Test Report

Product: Li-SOCI2 Battery

Model: VTC-ER14250

Test type: Battery cycle life

VTC Power Co.,Ltd

R&D Laboratory

1、Introduction

Battery life include cycle life and storage life.

Cycle life: battery working/using time under certain conditions (temperature and humidity load method).

Storage life: the time for a battery to be stored in a certain environment and its capacity fall to 80% ,but different manufactures and different batteries have different definitions. Base on theelectrochemical point, there are three kinds of test methods for battery life and self-discharge in general laboratories:

(1) Measure battery self-discharge: After the storage time is determined, the capacity of the battery is directly measured.

(2) High temperature storage testing: increase battery self-discharge rate and accelerate the cycle life measurement.

(3) Microthermal analysis method through direct measurement of heat consumption.

Remark: (1) and (2) methods are commonly used by battery manufacturers for self-discharge testing, and (3) methods need to be used first the measurement instrument, few battery manufacturers use this method.

2、 Self-discharge Testing

2.1 The definition of self-discharge: battery capacity will automatically decrease when it is stored under some conditions. This phenomenon is called self-discharge.

2.2 Self-discharge calculation formula: see equation

Self-discharge=(C0-Ct)÷C0 ÷t×100%

C0 ——Capacity before storage /Ah

Ct ——Capacity after storage/Ah

t ——Storage time(day/week/year)

3、Testing

3.1 Testing equipment or instrument:

The internal resistance of DC voltmeter or oscilloscope with accuracy not less than 0.5 should be greater than 10MΩ.

Precision resistance: tolerance less than 0.5%

Resistance box: tolerance less than 0.5%

Thermostat: tolerance less than ±1.5℃

Battery program control tester: tolerance is less than ± 0.3%

3.2 Testing Terms

No.	Testing Terms	Sample Qty
FA1	The new cell is continuously discharged at the standard temperature of 23±3℃ with the standard current of 3.5KΩ(~1mA) Discharge capacity up to 2V. (pre-storage test)	3PCS
FB1	The new cell is stored at 23±3℃ for 1 year, 3 years and 6 years at the standard current of 3.5KΩ(~1mA). Discharge capacity of continuous discharge to 2V. (Long-term storage test)	3×3PCS
FC1	The new cell is stored at 70±3℃ for 180 days and discharged continuously at the standard current of 3.5KΩ(~1mA) Discharge capacity up to 2V. (High temperature accelerated storage test)	3PCS

3.3 Testing

3.3.1、Testing Term—FA1

3.3.1.1 Testing Method:

After the new cell off the machine, in the thermostat (23±3℃) storage for 3 days, the battery cell in the thermostat (23±3℃) under the open circuit and capacity detection. When testing the capacity, the battery should remain upright with the positive terminal up and discharge to 2V.

3.3.1.2 Testing requirement:

(1) Open circuit voltage: 3.65~3.70V.

(2) Capacity test: 3.5KΩ(~1mA) continuous discharge, after 1 hour voltage reading value ≥3.50V, discharge to 2V capacity.

