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CONSOLIDATED VERSION

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colour inside

Secondary cells and batteries containing alkaline or other non-acid electrolytes – Secondary lithium cells and batteries for use in industrial applications

Accumulateurs alcalins et autres accumulateurs à électrolyte non acide – Eléments et batteries d'accumulateurs au lithium pour utilisation dans les applications industrielles

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Charge and discharge currents for the tests shall be based on the value of the rated capacity (C_n Ah). These currents are expressed as a multiple of I_t A, where: I_t A = C_n Ah/1 h.

C_n is the rated capacity declared by the manufacturer in ampere hours (Ah), and n is the time base in hours (h) for which the rated capacity is declared. n is 5 for E, M and H discharge rate type cells or batteries, n is 8, 10, 20 or 240 for S discharge rate type batteries.

See Table 2.

6.2 Charging procedure for test purposes

Prior to charging, the cell or battery shall be discharged at 25 °C ± 5 °C at a constant current of 1/n I_t A, down to a specified final voltage.

Unless otherwise stated in this standard, cells or batteries shall be charged, in an ambient temperature of 25 °C ± 5 °C, using the method declared by the manufacturer.

NOTE The final voltage in discharge tests is declared by the manufacturer. All tests are performed with the same final voltage value. For example, the manufacturer cannot use different final voltage values for discharge performance tests at 25 °C ± 5 °C, at low temperature, for the endurance tests, etc.

6.3 Discharge performance

6.3.1 Discharge performance at +25 °C

This test verifies the rated capacity of a cell or battery.

Step 1 – The cell or battery shall be fully charged in accordance with 6.2.

Step 2 – The cell or battery shall be stored in an ambient temperature of 25 °C ± 5 °C, for not less than 1 h and not more than 4 h.

Step 3 – The cell or battery shall then be discharged in the same ambient temperature and as specified in Table 2 to the final voltage specified by the manufacturer in 6.2.

Step 4 – The capacity (Ah), delivered during step 3, shall not be less than that specified for this characteristic in Table 2.

Table 2 – Discharge performance at +25 °C ± 5 °C

Discharge conditions		Minimum discharge capacity			
Rate of constant current	Final voltage declared by the manufacturer	Discharge rate type			
A	V	S	E	M	H
(1/n) I_t	Refer to 6.2	100 % Cn Ah			
0,2 I_t [a]	Refer to 6.2		100 % C_5 Ah	100 % C_5 Ah	100 % C_5 Ah
1,0 I_t	Refer to 6.2		–	95 % C_5 Ah	95 % C_5 Ah
5,0 I_t [b]	Refer to 6.2		–	–	90 % C_5 Ah

[a] Five cycles are permitted for this test which shall be terminated at the end of the first cycle which meets the requirement

[b] Prior to the 5 I_t A discharge tests, a conditioning cycle may be included if necessary. This cycle shall consist of charging and discharging in accordance with 6.2.

6.3.2 Discharge performance at low temperature

This test identifies the temperature at which a capacity of not less than 70 % of the rated capacity can be achieved.

This test verifies the discharge performance at low temperature of the cell or battery. It shall be measured in accordance with the following steps.

Step 1 – The cell or battery shall be fully charged in accordance with 6.2.

Step 2 – The cell or battery shall be stored for not less than 16 h and not more than 24 h at an ambient “target” test temperature which is specified by the manufacturer.

Step 3 – The cell or battery shall then be discharged at the same target test temperature and at the discharge rates specified in Table 3 to the manufacturer’s declared final voltage as defined in 6.2.

Step 4 – The capacity (Ah), delivered during step 3 shall be not less than that specified for the cell type and discharge currents in Table 3.

The cell or battery's low temperature ~~discharge performance~~ grade TL can be declared at 10 °C intervals, such as +10 °C, 0 °C, −10 °C and −20 °C. The declared temperature should be in the range of the target test temperature and target test temperature plus 10 °C. For example, if the test is performed at −27 °C, the declared temperature should be −20 °C. The temperature grade is the highest temperature among the tests for discharge rate type M and H. For example, if an "H" type cell has a discharge capacity higher than 70 % of the rated capacity: at −30 °C with 0,2 I_t A, at −20 °C, with 1,0 I_t A and at −10 °C with 5,0 I_t A, the temperature grade is judged as "−10 °C".

