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, precise termination method and safety protection in addition to that provided during battery manufacture.

Pulse current, with duty cycle of 5 to 1, is used until maximum voltage is reached. The pulse amplitude is dropped at this point until maximum voltage is reached one more time. This process is repeated until the value of a predetermined minimum current is reached. This procedure excludes staying too long with constant voltage and thereby decreasing the probability of electrolyte decomposition, without substantially sacrificing charging capacity and charging time. The rest period in the TBM charging profile is used for measuring open-circuit voltage (OCV), also ohmic and chemical polarization. Control of these parameters allows us to recognise hard, soft and chemical shunts as well and to make some adjustments to the charging profile.

The potential chemical shunt for example, which is specified as the reaction between electrolyte and metallic lithium, can be recognized from measurement of chemical polarization, which is inversely dependent on cell temperature. The battery response to an internal source of heat, from chemical polarization, is much faster than that of an external thermistor. Hard shunt identification is provided monitoring for a fast drop in the charging voltage, with the identification of soft shorts by monitoring the change in OCV. The conditions for creation of dendrites are monitored as a rise in chemical (concentration) polarization and the charging current is then tapered as necessary.

The cell equalization procedure includes measuring the OCV of individual cells, both at the beginning and end of charge, to identify any cell inbalance.

The rate of response during charging for a soft short is about one second, including conformation time, and less than 20 ms for a hard shunt. The measurement accuracy is ± 8 to 10 mV for full battery voltage.

The charge process provides a highly efficient transfer of energy from any power supply (linear or switching) to the battery terminals by the use of pulse width modulation.

The lithium charging algorithm can be used with regular microcontroller parameters: 8-bit word length, a frequency of at least 2 Mhz, four or more ADC inputs and at least one 8-bit parallel port.

P26

The morphology of microporous polyethylene separators and its significance for the performance of lithium batteries

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Solupor™ is a novel microporous (ultra) high molecular weight polyethylene membrane, fabricated in standard grades with base weights ranging from 7 to 16 g m^{-2} and mean pore sizes ranging from 0.1 to 2.0 μm and a porosity of 80 to 90%. The suitability of Solupor™ membranes as separator material in lithium batteries is demonstrated. These membranes have good wettability and thermal stability and pass voltage breakdown testing.

McMullin numbers are reported, ranging from 4 to 20 and tortuosities ranging from 1.8 to 4.1.

Electrical resistance is lowest for membranes with the highest pore size. Solupor™ membranes were tested in primary Li/MnO_2 cella and have load characteristics equal to or slightly better than commercial reference materials.

A special Solupor™ grade has been developed for an application in a battery production process for R6-size ("AA") cells, in which the separator experiences high winding forces. At present, another special grade is under development, being a membrane with thermal shutdown capability and high permeability.

P27

Model of a powerful high-temperature primary battery

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The design of thermal chemical current sources (TCCS) for the solving of specific technological problems necessitates testing a large number of arrangements having various characteristics. One of the ways of reducing the volume of preliminary experimental work is computer simulation.

A mathematical model of thermal regimes of thermal batteries of filter-press design with cylindrical symmetry has been developed. This model is described by a heat balance equation in a region G with boundary S:

$$\iiint_G c(X,U).\rho(X,U)\{U(X.t_2) - U(X,t_1)\}\mathrm{d}V$$

$$= \int_{t,S}^{t2} \phi\{W(X,t,U).\mathrm{d}\sigma\} + \iiiint_{G\ t}^{t2} ,f(X,t,U)\,\mathrm{d}t\mathrm{d}V$$

$$\mathrm{W}_\alpha(\mathrm{X,t,U}) = -\lambda(\mathrm{X,U}).\frac{\partial U(X,t)}{\partial x_\alpha}$$

where:

$c\ (X,U)$	is the thermal capacity at point (x, y, z), having temperature U;
$\rho\ (X,U)$	is the density at point (x, y, z);
$U\ (X,t)$	is the temperature at point (x, y, z), at time t;
$W_\alpha\ (X,t,U)$	is the heat flow in the direction of Ox_α
$\lambda\ (X,U)$	is the thermal conductivity at point (x, y, z);