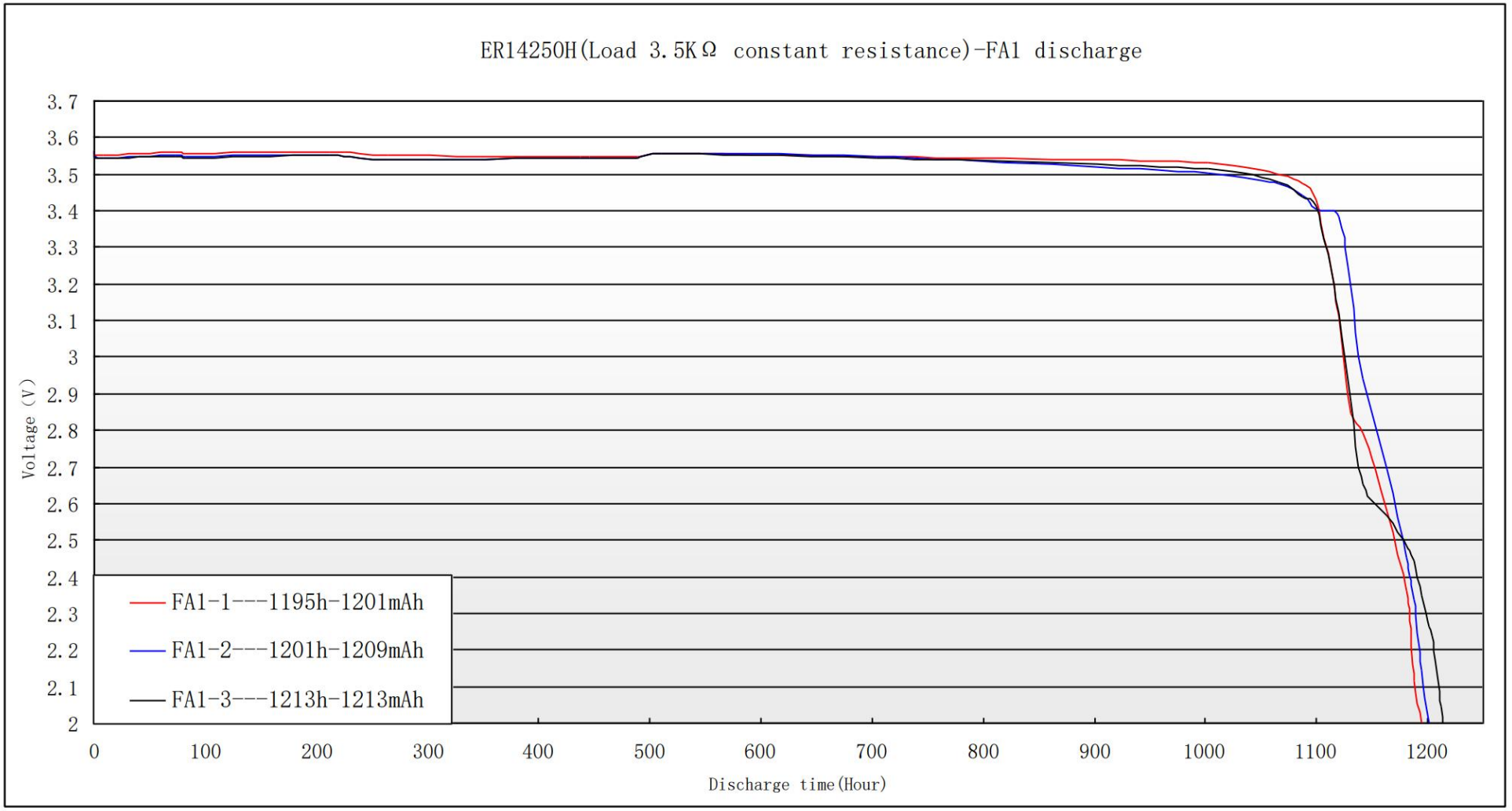
(3) The battery should not have leakage.

3.3.1.3 Test results are shown in Table 3.3.1.3-1

Table 3.3.1.3-1

No.	Open circuit voltage	Working voltage	Discharge capacity	Average Capacity	Visual leakage
1	3.663V	3.552V	1201mAh	1208mAh	No
2	3.663V	3.547V	1209mAh		No
3	3.662V	3.545V	1213mAh		No

Discharge curve(1)



3.3.2、Testing Term—FB1

3.3.2.1 Testing Method：

After the new battery cell off the machine, in the incubator (23±3℃) storage for 3 days, the battery in the incubator (23±3℃) under the condition of open detection, and then continue to store at the temperature for 1 year, 3 years, 6 years respectively capacity detection. When testing the capacity, the battery should remain upright with the positive terminal up and discharge to 2V.

