Provincial Battery Electric Vehicle Risk Assessment Workshop Results – A focused approach to improving workplace health & safety

August 11, 2021

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RA = risk assessment

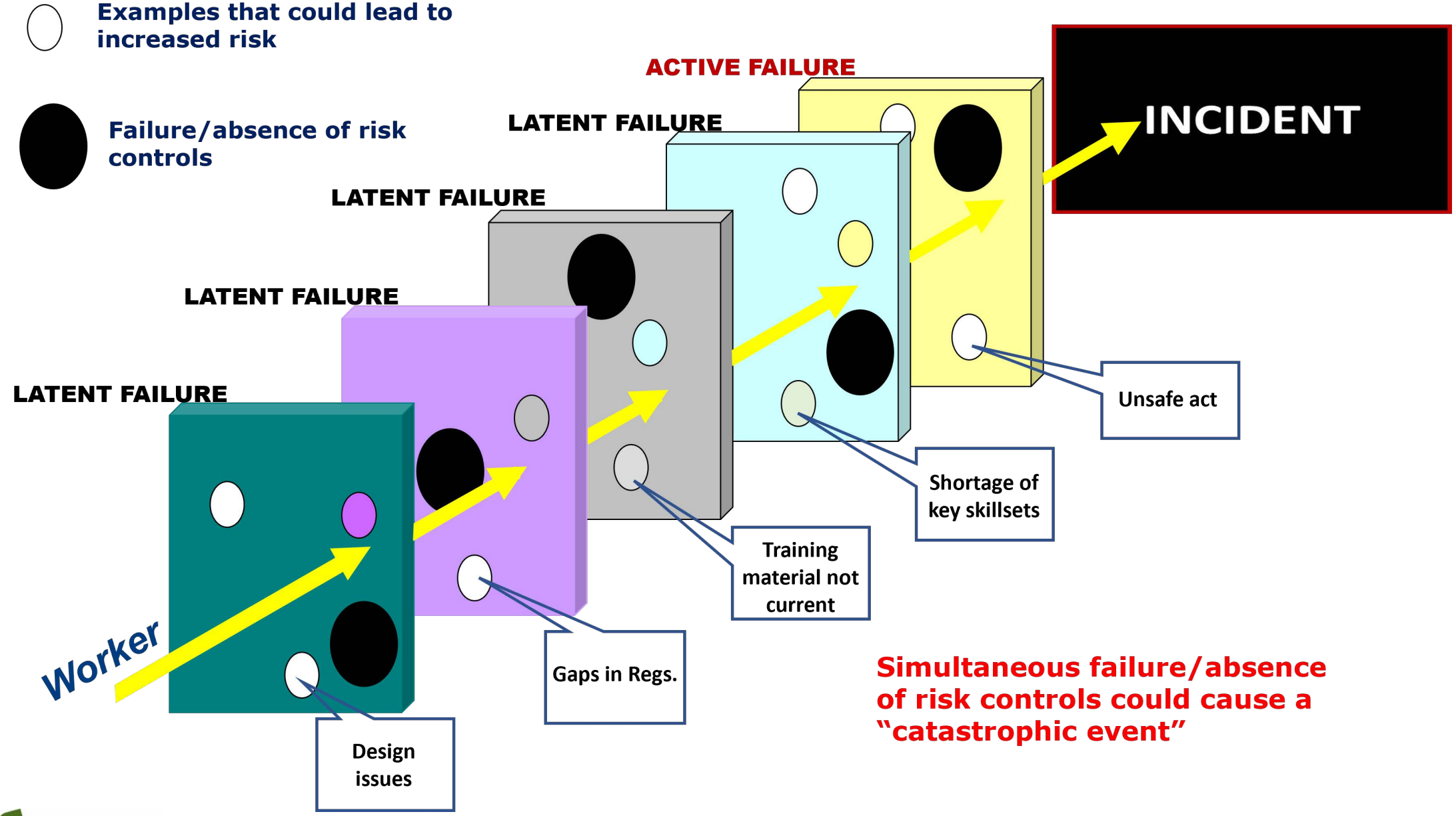
BEV = battery electric vehicle

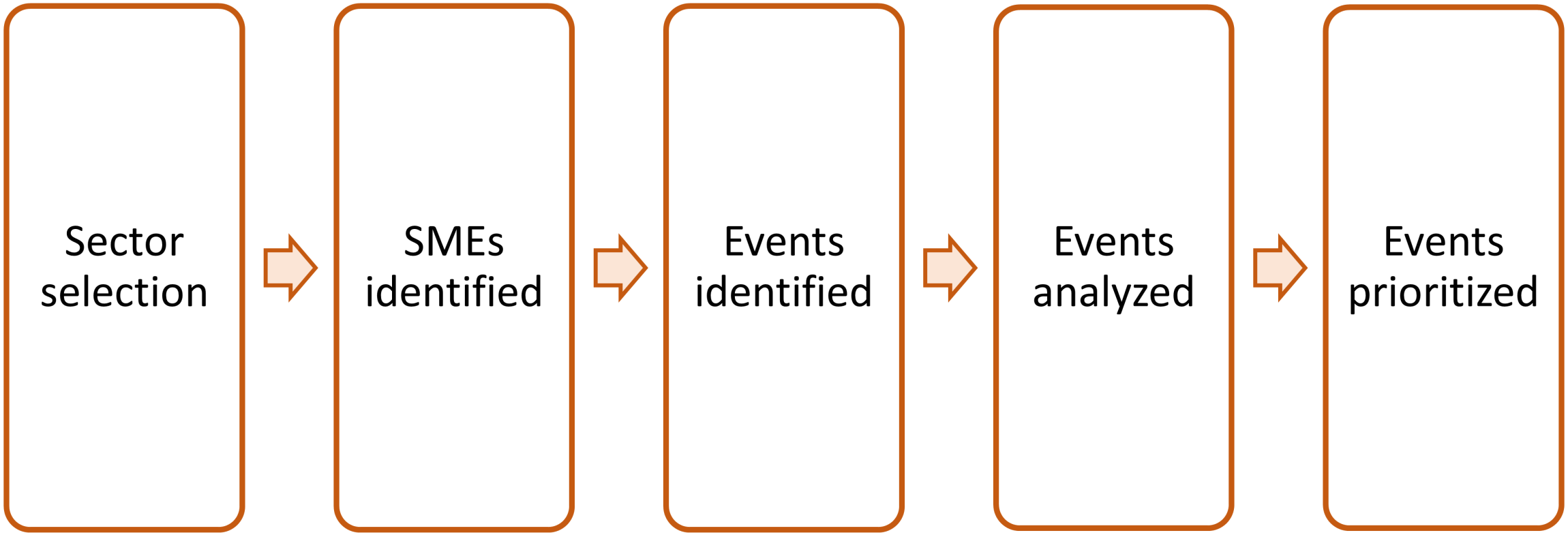
Risk Assessment: Introduction

- **<u>2013:</u> MLTSD 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, MLTSD & WSN planned & facilitated the **Battery Electric Vehicle 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**


Examples that could lead to increased risk
Failure/absence of risk controls
ACTIVE FAILURE
LATENT FAILURE
LATENT FAILURE
LATENT FAILURE
LATENT FAILURE
INCIDENT
Worker
Unsafe act
Shortage of key skillsets
Training material not current
Gaps in Regs.
Design issues
Simultaneous failure/absence of risk controls could cause a "catastrophic event"


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/HSA
- 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 Genesse	Impala - Lac Des Iles
3	Curtis Sarvas	Glencore
4	Matthew Curtis	Newmont
5	Natalie Kari	Vale
6	Andrew Schinkel	Kirkland Lake Gold

WORKSHOP PARTICIPANTS		
#	Name	Company/Representative
7	Derek Budge	Mining Legislative Review Committee
8	Malcolm Mills	Mining Legislative Review Committee
9	Bob Barclay	MLTSD: Senior Manager, Mining
10	Scott Secord	MLTSD: Inspector
11	Tom Welton	Workplace Safety North: Facilitator
12	Tiana Larocque	Workplace Safety North: Tech Support
13	Tricia Valentim	Workplace Safety North: Tech Support

Worker Representation

Employer Representation

***MLTSD**: Ministry of Labour, Training, and Skills Development*

Risk Assessment Workshop: Event Categories

1. Fire
2. Training
3. Arc flash
4. Explosion
5. Electric Shock
6. Collision
7. Ontario Mine Rescue (OMR)
8. Gas
9. Policies/procedures
10. Occupational health
11. Design

