Using RISKGATE to shift industry's focus to control effectiveness

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Abstract

RISKGATE® is an online body of knowledge built using coal industry expertise. It is designed to help mine personnel understand and control selected major incidents and connects them to information about event-specific controls. It will help them find gaps in their own controls based on systematic consideration of incidents, including their causes and consequences. Practical bow-tie-based information can be printed out as checklists that can be used within current mine activities and systems.

RISKGATE is an easy-to-use, interactive tool providing information about 15 high-consequence risk areas across coal mining operations. It can be used to conduct or develop risk assessments, audits, incident investigations and management systems. It is designed for mine personnel who are responsible for these tasks and helps challenge their thinking about priority incidents and to drive a careful review process to identify potential controls.

The Australian coal mining industry is making a step change in risk management by focusing on control effectiveness using bow-tie methods. This step change will take several years to be fully implemented across the industry and RISKGATE is an integral part of this process.

Introduction

Operational risk management has been part of the Australian coal mining industry for more than a decade. Over this period the industry has made major progress on the management of risks, including the prevention of catastrophic events, and this work is recognised around the world.

However, opportunities exist for improving risk management particularly around the need to more carefully consider the existence and effectiveness of controls for major incidents. Current industry practice, such as using WRAC, TBRA or similar multi-column risk assessment methods, does not usually provide adequate opportunity to consider the controls for potential high-risk events. It is also common for sites to use a risk matrix (the '5 by 5') to re-rank risk based on limited control information. This practice cannot provide a reliable image of tolerable risk; that is, risk cannot be re-ranked from 'red' to 'green' based on a few randomly identified controls. This practice presents a significant risk in itself.

In addition, defining a specific control or set of controls for *all* sites assumes that all sites are the same and, clearly, that is not the case. Each mine has different characteristics which need to be considered in the context of risk management. There is no 'one size fits all' solution.

To address these issues, the Australian coal mining industry is making a step change in risk management by focusing on control effectiveness using bow-tie methods. This step change will take several years to be fully implemented across the industry and RISKGATE is an integral part of this process.

What is RISKGATE?

RISKGATE® is an online body of knowledge built using coal industry expertise – thousands of hours of mining professionals' input collected during a series of guided workshops.

It is designed to help mine personnel understand and control selected major incidents and connects them to information about event-specific controls. It will help them find gaps in their own controls based on systematic consideration of incidents, including their causes and consequences. Practical bow-tie-based information can be printed out as checklists that can be used within current mine activities and systems.

RISKGATE is an easy-to-use, interactive tool providing information about 15 high-consequence risk areas across coal mining operations: fires; strata control for underground mining; ground control for open-cut mining; tyres; isolation; collisions; explosions and explosives; manual tasks; trips, slips and falls; chemicals; occupational health; inrush and outburst; and interfaces.

The tool can be used to conduct or develop risk assessments, audits, incident investigations and management systems. It is designed for mine personnel who are responsible for these tasks and helps challenge their thinking about priority incidents and to drive a careful review process to identify potential controls.

What is bow-tie analysis?

RISKGATE uses a method called bow-tie analysis which identifies event-specific controls and considers the range of causes and consequences for selected priority incidents.

Bow-tie analysis is currently used by many mine sites around the world. When a potential incident has been identified, such as an underground fire or a highwall collapse, bow-tie analysis is used to identify controls that could prevent the incident, as well as controls that could reduce the consequences of the event.

In RISKGATE, this method is used to identify all potential causes and consequences, and thereby present a full image of potential controls. As such, it provides a way to 'walk-through' the relevant events, identify relevant causes and consequences and then consider the status of existing controls against those outlined in RISKGATE – in essence, taking a site-specific approach to identifying the right controls for individual sites.

The term 'bow-tie' is derived from the article of clothing worn around the neck. In bow-tie analysis, the knot or centre of the bow-tie describes a single 'initiating event'. Typically this is the instance the energy is released and the incident begins to occur. On the left side of the bow-tie (see Figure 1) there is a list of the various causes that might lead to the initiating event. On the right side there are the consequences that stem from the initiating event.

