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Riskgate and Australian Coal Operations

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RISKGATE AND AUSTRALIAN COAL OPERATIONS

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ABSTRACT: The major Australian Coal Association Research Program (ACARP) project, RISKGATE has now completed three years of knowledge capture and system development. The body of knowledge for risk management of tyres, collisions, fires, isolation, strata underground, ground control open cut, explosions, explosives underground, explosives open cut, manual tasks and slips/trips/falls was launched in December 2012. Recently, the project added knowledge about outbursts, coal bumps and bursts, human-machine interface, tailings dams, occupational hygiene and inrush to the original 11 topics. In 2014, the project plans (pending ACARP funding approval) to focus on issues around Fitness for Work. RISKGATE provides an environment for knowledge capture and knowledge exchange to drive innovation and cross industry sharing of current practice in the identification, assessment and management of risk. By capturing operational knowledge from industry experts, RISKGATE provides a cumulative corporate memory at a time of high personnel turnover in the coal industry. RISKGATE is the largest single ACARP Occupational Health and Safety (OHS) initiative to date. This paper presents an overview of the first seventeen topics, topic structures, and contrasts and inter-relationships between topics. The second part of the paper discusses some early steps that companies are taking to integrate RISKGATE into their operations; and conclude with some thoughts on where RISKGATE can go in the future.

INTRODUCTION

RISKGATE is a web-based tool (RISKGATE, 2013) providing clear, up-to-date and practical checklists for controlling risks across 17 specific high priority unwanted events in Australian coal mining. Based on interactive Bow-Tie Analysis (BTA) to assist in the implementation of safer operations, each RISKGATE topic and each bow-tie is centred on a specific unwanted or initiating event. The funneling of causal factors and consequences through this initiating event keeps the information concise, intuitive and targeted. Users can generate checklists that will deliver on-site managers and engineers quick and relevant access to broad industry-based current practice controls for consideration at their own site. These checklists are designed as prompts regarding current practice that could assist with risk assessment, auditing, accident investigation, and training. User guides and other materials that assist in implementation of this body of knowledge in coal mining operations can be obtained from the author, or online (RISKGATE, 2013).

RISKGATE is funded by the Australian Coal Association Research Program (ACARP); managed and implemented by the University of Queensland; and each of the thousands of specific controls loaded into the RISKGATE system have been instigated and assessed by industry experts from Australia's leading mining companies. RISKGATE is built on a foundation of industry expert knowledge gathered through topic specific action research workshops (Kirsch, *et al*., 2012, 2013ab; Worden, *et al*., 2013). Topics which have been completed to date include: fires (Harris *et al*., 2012), underground strata control (Kirsch, *et al*., 2013c), open cut ground control, collisions, tyres, isolation, explosions (Kirsch, *et al*., 2013c), explosives (Harris, *et al*., 2013), manual tasks, and slips trips and falls (Lynas, *et al*., 2014, in press). The intent of RISKGATE is not to specifically assess risk for any unique site, but instead provide a decision support tool, resources and outputs, such as tailored checklists, that can assist users in their site-specific risk assessment and risk management.

RISKGATE 2011-2013

In response to a request from ACARP, in 2010 the University of Queensland's Minerals Industry Safety and Health Centre (MISHC) developed a RISKGATE scope in consultation with selected coal industry representatives (Kirsch, *et al*., 2012). Importantly, this identified key coal mining hazards (referred to as topics in RISKGATE) that RISKGATE would address. Over the last three years, this scope has expanded at the request of the industry from the original 12 topics to the current set of 17 topics

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described herein (Figure 1). Every RISKGATE topic is focused on coal industry activities (mining, processing, transport and storage) in both open cut and underground mine environments. The scope includes mine sites, lease areas, and mine infrastructure (e.g. mobile, fixed plant, field equipment, buildings and transport, including road and rail); and all aspects of the mine life cycle from design through to decommissioning. The topics recognise that 'loss of control' can result in personnel injury and/or fatality, equipment damage, production loss, reputation loss and environmental damage. However, the priority focus throughout RISKGATE is personnel safety.

