintenance – clean/replace engine air inlet filter; clean flame trap, check valve clearance, replace injector(s), compression test, replace diesel pump, clean/replace diesel particulate filter	Sample x% of opacity test reports exceeding set-point, and check that maintenance was conducted and in accordance with OEM specifications	Maintenance manager
6 What is the target performance for critical control? Maintenance requirements identified are conducted 100% of the time, and back-pressure sensor calibration is within tolerance for 100% of tests			
7 What is the critical control performance trigger for shutdown, critical control review or investigation? Diesel particulate filter housing/ductwork damaged, or back-pressure sensor alarm triggered			

STEP 8: VERIFICATION AND REPORTING

Target outcome

Implement verification activities and report on the process. Define and report on the status of each critical control.

Step 8 is the first practical step in the CCM process. The verification and reporting activities will be carried out by the owners of each activity. The site CCM manager should assist with the first iterations, assisting owners with their functions within the CCM process.

Actions for verification and reporting

Action 1: Undertake verification activities

Action the verification activities described in Step 6. During Action 1 the health of a critical control will be reported on by critical control owners, allowing the MUE owner to report on the overall health of an MUE. This allows an organisation-wide assessment of the critical control to be identified. Action 1 involves:

- verification activities being carried out by the verification activity owner(s), with verification activity reports summarised regularly
- review of verification activity reports regularly by the critical control owner(s), with critical control summary reports
- review of critical control summary reports regularly by the MUE owner, who will provide critical control summary reports and MUE summary reports
- review and collation of results from MUE reports by a member of the leadership team who will circulate the actions needed with senior managers on-site and with the corporate CCM manager.

Conduct verification activity by active monitoring (as outlined in the Good Practice Guide). Active monitoring refers to the process of checking the extent to which the performance requirements, set for a critical control, are being met in practice. Company health and safety management systems might use a variety of terms for "verification" activities. Common terms include audit, review and monitoring. Active monitoring may include activities such as:

- checking maintenance logs
- accompanying operators on routine inspections for quality assurance
- reassessing the critical performance requirements on a regular basis – for example, a critical control of "probe calibration" should see the control owner assessing if the calibration settings are appropriate to take accurate readings.

Action 2: Reporting

The purpose of reporting is to efficiently communicate variances between expected and actual performance. There are a number of levels of reporting in the CCM process, as described in Step 6. Reports for each step of the process (verification activities, critical controls and MUEs) often consist of a summary of inputs. As such, a critical control report is a summary of its verification activity health, and so on.

Reporting the outcomes of verification activities is the "base level" report. It can be achieved through modifying existing practices, such as work logs and daily checklists. The activities should consist of yes/no answers, with detail to be included only when there is a difference between expected and actual performance.

Critical control reporting
Critical control summary reports are a collation of verification reporting activities presented in a single metric or series of metrics. For example, a critical control report may include a single metric that summarises the verification activity reports, or a number of metrics

that represent different aspects of multiple verification activities. The level of detail should be determined on a site-specific basis depending on the complexity of the critical control. Despite the number of metrics presented, there must be a single metric that reports on the overall health of the critical control.

Critical control reports may use a "traffic light" reporting system to allow quick identification of performance. A traffic light system categorises the health into one of three categories. While the definition of each category should be decided by each organisation, example definitions are included in Table 7.

This allows for simple reporting of both critical control health and MUE health. An example of an MUE health report is included in Table 8. When determining the single metric that represents the overall health of an MUE, consider using an average score of the controls, or report the overall health as equal to the lowest critical control health.

Assessing the reporting process

Assurance that the verification and reporting process is working correctly can be provided by critically assessing regular reports and establishing a formal assurance mechanism. When critically assessing reports:

- Consider whether a critical control or MUE is reported as consistently "green". This indicates the reporting process may be defective and needs refinement, or owners need further CCM training. In addition, consistently "red" health may indicate the assessment criteria might be too stringent and need refining. Alternatively, consistent health across all controls may indicate verification activities are not being implemented appropriately.
- When assessing a control's performance, consider the history of the health of the control. Review previous reports to understand the trend. If the overall health trend is red, consider if additional maintenance is needed. For example, the control performance standards or objectives could need updating, or the control's "critical" status could be reviewed.