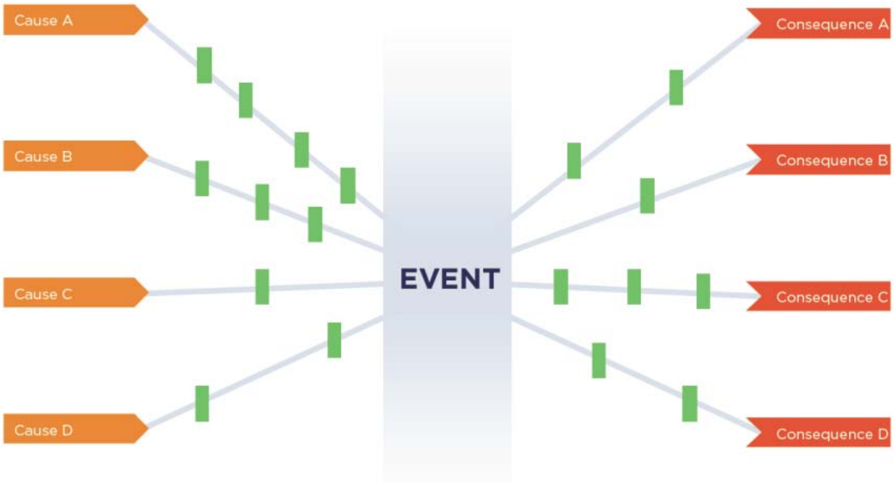

Figure 1: Bow-tie conceptual diagram.

In bow-tie analysis the focus is on ‘cause, event and consequence’, rather than the simple model of ‘cause and consequence’. Between each cause and its initiating event are the various preventive controls that can be implemented to reduce the likelihood that the initiating event will happen. On the other side of the bow-tie, between the event and each consequence, are the various mitigating controls that can either prevent, or reduce the severity of the consequence.

Each bow-tie consists of a single initiating event in the centre; a list of possible causes on the left – each with its own specific preventive controls; and stemming from the initiating event on the right is a list of possible consequences – each with its own specific mitigating controls.

Using bow-ties requires a shift in thinking when considering other common mining risk management tools. When using bow-ties it is important to recognise that a cause can potentially lead to *any* of the consequences, and that bow-tie modelling doesn’t form a direct relationship between individual causes and individual consequences. The relationship between causes and consequences is managed through the central knot, or initiating event. So the thinking is not ‘cause and effect’, or ‘cause and consequence’; it is ‘cause and event’, then ‘event and consequence’. Following this logical approach to considering relevant priority incidents will provide mine personnel with a more accurate view of risk.

Our progress

RISKGATE is being developed by the Minerals Industry Safety and Health Centre (MISHC) at The University of Queensland and is funded by the Australian Coal Association Research Program (ACARP). It represents ACARP’s largest single investment in health and safety to date.

MISHC has adopted a staged approach for its three-year research and development program (Table 1). The first six high-consequence risk areas (called topics in RISKGATE) – tyres, isolation, fires, collisions, strata control for underground mining and ground control for open-cut mining – was completed in 2011. Explosions, explosives, manual tasks, and slips, trips and falls are being carried out this year, with chemicals, occupational health, inrush, outburst and interfaces being undertaken in 2013-14.

Table 1: RISKGATE schedule for topic area delivery 2011-2014

2011	FIRES	TYRES	ISOLATION	STRATA U.G.	GROUND O.C.	COLLISIONS
2012	EXPLOSIONS	EXPLOSIVES	MANUAL TASKS	TRIPS & FALLS		
2013/ 2014	INTERFACE	WORKPLACE	INRUSH	CHEMICALS	OUTBURST	

Every RISKGATE topic is focused on coal industry activities (mining, processing, transport and storage) in open cut and underground mine environments. The scope includes mine sites, lease areas, and mine infrastructure (mobile, fixed plant, field equipment, buildings, road and rail transport), and all aspects of the mine life cycle from design through to decommissioning. The topics uniformly recognise that 'loss of control' can result in injury or fatality, equipment damage, production loss, reputation loss and environmental damage. However, the priority focus for RISKGATE is the safety of mine personnel.

The following paragraphs summarise what mine personnel can expect to find within 10 of the 15 topics. These first ten topics will be available to ACARP member companies by the end of 2012.