2011	COLLISIONS	FIRES	ISOLATION	GROUND CONTROL	STRATA CONTROL	TYRES
2012	EXPLOSIONS	EXPLOSIVES OPENCUT	EXPLOSIVES UNDERGROUND	MANUAL TASKS	SLIPS TRIPS & FALLS	
2013	COAL BURSTS & BUMPS	INRUSH	INTERFACE	OCCUPATIONAL HYGIENE	OUTBURST	TAILINGS DAM
2014	Fitness for Work					

Figure 1 - RISKGATE topics and development schedule 2011-2014

RISKGATE topic summaries

The RISKGATE system applies a standard structure across the body of knowledge. Each topic is defined in terms of what is considered, and also in terms of areas that have been excluded. Within each topic, a further definition has been developed to provide terms of reference for the individual initiating events. The intention is that any users can quickly understand the way knowledge is structured, and zero in on the areas that are most relevant to their task. For example, a RISKGATE user conducting an incident investigation might start with the information about the consequences of an unwanted event (i.e. information on the right-hand side of the bow-tie), while a user conducting a risk assessment scoping exercise might initially focus their attention on the various causes and preventive controls of the event (i.e. information on the left-hand side of the bow-tie). Individual topic definitions are summarised as follows:

- FIRES relates to the unwanted or unexpected combination of a fuel source and an ignition source that results in fire. It provides controls to address four mining-related contexts: fires in mobile plant and field equipment, on fixed plant and infrastructure, on stockpiles and spoil heaps, and in the natural environment. Fuel sources are any flammable material including flammable liquids (i.e. motor fuel, lubricant, transformer fluid, hydraulic fluid and coolant), pressurised gases (LPG, natural gas, acetylene) coal, other solids (e.g. rags, timber, etc.) and other flammable fluids (e.g. cleaning fluids). Ignition results from sources of energy that include electrical, friction, hot work, lightning induction, hot surfaces and other miscellaneous sources (e.g. contraband). FIRES does not address explosions or spontaneous combustion which are addressed in RISKGATE EXPLOSIONS.
- TYRES provides information about management and prevention of incidents and accidents associated with the use of off-the-road (earthmover), industrial and other types of tyres, rims and wheels in open cut and underground coal mining. Here, the use of tyres includes all aspects of the tyre and rim management lifecycle - including selection, procurement, transport, fitting (installation and removal), maintenance, operation, storage and disposal. The scope includes the management of tyres, rims and wheels on the mine site and lease.
- ISOLATION provides information about management and prevention of incidents and accidents due to failure of the isolation process in open cut and underground mining. Relevant energies include electrical, hydraulic, pneumatic, gravity, mechanical, kinetic, chemical, thermal, and radiating (radioactive/microwave/other). Specifically, this topic addresses the control of energies and establishment of barriers to separate energies and prevent interaction with people. Each element of the isolation process (i.e. identification of an energy point/source, operation of the

physical isolation device, verification, and lock-out) is considered across the full life cycle of the isolation device/s.

