



AVOIDING RECALLS

EFFECTIVE AUDIT STRATEGIES FOR LI-ION CELL & PACK MANUFACTURERS

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AGENDA

- Domains of Review
- Introduction to Quality Control
- Cell Manufacturing Overview
- Battery Pack Manufacturing Overview
- Conclusion

DOMAINS OF REVIEW

INTRODUCTION TO DOMAINS OF REVIEW

Compliance with regulations

Quality Control & Assurance

Supply Chain Management

Technical Capabilities

Financial Health

Corporate Social Responsibility & Sustainability

Business Continuity Planning

Information Security

Innovation & improvement

INTRODUCTION

QUALITY CONTROL AND ASSURANCE

UNDERSTANDING THE NEED FOR EFFECTIVE AUDIT STRATEGIES

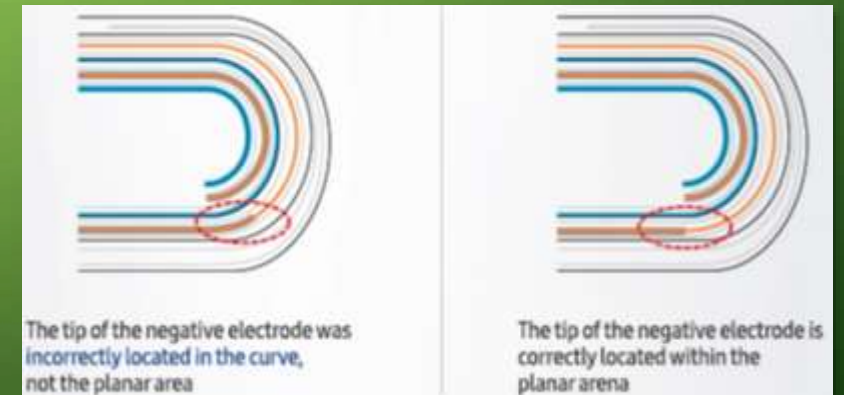
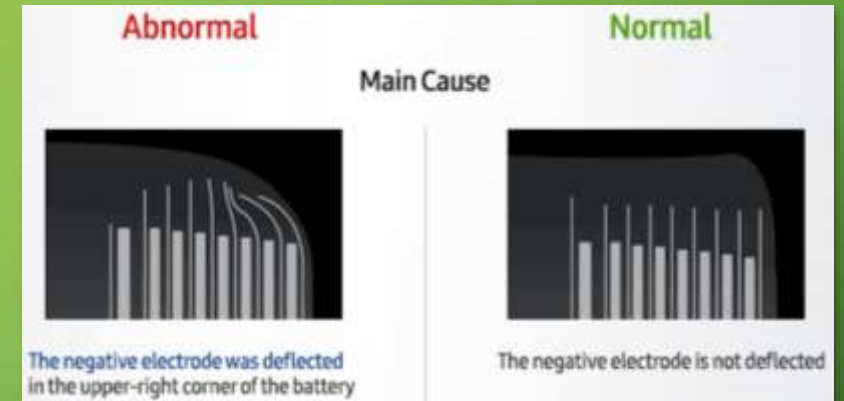
- Despite their general safety, lithium-ion batteries have featured in significant product recalls, with substantial financial and reputational costs.
- For instance, the Samsung Galaxy Note 7 recall, primarily due to battery issues, cost an estimated \$17 billion, highlighting the potential risks associated with these products.



CHALLENGES IN QUALITY ASSURANCE

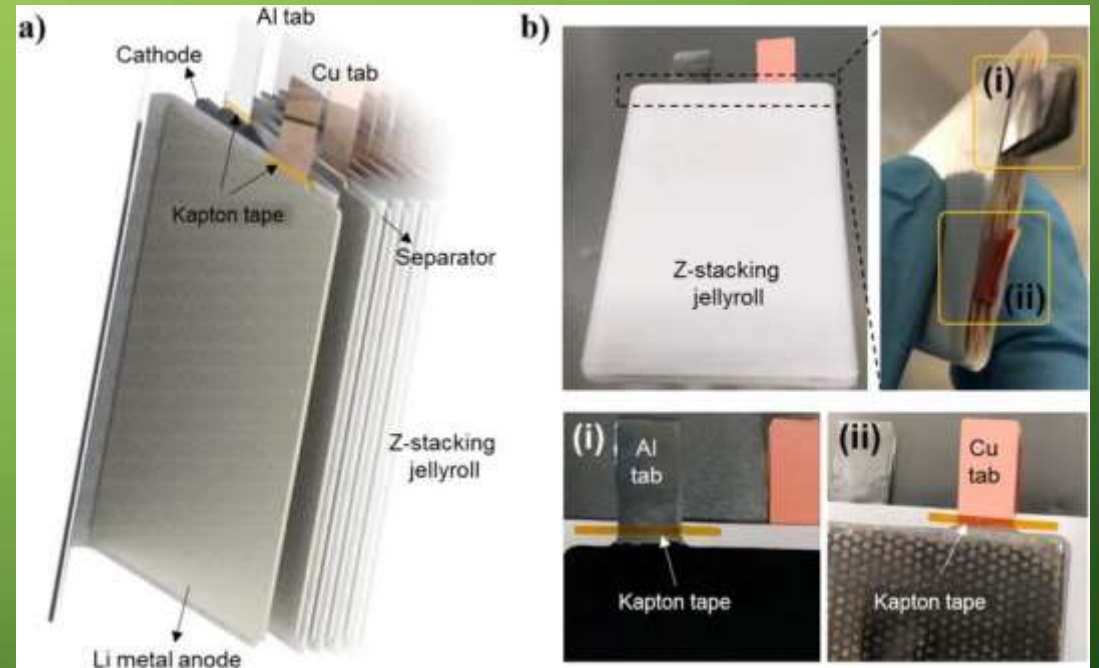
In the case of the Samsung Note 7 there were two totally different reasons

