

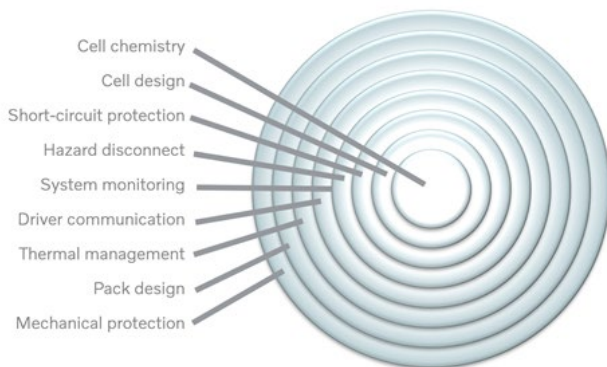
# VOLVO BZL ELECTRIC

## Energy Storage System (ESS)

Electric vehicle cell protection is formed at many levels. It is not just about the cell chemistry but also and most importantly, about the multiple layers of passive space safety systems including cell design, short circuit protection, disconnect measures, battery management systems, general battery pack design, thermal management control and abuse/crash protection, all designed to protect the battery in the unlikely event of a malfunction. Experts have acknowledged that the best systems have several 'layers' of safety. Most electric vehicle manufacturers have one to two defensive lines, with few manufacturers having defensive lines beyond this.

### Volvo's 9 layers of defence

Volvo have 9 safety layers from chemistry choice to mechanical protection to ensure overall ESS safety, importantly but not limited to Thermal Runaway.



*Energy Storage System (ESS) and Battery System Design Safety Philosophy*

### Thermal Runaway and Cell Propagation

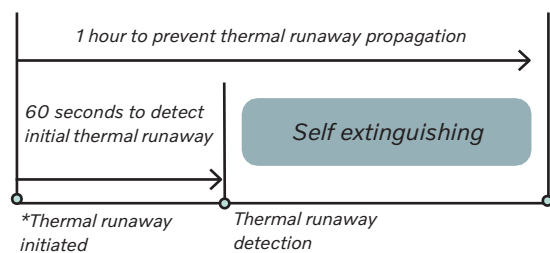
Thermal runaway is a situation that is cause for the most attention when it comes to battery safety. It may start from a single cell (Single Cell Thermal Runaway) and then propagate to other cells leading to an exothermic event or thermal runaway. In designing of the battery cells themselves, reducing this risk above legislative requirements was a critical requirement. For the Volvo ESS Energy Storage System, the battery cell (Single Cell) itself is designed to 'self-extinguish' in the event of a thermal issue. This further reduces the risk of a single cell issue, propagating to other parts of the battery and potential runaway events.

### The safer chemistry choice

Safety is much more than just the base chemistry. No chemistry is poor. Chemistry choice also intrinsically includes battery safety measures using layered monitoring and protection circuits. This is irrespective of the type of cell chemistry. Volvo's main reason for using NCA battery is safety and energy content/density.

NCA batteries offer high specific energy as well as a long-life span compared to other chemistries and have a higher energy density thus allowing for a higher capacity battery per compliance to UN ECE R100.2 for battery design safety. UN ECE R100.2 covers many aspects including but not limited to Insulation, Mechanical shock, Fuel fire, Vibration and Overcharge/over-discharge.

### Timeline of Self Extinguishing



*This single cell 'self-extinguish' feature exceeds the R100.2 requirement of a time window of 5 minutes for propagation. At the same time the driver is given a warning message to advise of the issue and allow sufficient time to activate safety plans.*