Table 7: Traffic light reporting criteria

Score	Criteria
	Expected performance not achieved – control is working unsatisfactorily
	Expected performance achieved inconsistently – control effectiveness decreased
	Expected performance consistently matches actual performance – control is effective

Table 8: MUE traffic light report example

MUE name: Underground fire and explosion			Overall health
Controls	**Owner**	**Health**	**Comments**
Critical Control 1	Supervisor 1		Control matching expected performance
Critical Control 2	Supervisor 2		Control not consistently matching expected performance
Critical Control 3	Supervisor 3		Control consistently achieving performance just below expected performance threshold
Critical Control 4	Supervisor 4		Control matching expected performance

A formal assurance mechanism should include activities at defined intervals (eg quarterly or biannually). This assurance process should assess whether:

- verification activities are suitable for assessing the health of a control
- the verification activities are being undertaken in a robust and thorough manner
- the critical control owner is making an accurate assessment of the health of the critical control
- the MUE owner is making an accurate assessment on the health of the MUE.

This process should allow scoring of different aspects of the process, providing comments on its suitability or how it could be improved. The outcomes should be considered alongside reviews of critical control and MUE reports when looking at long-term performance.

WHAT DID EAST COAST COAL OBSERVE IN THEIR VERIFICATION AND REPORTING ACTIVITIES?

Who does verification – line managers or HSE?

The ECC working group decided not to assign accountabilities for the MUEs, critical control implementation and verification of the controls until they had more experience of identifying and implementing a number of critical controls.

The working group has a mixture of line managers, technical subject-matter experts and HSE personnel. The initial view of most of the working group members was that the HSE team would be responsible for carrying out the verification activities. The HSE representative disagreed. The discussion centred on the respective responsibilities of line managers and support personnel such as HSE.

The working group quickly agreed that it was line managers' responsibility to implement the critical controls, but there was still disagreement about the verification activities. Some members said that HSE already did audits, and the verification was just another type of audit, so they should be responsible for the verification of critical controls as well.

The opposite view was put by the senior manager and project sponsor who was present. The project sponsor argued that an essential part of any line manager's job was to check (or verify) that tasks within their sphere of responsibility were being done as intended. This applied to critical controls too. HSE should not be expected to do the line manager's job for them.

This was accepted by the working group. However, the question was raised as to what was the role of HSE if it was not to verify the controls? HSE said that as the CCM programme dealt with very significant (material) risks, internal audit would design an assurance programme on behalf of the company's audit and risk committee. HSE would work with internal audit to determine what was audited as part of that programme once the CCM process was implemented. This assurance programme is not covered by the CCM process.

East Coast Coal's verification experience

The site-specific CCM process had been implemented on-site, and ECC has begun verification activities and reporting. The critical control owner (Line Manager 1) for sharp picks on shearers was conducting a routine review of the verification activities with the respective owners: the shearer operator, the longwall operator and maintenance staff. The critical control owner had found the verification activities included:

- review of the shearer inspection records – the inspection records had found all visual inspections had occurred as intended; however, Shearer 5 was overdue for an inspection
- review of maintenance records – Shearer 3 had been flagged for maintenance in the following week, while all maintenance for the past three weeks (including the maintenance inspections for Shearers 6, 7 and 8) had been delayed due to urgent maintenance on the ventilation system
- review of quartz content inspection record weekly – regular sampling of the quartz content in the coal seam, with samples taken at every 50m to determine if the quartz content is above 5% (the records showed the quartz content remained above 5% and there was still a high risk of sparking).

Line Manager 1 collated the weekly critical control report as follows:

Critical control: Sharp picks on shearers			Overall control health
Related MUE: Underground fire and coal dust explosion			
Verification activities	Owner	Health	Comments
Review the shearer inspection records	Shift supervisor		One shearer overdue for inspection. Inspection planned for next week.
Review of maintenance records	Maintenance supervisor		Maintenance delays on three shearers for three weeks due to emergency maintenance needed on other critical systems.