- STRATA CONTROL provides information on the management and prevention of failures due to loss of strata control in the underground mine environment. Eight core initiating events have been identified as priority areas where heightened awareness of preventive and mitigating controls could dramatically reduce the likelihood and/or severity of consequences. The initiating events are:
  - Loss of strata control at/in: longwall face, outbye roadways, development roadway and face, shafts, goaf edge in pillar extraction, and stress relief mining systems
  - Pillar system instability, and control of caving
- GROUND CONTROL provides information on the management and prevention of incidents and accidents due to ground instability in open cut coal mining. Ground instability refers to the failure of mining slopes that is outside expectation of the ground/strata control management system (e.g. collapse or displacement). Controls are provided to manage potential unwanted events (i.e. initiating events) associated with activities conducted at the following locations: box cuts, highwall, end wall, low wall, truck dump, stockpiles, and truck and shovel benches (also known as pre-strip benches). Outcomes range from small individual rock falls to large-scale rock mass failures (e.g. wedge and slab failures).
- COLLISIONS relates to the unwanted or unexpected interaction between people, mobile and field equipment, or fixed plant; including uncontrolled movements of mobile plant (where no other vehicle or pedestrian is involved), resulting in skidding, sliding, roll-over and falling over edges or down voids. Mobile and field equipment (vehicles) are defined as self-propelled machines or machines that are transportable around the mine in order to perform core functions (e.g. heavy and light vehicles, including dump trucks, industrial lift trucks (forklift), mobile cranes, earthmoving equipment, drag-lines, skid mounted equipment, lighting towers, continuous miners, shuttle cars, 4WD, utes). Fixed plant refers to non-transportable infrastructure or equipment (e.g. buildings, park up areas, installations, dams, tank farms, stockpiles, power lines, and transport networks). It addresses unwanted vehicle-vehicle, vehicle-people (including rollover), and vehicle-infrastructure interactions that may result in a single or multiple incidents.
- EXPLOSIONS is defined as the unwanted or unexpected combination of a fuel and an ignition source that results in a fire or explosion. This topic focuses on coal mining and processing in open cut and underground mining. It addresses the potential for a fire or ignition to propagate into a larger fire or explosion with the consequent potential for multiple fatalities and widespread damage. Fuel sources are coal or flammable gases such as methane, ethane, carbon monoxide and hydrogen. Ignition results from sources of energy that include electrical, friction, hot work, lightning induction, hot surfaces, spontaneous combustion and other miscellaneous sources (e.g. contraband). They also include fires already existing on mobile plant, infrastructure, the natural environment, stockpiles and spoil heaps. Control of flammable gas atmospheres is to be achieved through adequate ventilation practice, including gas drainage. Here, mine workings include all areas of the mine where coal is being produced, areas that are being prepared for coal extraction and those areas which have had coal extracted from them.
- EXPLOSIVES OPEN CUT relates to the unplanned release of energy from explosives. This topic is focused on overburden removal and coal extraction in open cut mine operations. It also relates to post blast events both within and beyond established exclusion and management zones for machinery and people. The topic covers the manufacturing, transport, storage and use, as well as disposal of explosive products on a mine lease. This material may be applicable to other (non-coal) open cut blasting operations (e.g. metal mining, quarrying, civil engineering).
- EXPLOSIVES UNDERGROUND relates to the unplanned release of energy from explosives and unplanned fire or explosion consequent to explosives activity, with a focus on the use of explosives in underground coal mine operations. It also relates to post blast events both within and beyond established exclusion and management zones for machinery and people. The topic covers the transport, storage and use, as well as disposal of explosive products on a mine lease. Aspects of this material may be applicable to other underground operations (e.g. metal mining, tunnelling).
- MANUAL TASKS is focussed on hazardous manual tasks which lead to musculoskeletal disorders. Musculoskeletal disorders caused by hazardous manual tasks include sprains, strains, or tears of connective tissues (muscle, ligament, tendon, intervertebral discs); stress

fractures; tendonitis; and vascular or neural disorders. This topic considers hazardous manual tasks performed by people during exploration and the surface and underground extraction of coal; as well as the transport of coal to, and processing in, coal handling and preparation plants.