FIRES: Fires in open-cut and underground coal mines can cause personal injury, fatality or equipment damage. Fire fuel sources include flammable liquids (motor fuel, lubricant, transformer fluid, hydraulic fluid, coolant), pressurised gases (LPG, natural gas, acetylene), coal, other solids (rags, timber) and other flammable fluids (cleaning fluids). Sources that could cause an ignition include electrical sources, friction, hot work, lightning induction, hot surfaces and other miscellaneous sources such as contraband. Four core initiating events have been identified: fire on mobile plant and field equipment, fire on fixed plant and infrastructure, fire in the natural environment, and fire on stockpiles or spoil piles. Preventive controls have been developed around the context of mine design and operation. Recommended mitigating controls include fire suppression and the development and implementation of an emergency response plan that deals with fire fighting, evacuation, first aid and external resources.

GROUND CONTROL: Ground instability in open cut mines – ranging from small individual rock falls to large-scale rock mass failures – can cause personal injury, fatality, equipment damage or production loss. The Ground Control topic provides information on the management and prevention of incidents and accidents due to these conditions. Seven core initiating events have been identified. These are loss of ground control associated with box cuts, highwalls, end walls, low walls, truck dumps, stockpiles and pre-strip benches. Preventive controls have been developed around life-of-asset and life-of-mine scenarios.

STRATA CONTROL: Techniques for managing strata control issues in underground mines are provided in this topic. Seven core initiating events have been identified as priority areas where a better understanding of the relevant preventive and mitigating controls could dramatically reduce the severity or likelihood of hazardous outcomes. The two initiating events are loss of strata control at the longwall face, outbye roadways, development roadway and face, shafts, and the goaf edge in pillar extraction; and loss of pillar system stability and loss of control of caving. Preventive controls have been developed around mine design and operation. This topic aims to help mine personnel prevent or mitigate the consequences of strata control issues including personal injury, fatality, equipment damage, disruption to underground services (ventilation, conveyance, egress, water, power, roads), loss of coal resources, surface damage due to subsidence and production loss.

ISOLATION: Open cut and underground mines use a range of energy sources in their day-to-day activities, including electrical, hydraulic, pneumatic, mechanical (gravity, mechanical, kinetic, potential, stored) and radiating (thermal, radioactivity/microwave/other) energy. Failure to effectively isolate plant and equipment can result in personal injury, fatality, equipment damage, production loss, environmental damage or loss of reputation. Effective isolation processes cover the control of energy and the use of barriers to prevent the interaction of energy and mine personnel. This topic covers the design, operational and maintenance processes that can affect isolation control across mine sites, leases and infrastructure. Design processes comprise the full life cycle management of the asset – design and procurement, identification of energy sources, assessment of risk, and implementation of risk management techniques. Operational processes include identification of an energy source, isolation, confirmation, dissipation, and lock out of that source. Maintenance processes cover inspection, testing, verification, shut down and start up.

COLLISIONS: Unexpected interaction between mine personnel, mobile plant, field equipment or fixed plant can result in personal injury, fatality or equipment/property damage. Mobile plant and field equipment include heavy vehicles, light vehicles (4WD, utes), dump trucks, industrial lift trucks (forklifts), mobile cranes, earthmoving equipment, draglines, skid-mounted equipment, lighting towers, continuous miners and shuttle cars. Fixed plant is non-transportable infrastructure or equipment, such as buildings, park-up areas, installations, dams, tank farms, stockpiles, power lines and transport networks (road and rail). Three core initiating events have been identified: vehicle-to-vehicle incidents, vehicle-to-people (including rollover) incidents, vehicle-to-infrastructure incidents.

TYRES: Managing the full life cycle of the tyres, rims and wheels of mining machinery is a challenging process, which encompasses selection, procurement, transport, fitting (installation and removal), maintenance, operation, storage and disposal across open cut and underground mine sites and leases. This topic provides techniques to manage the control of energy associated with tyres, rims, wheel assemblies and related equipment to prevent personal injury, fatality or equipment damage. Four core initiating events have been identified: loss of control of tyre/rim assemblies during handling, storage and disposal, loss of control of equipment, tools and vehicle stability, loss of control of tyre/rim assemblies while in operation, and loss of control of tyre/rim assemblies during fitting and maintenance. Preventive controls have been developed around tyre operation and life cycle. Experts from mining organisations, tyre OEMs and ancillary service providers have developed a comprehensive and specific set of controls highlighting best practice in tyre management systems.