3.3.2.2 Testing Requirement：

(1) Open circuit voltage: 3.65~3.70V

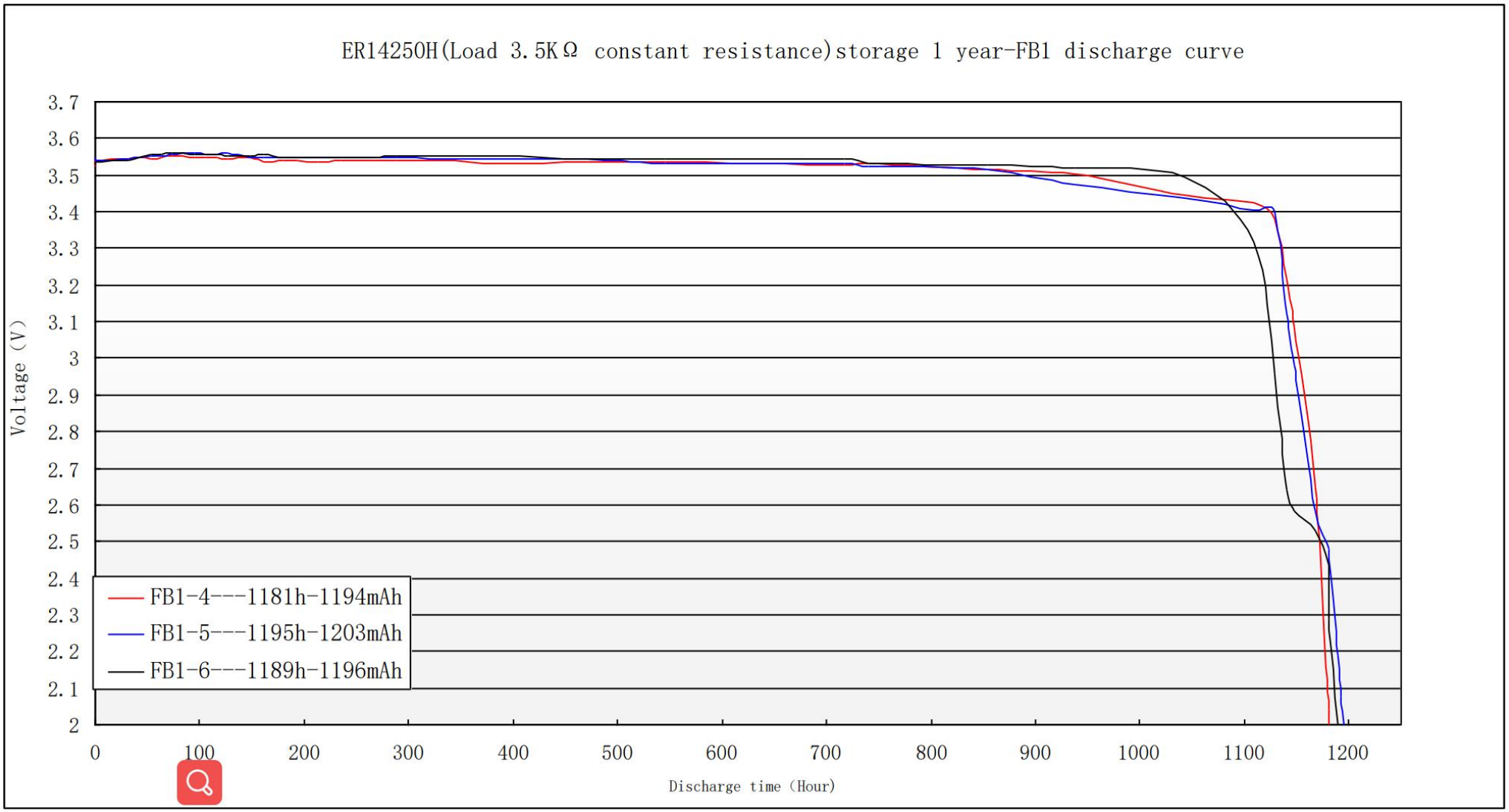
(2) Capacity test: 3.5KΩ(~1mA) continuous discharge, after 1 hour voltage reading value ≥3.50V, discharge 2V capacity.