STEP 8: CASE STUDY

The overall health of the critical control was red. The line manager did a critical assessment of the report and then reported the findings to the MUE owner. The MUE owner's report of critical controls consisted of:

MUE: Underground fire and coal dust explosion				Overall MUE health
Critical controls	**Owner**	**Health**	**Comments**	
Sharp picks on shearer	Line Manager 1		Action: clear maintenance backlog	
Water sprays on shearer head	Line Manager 1		Action: final visual inspection report	
Removal of coal fines from under rollers	Line Manager 3		Action: review recording of daily/weekly inspections	

The MUE reports were then collated by the CCM site manager who was the allocated review owner. The reports were then assessed for high-potential incidents, and a summary of the sites' MUE health was reported at the monthly senior management meeting.

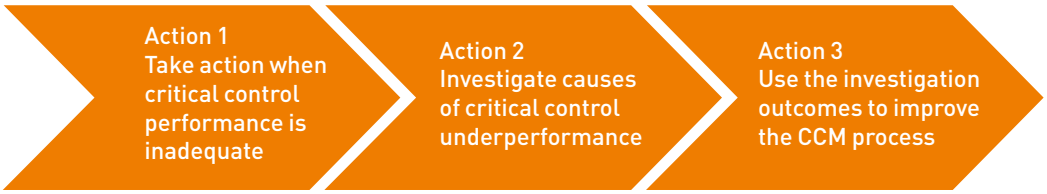
STEP 9: RESPONSE TO INADEQUATE CRITICAL CONTROL PERFORMANCE

Target outcome

Critical control and MUE owners are aware of critical control performance. If critical controls are underperforming, or following an incident, investigate and take action to improve performance or remove critical status from controls.

The response to inadequate critical control performance will be determined by the outcomes of the verification and reporting activities discussed in Step 8. This response is important as it assists with reviewing critical controls, and assists within improving the CCM approach overall.

Actions in response to critical control performance



Action 1: Take action when critical control performance is inadequate

The immediate response to inadequate critical control performance is initiated when the critical control performance reaches below the trigger threshold defined in the critical control information summary (tailored to be site specific in Step 7). The response to the trigger may include suspension or shutting down a part of the operation, process materials being diverted or reducing the rate of production while the next actions are undertaken. The absence of accidents or incidents must not be taken as evidence that controls are working adequately. Common methods of where the failure of critical controls are detected include:

- a hazard or at-risk situation (usually associated with a human action/error)
- a failure of the critical control
- an event that resulted in serious harm or the potential to cause serious harm.

Action 2: Investigate causes of critical control underperformance

Once a critical control is underperforming, investigate the causes to understand why it has underperformed. Note that the outcomes of this investigation may require the design of the critical control to be improved. The Good Practice Guide includes a list of questions that can assist with this investigation.

Action 3: Use the investigation outcomes to improve the CCM process

Continual improvement of the CCM process provides assurance and integrity. As CCM is a cyclical process, controls need to be assessed and updated as operations change. Consider:

- Assess the outcomes of the investigation for seriousness and urgency.
- An investigation may find a degree of "creep" in the performance of a control that has become gradual over time. This can be referred to as a "normalisation of deviance". An example of this may be an increasingly delayed action to remove rainwater within a bund throughout a site's wet season, which affects the performance standard (ie capacity) of the bund. The slipping of performance standards in this way may result from either lax reporting, a failure of the assurance process or a cultural issue on-site.
- Investigation outcomes may require revisiting one or more steps in this process. For example, the outcomes may initiate a review of MUEs (Step 2), the control's design, objectives or performance requirements (Step 3) or a verification activity and its performance (Step 5). After you have implemented the necessary changes, monitor and assess the controls for improved performance.
- If required, escalate the investigation findings to the corporate area of the company. This will allow for the review of other sites in the company with similar controls, who may need to improve their CCM based on the outcomes of the investigation. This allows for common mode failures to be assessed across sites.

STEP 9: CASE STUDY

EAST COAST COAL'S RESPONSE TO INADEQUATE CRITICAL CONTROL PERFORMANCE

There was disagreement within the working group on how to handle the response to inadequate critical controls. One line of argument was that it should be handled in the same way as a breach of a fatal risk control or a golden rule and prompt an investigation as a high-potential incident. Another member said it should prompt disciplinary action. Others were less sure. It was pointed out by others in the working group that handling inadequate control performance through disciplinary action was almost guaranteed to reduce reporting, and you cannot manage what you do not know about. Another working group member was concerned that they did not have sufficient experience of implementing CCM and until they had more knowledge they should be careful not to implement black and white rules on what would happen when substandard control performance was found. They argued that in the early stages of implementing a new approach it was almost inevitable that substandard performance was found. They did not want to deter open and frank reporting. Without this, improvement would be difficult.