EXPLOSIONS: The Explosions topic addresses fires and explosions in open cut or underground coal mines. An unwanted or unexpected combination of fuel and ignition sources can cause explosions, resulting in injuries, fatalities or equipment damage. Fuel sources include coal and flammable gases such as methane, carbon monoxide and hydrogen, while ignition can be caused by electrical energy, friction, hot work, lightning induction, hot surfaces and other miscellaneous sources such as contraband. Thirteen core initiating events have been identified: fire on the development face, in stowed or accumulated coal, sealed goaf, active goaf, longwall face, and mine roadway; ignition at a longwall face, on a development face, in a sealed goaf, active goaf, or mine roadway; methane explosion; and coal dust explosion. Mitigating controls focus on suppressing fires or explosions, and developing and implementing an emergency response plan that covers fire fighting, evacuation, first aid and external resources.

EXPLOSIVES: The Explosives topic deals with the manufacture, transport, storage, use and disposal of explosives products on mine leases. Four different streams have been considered: high explosives (initiation systems) such as detonators, detonating cords and primers; explosive precursors including ammonium nitrate; manufactured explosives used for secondary blasting in enclosed spaces such as hoppers, coal bins and crushers. Four initiating events have been identified: loss of control of explosives in storage on site, during transport, manufacture, and handling, use and disposal.

MANUAL TASKS: Hazardous manual tasks can stress the body, leading to injury or musculoskeletal disorders. These tasks require personnel to lift, lower, push, pull, carry, move, hold or restrain a person or object, and require personnel to use repetitive or sustained force, high or sudden force, repetitive movement, sustained or awkward posture, or direct stress to the body. Musculoskeletal disorders associated with hazardous manual tasks include sprains, strains or tears of connective tissues; stress fractures; tendonitis; and vascular or neural disorders. Factors that need to be considered are forceful exertions, length of exposure, repeated similar movements, extreme temperatures, concurrent exposure to vibration, and presence of unwanted psychosocial characteristics.

TRIPS, SLIPS AND FALLS: Trips, slips and falls can result in minor or serious injuries such as sprained or twisted knees and ankles, bruising, broken bones and skull fractures; fatalities; loss of control of loads; and loss of control of the equipment being used such as power tools. This topic relates to hazards associated with personnel slipping or tripping at ground level or on stairs, ladders, or platforms including temporary structures; and the hazard of falling. It covers mobile equipment (particularly access and egress) and fixed plant (such as preparation plants), and considers construction, operation and maintenance tasks, as well as pedestrian movement around mine sites. It addresses all stages of the mine life cycle, from exploration to decommissioning.

Already RISKGATE contains a comprehensive collection of information around the initiating events, causes, controls and consequences of priority incidents relating to fires, strata control, ground control, tyres and collisions (see Table 2). In April 2012 the project team had accumulated 29 bow ties, 671 causes, 2118 preventive controls, 248 mitigating controls and 75 consequences.

Table 2: Distribution of knowledge (initiating events, causes, controls, consequences) captured for RISKGATE Series One topics (current at 14 April, 2012).

RISKGATE topics	Bowties	Causes	Preventive controls	Mitigating controls	Consequences
FIRES	4	45	162	54	9
STRATA CONTROL	7	111	372	53	15
GROUND CONTROL	7	86	204	35	23
TYRES	4	75	471	32	13
ISOLATION	5	311	790	55	9
COLLISIONS	2	43	119	19	6
Totals	29	671	2118	248	75

How we collect the data

RISKGATE is built upon a foundation of mining industry expert knowledge gathered through a series of workshops. Each topic area is developed by a panel of subject-matter experts who contribute a broad range of risk management skills and competencies. Experts predominantly contribute from mining companies but also suppliers, original equipment manufacturers (OEMs), academic and regulatory authorities. They are selected based on their contribution to a broad knowledge base and to ensure a range of companies is represented.

The information is collected then refined by the project team based on participant feedback after each workshop. As a final step, once all information is collected, the RISKGATE project team undertakes usability testing with each topic panel to ensure language and system usability meet industry requirements.

Broad participation from the mining industry is the key factor underlying the successful development of RISKGATE. To complete the 2011 topic series, expert knowledge was contributed by 67 individual experts from 18 different organisations including seven mining houses (Adani, 3 days; Anglo American, 68 days; BMA/BHP Billiton, 45 days; Centennial, 32 days; Peabody, 54 days; Rio Tinto, 29 days; Xstrata, 56 days), resulting in an overall industry investment of 287 days.

In developing the first six RISKGATE topics the project team has used a three-phase approach, which has involved defining the priority incidents within the topic area and developing cause, control and consequence information for each priority incident (Figure 2).