(3) The battery should not have leakage.3.3.2.3 Testing Result： Table 3.3.2.3-2

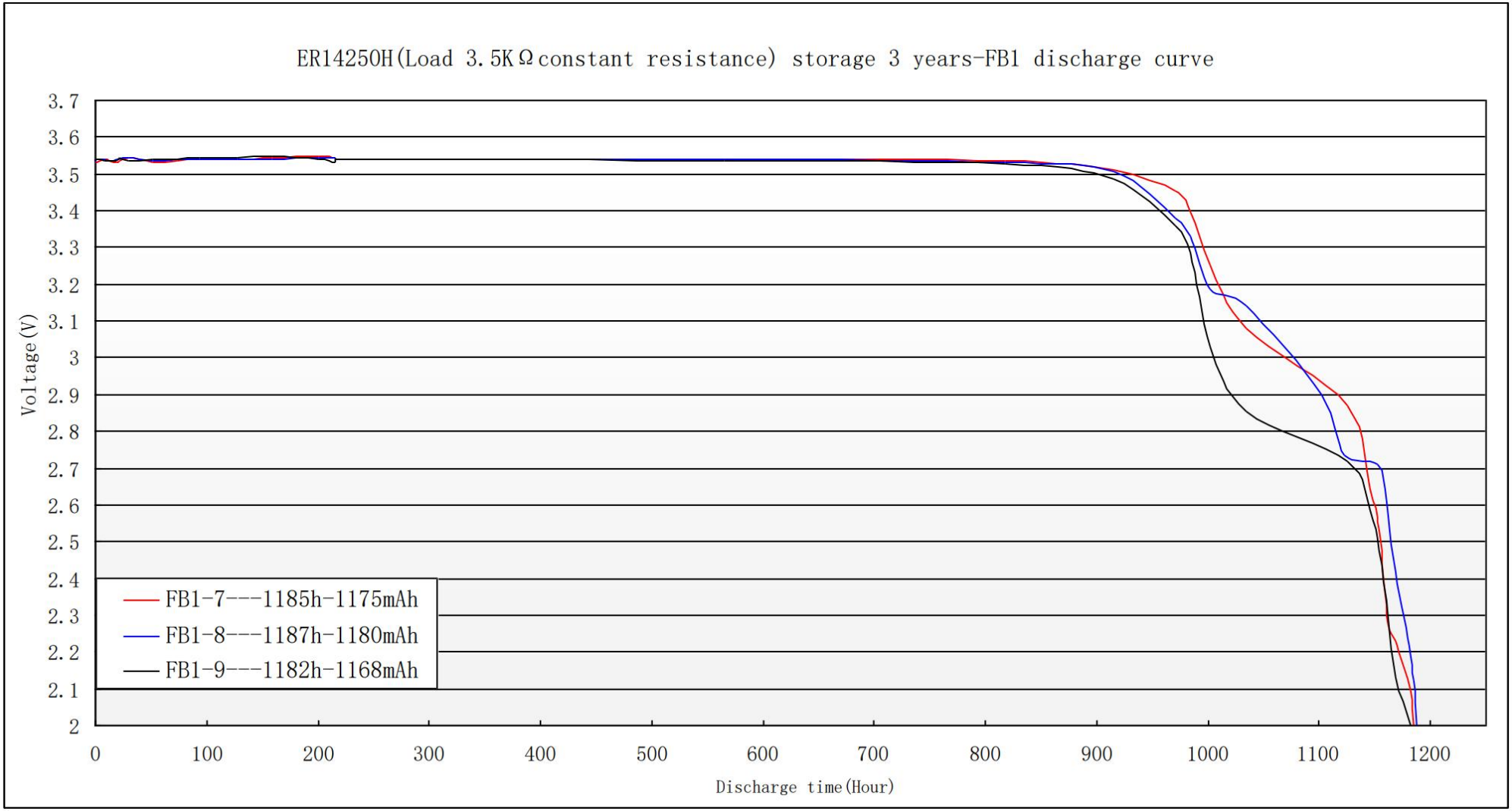
Table 3.3.2.3-2

Time	1year			3years			6years		
No.	4	5	6	7	8	9	10	11	12
Open circuit voltage (V)	3.661	3.662	3.661	3.663	3.663	3.662	3.663	3.662	3.661
