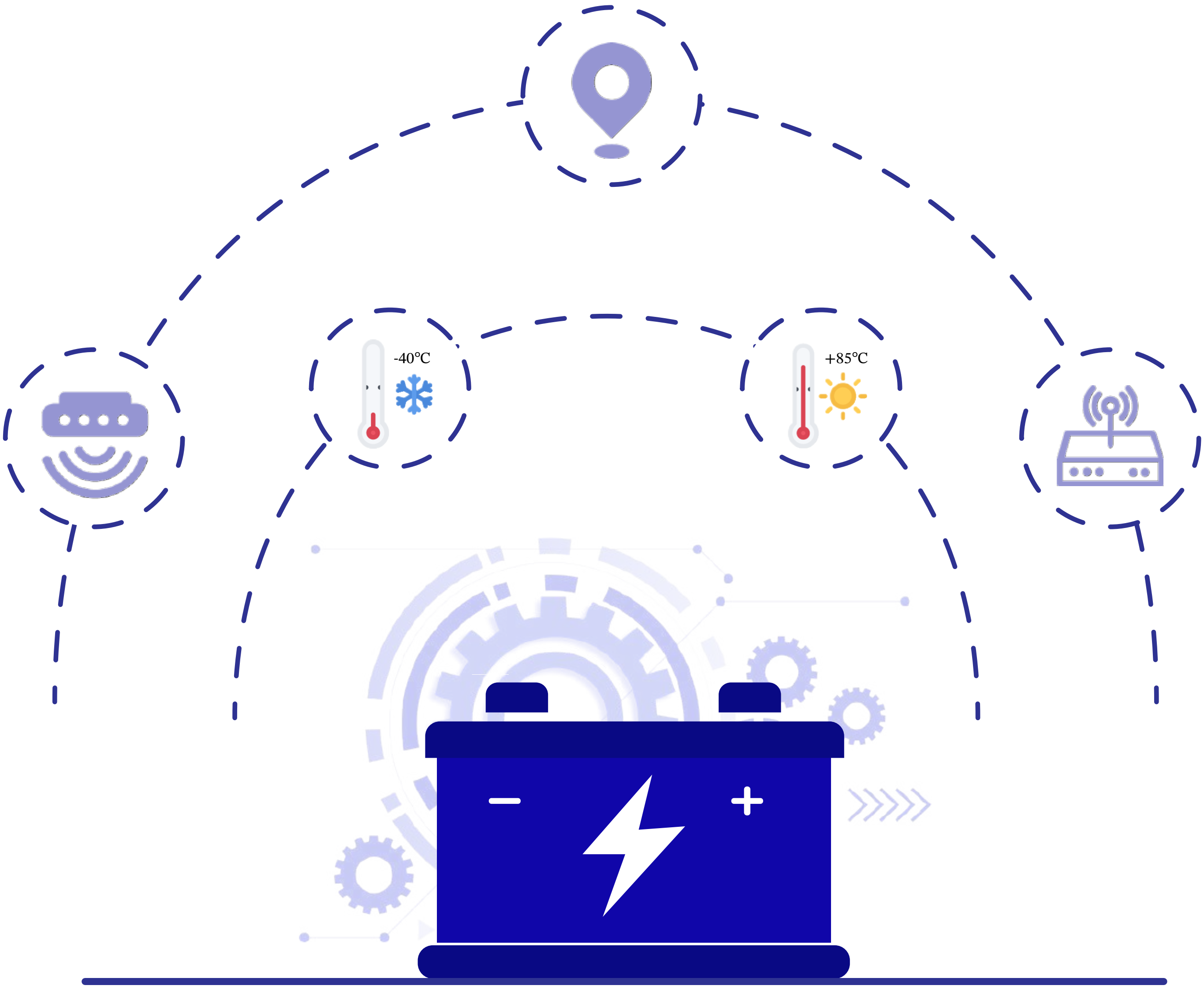
Powering IoT at the Edge

Designing Reliable Lithium Battery Packs for High-Temperature IIoT Applications

Stop Capacity Fade, Voltage Drop & Thermal Runaway in Industrial IoT Devices



UN38.3 Transport-Safety Tested | ISO9001:2015 Certified Manufacturing facility| UL optional Per-project Certification | 15+ Years Battery Engineering Experience

High-Temperature 18650 & 14500 Battery Packs for Industrial IoT

Powering IoT at the Edge: How to Stop Battery Failures Between -40°C and +85°C

Version : 2.0 – July 2026

Authors : Huahan Wang, BMS Design Lead | Zhiqiang Lan, Test Lab Lead

Contributors : Custom Battery Pack Engineering, BMS Design, Test Lab

> Reviewed by CM Batteries Engineering Team. Technical claims in this white paper are based on internal lab testing methodology aligned with UN38.3, IEC 62133, and UL94 standards. Detailed test reports are available to engineering teams under NDA — contact engineering@cmbatteries.com.