After discussion, the working group decided that:

- there would not be any automatic or fixed response to detecting inadequate critical control performance in the first year to avoid unintended consequences such as deterring reporting
- line managers would be expected to address any detected deficiencies
- the reasons for this approach would be widely circulated within the company
- approval for this approach would be sought from the leadership team and explained to the board
- this decision would be reviewed after 12 months of experience.

AFTER THE PROCESS

Once reaching the end of the CCM process, the activities that support it outlined in Steps 2–9 should be embedded in business-as-usual processes and procedures. This includes handing over full oversight of the CCM process from the project implementation team to the site manager.

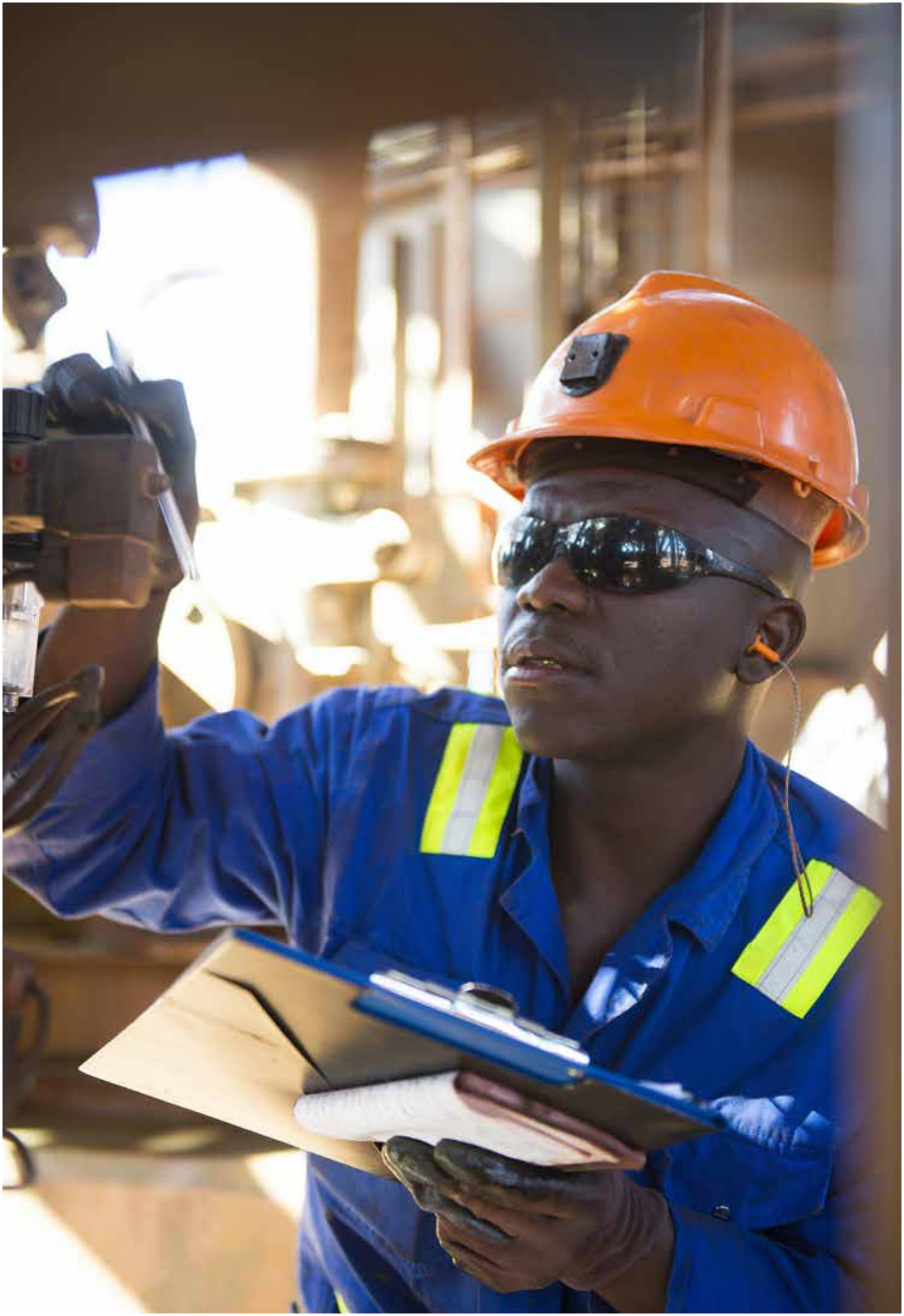
It is important for sites to maintain their focus on the CCM. You may choose to maintain dedicated staff to help promote it. Actions to consider after the process include:

- implementing a process to review the existing MUEs and scan for new or emerging ones that may arise through normal business operations
- providing assurance and review of the reporting
- updating training in the CCM as necessary
- recognising when business changes may require the CCM approach to be revisited (eg if a company acquires new assets, or changes to systems, technology or rates in production)
- reviewing the benefits of implementing the CCM process in your organisation.

What does success look like?

A review should be conducted at an appropriate time following CCM implementation. Consider if the organisation has achieved:

- integration of scheduled activities into the current system – a successful CCM process will have monitoring and reporting components embedded into business-as-usual operations (this includes integrating scheduled verification activities and reporting into current maintenance and inspection systems)
- a fundamental understanding of the CCM approach at all levels of the organisation
- integrated internal capacity of CCM knowledge in the organisation
- an iterative process of review – a process where MUEs and controls are reviewed and updated (there must be scope to recognise where external expertise is needed).



APPENDICES

APPENDIX A
DEFINITIONS AND ABBREVIATIONS

Bowtie analysis
An analytical method for identifying and reviewing controls intended to prevent or mitigate a specific unwanted event.

Cause
A brief statement of the reason for an unwanted event (other than the failure of a control).

Consequence
A statement describing the final impact that could occur from the MUE. It is usual to consider this in terms of the maximum foreseeable loss.

Control
An act, object (engineered) or system (combination of act and object) intended to prevent or mitigate an unwanted event.

Critical control
A control that is crucial to preventing the event or mitigating the consequences of the event. The absence or failure of a critical control would significantly increase the risk despite the existence of the other controls.

In addition, a control that prevents more than one unwanted event or mitigates more than one consequence is normally classified as critical.

Critical control management (CCM)
A process of managing the risk of MUEs that involves a systematic approach to ensure critical controls are in place and effective.

Diesel particulate matter
A complex mixture of organic compounds, sulphates, nitrates, metals and other toxins that form a cohesive layer on the particulate from diesel exhaust.

Hazard
Something with the potential for harm. In the context of people, assets or the environment, a hazard is typically any energy source that, if released in an unplanned way, can cause damage.

Health, safety and environment (HSE)

International Council on Mining and Metals (ICMM)
A membership organisation representing mining and metals companies and associations.

Lost time injury frequency rate (LTIFR)
A measurement of the number of injuries that require time off work per million hours worked.

Material unwanted event (MUE)
An unwanted event where the potential or real consequence exceeds a threshold defined by the company as warranting the highest level of attention – for example, a high-level health, safety or environment impact.

Mitigating control
A control that eliminates or reduces the consequences of the unwanted event.

Occupational health and safety (OHS)
The discipline concerned with protecting the health and safety of workers.

Preventing control
A control that reduces the likelihood of an unwanted event occurring.

Risk
The chance of something happening that will have an impact on objectives. It is usually measured in terms of event likelihood and consequences.

Safety critical element (SCE)
Similar to critical controls, an SCE is a component whose failure could lead to a major accident. This term is used primarily in the oil and gas industry.

Subject-matter expert
A person who is an authority in a particular area of topic.

Unwanted event
A description of a situation where the hazard has or could possibly be released in an unplanned way, including a description of the consequences.

Verification activities
The process of checking the extent to which the performance requirements set for a critical control are being met in practice. Company HSE management systems may use a variety of terms for "verification" activities. Common terms in use include audit, review, monitoring or active monitoring.

