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Battery Durability and Standards

Performance Testing – Ensuring Quality, Reliability, and Market Readiness

SEES Höstkonferens, den 4-5 november, Södertälje

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Agenda

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Setting the stage: The importance of battery cell durability and performance in today's energy landscape.

02 **The Role of Durability Testing Across the Value Chain**
From R&D to commercialization – understanding how testing supports innovation, quality assurance, and regulatory compliance.

03 **Testing Methodologies**
A look at established protocols and measurement techniques used to assess cell performance and durability.

04 **Interpreting Test Results**
What the data tells us – and how deep-dive analyses such as tear-downs reveal crucial insights.

05 **Standards**
Examples of available standards for different applications and chemistries

06 **Conclusion and Outlook**
Key takeaways and how durability testing drives better, safer, and market-ready battery technologies.

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GLOBAL MARKET LEADER IN ASSURANCE

3,000 AUDITORS

100,000+ AUDITS

100+ COUNTRIES

GLOBAL MARKET LEADER IN TIC

1,000+ LABS & OFFICES

80+ LANGUAGES

Systemic approach to Quality and Safety

ASSURANCE | TESTING | INSPECTION | intertek CERTIFICATION

Our Sectors

Products | Trade | Resources

THE TOTAL QUALITY – BATTERY PACKS, MODULES AND CELLS

Assurance, Testing, Inspection and Certification

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FAILURE ANALYSIS

Find and mitigate product safety risks with Intertek's failure analysis service. Our battery expert team has years of experience helping with independent systematical battery failure analysis.

SUSTAINABILITY

Validate sustainability claims through testing, engineering review of the battery design and audits of the manufacturing processes. Intertek's comprehensive sustainability solutions support and verify your organization's sustainability initiatives.

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Intertek is an industry-leading supply chain assurance provider that have years of experience in delivering end to end solutions that help you mitigate your organization's supply chain risk and protect your brand.

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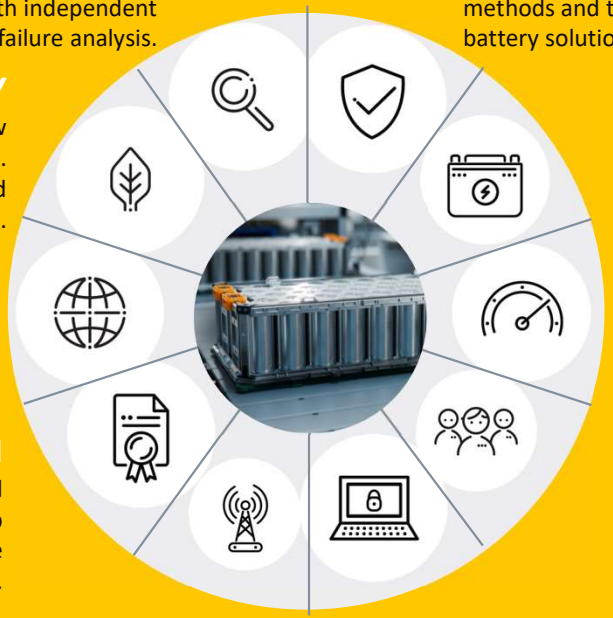
Navigate complex global regulations with our Auditing and Certification Services. We provide a unique mix of deep knowledge and worldwide presence, supporting standards like ISO 9001 and ISO 14001.

EMC, RADIO AND WIRELESS

Utilize Intertek's global network of EMC chambers. We provide comprehensive testing and certification in EMC, Bluetooth and wireless technologies.



BATTERY EXPERT SUPPORT

Intertek's battery expert team leverages years of experience to offer best practices, test methods and technical manufacturing audits when you select and develop an optimized battery solution.

GLOBAL MARKET ACCESS

Accelerate your product's global market access and time to market by utilizing Intertek's regulatory research and training services.

PERFORMANCE, DURABILITY AND ENVIRONMENTAL TESTING

Exceed mandatory testing by evaluating the performance and durability of your battery. Ensure that your battery meets eco design requirements by testing to IEC/EN battery performance standards. Expand into international markets with Intertek's IECEE CB Scheme Testing and Certification.

SAFETY AND ABUSE

Ensure that your battery meets complex global compliance by testing to IEC/EN and UL battery safety standards as well as applicable electrical safety standards. Expand into international markets with Intertek's IECEE CB and ETL Scheme Testing and Certification.

FUNCTIONAL SAFETY

Perform functional safety evaluations of your battery management system to meet safety requirement for industrial and EV batteries.

