



## **Notebook Computer Battery Pack Test Plan Considerations**

*Kristen Shappert and Cindy Millsaps*

*Motorola Energy Systems Group*

Market globalization has changed the dynamic of today's workplace. Employees no longer consistently work standard business hours in a traditional office. Instead, many workers perform their jobs from a variety of locations and environments. These mobile employees demand flexibility, portability and long run times in their work tools. In response, the market is flooded with a proliferation of products, such as notebook and handheld computers, to support today's itinerant workforce.

With the increasing energy demands from portable electronic devices, it is clear that the varying degrees of end consumer usage patterns need to be evaluated. If these usage patterns are not accounted for in the product development testing stages, it can lead to product degradation over time and result in customer dissatisfaction. With respect to notebook computers, users fall into two primary categories: the "casual user" and the "road warrior." These very different consumer usage profiles present unique challenges to the notebook energy system. To ensure best results, product testing at the development stage should be customized to fit the intended usage profile.

The "casual user" has a notebook computer, but does not fully utilize the mobility that it offers. Instead, the notebook functions essentially as a standard desktop computer, remaining in the docking station. This computer is powered by the external power supply when not in the docking station. In this situation, the battery capacity is rarely depleted and the battery is rarely removed from the host device. The notebook computer itself is stored primarily on the desk and thus has limited in-case transport.

In direct contrast to the "casual user" is the "road warrior." The "road warrior" transports the notebook computer constantly and rarely leaves the computer in a docking station. The computer and battery pack are frequently transported in a carrying case and the battery pack is worn down fully before charging. Typically, a spare battery is carried and swapped out frequently by this type of user.

Obviously, the different usage patterns described above would put the notebook battery pack under differing degrees of strain. In order to account for the different stress levels, testing at each extreme must be considered.

The "road warrior" usage profile includes high cycles, possible mechanical abuse and short term insulated storage. The following test profile outlines possible tests for this user group:

- *Cycle life testing with full charge and discharge cycles at room temperature* – This test simulates the full discharge pattern and the good airflow conditions in the user environment. Since the notebook computer is not typically operated in the docking station, the battery compartment does not get excessively hot during use. The rate of discharge would be either constant power based on the rating of the computer manufacturer, or if this were not known, a C/5 discharge rate would suffice. The charge rate would be at 1C, typical for computing applications.
- *Environmental stress testing* - This type of testing is performed to simulate common abuse situations such as drop, mechanical shock, vibration, temperature shock, temperature cycling,

and humidity changes. A battery pack that is transported and exchanged frequently is more susceptible to these kinds of common abuses.

- *Residual and recoverable capacity testing to be performed on fully charged batteries at elevated temperatures* - This test simulates the storage of a fully charged battery pack in an insulated carrying case and could be relatively short in length at 3 to 4 days.
- *Residual and recoverable capacity testing* - Performed on fully discharged batteries at elevated temperatures, this test accounts for the storage of fully depleted packs in an insulated carrying case.
- *Short circuit testing at elevated temperatures* - Possible fault conditions that could occur in transport in either a designated carrying case or other bag are analyzed during this test.

The “casual” usage profile includes very low discharge and constant trickle charge exposure, little airflow, and desktop storage and usage. The following test profile outlines possible tests for this profile:

- *Cycle life testing done with a shallow discharge, but at an elevated temperature (45°C or 60°C)* – This test simulates lower discharge profiles, while also accounting for the heat generated by the docking station. The rate of discharge would be similar to the test conditions for the “road warrior,” but with a more shallow discharge of 80 percent or 3.8V per cell pair. For a 2 parallel, 4 series cell configuration, this would mean a discharge to about 15.2V. A charge current of 1C could still be used, but a new step in the cycle to account for trickle charging should be included by adding a low current (C/100) charge step to the cycle life. Cycle life testing would also need to be conducted for more cycles than the “road warrior” regimen. This is attributed to the increased volume of shallow discharges that are completed in the same timeframe as a full charge and discharge cycle for the “road warrior.” As many as 600-800 cycles should be completed for this test.
- *Environmental stress testing* - While less intensive than for the “road warrior” environmental stress testing regimen, “casual users” battery packs would still be exposed to some impact or drop type abuses. Although limited, even in normal desktop use with limited exposure to abusive situations, notebook computer batteries are exposed to conditions that can degrade the usability of the device.
- *Residual and recoverable capacity testing performed on fully charged batteries at elevated temperatures, 45°C and 60°C, for 1 month and 1 week* – This test provides valuable information by simulating the storage of the fully charged pack in the notebook computer for weeks or months. This approach is consistent with a notebook remaining in the docking station and powered on.
- *Room temperature storage (self-discharge)* - This test provides information about the normal losses of the pack’s charge in non-use conditions that could affect performance once the battery is put back into use.
- *Short circuit at room temperature* – If the battery is removed from a system in this type of usage profile, it is likely to be tossed into a drawer or on the desktop. Therefore, a short circuit at room temperature would be a potential safety concern that this test would evaluate.

