Let's Talk! Podcast Series

An initiative of Electrochemical Safety Research Institute (ESRI), Underwriters Laboratories

Topic: High-Quality and Safety in Lithium-ion Cell and Battery Manufacturing
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Introduction:

Lithium-ion cells and batteries have become the battery chemistry of choice for a multitude of applications from consumer devices to large EV and stationary grid energy storage (ESS) applications as well as in marine and space applications.

With the number of fires observed in EVs and ESS in the field, several reasons have been provided for the cause of fires. One of the important factors that is overlooked is the quality of the cell and battery manufacturing process and the importance of the correlation between quality and safety. You have been in the area of both cell and battery manufacturing for applications in several sectors from underwater environments to space environments and everything in between. This discussion between us will help the audience to learn more about how quality and safety in the manufacturing process go a long way in keeping the cells and batteries safe in field use, be it consumer applications, EV, ESS, marine or space.

Question & Answer:

1. Inoue-san, you have been involved in cell and battery manufacturing for a long time. What was the background that brought you into this industry?

I got a master's degree from the Kyoto Institute of Technology Graduate School in Japan in 1993, and then thought about getting a job at a company. At that time, there were various environmental problems in the world, and it was thought that the overweight of fossil fuels was one of the causes. I thought that batteries would be the next-generation key device to solve such problems, so I chose the current GS Yuasa Battery, which was a major battery manufacturer in Japan, and got a job. At that time, lithium-ion was developed, and mass production of small lithium-ion batteries for portable devices was about to begin.

I applied the materials and the electrodes design technology to large lithium-ion batteries and engaged in the development of large lithium-ion batteries for deep-sea exploitation vehicle, satellites, and the International Space Station for about 20 years. In each development work, we carefully verified the safety as well as the performance and life, and completed it as a product, and succeeded in obtaining the certification of the Government space agency and space related companies. I was proud to confirm that the developed battery can actually be used in the deep sea and space fields for a long period of time. After that, I have also experienced a sections that treat large lithium-ion batteries used in electric vehicles, railways, ships, electrical power storage systems, power supplies for emergency back-up, etc.

2. You have been involved in a number projects related to various sectors. I would like to focus specifically in the areas of commercial type of applications and other unique areas such as for space applications. Is there a difference in the manufacturing process as well as requirements for quality and safety for these varied sectors?

The major application of our space batteries is space satellites. The battery life requirements are long, 3 to 8 years for low earth orbit satellites and 15 to 20 years for geostationary satellites. Batteries must ensure the life requirements. In addition, satellites orbit away from the earth, so even if there is a problem occur in the battery, it cannot be replaced. Then, batteries are required to have a long life and extremely high reliability.

In the topic of misuse, space batteries are controlled by a computer, and the equipment is designed and assembled by a major space equipment company closely related to us and the government's Space agency. Therefore, human error is unlikely to occur in that application.

On the other hand, in commercial-type and consumer-type applications, batteries are used in various way, and the equipment that controls the batteries is far from overseas where our control does not work. It could also be a local company. In addition, there are many situations in which a person operates the battery, then human error may occur.

Therefore, although the life, reliability, and failure rate of commercial type batteries are not as high as those for space use, it is necessary to ensure safety in consideration of misuse.
Therefore, the battery design, manufacturing process, inspection items and their parameters also differ in consideration of the above.

3. Lithium-ion cells are manufactured using different source materials. For each model of cells that are manufactured, you may need more than one lot of materials. It is expected that cells from new lots should have the same performance and safety characteristics as the original lot. However, in the manufacturing process there could be slight variations which can then change this performance and safety. What are your thoughts on confirming that the new lots have the same characteristics as the original lot using random lot sample testing?

It is not simple answer I have. Firstly, the definition of “lot” is different (in manufacturers). The important thing is purchasing the material with matured specification which controls the performance and safety properties of cell. Long time ago, we purchased a material with unmatured specification. Then, the material seemed unintended change (on un-specified property) and the cell showed different performance. After that we investigate the cause and took it to the material purchasing specification. We have repeated those activity. Now we have very much investigated and matured material purchasing specifications. Therefore, we have confidence to make cells with very stable performance and safety properties. However, just in case, we are doing periodical detail performance test such as high rate capability, temperature performance and life, and safety test for trend check. They are addition to our 100% inspections on important properties such as capacity, internal resistance, and cell sizes. Both usual 100% inspections and periodical detail tests are important.

4. When you think about lithium-ion cells and batteries, will you be able to go through the various stages of manufacturing and mention the areas that really require close attention in order to produce high-quality cells and batteries? And discuss how quality affects the safety of the cells and batteries?

