Workplace Safety North™

The Reality Of Implementing BEVs In Operations

February 09, 2023

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Mayhew Performance

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Agenda

- Introduction
- About Mayhew Performance
- Safety and Mine Operations
- BEV Awareness, Risk, Hazards and Fires
- BEV Production and Maintenance
- BEV Engineering Design
- BEV Charging Methodology
- Lessons Learned and Case Study
- Operational Readiness

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About us

- Mayhew Performance was founded in 2020 with over 150+ years of combined experience.
- Mayhew Performance is a boutique consulting firm specializing in BEV Mining Studies, Mine Evaluation, Operational Readiness, Training, GHG and Net Zero Assessment.
- Mayhew Performance partners with global mining clients around the world.

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Background

- Over 30 years of mining experience.
- Served as Vice President of Stantec and worked for several OEM’s.
- Worked as Mine Superintendent and Shaft Integration Manager at Kirkland Lake Gold.
- Developed world’s first 40 tonne BEV Truck – Artisan Z40 (Now Sandvik)
- Founded Mayhew Performance in 2020.
- Specializes in BEV Studies, Training and Operational Readiness.
- Developed off-grid Solar Energy charging for Electric vehicles.
- Subject Matter Expert in BEV implementation.

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Why BEV?

- Commitment to Health and Safety and people.
- Commitment to Net Zero.
- Ability to mine at depth (Heat, Cooling, Ventilation).

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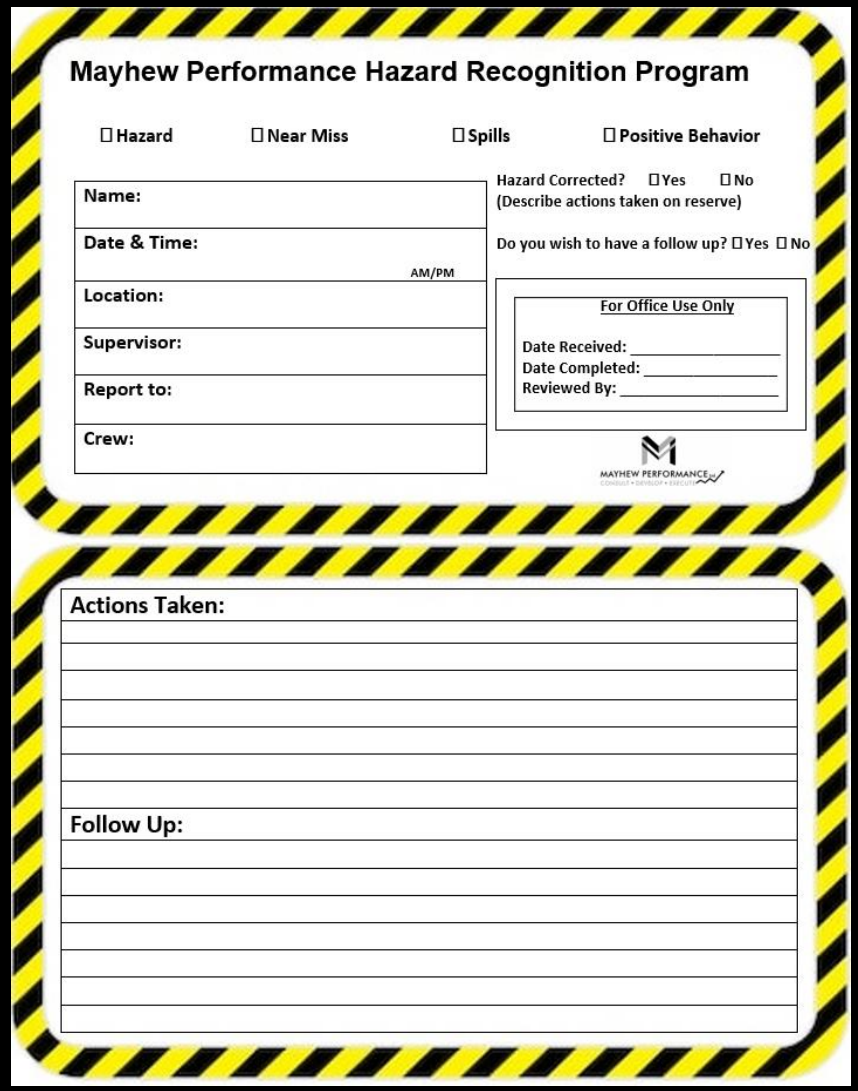
Safety

- Is everyone working safe and any incidents?
- Did we have any first aids, near miss or medical aid?
- Any reports on oil spillage or environmental report?
- Are the SOPs followed? (Blasting, Remote Mucking, Boreholes)
- Are the Job Observation Cards being completed and audited?
- Hazard Recognition Program and positive feedback?



