uncountable®

The Battery R&D Data Guide

A guide for battery R&D directors, cell and materials scientists, and quality and engineering leads at battery and battery-materials manufacturers.

Table of Contents

Introduction

Battery development moves fast and fails expensively. A new cathode chemistry, a binder change, an electrolyte additive, a change in coating thickness: each one ripples through capacity, cycle life, rate capability, and safety in ways that only the data can untangle. The teams that win are not the ones running the most cells. They are the ones that can find, compare, and learn from the cells they have already run.

That is harder than it sounds, because battery R&D data is generated in pieces. Formulation lives in one place, process parameters in another, electrochemical results in the cycler software, characterization in instrument exports. By the time a promising result needs to be reproduced at a larger format, the context that explains it is scattered across tools and people.

This guide is about closing that gap. It covers what battery R&D data is, why it fragments, how the EU battery passport raises the stakes, and what a connected approach to battery materials data management makes possible.

What Data Does Battery R&D Generate?

Battery R&D generates a wide range of linked data. On the materials side: cathode, anode, and electrolyte formulations, with the active materials, binders, conductive additives, and solvents that make them up, each at specific loadings. On the process side: slurry solids content and mixing shear, coating gap and line speed, drying profile, calendering pressure and the resulting porosity, cell assembly, and formation protocol, all of which shape the final cell as much as the chemistry does.

Then there is the evidence. Electrochemical testing produces capacity, Coulombic efficiency, rate capability, impedance spectra, and cycle and calendar life curves that stretch across weeks for early screening and years for full calendar-life qualification. Characterization adds XRD, SEM, particle size distribution, BET surface area, and ICP elemental analysis. Each data type is valuable on its own, but the value compounds only when every result stays linked to the exact material and process that produced it.

Why Battery R&D Data Fragments

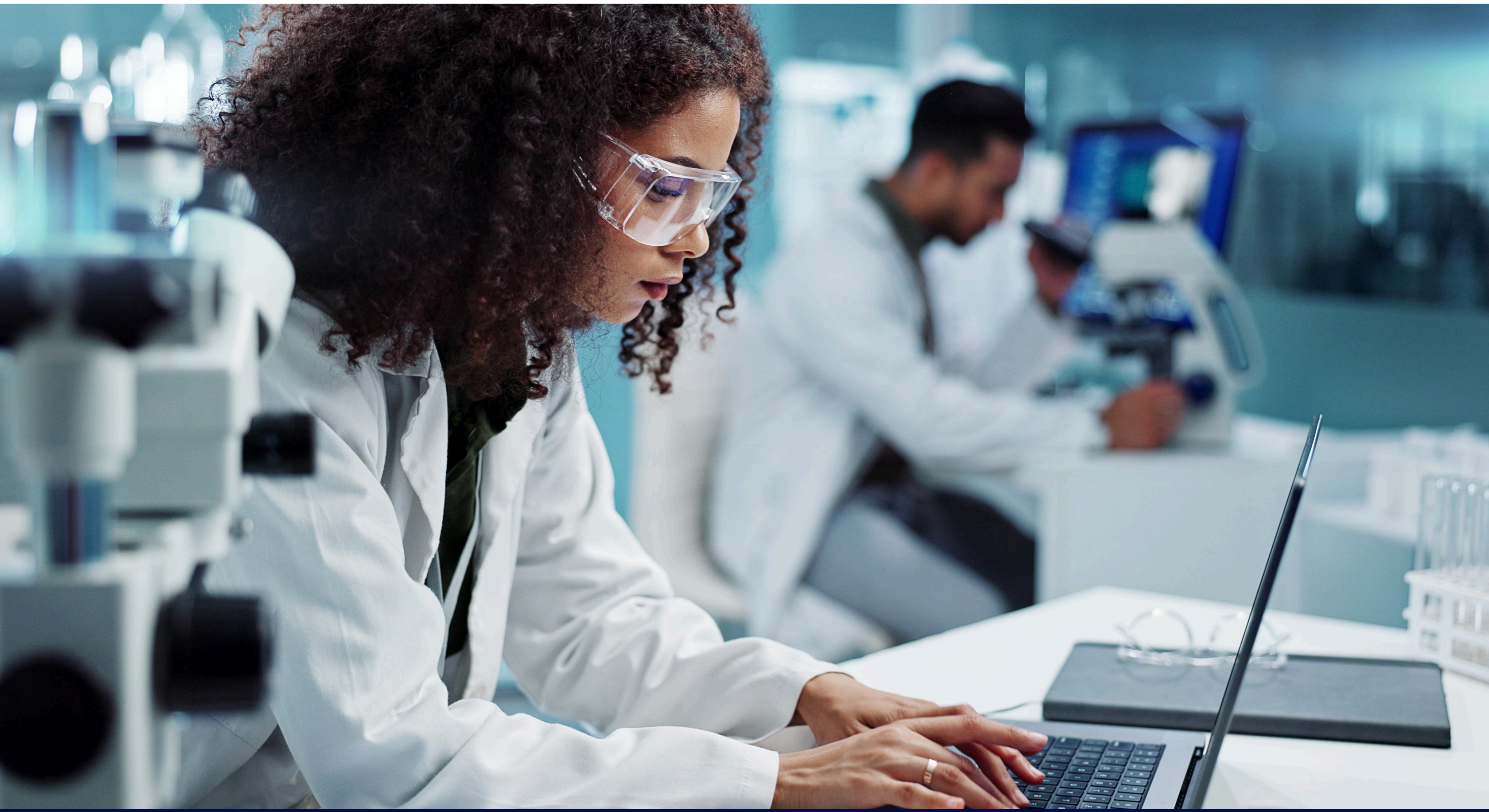
Battery data fragments because development happens in stages, and each stage tends to get its own tools. The coin cell screening work sits in one system. The pouch cell builds sit in another. The pilot line generates its own records, and production sits downstream again. Formulation is often tracked in spreadsheets, process parameters in batch sheets, and cell results in the cycler software that never talks to either.

