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## **ALKALINE BATTERY DISCHARGE TESTING**

With respect to the alkaline primary battery types LR20, LR14, LR6, LR03, 6LR61, 6LP3146, the standardization of dimensions, nomenclature, terminal configurations, markings, test methods, battery performance, safety is officially described in IEC 60086-1, IEC 60086-2 and IEC 60086-5.

More precisely, IEC 60086-1 chapter 4, 5 & 6 and IEC 60086-2 chapter 6 are especially dedicated to battery discharge testing:

- Standard discharge conditions
- Standard test conditions for discharge testing
- Standard measuring equipment specifications
- Standard discharge conformity check

### **Standard discharge conditions**

IEC 60086-2 chapter 6 details specifications with a variety of discharge tests for the most relevant primary battery types (LR20, LR14, LR6, LR03, 6LR61, 6LP3146). These so called application tests simulate their common electrical usage by a regular consumer. Important to know is that all IEC application tests have an intermittent and not continuous drain profile which is in line with the common usage pattern of batteries by consumers.

However, electrochemically within the battery the difference between an intermittent and continuous drain profile is very significant. Intermittent drain allows the battery to recover and increase its discharge efficiency and corresponding capacity. The efficiency of recovery is based on several items but also the battery recipe itself and significant differences can be measured between battery brands and grades.

Furthermore testing one drain profile gives also a very selective view on the total battery discharge performance. E.g. for LR6 eight different application tests are currently included in IEC simulating low, middle and high drain battery usage. Very good performing batteries in low drain do not automatically perform well in high drain usage and vice versa. In order to have a good overall discharge performance of a battery, the 8 intermittent IEC application tests need to be considered.

Only 2 out of 8 IEC application tests are considered 'high drain' (Digital camera, photoflash) which already indicates the importance of the low/middle drain discharge profiles given by IEC.

### **Standard conditions during discharge testing**

IEC 60086-1 chapter 6 clearly describes the conditions during discharge testing. Storage before discharge testing and the actual discharge test is carried out under well-defined conditions.

Type of test	Storage conditions			Discharge conditions	
	Temperature °C	Relative humidity %	Duration	Temperature °C	Relative humidity <sup>d</sup> %
Initial discharge test	20 ± 2 <sup>a</sup>	55 ± 20	60 days maximum after date of manufacture	20 ± 2	55 ± 20

Especially temperature is of great importance for high drain application tests. Small temperature fluctuations of 2°C can already have a significant impact on the battery performance. Furthermore due to the relative high heat capacity of a battery, at least one day in these conditions need to be considered for normalization before starting a discharge test after storage at high temperature.

The relative humidity control is important to avoid condensation effects on the battery itself.

### **Standard measuring equipment specifications**

The specifications of the measuring equipment is of great importance in order to obtain reliable test data.

The specified IEC tests can be divided in three different load categories: constant resistance, constant current and constant wattage tests.

Constant resistance tests have been chosen to permit simplicity of test equipment design. In order to measure constant current and constant wattage discharge conditions, more sophisticated equipment is necessary.

Nevertheless, IEC gives very clear tolerances for the used load ( $\pm 0.5\%$ ) and the measured time 'accuracy'. The usage of non-calibrated toys, flash lights,... in battery performance testing are therefore not appropriate and considered to be useless. Moreover, the maintenance of the measuring equipment is also very important, especially for carrying out high drain tests. Contact resistances due to bad-maintained contacts, wires,... are quite often a source of misjudgment of the real battery discharge duration.

Test parameter	Tolerance	
Temperature	$\pm 2 \text{ }^\circ\text{C}$	
Load	$\pm 0,5 \%$	
Voltage	$\pm 0,5 \%$	
Relative humidity	$\pm 20 \%$ RH except "P" system $\pm 10 \%$ RH	
Time "accuracy"	Discharge time $t_d$	Tolerance
	$0 < t_d \leq 2 \text{ s}$	$\pm 5 \%$ of $t_d$
	$2 \text{ s} < t_d \leq 100 \text{ s}$	$\pm 0,1 \text{ s}$
	$t_d > 100 \text{ s}$	$\pm 0,1 \%$ of $t_d$

### **Standard discharge conformity check**

If third parties to the manufacturers wish to check the discharge duration 'conformity' of a battery, following procedure needs to be followed as described in IEC 60086-1:

- Test nine batteries
- Calculate the average without the exclusion of any result
- If this average is equal to or greater than the specified figure and no more than one battery has a service output of less than 80% of the specified figure, the batteries are considered to conform to service output
- If this average is less than the specified figure and/or more than one battery has a service output of less than 80% of the specified figure, repeat the test on another sample of nine batteries and calculate the average as previously
- If the average of this second test is equal or greater than the specified figure and no more than one battery has a service output of less than 80% of the specified figure, the batteries are considered to conform to service output.
- If the average of the second test is less than the specified figure and/or more than one battery has a service output of less than 80% of the specified figure, the batteries are considered not to conform and no further testing is permitted.

Based on the product variation within each battery manufacturing process, statistically a minimum of nine batteries need to be checked for each discharge conditions in order to make a reliable statement of the battery discharge performance. No statistical justification of battery service output is possible if less than 8 batteries are considered in a battery test.