A note on terminology: major unwanted events, major accident events and process safety
There is no one term used in the western industrial world to describe those rare but disastrous incidents that can occur in transport, especially aviation, marine and rail transport, the petroleum industries (upstream and downstream) and the chemical-processing industries. Each industry tends to develop its own language and labels. The mining industry has adapted the term material unwanted event. Major accident events (or hazards) is the term widely used in safety-case regulatory systems, but process safety is probably the most widely used term globally. However, despite its familiarity, it does not resonate with all industries and is often misunderstood in two main areas. Firstly, in relation to the safety word, process safety is usually defined as being about preventing events with the potential for catastrophic incidents that may kill or injure people, the environment and equipment (as well as damage reputations and cost a lot of money). Secondly, the term "process" is frequently misunderstood as referring to business processes as opposed to chemical processes, which is where the term originated.

APPENDIX B

A GUIDE TO BEHAVIOURS TO FOSTER A POSITIVE RISK MANAGEMENT CULTURE

Leaders and managers can promote an effective risk management culture within an organisation by their behaviour. This section suggests leadership behaviours that staff can adopt to promote an effective risk management culture. Adopting these behaviours will help implement the CCM process and support effective MUE management into the future.

Leaders should ...	Leaders should not ...
• actively seek evidence about the functioning and effectiveness of critical controls and verification activities • conduct formal meetings to see how critical controls and verification activities work in practice* • make informal "visits" to see how critical controls and verification activities work in practice • focus feedback to people (positive or negative recognition) on how Critical controls are working in the field.	• wait for something to go wrong before making enquiries about the MUE and the critical controls • assume critical controls are working well in practice without direct observation and other evidence.
• expect their own support staff to establish monitoring and reporting systems to assist them to actively monitor the effectiveness of critical controls and verification activities.	• trust that monitoring and reporting systems have been established and are active without evidence.
• welcome information that indicates monitoring and reporting systems are not working as well as they should • use this information to continually improve the management of the MUE.	• show displeasure when given bad news about an MUE, critical control or verification activity (either on a one-to-one basis or in meetings) – showing displeasure will reduce the chance that personnel will report control failure.
• recognise the receipt of information on inadequate critical controls as an opportunity to improve control of MUEs.	• blame individuals for inadequate critical control but focus on how the critical control system can be improved.
• ask to see the evidence when advised that all is well with a MUE or that a critical control is working well.	• accept unsupported assertions that all is well with critical controls for MUEs – expect verifiable evidence.
• ask to see the evidence when advised that all is well with a MUE or that a critical control is working well.	• accept unsupported assertions that all is well with critical controls for MUEs. Expect verifiable evidence.

