

UN Recommendations on the Transport of Dangerous Goods  
 - Manual of Tests and Criteria - 38.3 Lithium Batteries

1. Sample model name : Small Lithium ion rechargeable battery
2. Model name / Ratings : SLB03070LR35 / 2.4V 0.35mAh
3. Spec. (Charge/Discharge current) : Maximum 7mA, Normal 0.35mA
4. Date of test : 6.Nov.2018 to 15.Dec.2018
5. Company information

Test : Nichicon Ohno Site III, 4085 Toyoshina, Azumino-shi, Nagano Pref., Japan, 399-8205  
 Tel +81 263 72 2830

Manufacturer : Nichicon Ohno Site II, 4-25-15, Tsuchifugo, Ohno-shi, Fukui Pref., Japan, 912-0805  
 Tel +81 779 65 8800

6. Test Criteria

	Test item	Criteria
T1	Altitude Simulation	No leakage, vent release, rupture, cleavage and ignition. OCV shall be over 90% before the testing.
T2	Thermal test	No leakage, vent release, rupture, cleavage and ignition. OCV shall be over 90% before the testing.
T3	Vibration	No leakage, vent release, rupture, cleavage and ignition. OCV shall be over 90% before or during the testing.
T4	Shock	No leakage, vent release, rupture, cleavage and ignition. OCV shall be over 90% before the testing.
T5	External short circuit	External temperature shall not exceed 170 ° C. No rupture, cleavage and ignition during the test and within 6 hours after the test.
T6	Impact / Crush	External temperature shall not exceed 170 ° C. No rupture, cleavage and ignition during the test and within 6 hours after the test.
T7	Overcharge	Not applicable
T8	Forced discharge	There shall be no rupture or ignition within the test and within 7 days after the test.

- In test T.1~T.5, it must be done continuously for the same specimen.

When testing specimen on the basis of test T.1~T.5, the object of implementation is as follows.

Specimen in a fully charged state in the first cycle: 10 pcs

- Test T.6 & T.8 shall be carried out using a specimen not used for other tests.

1. When testing specimen on the basis of test T.6, the object of implementation is as follows.

Charged specimen charged to 50% of the rated capacity determined by the manufacturer in the first cycle: 5 pcs

2. When testing specimen on the basis of test T.8, the object of implementation is as follows.

(1) Specimen in fully discharged state in the first cycle: 10 pcs

(2) Specimen in fully discharged state after 50 times charge and discharge cycle: 10 pcs

Test Standards ST/SG/AC.10/11/Rev.6

Recommendations on the Transport of Dangerous Goods:  
 Manual of Test and Criteria, Part III, Sub-Section 38.3  
 Lithium metal and lithium ion batteries

## Test T.1; Altitude simulation

- **Purpose**

This test assumes a low-pressure condition during air transport.

- **Test method**

Specimen; Store n = 10 for at least 6 hours at ambient temperature ( $20 \pm 5$  ° C) and atmospheric pressure 11.6 kPa or less.

- **Requirements**

The specimen shall be free from leakage, valve actuation, rupture, cleavage and ignition and the open-circuit voltage after the test is the voltage immediately before the test 90% or more.

- **Judgment**

Test T.1 Fulfill the requirements for the implementation conditions and judge it to pass.

### Evaluation method

Cell of  $\phi 3 \times 7$  L (0.35 mAh) is charged to 100% SOC. After that, Perform the test with standing for 5 hours in an open circuit. Reduce to 11.6 kPa or less with an environmental testing machine in a dry room at 20 ° C, and hold for 6 hours as it is. Also, confirm there is no change in voltage and appearance before and after the test.

### Result

All of the 10 tests, there was no leakage, valve actuation, rupture, cleavage and ignition. Before and after the test., it was confirmed that the voltage drop of the specimen satisfied the requirements.