Regardless of the established usage profile, there are certain tests that should be performed regardless of user type, as either required by law or to verify safety and functionality of the product. A brief description of these tests follows:

- *Regulatory compliance testing* - For notebook computer batteries, there are 2 options in the United States, UL60950 or UL2054. Customer requirements determine which test sequence is performed. UL60950 covers Information Technology Equipment standards and is internationally harmonized so that one test program can cover all global compliance needs. The corresponding international standards are IEC60950/EN60950. UL2054 covers

Household and Commercial Batteries standards and is currently limited to United States applications only.

- *Transport testing requirements for lithium and lithium-ion cells and battery packs* - Testing is required in accordance with the Third Revised Edition of the United Nations Manual of Tests and Criteria Part III, subsection 38.3 and applies to the bulk transportation of lithium and lithium-ion cells and battery packs.
- *Temperature shock* - This test quickly exposes potential latent design or material issues and should be performed on all products.
- *Overcharge testing* – Performing this test can reveal important safety information about the product by verifying that battery safety circuitry operates properly when overcharged past the recommended charge voltage and current specifications.

Since anticipating consumer behavior is difficult, an efficient test flow would include all mandatory regulatory tests and a combination of both user profile test regimes. Such a comprehensive test plan provides optimal results with minimal extraneous testing. Consideration of which tests are most stringent or abusive and where the profiles and test programs overlap will lead to an effective test program. For example, the following test plan would be appropriate for a notebook computer battery pack and sufficiently cover both user profiles:

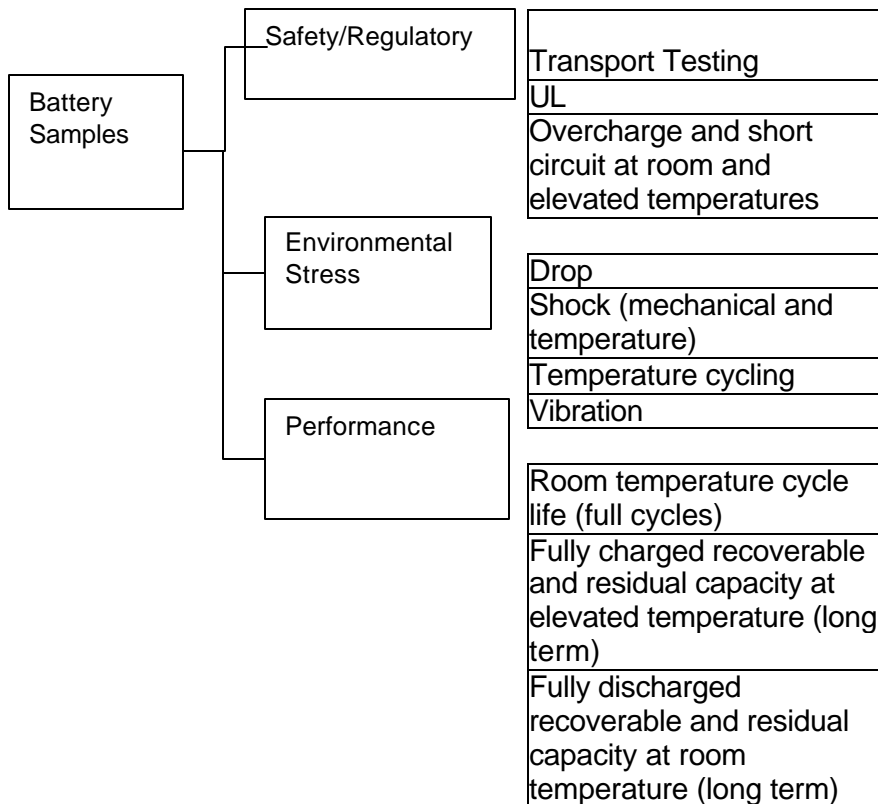


Figure 1: Optimum Notebook Computer Battery Pack Test Flow

The profiles provided in this article outline tests that are valuable for evaluating product performance for varying user profiles and conditions. Performing such tests during the design phase of a product will allow engineers to assess test results and determine whether design changes are required. Testing the completed product allows designers to understand the product's performance under varying usage conditions and enables them to convey this information in user operating

manuals. While customized testing can be performed for either usage profile, the consolidated test flow is the most efficient method to determine the optimum product performance and safety for all user profiles. The test flows presented, which are typical of those performed by Motorola Energy Systems Group, take into consideration the most stringent situations and how they will affect the performance and safety of a battery pack.

About the authors:

At Motorola Energy Systems Group, Kristen Shappert is an OEM Notebook Program Manager and Cindy Millsaps is a Senior Staff Compliance Engineer. In her role, Ms. Shappert is responsible for launching and supporting programs from their conception to end of life. She holds a BS in Industrial Engineering and a Masters of Business Administration in Marketing. In her role, Ms. Millsaps is responsible for regulatory compliance for power supplies, chargers and battery packs. She holds a BS in Electrical Engineering and prior to joining Motorola, worked at Underwriters Laboratories. Combined they have more than 18 years experience in working with product development, program management and test planning.

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