The result is that the most important relationships in battery R&D, which material plus which process produced which performance, exist only in people's heads and in file names. When a scientist asks which high-nickel formulations held capacity best at a given C-rate, and at what slurry mixing conditions each of those materials dispersed well, the answer requires assembling data by hand from several systems.

One Cell, Many Histories: The Full-Cell Traceability Problem

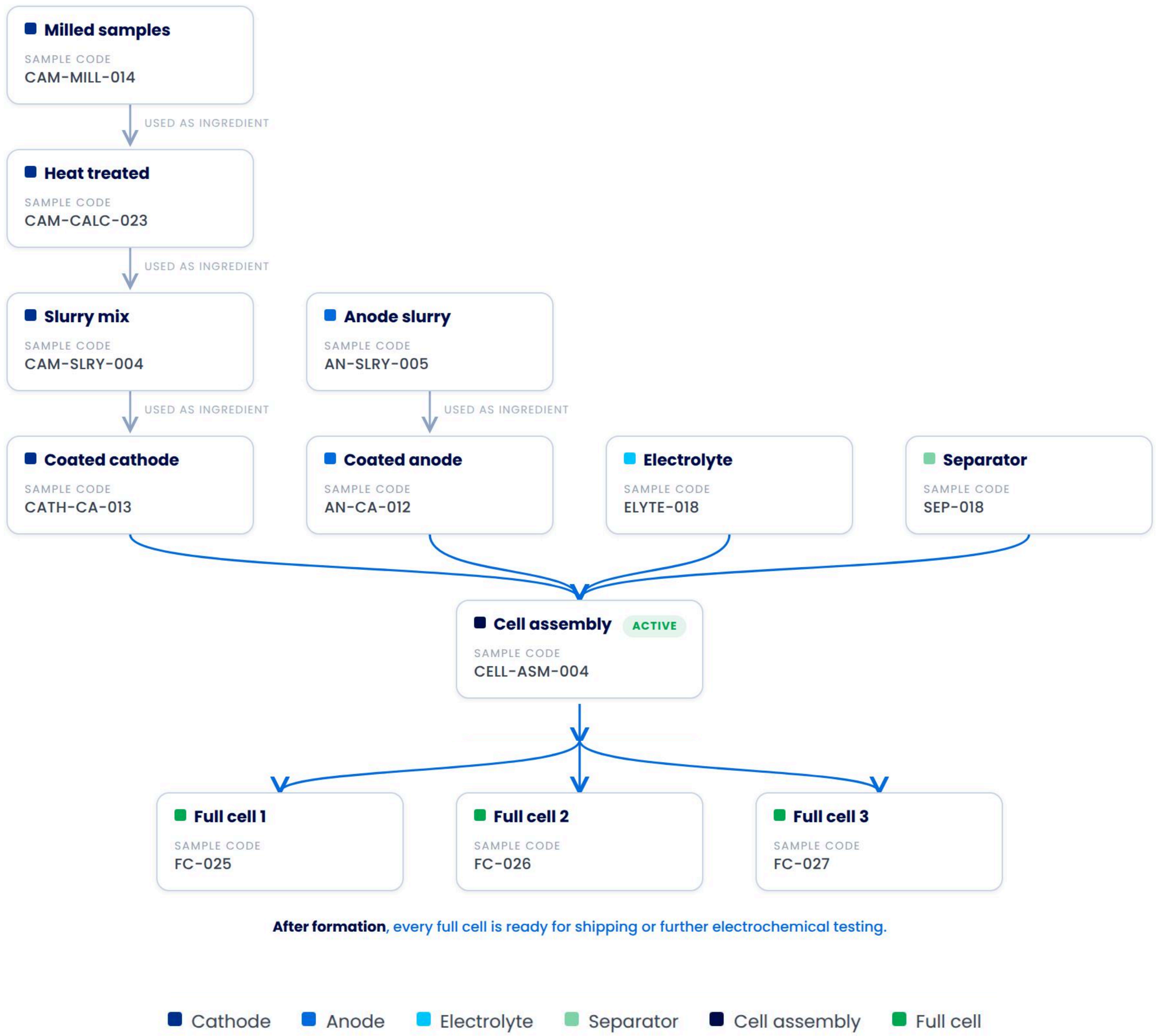
A finished cell is the convergence of several independent histories, each with its own materials and its own process trail. The cathode has a formulation and a process history of its own, from milling through coating, drying, and calendering. The anode has a separate formulation and its own process history. The electrolyte has a formulation and an additive package. The separator has its own specifications. Cell assembly and formation add another set of parameters. All of these come together into a single pouch, prismatic, or cylindrical cell.