(Vave. = 99.15%, Vmax. = 99.57%, Vmin. = 98.42%)

It satisfied the requirements because leakage was not observed from appearance and weight loss confirmation.

Table1. Appearance of test article after test T.1

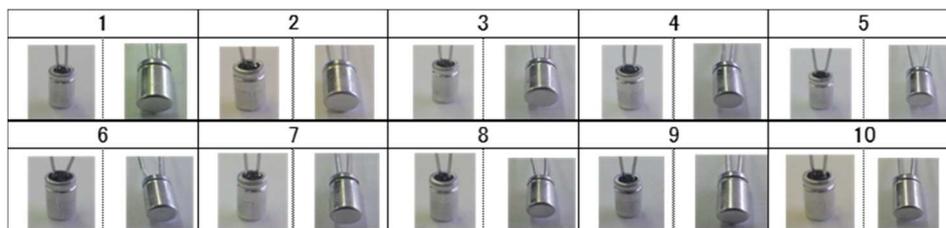


Table2. Voltage and weight change of specimen before and after test T.1

No.	Before: $V_B$ (V)	After: $V_A$ (V)	$V_A / V_B$ (%)	Judgement	No.	Before (g)	After (g)	$\Delta$ wt%	Judgement
1	2.792	2.777	99.46	Passed	1	0.1381	0.1380	0.08	Passed
2	2.792	2.756	98.71	Passed	2	0.1371	0.1370	0.11	Passed
3	2.792	2.777	99.46	Passed	3	0.1366	0.1365	0.07	Passed
4	2.792	2.780	99.57	Passed	4	0.1390	0.1389	0.06	Passed
5	2.751	2.709	98.47	Passed	5	0.1375	0.1374	0.08	Passed
6	2.791	2.774	99.39	Passed	6	0.1380	0.1379	0.04	Passed
7	2.791	2.772	99.32	Passed	7	0.1379	0.1378	0.08	Passed
8	2.791	2.747	98.42	Passed	8	0.1385	0.1384	0.06	Passed
9	2.790	2.768	99.21	Passed	9	0.1366	0.1364	0.11	Passed
10	2.791	2.775	99.43	Passed	10	0.1375	0.1373	0.11	Passed
ave.	2.787	2.764	99.15		ave.	0.1377	0.1376	0.08	
max.	2.792	2.780	99.57		max.	0.1390	0.1389	0.11	
min.	2.751	2.709	98.42		min.	0.1366	0.1364	0.04	

## Test T.2; Thermal test

- **Purpose**

This test evaluates the product's sealability and internal electrical connections.

For this test, rapid and extreme temperature change is used.

- **Test method**

Store specimens at a test temperature of  $72 \pm 2^\circ\text{C}$  for a minimum of 6 hours and then store at minimum test temperature  $-40 \pm 2^\circ\text{C}$  for at least 6 hours. (The interval between test temperatures shall be at most 30 minutes) After this test, procedure is repeated ten times in total, store the specimen at ambient temperature ( $20 \pm 5^\circ\text{C}$ ) for 24 hours.

- **Requirements**

The specimen shall be free from leakage, valve actuation, rupture, cleavage and ignition and the open-circuit voltage after the test is the voltage immediately before the test 90% or more.

- **Judgment**

Test T.2 Fulfill the requirements for the implementation conditions and judge it to pass.

### Evaluation method

T.2 test is carried out using  $\phi 3 \times 7\text{ L}$  (0.35 mAh) cells after T.1 was performed. A small thermal shock device (TSE-12-A; ESPEC) is used for the test. After holding at  $72^\circ\text{C}$  for 6 hours, perform a test to hold at  $-40^\circ\text{C}$  for 6 hours. (Intervals are not taken when high temperature  $\leftrightarrow$  low temperature movement)

### Result

All of the 10 tests, there was no leakage, valve actuation, rupture, cleavage and ignition. Before and after the test., it was confirmed that the voltage drop of the specimen satisfied the requirements.