In the manufacturing process, it is necessary to determine the inspection items and allowable tolerances according to each requirement and manufacture and inspect. Dimensional abnormalities and defects of the electrode plate, burrs, poor connection of the current collector parts connecting the electrode plate and the terminal, and processing mistakes may cause an internal short circuit of the battery, so appropriate processing and inspection should be performed to maintain quality. It is important.

In addition to the physical internal short circuit described above, lithium-ion batteries have the unique problem of electrochemically dissolving and precipitating metal foreign substances that have entered the plate or inside to create a counter electrode and a short circuit path. In order to prevent this electrochemical internal short circuit, one of the points is very strict control of metallic foreign matter in the manufacturing process of the electrode plate material of the lithium ion battery and the manufacturing process of the electrode plate and the cell. Preventing foreign matter from entering the positive electrode material such as lithium metal oxides and binders by setting appropriate standards, or obtaining materials that are guaranteed to be prevented, and the electrode plate manufacturing process such as kneading, coating, pressing, and cutting. Even in the cell assembly process, it is necessary to prevent and control metal foreign matter from the surrounding equipment. Furthermore, it is necessary to strictly inspect the internal short circuit (self-discharge) of the completed cell to ensure quality. These cannot be done overnight because it is necessary to understand the mechanism of short-circuit occurrence, and to set the standard of process quality by accumulating research and experience on what kind and size of metal foreign matter causes problems.

Furthermore, since the electrolyte of lithium-ion batteries is flammable, if the liquid leaks due to improper sealing of the cell case, even a relatively safe iron phosphate-based lithium-ion battery may lead to a fire accident. For this reason, it is necessary to select a case material with high reliability and durability at the design stage, and to thoroughly inspect for welding and sealing defects at the time of manufacture.

In the above, we mentioned ensuring quality during manufacturing, but in the case of lithium-ion batteries, material selection and charging voltage settings, positive and negative electrode balance, electrode porosity, electrolyte type and salt concentration, and additives There are numerous design factors, such as the choice of type and concentration, the choice of cell case type and sealing method.

It is important to identify the capacity, life, high rate charge / discharge characteristics, and safety requirements and design accordingly. The design also includes the selection of various materials such as positive and negative electrodes, separators, and electrolytes, as well as the thickness and size of the electrode plate, and the setting of the type and amount of electrolyte. In addition, the design of the case and terminals also requires a robust mechanical design that takes into consideration the requirements of the application and the presence or absence of misuse such as dropping or impact, and if necessary, does

not cause unsafe events even in those incidents. .. There are trade-offs in many parameters such as capacity, safety, lifespan, and cost, and the optimum value is selected according to the requirements and importance. It is important to determine the safety level and performance required for the target product and design appropriately.

5. You are also involved in the IEC committees and you are the leader in working groups to not only write but also update the IEC standards for stationary grid energy storage system batteries. So, what are your thoughts on the importance of standards to confirm safety? You can share all thoughts that you have in this regard.

There are various designs for lithium-ion battery cells and battery packs and battery systems that use them, and there is more than one possible approach to ensuring safety. Therefore, it is not easy to set test conditions to confirm safety. In such a situation, it is important to set common and minimum required safety requirements and incorporate them into the standard when creating the standard. While understanding various design approaches, I carry out standardization activities with an awareness of setting technically fair and effective test conditions to ensure safety.

6. What is your advice to the battery community that is involved in the manufacturing of cells and batteries, in the integration of battery systems and also those involved in regulating the integration and installations.

Following the mass production and market launch of lithium-ion batteries for portable devices that began in the 1990s, the lithium-ion battery industry is currently expanding rapidly in the electric vehicle industry. On the other hand, it is also a fact that the number of fire accidents and recalls in response to them is increasing.

I would like both the equipment manufacturer and the battery manufacturer to be more aware of safety.

7. Are there any other general thoughts you would like to share?

I'd like to talk about standards. In order to ensure and confirm safety, the safety policies and policies of equipment manufacturers and battery manufacturers are important, but we believe that the standard exists as a guide. If a standard exists, the manufacturer will design and develop improved products based on passing this standard, so the safety standards, assumed scenarios, and test methods in the standard must be appropriate. For example, in a lithium-ion battery system, the safety of the cell itself and the system safety protection are both important for ensuring the safety of the entire battery system. If a standard neglect the safety of the cell and only regulates the system protection, the motivation of the manufacturer to develop a safe cell is reduced.

From this, I think it is important to set test conditions and scenarios with an eye on the fact that safety tests based on standards will affect future product development trends.