CM Batteries (CMB) is a Shenzhen-based, ISO 9001: 2015 –certified custom lithium-ion battery pack manufacturer serving OEMs across IoT, medical, robotics, consumer, and marine applications. With 15+ years of engineering and manufacturing experience and custom battery packs shipped to OEMs across North America, Europe, and Asia, we help engineering teams solve real-world power challenges — not just supply cells.

This white paper focuses on one specific area:
high-temperature lithium-ion battery packs for IIoT devices operating at -40°C to +85°C, built on 18650 and 14500 cell platforms, with UN38.3 export certification. For other applications (low-temperature, waterproof, high-rate, etc.), please refer to our website or contact our engineering team.

Our general capabilities include:

· Wide-temperature range: -40℃ to +85℃

· Cell formats: 18650,14500

· Protection & fuel g auge: TI BQ-series ICs for overcurrent, overvoltage, short-circuit, and state-of-charge monitoring

---

Technical inquiries	Sales & support	US contact (Mountain View, CA)	FR contact (Douai, France)
engineering@cmbatteries.com	sales@cmbatteries.com	ray@cmbatteries.com	ding@cmbatteries.com

CONTENTS

The Standard 18650 & 14500 Cell Wasn't Built for 85°C

In industrial IoT deployments, heat — not age or vibration — is the #1 cause of battery failure. Agricultural sensors in open fields, outdoor data loggers, and monitors mounted near industrial heat sources routinely see ambient temperatures above 70°C. At that point, standard 18650 and 14500 li-ion cells degrade fast: capacity fades, internal resistance climbs enough to disrupt wireless transmission, and in the worst case, thermal runaway becomes a real risk. (The mechanics of exactly how each failure happens are covered in Chapter 2.)

The cost is rarely just the battery. A single field replacement typically runs 10–50× the price of the battery itself — before counting data loss, device downtime, and delayed projects.

CMB's answer:

A battery pack engineered specifically for this environment — high-temperature-grade 18650 and 14500 cells, a BMS tuned for over-temperature protection, and connectors built to survive sustained heat. Validated for continuous operation across -40°C to +85°C.

KEY TAKEAWAYS

· ≥90% capacity retention at 85°C under 0.5C discharge

· ≥80% cycle life retained after 500 cycles at high temperature

· Field-proven across 3 IIoT deployments on 3 continents — full data in Chapter 4

（Based on internal lab testing. Full methodology and raw data in Section 4.1–4.3. ）

BY THE END OF THIS WHITE PAPER, YOU'LL BE ABLE TO:

· Diagnose the real failure mechanism behind a battery that "shouldn't have died yet"

· Specify the design parameters — charge voltage, NTC thresholds, IR tolerance — that actually matter above 70°C

· Screen any battery supplier with the 4 questions most won't want to answer → Chapter 5

Choose a battery that won't fail when the temperature rises. Chapter 2 starts with why it fails in the first place.

Three Ways Li-ion Batteries Fail in High-Temperature IIoT Environment

Every high-temperature battery failure traces back to one of three root causes. This chapter explains why each happens and what it costs you in the field. The exact voltage thresholds, NTC set-points, and assembly tolerances CMB uses to prevent each one are detailed in Chapter 3 — this chapter is about the mechanism, not the spec sheet.

Accelerated Capacity Fade

WHY IT HAPPENS

High temperature causes the SEI (solid electrolyte interphase) layer inside the cell to grow too fast, consuming active lithium; the electrolyte also decomposes faster than at room temperature.

RESULT

Runtime drops significantly within just a few months — especially once ambient temperature exceeds 60°C. For a 200- unit sensor fleet, that means a full-fleet battery swap within a single deployment season, not the 2–3 years the spec sheet implied.