(Vave. = 96.92%, Vmax. = 97.65%, Vmin. = 96.50%)

It satisfied the requirements because leakage was not observed from appearance and weight loss confirmation.

Table3. Appearance of test article after test T.2

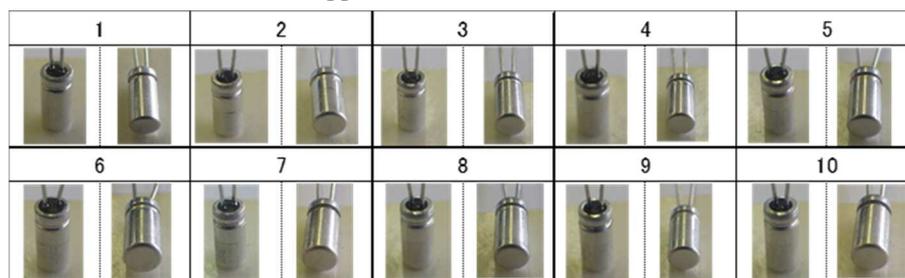


Table4. Voltage and weight change of specimen before and after test T.2

No.	Before: $V_B$ (V)	After: $V_A$ (V)	$V_A / V_B$ (%)	Judgement	No.	Before (g)	After (g)	$\Delta$ wt%	Judgement
1	2.730	2.654	97.22	Passed	1	0.1379	0.1376	0.22	Passed
2	2.742	2.657	96.91	Passed	2	0.1366	0.1363	0.25	Passed
3	2.771	2.674	96.50	Passed	3	0.1361	0.1358	0.19	Passed
4	2.737	2.658	97.12	Passed	4	0.1385	0.1382	0.15	Passed
5	2.705	2.641	97.65	Passed	5	0.1369	0.1367	0.13	Passed
6	2.768	2.672	96.53	Passed	6	0.1374	0.1373	0.11	Passed
7	2.753	2.668	96.91	Passed	7	0.1374	0.1372	0.10	Passed
8	2.738	2.652	96.87	Passed	8	0.1379	0.1376	0.25	Passed
9	2.764	2.668	96.53	Passed	9	0.1360	0.1359	0.06	Passed
10	2.745	2.661	96.94	Passed	10	0.1369	0.1368	0.03	Passed
ave.	2.745	2.661	96.92		ave.	0.1372	0.1370	0.15	
max.	2.771	2.674	97.65		max.	0.1385	0.1382	0.25	
min.	2.705	2.641	96.50		min.	0.1360	0.1358	0.03	

## Test T.3; Vibration

- **Purpose**

This test assumes vibration during shipment.

- **Test method**

Fix the vibrating device firmly on the platform (vibration table) of the vibrating device so that vibrations are reliably transmitted without deforming the specimen. Vibration shall be logarithmic sweep of sinusoidal waveform and sweep frequency 7 Hz → 200 Hz → 7 Hz in 15 minutes. Repeat this set twelve times for each of the three alternating vertical directions of the specimen. That is, the test time is 3 hours in each direction, for a total of 9 hours. One of the directions of vibration must be perpendicular to the terminal face.

Logarithmic sweep rate; Maintain peak acceleration at 1gn from 7 Hz to 18 Hz. After that, the amplitude is kept at 0.8 mm (full amplitude 1.6 mm), and the vibration is increased until the peak acceleration becomes 8 gn (about 50 Hz). After that, maintain a peak acceleration of 8 gn until the vibration rises to 200 Hz.

- **Requirements**

The specimen shall be free from leakage, valve actuation, rupture, cleavage and ignition and the open-circuit voltage after the test is the voltage immediately before the test 90% or more.

- **Judgment**

Test T.3 Fulfill the requirements for the implementation conditions and judge it to pass.