When that finished cell underperforms, with low capacity, poor cycle life, or a safety event, the root cause can sit in any one of those branches, or in the way they interacted. That is a far harder search than debugging a single formulation, and it is close to impossible when each branch lives in a different tool. With one connected data model, every branch's materials and process history stays linked to the finished cell, so a scientist can trace a result back across all of them at once and narrow where it actually went wrong. This convergent traceability is what battery teams keep asking for, and it is the same structure the battery passport will later ask for.



One Finished Cell, Four Material Histories

Every arrow reads “used as ingredient”, so a result traces back across all four branches at once.



One finished cell, traced back through four independent material histories. *The cathode runs from milled and dried powder through calcination, slurry mixing, and coating (CAM-MILL-014 to CATH-CA-013); the anode from slurry mix to coated electrode (AN-SLRY-005, AN-CA-012); the electrolyte and additive package (ELYTE-018) and the separator (SEP-018) each carry their own record. All four converge at Cell Assembly (CELL-ASM-004). Formation (CELL-FRM-011) is then applied to every assembled cell, after which each full cell (FC-025 to FC-027) is ready for shipping or further electrochemical testing. When a cell underperforms, the root cause can be traced back across all four branches at once.*

From Coin Cell to Gigafactory: Where Data Breaks at Scale-Up

The hardest transition in battery development is scale-up, and it is where disconnected data costs the most. A chemistry that performs in a coin cell can disappoint in a pouch cell or on a pilot line, because the process changed and the process context was never captured alongside the formulation. Coating, drying, and calendering behave differently at scale, and without a record that links those parameters to cell performance, the team is debugging blind.

When formulation, process, and test data share one record, a change at any stage stays connected to its outcome. A scientist can compare the same chemistry across coin cell, pouch, and pilot builds, see which process variables moved, and separate the effect of each. That is the difference between a scale-up that is engineered and one that is guessed.

NMC811 cathode, one bill of materials across three build formats

	Coin cell	Single-layer pouch	Pilot line	
Bill of materials			identical across all · slurry basis	
Active material, NMC811 (%)	58.5	58.5	58.5	
Binder, PVDF (%)	1.95	1.95	1.95	
Conductive carbon (%)	1.95	1.95	1.95	
Solvent, NMP (%)	37.6	37.6	37.6	
Electrode processing			two variables move	
Wet coating thickness (μm)	150	175	195	▲
Calendered density (g/cm³)	3.30	3.40	3.50	▲
Drying temperature (°C)	120	120	120	
Performance				
Areal capacity (mAh/cm²)	2.8	3.5	4.2	▲
Specific capacity at C/10 (mAh/g)	200	198	195	
First-cycle Coulombic efficiency (%)	88	87.5	87	
Rate capability, 2C/0.1C (%)	87	82	76	▼
Cycle-life retention at 500 cycles (%)	92	91	89	

Same bill of materials across three build formats. Cell architecture also changes across the columns, from single-sided small-area electrodes in the coin cell to double-sided larger-area electrodes on the pilot line, so these are not like-for-like performance comparisons.

