Empowering Change: Exploring the Intersection of Electric Vehicles and Safety

Risk assessment: A focused approach to improving workplace health and safety

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Risk Assessment: Introduction

<u>2013:</u> Ministry and WSN launched project toward an integrated risk assessment methodology to:

- identify health and safety risks
- work with employers and workers toward risk reduction
- provide more information to employers, workers & their representatives about risks **at the sector level**

Risk Assessment: Introduction

<u>2020 - 2023:</u> With MLRC support, Ministry and WSN planned and facilitated the **Battery Electric Vehicle (BEV) Risk Assessment**

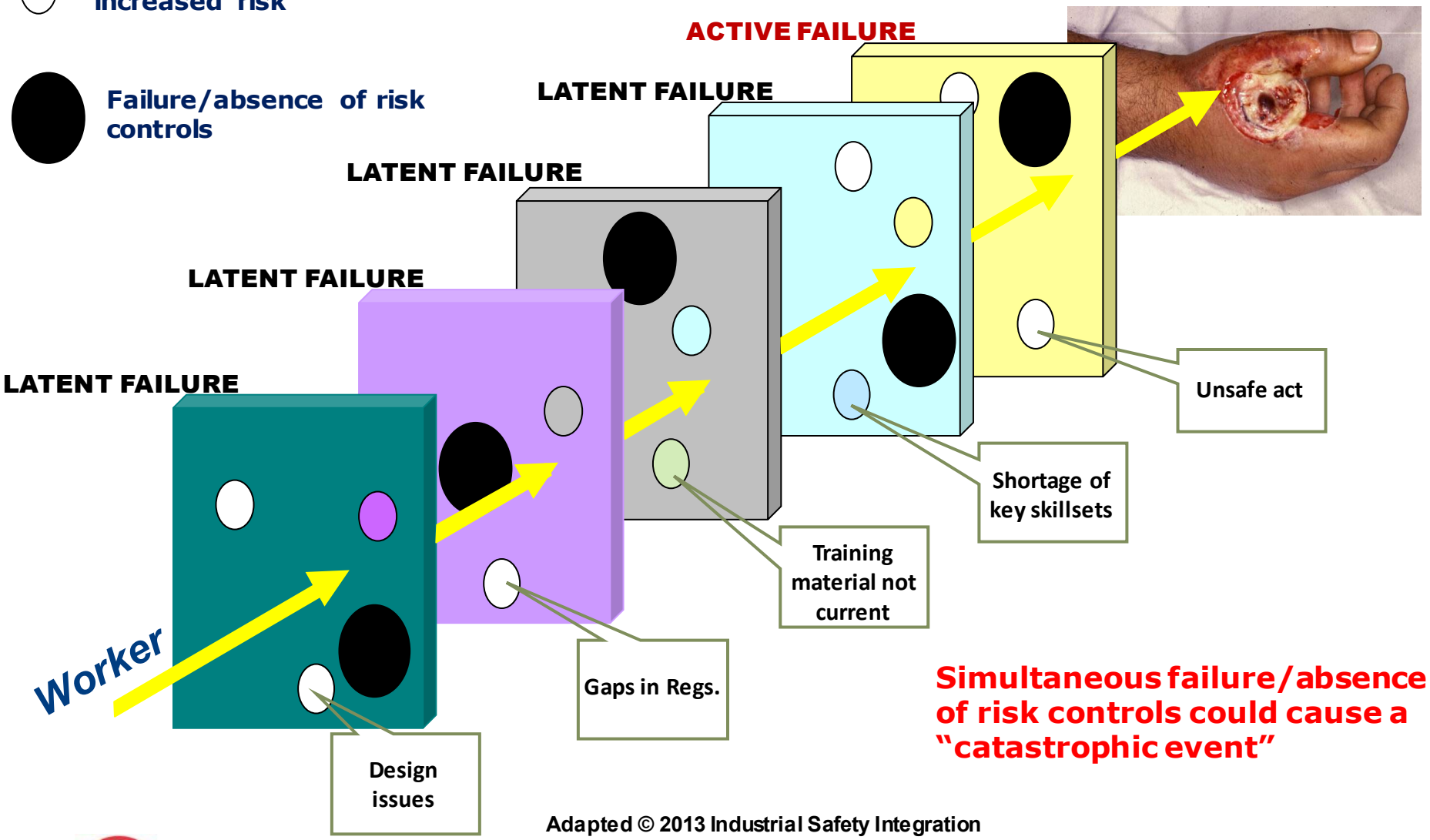
Harnessed collective cross-sector wisdom in a tripartite process to focus the industry, health and safety associations (WSN), and regulator on highest risks to health and safety

