

Bow Ties and BEVs Underground

Presentation to Workplace Safety North Symposium “BEV Safety in Mines”

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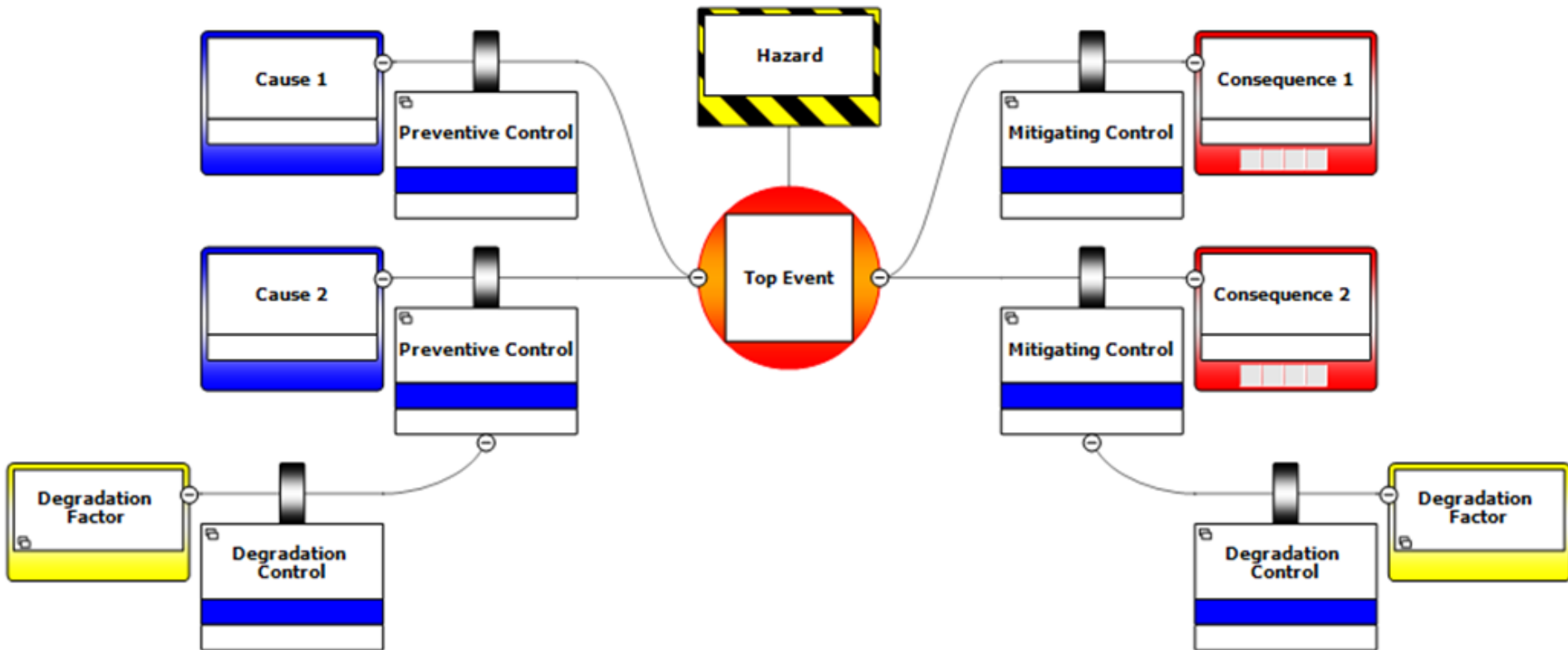
February 12, 2020



Agenda

1. Overview of the Bow Tie Method
2. Our attempt to apply the bow tie method to BEVs underground
3. Outcomes

Bow Tie Analysis



**Scope, Context and
Criteria**

Risk Identification

Risk Analysis

Risk Evaluation

Risk Treatment

**Risk
Assessment**

Objectives:

Help with risk analysis of potential MUEs from

- Fire, and
- Electric shock,

... involving battery electric vehicles in underground mining

Meetings:

Fire scenario

- July 8, 2019
- 22 participants

Electric shock scenario

- October 2, 2019
- 45 participants

Hazards

Defined by:

- Activities:
 - Operating
 - Transporting
 - Servicing
 - Charging
 - Long Term Storage
 - Mine Rescue
- Battery Types:
 - Lithium Iron Phosphate (LFP);
 - Lithium Nickel Manganese Cobalt (NMC);
 - Lithium Titanate (LTO)

Results

We attempted bow ties for:

- Three fire scenarios:
 - Scenario 1:
 - Hazard: Charging NMC battery, on-board
 - Top Event: Battery cell reaches ignition temperature
 - Scenario 2:
 - Hazard: Operating NMC BEV underground
 - Top Event: Battery cell reaches ignition temperature in vehicle collision
 - Scenario 3: Same as scenario 2, for LFP battery

Results

- Two electric shock scenarios:
 - Scenario 1:
 - Hazard: Servicing BEV (incl. mechanical and electrical ($\geq 30V$); field and shop; troubleshooting and washing)
 - Top Event: Exposed live DC electrical energy
 - Scenario 2:
 - Hazard: Charging (both on-board and off-board); including hibernation
 - Top Event: Exposed live AC electrical energy from the grid

Outcomes

We drafted three bow ties for fire and two for electric shock

- Potential uses:
 - A starting point to build understanding
 - Templates for other similar hazards
- We learned about:
 - Potential MUEs involving battery electric vehicles
 - Bow tie facilitation with large, multidisciplinary groups

References

1. Center for Chemical Process Safety. Bow Ties in Risk Management: A Concept Book for Process Safety. Hoboken, NJ : John Wiley & Sons, 2019.
2. International Council on Mining and Metals. Health and Safety Critical Control Management: Good Practice Guide. London, England : International Council on Mining and Metals, 2015.
3. ISO 31000:2018, *Risk management – Guidelines*