### Evaluation method

T.3 test is carried out using a cell of  $\phi 3 \times 7$  L (0.35 mAh) after T.2 was performed. A vibration test apparatus is used for the test. According to the conditions described in the test method, it is accelerated at 1 G for 7 → 18 Hz, 8 G at 18 → 200 Hz. At that time, the amplitude is fixed at 1.8 mm. After reaching 200 Hz, deceleration is performed under reverse conditions as one cycle, and a total of 12 cycles were performed. This is done for X, Y, Z direction. Confirm that there is no change in voltage and appearance after the test.

### Result

All of the 10 tests, there is no leakage, valve actuation, rupture, cleavage and ignition. Before and after the test., it was confirmed that the voltage drop of the specimen satisfied the requirements.

(Vave. = 98.78%, Vmax. = 99.63%, Vmin. = 97.57%)

It satisfied the requirements because leakage was not observed from appearance and weight loss confirmation.

Table5. Appearance of test article after test T.3

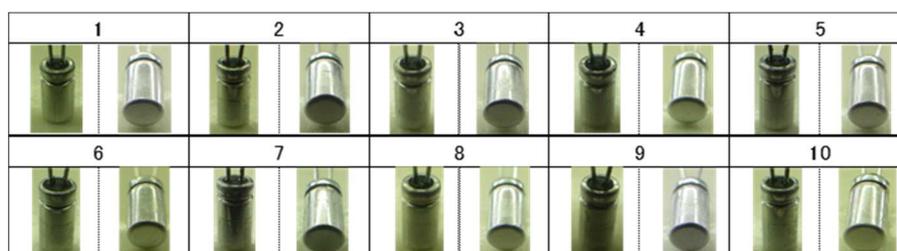


Table6. Voltage and weight change of specimen before and after test T.3

No.	Before: $V_B$ (V)	After: $V_A$ (V)	$V_A / V_B$ (%)	Judgement	No.	Before (g)	After (g)	$\Delta$ wt%	Judgement
1	2.654	2.638	99.38	Passed	1	0.1376	0.1376	0.03	Passed
2	2.657	2.647	99.63	Passed	2	0.1363	0.1363	0.00	Passed
3	2.674	2.659	99.44	Passed	3	0.1358	0.1358	0.00	Passed
4	2.658	2.594	97.57	Passed	4	0.1382	0.1382	0.00	Passed
5	2.641	2.610	98.82	Passed	5	0.1367	0.1367	0.00	Passed
6	2.672	2.658	99.49	Passed	6	0.1373	0.1373	0.01	Passed
7	2.668	2.633	98.68	Passed	7	0.1372	0.1372	0.00	Passed
8	2.652	2.627	99.06	Passed	8	0.1376	0.1376	0.00	Passed
9	2.668	2.618	98.13	Passed	9	0.1359	0.1359	0.01	Passed
10	2.661	2.598	97.62	Passed	10	0.1368	0.1368	0.00	Passed
ave.	2.661	2.628	98.78		ave.	0.1370	0.1369	0.01	
max.	2.674	2.659	99.63		max.	0.1382	0.1382	0.03	
min.	2.641	2.594	97.57		min.	0.1358	0.1358	0.00	

### Test T.4; Shock

• **Purpose**

This test evaluates the toughness of the product against the accumulation of impact.

• **Test method**

The sample to be tested rigidly fixes all fixation surfaces to the test equipment. Give each sample a peak acceleration of 150 gn, a half-sine impulse with a pulse duration of 6 ms. Shock each sample a total of 18 times (three times in the positive direction and three times in the negative direction) in three mutually perpendicular directions.

• **Requirements**

The specimen shall be free from leakage, valve actuation, rupture, cleavage and ignition and the open-circuit voltage after the test is the voltage immediately before the test 90% or more.

• **Judgment**

Test T.4 Fulfill the requirements for the implementation conditions and judge it to pass.