- SLIPS, TRIPS and FALLS provides information to manage hazards associated with people slipping or tripping at ground level or on stairs, ladders, or platforms including temporary structures (e.g. scaffolding), and the hazard of falling. The topic covers mobile equipment (especially access and egress) and fixed plant (including coal preparation plants), and includes consideration of construction, operation and maintenance tasks, as well as pedestrian movement around sites. The topic includes loss of balance or falls of people on the same level, and falls from one level to another. Potential consequences include minor or serious injury (e.g. sprained/twisted ankles/knees, bruising, broken bones, skull fracture), fatalities, loss of control of loads or being carried or equipment being operated (e.g. power tools). The scope of this topic extends across all life of mine stages from exploration through to decommissioning (including the transport of coal to, and processing in, coal handling and preparation plants).
    - Controls address both short term and long term situations. For example, different measures may be needed for long term existing infrastructure that does not conform to current standards.
- COAL BUMPS AND BURSTS provides information on the management and prevention of strata failures due to bump or burst in underground coal mining. The terms bump and burst are often used interchangeably, and bump is used throughout this topic. The term bump describes a violent, brittle, dynamic failure of strata (pillar, rib, face, roof, floor) in or adjacent to the working section due to stress with a sudden release of energy. There may also be a liberation or ejection of coal or rock as a result of the energy release. This is more commonly described as a burst. The occurrence of bump and burst is directly related to stress, and will potentially increase with depth. (In the hard rock mining environment, bump or burst phenomena are called strainburst or rockburst.)
- INRUSH is the sudden and unplanned or uncontrolled inflow of liquid, gas or other material into coal mine workings which may result in unacceptable risk to health and safety. The risks are considered under two initiating events: inrush into surface workings and inrush into underground workings. To characterise the hazard associated with inrush requires a comprehensive three-dimensional spatial understanding to enable development and implementation of effective controls. Given the nature of risk associated with inrush, it is important to continuously verify that ongoing changes in the environment do not impact the validity of the original risk assessment (e.g. change in circumstances in neighbouring mines, different surface infrastructure). Inrush is a broad subject that interacts with a range of other management systems, including ground control (surface and underground), ventilation, water, engineering maintenance plan, survey control, inspections, defect management, and emergency response plan.
- HUMAN-MACHINE INTERFACE relates to interfaces (e.g. controls and displays) which are the means by which people:
    - operate and maintain plant or equipment, whether fixed, portable or mobile
    - gain and maintain situation awareness about the current and potential future state of plant within the mine and/or relevant aspects of the mine environment (e.g., the presence and location of other equipment or people; presence of methane; slope stability)
    - gain and maintain situation awareness about the current and potential future states of the mine and relevant environment (e.g. ventilation; manning, vehicle and machinery movements; production, development and maintenance activities; water management; security; and weather forecasts)
- Operator interfaces include levers, push buttons, dials, pedals, wheels, switches, touch screens, joy sticks, valves, keyboards, remote controls and communication devices. Display interfaces include sources of visual information (eg. windows, mirrors, computer screens, gauges, video monitors, cap lamps, mimic boards, tag boards, labels, signage, visual indicators, lights, pictograms, and white boards) as well as auditory displays (e.g. audio alarms, buzzers, communication devices) and haptic feedback devices (e.g. vibrating joystick). The detection and perception of information provided by displays allows situation awareness to be gained and maintained. This situational awareness is typically discussed in terms of individual awareness but may also include more complex automated systems and multiple operators. Errors in the use of controls, or suboptimal operation of controls, may result in unintended, delayed or sub-optimal movement or action of the plant or equipment being operated, leading to unwanted

consequences including injury, fatality, equipment damage/increased maintenance and/or poor performance).

  - The loss of awareness of the state of the mine, or plant, may result in making incorrect, delayed or sub-optimal decisions which lead to unwanted consequences including fatality, injury or poor performance.