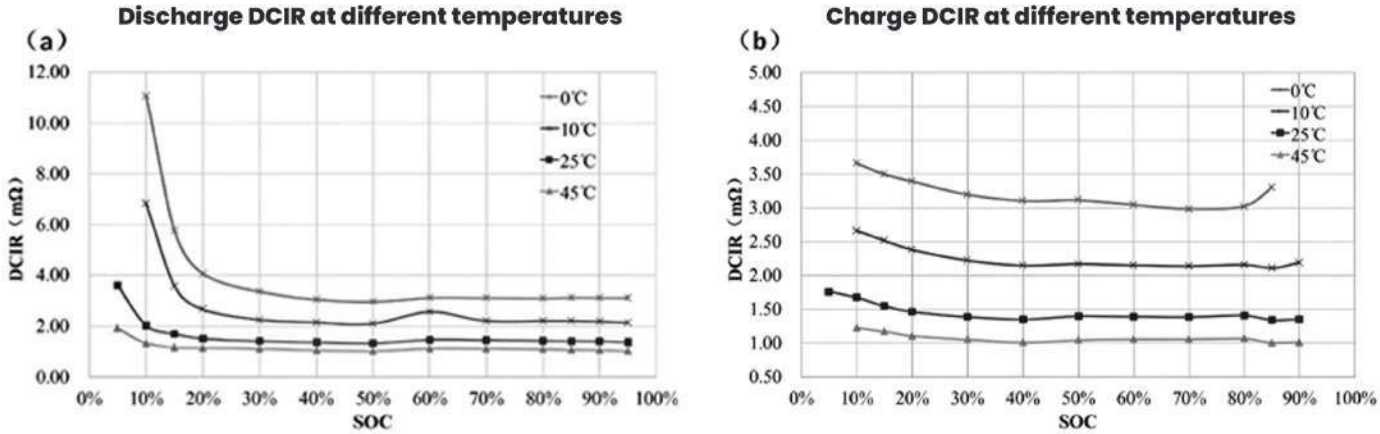
CMB SOLUTION

We control this failure mechanism at the design source — not through after-the-fact fixes — by strictly capping charge voltage below 4.2V and pairing it with real-time voltage monitoring from a dedicated BMS IC.

Rising Internal Resistance —and Lost Pulse Current

WHY IT HAPPENS

Standard cells show a significant IR increase at high temperature. CMB's high-temperature-grade cells have lower IR than standard cells of the same capacity, and stay stable across 60°C–85°C.



RESULT

With ordinary batteries: IR rises under heat → voltage sags during transmission → undervoltage lockout triggers → device reboots — and the reading is gone. At a 15-minute report interval, a handful of heat-triggered reboots a day is enough to turn continuous monitoring data into a series of unexplained gaps.

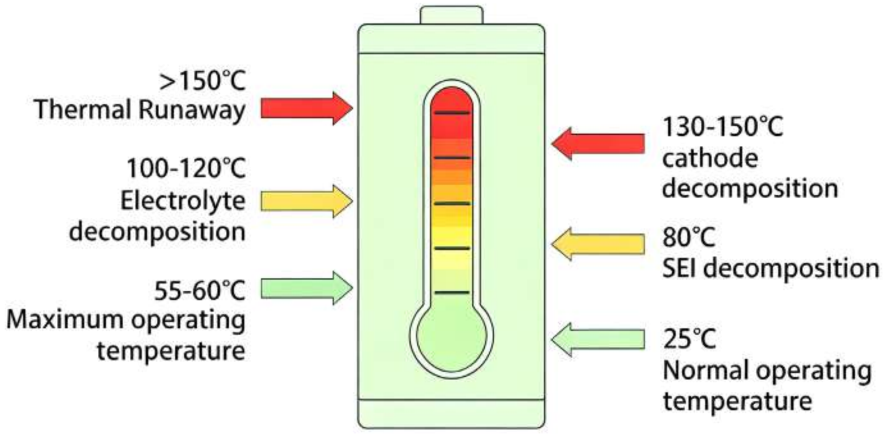
CMB SOLUTION

High-temperature cells with inherently lower, more stable IR, screened for pack-to-pack consistency, paired with low-impedance connections engineered specifically for pulse loads

Thermal Runaway and Safety Hazards

WHY IT HAPPENS

Sustained high heat can trigger a chain reaction inside the cell:
SEI decomposition (>80°C) → separator shrinkage or melting (>120°C) → internal short circuit → cathode oxygen release → electrolyte combustion → thermal runaway.



RESULT

Ordinary batteries may swell, leak, smoke, or in the worst case ignite in high-temperature environments — damaging equipment and creating a genuine safety risk. A single thermal event is rarely "just" a hardware failure: it's an incident report, potential equipment damage, and in regulated industries, a compliance review.

CMB SOLUTION

We use high-temperature grade cells with enhanced thermal stability, paired with BMS charge voltage limited to 4.1V and NTC temperature protection (charge cutoff >60°C, discharge derating >75°C, discharge cutoff >85°C). Thermal barriers (aerogel or mica) are placed between cells, and flame-retardant thermally conductive potting (UL94 V-0) is applied.