- The original Note 7 batteries suffered a design that deformed the negative electrode within the battery so that it wound up touching the positive electrode within the battery pouch.
 - According to Samsung US marketing VP Justin Denison, the battery manufacturer (Samsung SDI) "designed the pouch such that it did not have sufficient space around the upper righthand corner to allow for the normal expansion and contraction of the battery that occurs when you go through normal charge and discharge cycles.



CHALLENGES IN QUALITY ASSURANCE

- The problem with batteries in the replacement phones came down to issues with welding, as well as a crucial piece of tape left out of some batteries.
 - Essentially, the manufacturer (Amperex technology) didn't do a good enough job welding the positive tab and left a tiny nodule of material sticking out, large enough to perforate the insulating tape material separating the positive and negative poles and cause the battery to short circuit.
 - But Samsung and its partners found another problem, too. Not every phone had insulation tape separating the two elements. Some phones were missing the tape completely.



CHALLENGES IN QUALITY ASSURANCE

- The Samsung Galaxy Note 7 was therefore struck by
 - A cell design error
 - A manufacturing process engineering error
 - A quality assurance error
- It is important to realize that it is unlikely that any of these faults would come up in a small batch of cells in a cyclor. It is obvious the quality assurance of lithium-ion cells requires more attention.

BEST PRACTICES



Product Performance Compliance

- Climate chamber & cyclers