- OCCUPATIONAL HYGIENE addresses chemical, physical and biological stressors. It focuses on coal mining and processing in open cut and underground environments across the lifespan of the mine (exploration, operations, closure). It addresses the key hazards of coal dust, silica dust, Diesel Particulate Matter (DPM), noise, and the thermal environment (e.g. heat stress, and cold). Other hazards include other air-borne contaminants (e.g. fumes, fibres, gases, vapors, combustion products; including the effect of confined spaces), waterborne contaminants (e.g. Legionella, E. coli (UG sanitation)), chemicals (e.g. PUR, solvents, glues, cleaning compounds), ionizing and non-ionising radiation (e.g. welding flash), vibration, and not fit for purpose lighting. Less than adequate control of these stressors in the working environment may result in harm to workers. Adverse health outcomes might be felt immediately, short-term or many years after exposure (e.g. acute, cumulative or chronic effects, long latency period).
- OUTBURST relates to the sudden release of gas and material under pressure from the working place that has the potential to affect health and safety in coal mining. Outbursts occur when there is gas of sufficient volume and pressure to exceed the confining strength of the material within the seam being mined, or within seams above and below the active seam. Outbursts generally occur at the working face (development, driveage or longwall). Historically, outbursts have mostly occurred at the development face, though a lesser number have occurred at the longwall face.
- TAILINGS DAMS addresses a key risk of catastrophic dam failure due to geotechnical instability of the dam itself or of its foundation, overtopping and erosion of the dam wall and piping failure of the dam itself or of its foundation. Coal mine tailings dams are also prone to seepage to the foundation and through the wall, particularly during operation when large volumes of water are discharged with the tailings. The most significant risk associated with this is the spillage and seepage of potentially contaminated water. Contamination can take the form of elevated salinity, acidity and dissolved metals, and sulphate. Run-off from coal mine tailings storages can cause erosion and can also potentially contain contaminants. Both the tailings and the water could be benign or potentially contaminating. Tailings can potentially be released by failure of the dam. Such failure could be by geotechnical slope instability, piping, or erosion due to overtopping. Water can potentially be released by failure of the dam, or by overtopping of surface run-off, or by seepage to the foundation and/or through the wall.

The RISKGATE team assembled individual topic panels (teams of industry experts) to discuss and develop the expert content (industry knowledge) for each specific topic. Optimal system content and wording was captured from discussion and debate within the group via a semi-structured action research workshop cycle described in more detail in Kirsch *et al*. (2012, 2013a,b) and Worden *et al*. (2013). As a result, each of the thousands of specific causes, controls and consequences within RISKGATE was identified, created, assessed and confirmed by industry experts from Australia's leading mining companies prior to upload into the system.

RISKGATE RESEARCH PROGRAMME AND PARTICIPANTS, 2011-2013

Workshop activity can be summarised as follows:

- 2011: 86 workshop days, 422 individual days of mining industry expert time
- 2012: 39 workshop days, 164 individual days of mining industry expert time
- 2013: 34 workshop days, 149 individual days of mining industry expert time

These experts, bringing broad ranging experience and training in underground, open cut, coal and hard rock environments, have contributed a collective equivalent of 735 individual days to the RISKGATE programme, with the mean years of experience in the industry for specific topics ranging from 10.5 years (Slips, Trips, Falls) to 31.4 years (Outburst) (Table 1).

Table 1 - Industry expert participation in RISKGATE workshops

Topic	Number of workshop days	Workshop attendance (personnel days of Mining and Industry Experts)	Mean workshop participant experience (yrs)
Collisions	11	51	24.8 (1-39)
Fires	15	81	26.5 (9-48)
Isolation	15	83	19.3 (14-39)
Ground Control	14	45	21.3 (5-37)
Strata Control	16	75	19.4 (5-37)
Tyres	15	142	22.0 (1-42)
Explosions	11	47	26.9 (15-38)
Explosives Opencut	11	62	22.9 (9-40)
Explosives Underground	3	14	20.0 (5-41)
Manual Tasks	8	58	17.7 (4-38)
Slips, Trips and Falls	9	39	10.5 (1-22)
Coal Bursts and Bumps	3	14	24.0 (7-40)
Inrush	8	42	30.5 (15-39)
Interface	4	20	15.5 (1-23)
Occupational Hygiene	10	49	17.8 (3-24)
Outburst	4	20	31.4 (16-40)
Tailings Dam	4	15	20.7 (10-27)
	161	857	

Workshop participants represented a broad array of industry knowledge and professional expertise acquired across a spectrum of ten mining companies, fourteen OEM or suppliers, two universities, and two regulatory agencies (NSW, QLD) (Table 2). Collaborative industry efforts provided the foundation upon which RISKGATE was built, with outcomes a reflection of how leading practitioners share and negotiate current practice. Integration of cross-sectorial industry knowledge, further supported by a substantive and diverse array of industry, academic and technological resources, means RISKGATE can offer a continuum for knowledge transfer and redefining best practice in risk identification, assessment and management in the coal industry.