Approach draws on industry, worker, WSN, and Ministry knowledge of risk and recognizes that <u>one-size approach does not fit all</u>; draws on empirical insights of risk management and operations research/decision science

Risk Assessment Project

Examples that could lead to increased risk

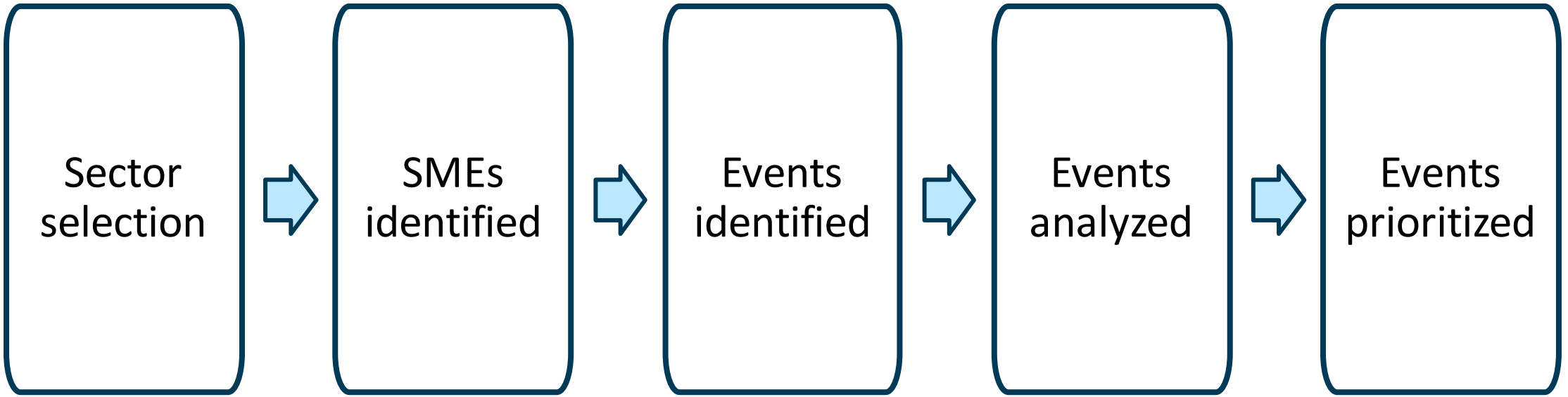
Failure/absence of risk controls



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

Adapted © 2013 Industrial Safety Integration

Workshop: A tripartite and collective process



Risk assessment: Criteria for measurement

After discussion on each event, **two criteria were used to analyze risks** (with current controls in place):

- The **Likelihood** of the event occurring
- Severity of the **Consequence** if the event were to occur

Assessing risk levels requires judgment. Experts used:

- Experience
- Knowledge
- Intuition

Risk Assessment: Prioritize risks

- Assess risk level; establish risk priorities
- **Risk – average Likelihood (L)** multiplied by **average Consequence (C)** for each event – 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