- Lab work



Manufacturing Quality Assurance

- Plant audit

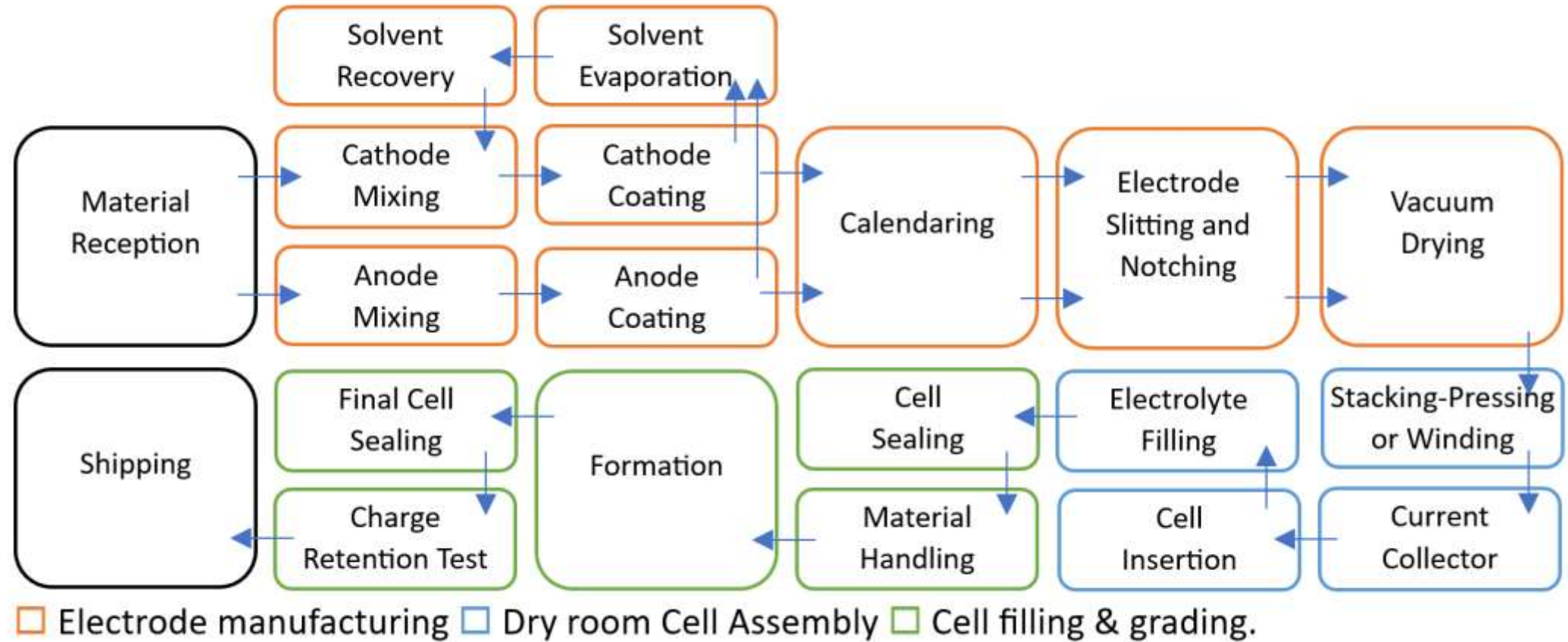


Third-party Cell design Analysis

- Design review
- Validation review
- Lab review

CELL MANUFACTURING OVERVIEW

INTRODUCTION TO THE MANUFACTURING PROCESS



FOCUS OF THE PRODUCTION PROCESS AUDIT

- Li-ion cell manufacturing is a complex process with several critical stages, each having potential failure points.
- An audit focuses on
 - CTQs (Key points from the job instruction, performance and checking)
 - CTPs (equipment features & settings, maintenance, calibration, ...)
 - Typical values & tolerances
 - Measurement methods
 - Shelf-life for process input materials
 - Common mistakes

DUAL APPROACH TO AUDITING

PRODUCTION PROCESS

- For each CTQ/CTP, consider
 - The probability of an issue arising if that aspect is inadequately managed
 - Effect of the process step in terms of product performance & safety
 - Effect of the process step in terms of product failure, resulting in scrap or warranty claims

PRODUCTION ENVIRONMENT

- Even minor variations in environmental conditions can have impact on cell quality
 - Cleanliness
 - Humidity & temperature control
 - Impurities & Cross-contamination
 - Staff training
 - Etc...

COMMON MISTAKES

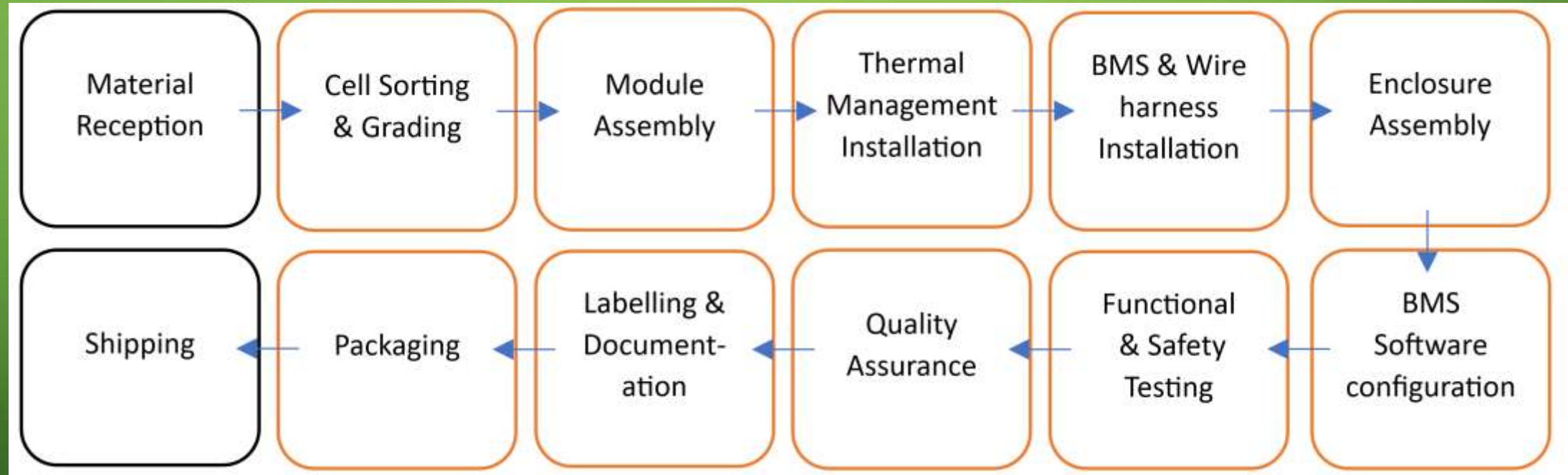
- Inadequate validation of control systems & sensor calibration
- Poor documentation or standard operating procedures
- Skipping regular maintenance
- Contamination of materials and cross-contamination
- Freshness and shelf life (FIFO)
- Inadequate training, ignoring early signs
- Incorrect equipment or process settings