Table 2 - Workshop participants 2011-2013

Anglo American BMA/BHP Bandana Centennial Coal Downer EDI Gujarat Peabody Energy Rio Tinto Glencore Adani Caledon	Bridgestone Good Year Marathon Michelin Titan	Aystar Dyno Nobel Golder Ergo Enterprises Job Fits System Orica Mining Services Otraco Klinge Group Pulford	The University of Queensland University of New South Wales University of Wollongong	Qld Department of Employment, Economic Development and Innovation (DEEDI) Qld Department of Natural Resources and Mines (DNRM) New South Wales Trade and Industry Workplace Health and Safety

Knowledge distribution across the RISKGATE Bow-Tie

RISKGATE's body of knowledge is built using BTA, a risk management method that helps users consider the entire context of an unwanted event associated with a particular hazard: its causes, consequences and most importantly the controls used to prevent the unwanted event or to mitigate or reduce the consequences of it should it occur. A key advantage of this method is its focus on control effectiveness.. Detailed explanation of BTA application within the RISKGATE program can be found in Kirsch *et al*. (2012, 2013a,b) and Worden *et al*. (2013). A brief summary is presented here for the any new users.

Bow-Tie elements

There are typically between four and nine bow-ties within each RISKGATE topic with each bow-tie centred on a specific *initiating event* (or unwanted event). The initiating event, or 'knot', of the bow-tie represents the point at which energy control is lost; with the primary causes and the unwanted consequences of the initiating event tabulated on either side of the knot. A *cause* is any occurrence or reason that could lead to an event via the release of the hazard(s). Correspondingly, a *consequence* is any negative outcome that arises from an initiating event. In RISKGATE consequences primarily are associated with injury or illness of people, but also include damage to equipment and/or the environment, though there may be other important negative consequences.

Controls include any process, policy, device, practice, or other action that is intended to reduce the likelihood of an unwanted event occurring or that reduces the magnitude of the consequences of an unwanted event. Causes are prevented from triggering the event through specific preventive controls. Should these preventive controls fail, the severity of the consequences of the unwanted event are minimised through mitigating controls designed and implemented before the event occurs.

The RISKGATE BTA tool has sufficient flexibility to accommodate a growing depth of knowledge beyond forecast user requirements, as has been experienced during this project. The actual number of data elements collected to date for each initiating event per topic is summarised in Table 3. Note, these estimates are conservative as many of the controls are further broken into multiple options or 'sub-control' data points. Totals for Inrush, Tailings Dams and Occupational Hygiene are not included in Table 3, as this topic content is still going through final review at the time of preparation of this conference manuscript.

Table 3 - Summary of RISKGATE bow-tie element data (one initiating event per topic)

Topic	Number of Initiating Events	Causes	Preventive Controls	Consequences	Mitigating Controls
Tyres	4	28	146	9	29
Collisions	2	45	133	4	11
Strata Control	8	114	383	21	4
Ground Control	7	86	204	23	35
Fires	4	46	165	9	54
Isolation	5	301	792	11	65
Explosives O/C	5	55	127	18	39
Explosives U/G	4	35	84	10	24
Explosions	7	50	240	7	43
Manual Tasks	3	39	114	3	6
Slips Trips and Falls	3	26	57	3	11
Coal Bumps and Bursts	3	3	20	9	20
Outburst	1	7	31	1	6
Interface	3	52	216	3	31