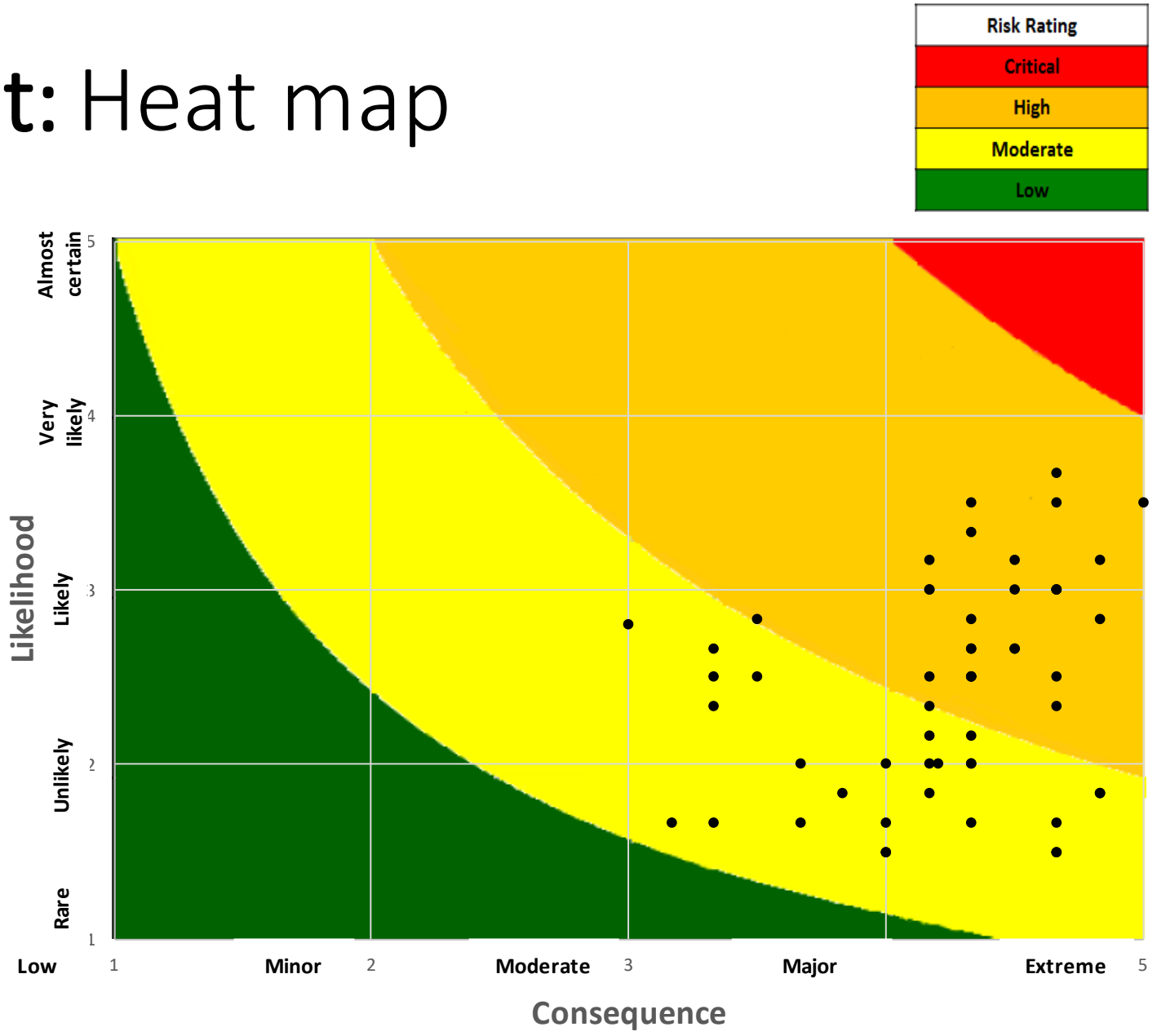
CONSEQUENCE

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

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]