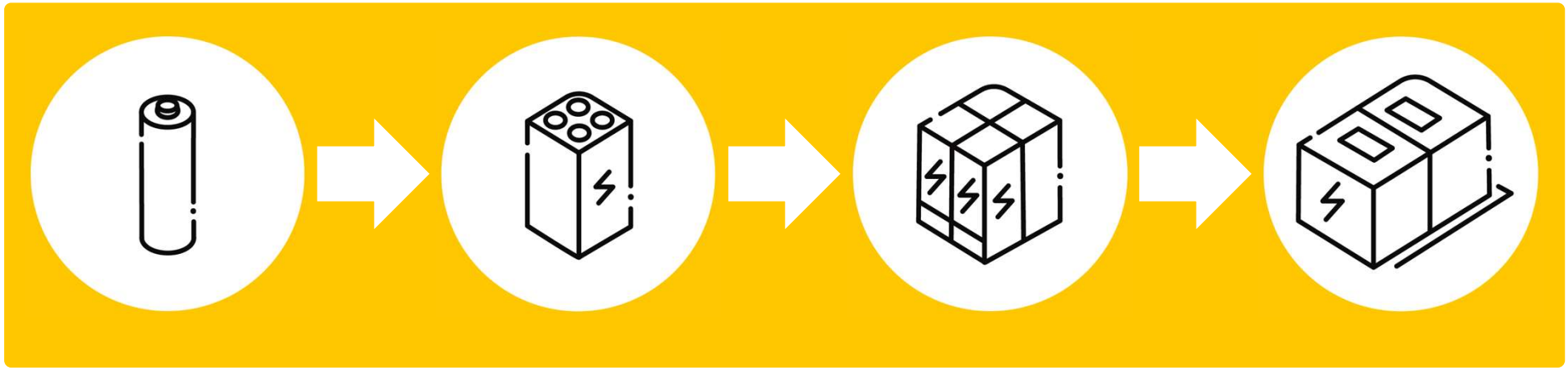
CYBERSECURITY

Intertek's Connected World team provides comprehensive services from penetration and wireless testing to full evaluation and certification to IEC, EN and UL standards.

INTERTEK'S Global battery centres of excellence

intertek battery Xcellence Centre

Introduction – from Cell to System



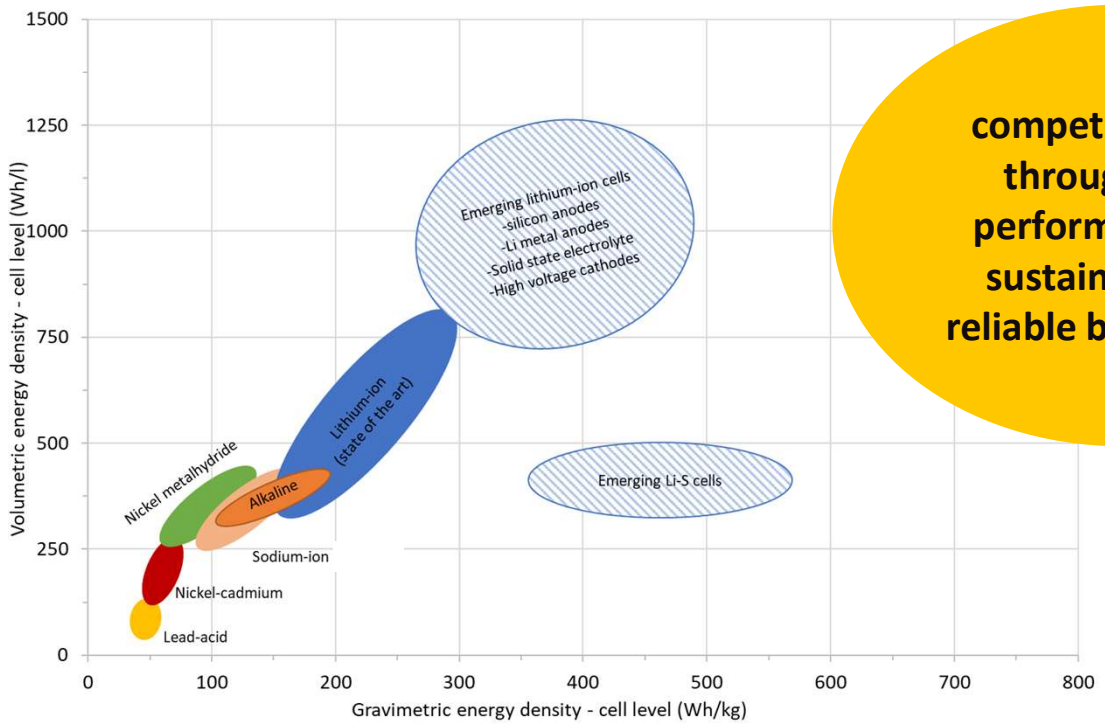
Cell
(Single battery)