RISKGATE: Knowledge models per topic

During the workshops the industry experts found BTA to be more effective when structured within a recognised industry model to assist in system design and user implementation. The expert panels within each topic area chose a different model or industry framework to structure knowledge acquisition and presentation in the online system. These tended to match the unique approaches that the different mining experts used '*in situ*' to manage their particular hazard. For example, both the Fires and Explosions topics were structured around fuel or ignition sources, with fuel sources for the Fires topic divided into flammable liquids; coal; other solids; pressurised gases; and other flammable fluids. The Strata (underground) and Ground (open cut) topics were divided according to unwanted events at different mine locations, and controls for each of these were categorised according to whether they addressed design or operational issues. The information in the tyres topic was developed around the tyre life cycle from procurement to disposal. The explosives open cut topics also took this format, focussing on the lifecycle of the various classes of explosives on the mine site, from manufacturing to disposal. The Isolation topic was possibly the most complex structure with a 5x4 matrix between the 'Life of the Asset' (design/procurement; installation/commissioning\; operation/maintenance; modification; and decommissioning) and the 'Isolation Steps' (identification; operation; verification; and securing). These models or frameworks were used throughout the action research workshops to ensure that different hazards were addressed in a systematic and comprehensive way.

RISKGATE: Integration in company operations

The first 11 RISKGATE topics were launched in December 2012, with an additional six topics coming online by the end of December 2013. Therefore, technology transfer and system implementation is still in an early phase within the Australian coal industry. However, the following case studies provide examples of how RISKGATE is currently being used within different coal mining companies:

Use of RISKGATE as a reference / body of knowledge

The first entry point for new RISKGATE users is to familiarise themselves with the structure of the site, and then download information in the form of customised checklists that can be used to inform corporate or site-level risk assessments, incident investigations, audits and for the development of management systems. For example, Peabody Energy Australia is using the RISKGATE Strata Underground and Ground information as reference material for audits of their geological/geotechnical principal hazard management plans at specific operations.

Consideration for RISKGATE content in development of corporate practice

Once familiar with the system, and this detailed body of knowledge, companies are starting to use the RISKGATE information as a comparative data base for gap analysis of corporate standards and to inform the development of new standards or recommended practice. Anglo American has used RISKGATE to benchmark their global isolation standard; and their new recommended practice for collision avoidance systems was built using the RISKGATE Collisions knowledge as a primary source.

Integration of RISKGATE content into operating systems

Some coal companies are actively integrating RISKGATE into their risk management processes. In the vanguard of these is Centennial Coal, which has fully embraced the use of RISKGATE and developed a software interface that enables seamless integration of the RISKGATE knowledge base into their internal risk management software system, Stature. Centennial staff can log into the RISKGATE site, customise information checklists for their specific application, save these checklists into a Stature format on their home computer; and then log into Stature on their home computer and upload the RISKGATE file so that it is displayed within the Stature page. When this is completed, the risk manager is able to return to the standard and routine procedures established for management of hazards, but equipped with the Australian coal industry's body of knowledge for that hazard. It is simply like bringing the whole industry into the room at one time. This process has particularly proven beneficial in the scoping of risk assessments, where users are able to compile a collection of their own current controls with those of RISKGATE about a particular unwanted event or hazard, and then bring this information to the wider group to conduct the risk assessment task.

RISKGATE: Next steps and future opportunities

In 2014, RISKGATE will focus on the remaining topic Fitness for Work, pending continuing ACARP funding. It is proposed that the topic will be divided into five key areas to address drugs (legal and illegal), alcohol, fatigue, physical wellbeing and psychological wellbeing. In August 2013, the RISKGATE team surveyed 106 mining industry representatives in Australia to help the team develop a fitness for work project scope and obtain further input for the proposed action research workshops. The survey results showed very strong support for the five topic categories and respondents provided suggestions on what could be included within these categories. These included:

- Caffeine, synthetics and the impact of families – drugs
- Understanding what 'normal' consumption might be – alcohol
- Commuting, personal duty of care, self-management , performance impact, personal health, and alcohol and sleep – fatigue

- Pain management, sleep disorders, personal duty of care, physical fitness requirements for emergency egress, musculoskeletal conditions – physical wellbeing
- Cognition, medication impacts, assessment techniques, family support – psychological wellbeing.

