The charge collector (a metallic mesh) is incorporated into the structure of the electrode by pressing it in with the web of catalyst. The electrode is removed from the felt and further dried by using a drum dryer and hot air. Remaining traces of surfactant can be removed using a spray of solvent. Finally, the electrode material so produced can be cut or rolled as desired. The proposed system is able to control electrode properties such as porosity, catalyst loading and thickness.

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P21

Classification and characterisation of primary batteries
Part 1: Standardised conditions for the experimental determination of performance characteristics

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Performance characteristics that are addressed in this poster refer essentially to energy content, capacity, discharge voltage, time of discharge, internal resistance and more specifically to standard conditions under which these values are obtained.

The need for relevant standard conditions becomes obvious when studying the technical literature on primary batteries — including technical handbooks and data sheets of manufacturers. It appears that the experimental conditions for product characterisation are differing, thus the performance comparision for a given battery is not always based on the same grounds. In order to permit battery comparison, the IEC (International Electrotechnical Commission) has introduced standardised application and/or service output-tests [1], the results of which are given in terms of discharge durations. An IEC method for the determination of a primary battery's capacity, energy content and load capability is not available yet.

The intent of this poster is to propose a standard method that deals with the above deficiencies — it is based on the so-called standard discharge voltage, which only depends on the electrochemical system and not on the size of the battery, nor on its internal construction. The experimental determination of the standard discharge voltage for a given electrochemical system is obtained via a capacity/discharge resistance curve (C/R-plot) by employing a method to be presented.

It actually is the mean discharge voltage, determined from the discharge curve, that yields 98% of the maximum capacity C(max). The C(max) value is characterized by a capacity plateau, i.e: $dC/dR = 0$. The standard method furthermore permits us to address and quantify terms like energy content, capacity and time of discharge When introducing load resistance R(C/2), that yields half the capacity, it is possible to also address the battery's rate capability under standardized conditions.

When doing so, vague terms like *high rate* or *low rate* in relation to the specific power output P* of batteries may be replaced by an experimental value. Values of presently standardized primary batteries were determined to be within a range of $3\ \text{mW cm}^{-3} \leq p^* \leq 380\ \text{mW cm}^{-3}$.

To prove the validity of this approach, more than ten different systems (aqueous and non-aqueous) as well as different battery constructions were analysed.

From future work it is expected that the above method may be also employed to characterize secondary batteries.

Reference

[1] *IEC Publication 96, part 2*, IEC Central Office, 3 rue de Varambé, CH-1211 Geneva 20, Switzerland.

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Classification and characterisation of primary batteries
Part 2: System and performance characteristics and their application to matters of safety and nomenclature

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1. Application to matters of safety

The approach discussed in Part 1 (Poster 21) of this presentation is helpful in solving existing issues of International Standardisation in the attempt to provide Safety Standards to the public.

One of the issues is the question of electrical interchangeability of batteries having the same physical envelope and identical terminal arrangements, but however, exhibiting markedly different voltages. Reference is made, for example, to 3 V lithium batteries being physically interchangeable with 1.5 V batteries. They never will be standardised by the I.E.C. due to safety reasons.

Two voltage ranges have been defined so far. A formula was derived to describe these ranges. *Voltage range I* encompasses a range from 1.19 V/cell to 1.61 V/cell, *Voltage range II* encompasses a range from 2.3 V/cell to 3.65 V/cell. Within each voltage range, batteries may be manufactured to be physically interchangeable (identical physical envelope and terminal arrangements). For Safety reasons the physical envelope and terminal arrangements of batteries belonging to *range I* must differ from those of *range II* to meet the requirements for standardisation.

The above-mentioned voltage ranges are presently under consideration by the I.E.C. The determinant, that decides whether or not a given electrochemical system fits into which voltage range, is its Standard Discharge Voltage, which is presented. and discussed in part 1.

2. Application to the new nomenclature

Present battery volumes from button cells to lead-acid batteries cover a range of more than four orders of magnitude. When using a double-logarithmic plot of the standard energy content E_s for batteries of a given electrochemical system versus battery volume V_b it turned out that the logarithmically coded battery volume may serve as a base for a unique battery designation system for both primary and secondary batteries. The designation system may be expanded to also include additional physical and performance characteristics, like the load capability or special arrangements to the benefit of the battery expert or it may be abbreviated to serve the needs of the end user. The inclusion of the load capability into the nomenclature is an important feature with respect to safety, since the present nomenclature does not differentiate between, for example, a high-rate and a low-rate lithium battery.

It also allows the setting up of a logically structured data base that handles all portable batteries by system, size, shape and load capability. In principle, it addresses battery sizes from 1 mm^3 up to 10 m^3 while providing a capacity for 120 different primary plus 120 secondary systems, which should be abundant for future purposes. This nomenclature system fully complies with the requirements of the IEC/ISO Directive, part 2, of International Standardization.

The poster will have a demonstration of the capabilities of this data base.

P23

The development of a multi-purpose battery information system

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There is presently a lack of a complete, well-utilized, accurate database of batteries throughout the Canadian and U.S. military. Such a tracking tool could dramatically assist in reducing the proliferation of unique batteries and in serving as a designers' tool for standardizing families of batteries for particular families of systems. The battery maintenance procedures within the military organisations could be updated, and training of personnel could reduce maintenance costs, Many battery chemistries require standard, periodic, maintenance that prolong the life of the battery. If these maintenance procedures or time intervals are not followed, battery life decreases, resulting in unnecessary maintenance or replacement costs.

This paper presents a knowledge framework for the organization of battery informational support of the life cycle management of battery systems used in the military.

P24

Evaluation of lithium primary cells for long-life applications

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The new types of ultrasonic domestic gas meters used by British Gas plc are significantly different from the previous self-powered mechanical diaphragm meter, in that it is powered by "D" or "C"- sized primary lithium batteries. A paper describing hazard evaluations of the range of lithium battery candidates was presented at the 1995 International Power Sources Symposium, and in this poster the work reported extends to cover evaluations of electrical performance and reliability of candidate cells.

The meters require reliable, continuous, operation of batteries over a period of at least 11.5 years, in both internal and external environments. Initial tests evaluated the performance of batches of batteries discharged under continuous load, at currents over the range 3 to 30 mA, under a thermal cycle designed to represent operation in the UK seasonal and diurnal climatic changes. In order to trap short-term voltage excursions and to achieve reasonable sampling rates, a 1024 channel data acquisition and control test rig and associated data processing software was developed.

To date, a range of lithium/thionyl chloride, manganese dioxide and polycarbon monofluoride cells have been tested, and base-line data have been generated for a range of batteries which characterise the voltage/temperature relationships and the effective capacity under these discharge conditions. The data are successful in identifying possible failure modes and has indicated the need for further work under pulsed loads.

P25

Safe and efficient charging algorithm for lithium batteries

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The Total Battery Management (TBM) charging algorithm for lithium batteries provides efficient energy transfer,