Working voltage (V)	3.540	3.538	3.535	3.530	3.538	3.539	3.547	3.548	3.545
Discharge capacity (mAh)	1194	1203	1196	1175	1180	1168	1135	1135	1132
Average Capacity (mAh)	1198			1174			1134		
Visual leakage	No	No	No	No	No	No	No	No	No

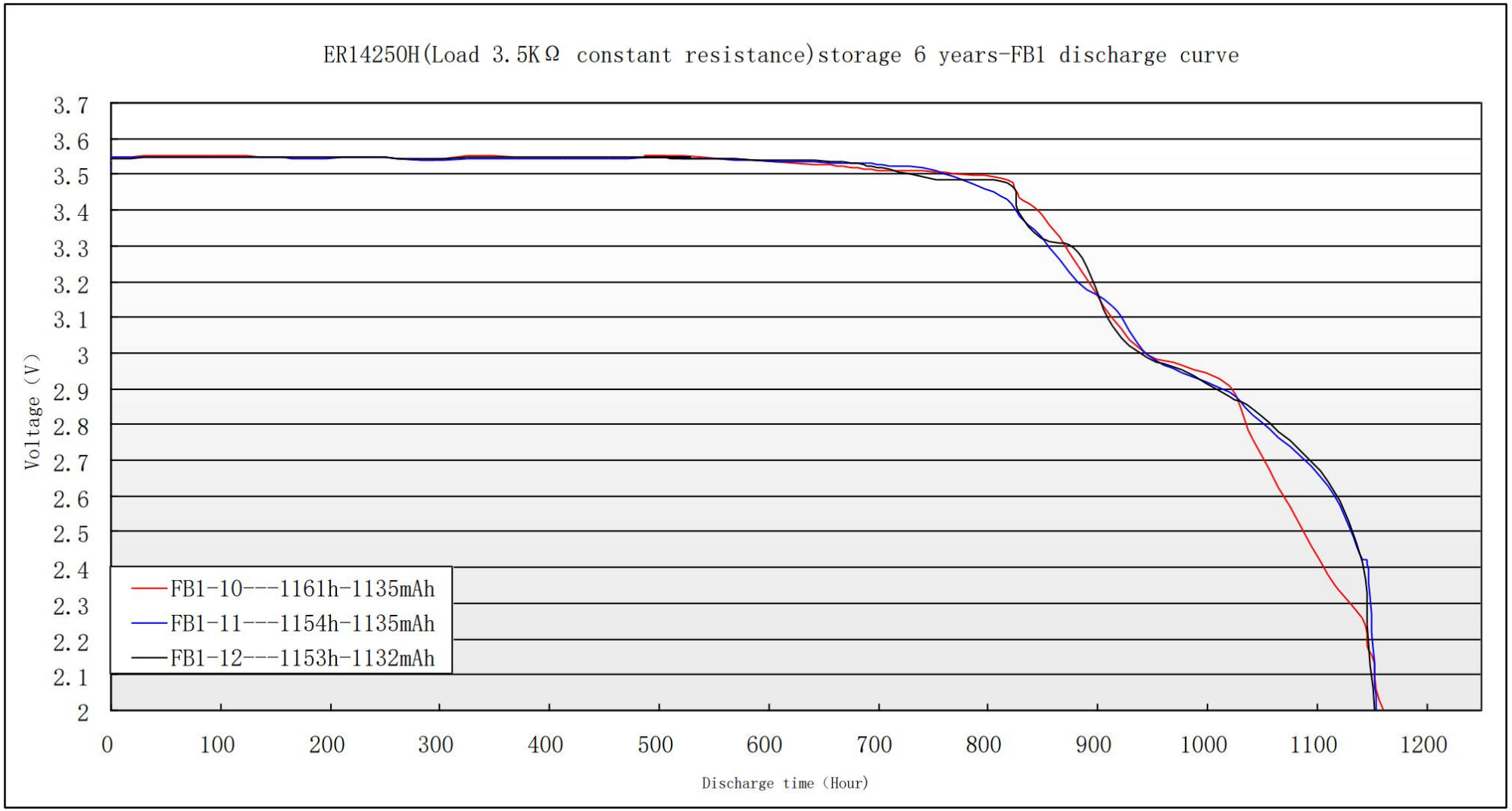
Discharge curve (2)