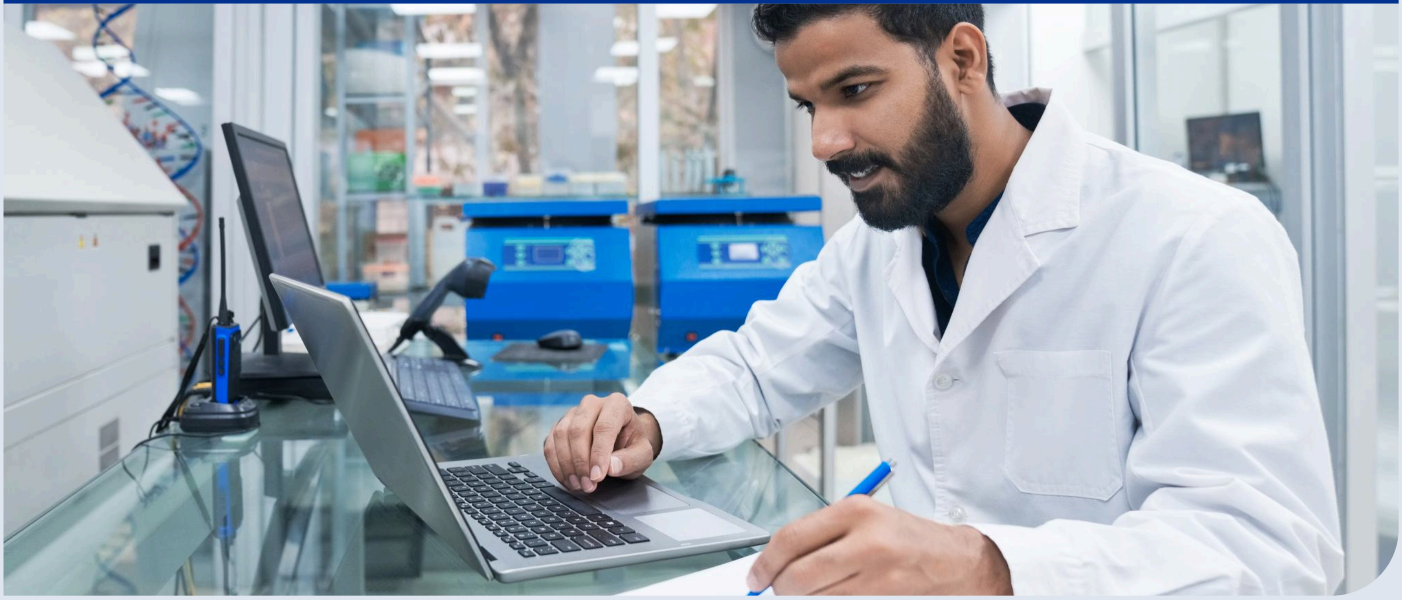
The same NMC811 chemistry across coin cell, pouch, and pilot. *The bill of materials is identical in all three columns, but almost everything else moves at once: the electrode goes from single-sided to double-sided, area and layer count grow, coating thickness rises from 150 to 195 μm, and calendered density from 3.30 to 3.50 g/cm³. Areal capacity climbs 50% (2.8 to 4.2 mAh/cm²), rate capability falls hardest (87 to 76%), and cycle-life retention slips only slightly (92 to 89%). Isolating which of those changes drove which effect is the real work of scale-up, and it is only possible when architecture, process, and performance are captured against the same cell.*

Market Access Now Depends on What You Can Prove

From 18 February 2027, the EU battery passport becomes mandatory under Article 77 of the EU Battery Regulation. Every electric vehicle battery, light means of transport (LMT) battery, and industrial battery above 2 kWh placed on the EU market will need an electronic record, accessible by QR code, covering chemistry, carbon footprint, recycled content, state of health, and supply chain due diligence. It is the first Digital Product Passport to take effect and the template for the broader Ecodesign for Sustainable Products Regulation that will follow across other product categories.

INSIGHT

The same pattern is appearing outside the EU with different vocabulary. In the United States, sourcing has become a calculation: the material assistance cost ratio, or the share of a product's direct material cost that does not originate with a prohibited foreign entity. **For battery components, the ratio must be at least 60% in 2026, rising to 65% in 2027, 70% in 2028, 80% in 2029 and 85% from 2030 onward.** Customers are asking for the same provenance data contractually, whether or not a regulator is.



