Quality Assurance – the Key for Risk Minimization in Li-Ion Battery Packs

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Due to the many past and recent events using Li-Ion batteries, quality assurance is gaining in importance for error and risk prevention. Hereby, the holistic quality approach across the product lifecycle is ever more important for achieving high quality, flawless and environmentally-friendly products.

Quality Assurance

Quality and your safety are the main requirements of Li-Ion battery packs. For the development and manufacture of Li-Ion battery packs, a lot needs to be considered from a quality assurance perspective in order to ensure these basic requirements.

Battery pack definition

Quality assurance should already be a part of the creation and definition of the requirements proposal (document) for the Li-Ion battery pack to be developed. Hereby, the markets, customer needs and application requirements must be considered. All applicable standards and regulations must also be included in the proposal. In addition, a view to the future, recognizing which standards and regulations might change or be added during the development, is also necessary.

Supplier/ manufacturer's qualifications

The qualification of suppliers and manufacturers runs parallel to the development process. The selection and qualification is driven by the standard requirements and the previously defined requirements document. Here, it must be observed that fundamental quality management standards, as described in ISO9001, ISO13485, TS16949 and ISO14001, must be adhered to by the suppliers and manufacturers.

The correct choice of suppliers is crucial. Good supplier management includes supplier selection, supplier qualification, supplier development and assessment. This starts with an appropriate supplier selection process. Once a supplier has been chosen, it is necessary to assess, develop and improve this supplier over time according to the requirements.

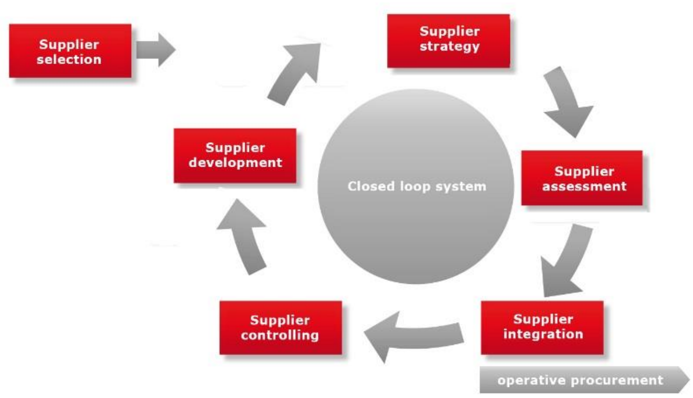
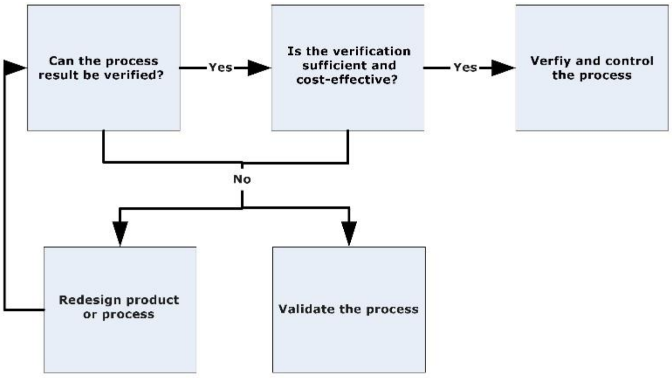


Illustration of the supplier management cycle

For components and assemblies that do not conform to a standard, the manufacturing processes must be viewed in more detail and, where required, these processes must be validated and/or the results verified. Outsourced processes are also included in this assessment.

The following figure shows, by way of example, when processes need to be validated.



The statistical process control (SPC), the recording of process key figures and the actions for correction and improvement derived from this work, should be used as an aid for the process control in the manufacturing process.

Product development
The product development is based on the requirements catalog and runs parallel to the supplier development.

Based on the requirements catalog, the battery is developed by the Development department and tested and verified by an internal and / or external independent body. Hereby, the qualification approach according to the V-model has proved itself.

The battery is subjected to different tests and testing standards, e.g. electrical safety, temperature test, shock and vibration tests in various environmental conditions (humidity, temperature, pressure). Charging and discharging cycles are performed with various flows.

Thereafter, the battery is checked in the overall application system, making sure it meets all the requirements.

Temperature and the value of charging/discharging currents has shown to be a special stress factor for the lifecycle and charge cycles of the batteries.

Each battery carries its own risk, which must be assessed. On the one side, there is a risk on the battery-cell level and on the other side, there is the risk that the Li-ion battery poses in the application. A common method of risk assessment, risk analysis and risk / error reduction is the (P) FMECA.

Derived from the requirements catalog and the FMECA, the materials used for the batteries are qualified by their development. The supplier or an independent body (test laboratory) must provide proof that the materials meet the requirements.

