# Cycle Life Test

A process was developed for the accelerated life testing of a particular cell or battery which comprises the comparison and extrapolation of the end of discharge voltages plotted versus the logarithm of the cycle number in combination with prior knowledge about the probable cycles to failure for similar cells or batteries under the same end use conditions. When the slope of the voltage-log cycle line in the test can be made to coincide with similar slopes from prior knowledge, the battery under test will have the same cycle life and failure mechanism as prior cells or batteries. Acceleration of the test results is achieved because a duplication slope for the data obtained during about the first hundred cycles indicates the probable presence of thousands of cycles anticipated by the prior knowledge.

State-of-health Estimation of Li-ion BatteriesCycle Life Test MethodsCycle Life Testing of Vented, Rechargeable Silver-cadmium Cells

This Standard specifies the test method for discharge plateau capacity ratio and cycle life for lithium nickel cobalt manganese oxide of lithium-ion battery cathode material. This Standard applies to the testing of discharge plateau capacity ratio and cycle life for lithium nickel cobalt manganese oxide of lithium-ion battery cathode material.

The objectives of this program was to cycle life test vented silver-cadmium cells, in four sizes with a common base area. The rated cell capacities, at the five-hour discharge rates, were: 7.0 ampere-hours, 15.0 ampere-hours, 22.0 ampere-hours, 31.0 ampere-hours. The report gives the cell capacities for each of the 112th manual discharge cycles, following 110 successive automatic and one manual cycle at 62-1/2% depth of discharge. The automatic cycling regime

consisted of a 6 hour orbit, 3-1/2 hours of charging, and 2-1/2 hours of discharge. The report gives data on cell capacities for a total of 1008 cycles. (Author).

Tests designed to show effects of separator overhang continued with both positive and negative plates reduced in area to obtain sufficient separator overhang. Cells containing various combinations of acrylonitrile type separations wrapped around negatives did not show any significant improvement in cycle life as compared to control cells. Cells containing NaOH electrolytes completed over 1500 cycles before failure. Experimental results of tests made on some potential electrolyte materials are reported. Evaluation tests on sample separator materials are nearly completed, and pilot run materials are on order. (Author).

The Advanced Technology Development Program has completed performance testing of the second generation of lithium-ion cells (i.e., Gen 2 cells). The 18650-size Gen 2 cells, with a baseline and variant chemistry, were distributed over a matrix consisting of three states-of-charge (SOCs) (60, 80, and 100% SOC), four temperatures (25, 35, 45, and 55°C), and three life tests (calendar-, cycle-, and accelerated-life). Thecalendar- and accelerated-life cells were clamped at an open-circuit voltagecorresponding to the designated SOC and were subjected to a once-per-day pulse profile. The cycle-life cells were continuously pulsed using a profile that was centered around 60% SOC. Life testing was interrupted every four weeks for reference performance tests (RPTs), which were used to quantify changes in cell degradation as a function of aging. The RPTs generally consisted of C1/1 and C1/25 static capacity tests, a low-current hybrid pulse power characterization

test, and electrochemical impedancespectroscopy. The rate of cell degradation generally increased with increasing testtemperature, and SOC. It was also usually slowest for the calendar-life cells and fastestfor the accelerated-life cells. Detailed capacity-, power-, and impedance-basedperformance results are reported.
Lists citations with abstracts for aerospace related reports obtained from world wide sources and announces documents that have recently been entered into the NASA Scientific and Technical Information Database.
This Standard specifies the test method for discharge plateau capacity ratio and cycle life of lithium manganese oxide as the cathode material of lithium ion batteries. This Standard is applicable to the test of discharge plateau capacity ratio and cycle life of lithium manganese oxide as the cathode material of lithium ion batteries.
Product reliability engineering from concept to marketplace In today's global, competitive business environment, reliability professionals are continually challenged to improve reliability, shorten design cycles, reduce costs, and increase customer satisfaction. "Life Cycle Reliability Engineering" details practical, effective, and up-to-date techniques to assure reliability throughout the product life cycle, from planning and designing through testing and warranting performance. These techniques allow ongoing quality initiatives, including those based on Six Sigma and the Taguchi methods, to yield maximized output. Complete with real-world examples, case studies, and exercises, this resource covers: Reliability definition, metrics, and product life