### Evaluation method

T.4 test is carried out using a cell of  $\phi 3 \times 7$  L (0.35 mAh) after T.3 was performed. An impact test device is used for the test. According to the conditions described in the test method, Give each sample a peak acceleration of 150 gn, a half-sine impulse with a pulse duration of 6 ms. Shock each sample a total of 18 times (three times in the positive direction and three times in the negative direction) in three mutually perpendicular directions.

### Result

All of the 10 tests, there was no leakage, valve actuation, rupture, cleavage and ignition. Before and after the test., it was confirmed that the voltage drop of the specimen satisfied the requirements.

(Vave. = 99.75%, Vmax. = 99.89%, Vmin. = 99.55%)

It satisfied the requirements because leakage was not observed from appearance and weight loss confirmation.

Table7. Appearance of test article after test T.4

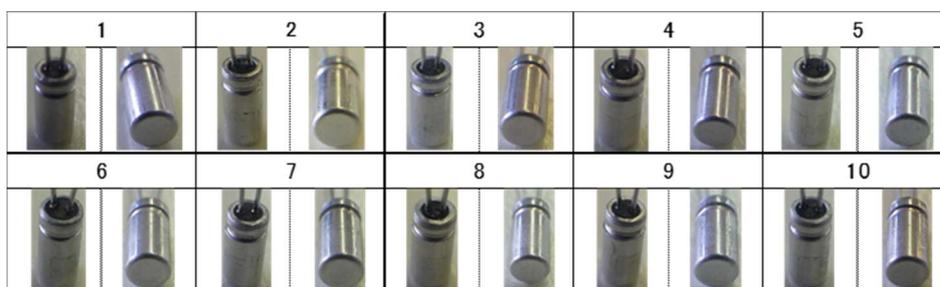


Table8. Voltage and weight change of specimen before and after test T.4

No.	Before: $V_B$ (V)	After: $V_A$ (V)	$V_A / V_B$ (%)	Judgement	No.	Before (g)	After (g)	$\Delta$ wt%	Judgement
1	2.638	2.635	99.89	Passed	1	0.1376	0.1376	0.00	Passed
2	2.647	2.644	99.86	Passed	2	0.1363	0.1363	0.00	Passed
3	2.659	2.649	99.62	Passed	3	0.1358	0.1358	0.00	Passed
4	2.594	2.585	99.66	Passed	4	0.1382	0.1382	0.03	Passed
5	2.610	2.605	99.79	Passed	5	0.1367	0.1367	0.00	Passed
6	2.658	2.656	99.89	Passed	6	0.1373	0.1373	0.00	Passed
7	2.633	2.621	99.55	Passed	7	0.1372	0.1372	0.02	Passed
8	2.627	2.623	99.83	Passed	8	0.1376	0.1376	0.00	Passed
9	2.618	2.610	99.67	Passed	9	0.1359	0.1359	0.00	Passed
10	2.598	2.591	99.75	Passed	10	0.1368	0.1368	0.01	Passed
ave.	2.628	2.622	99.75		ave.	0.1369	0.1369	0.01	
max.	2.659	2.656	99.89		max.	0.1382	0.1382	0.03	
min.	2.594	2.585	99.55		min.	0.1358	0.1358	0.00	

## Test T.5; External short circuit

- **Purpose**

This test assumes an external short circuit.

- **Test method**

Heat the sample to be tested for a certain time so that the temperature of the outer case is evenly stabilized at  $57 \pm 4$  ° C. It is desirable that this time is determined by the size and type of sample and documented. If it can not be determined, in the case of a small sample, it is exposed temperature for 6 hours. Then, the sample is brought to a single short circuit condition at  $57 \pm 4$  ° C. with a total external resistance less than 0.1  $\Omega$ . The short circuit condition is maintained for at least 1 hour after the temperature of the outer case of the sample has returned to  $57 \pm 4$  ° C.