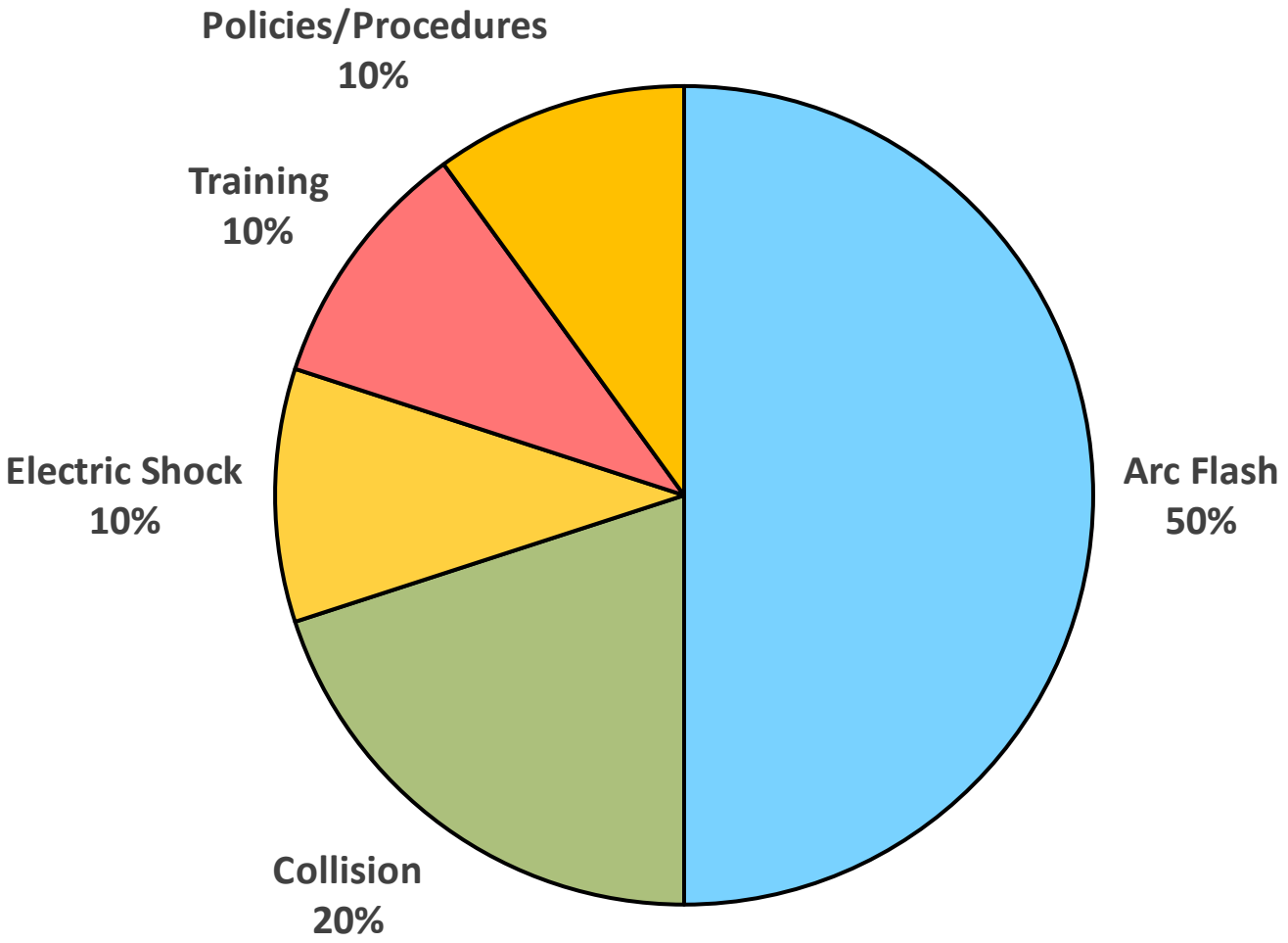


BEV Heavy Vehicle Risk assessment:

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

Top 10 BEV Heavy Vehicle risks by category



Analysis of top five risks: Risks and undesired outcomes identified in ranking/categories

Risk Rank	Risk Category	Contributing Factor	Result
1	**Arc Flash**	• Improper live troubleshooting • Mobile Equipment Fire (BEV Fire) Fire occurring while operating BEV • Inadequate specifications, standards, regulations – provincial • Inadequate management of change process In field repairs	**Thermal runaway**
2	**Collision**	• Lower sound or awareness of nearby operation	**Collision with people or other equipment**
3	**Training**	• Lack of training for maintenance and operators • Improper/unclear work delineation; worker assumes authorized to perform work on traditional work experience	**Injury to worker** **Damage to equipment** **Loss of process**
4	**Policies and Procedures**	• No standardized industry regulations with regard to BEV charge stations and charge locations	**Inadequate management of change process**
5	**Electric Shock**	• Loss of control of a particular Li-Ion based battery chemical energy source	**Exposure to electric shock**

Analysis of top risks and proposed controls: Risk categories and proposed control measures

Risk Rank	Risk Category	Current and Proposed Controls (includes but not limited to)	Goal to eliminate
1	**Arc Flash**	• Electrical Protection Design (Type tested equipment insulation, etc) • OEM Controls and Battery Monitoring System • Arc Flash Hazard Plan • Daily Inspection of Charging Infrastructure before use • Management of change process	**Thermal runaway**
2	**Collision**	• Vehicle lights and enhanced auditable sounds (Tied with personal tracking system) • Collision avoidance system and Proximity detection system • Traffic management plan (Fleet monitoring system to avoided congestion)	**Collision with people or other equipment**
3	**Training**	• Only qualified and authorized persons work on BEV equipment • Mechanical and Operator BEV activity specific task requirements as a terminal performance objective • Delineation of authorization (by vehicle, voltage and battery assembly work) and mechanical or electrical requirements and OEM Only specified BEV requirement	**Injury to worker** **Damage to equipment** **Loss of process**

Arc Flash resulting in Thermal Runaway: EV traction battery fires are very rare. In fact, the chance of your plug-in passenger EV battery catching fire is around 0.0012%, a figure that is based on finding less than 200 verified traction battery fires in a global stock of 10 million EVs as of December 2020. (*Australian Department of Defense*)

Global fire risk of EVs

- As of 2022, there have been **337 EV traction fires today**.
- **105 were in 2022**, with Tesla being the most common.
- 21% of the fires **caused by collision or debris**.
- Some risks associated with EV fires are:
  - Ignition (fire);
  - Vapour cloud explosion; and
  - Electrocution.