distributions (exponential, Weibull, normal, lognormal, and more) Methodologies, tools, and practical applications of system reliability modeling and allocation Robust reliability design techniques Potential failure mode avoidance, including Failure Mode and Effects Analysis (FMEA) and Fault Tree Analysis (FTA) Accelerated life test methods, models, plans, and data analysis techniques Degradation testing and data analysis methods, covering both destructive and nondestructive inspections Practical methodologies for reliability verification and screening Warranty policies, data analysis, field failure monitoring, and warranty cost reduction All reliability techniques described are immediately applicable to product planning, designing, testing, stress screening, and warranty analysis. This book is a must-have resource for engineers and others responsible for reliability and quality and for graduate students in quality and reliability engineering courses.
In support of the Partnership for a New Generation of Vehicles (PNGV), the Idaho National Engineering and Environmental Laboratory (INEEL) has developed novel testing procedures and analytical methodologies to assess the performance of batteries for use in hybrid electric vehicles (HEV's). Tests have been designed for both Power Assist and Dual Mode applications. They include both characterization and cycle life and/or calendar life. At periodic intervals during life testing, a series of Reference Performance Tests are executed to determine changes in the baseline performance of the batteries. Analytical procedures include a battery scaling methodology, the calculation of pulse resistance, pulse

power, available energy, and differential capacity, and the modeling of calendar- and cycle-life data. PNGV goals, test procedures, analytical methodologies, and representative results are presented.

Electric Vehicle Battery Systems provides operational theory and design guidance for engineers and technicians working to design and develop efficient electric vehicle (EV) power sources. As Zero Emission Vehicles become a requirement in more areas of the world, the technology required to design and maintain their complex battery systems is needed not only by the vehicle designers, but by those who will provide recharging and maintenance services, as well as utility infrastructure providers. Includes fuel cell and hybrid vehicle applications. Written with cost and efficiency foremost in mind, Electric Vehicle Battery Systems offers essential details on failure mode analysis of VRLA, NiMH battery systems, the fast-charging of electric vehicle battery systems based on Pb-acid, NiMH, Li-ion technologies, and much more. Key coverage includes issues that can affect electric vehicle performance, such as total battery capacity, battery charging and discharging, and battery temperature constraints. The author also explores electric vehicle performance, battery testing (15 core performance tests provided), lithium-ion batteries, fuel cells and hybrid vehicles. In order to make a practical electric vehicle, a thorough understanding of the operation of

a set of batteries in a pack is necessary. Expertly written and researched, Electric Vehicle Battery Systems will prove invaluable to automotive engineers, electronics and integrated circuit design engineers, and anyone whose interests involve electric vehicles and battery systems. * Addresses cost and efficiency as key elements in the design process * Provides comprehensive coverage of the theory, operation, and configuration of complex battery systems, including Pb-acid, NiMH, and Li-ion technologies * Provides comprehensive coverage of the theory, operation, and configuration of complex battery systems, including Pb-acid, NiMH, and Li-ion technologies

Dynamic Stress tests (DST) of. small lithium-ion cells have demonstrated that the systems delivers high energy (65 Wh/kg, 4.3 hours runtime) with reasonable cycle-life (375--480 cycles) under the full USABC mid-term dynamic-stress-test conditions (150 W/kg). At lower DoD substantially higher cycle life was observed (2800 cycles at 44% DoD, 1.9 hours runtime). Both the DoD and charging voltage V{sub c} (4.1V V{sub c}

Sealed lead acid cells are used in many projects in Sandia National Laboratories Department 2660 Telemetry and Instrumentation systems. The importance of these cells in battery packs for powering electronics to remotely conduct tests is significant. Since many tests are carried out in flight

or launched, temperature is a major factor. It is also important that the battery packs are properly charged so that the test is completed before the pack cannot supply sufficient power. Department 2665 conducted research and studies to determine the effects of temperature on cycle time as well as charging techniques to maximize cycle life and cycle times on sealed lead acid cells. The studies proved that both temperature and charging techniques are very important for battery life to support successful field testing and expensive flight and launched tests. This report demonstrates the effects of temperature on cycle time for SLA cells as well as proper charging techniques to get the most life and cycle time out of SLA cells in battery packs.

This contributed volume collects insights from industry professionals, policy makers and researchers on new and profitable business models in the field of electric vehicles (EV) for the mass market. This book includes approaches that address the optimization of total cost of ownership. Moreover, it presents alternative models of ownership, financing and leasing. The editors present state-of-the-art insights from international experts, including real-world case studies. The volume has been edited in the framework of the International Energy Agency's Implementing Agreement for Cooperation on Hybrid and Electric Vehicles (IA-HEV). The target audience primarily comprises practitioners and

decision makers but the book may also be beneficial for research experts and graduate students.

