

**HPB Solid-State Battery | Abuse tests**

The following tests were carried out according the specification PV8450-2021 except altitude simulation and forced discharge. These tests were carried out according UN38.3. The test results were classified according SAND2017-6925 "Hazard Severity Level (HSL)". The specification PV8450-2021 based on this classification.

Kind of test	max. Hazard Level (HL)	Test result
Internal short circuit (RT/60 °C)	3	no rupture, no fire, no explosion
External short circuit (RT/60 °C)	4	no rupture, no fire, no explosion
Overcharge (RT/60°C)	≤2*	no rupture, no fire, no explosion
Forced discharge	≤2*	no rupture, no fire, no explosion
Altitude simulation	0	no rupture, no fire, no explosion
Thermal stability	3	no rupture, no fire, no explosion
Nail penetration	3	no rupture, no fire, no explosion

\*HLO possible for this cell chemistry. The categorisation would have to be evaluated using further tests, which were not part of this project. For example measuring the capacity loss over lifetime or SEM images to determine whether dendrite growth is present. Even declaration of safety limits of cell could show that the cell was never out of specification.

The tests and measurements described above were conducted on a limited number of HPB Solid-State Battery sample cells. Not all tests and measurements were performed on every sample. Specifications and performance characteristics of final HPB product will depend on the final design of the battery package and may differ from those of initial low volume samples.

**SAND2017-6925 "Hazard Severity Levels:**

Hazard Level	Description	Test result
0	No effect	No effect. No loss of functionality.
1	Passive Protection activated	No damage or hazard; reversible loss of function. Replacement or re-setting of protection device is sufficient to restore normal functionality
2	Defect/Damage	No hazard but damage to RESS; irreversible loss of function.
3	Minor Leakage or Minor Vent	Visual or audible evidence of leaking or venting. Leak without significant pooling or collection of free liquid. Venting without significant smoke or loss of particulate material. No visual obstruction of the RESS.
4	Major Leakage or Major Vent	Visual evidence of leaking or venting. Leaking with significant pooling or observed free liquid. Venting with significant smoke, solvent vapor, and/or loss of particulate material. Visual obstruction of the RESS by vent gases and/or smoke. Total RESS mass loss < 30 %.
5	Rupture	Loss of mechanical integrity of the RESS package, resulting in release of contents. The kinetic energy of released material is not sufficient to cause physical damage external to RESS. Rupture may be the result of RESS thermal runaway (but not necessarily). Total RESS mass loss 30-55 %.
6	Fire or Flame	Ignition and sustained combustion of flammable gas or liquid (≥ 1 s sustained fire). Sparks or incandescent material is not considered a fire or flame.
7	Energetic Failure	Fast release of energy sufficient to cause pressure waves (slower than the speed of sound) and/or projectiles that may cause considerable structural and/or bodily damage, depending on the size of the RESS. The kinetic energy of flying debris from the RESS may be sufficient to cause damage as well. Total RESS mass loss ≥ 55 %