Mayhew Performance Hazard Recognition Program

☐ Hazard ☐ Near Miss ☐ Spills ☐ Positive Behavior

Name:

Date & Time: AM/PM

Location:

Supervisor:

Report to:

Crew:

Hazard Corrected? ☐ Yes ☐ No
(Describe actions taken on reserve)

Do you wish to have a follow up? ☐ Yes ☐ No

For Office Use Only

Date Received: _____
Date Completed: _____
Reviewed By: _____

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Actions Taken:

Follow Up:

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Electrical Awareness

- BEV has a different system than Diesel.
- There is less maintenance in Battery Electric Vehicles due to fewer moving parts.
- Few Electrical components consist of High Voltage Interlock, Isolation Fault monitoring systems, Fusing/Breakers, Battery disconnects, CANBUS, and other higher layer protocol systems.

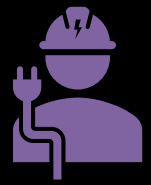
Maintenance	BEV	Diesel
Battery	x	
Charger	x	
BMS (Battery Management System)	x	
Inverters	x	
Electric Motors	x	
Electrical System	x	x
Hydraulic Components	x	x
Drive Train (Axle/Drive Line)	x	x
Diesel Engine		x
Transmission		x
Torque Converter		x
Engine Oil		x
Transmission fluid		x
Diesel Fuel		x
Filters		x
Alternator Belts		x

Hazards

There are 4 main areas of risks and hazards with BEVs:

Electrical

Large Batteries



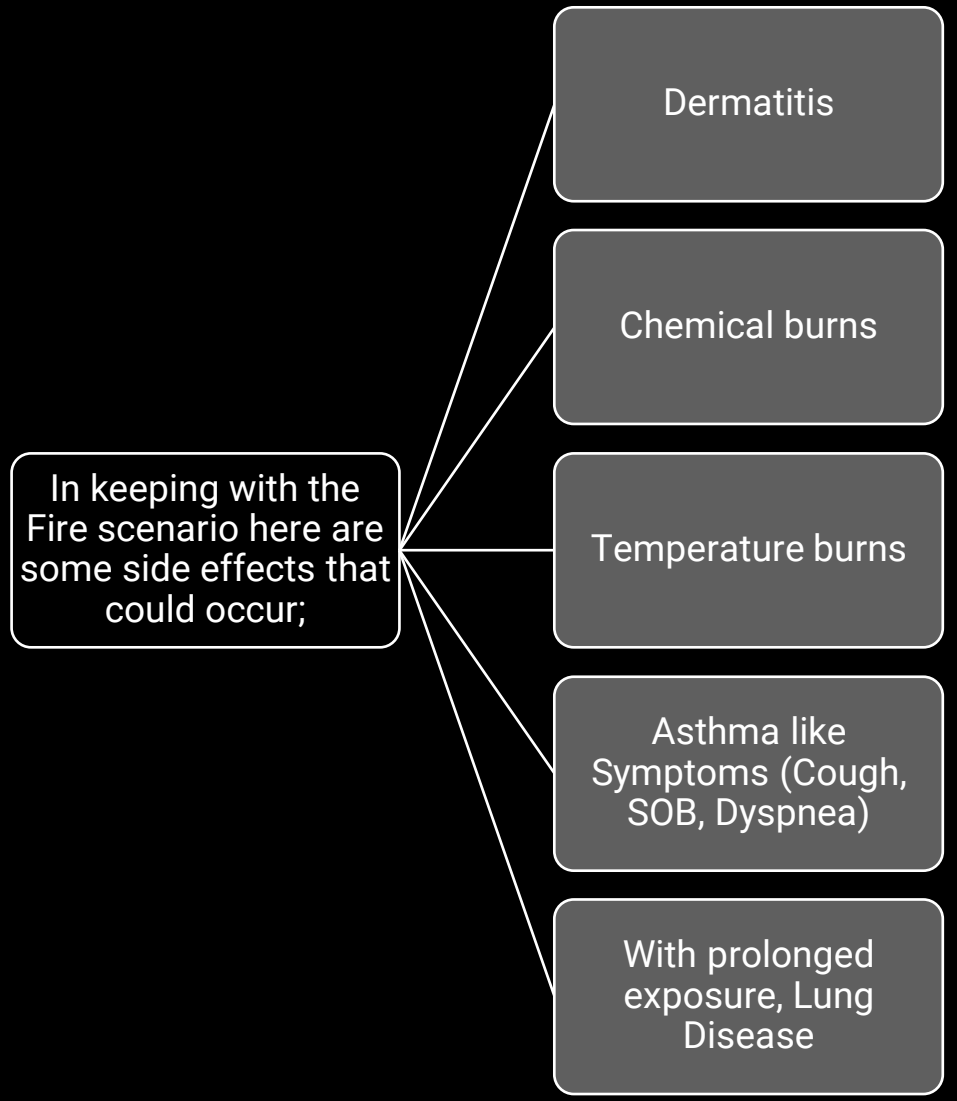
Loss of Power

Fire

Are Batteries Safe Underground?

No Side effects using batteries in normal conditions. However, if the outer capsule is damaged, a wide variation of effects may occur.

- Smoke/gas inhalation vary from; Carbon Monoxide, Carbon Dioxide, Lithium Oxide and potentially others.
- Safety Data Sheets (SDS) will vary with the type of battery and the capsule the cells are kept together with.



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BEV Fire Incidents

Incident 1

- Company: Goldcorp/Newmont, Borden Gold, 2019
- **Root cause:** Thermal Runaway due to battery isolation fault (coolant leak)

Incident 2

- Company: Glencore, Onaping depth project, 2020
- **Root cause:** Non-OEM replaced fuses.

Incident 3

- Company: Barrick Gold, Turquoise ridge, 2021
- **Root cause**: Battery arcing due to isolation issue and Transportation.

Production

- Did we work safe and no injuries?
- Did we achieve target for the shift?
- What is the grade and ounces going to the mill?
- Production and development by mining zone?
- Utilization and availability of equipment?
- Maintenance schedule and planning.
- Construction and execution.

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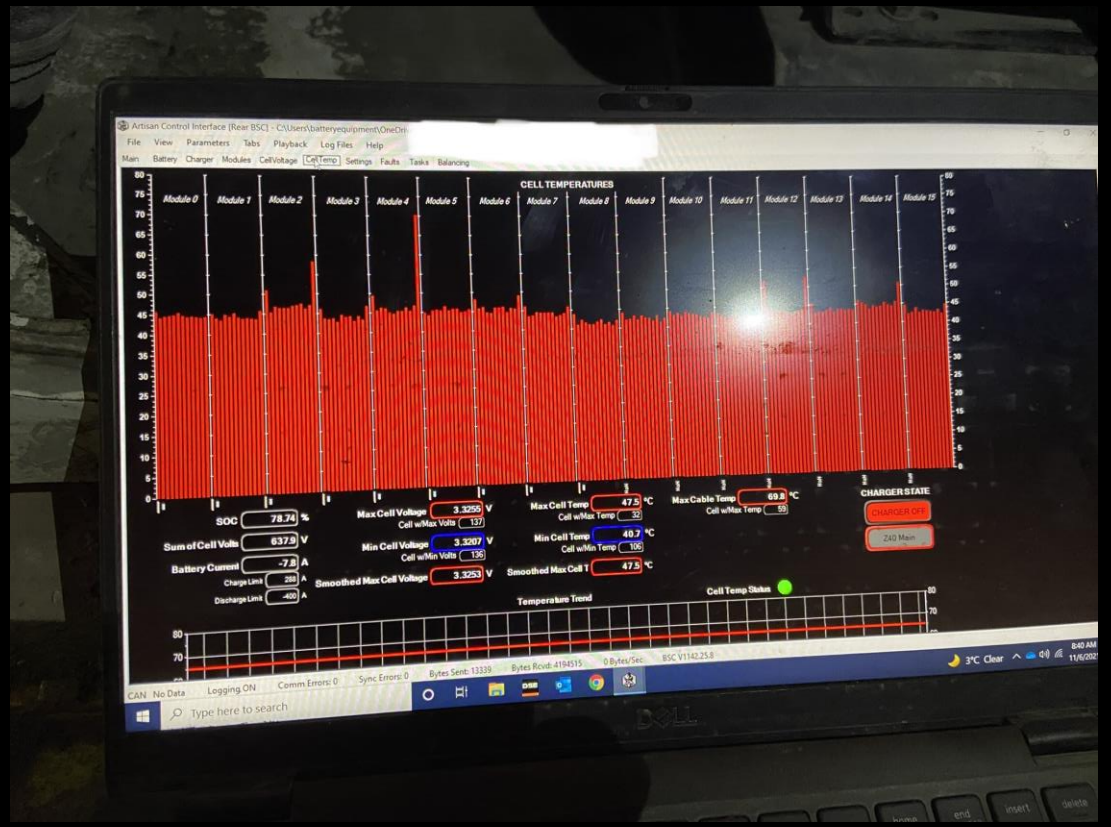
Maintenance Program

