Strategies for Optimized Environmental Protection of Battery Modules

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Problem Statement

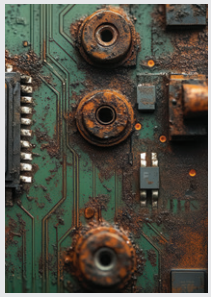
Battery modules, such as those used in BESS installation, should be protected from environmental perils such as moisture and particulate ingress. However, hermetic sealing of modules is not ideal, as the heat produced during charge/discharge will result in substantial pressure differentials. These conditions can damage internal components and compromise gasket/seal integrity over time, resulting in significant ingress potential and early component failure.

Risks of Electronic Enclosure Seal Failure

Condensation

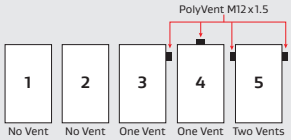
Contamination

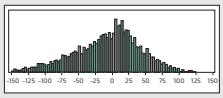
Corrosion



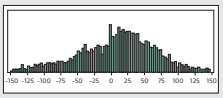
Protective Venting Experiment

For the past nine years, an ongoing experiment has been conducted with pressure-sensored electronic enclosures mounted on the rooftop of an office building near Munich, Germany. These enclosures feature various protective vent configurations. The data below illustrate the maximum differential pressure (dP) experienced by the enclosures throughout the nine-year experimental period.

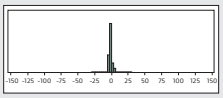




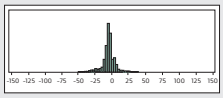
-150 mbar ↔ 131 mbar
Box 1: No Vent



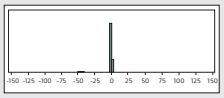
-149 mbar ↔ 147 mbar
Box 2: No Vent



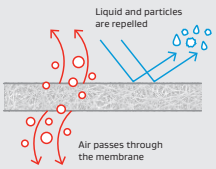
-30 mbar ↔ 30 mbar
Box 3: One Vent (side)

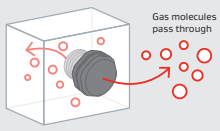


-50 mbar ↔ 41 mbar
Box 4: One Vent (top)



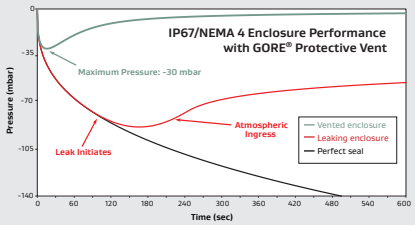
-4 mbar ↔ 4 mbar
Box 5: Two Vents (side)





Pressure Modeling

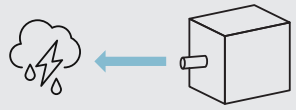
The chart the the right demonstrates the pressure equalization which is accomplished via optimized protective venting of the electronic enclosure.



Moisture Modeling

Moisture movement is not always intuitive – conditional modeling (shown below) can be used to predict moisture movement and inform the optimization of protective venting strategies to maximize environmental protection.

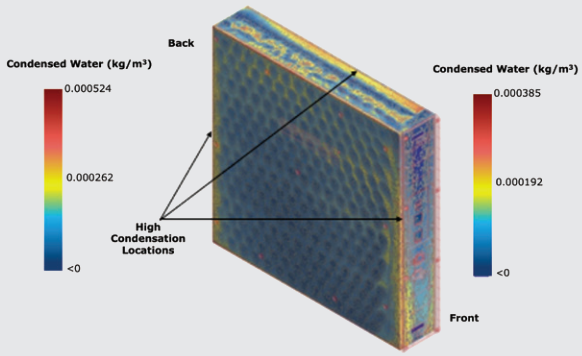
Which way will moisture move under the conditions to the right?



External Conditions
Temp = 25°C
RH = 90%
AH = **20.7 g/m³**

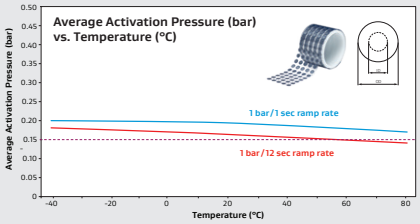
Internal Conditions
Temp = 50°C
RH = 35%
AH = **29 g/m³**

Condensed Water



Dual Function Evacuation Vent Technology

A Dual-Function Evacuation Vent (DFEV) is designed to provide pressure equalization during normal operation while incorporating a burst function to enable rapid pressure evacuation if required, such as during a thermal runaway event. The developmental Gore DFEV offers a consistent activation pressure in a low profile, cost-effective design while enabling IP68 (1 meter/24 hour) ingress protection.



Proposed Gore Dual Function Battery Evac Technology Benefits

- Low profile, smaller diameter, lower weight – enables design freedom
- Consistent activation pressure
- Simple design = Cost effective solution – compared to current competitors
- Easier installation & reduced manufacturing costs

Preliminary Performance Specifications

Vent Criteria	Target Value
Target Activation Pressure for Evacuation Airflow	150±50 mbar
Pressure Equalization Airflow	40 L/hr @ 70 mbar
Evacuation Airflow	30 L/s @ 150 mbar
Ingress Protection – Immersion	IP68 – 1m/24 hr
Ingress Protection – Spray	IP64 (dust, splashing water)
Part Size Diameter/Height	<35 mm/1 mm

Conclusions

Optimal protection of battery modules from environmental perils such as moisture & particulate ingress and damage from pressure differentials can be achieved through protective venting strategies. Gore offers a combination of commercial industry-leading protective venting products, developmental protective technology and expertise in venting and conditional modeling to ensure our customers have optimal protection for battery and electronic modules.

Together, improving life