- **Requirements**

The specimen shall be free of rupture, cleavage and ignition during the test and within 6 hours after the test and the external temperature of the sample shall not exceed 170 ° C.

- **Judgment**

Test T.5 Fulfill the requirements for the implementation conditions and judge it to pass.

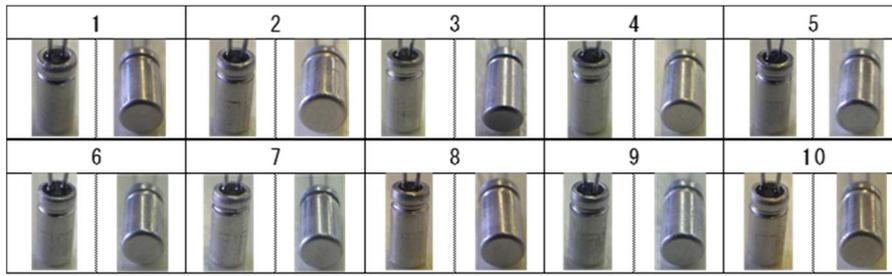
### Evaluation method

T.5 test was carried out using a cell of  $\phi 3 \times 7$  L (0.35 mAh) after T.4 was performed. After exposing the specimen to an environmental test machine of 57 ° C for 6 hours or more, the test was short-circuited by connecting a shunt resistor of 5 mohm from the outside of the environmental testing machine. Check the voltage drop due to the short circuit during the test, the temperature of the outer wall of the specimen accompanying it, and the appearance after the test is not abnormal.

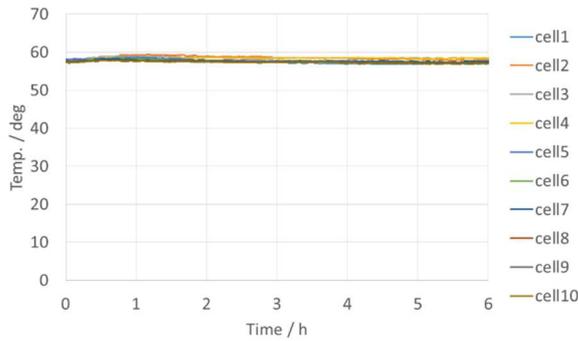
### Result

All of the 10 tests, there was no remarkable heat generation in the outer wall of the test article and no abnormality was confirmed on the appearance after the test.

Table9. Appearance of test specimen after test T.5



Graph1. Test T.5 Temperature during test



Graph2. Test T.5 Voltage under test

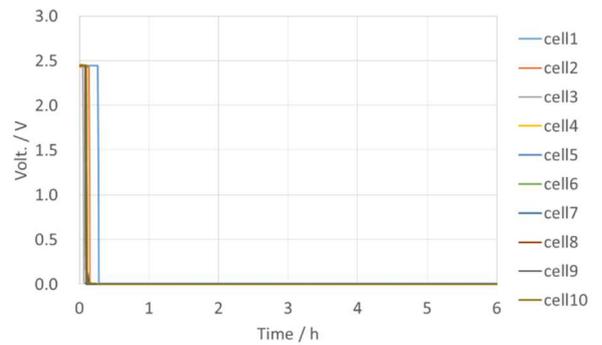


Table10. Voltage and temperature of specimen after 6hours

	Temp.(deg)	Volt.(V)
Cell 1	57.0	0.002
Cell 2	57.8	0.001
Cell 3	57.8	0.001
Cell 4	57.9	0.002
Cell 5	57.2	0.002
Cell 6	57.4	0.002
Cell 7	57.5	0.002
Cell 8	57.1	0.002
Cell 9	57.1	0.002
Cell 10	57.0	0.002

## Test T.6; Impact / Crush

### • Purpose

This test assumes a mechanical malfunction at crush which can cause internal short circuit.

### • Test method

Sandwich the specimen between two flat plates and crush. Crush the first contact point at a speed of approximately 1.5 cm / s. Crush continues until it reaches any of the following three conditions.