The RISKGATE team is seeking industry experts who can contribute their knowledge to the 2014 Fitness for Work action research workshops. Workshop participation presents opportunities for networking, reflection and sharing of lessons learned, keeping abreast of current and emerging control technologies, instigating a shift in existing safety culture, and elevating the accepted levels of current practice.

However, this body of knowledge has application beyond the coal industry. Many hazards in the coal industry, such as collisions, hazardous energy (for example electricity or hydraulic pressure), fires, explosions and slips, trips and falls are common to other mining domains and beyond in other industries. Coal mining is recognised globally as a hazardous activity and, as a result, operates under high levels of regulatory and public scrutiny. Other high-risk industries, often associated with the coal supply or energy chains – including power generation and transmission, construction, rail transport, road transport and shipping – and other mining industries all need to manage workforces operating in similar high-risk environments. From a broad industry perspective, the RISKGATE platform provides an environment for knowledge capture and knowledge exchange regarding current practice, and facilitates the establishment of a cumulative corporate memory. Practitioners from other high-risk industries are encouraged to engage with the RISKGATE process to help improve their risk management outcomes.

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REFERENCES

Harris, J, Kirsch, P, Sprott, D, Spinks, M, Goater, S and Cliff, D, 2012. RISKGATE - a case study in application to fires on mobile plant. *Proceedings of the Eighth AUSIMM Open Pit Operators Conference*, Perth, 18-19 September 2012, Perth, Australia. The Australasian Institute of Mining and Metallurgy (The AusIMM)

Harris, J, Sprott, D, Torrance, A, Shi, M, Ranjan, A, Sharma, S, Biswas, T, Sharma, S. and Kirsch, P A, 2013. Sharing industry knowledge to improve management of risks and safety in the use of explosives in surface mining. *Proceedings of the World Mining Congress*, Montreal, Canada, August 11-15, 2013.

Kirsch, P, Goater, S, Harris, J, Sprott, D, and Joy, J, 2012. RISKGATE: Promoting and redefining best practice for risk management in the Australian coal industry. *Proceedings of the 12th Coal Operators' Conference*, University of Wollongong and The Australasian Institute of Mining and Metallurgy, 2012, 315-325. http://ro.uow.edu.au/coal/421/.

Kirsch, P, Harris, J, and Sprott, D, 2013a. Vertical integration of risk management in the Hunter Valley Coal Chain – application of the coal industry's RISKGATE platform. *The AUSIMM Bulletin* February 2013, 45-49.

Kirsch, P A, Harris, J, Cliff, D and Sprott, D, 2013b. Industry scale knowledge management – RISKGATE and Australian coal operations. *Proceedings of the World Mining Congress*, Montreal, Canada, August 11-15, 2013.

Kirsch, P A, Harris, J, Cliff, D, Hebblewhite, B, Sprott, D, Shi, M, Ranjan, A, Sharma, S, Biswas, T, and Sharma, S, 2013c. Industry scale knowledge management – introducing the RISKGATE Underground Strata and Explosions Body of Knowledge. *Proceedings of the World Mining Congress*, Montreal, Canada, August 11-15, 2013.

Kirsch, P, Harris, J, Sprott, D, and Cliff, D, 2014. RISKGATE and Australian coal operations. *Proceedings of the 14th Coal Operators' Conference*, University of Wollongong and The Australasian Institute of Mining and Metallurgy, 2014 (this volume).

Lynas, D, Burgess-Limerick, R, and Kirsch, P A, 2014 (in press). RISKGATE analysis of Slips, Trips and Falls at NSW surface and underground coal mines. *Journal of Health and Safety Research and Practice*

RISKGATE, 2013. www.riskgate.org.

Worden, S, Sprott, D, and Whittaker, B, 2013. Risk management competence in Australia gets a boost from new software. *Mining Engineering* 65 (July): 22-33.