Discharge curve (3)



Discharge diagram (4)



3.3.3、Testing Term—FC1

3.3.3.1 Testing Method：

After the new battery cell off the machine, in the incubator (23±3℃) storage for 3 days, the battery in the incubator (23±3℃) under the condition of open test, and then in the incubator (70±3℃) under the condition of storage for 180 days (relatively equivalent (23±3℃) under the storage of 20 years) capacity test. When testing the capacity, the battery should remain upright with the positive terminal up, and discharge to 2V.

3.3.3.2 Testing Requirement：

(1) Open circuit voltage: 3.65 to 3.70V

(2) Capacity test: 3.5KΩ(~1mA) continuous Discharge, after 1 hour voltage reading value is not less than 3.50V, Discharge to 2V capacity.

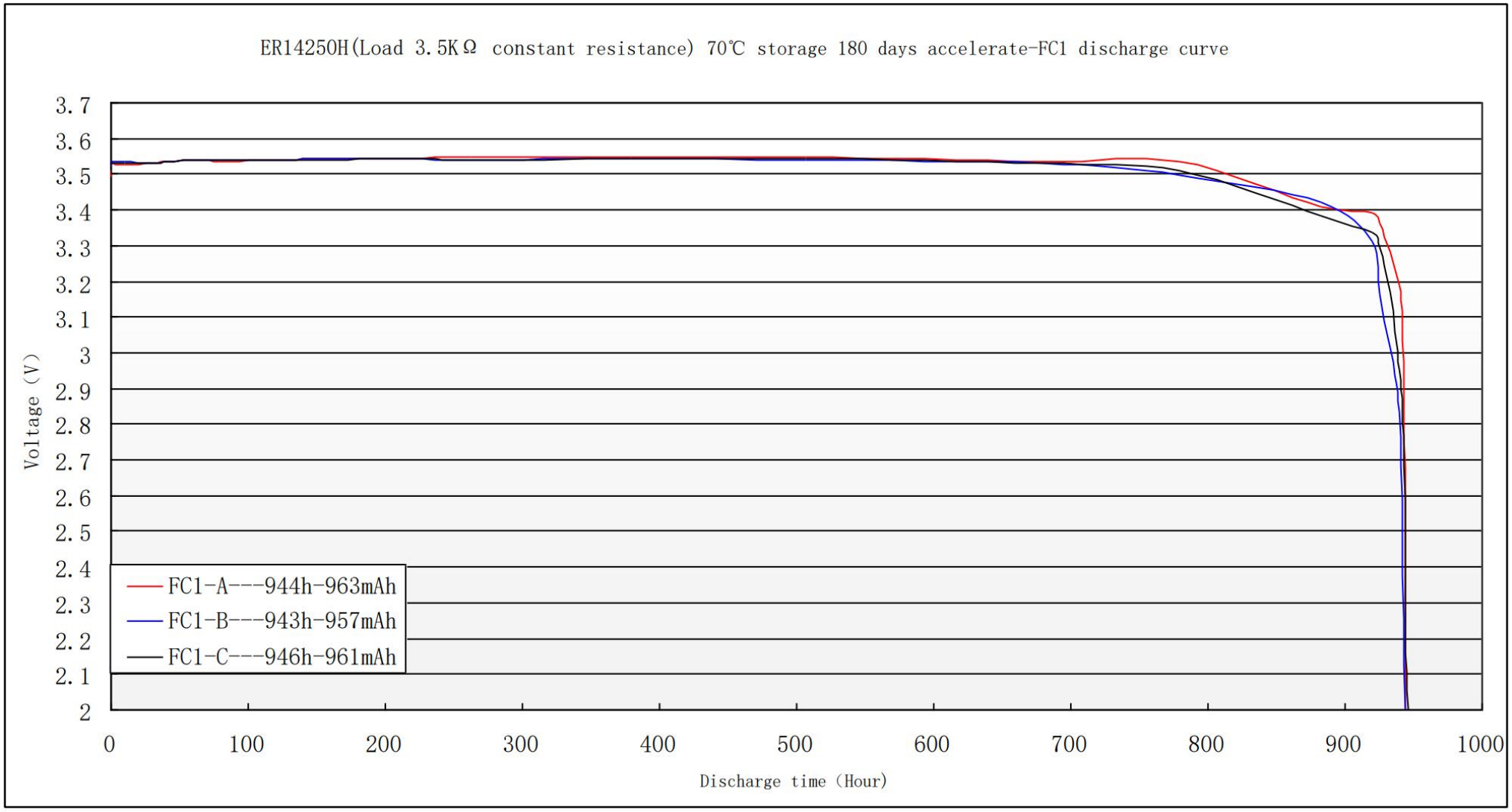
(3) The battery should not have leakage.

