

**Performance and Safety Tests on Samsung 18650
Li-ion Cells with Two Capacities**

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Abstract

In order to meet the applications for Space Shuttle in the future, Samsung 18650 cylindrical Li-ion cells with two different capacities have been evaluated. The capacities are 1800 mAh, and 2000 mAh. The studies focused on the performance and safety tests of the cells.

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Introduction

In order to meet the applications for space shuttle in future, two types of Samsung cells, with capacity 1800mAh and 2000mAh, have been investigated. The studies focused on:

- **Performance tests**

- Completed 250 cycles at various combinations of charge/discharge C rates

- Discharge capacity measurements at various temperatures

- **Safety tests**

- Overcharge and overdischarge

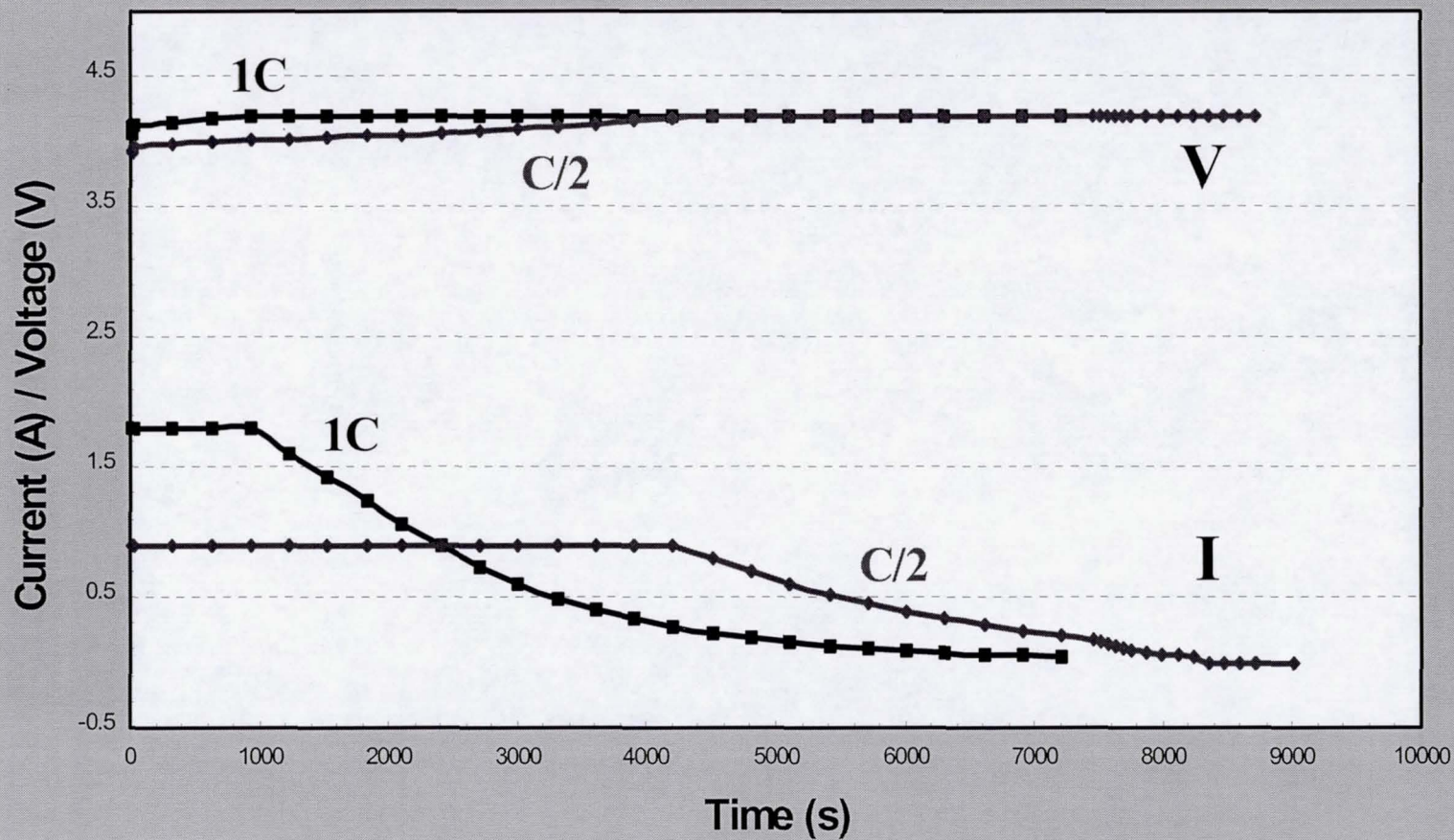
- Heat abuse

- Short circuit: Internal and external short

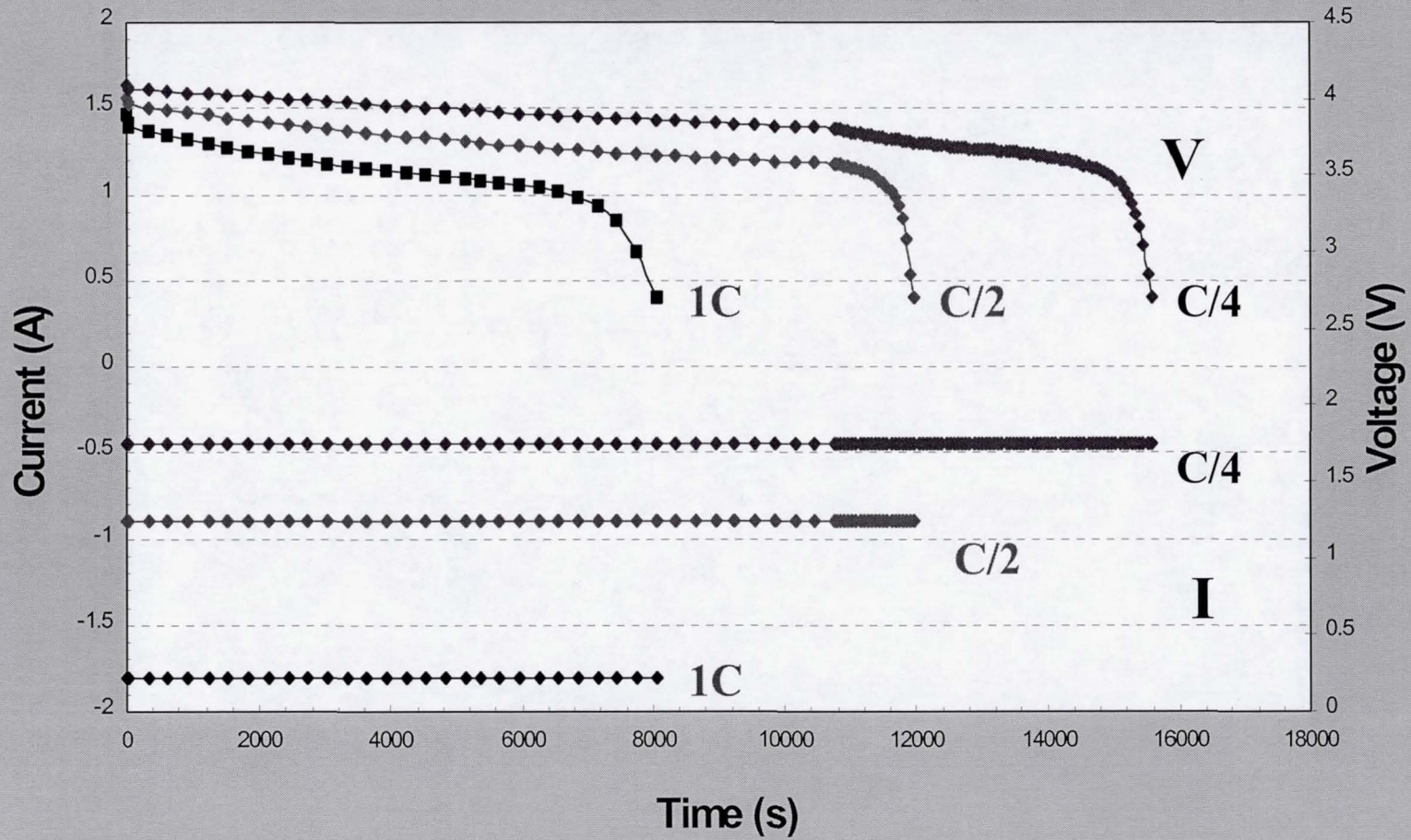
- Vibration, vacuum, drop tests

Performance tests

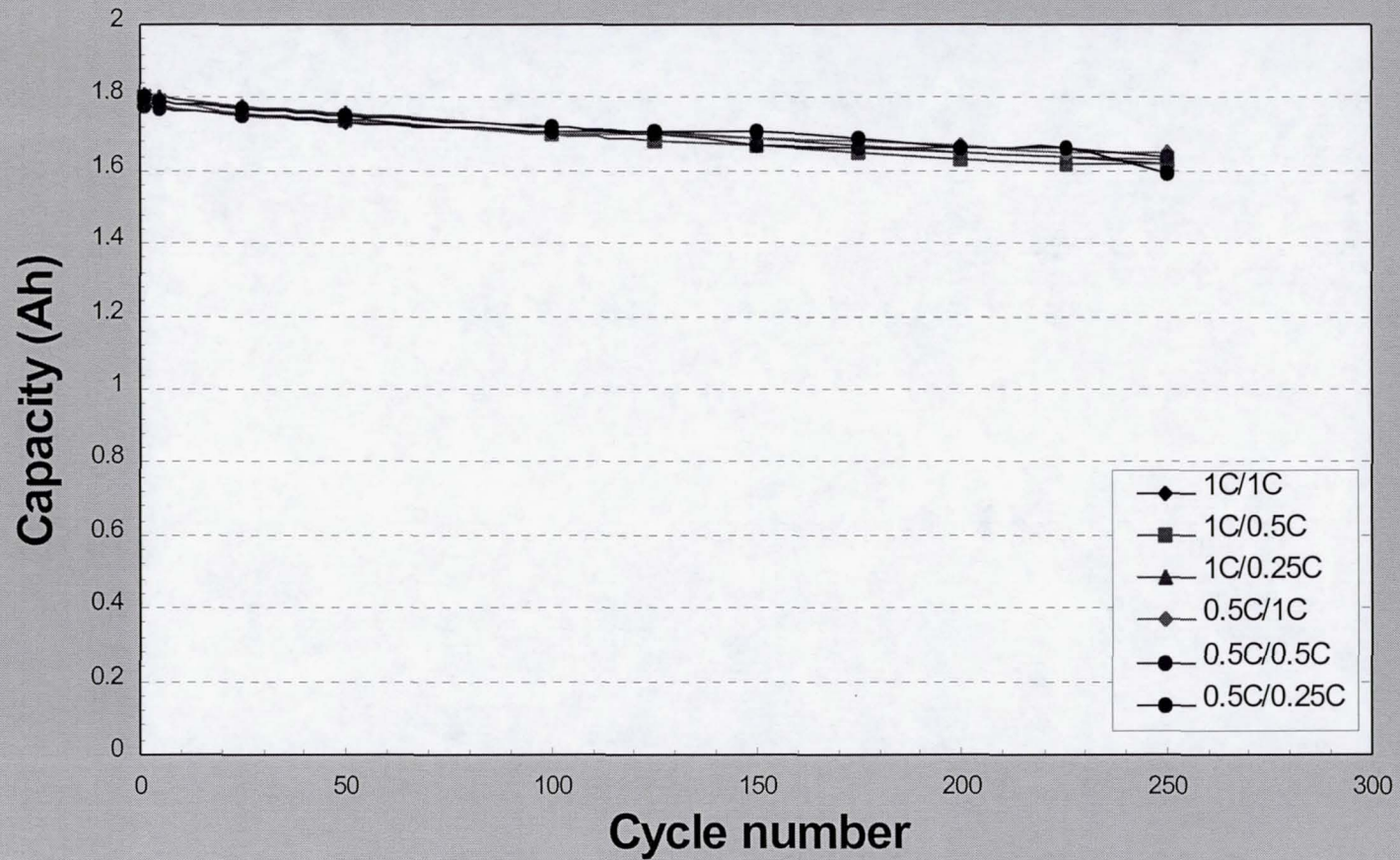
Plot of CC/CV charge for 1.8 Ah Samsung Li-ion cells at two different rates



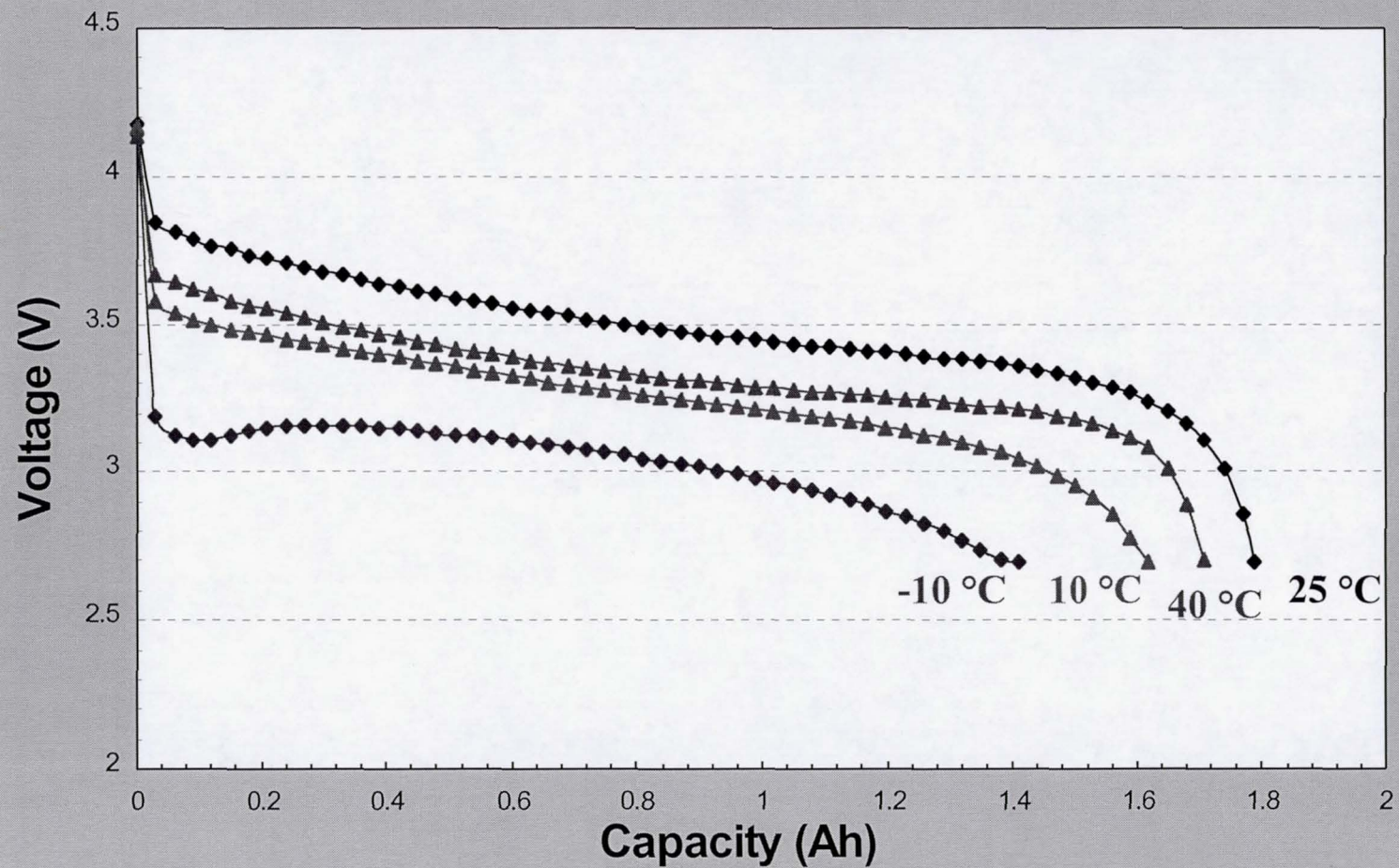
Plot of discharge of Samsung 1.8 Ah li-ion cells at various C rates