Module
(Collection of cells connected together)

Pack/Unit
(Series of modules connected)

System
(Series of packs connected in a large controlled environment)

Introduction – The importance of battery cell performance and durability in today's energy landscape



competitive edge through high-performing, safe, sustainable and reliable battery cells

The role of durability and performance testing across the value chain -From R&D to commercialisation

FUNDAMENTAL RESEARCH → **APPLIED RESEARCH AND PROOF OF CONCEPT** → PROTOTYPE DEVELOPMENT → PROCESS DEVELOPMENT → SCALE-UP AND MANUFACTURING → COMMERCIALIZATION

Discharge capacity

Coulombic and energy efficiency

DC resistance (charge/discharge)

Impedance (frequency range)

Self discharge

→ Specific energy

Energy density

Cycle life

Coin cells

Small pouch cells

The role of durability and performance testing across the value chain
From R&D to commercialisation

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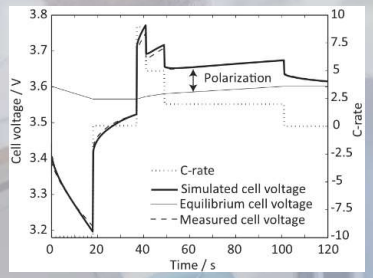
A samples

B samples

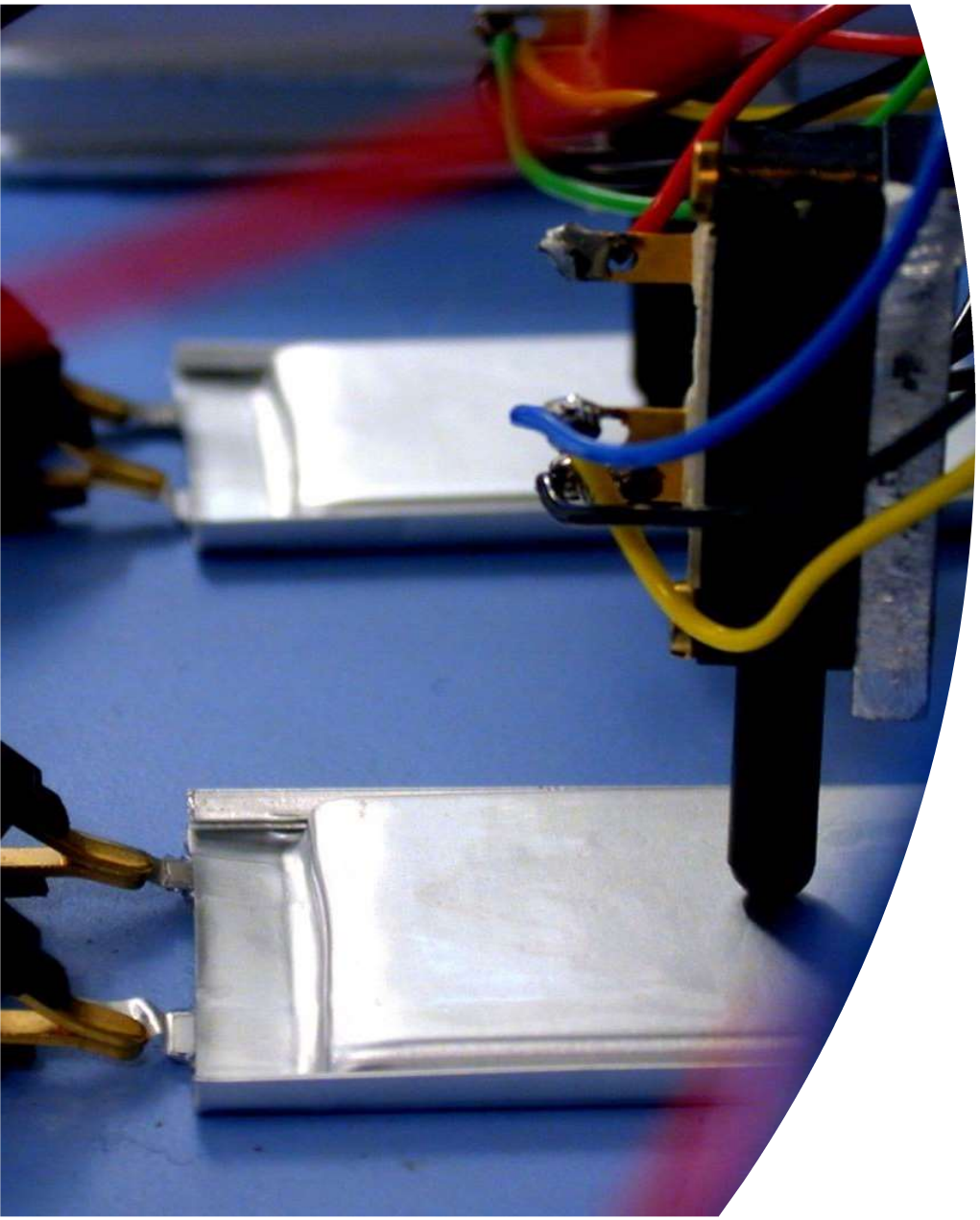
C samples

Validation and verification of mathematical models



Quality and performance of serially manufactured cells

Qualification of different suppliers



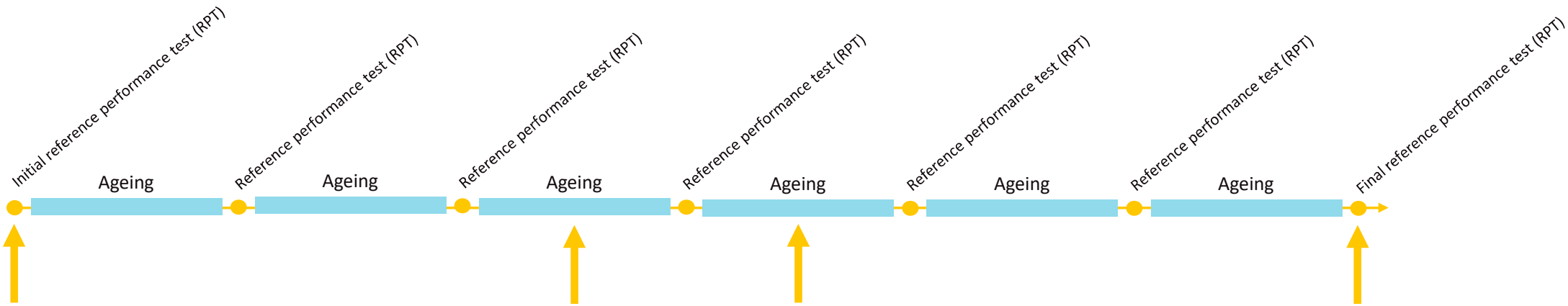
Standards and Testing Methodologies

Testing at controlled environment

- Electrical connection
- Heat transfer environment
- Possible physical constraint

Testing methods depends on the application and chemistry

Standards and testing methodologies – durability testing explained



In the reference performance tests, the performance parameters are measured:

- Capacity (in Ah)
- Power (in W)
- Internal resistance (in Ω)
- Energy round trip efficiency (in %)

The conditions at which the ageing is performed:

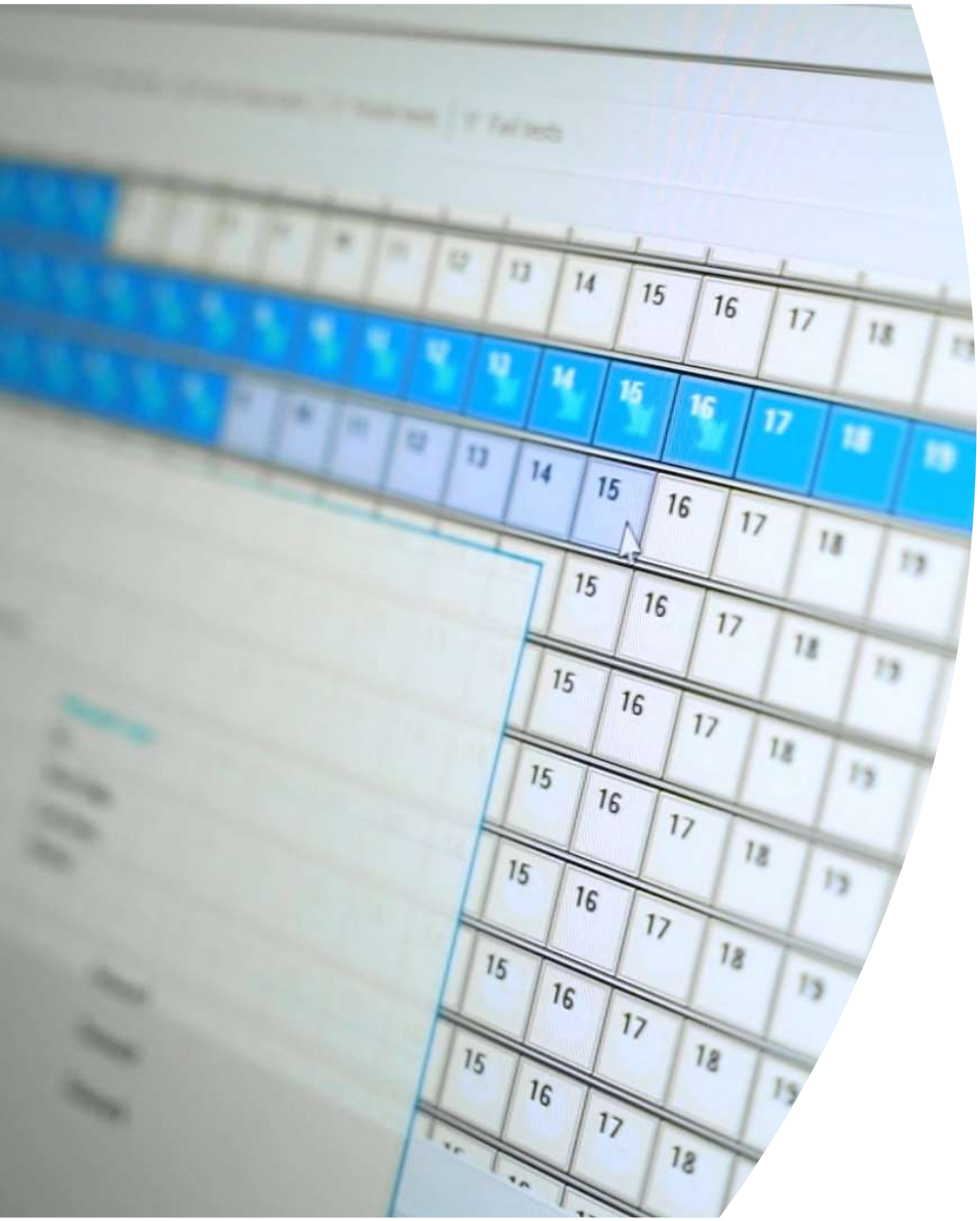
- Cycling ageing:
  - Operating temperature
  - State of charge window
  - Charging and discharging rates
- Float charge ageing:
  - Operating temperature
  - Charging voltage
- Storage ageing:
  - Storage temperature
  - State of charge

End of life is defined based on termination criteria involving one or several performance parameters e.g.

- The measured capacity has decreased to 80 % of the rated capacity.
- The internal resistance has increased to 200 % of the initial value.

The final reference performance test is performed when the termination criteria has been achieved.

Lifetime of the battery under the ageing conditions



Interpreting Test Results – Analyzing of data

Resolution of data <–> size of data files

- Δvalue
- Δtime

Automatization of data analysis

- Python
- Matlab

Regular data analysis during testing to detect any abnormalities early

Interpreting Test Results – Tear down of cells

- Opening cells and examining cell internals is perhaps the best tool available for identifying cell related root cause.
- All lithium metal and Li-ion cells need to be opened under dry inert gas atmospheres. This not only preserves lithium/electrode surface purity, but is highly recommended from a safety perspective.

When the cells have been dissected, it is possible to further study the components to identifying possible root causes to the ageing. Battery components can for example be studied by:

- Physical examination of electrodes with microscope
- Chemical analysis e.g. SEM-EDX

- If the cell needs to be intact, an X-ray (or CT-scan) of the cell can reveal signs of abnormalities within the cell enclosure without opening the battery.

