



SURFACE VEHICLE RECOMMENDED PRACTICE

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Standards for Battery Secondary Use

RATIONALE

Many, if not most, Battery Electric Vehicle (BEV) battery packs removed from original service have a capacity that could be useful in a second life application. Some battery packs can be placed directly into secondary-use, while some packs are in a condition that refurbishment can restore them for secondary-use. A secondary-use could be for installation in a BEV as a replacement pack, integration into a stationary energy storage system, or breaking down and reconstituting into smaller or larger battery packs. Designing for secondary-use can be financially beneficial versus immediate recycling. Battery pack data availability can enhance EV residual values because certainty improves valuations as less “cushion” needs to be added to compensate for underperforming packs. Improved battery pack design can reduce the time and cost of battery repair and/or refurbishing. Further, the secondary-use of EV batteries improves a battery’s carbon footprint as there is a negligible amount of carbon expended in secondary-use as compared to their initial manufacture.

A battery pack removed from original service often has a capacity that would be useful in stationary storage because volume and energy density are not as critical as it is in an automobile. Because a battery pack is only as strong as its weakest link, replacing an underperforming module (or modules) can enable a pack to be reinstalled in its original use or utilized in a secondary-use with minimum effort if the design of the battery pack supports secondary-use and repair.

The physical design of a battery pack can have a major impact on its ability to be repaired or integrated into secondary-use. A battery pack that has mechanical fasteners that can be easily separated is preferable to one that is tab welded. At present, there is no practical way to separate tab-welded cells or modules for secondary-use. Similarly, there is no practical or cost-efficient method to remove adhesive and/or encapsulating material that binds cells and modules together as seen in some designs. Design for secondary-use is an important consideration to reduce a battery pack’s life-cycle cost and carbon footprint.

Regardless of the design of a pack, any battery considered for secondary-use should be evaluated for safety as well as its state of health (SOH) and capacity. Two of the key indicators for SOH are the individual cell resistances and capacities. While many manufacturers and system integrators have their own method of analyzing battery data to reach an estimate of the SOH and capacity, the basic data used are the same. Data used in SOH estimations are values or changes in the values of voltage, current, temperature, and impedance. Unless the data is stored in the cloud and/or the battery management system (BMS) and made available for download and analysis, this evaluation can be man-hour time consuming. This evaluation also requires costly machine time. The challenge is that the cost of man-hours and machine time continue to increase. As the cost of new batteries continues to decrease, and the more man-hours and/or machine time required in analyzing batteries for secondary-use, the less attractive a battery pack will be for secondary-use. It would be beneficial for the industry to establish a range of best practices that would improve the economics of EV residual values and increase secondary-use while also decreasing the total lifetime carbon footprint of batteries.

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FOREWORD

The secondary-use of batteries must be financially profitable in order for the practice to become widespread without policy intervention. Aside from sourcing, the primary cost involved in preparing secondary-use batteries for use in second-life applications is the evaluation of the pack's cells and/or modules to determine their SOH and capacity. The physical testing of each module (or cell) takes both machine time and man-hours, with both costs trending up. With the cost of new batteries trending down, these trends will continue to place pressure on reducing the cost of evaluating batteries for secondary-use. Battery data storage can reduce the cost of secondary-use by eliminating the need for extensive performance testing. With targeted battery historical data available, an accurate estimation can be determined electronically without touching the battery pack. This data can be encrypted and made available by OEMs only to entities they approve and who have sufficient training.

The physical design of the battery pack will also determine whether it can be repaired or if it must be reused "as is." The capacity of a series string can drop the capacity to the lowest cell in the string. Therefore, the smaller the string, the fewer cells to be replaced should a single cell be responsible. Also, the smaller the string, the less wasted capacity. For example, a hypothetical BEV may utilize a battery pack that integrates cylindrical cells that are welded together in four large modules, two of which contain 1058 cells and two of which contain 1150 cells. If any single cell fails, one of these modules must be replaced. Another BEV example consists of three module sub-pack sizes, each of which can be mechanically broken down into an eight-pouch cell module unit. Replacing eight cells due to a cell underperforming is more economical than replacing over 1000 cells.

The replacing of cells or modules assumes that the cells or modules can be economically extracted. Welded connections and/or glue or potting material surrounding cells or modules can make refurbishment without destruction or damage to other cells very difficult. Battery pack designs that incorporate battery performance data availability, pack serviceability, and that facilitate recycling could improve residual values of the EVs. This could also increase the value of batteries removed from EVs, thus enhancing secondary-use.

The design of the battery pack would best consider access to the cells and modules for ease of repair and refurbishment. Designing for secondary-use and serviceability could improve residual value of the vehicle as well as improve the value of a battery removed from primary service. Data availability will allow the highest vehicle residual value and highest used part values to benefit the EV OEM even without having any interest in secondary-use of EV batteries. The secondary-use EV battery practitioner can avoid blind-buying and, through reuse, extend the CO₂ benefit contributions of the EV battery before ultimately being recycled.

1. SCOPE

This document provides recommendations involving BEV battery data retention and battery design that enhance the potential for BEV battery reuse and serviceability and that can improve recyclability. These recommendations have been developed by a group of professionals skilled in the secondary-use of batteries and in the research, development, and manufacture of BEV batteries and battery systems.

1.1 Purpose

This SAE Recommended Practice provides guidelines for:

- a. Battery data that would be helpful to be retained and allowed to be accessed for use in calculating a traction battery's SOH and capacity, whether the battery is onboard or has been removed from the vehicle.
- b. Design features in EV batteries that can aid in their servicing, reuse, and recycling.

2. REFERENCES

There are no referenced publications specified herein.