Furthermore, the material flow is also subject to quality assurance. Various tools have proved suitable for this. It starts with the qualification of the material by means of initial sample inspection reports within the framework of the battery development.

Manufacturing

In the battery manufacturing process, the incoming material is subjected to an incoming materials test, or an outgoing materials inspection when the manufacturer ships the goods. Hereby, for the incoming materials test, random samples are taken according to the defined AQL (Acceptance Quality Level), and tested according to pre-determined test specifications.

In battery manufacture, a relevant quality control is performed after each production step. Here, there is a differentiation between 100% testing (QC) and random sample testing "in-process-quality-control steps" (IPQC). For IPQC steps, random sample quantities are tested at regular predetermined intervals, defined by quantity or time, in order to monitor the production process.
All assembled battery packs undergo a 100% materials outgoing control (OQC). This multi-step testing concept and the different quality gates which a Li-ion battery pack must pass, ensures the manufacturing and product quality.

Traceability

Each individual battery cell has its own serial number, which, in combination with the serial number of the assembled printed circuit board in the memory chip of the pack, can also be linked to an ID number on the outside of the pack. This linking of the different numbers creates a "Unique Device Identifier" (UDI). Additionally, the date code must be printed on the battery pack label. This marking allows for the identification of the assembly groups used.

This battery pack information, including manufacturing information, is stored, together with the results of the outgoing testing, in a separate external secured database. The traceability of the individual cells, the assembled printed circuit board (PCBA) and the relevant battery pack production data, is therefore ensured.

Example of a barcode label

Logistics

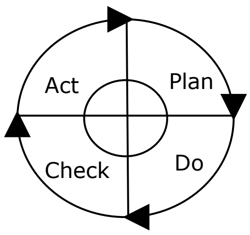
Before lithium-metal or lithium-ion cells and battery packs can be transported, they must be tested according to the UN38.3 testing method for transport. When this test is passed, the battery packs are marked accordingly with the UN symbol. For the transport of Li-ion batteries, the correct packaging, package size and quantity must be observed.

Only Li-ion packs marked with the UN symbol may be transported. Without this marking, a transport permit is required.

UN symbol

Quality assurance in the market
After the goods have been put on the market, the quality assurance measures continue. A "Complaint Management" according to the requirements of ISO13485 guides this process.

All complaints from the market are analyzed. For this, the error frequency of the individual error indication is analyzed. For each error indication, the error causes are determined via an 8D error report and correctional or preventative and improvement measures are initiated. The most commonly used quality tools for the error cause analysis are "Ichikawa" and "5W". The actions for improvement follow the PDCA cycle according to Deming. In addition, the error risk and its effect on persons and property must be assessed for each error.



PDCA cycle according to Deming

Furthermore, market observations help all manufacturers in recognizing and preventing errors, before own products and / or own battery packs display these errors.

Environment
With an increased environmental awareness and the impact of batteries on the environment, a functioning environmental management system is becoming ever more important. For this, manufacturers of Li-ion battery packs and their production processes are checked to determine whether they comply with the current QM standards (ISO14001) and regulations (e.g. RoHS, REACH).

Also, the issues of ecological balance and the "carbon foot print" must be taken into account in the manufacture of Li-ion batteries.

The entity that puts batteries on the market in the EU, is obliged to take back these batteries and informs the consumer where and how they can dispose of batteries for recycling. Li-ion batteries must be marked with the WEEE label ("crossed out garbage bin") as well as with the Li-ion recycling symbol.

Furthermore, each country has its own recycling and statutory environmental requirements, which must be met. For Europe, these are: the RoHS directive, the REACH regulation and the Battery regulation. For China, the China RoHS directive applies.

Example: Battery markings with different country approvals and recycling symbols

Social responsibility
The USA is considered the pioneer in social responsibility. In 2010, the USA set new requirements for the minerals used in products, based on the "Due Diligence Guidance" of the OECD within the meaning of social responsibility. The regulation was codified in the "U.S. Dodd-Frank Wall Street Reform and Consumer Protection Act - Conflict Minerals".

All companies that commit to this regulation, declare that the minerals tantalum, tin, tungsten and gold, which are used in their products (components), do not originate from the countries Democratic Republic of the Congo, Angola, Burundi, Central African Republic, Republic of the Congo, Rwanda, South Sudan, Tanzania, Uganda or Zambia.

Many American and globally active companies have committed to the "Dodd-Frank Act", as well.

Summary
Development, design, testing, producing and delivering a high quality Li-Ion battery pack requires a commitment to and an embracement of quality assurance. By following the guidelines above, companies can move down a path towards developing exceptional products.

Sources:
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- OECD (2013), OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas: Second Edition, OECD Publishing. ISBN 978-92-64-18501-2 (print), ISBN 978-92-64-18505-0 (PDF)