Cycle life tests for 1.8 Ah Li-ion cells at various C rate combinations of charge/discharge



Characterization of capacities of 1.8 Ah cells at various temperatures



Discharge capacity at different temperatures

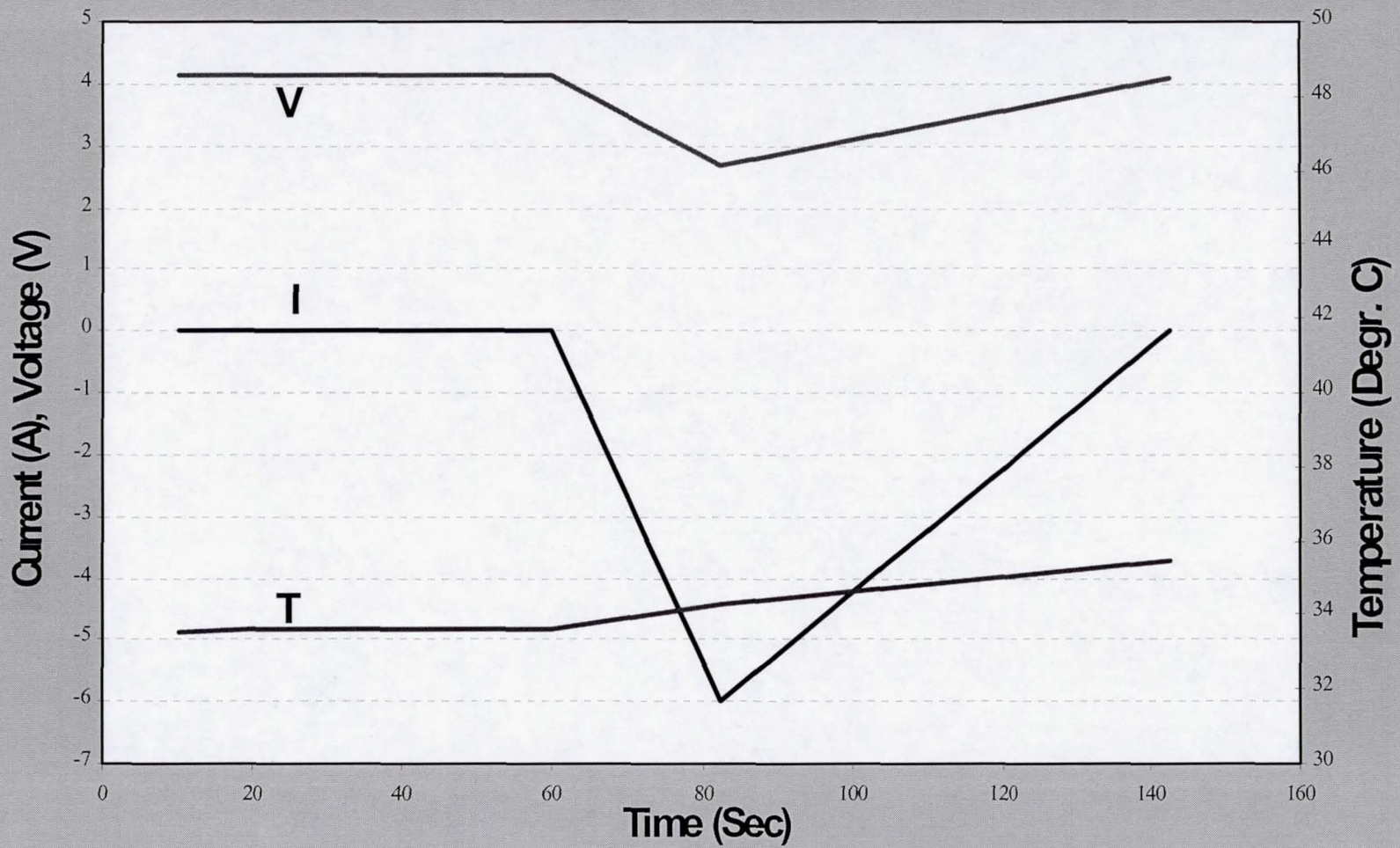
1.8 Ah cells			2.0 Ah cells		
Test temperature (°C)	Capacity of discharge (Ah)		Test temperature (°C)	Capacity of discharge (Ah)	
40	1.71	95.6%	40	1.82	95.8%
25	1.79	100%	25	1.90	100%
10	1.62	90.6%	10	1.75	92.1%
-10	1.41	78.8%	-10	1.34	70.5%