The maintenance program should support the following for BEV implementation:

- Scheduling and Planning.
- Qualified Training (Electrician, Mechanics).
- Certified PPE for High and Low Voltage.
- Certified Tools for BEV Maintenance.
- Critical Spare Parts Onsite.
- Underground Shop or Satellite Facility.



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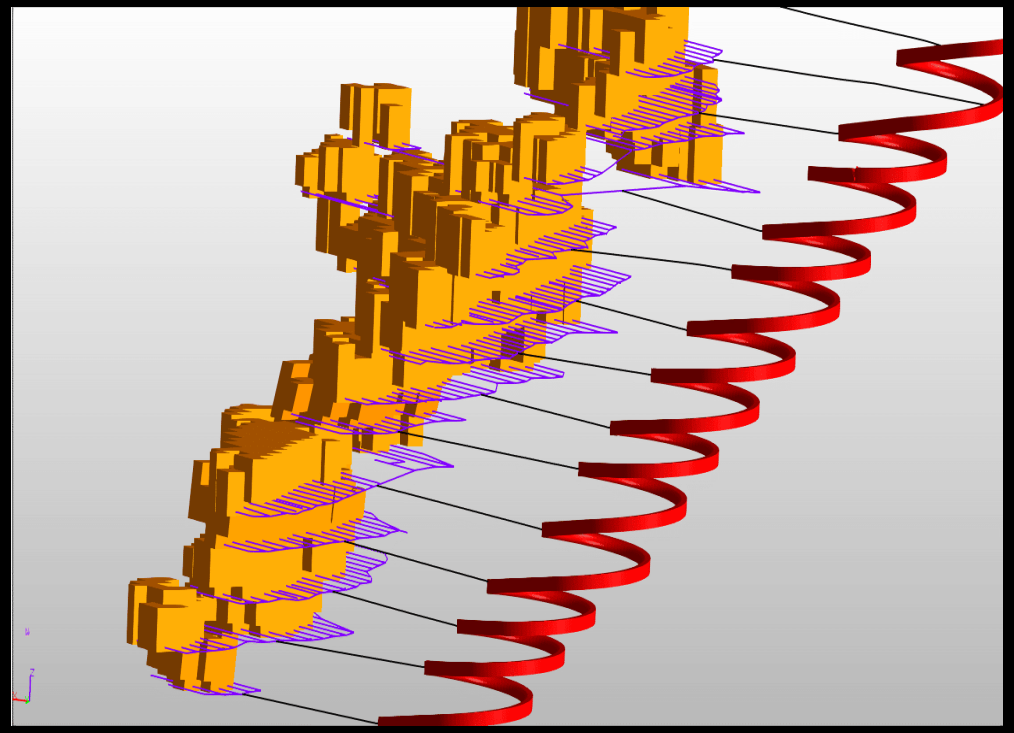
Mine Design