Key Engineering Takeaways

Pack Engineering Matters More Than Cell Brand

High temperature causes three real, compounding problems — accelerated capacity fade, rising internal resistance, and thermal runaway risk. None of them can be solved by the cell

CMB'S SOLUTION IS A COMPLETE PACK ENGINEERING SYSTEM

· High-temperature-grade cell screening
· IR consistency control across every pack
· 4.1V charge strategy
· Three-level NTC temperature protection
· Thermal barriers & flame-retardant potting
· Pressure relief design
· Mandatory high-temperature testing on every prototypeEvery high-temperature battery pack prototype undergoes high-temperature testing.

In high-temperature IIoT applications, this system — not the cell datasheet — is what determines whether a device survives its first summer. CMB delivers a power system proven at 85°C, not just a cell assembly.

Chapter 3 walks through exactly how each layer of this system is engineered — starting with cell qualification.

Key Design Parameters of CMB High-Temperature Battery Packs

Chapter 2 covered why heat breaks a standard pack. This chapter covers exactly how CMB engineers around each failure mode — the cell criteria, BMS logic, and assembly tolerances behind every claim in Chapter 2.

Cell Selection & Qualification Process

CM Batteries is deliberately slow to approve a new cell model. Every candidate goes through no less than six months of internal testing — high-temperature cycle life, pulse capability at various temperatures, storage aging, self-discharge, and safety testing. Only battery cells that clear every threshold are approved for use in a custom battery pack.Every high-temperature battery pack prototype undergoes high-temperature testing.

Parameter	Specification	Why it Matters
Cell Format	18650 & 14500 High-Temperature Grade	Matches most IIoT sensor / tracker form factors
Capacity Options	14500: 750mAh | 18650: 2000/2900/3200/3340mAh	Sized to runtime target, not forced to one SKU
Internal Resistance	10-20% lower than standard cells of same capacity	Less self-heating, more stable pulse output
IR consistency (pack-level)	<5% deviation across cells in the same pack	Re-verified every production batch — Section 3.4

These in-house qualification categories mirror the test scope of UN38.3 and IEC 62133, extended with CMB-specific high-temperature endurance criteria beyond what either standard mandates.

BMS & Charging Strategy

The BMS is the brain of a high-temperature pack. CMB's strategy for IIoT applications is built around two goals: reduce thermal aging over the device's service life, and guarantee pulse current is still available when a radio keys up at 85°C.

ENGINEERING TRADE – OFF — WHY 4.1 V, NOT 4.2 V

Charging to the standard 4.2V at elevated temperature sharply accelerates cathode side reactions and capacity fade.Capping charge voltage at 4.1V sacrifices roughly 10% of per-cycle energy — but more than doubles cycle stability and storage life at high temperature. For an IIoT device that needs to survive years in the field rather than maximize a single spec-sheet number, CMB makes this trade deliberately.

Parameter	Specification	Why it Matters
Charge voltage limit	4.1V (vs. 4.2V standard)	See trade-off above
NTC charge cutoff	› 60°C	Stops charging before thermal aging accelerates
NTC discharge derating	50% of rated current above 75°C	Protects cells while keeping the device alive
NTC discharge cutoff	› 85°C → safe state	Hard stop before thermal runawayrisk (Ch.2.3)
UVLO delay	50–200ms	Backup only — low IR keeps pulse sag minimal
Cell balancing	Passive, enabled for 2S–4S strings	Prevents capacity loss from cell mismatch

Electrical Connection & Precision Assembly

At high temperature, connection reliability is the failure mode engineers most often overlook. CMB's strategy is to reduce heat at the source, then hold every mechanical connection to a tolerance tight enough that heat and vibration can't work it loose.

Per Joule's law (heat = I^2R), the 10–20% lower internal resistance established in Section 3.1 directly means less self-generated heat at the same current — the cells act as their own "cooler source" inside the battery pack.

Parameter	Specification	Why it Matters
Nickel tabs	Custom-shaped & thickness-selected per series/parallel config	See trade-off above
Welding	Precision spot welding, parameters verified per cell	Protects cells while keeping the device alive
Assembly tolerance	±0.1mm	Hard stop before thermal runaway risk (Ch.2.3)
External pack impedance	< 10mΩ	Backup only — low IR keeps pulse sag minimal
Connectors	Custom length / gauge / terminal, hightemp wire	Prevents capacity loss from cell mismatch

Testing & Validation

A well-designed parameter is only a number until it's verified. CMB enforces a mandatory three-tier testing process for every high-temperature battery pack:

Prototype Testing

Mandatory per design. Must pass fullload discharge and pulse testing at 85°C, meeting the thresholds disclosed in this white paper before production readiness.

