Provincial Underground Mining Sector Risk Assessment Workshop Results

A focused approach to improving workplace health & safety

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RA = risk assessment

U/G = underground

Risk Assessment: Introduction

- **2013: MLITSD launched project to put in place an integrated risk assessment methodology to:**
  identify risks to worker health and safety & work with employers and workers on reducing those risks
  provide more information to employers, workers & their representatives about risks at the **SECTOR** level

With support of the MLRC and MLITSD, WSN planned & facilitated the **Underground Mining Sector Risk Assessment**

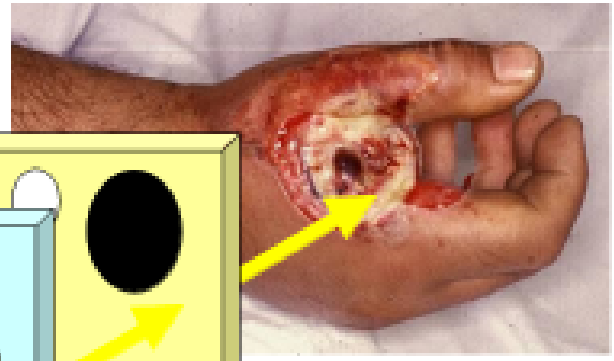
- **Harness collective wisdom across the sector in a tripartite process to focus the industry, health & safety associations (HSAs), and regulator on highest risks to health and safety**
- **Approach draws on industry, worker, HSA, & Ministry knowledge of risk and recognizes that one-size approach does not fit all**
- **Approach draws on empirical insights of risk management & operations research/decision science**

The Swiss Cheese Model of Accident Causation

Prevention

Examples that could lead to increased risk

Failure/absence of risk controls



ACTIVE FAILURE

LATENT FAILURE

LATENT FAILURE

LATENT FAILURE

LATENT FAI LURE

Unsafe act

Fatigue

Training material not current

Gaps in Regs.

Design issues

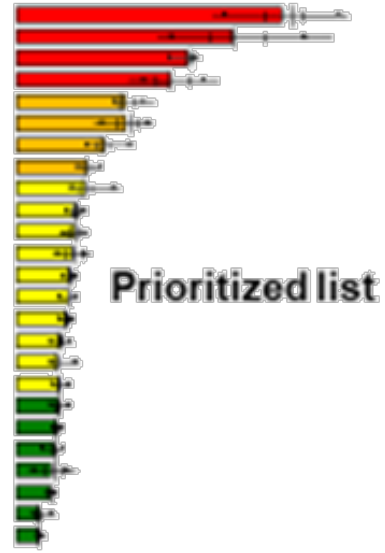
Worker

Simultaneous failure/absence of risk controls could cause a "catastrophic event"

Ontario

Workshop: A Tripartite and Collective Process

Sector Selection ⇨ SMEs Identified ⇨ Events Identified ⇨ Events Analyzed ⇨ Events Prioritized



Workshop: A Tripartite and Collective Process

Workshop process was open, transparent, and collaborative:

- Ensured any perspective or viewpoint was heard
- Each response received was respected and not freely edited
- Final list shared with workshop participants before the workshop
- Final workshop results reviewed/validated by industry participants

Finding acceptable solutions that all members can support:

- Only industry experts ranked the risks, not government or WSN
- Process was NOT about consensus, although the results demonstrate a significant degree of convergence

Risk Assessment Workshop: Attendees

SUBJECT MATTER EXPERTS		
#	Name	Company/Representative
1	Craig Allair	Vale
2	Richard Claveau	Newmont
3	Nav Gill	KGHM
4	Billy Smith	Glencore
5	Jerry Thibeault	Vale
6	Chris Betsill	Redpath
7	Loye Halteman	Barrick
8	Jake Hughes	Technica
9	Michelle Hulme	Vale
10	Darren Raymond	Compass Minerals

WORKSHOP PARTICIPANTS		
#	Name	Company/Representative
1	Derek Budge	Mining Legislative Review Committee
2	Malcom Mills	Mining Legislative Review Committee
3	Rick Legree	Barrick: Worker Advisor
4	Scott Secord	MLITSD: Inspector
5	Tom Welton	Workplace Safety North: Tech Support
6	Robert Marin	Workplace Safety North: Facilitator
7	Sam Barbuto	Workplace Safety North: Facilitator
8	Tiana Larocque	Workplace Safety North: Tech Support
9	Tricia Valentim	Workplace Safety North: Tech Support
10	Harsim Kalsi	MLITSD: Provincial Mining Coordinator