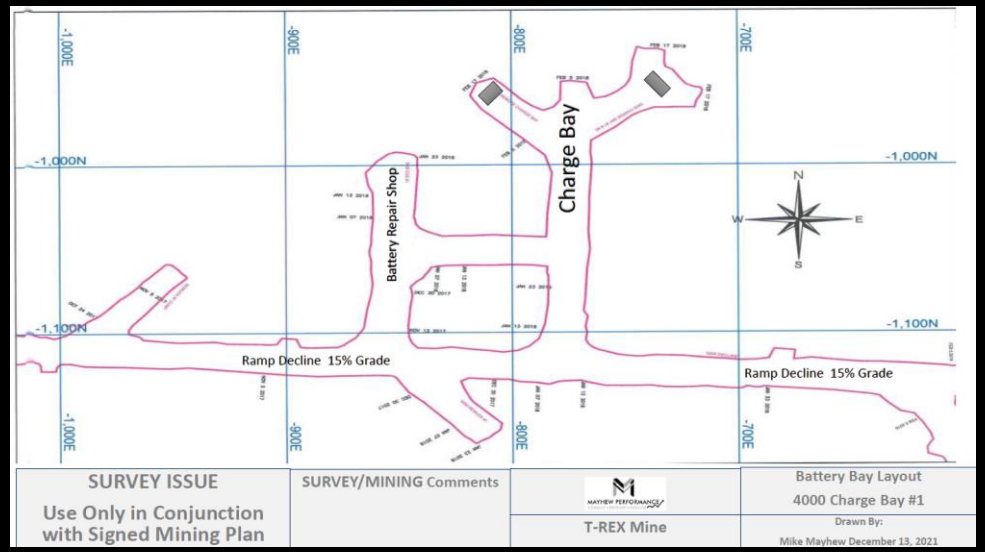
The mining method and design must support the following BEV criteria:

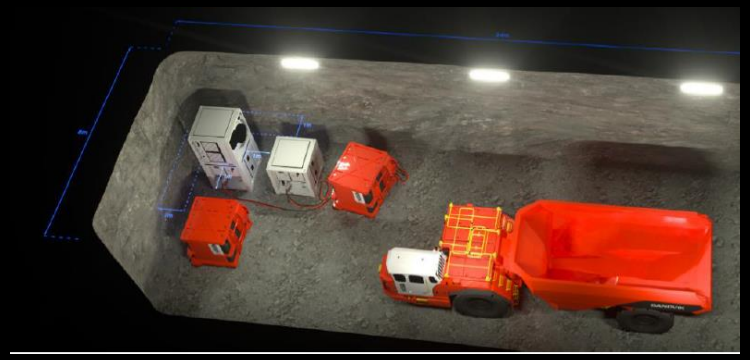
- Power and infrastructure validation
- Ventilation design and criteria
- Regenerative braking opportunities
- Standardize charging methodology
- Automation or autonomous
- IT communication and reporting
- Logistics and traffic management

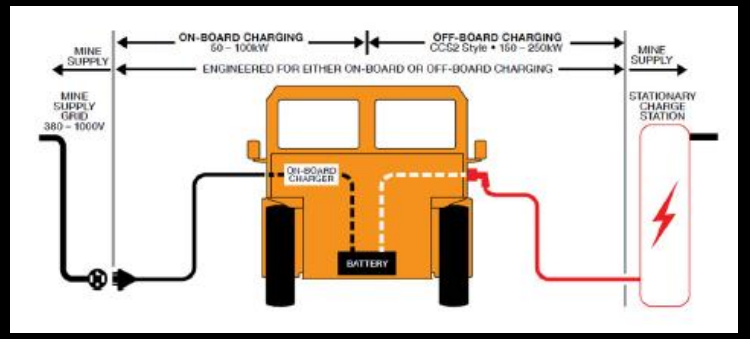


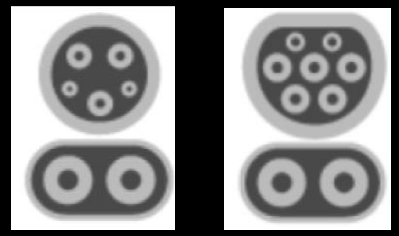
Charging Methodology

- Onboard Charging
- Off Board Charging
- Swap Charging
- Opportunity Charging
- Centralized Charging
- Combine Charging System (CCS1, CCS2)









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Lessons Learned

- Business case and stakeholder engagement.
- Understanding of the equipment design and functionality.
- Mine design and charging methodology to suit the mining method.
- Advance training for operators and maintenance prior to implementation.
- Data collection and reporting (Performance and Maintenance).
- Operational readiness and risk mitigation (Safe Handling, Training, Mine Rescue).

Case Study (On Average)

Performance:

- 8 to 10% faster during the mucking and haulage cycle.
- 15 to 20% more carrying capacity vs Diesel in same working environment.