Batch Spot Checks

Sample packs from each production batch are re-tested, with particular focus on internal resistance consistency (deviation <5%) and high-temperature discharge capacity, catching drift before it reaches the field.

Safety Certification Testing

UN38.3 transport safety testing, plus UL / IEC 62133 as required. Full test reports are available on request.

FOUR SYSTEMS , ONEENGINEERING LOGIC :
CONTROL HEAT AT THE SOURCE

Cell qualification

≥6 months of testing to select reliable high-temperature cells

BMS strategy

4.1V charge voltage
three-level NTC protection
UVLO delay

Electrical connection

low-IR cells
custom nickel tabs
±0.1mm precision assembly

Testing & validation

mandatory 85°C prototype testing
batch spot checks
safety certification

Every CMB high-temperature pack is engineered and validated through this same process — not by relying on external cooling, but by controlling heat and risk at the cell, circuit, and connection level.

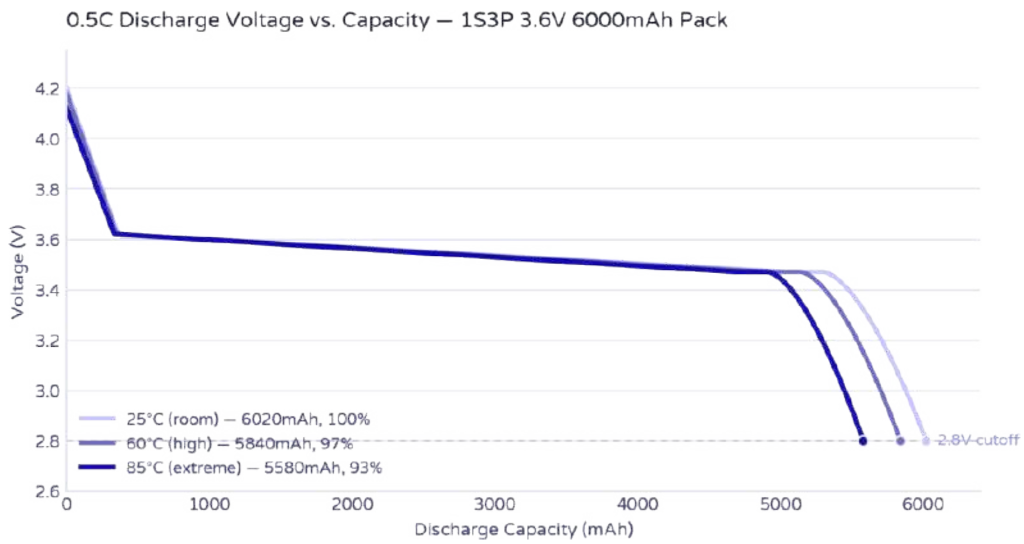
The next chapter presents measured data and typical application cases of CMB high-temperature battery packs.

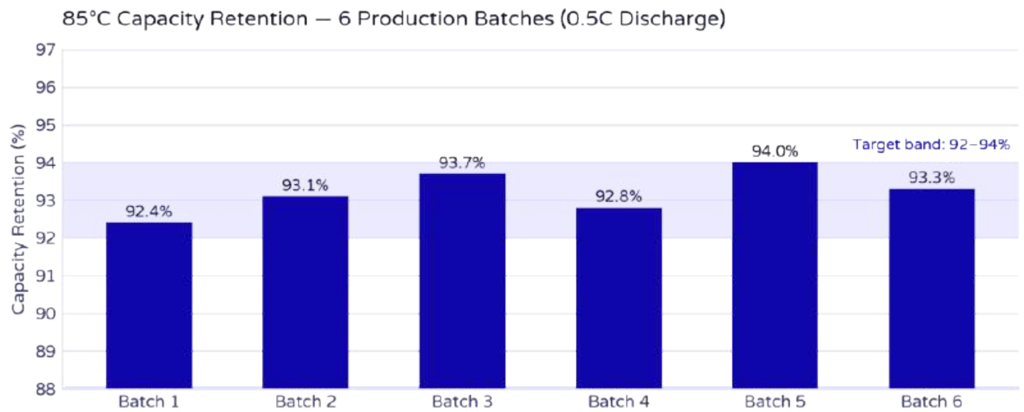
CMB High-Temperature Battery Pack – Measured Data & Application Cases

Every result below was produced under the three-tier testing process in Section 3.4 — not a single best-case lab run. The test unit is a 1S3P 3.6V 6000mAh pack (three 18650 2000mAh high-temperature cells in parallel), built for an outdoor IIoT monitoring device rated to 85°C.