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

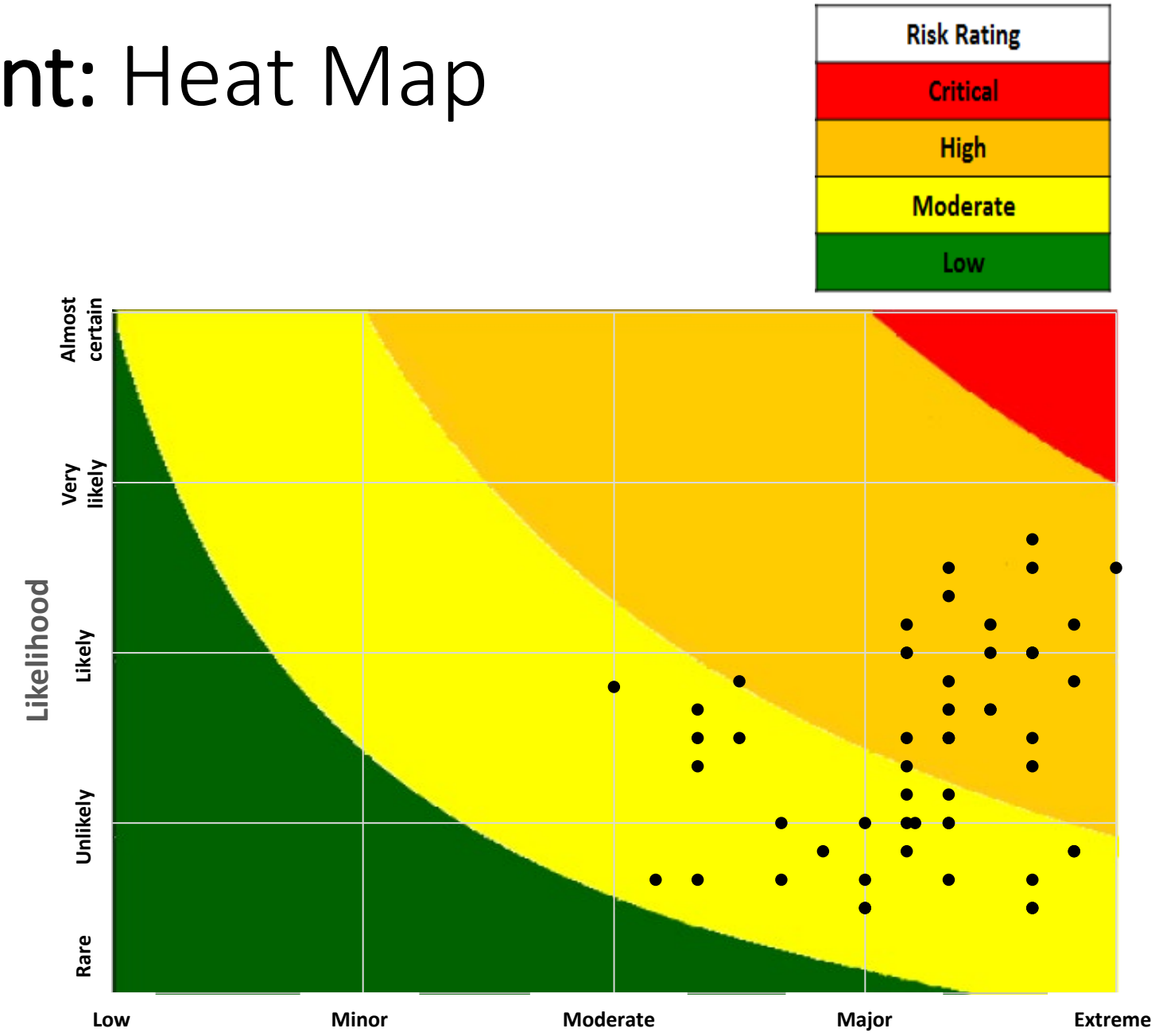
CONSEQUENCE

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

BEV Risk Assessment: Heat Map

CONSEQUENCE	DESCRIPTION
Extreme [5]	**Fatality or Permanent Disability** [or extreme impact/importance]
Major [4]	**Serious Event/ Critical Injury or Critical Illness** [or major impact/importance]
Moderate [3]	**Temporary Disability (Lost Time): Injury/Illness** [or moderate impact/importance]
Minor [2]	**First Aid Treatment (No Lost Time)** [or minor impact/importance]
Low [1]	**No injury or Illness** [or negligible impact/importance]

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



BEV Risk Assessment: Top 10 of 55 identified events

Rank	Category	Event (Situation/Condition) that could result in Injury or Illness OR What could keep you up at night?	Risk				Risk
			L	sd-L	C	sd-C	
1	Collision	Personnel struck by battery electric equipment	3.50	0.55	5.00	0.00	17.50
2	Training	Lack of training for maintenance employees	3.67	0.52	4.67	0.52	17.11
3	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Improper live troubleshooting)	3.50	1.05	4.67	0.52	16.33
4	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Improper/unclear work delineation (worker assumes authorized to perform work on traditional work experience)	3.17	0.98	4.83	0.41	15.31
5	Policies/ procedures	There are no standardized industry regulations with regards to BEV charge stations and charge locations	3.50	1.05	4.33	1.21	15.17
6	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Inadequate specifications, standards, regulations - provincial)	3.33	0.52	4.33	0.82	14.44
7	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Inadequate management of change process)	3.17	0.75	4.50	0.55	14.25
8	Electric shock	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Electric shock	3.00	0.63	4.67	0.52	14.00
9	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Field repairs)	3.00	0.63	4.67	0.52	14.00
10	Collision	Inability to identify presence of an oncoming vehicle while traveling in a ramp system or around corners	3.00	0.63	4.67	0.82	14.00