***MLITSD**: Ministry of Labour, Immigration, Training, and Skills Development*

Worker Representation

Employer Representation

Risk Assessment Workshop: Event Categories

1. Equipment, materials, machinery
2. Fire and explosion
3. Musculoskeletal disorder hazards
4. Ground Control
5. Occupational illness/disease
6. Environment
7. Psychosocial hazards
8. New/young workers
9. Temperature stress
10. Work practices
11. Water management
12. Shaft hazards

Risk Assessment: Prioritize risks

- The purpose of this stage is to assess the level of risk and establish risk priorities
- **Risk**, which is the **average Likelihood (L)** multiplied by the **average Consequence (C)** for each event, then is categorized with respective risk ratings using the **Risk Matrix (Heat Map)**

LIKELIHOOD	Low (1)	Minor (2)	Moderate (3)	Major (4)	Extreme (5)
Almost Certain (5)	5	10	15	20	25
Very Likely (4)	4	8	12	16	20
Likely (3)	3	6	9	12	15
Unlikely (2)	2	4	6	8	10
Rare (1)	1	2	3	4	5

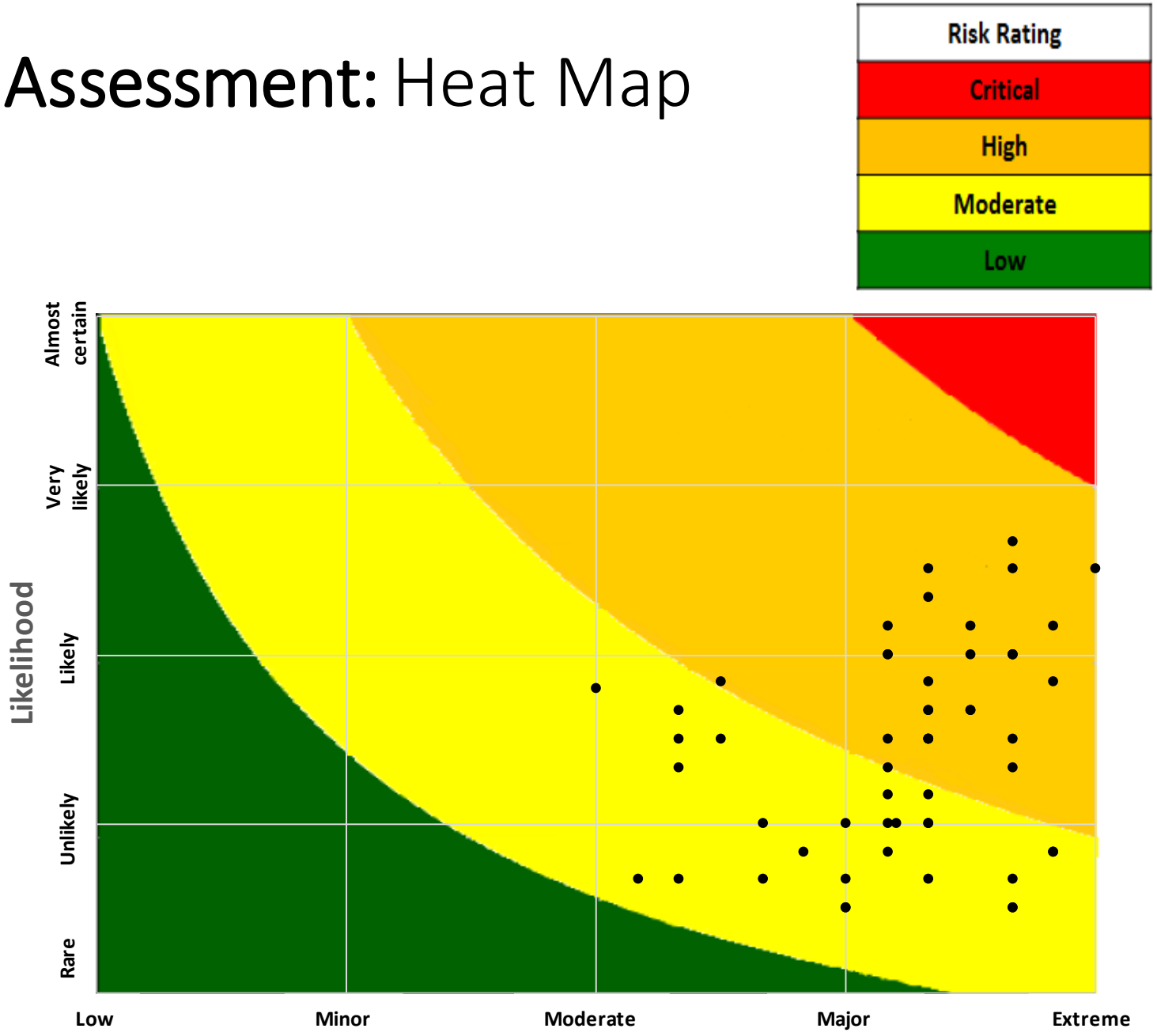
CONSEQUENCE

Risk Matrix Result	Risk Rating
20 to 25	Critical
12 to 16	High
5 to 10	Moderate
1 to 4	Low

U/G Mining Sector Risk Assessment: Heat Map

Likelihood	Description
[1] Rare	Very low probability for unwanted event to occur in the next year [or less than 5% of occurrence]
[2] Unlikely	Low probability for unwanted event to occur in the next year [or between 5%-20% chance of occurrence]
[3] Likely	It is possible for unwanted event to occur in the next year [or between 20%-50% chance of occurrence]
[4] Very likely	High probability for unwanted event to occur in the next year [or between 50%-90% chance of occurrence]
[5] Almost certain	Unwanted event is almost certain to happen in the next year [or 90% or greater chance of occurrence]

Consequence	Description
[1] Low	No injury or illness [or negligible impact/importance]
[2] Minor	First aid treatment (no lost time) [or minor impact/importance]
[3] Moderate	Temporary disability (lost time): Injury/illness [or moderate impact/importance]
[4] Major	Serious event/critical injury or critical illness [or major impact/importance]
[5] Extreme	Fatality or permanent disability [or extreme impact/importance]



U/G Mining Sector Risk Assessment:

Top 10 of 54 identified events