Summary for performance tests

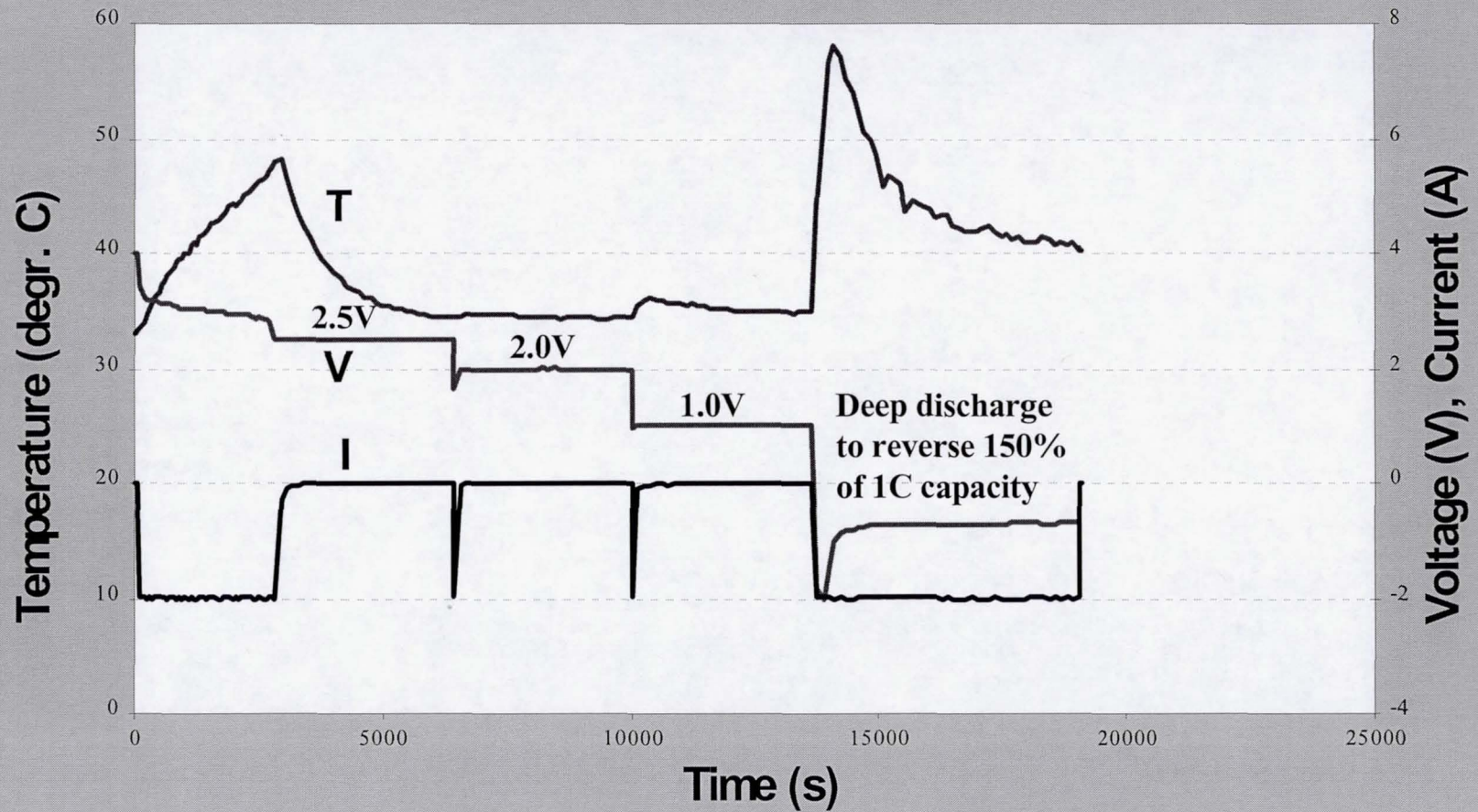
- In 250 cycles, the capacity drops with 100% DOD were 11%-12% both for 1.8Ah and 2.0Ah cells regardless combination of C rate at range from 1C to C/4.
- Comparing with 25 °C discharge capacities (100%) of cells, the 1.8Ah cell delivered 95.6% at 40 °C, 90.6% at 10 °C, and 78.8% at -10 °C. For 2.0Ah cell, it delivered 95.8% at 40 °C, 92.1% at 10 °C, and 70.5% at -10 °C.