Table 3 – Discharge performance at low temperature

Discharge conditions		Minimum discharge capacity			
Rate of constant current	Final voltage declared by the manufacturer	Discharge rate type			
A	V	S	E	M	H
$(1/n)\ I_t$	Refer to 6.2	70 % Cn Ah	–	–	–
0,2 I_t	Refer to 6.2		70 % C_5 Ah	70 % C_5 Ah	70 % C_5 Ah
1,0 I_t	Refer to 6.2		–	70 % C_5 Ah	70 % C_5 Ah
5,0 I_t	Refer to 6.2		–	–	70 % C_5 Ah

6.3.3 High rate permissible current

6.3.3.1 General

This test is to evaluate the ability of an “H” or “M” type cell or battery to withstand high currents.

6.3.3.2 Test method

Step 1 – The cell or battery shall be fully charged in accordance with 6.2.

Step 2 – The cell or battery shall be stored for not less than 1 h and not more than 4 h in an ambient temperature of 25 °C ± 5 °C.

Step 3 – It shall then be discharged for 5 ± 0,1 s at 25 °C ± 5 °C and at the currents specified in Table 4. During the discharge the terminal voltage shall be recorded.

Step 4 – The capacity at 0,2 I_t A of the cell or battery is measured according to 6.3.1.

Table 4 – Discharge current values for high rate permissible test

Discharge rate type	Rate of constant current
S	N/A
E	N/A
M	Minimum 6 I_t A
H	Minimum 20 I_t A

6.3.3.3 Acceptance criterion

No fusing, no deformation of the cell or battery case, and no leakage shall be observed. In addition, the cell or battery voltage during the discharge shall show no discontinuity. The capacity of the cell or battery shall be not less than 95 % of the rated capacity.

6.4 Charge (capacity) retention and recovery

6.4.1 General

This test determines firstly the capacity which a cell retains after storage for an extended period of time, and secondly the capacity that can be recovered by a subsequent recharge.

6.4.2 Test method

Step 1 – The cell shall be charged in accordance with 6.2.

Step 2 – The cell shall be stored in an ambient temperature of 25 °C ± 5 °C, for 28 days.

Step 3 – The cell shall be discharged in an ambient temperature of 25 °C ± 5 °C, at a constant current of 0,2 I_t A, until its voltage is equal to the specified final voltage in accordance with 6.2.

Step 4 – The cell shall then be charged in accordance with 6.2, within 24 h following the discharge of step 3.

Step 5 – The cell shall be stored, in an ambient temperature of 25 °C ± 5 °C, for not less than 1 h and not more than 4 h.

Step 6 – The cell shall be discharged, in an ambient temperature of 25 °C ± 5 °C, at a constant current of 0,2 I_t A, until its voltage is equal to the specified final voltage in accordance with 6.2.

6.4.3 Acceptance criterion

The charge retention value which is the value of the discharged capacity obtained at Step 3 shall be not less than 85 % of the rated capacity.

The charge recovery value which is the value of the discharged capacity obtained at Step 6 shall be not less than 90 % of the rated capacity.

6.5 Cell and battery internal resistance

6.5.1 General

This test determines the internal resistance of a secondary lithium cell or battery. The alternating current (a.c.) method is only applied for the cell. The direct current (d.c.) method is applied for the cell and for the battery.

It is not necessary to discharge and charge the cell for re-adjusting the charge level between conducting the a.c. and d.c. measurements.

Step 1 – The cell or battery shall be charged in accordance with 6.2.

Step 2 – The cell or battery shall be stored, in an ambient temperature of 25 °C ± 5 °C, for not less than 1 h and not more than 4 h.

Step 3 – The cell or battery shall be discharged at 25 °C ± 5 °C until the capacity discharged becomes equal to 50 % ± 10 % of the rated capacity.

Step 4 – The measurement of internal resistance shall be performed in accordance with 6.5.2 (cell only) and 6.5.3 in an ambient temperature of 25 °C ± 5 °C.