Both are the same underlying request: prove where each material came from, what it contained, and what it took to make. A manufacturer holding supplier lots, composition, recycled content, process data, and bill-of-materials cost on one connected record can produce a passport record, a sourcing ratio, and a cost per cell from data it already has. The supplier lot that satisfies a regulator carries its price as well, so compliance reporting and cost analysis stop being separate exercises. One holding it across disconnected tools will assemble each report by hand, every time a new jurisdiction or a new customer asks.

FC-025 **Passport and sourcing record**
Full cell (pouch) · NMC811 / graphite

Cell chemistry	**NMC811 / graphite**
Cell format	**Full cell (pouch)**
Formation protocol	**C/10 CC-CV, 2.8-4.3 V, x3**
Carbon footprint boundary	**Cradle-to-gate, cell level**

RECYCLED CONTENT

12%	20%	6%
Nickel	Cobalt	Lithium

Carbon footprint · cradle-to-gate, cell level **65 kg CO_2e/kWh**

SOURCING

72% of direct material cost from non-prohibited suppliers

0% — **2026 threshold 60%** — 100%

4 of 4 certified Supplier origin and certification status recorded per lot

MATERIAL LOTS

- CAM supplier lot — **CAM-811-2610-A009**
- Ni precursor lot — **PCAM-N80-2608-A047**
- Lithium source lot — **LIOH-BG-2606-C112**
- Graphite anode lot — **GR-AN-2607-D058**

Illustrative values. Passport fields per Regulation (EU) 2023/1542; sourcing share shown against the 2026 battery-component threshold.

The same NMC811 and graphite cell, with the EU battery passport data points held as structured fields on the R&D record: *cell chemistry, recycled content (Ni, Co, Li), a cradle-to-gate carbon footprint, and supplier lots for each material, cited to Regulation (EU) 2023/1542. The passport data falls out of connected R&D rather than a separate reporting project.*

What Connected Battery R&D Data Makes Possible

When battery materials data is structured and connected, the everyday work changes. Teams can search by what is in a cell, by active material, additive, loading, or coating thickness, rather than by file name, and surface every past build that matches. Failed experiments stay findable, so a chemistry that broke down at a given temperature is a result the team can reuse rather than a lesson it has to relearn.

INSIGHT

Designed experiments narrow the search space, mapping the interactions between formulation and process in fewer cells than changing one variable at a time. Full instrument data stays co-located with the formulation, so impedance spectra and aging curves can be interrogated later, not flattened to a single number. And because the data is structured, machine learning has something real to work on. The order matters: structure first, intelligence second. A model can only learn from battery history that is consistent, connected, and complete.

What to Look for in a Battery R&D Data Platform

A platform worth evaluating should capture formulation, process, and test data in one connected record, not in separate tools that need manual reconciliation. It should:

1. Preserve full instrument and cycler data, not just summary numbers, with visualization and analysis built in, so teams can plot and compare cycling behavior where the data sits and search by composition and process across the entire history.
2. Connect R&D to quality and downstream manufacturing, so a result can be traced back across the cathode, anode, electrolyte, and cell-assembly histories that produced it.
3. Make traceability and reporting, including the data the battery passport requires, a byproduct of normal work rather than a separate project.

Ask any vendor to demonstrate these on realistic battery data, from coin cell screening through scale-up.

CASE STUDY

Mitra Chem, which develops iron-based cathode active materials, runs its battery materials R&D on Uncountable, capturing formulation and test data in a structured, queryable system from the start. That structure is what lets research data also serve downstream traceability and reporting, instead of requiring a parallel effort later.

"I shudder to think what our operations would look like without Uncountable. Its flexibility, comprehensive data tracking, and seamless integration have made it indispensable."

– Marie Herring | Engineering Manager | Mitra Chem

How Uncountable Approaches Battery R&D Data

Uncountable connects battery R&D, quality, and product lifecycle data in one platform. Formulation, process parameters, electrochemical results, and characterization data live in one structured, queryable record, so every cell result stays linked to the exact material and process that produced it, from coin cell through scale-up.

That foundation does double duty. It speeds development, through search by composition, designed experiments, and machine learning that runs on the team's own history, and it makes traceability a byproduct of the work, so the chemistry, recycled content, and provenance behind a product are already structured when a battery passport or a customer audit asks for them. Structure first, intelligence second, and market access by default rather than by scramble.

See the Platform Behind the Guide

Uncountable connects R&D, quality, and product lifecycle data in one platform. Book a personalized demo and we'll show you how it applies to your lab.

Request a demo