Safety tests

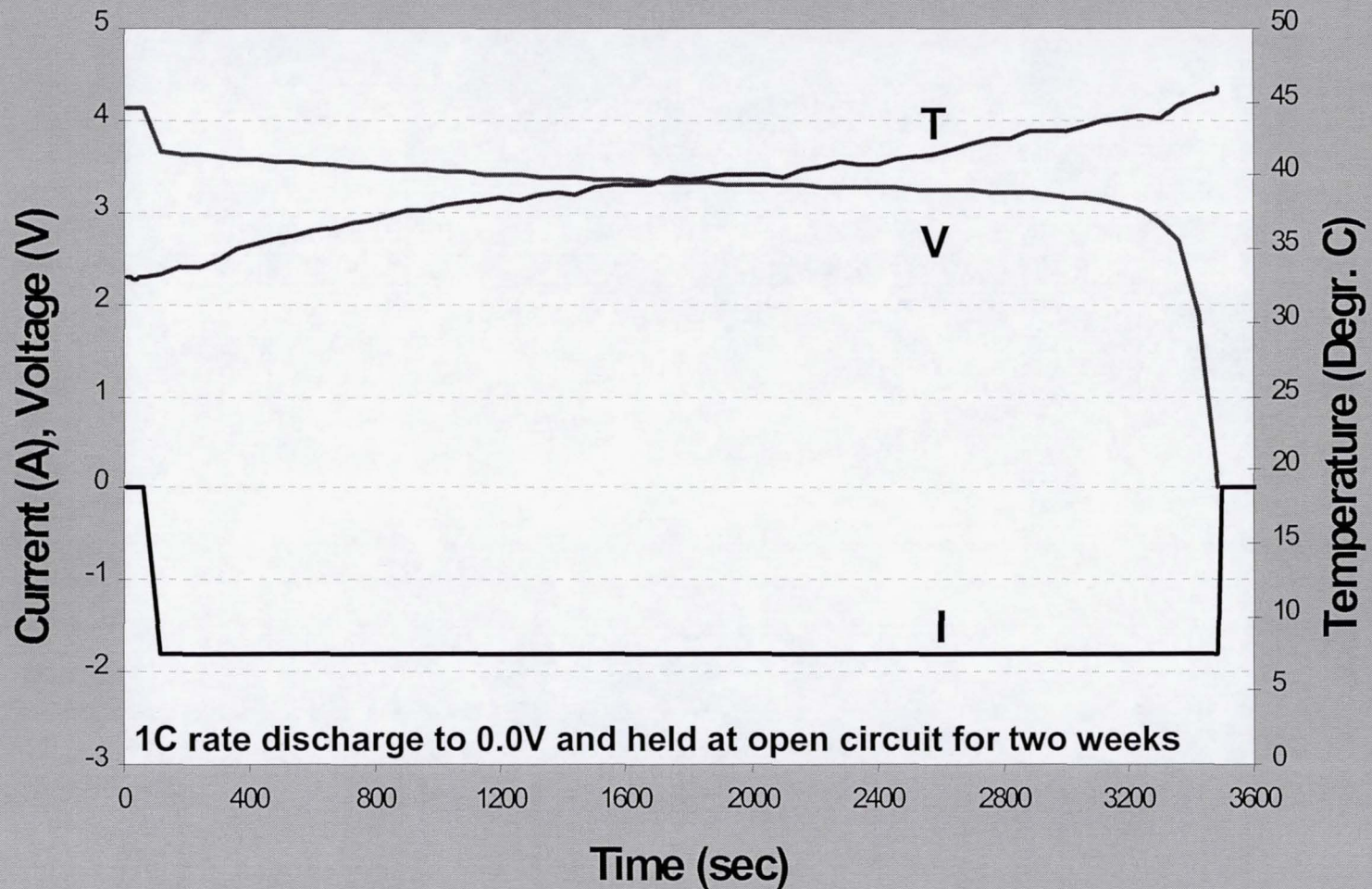
3C high rate discharge of 2.0 Ah cell



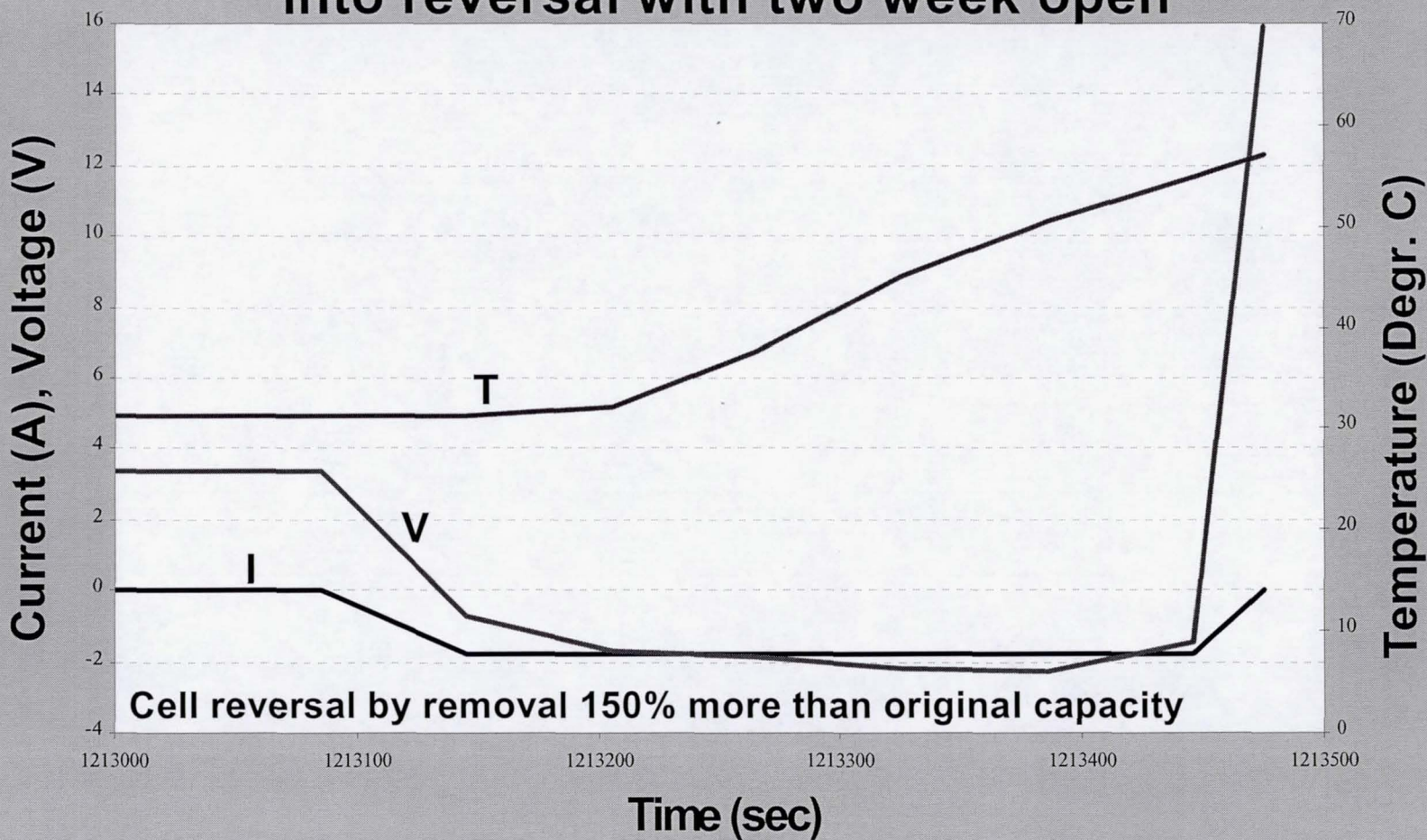
Over-discharge of Samsung 2.0 Ah li-ion cell at 1C rate into reversal