Rank	Category	Event (Situation/Condition) that could result in Injury or Illness OR What could keep you up at night?	Risk
1	Equipment, materials, machinery	Interaction with Mobile Equipment – Equipment collision with other equipment (Large vs small) - Traffic Control	19.78
2	Equipment, materials, machinery	Interaction with Mobile Equipment and pedestrian	17.60
3	Fire and explosion	Adoption of new Technology: Battery Electric Vehicle Fires - Battery electric vehicle overheats, catches fire, or explodes underground (injuring operators, miners and/or mine rescue personnel)	15.12
4	Musculoskeletal disorder hazards	Worker suffers manual handling or repetitive strain injury	15.04
5	Ground control	Ground control failure causing injury	14.80
6	Occupational illness/ disease	Exposure to airborne hazardous substances	14.80
7	Equipment, materials, machinery	Interaction with Mobile Equipment – collision with infrastructure (conveyors, towers, etc.)	14.62
8	Equipment, materials, machinery	Inadvertent contact with stored energy	14.62
9	Occupational illness/disease	Hearing loss	14.52
10	Fire and explosion	Major fire underground from mobile Equipment	13.76

U/G Mining Sector Risk Assessment:

Top 10 risk by category

Rank	Category	Event (Situation/Condition) that could result in Injury or Illness OR What could keep you up at night?
1	Equipment, materials, machinery	Interaction with Mobile Equipment – Equipment collision with other equipment (Large vs small) - Traffic Control
2	Equipment, materials, machinery	Interaction with Mobile Equipment and pedestrian
3	Fire and explosion	Adoption of new Technology: Battery Electric Vehicle Fires - Battery electric vehicle overheats, catches fire, or explodes underground (injuring operators, miners and/or mine rescue personnel)
4	Musculoskeletal disorder hazards	Worker suffers manual handling or repetitive strain injury
5	Ground control	Ground control failure causing injury
6	Occupational illness/ disease	Exposure to airborne hazardous substances
7	Equipment, materials, machinery	Interaction with Mobile Equipment – collision with infrastructure (conveyors, towers, etc.)
8	Equipment, materials, machinery	Inadvertent contact with stored energy
9	Environment	Hearing loss
10	Fire and explosion	Major fire underground from mobile Equipment