ADJUSTMENT OF AUDIT PROCESS

- While the basic process is similar, manufacturers may have unique recipes and techniques, affecting the critical-to-quality (CTQ) aspects.
 - Examples
 - Different cell form factors (cylindrical, prismatic or pouch)
 - Solvent-based vs water-based slurry
 - Batch vs continuous slurry production
 - Electrode die cutting vs laser cutting (notching)

BATTERY PACK MANUFACTURING OVERVIEW

INTRODUCTION TO THE MANUFACTURING PROCESS



COMMON MISTAKES

- Freshness of inventory
- Lack of understanding of cell sorting protocols
- Incorrect handling of electronics (ESD)
- Insufficient EOL testing (e.g. balancing)
- Poor TIM sheet placement
- Enclosure or thermal management system leak checking
- Wire harness routing and fixing
- Inaccurate torquing

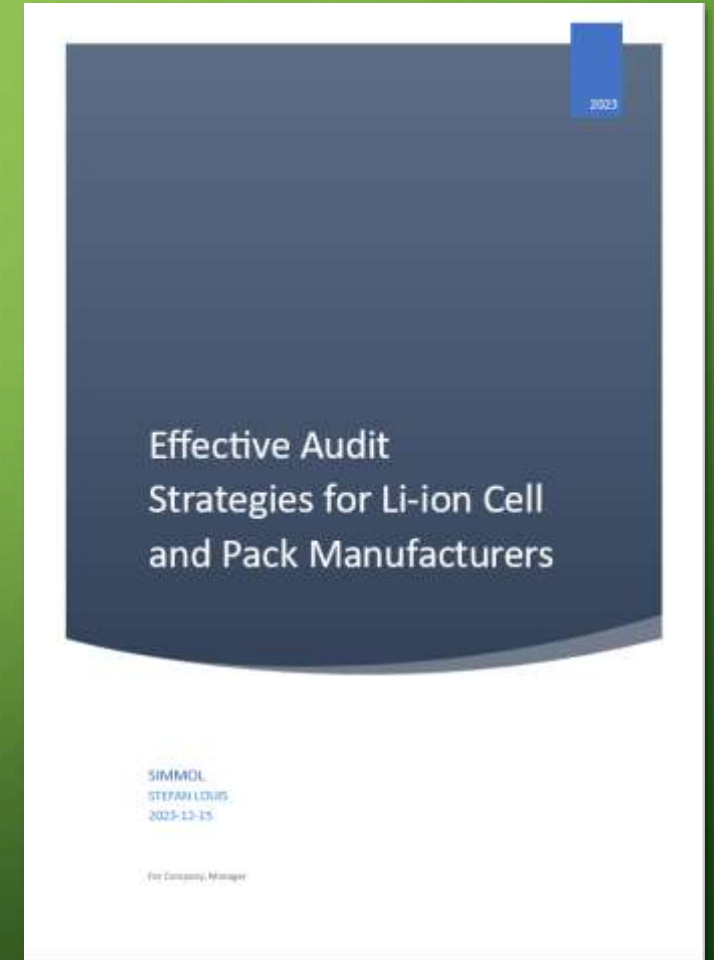
CONCLUSION

CONCLUSION

- We've explored the criticality of comprehensive auditing in li-ion cell and pack manufacturing, covering essential domains and the intricate manufacturing process.
- Testing cells in a lab is good, but not sufficient. Auditing the manufacturing line is better, analysing the cell design is best
- All three activities require years of experience and expertise
- This policy aims to not only prevent costly recalls but also to foster sustainability, safety, and reliability in the industry
- We urge all stakeholders in the li-ion battery supply chain to adopt and adapt these strategies for a more robust and sustainable future

EFFECTIVE AUDIT STRATEGIES - WHITE PAPER

- Pre-read available on www.simmol.com



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SIMMOL - TECHNICAL SERVICES



Product design

Requirements review

Cell & chemistry design

Module & Pack/Rack design

Design progress review

- Electrochemical, mechanical, thermal, electrical, electronic, software
- DFMEA

Validation review

- Simulation review, validation plan, risk analysis



Lab & Production setup

Lab & Pilot setup

Supply Chain Development

Process review

- PFMEA

Equipment

- Definition & selection
- Contracting



R&D Road map

Architecture modelling

Cell chemistry & form factor

Cell to Pack design

SIMMOL - BUSINESS SERVICES



Strategy

M&A and technology licensing

- Definition, identification, transfer & integration
- In English & Mandarin

Business modelling / Value proposition

- Workshops

Innovative business strategy

- Definition, testing



Team management

Recruitment interviews

Waterfall & agile project management