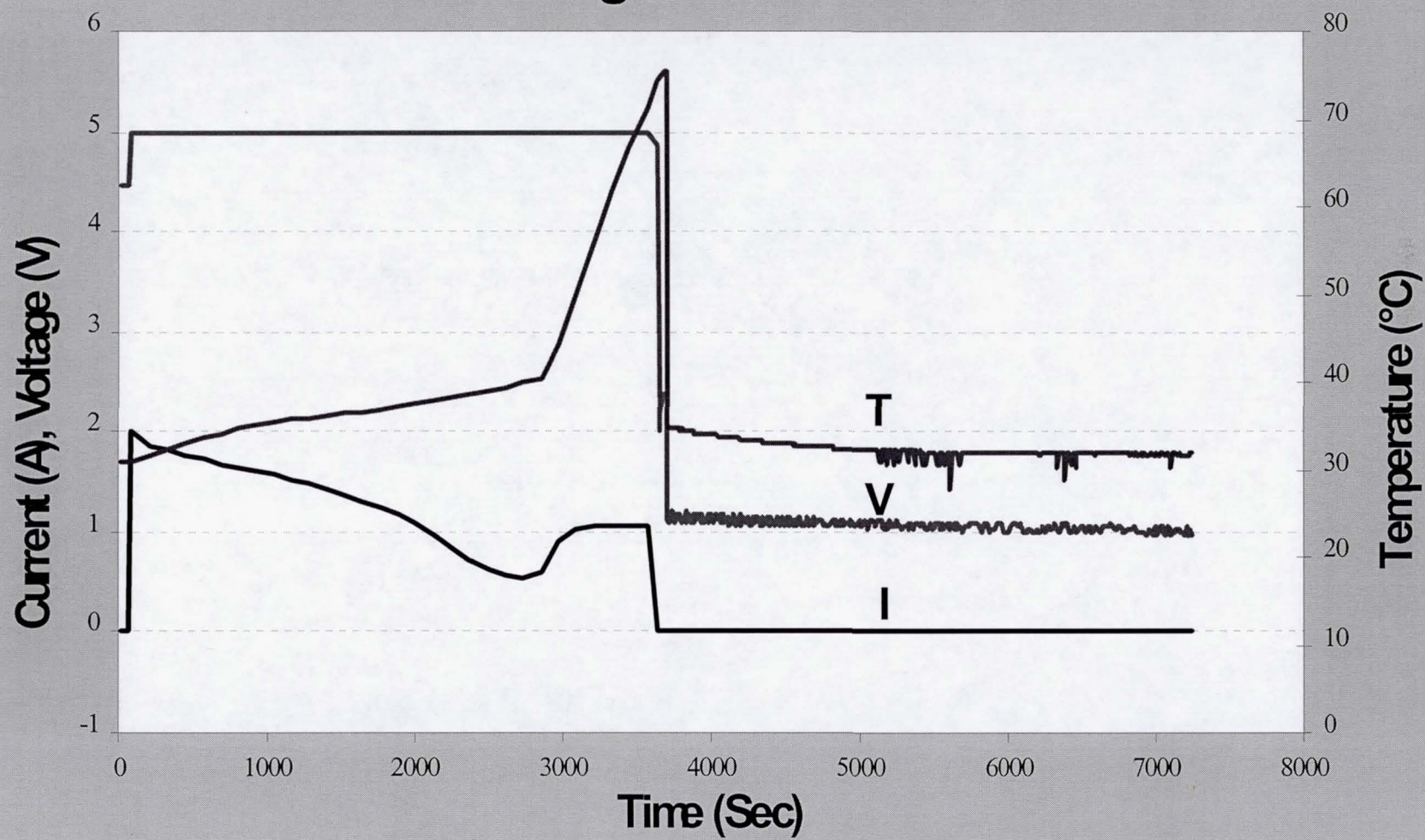
Over discharge 1.8 Ah cell to 0.0V



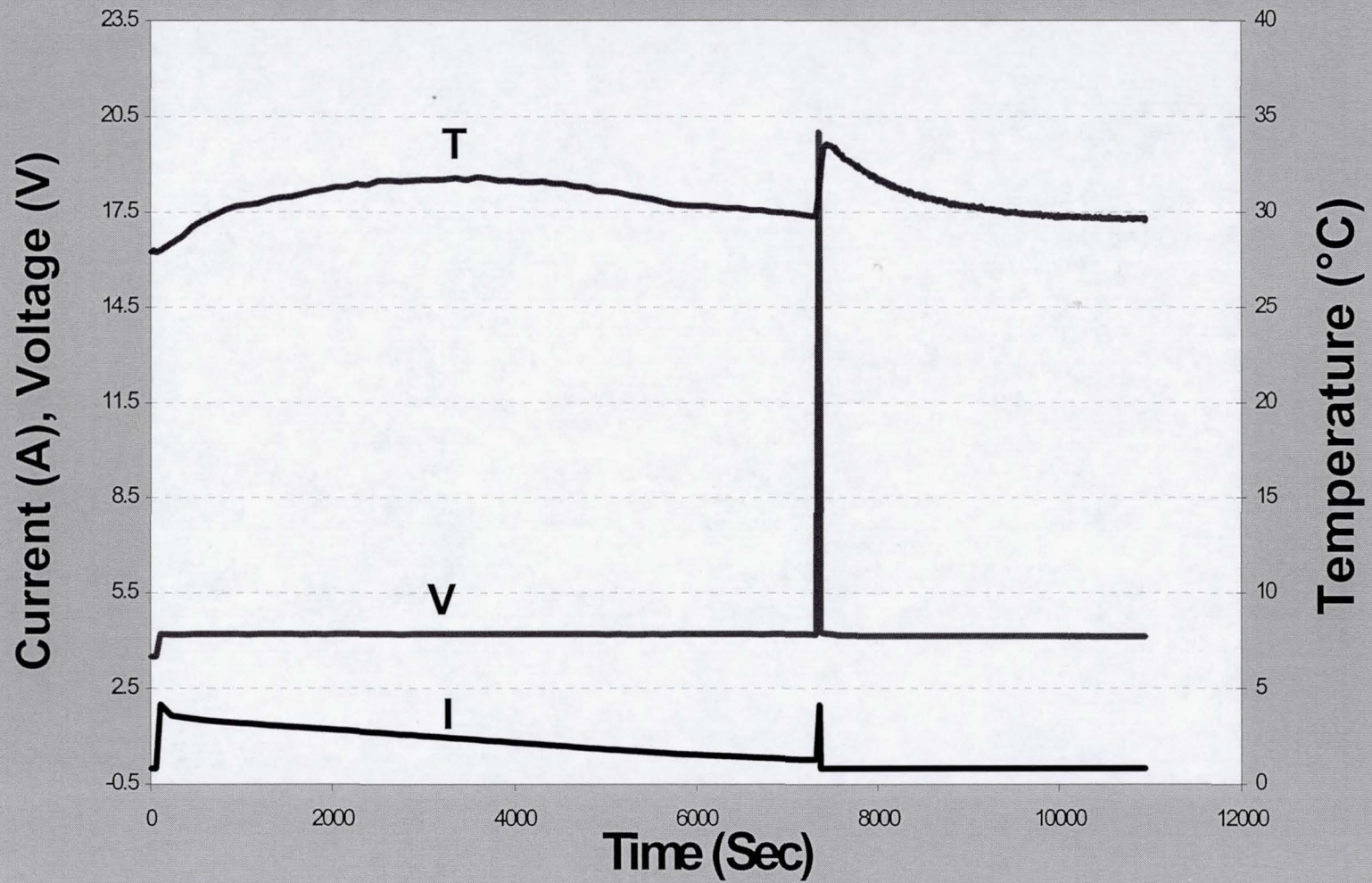
Deep discharge of 1.8Ah cell at 1C rate into reversal with two week open