High-Temperature Discharge Performance

The pack was discharged at 0.5C (≈3A) at three ambient temperatures: 25°C (room), 60°C (high), and 85°C (extreme). Voltage vs. capacity was recorded:





This 1S3P pack consistently achieves 92%–94% capacity retention at 85°C across batches. Even when the device's internal temperature exceeds 80°C, the battery delivers nearly its full rated runtime.

> Performance traces directly to the cell qualification and 4.1V charge strategy established in Sections 3.1–3.2 — this section reports the outcome, not the mechanism.

What this means for customers:

· In sun exposure , or near heat sources, runtime is not cut dramatically by heat.

· No need to oversize the battery pack just to add a safety margin.

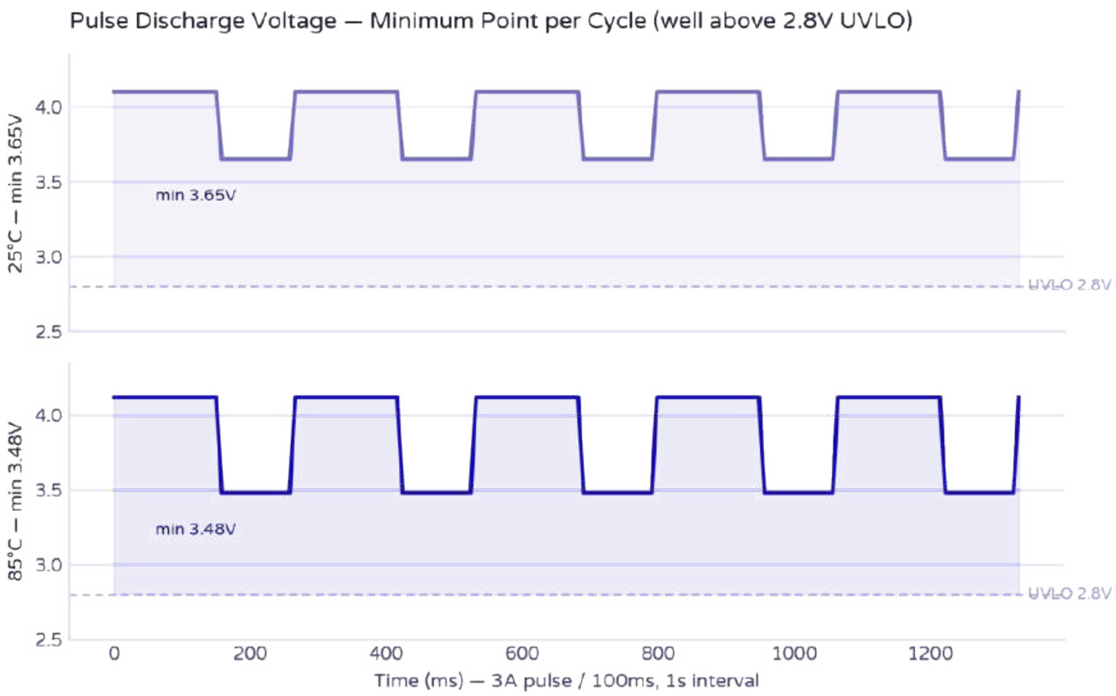
Full test reports (including different C-rates and batch data) are available upon request.

Pulse Discharge Capability Validation

Wireless transmission (4G, NB-IoT, LoRa) draws a short 2–5A current pulse. If IR is too high, voltage sags below the BMS undervoltage lockout (UVLO) threshold — and the device reboots mid-transmission.

TEST METHOD

Battery Pack charged to 4.1V · soaked at 85°C for 2 hours · discharged at 3A for 100ms (simulating transmission), recovered at 0.5A standby for 1s, repeated · minimum voltage recorded per cycle.



Minimum voltage per pulse cycle, 25°C vs.

3.65V	3.48V	0
MIN VOLTAGE @ 25°C	MIN VOLTAGE @ 85°C	UVLO TRIPS (vs. 2.8V THRESHOLD)

Achievable because of the low, stable IR from Section 3.1 and the <10mΩ external pack impedance from Section 3.3 — the UVLO delay is a backup that, in practice, is never needed.

What this means for customers:

· Even transmitting at 85°C, the device will not shut down from voltage sag

· Data transmission success approaches 100% — no retry logic or supercapacitors required

High-Temperature Storage Performance (Self-Discharge)

IIoT devices often sit in standby for months before deployment or between reports. Self-discharge rate at high storage temperature directly determines standby time and maintenance intervals.