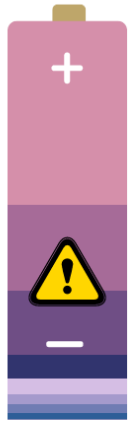
EV LiB fires are very rare

In passenger plug-in EVs, we have verified*:

337 EV traction battery fires globally, 2010-today

+ 82 currently being cross checked

Causes of battery cell abuse



Unknown	49%
Collision / debris	21%
OEM fault	12%
Submersion	6%
Arson / malicious	3%
External fire	3%
Repair / workshop	3%
Overheating / electrical	2%
Human error	1%
Manufacturing defect	1%

*Data current June 2022
^Percentage of incidents EVFS studied

Sutcliffe, E. (2023, January). *EV Fire Safe Information Pack.* Retrieved from EV Fire Safe: https://www.evfiresafe.com/_files/ugd/8b9ad1_b877cda4c4bd49bca49e12f4b9c154a5.pdf

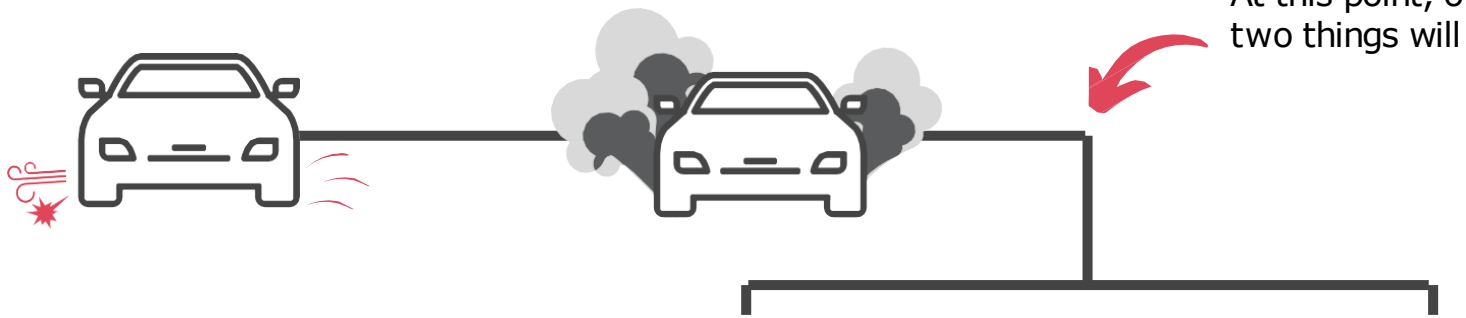
Early warning signs

Thermal runaway looks and sounds like this:

Popping - gunshots
Hiss/whistle - gas venting
'Cherry bubblegum' smell
Projectiles - cell debris

Dark vapour cloud,
light vapour cloud
(it's NOT smoke)

At this point, one of two things will occur



Ignition
Jet like, directional flames

~95%

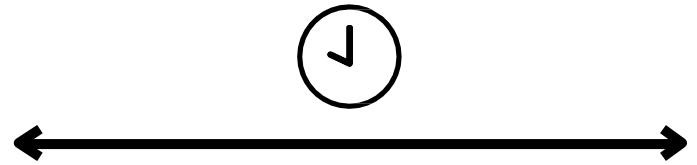
Vapour cloud explosion
Violent deflagration

~5%

Suppression = time, resources

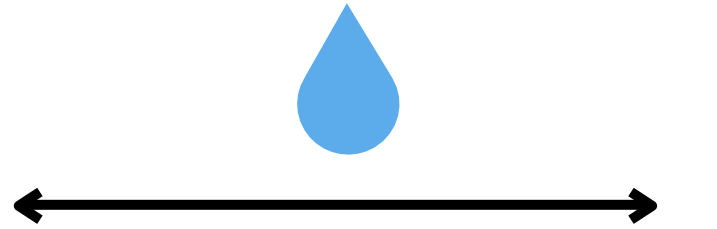
Suppression time depends on a range of factors, but 3-5 hours common