6.5.2 Measurement of the internal a.c. resistance

6.5.2.1 Measurement

The alternating r.m.s. voltage, U_a, shall be measured while applying an alternating r.m.s. current, I_a, at the frequency of 1,0 kHz ± 0,1 kHz, to the cell, for a period of 1 s to 5 s.

NOTE 1 All voltage measurements are made at the terminals of the cell independently of the contacts used to carry current.

The internal a.c. resistance, R_{ac}, is given by:

$$R_{ac} = \frac{U_a}{I_a}\ (\Omega)$$

where

U_a is the alternating r.m.s. voltage;

I_a is the alternating r.m.s. current.

NOTE 2 The alternating current is selected so that the peak voltage stays below 20 mV.

NOTE 3 This method will measure the impedance, which at the frequency specified is approximately equal to the resistance.

6.5.2.2 Acceptance criterion

The internal a.c. resistance of the cell shall not be greater than the value of R_{ac}, declared by the manufacturer.

6.5.3 Measurement of the internal d.c. resistance

6.5.3.1 Measurement

This test verifies the internal d.c. resistance of the cell or battery. It shall be measured in accordance with the following steps.

Step 1 – The cell or battery shall be discharged at a constant current of value I_1 as specified in Table 5. At the end of a discharge period of 30 ± 0,1 s, the discharge voltage U_1 under load shall be measured and recorded.

Step 2 – The discharge current shall then be immediately increased to a value of I_2 as specified in Table 5 and the corresponding discharge voltage U_2 measured under load and recorded again at the end of a discharge period of 5,0 ± 0,1 s.

Table 5 – Constant discharge current used for measurement of the internal d.c. resistance

Discharge current	Discharge rate type			
	S	E	M	H
I_1	1/5n It or more A	0,04 I_t A	0,2 I_t A	1,0 I_t A
I_2	1/n It or more A	0,2 I_t or more A	1,0 I_t or more A	5,0 I_t or more A
NOTE All voltage measurements are made at the terminals of the cell or battery independently of the contacts used to carry current.				

The internal d.c. resistance, R_{dc}, of the cell or battery shall be calculated using the following formula:

$$R_{dc} = \frac{U_1 - U_2}{I_2 - I_1}(\Omega)$$

where

I_1, I_2 are the constant discharge currents;

U_1, U_2 are the appropriate voltages measured during discharge.

6.5.3.2 Acceptance criterion

The internal d.c. resistance of the cell or battery shall be not greater than the value of R_{dc}, declared by the manufacturer.

6.6 Endurance

6.6.1 Endurance in cycles

6.6.1.1 General

This test is conducted on cells or batteries which are designed for cycle applications (discharge and charge repeating them by turns).

This test verifies the capacity of the cell after 500 cycles. It shall be measured in accordance with the following steps.

6.6.1.2 Measurement

Step 1 – The cell or battery shall be discharged at 25 °C ± 5 °C at a constant current of 1/n I_t A, down to a specified final voltage. The final voltage shall be the same as that declared by the manufacturer according to 6.2.

Step 2 – The cell or battery shall be charged, in an ambient temperature of 25 °C ± 5 °C, using the method declared by the manufacturer.

Step 3 – The cell or battery shall be discharged, in an ambient temperature of 25 °C ± 5 °C, at a constant current of 1/n It A, until its voltage is equal to the specified final voltage. The final voltage shall be the same as that declared by the manufacturer according to 6.2.

NOTE 1 If the manufacturer would like to shorten the time to conduct step 3, the following discharge currents are declared and used: 0,5 I_t A * for E type cell or battery, 1,0 I_t A * for M and H type cell or battery.

Step 4 – Steps 2 and 3 shall be repeated for 500 cycles.

Step 5 – After completing 500 cycles, the capacity measured in discharge at 1/n I_t A is determined according to 6.3.1.

Step 6 – The retention rate shall be calculated from the rated capacity and the capacity measured in step 5.

NOTE 2 n is 5 for E, M and H discharge rate type cells or batteries; n is 8, 10, 20 or 240 for S discharge rate type batteries.

