Safety Bulletin

Date: February 2023

Explosion risk of battery units for underground battery electric vehicles

This safety alert provides safety advice for the NSW mining industry.

Issue

The use of lithium-based chemistries in battery design is rapidly increasing. There has been a corresponding increase in incidents involving equipment fitted with these batteries.

The NSW Resources Regulator has previously issued safety bulletin SB21-05 *Fire risk of battery units for underground battery electric vehicles* and SB22-17 *Fires on battery powered tools increase*. Both of these bulletins have focused on the risks associated with lithium based batteries (LiBs) catching fire.

Areas of concern

In addition to the risk of fire, LiBs may also pose a risk of explosion resulting from the generation of explosive vapours from the chemical reactions which occur during thermal runaway of the battery cells.

Thermal runaway may be initiated by overcharging or short circuiting, or may result from physical damage, such as heating, penetration, crushing or vibration. Regardless cause, once a critical temperature is reached the cell will go into thermal runaway with the exothermic reaction causing cell temperature to continue to increase. At this point the reaction is self-sustaining and the only way to stop it is to cool the cell.

The internal pressures generated during the reaction can cause the cell casing to rupture, if it is not already damaged.

If a LiB cell goes into thermal runaway it may ignite. This normally consumes any flammable vapours generated by the exothermic reaction, however not all failures will result in ignition of the flammable vapours, especially if the battery has a low state of charge. In this case the vapours may freely vent to atmosphere and accumulate in locations where there are low levels of ventilation. Examples of this would include cabins of vehicles and inside enclosures, as well as stubs and cut-throughs in coal mines and cuddies in metalliferous mines. Smaller accumulations may also occur in roof or floor cavities.

The composition and the flammability of these vapours is dependent on the materials used in the electrolyte and the cathode of the cell. Some elements of the vapour cloud will be denser and will tend to sit at floor level, while other elements are less dense and will tend to sit at roof level. The composition and density of a vapour cloud will vary depending on the specific chemistry of the cells.

Flammable vapours generated during a thermal runaway event include:

- organic solvent vapour (small droplets)

- hydrogen (ca. 30-50%)
- ethane
- methane
- other hydrocarbons

If a LiB fire is extinguished, the damaged or defective cell(s) must be cooled or the thermal runaway condition will continue to generate flammable vapours. Extinguishing the fire in this situation may have controlled the immediate fire risk, however the risk of explosion may still exist and have to be managed.

Where a LiB has been in thermal runaway and the incident has been brought under control, the battery unit must be removed from the underground parts of the mine and stored in a location where a re-initiation of the thermal runaway will not place personnel or other plant and structures at risk.

Additional risks

Additional risks associated with damaged batteries include:

- Exposure to toxic gases generated during thermal runaway include:
  - carbon monoxide
  - carbon dioxide
  - hydrogen fluoride
  - hydrogen chloride
  - hydrogen cyanide
  - sulphur dioxide
  - nitrogen oxides
- electric shock and arc flash to occupants, first responders, or maintenance personnel from exposure to high-voltage conductors if electrical insulation is damaged.

Recommendations

In addition to the recommendations in SB21-05:

- Designers should consider risk associated with the generation of explosive gases during a thermal runaway event and provide facilities that enable cells in thermal runaway to be cooled.
- Mine operators should ensure adequate ventilation is provided where battery vehicles are being used, stored or charged to minimise risks to workers.

Mine operators should also ensure that:

- Emergency management plans include suitable controls and procedures for lithium-based battery fires.
- First responders have ready access to, and are trained in the use of, PPE suitable to protect from exposure to toxic and corrosive chemicals that may be liberated during and following a thermal runaway event.
- First responders are trained in the mine's procedures and understand the risks associated with the lithium-based batteries in use at the mine. This should also include awareness of the risk of electric shock and burns from stranded energy in a damaged battery unit and of exposure to toxic gases.
- Ventilation quantities in areas where battery powered equipment is operated, stored or charged is sufficient to dilute any potential accumulation of flammable gasses in the event of a battery

failure. In the case of an underground charging station, this should include ventilation direct to a return airway.

- Emergency procedures require a damaged battery unit to be removed from the underground workings and stored away from personnel, buildings or other vehicles, and is monitored until correctly disposed.

Additional Information:

https://www.afac.com.au/docs/default-source/doctrine/incidents-involving-electric-vehicles_v1-0.pdf?sfvrsn=0&download=true

https://www-nyserda-ny-gov.webpkgcache.com/doc/-/s/www.nyserda.ny.gov/-/media/Project/Nyserda/files/Publications/Research/Energy-Storage/20170118-ConEd-NYSERDA-Battery-Testing-Report.pdf

https://www.dnv.com/Publications/technical-reference-for-li-ion-battery-explosion-risk-and-fire-suppression-165062

Note: Please ensure all relevant people in your organisation receive a copy of this safety alert and are informed of its content and recommendations. This safety alert should be processed in a systematic manner through the mine's information and communication process. It should also be placed on the mine's common area, such as your notice board where appropriate.

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