3.3.3.3 Testing Result： table 3.3.3.3-1

Table 3.3.3.3-1

No.	Open circuit voltage	Working voltage	Discharge capacity	Average capacity	Visual leakage
A	3.663V	3.525V	963mAh	960mAh	No
B	3.662V	3.535V	957mAh		No
C	3.662V	3.532V	961mAh		No

Discharge curve (5)



3.4、Calculate self-discharge data

3.4.1 Calculate self-Discharge rate storage at 23±3℃

◎Storage 1 year annual self-discharge rate

self-discharge 1=(C0-Ct) ÷C0 ÷t×100%

=(1208-1198)÷1208÷1× 100%

≈0.83%

◎Storage 3 years annual self-discharge rate

self-discharge 2=(C0-Ct) ÷C0 ÷t×100%

=(1208-1174)÷1208÷3×100%

≈0.94%

◎Storage 6 years annual self-discharge rate

self-discharge 3=(C0-Ct) ÷C0 ÷t×100%

=(1208-1134)÷1208÷6×100%

≈1.00%

Relative rated capacity (1200mAh) year self-discharge rate≈0.93%

3.4.2 Calculate self-discharge rate , storage at 70±3℃

◎Storage 180 days self-discharge rate

self-discharge4=(C0-Ct) ÷C0 × 100%

=(1208-960)÷1208×100%

≈20.53%

4、Conclusion:

○ Under standard storage conditions, the rated battery capacity loss is less than one percent per year. ER14250H self-discharge The current is about 1.27uA.

○ Storage service life is defined as 20 years for the battery capacity to be reduced to 80% of the rated capacity under standard storage conditions.

○ 20% self-discharge rate at 70±3℃ for 180 days is equivalent to 20 years under standard conditions.

○ Operating current of 10uA plus battery self-discharge1.27uA under standard conditions, total current of 11.27uA, 99mAh/year, the use of year limit by 2V termination voltage calculation, the battery can use 1200mAh÷99 mAh/year ≈12years.