- The applied pressure reaches 13 kN  $\pm$  0.78 kN.
- The voltage drop of the single cell becomes at least 100 mV or more.
- The unit cell collapses to 50% or less of the initial thickness.

In case of any of (a), (b), (c), the pressure must be released.

In the case of cylindrical cells, the compression pressure is applied perpendicular to the vertical axis.

Each specimen must be crushed only once and observed for another 6 hours. In addition, the test shall be conducted using a sample not subjected to other tests in advance.

- **Requirements**

The specimen shall be free of rupture, cleavage and ignition during the test and within 6 hours after the test and the external temperature of the sample shall not exceed 170 ° C.

- **Judgment**

Test T.6 Fulfill the requirements for the implementation conditions and judge it to pass.

**Result**

All of the 5 tests, there was no remarkable heat generation in the outer wall of the test article and during the test and within 6 hours after the test.

No rupture or ignition was confirmed.

Graph3. Test T.6 Temperature during test

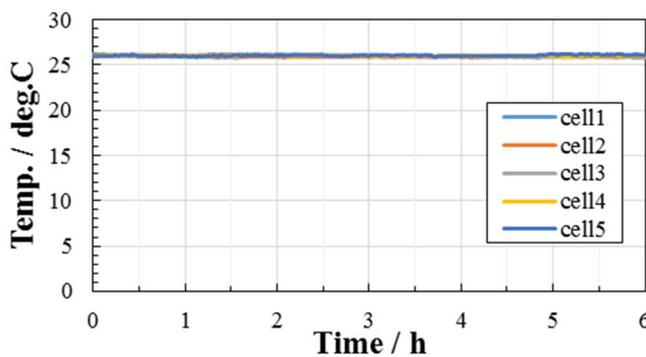
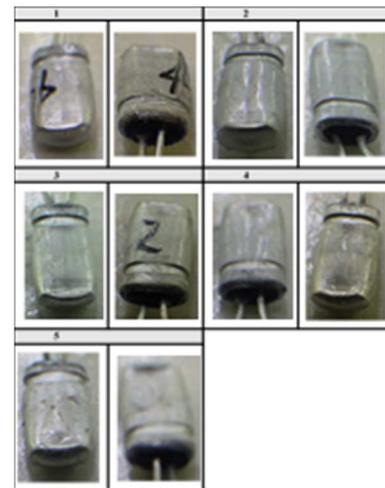


Table11. Appearance of test specimen after test T.6



**Test T.8; Forced discharge**

- **Purpose**

This test evaluates the endurance of the product against forced discharge conditions.

- **Test method**

Each specimen is connected in series with a 12 V DC power supply and forcedly discharged at room temperature with an initial current equal to the manufacturer determine maximum discharge current. A specific discharge current shall be obtained by connecting a resistive load of appropriate size and rating in series to the specimen. Each specimen forcedly discharges for a time (hour) equal to the rated capacity divided by the initial test current (amps).

- **Requirements**

The specimen shall not show rupture or ignition within the test and within 7 days after the test.

- **Judgment**

Test T.8 Fulfill the requirements for the implementation conditions and judge it to pass.

**Evaluation method**

Prepare 10 specimens each of (a) and (b).

- a. Specimens in the fully discharged state in the first cycle
  - b. Specimens in the fully discharged state after After 50 charge / discharge cycles
- (charge and discharge cycles are performed with SOC 0 - 100% at 20 Cycle)

After connecting them to the DC power supply device with reverse terminals, apply a maximum of 12 V at the rated maximum current (20 C = 7.0 mA) and reverse charge for 3 minutes. Confirm that abnormality does not occur in the appearance during the test and after the test.

**Result**

(a) , (b) For all specimens, there is no rupture or ignition was observed during the test and within 7 days after the test.