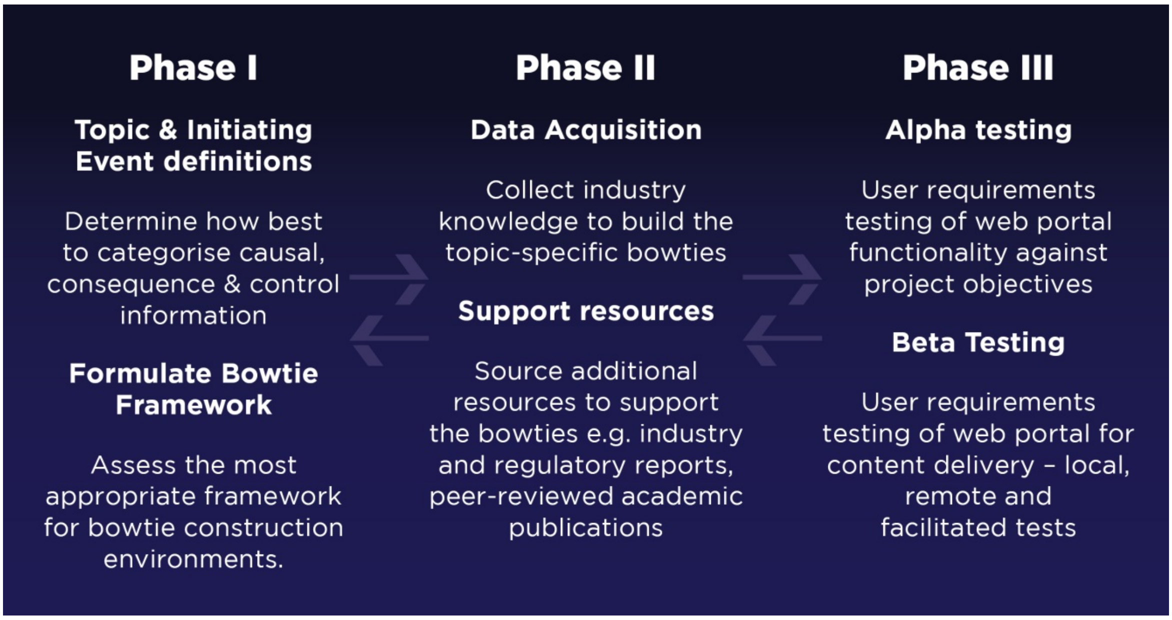

Figure 2: The three-phase action research program to capture of RISKGATE knowledge and confirm system usability

Conclusion

RISKGATE is an effective and efficient cross-industry mechanism for a step change in proactive thinking and risk analysis. It can supplement and possibly replace some current risk reduction activities across Australian coal mines and it helps mine personnel address two important needs:

- To more carefully consider the existence and effectiveness of controls for major incidents
- To recognise that every site is different, requiring a specific approach to considering adequacy of control.

When RISKGATE has been completed it will deliver:

- A comprehensive expert knowledge database for more than 15 high-consequence risk areas across Australian coal mining operations
- A permanent body of knowledge about managing these events
- Unequalled breadth of information shared and recorded from a multitude of organisations, including the largest six Australian coal companies
- A coal mining focus – RISKGATE is essentially ‘built by coal miners for coal miners’
- Simple intuitive use
- The ability to search across all of the separate priority incidents and identify causes and controls from one area that could be applied elsewhere
- A process for user feedback to ensure the information in the system remains current.

Acknowledgements

Broad participation from the Australian coal mining industry (ACARP member companies) is the key factor underlying the successful development of RISKGATE to date: 297 industry days of expert knowledge was contributed to complete the 2011 Topic series by 67 individual experts from 18 different organisations including seven mining houses (Adani 3 days, Anglo American 68 days, BMA/BHP 45 days, Centennial 32 days, Peabody 54 days, Rio Tinto 29 days, Xstrata 56 days). We likewise acknowledge the ongoing contributions of participants and companies working on the Series Two topics in 2012.

We express thanks to each of the companies for their support and provision of both experts and technical resources. We thank the Series One (2011: (Bruce Hebblewhite, David Cliff, Guldidar V. Kizil, Tilman Rashe, Mark Spinks), and Series Two (2012: Robin Burgess-Limerick, Alastair Torrance, David Cliff) topic leaders. This project is funded through ACARP grant no. C20003.