APPENDIX C
PROJECT PLANNING CHECKLIST

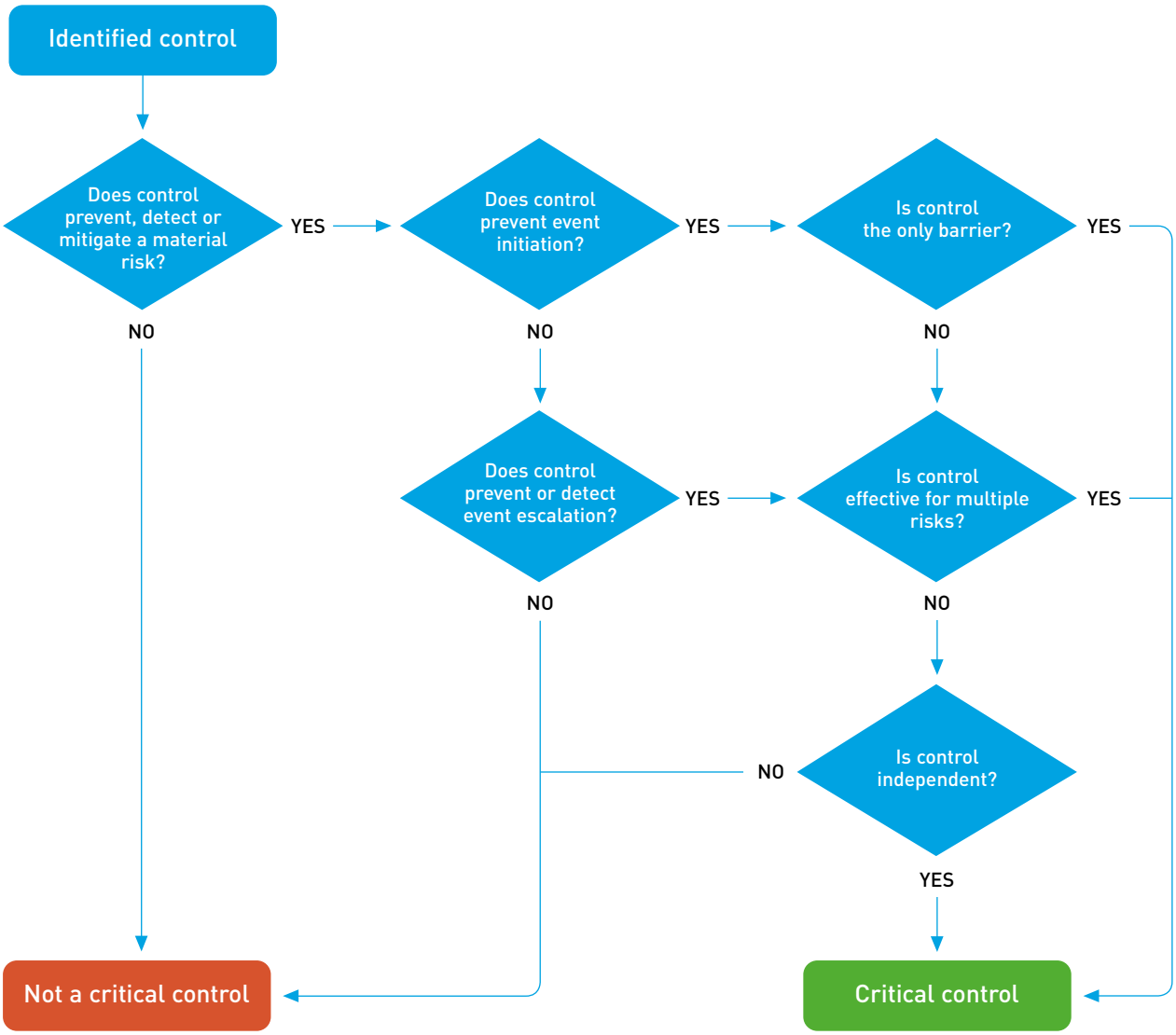
Project planning tasks	Check when complete
What is the organisational context? Are there existing projects at a corporate, business unit or site level that complement or conflict with this work? If so, assess your current projects and how they might be used or tailored to the CCM process.	☐
How will the impact of the CCM initiative be measured?	☐
Is there a clear objective and what are the specific deliverables of the project?	☐
What business units will be involved?	☐
Who will need to be involved for the project to succeed?	☐
What resources, and to what extent, will resources be needed (time, financial, personnel)?	☐
What methods will be used to assess the risk of the identified unwanted events, including the criteria for an MUE?	☐
What method will be used to review MUE controls? What will the criteria be for critical control selection?	☐
How will the critical controls be checked?	☐
How will ownership and accountability be defined?	☐
How can critical control information be adapted to become site-specific?	☐
How will critical control performance be verified in practice?	☐
What methods will be used to investigate critical control underperformance?	☐

APPENDIX D

THE BHP BILLITON CRITICAL CONTROL DECISION TREE

The critical control decision tree is a tool to help identify if a control is a critical control. The tree is from the Good Practice Guide page 13.

Figure 7: BHP Billiton critical control decision tree



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ICMM members

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Working group

Chair: Andrew Lewin (BHP Billiton)

Nerine Botes Schoeman (African Rainbow Minerals)

Cas Badenhorst (Anglo American)

Frank Fox (Anglo American)

George Coetzee (AngloGold Ashanti)

Craig Ross (Barrick)

André Fey (Hydro)

Additional technical support (including non-ICMM members)

Rob McDonald (BHP Billiton)

Gerard Tiernan (BHP Billiton)

Andrew McMahon (Minerals Council of Australia)

Martin Webb (MMG)

Anthony Deakin (Rio Tinto)

Kylie AhWong (Glencore)

Henry Mushonga (Glencore)

Lucy Roberts (Glencore)

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MMG
Newmont
Polyus Gold
Rio Tinto
South32
Sumitomo Metal Mining
Teck

ICMM
35/38 Portman Square
London W1H 6LR
United Kingdom

Phone: +44 (0) 20 7467 5070
Fax: +44 (0) 20 7467 5071
Email: info@icmm.com

www.icmm.com

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