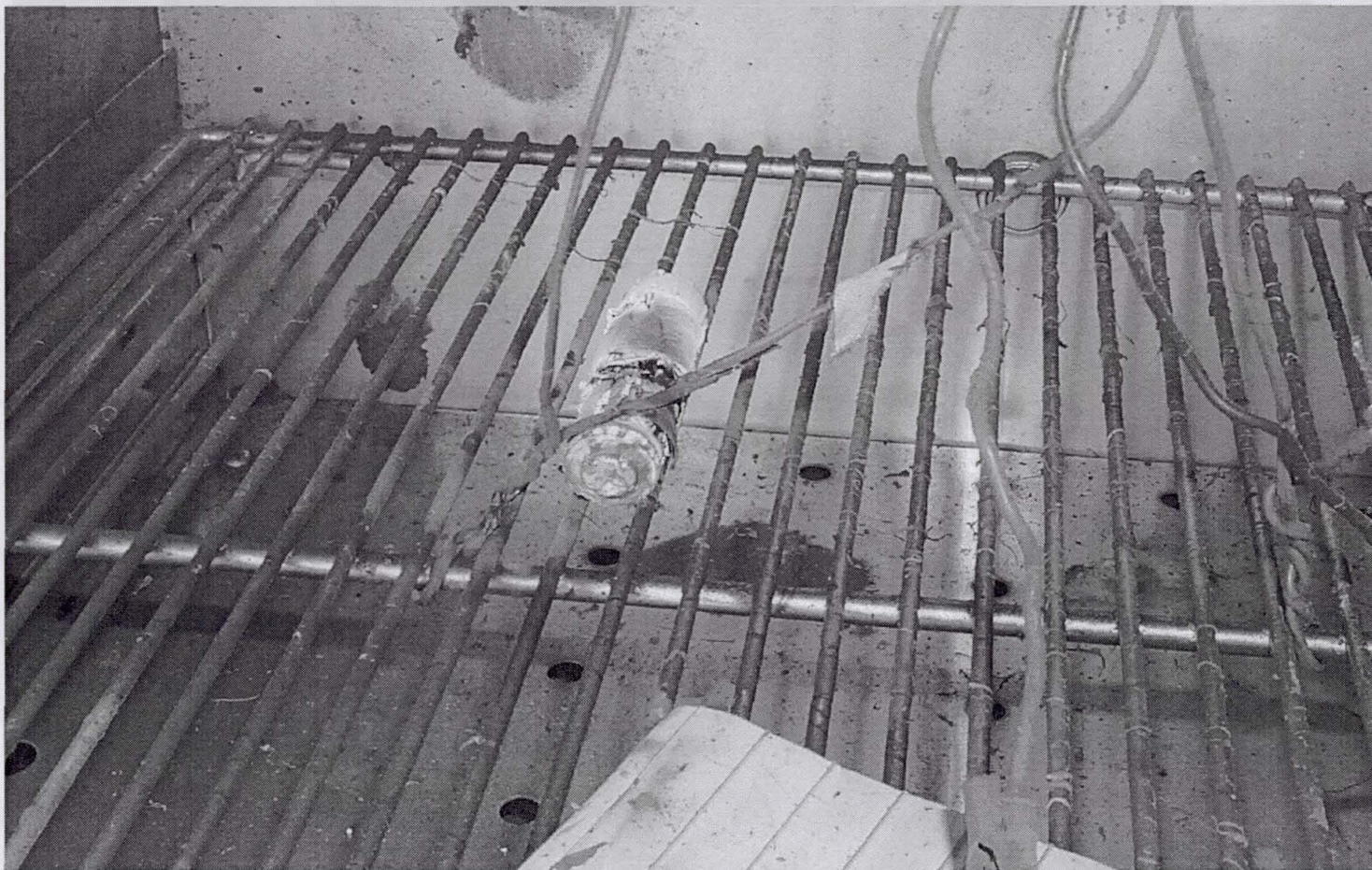
1C overcharge 2.0Ah cell to 5.0V



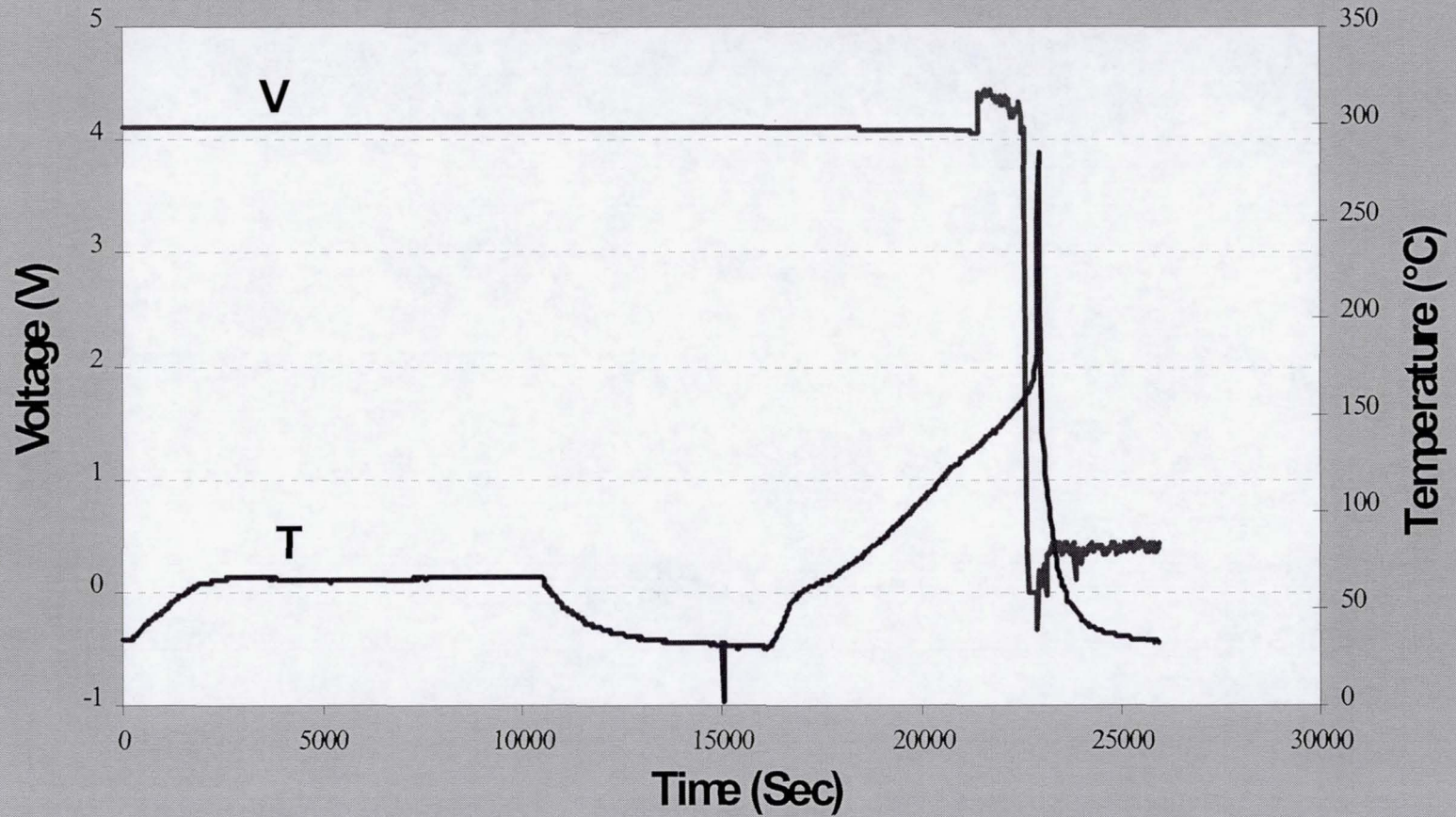
3C overcharge 2.0Ah cell to cut-off voltage at 12.0V max.