Worker vs. Workshop Results: Top 10 comparison

#	Category	Event (Situation/Condition) that could result in Injury or Illness OR What could keep you up at night?	RISK
1	Occupational illness/ disease	Exposure to airborne hazardous substances	20.30
2	Equipment, materials, machinery	Interaction with Mobile Equipment – Equipment collision with other equipment (Large vs small) - Traffic Control	19.17
3	Equipment, materials, machinery	Interaction with Mobile Equipment and pedestrian	17.50
4	Equipment, materials, machinery	Interaction with Mobile Equipment – collision with infrastructure (conveyors, towers, etc.)	14.57
5	Fire and explosion	Adoption of new Technology: Battery Electric Vehicle Fires - Battery electric vehicle overheats, catches fire, or explodes underground (injuring operators, miners and/or mine rescue personnel)	14.67
6	Musculoskeletal disorder hazards	Worker suffers manual handling or repetitive strain injury	14.40
7	Fire and explosion	Worker caught in smoke	13.20
8	Fire and explosion	Major fire underground from mobile Equipment	14.40
9	Equipment, materials, machinery	Inadvertent contact with stored energy	14.40
10	Environment	Contagious infections, flu etc.	13.33

Worker results

#	Category	Event (Situation/Condition) that could result in Injury or Illness OR What could keep you up at night?	RISK
1	Equipment, materials, machinery	Interaction with Mobile Equipment – Equipment collision with other equipment (Large vs small) - Traffic Control	19.78
2	Equipment, materials, machinery	Interaction with Mobile Equipment and pedestrian	17.60
3	Fire and explosion	Adoption of new Technology: Battery Electric Vehicle Fires - Battery electric vehicle overheats, catches fire, or explodes underground (injuring operators, miners and/or mine rescue personnel)	15.12
4	Musculoskeletal disorder hazards	Worker suffers manual handling or repetitive strain injury	15.04
5	Ground control	Ground control failure causing injury	14.80
6	Occupational illness/ disease	Exposure to airborne hazardous substances	14.80
7	Equipment, materials, machinery	Interaction with Mobile Equipment – collision with infrastructure (conveyors, towers, etc.)	14.62
8	Equipment, materials, machinery	Inadvertent contact with stored energy	14.62
9	Environment	Hearing loss	14.52
10	Fire and explosion	Major fire underground from mobile Equipment	13.76

Workshop results

Employer vs. Workshop Results: Top 10 comparison

#	Category	Event (Situation/Condition) that could result in Injury or Illness OR What could keep you up at night?	RISK
1	Equipment, materials, machinery	Interaction with Mobile Equipment – Equipment collision with other equipment (Large vs small) - Traffic Control	21.16
2	Equipment, materials, machinery	Interaction with Mobile Equipment and pedestrian	18.40
3	Ground control	Ground control failure causing injury	17.60
4	Environment	Hearing loss	16.56
5	Musculoskeletal disorder hazards	Worker suffers manual handling or repetitive strain injury	15.36
6	Fire and explosion	Adoption of new Technology: Battery Electric Vehicle Fires - Battery electric vehicle overheats, catches fire, or explodes underground (injuring operators, miners and/or mine rescue personnel)	15.20
7	Equipment, materials, machinery	Inadvertent contact with stored energy	14.72
8	Equipment, materials, machinery	Interaction with Mobile Equipment – collision with infrastructure (conveyors, towers, etc.)	13.80
9	Fire and explosion	Major fire underground from mobile Equipment	13.44
10	Ground control	Uncontrolled run of muck	12.92