6.6.1.3 Acceptance criterion

The capacity of the cell or battery shall not be less than 60 % of the rated capacity after 500 cycles.

6.6.2 Endurance in storage at constant voltage (permanent charge life)

6.6.2.1 General

This test is conducted on cells or batteries which are designed for stand-by applications.

This test verifies the upper limit of the storage temperature specified by the manufacturer in which a minimum capacity of 85 % of the rated capacity is maintained after 90 days of storage at a constant voltage corresponding to a 100 % state of charge (SOC).

6.6.2.2 Measurement

Step 1 – The cell or battery shall be discharged at 25 °C ± 5 °C at a constant current of 1/n I_t A, down to a specified final voltage.

Step 2 – The cell or battery shall be charged at the target test temperature using the method declared by the manufacturer.

Step 3 – The cell or battery shall be kept at the target test temperature during 90 days in charge at constant voltage corresponding to 100 % state of charge.

NOTE 1 For cells or batteries which are not charged by a “constant voltage charging method” or charged without the long “constant voltage charging” period, the constant charging voltage is specified in accordance with the following method:

Step a) Store the cells or batteries for not less than 1 h and not more than 4 h after step 2.

Step b) Measure the open circuit voltage of cells or batteries.

Step c) Define the voltage measured in step b) as the constant charging voltage.

Step 4 – The cell or battery shall be stored for not less than 8 h and not more than 16 h, in open circuit, in an ambient temperature of 25 °C ± 5 °C.

Step 5 – The capacity measured in discharge at 1/n I_t A is determined according to 6.3.1.

Step 6 – The percentage of rated capacity shall be calculated from the rated capacity and the capacity measured in step 5.

NOTE 2 n is 5 for E, M and H discharge rate type cells or batteries, n is 8, 10, 20 or 240 for S discharge rate type batteries.

6.6.2.3 Acceptance criterion

The capacity of the cell or battery shall not be less than 85 % of the rated capacity after 90 days.

The declared temperature should be in the range of the target test temperature and target test temperature minus 10 °C. For example in the case of test performed at 57 °C, the declared temperature should be 50 °C.

7 Type test conditions

7.1 General

The type test conditions and protocol should be agreed between the manufacturer and the customer. When this is not the case, the following type test conditions shall apply.

7.2 Sample size

Tests are made with the number of cells, cell blocks or batteries specified in Table 6, using cells or batteries that are stored under the condition specified by the manufacturer and that are not more than six months old. Unless otherwise specified, tests are carried out in an ambient temperature of 25 °C ± 5 °C.

NOTE Test conditions are for type tests only. The limit of six months is introduced for consistency and does not imply that battery performance is reduced after six months.

Table 6 – Type test

Test	Clause / Subclause	Cell or Cell block [a]		Battery [b]	
		E	M, H	S, E	M, H
Discharge performance at +25 °C	6.3.1	Y	Y	Y	Y
Discharge performance at low temperature	6.3.2	Y	Y	Y	Y
High rate permissible current	6.3.3	–	Y	–	Y
Charge (capacity) retention and recovery	6.4	Y	Y	–	–
Internal a.c. resistance	6.5.2	Y	Y	–	–
Internal d.c. resistance	6.5.3	Y	Y	Y	Y
Endurance in cycle [c]	6.6.1	Y	Y	Y	Y
Endurance in storage at constant voltage (permanent charge life) [d]	6.6.2	Y	Y	Y	Y

Key

"Y" indicates that the test is required: the sample number is at least one.

"-" indicates that the test is not required.

[a] The manufacturer can use a cell block instead of a single cell for the tests. The test report shall indicate whether a cell or cell block is used for each test in the test results.

[b] If a battery system can be divided into smaller unit, the divided unit can be used for the tests. When the smaller unit is used, the test can be performed by applying the function equipped in battery system. If the smaller divided unit is used for the tests, the tests should be performed under the same charge and discharge conditions as the battery system. The test report should clearly indicate about tested unit.

[c] The test is performed for cell, cell block or battery designed either for cycle application or for cycle and stand-by application.

[d] The test is performed for cell, cell block or battery designed either for stand-by application or for cycle and stand-by application.