The review and analysis reported here are the outcomes of a project carried out from 1998-2001 within the Energy Technology Department of the The Aerospace Corporation to examine the available results of different nickel-hydrogen life testing programs that had been or were being carried out for low Earth orbit (LEO) applications. The cycling programs, some of which are still in progress, were conducted under different sponsorships and carried out at different testing facilities.

This Standard specifies the requirements, test methods, inspection rules of standard cycle life and the test methods and inspection rules of operating-condition cycle life of traction battery of electric vehicle.

This comprehensive handbook covers all fundamentals of electrochemistry for contemporary applications. It provides a rich presentation of related topics of electrochemistry with a clear focus on energy technologies. It covers all aspects of electrochemistry starting with theoretical concepts and basic laws of thermodynamics, non-equilibrium thermodynamics and multiscale modeling. It further gathers the basic experimental methods such as potentiometry, reference electrodes, ion-sensitive electrodes, voltammetry and amperometry. The contents cover subjects related to mass transport, the electric double layer, ohmic losses and experimentation affecting electrochemical reactions. These aspects of electrochemistry are especially examined in view of specific energy technologies including batteries, polymer electrolyte and biological fuel cells, electrochemical capacitors, electrochemical hydrogen production and

photoelectrochemistry. Organized in six parts, the overall complexity of electrochemistry is presented and makes this handbook an authoritative reference and definitive source for advanced students, professionals and scientists particularly interested in industrial and energy applications.

The Advanced Technology Development Program is currently evaluating theperformance of the second generation of Lithium-ion cells (i.e., Gen 2 cells). The18650-size Gen 2 cells consist of a baseline chemistry and one variant chemistry. These cells were distributed over a matrix consisting of three states-of-charge (SOC)(60, 80, and 100% SOC), four temperatures (25, 35, 45, and 55°C), and three life tests(calendar-, cycle-, and accelerated-life). The calendar-life cells are clamped at an opencircuitvoltage corresponding to 60% SOC and undergo a once-per-day pulse profile. The cycle-life cells are continuously pulsed using a profile that is centered around 60%SOC. The accelerated-life cells are following the calendar-life test procedures, butusing the cycle-life pulse profile. Life testing is interrupted every four weeks forreference performance tests (RPTs), which are used to quantify changes in capacity, resistance, and power. The RPTs consist of a C1/1 and C1/25 static capacity tests, alow-current hybrid pulse power characterization test, and electrochemical impedancespectroscopy at 60% SOC. Capacity-, power-, and electrochemical impedancespectroscopy-based performance results are reported.

The Advanced Technology Development Program has completed the performance evaluation of the second generation of lithium-ion cells (i.e., Gen 2 cells). This report documents the testing and analysis of the Gen 2 GDR cells, which were used to learn and debug the newly developed Technology Life Verification Test Manual. The purpose of the manual is to project a 15-year, 150,000 mile battery life

capability with a 90% confidence interval using predictive models and short-term testing. The GDR cells were divided into two different matrices. The core-life test matrix consisted of calendar- and cycle-life cells with various changes to the four major acceleration factors (temperature, state-of-charge, throughput, and power rating). The supplemental-life test matrix consisted of cells subjected either to a path dependence study, or a comparison between the standard hybrid pulse power characterization test and the newly-developed minimum pulse power characterization test. Resistance and capacity results are reported.

This book systematically introduces readers to the core algorithms of battery management system (BMS) for electric vehicles. These algorithms cover most of the technical bottlenecks encountered in BMS applications, including battery system modeling, state of charge (SOC) and state of health (SOH) estimation, state of power (SOP) estimation, remaining useful life (RUL) prediction, heating at low temperature, and optimization of charging. The book not only presents these algorithms, but also discusses their background, as well as related experimental and hardware developments. The concise figures and program codes provided make the calculation process easy to follow and apply, while the results obtained are presented in a comparative way, allowing readers to intuitively grasp the characteristics of different algorithms. Given its scope, the book is intended for researchers, senior undergraduate and graduate students, as well as engineers in the fields of electric vehicles and energy storage.

Recent developments in order to represent the material behaviour of filler-reinforced elastomers under realistic operating conditions are collected in this volume. Special topics are finite element

simulations and methods, dynamic material properties, experimental characterization, lifetime prediction, friction, multiphysics and biomechanics, reinf

Special edition of the Federal Register, containing a codification of documents of general applicability and future effect ... with ancillaries.