Table.12 Appearance of test article after test T.8 (a)

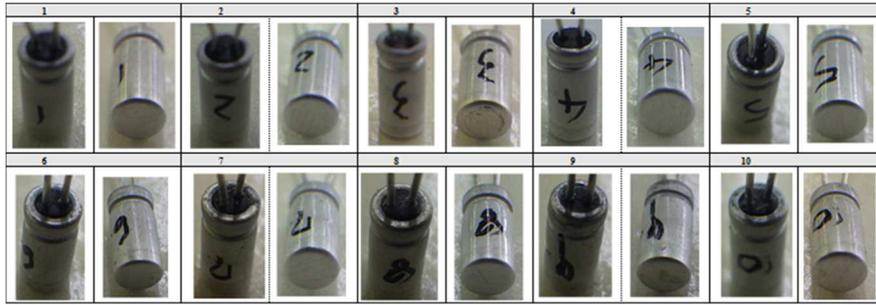
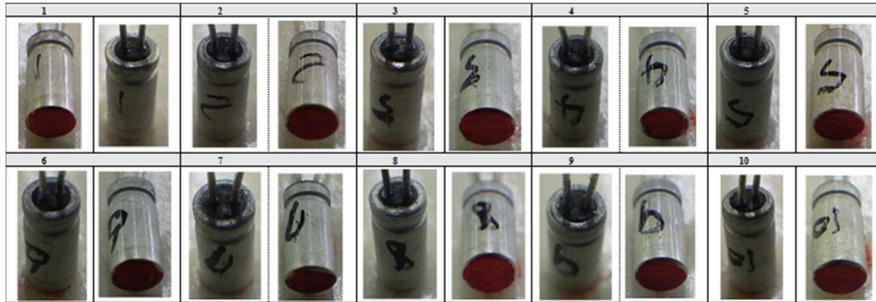
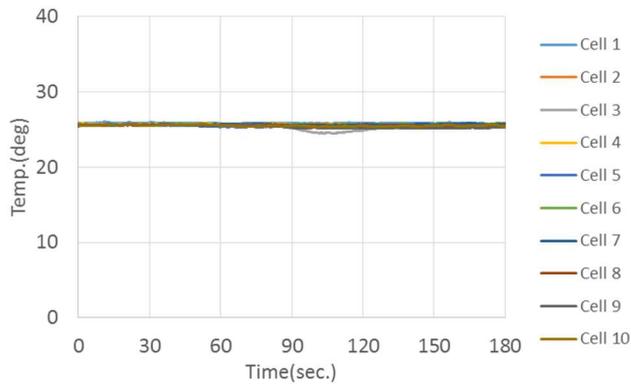


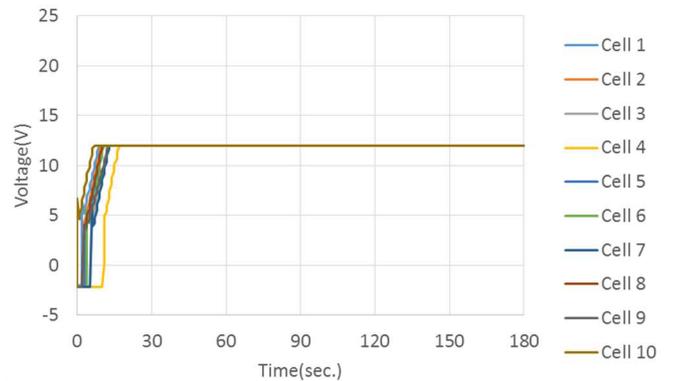
Table.13 Appearance of test article after test T.8 (b)



Graph4. Test T.8 Temperature during test



Graph5. Test T.8 Voltage under test



Thanks and Best regards

- The UN38.3 tests were performed by the following test house.

Manufacturer  
 4-25-15, Tsuchifugo, Ohno-shi, Fukui  
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 http://www.nichicon.co.jp/

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