Best case *Worst case*



10min

3-5 hours (>50 hours to clear highway)



1,000L

110,000L

BEV collision

- **Easy visualization of battery/vehicle damage in significant events**; therefore, appropriate action can be taken with battery fire risk
- **Moderate-to-difficult visualization** of battery/vehicle damage **in minor events**

BEV collision

- Lower sound or awareness of nearby operation
- **Vehicle-person interaction:** BEV striking a pedestrian or light vehicle (high visibility interaction with low visibility or person)
- Vehicle charge bay – vehicle contact with person on ground
- Collision causing vehicle fire

Delayed ignition risk

- In 2022, a Tesla Model S was involved in a collision **three weeks prior to going into thermal runaway** at the tow yard.
- This is the first verified delayed ignition globally.

Hazard alert: More fires linked to power tool batteries

- Recently, more reported fires linked to power tool batteries, especially lithium-ion batteries, in Ontario's mining sector
- Higher risk of fire or explosion if they are mishandled or not used correctly according to the manufacturer's instructions
- Thermal runaway fire can happen when batteries exposed to over-charging, impact, crushing, piercing, vibration, or extreme external heat
- Depending on battery charge level, thermal runaway could lead to battery cell rupture and a risk of fires, explosions, and the release of harmful gases

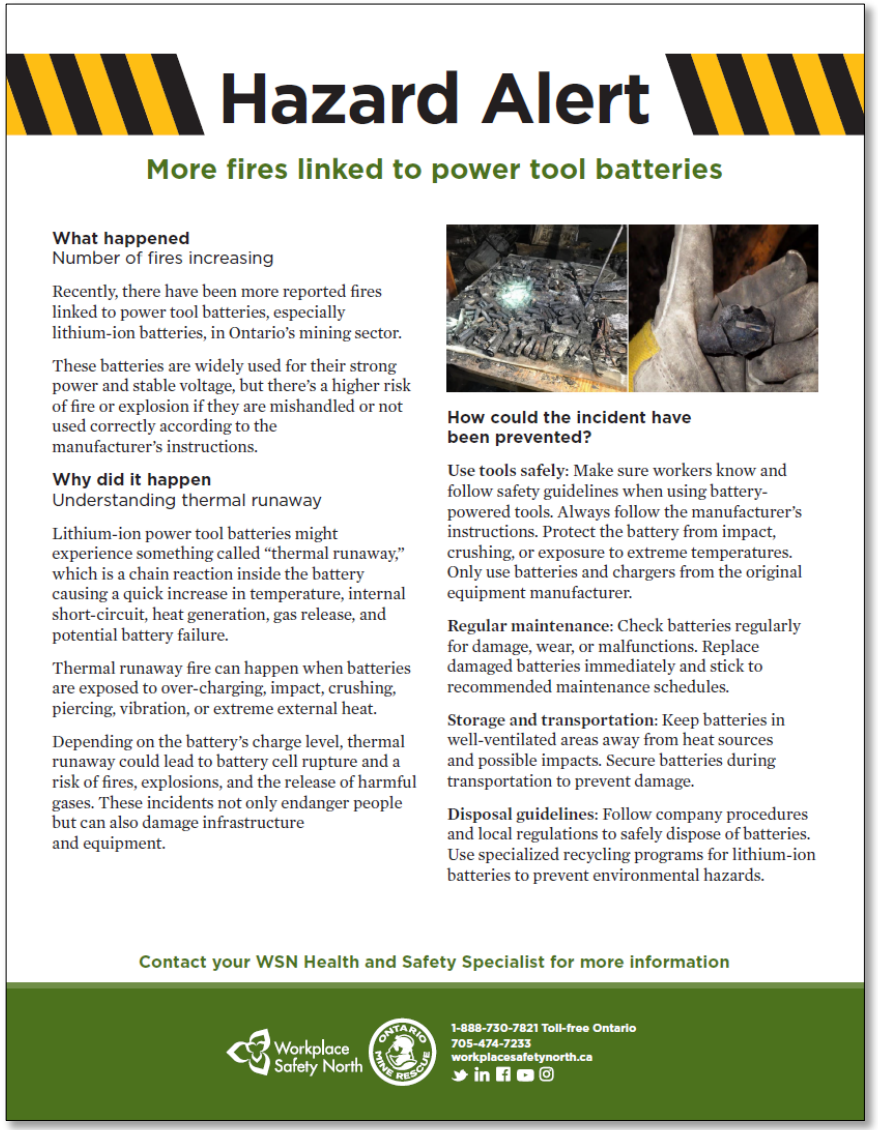
Safety guidelines when using battery-powered tools