TEST METHOD

Charge to 4.1V, measure initial capacity at 25°C · store at 60°C for 7 days · cool to room temperature, discharge at 0.5C to 2.8V · capacity recovery = remaining ÷ initial capacity.

≥95%	96–97%	0
CAPACITY RECOVERY AFTER 7 DAYS @ 60°C	TYPICAL RECOVERY OBSERVED	SWELLING OR LEAKAGE INCIDENTS

Driven by the same electrolyte/separator stability and 4.1V charge ceiling covered in Sections 3.1–3.2. Longer-term storage data (30-day, 90-day) is available on request.

What this means for customers:

· Devices stored in hot warehouses or outdoors for months still retain enough charge to operate

· Extended maintenance intervals reduce field battery-replacement costs

Typical Application Cases

Three deployments built on this same design system — different voltage/capacity configurations, same underlying engineering from Chapter 3.

Case 1 — North American Smart Farm: Soil Sensors

PROBLEM

Hundreds of soil sensors across a Midwest US precision-irrigation deployment; open-field summer ground temperatures routinely exceeded 70°C. Standard batteries cut runtime from a designed 6 months to under 2, driving frequent dropouts and high replacement labor.

7.2V 2900mAh · 2S1P
VERIFIED: INTERNAL LAB

CMB CONFIGURATION

· 2S1P 7.2V 2900mAh high-temperature battery pack – cell IR is 15% lower than ordinary cells of the same capacity; capacity retention at 85°C is 92%
· 4.1V charge strategy (4.1V per cell, 8.2V for the pack) reduces high-temperature side reactions
· BMS with NTC over-temperature protection (charge cut-off >60°C, discharge cut-off >85°C)
· Precision nickel-tab welding and custom connectors ensure reliable electrical connections under heat

LEARN MORE

After two full summer seasons (peak soil temperature 85°C), pack capacity retention remains >85%. Sensor online rate improved from 82% to 99.5%, and maintenance intervals extended to 12 months.

Case 2 — European Industrial Wireless Monitoring Node

PROBLEM

A German automotive-parts factory needed temperature/vibration monitoring nodes 1.5m from an annealing furnace — continuous 60–80°C ambient plus oil mist and dust. Prior industrial batteries swelled, leaked, or lost capacity within 3–6 months, creating gaps in quality-tracking data.

10.8V 2900mAh · 3S1P
VERIFIED: INTERNAL LAB

CMB CONFIGURATION

· 3S1P 10.8V 2900mAh high-temperature pack with low-IR cells
· Charge voltage limited to 4.1V per cell (12.3V pack); three-level NTC protection (charge cut-off, discharge derating, discharge cut-off)
· Thermal barriers (aerogel) between cells to slow heat propagation
· Flame-retardant thermally conductive potting compound (UL94 V-0) fills cell gaps – both heat dissipation and flame suppression
· Precision assembly and custom nickel tabs ensure stable connections at high temperatures

LEARN MORE

Continuously operated for 14 months without failure. Data upload success rate >99%. Post-operation disassembly showed no swelling or leakage.

Case 3 — US IIoT Asset Tracker: Wide-Temperature Cold Chain

PROBLEM

A US cold-chain logistics company tracks pharmaceuticals and fresh food from -20°C cold storage to 70°C on an equatorial container deck, reporting GPS/temperature every 30 minutes. Ordinary batteries showed a sharp IR increase above 60°C, causing a 15% data-upload failure rate; external capacitors helped only marginally and added size.

10.8V 6400mAh · 3S2P
VERIFIED: 3RD-PARTY LAB

CMB CONFIGURATION

· 3S2P 10.8V 6400mAh high-temperature pack – parallel configuration reduces overall IR
· Low-IR cells (20% lower than ordinary cells) maintain stable pulse capability at 85°C
· BMS under-voltage lockout delay set to 100ms to avoid false triggering during transmission
· Charge voltage limited to 4.1V per cell, reducing high-temperature storage aging
· Custom connector (high-temperature wire, terminals matched to customer interface)

LEARN MORE

Third-party lab test simulating 50 cycles between -20°C and 70°C: data upload success rate increased from 85% to 99.2% with no voltage-drop-induced resets. Customer has purchased 10,000 units and plans to roll out to global cold□chain operations.