Employer results

#	Category	Event (Situation/Condition) that could result in Injury or Illness OR What could keep you up at night?	RISK
1	Equipment, materials, machinery	Interaction with Mobile Equipment – Equipment collision with other equipment (Large vs small) - Traffic Control	19.78
2	Equipment, materials, machinery	Interaction with Mobile Equipment and pedestrian	17.60
3	Fire and explosion	Adoption of new Technology: Battery Electric Vehicle Fires - Battery electric vehicle overheats, catches fire, or explodes underground (injuring operators, miners and/or mine rescue personnel)	15.12
4	Musculoskeletal disorder hazards	Worker suffers manual handling or repetitive strain injury	15.04
5	Ground control	Ground control failure causing injury	14.80
6	Occupational illness/ disease	Exposure to airborne hazardous substances	14.80
7	Equipment, materials, machinery	Interaction with Mobile Equipment – collision with infrastructure (conveyors, towers, etc.)	14.62
8	Equipment, materials, machinery	Inadvertent contact with stored energy	14.62
9	Environment	Hearing loss	14.52
10	Fire and explosion	Major fire underground from mobile Equipment	13.76

Workshop results

Appendix A: Workshop Process Details

1. A sector is identified and defined for risk assessment
2. Subject matter experts (SMEs) from the selected sector are identified
3. Each of the selected SMEs list (identify) the situations or conditions (events) that could lead to injury or illness with appropriate evidence for each event (pre-workshop)
4. The lists are collected and amalgamated into one list (pre-workshop)
5. The amalgamated list is sent to each SME for review (pre-workshop)
6. A workshop is scheduled for the analysis and prioritization of each identified event on the amalgamated (final) list
7. Workshop conducted in blended face-to-face and videoconferencing format in light of necessary COVID-19 pandemic precautionary measures.
8. For each identified event on the list, SMEs contribute toward a robust discussion, generating deeper objective understanding and allowing for all perspectives to be heard (comments are NOT attributed)
9. After each discussion for each identified event, each SME "votes" (based on identified criteria/scale) to lock in a value judgement on **likelihood of the event occurring** and **severity of the consequence if the event was to occur**
10. Electronic voting tools are used to make voting easy and anonymous; results on each event are instantaneous
11. Project manager takes results to create a risk profile/heat map for the sector
12. Results validation includes "smell test" by industry SMEs before releasing final results

Appendix B: Risk Assessment Processes/Standards

1. Bayesian Analysis
2. Bow-tie analysis
3. Brainstorming (e.g. what-if)
4. Business impact analysis
5. Cause and effect analysis
6. Checklists
7. Computer Hazard and Operability Studies (CHAZOP)
8. Consequence Analysis (also called Cause-Consequence Analysis)
9. Likelihood/Consequence matrix
10. Construction Hazard Assessment and Implication Review (CHAIR)
11. Decision tree
12. Delphi technique
13. Energy Barrier Analysis (or Energy Trace Barrier Analysis)
14. Environmental risk assessment
15. Event tree analysis
16. Failure Mode and Effect Analysis (FMEA)
17. Failure mode, effect and criticality analysis
18. Fault Tree Analysis
19. Fishbone (Ishikawa) Analysis
20. Hazard analysis and critical control points
21. Hazard and Operability studies (HAZOP)
22. Human reliability analysis
23. Job Safety Analysis (JSA)
24. Level of Protection Analysis (LOPA)
25. Markov analysis
26. Monte Carlo
27. Preliminary Hazard Analysis (PHA)
28. Reliability centered maintenance
29. Scenario analysis
30. Sneak circuit analysis
31. Structured/semi-structured interviews
32. SWIFT (i.e. structured what-if)
33. Systemic Cause Analysis Technique (SCAT)
34. Human Error Analysis (HEA)
35. Workplace Risk Assessment and Control (WRAC)

Risk Management Standards:

1. Risk Management Principles and Guidelines (ISO 31000:2009)
2. Risk Assessment Techniques (ISO/IEC 31010:2009)
3. OH&S Hazard Identification and Elimination and Risk Assessment and Control (CSA Z1002)
4. Process Safety Management (CSA Z767-17)
5. Enterprise Risk Management (COSO 2004)
6. Global Minerals Industry Risk Management (GMIRM)
7. International Council on Mining & Metals (ICMM)

*** Not an exhaustive list**

Appendix C: Contacts

For additional information or questions, please contact:

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