Use tools safely: Make sure workers know and follow safety guidelines when using battery-powered tools. Always follow the manufacturer's instructions. Protect the battery from impact, crushing, or exposure to extreme temperatures. Only use batteries and chargers from the original equipment manufacturer.

Regular maintenance: Check batteries regularly for damage, wear, or malfunctions. Replace damaged batteries immediately and stick to recommended maintenance schedules.

Storage and transportation: Keep batteries in well-ventilated areas away from heat sources and possible impacts. Secure batteries during transportation to prevent damage.

Disposal guidelines: Follow company procedures and local regulations to safely dispose of batteries. Use specialized recycling programs for lithium-ion batteries to prevent environmental hazards.



Hazard Alert

More fires linked to power tool batteries

What happened
Number of fires increasing

Recently, there have been more reported fires linked to power tool batteries, especially lithium-ion batteries, in Ontario's mining sector.

These batteries are widely used for their strong power and stable voltage, but there's a higher risk of fire or explosion if they are mishandled or not used correctly according to the manufacturer's instructions.

Why did it happen
Understanding thermal runaway

Lithium-ion power tool batteries might experience something called "thermal runaway," which is a chain reaction inside the battery causing a quick increase in temperature, internal short-circuit, heat generation, gas release, and potential battery failure.

Thermal runaway fire can happen when batteries are exposed to over-charging, impact, crushing, piercing, vibration, or extreme external heat.

Depending on the battery's charge level, thermal runaway could lead to battery cell rupture and a risk of fires, explosions, and the release of harmful gases. These incidents not only endanger people but can also damage infrastructure and equipment.

How could the incident have been prevented?

Use tools safely: Make sure workers know and follow safety guidelines when using battery-powered tools. Always follow the manufacturer's instructions. Protect the battery from impact, crushing, or exposure to extreme temperatures. Only use batteries and chargers from the original equipment manufacturer.

Regular maintenance: Check batteries regularly for damage, wear, or malfunctions. Replace damaged batteries immediately and stick to recommended maintenance schedules.

Storage and transportation: Keep batteries in well-ventilated areas away from heat sources and possible impacts. Secure batteries during transportation to prevent damage.

Disposal guidelines: Follow company procedures and local regulations to safely dispose of batteries. Use specialized recycling programs for lithium-ion batteries to prevent environmental hazards.

Contact your WSN Health and Safety Specialist for more information

Workplace Safety North

1-888-730-7821 Toll-free Ontario
705-474-7233
workplacesafetynorth.ca

Training on BEVs

- **Lack of training** for maintenance and operators
- **Improper/unclear work delineation** – Worker assumes authorization to perform work based on traditional work experience