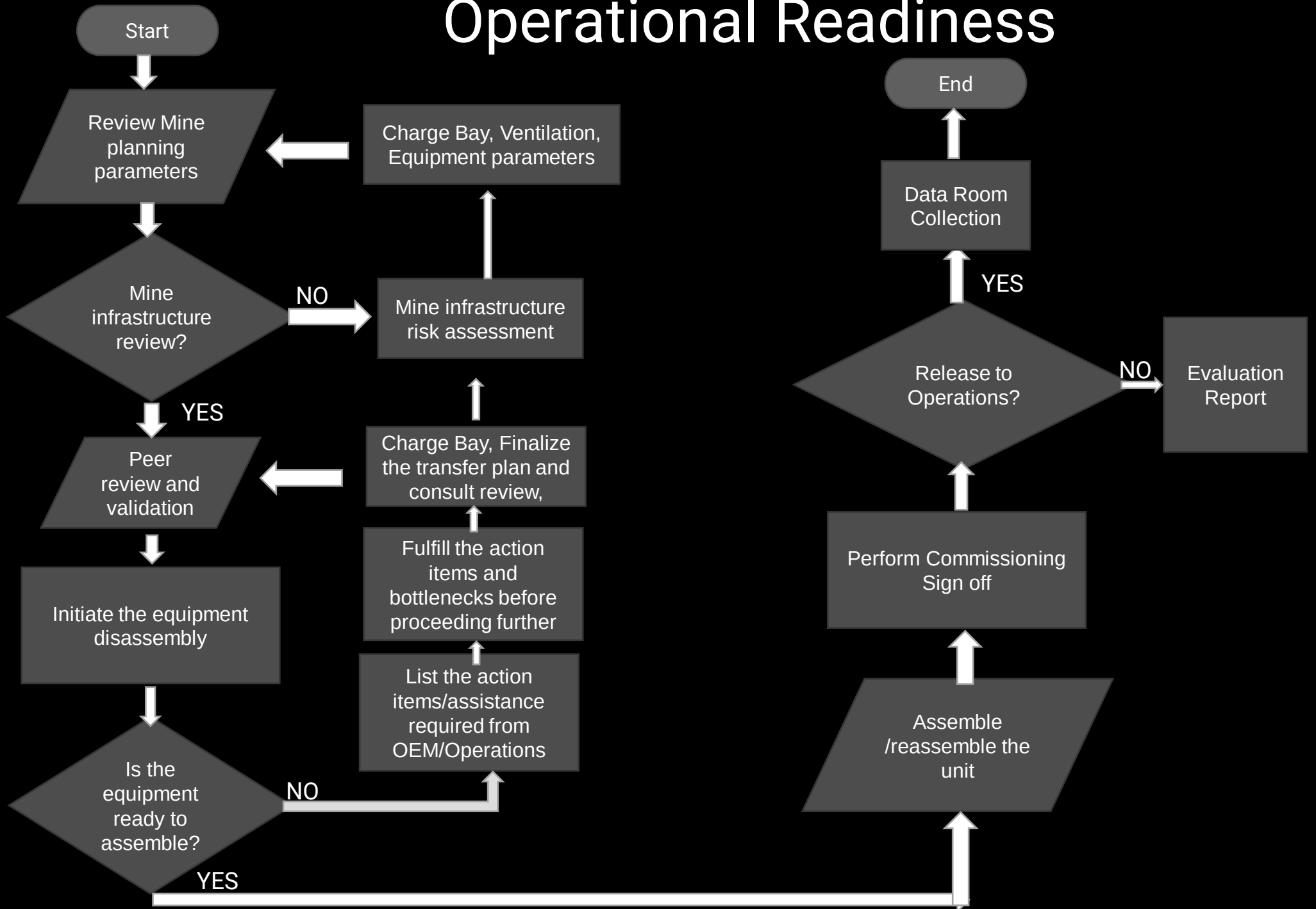
WBGT Temperature Rise:

- This translated to an observed temperature rise 4.4 to 4.7 times greater in Diesel.

Noise:

- BEV Operator Cab noise reduction of 5.8 - 6.0%.
- BEV External noise reduction is 21– 23%.

Operational Readiness



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Are You Ready?

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Conclusion

“BEV technology is forever changing, and we must implement training to manage risk and apply best practices by engaging key stakeholders within the mining operations.

By partnering with OEM’s and qualified industry experts, we will ensure a smooth BEV operational readiness program and a successful implementation.”

Mike Mayhew

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Questions?

Thank you for participating!

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