The role of durability and performance testing across the value chain From R&D to commercialisation

FUNDAMENTAL RESEARCH → APPLIED RESEARCH AND PROOF OF CONCEPT → PROTOTYPE DEVELOPMENT → PROCESS DEVELOPMENT → SCALE-UP AND MANUFACTURING → COMMERCIALIZATION

REGULATIVE REQUIREMENTS

EU Battery Regulation 2023/1542

Ecodesign for sustainable product regulation

UN GTR No.22 (In-vehicle Battery Durability for Electrified Vehicles)

VOLUNTARY REQUIREMENTS

CB scheme

Intertek Tick mark

Ecolabelling

Standards and testing methodologies – lithium-ion cells

IEC 61960-3:2017

PORTABLE

Discharge performance at 20 °C

Discharge performance at -20 °C

High-rate discharge performance at 20 °C

Charge retention and recovery

Charge recovery after long term storage

Endurance in cycles

Internal resistance

IEC 62620:2014+AMD1:2023

INDUSTRIAL

Discharge performance at 25 °C

Discharge performance at low temperature

High-rate permissible current

Charge retention and recovery

Internal a.c. and d.c. resistance

Endurance in cycles

Endurance in storage at constant voltage

IEC 62660-1:2018

AUTOMOTIVE

Discharge performance at 0, 25 and 45 °C

Power at -20 °C (50 %SoC), 0 °C (50 %SoC), 25 °C (20 %, 50 % and 80 % SoC) and 40 °C (50 %SoC)

Storage test

Cycle life test

Energy efficiency test

Ongoing durability and performance standardisation work in CENELEC

Industrial

prEN IEC 62620
Secondary cells and batteries containing alkaline or other non-acid electrolytes - **Secondary lithium** cells and

prEN 62675:2025
Secondary cells and batteries containing alkaline or other non-acid electrolytes - **Sealed nickel-metal hydride** prismatic rechargeable cells and batteries for use in industrial applications. batteries for use in industrial applications

prEN IEC 63115-1
Secondary cells and batteries containing alkaline or other non-acid electrolytes - **Sealed nickel-metal hydride** cells and batteries for use in industrial applications - Part 1: Performance

prEN IEC 63636
Secondary cells and batteries containing alkaline or other non-acid electrolytes - **Secondary sodium ion** cells and batteries for use in industrial applications

EN IEC 60896-11:2003/prAA, EN IEC 60896-21:2004/prAA and EN IEC 60896-22:2004/prAA

A1X Common modifications on EN IEC 60896-21 **Stationary lead-acid batteries** - Part 11: Vented types; General requirements and methods of test, Part 21: Valve regulated types - Methods of test and Part 22: Valve regulated types - Requirements

Ongoing durability and performance standardisation work in CENELEC

Industrial cont.

prEN IEC 60622:2025
Secondary cells and batteries containing alkaline or other non-acid electrolytes - **Sealed nickel-cadmium prismatic** rechargeable cells and batteries for use in industrial applications.

prEN IEC 60623:2025
Secondary cells and batteries containing alkaline or other non-acid electrolytes - **Vented nickel-cadmium prismatic** rechargeable cells and batteries for use in industrial applications.

prEN IEC 62259:2025
Secondary cells and batteries containing alkaline or other non-acid electrolytes - **Nickel-cadmium prismatic** rechargeable cells with partial gas recombination and batteries for use in industrial applications.

LMT

prEN 50762

Secondary lithium-ion batteries for light means of transport — Part 1: Test specifications for performance and durability aspects (open for future chemistries)

EN 18060

Road vehicles — Rechargeable batteries with internal energy storage - Instantaneous performance of Li-Ion, Pb, NiMH and combined chemistries electric vehicles modules and batteries

Scope

The European Commission published the standardization request M/579 to the European standardization organisations as regards to performance and durability requirements for batteries.

This document provides specific performance test procedures for EV batteries

This document describes the performance and durability test procedures and calculation methods for alkali-ion (for example Li-ion, Na-ion), Pb, NiMH and combined chemistries EV battery systems, battery packs, battery modules and battery cells.

Expected Life Time

The battery manufacturer defines a reference cycle with following:

depth of discharge;

average charge level;

operating temperature;

charge and discharge profiles; and

rest period between charge and discharge cycles.

following shall be determined at the end of the last reference cycle:

capacity fade;

power fade;

internal resistance increase; and

energy round trip efficiency fade.

For calendar ageing, the expected lifetime shall be specified in calendar years, where another reference cycle can be used.

Summary and Outlook

- Battery durability and performance is a key differentiator in competitive markets.
- Robust, reproducible, and application-relevant testing methodologies are needed. Particular attention must be paid to:
  - Electrical interfaces
  - Thermal management
  - Mechanical constraints
- Durability testing is essential for supplier qualification, helping to mitigate supply chain risks and ensure consistency across production batches.
- With the rise of sustainability-driven regulations, durability and performance testing is a strategic and necessary enabler for market access and regulatory compliance

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Thank you

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