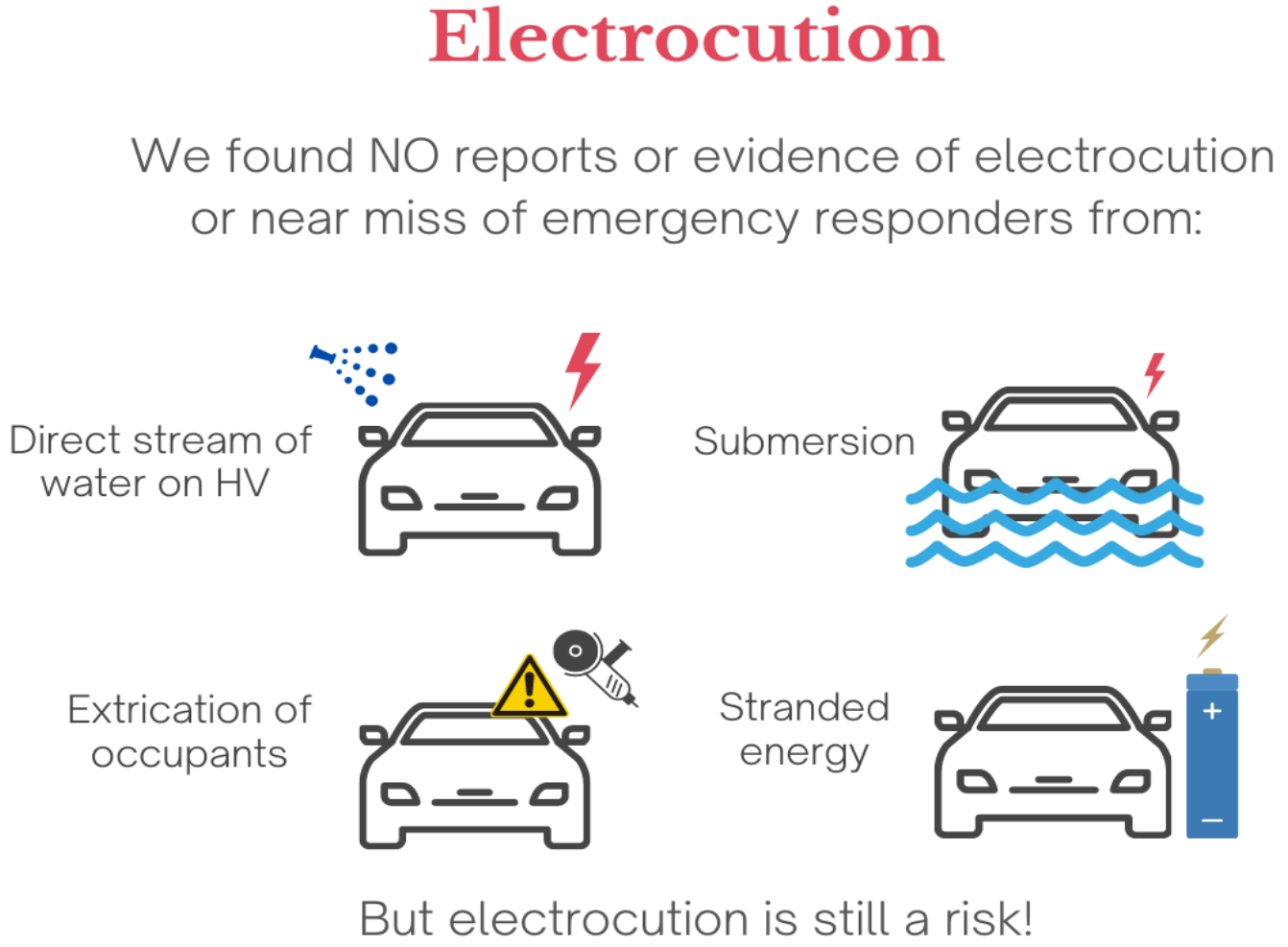
BEV-related policies and procedures

- **No standardized industry regulations** with regard to BEV charge stations and charge locations
- Industry and regulator catching up in providing standardized guidance

- CSA Group standard **CSA M424.4:22: Self-propelled, electrically driven, non-rail-bound mobile machines for use in non-gassy underground mines** was finalized in August 2022.

Electric shock

- **Loss of control of a particular Li-ion based battery chemical energy source: exposing personnel to thermal runaway (fire), arc flash, electric shock potential (Field Repairs)**



Access BEV risk assessments and root cause analyses on WSN website

Battery Electric Vehicles

- Battery Electric Vehicles Health and Safety Resources
- Article - Industry experts analyze causes of battery electric vehicle fires
- Mining poster - Top 10 Risks for Battery Electric Vehicles
- Mining poster - Top Root Causes of Battery Electric Vehicle Fires
- Battery Electric Vehicles Risk Assessment Workshop Results
- Battery Electric Vehicles Root Cause Analysis Workshop Results
- Recommended Practices for Battery Electric Vehicles in Underground Mining - Global Mining Guidelines Group

Visit webpage for more information:
https://www.workplacesafetynorth.ca/industries/mining

References

- Emma Sutcliffe, EV FireSafe, January 18, 2022: *How common are EV fires?* https://www.evfiresafe.com/post/how-common-are-ev-fires

- Emma Sutcliffe, EV FireSafe, n.d.: *Enhancing safety for emergency responders at electric vehicle fires*. https://www.evfiresafe.com/_files/ugd/8b9ad1_0c8c3c47ebc5466ca372a91bf453bf2e.pdf

Thank you for attending today's presentation and helping make workplaces safer.

Questions?

Workshop Contact

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