Summary

What the data shows

· **85°C discharge**: 92–94% capacity retention, stable voltage plateau

· **Pulse capability**: 3A/100ms at 85°C — 3.48V minimum, well above the 2.8V UVLO threshold

· **High-temp storage**: ≥95% capacity recovery after 7 days at 60°C

· **Field cases:** 3 deployments across North America, Europe, and the US — all >99% data success and 12+ month

Low-IR cells, 4.1V charging, three-level NTC protection, and precision assembly solve capacity fade, pulse insufficiency, and safety risk at 85°C — not as isolated fixes, but as one engineering system.

From Proof to Purchase Order

Conclusions

Chapter 4 laid out the data: 85°C capacity retention, pulse performance, storage recovery, and three field deployments — the full numbers are there, not repeated here. The conclusion is simple: low-IR cells, a 4.1V charge strategy, three level NTC protection, and precision assembly aren't independent features. They're one engineering system, and it's the system — not any single spec — that determines whether a pack survives its first summer at 85°C.

That system is what CMB engineers into every high-temperature pack, and it's what the rest of this chapter helps you specify.

Four Questions to Ask Any High-Temperature Battery Supplier

Not just us — ask any supplier building packs for extreme-temperature IIoT deployments. The answers separate an engineered pack from a cell in a box with a datasheet.

QUESTION 1

Can I see batch-to-batch consistency data, not just one best-case test result?

A single great test run proves a lab technique. Six consistent batches prove a manufacturing process.

This white paper → Section 4.1

QUESTION 2

What's your charge voltage strategy above 40°C, and why?

If the answer is "4.2V, same as always," they haven't engineered for heat — they've just sold you a standard cell.

This white paper → Section 3.2

QUESTION 3

Do you test complete packs at rated maximum temperature, or just individual cells at room temperature?

Cell-level room-temperature data doesn't predict pack-level behavior at 85°C. Ask specifically which was tested.

This white paper → Section 3.4

QUESTION 4

Can I see three-tier testing documentation—prototype, batch, and certification — not just a datasheet?

A datasheet describes a cell. A test report proves a pack. The two are not the same document.

This white paper → Section 3.4

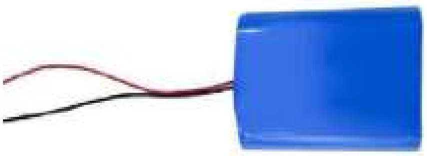
Selection Recommendations

CMB does not sell an off-the-shelf high-temperature battery. Voltage, capacity, size, pulse load, duty cycle, and installation environment differ on every IIoT project — so every pack is engineered to spec, on the same design system covered in Chapter 3.

Three Reference Configurations-
Recently Delivered(Not Standard SKUs)

7.2V 2900mAh (2S1P)
High Temperature Battery Pack

suitable for two-cell series sensors with moderate power consumption



10.8V 2900mAh (3S1P)
High Temperature Battery Pack

suitable for three-cell series industrial monitors with tight thickness constraints

10.8V 6400mAh (3S2P)
High Temperature Battery Pack

suitable for asset trackers requiring long runtime and high pulse current

All three incorporate the same low-IR cells, 4.1V charge limit, three-level NTC protection, and precision assembly from Chapter 3. For custom dimensions, connectors, pulse capability, or certifications, request an engineering review.

PARAMETERS TO PROVIDE FOR A CONCEPT EVALUATION

- ☑ Nominal voltage / series-parallel configuration
- ☑ Capacity requirement (or runtime target)
- ☑ Maximum pulse current and duration
- ☑ Operating temperature range (max / min)
- ☑ Mechanical size limits
- ☑ Connector type or interface definition
- ☑ Target certifications (UL / IEC62133 / others)

CMB's engineering team will provide an initial concept evaluation within 24 hours.

Next Steps

For sample orders, technical consultation, or a custom design review, contact CMB engineering directly.

ENGINEERING INQUIRIES
engineering@cmbatteries.com

SALES & SUPPORT
sales@cmbatteries.com

WHITEPAPER DOWNLOAD
cmbatteries.com/whitepaper/

We look forward to working with you to build reliable high-temperature power for your IIoT devices.

About the Authors & References

Huahan Wang

CTO

He owns an industry veteran with more than 20 years of experience in the lithium-ion battery industry.

Zhiqiang Lan

Process Engineer

Responsible for collecting and verifying all high-temperature test data in this paper.

This white paper was authored by CMB's engineering team and reviewed internally prior to publication. Technical standards referenced include UN38.3 (UN transport safety testing for lithium batteries), IEC 62133 (safety standard for portable batteries), and UL94 (flammability rating for materials).

> Data in this white paper is drawn from CMB's internal lab testing and field deployment feedback. Detailed test reports are available for technical review upon request at engineering@cmbatteries.com.