BEV Risk Assessment:

Top 10 risk categories based on highest risk within that category

Rank	Category	Event (Situation/Condition) that could result in Injury or Illness OR What could keep you up at night?
1	Collision	Personnel struck by battery electric equipment
2	Training	Lack of training for maintenance employees
3	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Improper live troubleshooting)
4	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Improper/unclear work delineation (worker assumes authorized to perform work on traditional work experience)
5	Policies/ procedures	There are no standardized industry regulations with regards to BEV charge stations and charge locations
6	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Inadequate specifications, standards, regulations - provincial)
7	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Inadequate management of change process)
8	Electric shock	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Electric shock
9	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Field repairs)
10	Collision	Inability to identify presence of an oncoming vehicle while traveling in a ramp system or around corners

Worker vs. Workshop Results: Top 10 comparison

Worker top 10

#	Category	Event (Situation/Condition) that could result in Injury or Illness OR What could keep you up at night?	RISK
1	Collision	Personnel struck by battery electric equipment	17.50
2	Training	Lack of training for maintenance employees	16.88
3	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Improper/unclear work delineation (worker assumes authorized to perform work on traditional work experience)	14.25
4	Electric shock	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Electric shock	13.81
5	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (MAINTENANCE)	13.81
6	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Inadequate management of change process)	13.50
7	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Improper live troubleshooting)	13.50
8	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Field repairs)	13.50
9	Fire	Inadequate or improper fire suppression of fire extinguisher on BEVs	13.50
10	Policies/procedures	There are no standardized industry regulations with regards to BEV charge stations and charge locations	13.06

Workshop results

#	Category	Event (Situation/Condition) that could result in Injury or Illness OR What could keep you up at night?	RISK
1	Collision	Personnel struck by battery electric equipment	17.50
2	Training	Lack of training for maintenance employees	17.11
3	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Improper live troubleshooting)	16.33
4	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Improper/unclear work delineation (worker assumes authorized to perform work on traditional work experience)	15.31
5	Policies/procedures	There are no standardized industry regulations with regards to BEV charge stations and charge locations	15.17
6	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Inadequate specifications, standards, regulations - provincial)	14.44
7	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Inadequate management of change process)	14.25
8	Electric shock	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Electric shock	14.00
9	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Field repairs)	14.00
10	Collision	Inability to identify presence of an oncoming vehicle while traveling in a ramp system or around corners	14.00

Employer vs. Workshop Results: Top 10 comparison

Employer top 10

#	Category	Event (Situation/Condition) that could result in Injury or Illness OR What could keep you up at night?	RISK
1	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Improper live troubleshooting)	22.50
2	Policies/procedures	There are no standardized industry regulations with regards to BEV charge stations and charge locations	20.25
3	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Field repairs)	17.50
4	Collision	Personnel struck by battery electric equipment	17.50
5	Collision	Inability to identify presence of an oncoming vehicle while traveling in a ramp system or around corners	17.50
6	Training	Lack of training for maintenance employees	17.50
7	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Improper/unclear work delineation (worker assumes authorized to perform work on traditional work experience)	17.50
8	Fire	Inadequate or improper fire suppression of fire extinguisher on BEVs	15.75
9	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Transportation)	15.75
10	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Inadequate specifications, standards, regulations - provincial)	15.75

Workshop results

#	Category	Event (Situation/Condition) that could result in Injury or Illness OR What could keep you up at night?	RISK
1	Collision	Personnel struck by battery electric equipment	17.50
2	Training	Lack of training for maintenance employees	17.11
3	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Improper live troubleshooting)	16.33
4	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Improper/unclear work delineation (worker assumes authorized to perform work on traditional work experience)	15.31
5	Policies/procedures	There are no standardized industry regulations with regards to BEV charge stations and charge locations	15.17
6	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Inadequate specifications, standards, regulations - provincial)	14.44
7	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Inadequate management of change process)	14.25
8	Electric shock	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Electric shock	14.00
9	Arc Flash	Loss of control of a particular Li-Ion based battery chemical energy source; exposing personnel to: Thermal runaway (fire), Arc Flash, Electric shock potentials (Field repairs)	14.00
10	Collision	Inability to identify presence of an oncoming vehicle while traveling in a ramp system or around corners	14.00

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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