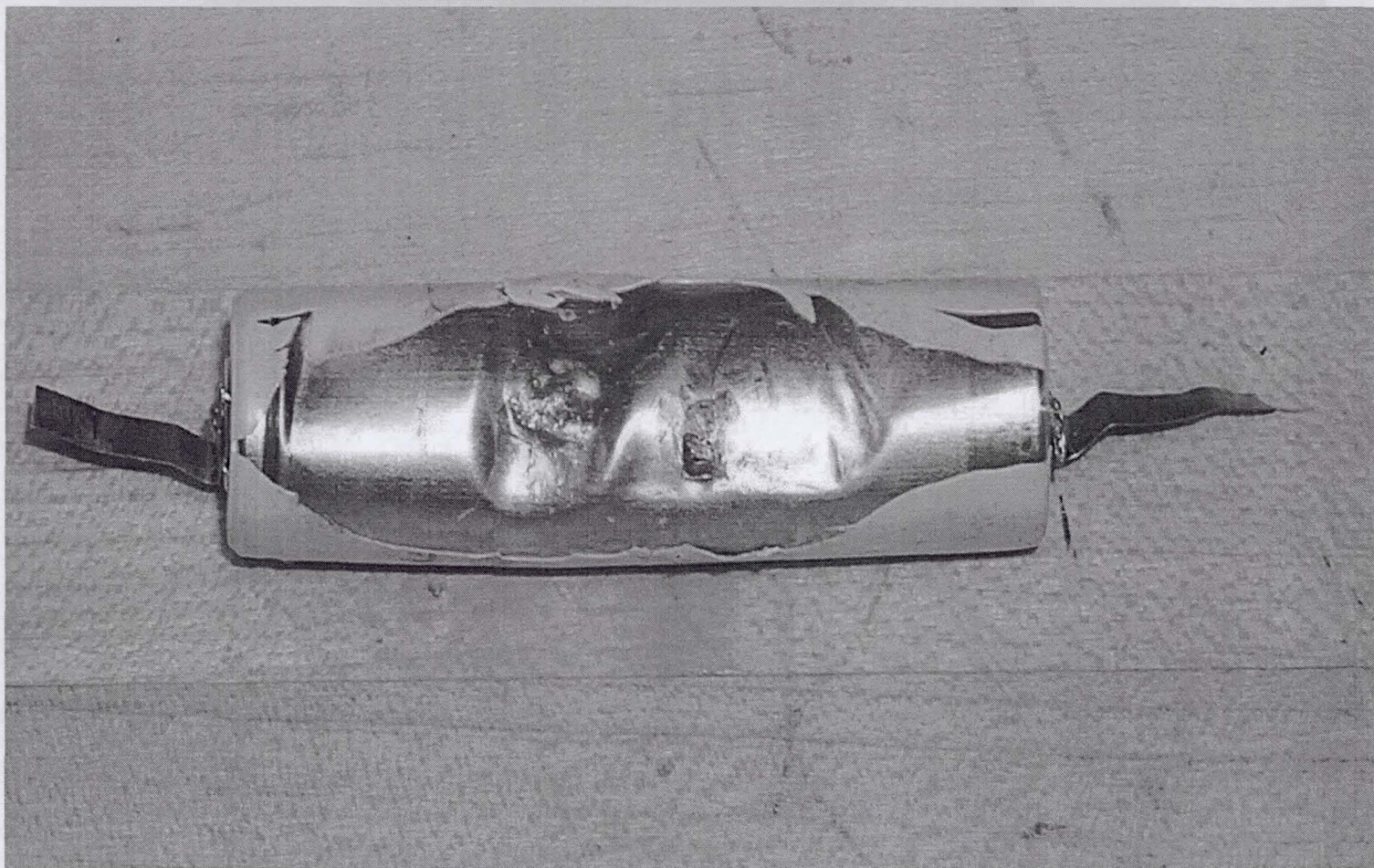
Heat abuse test



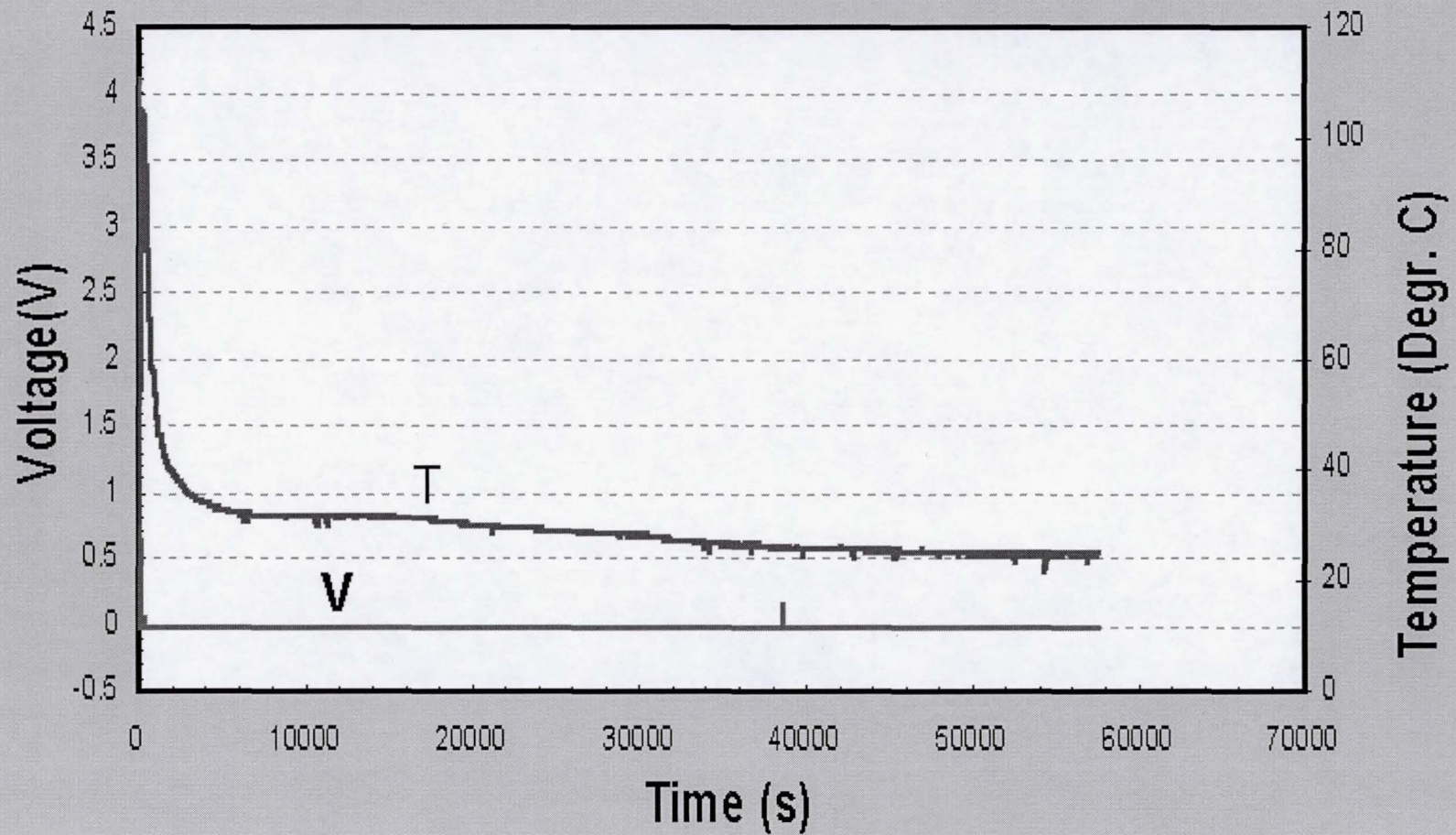
High temperature exposure and heat-to-vent



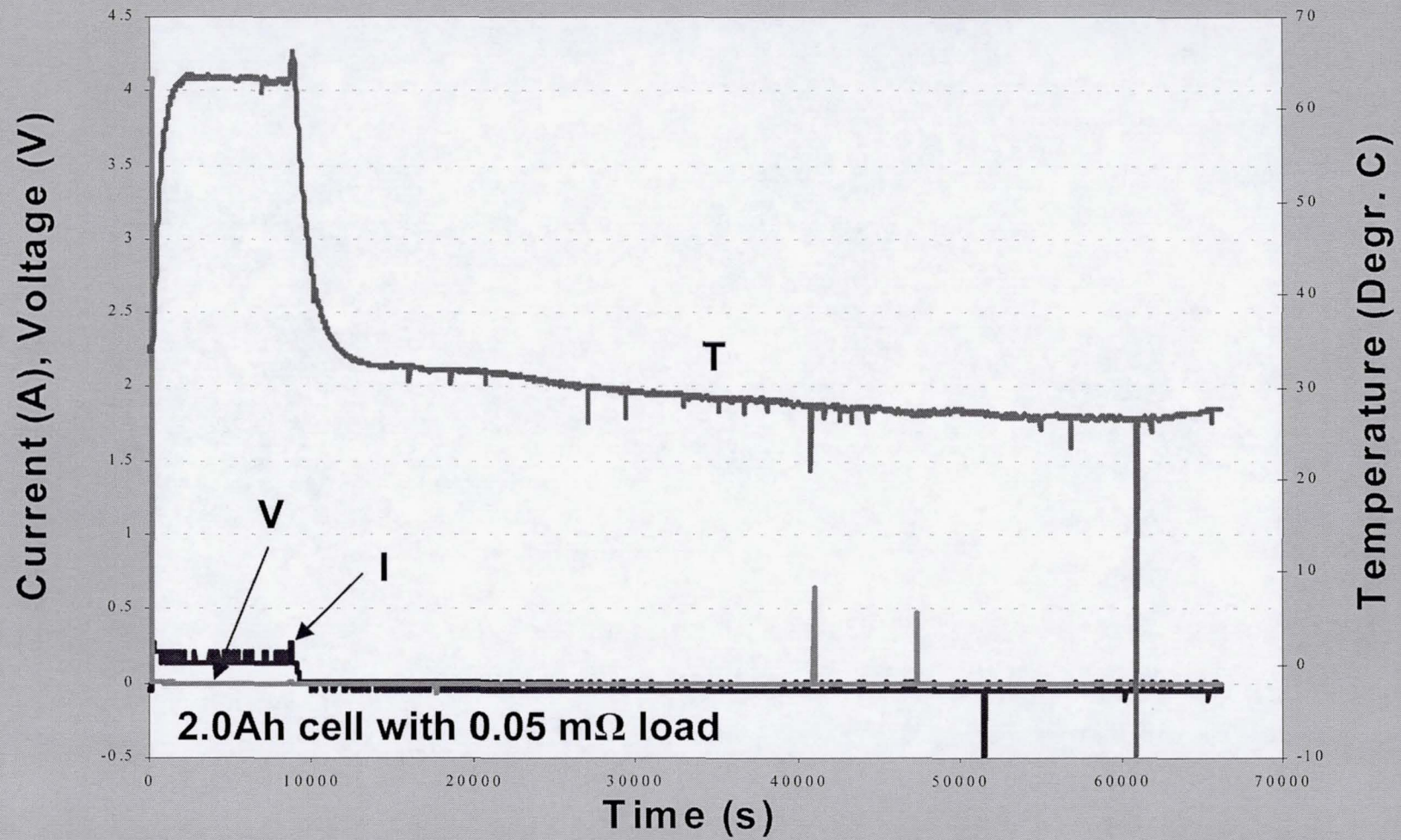
Internal short circuit test



Short circuit: Internal short



Short circuit: External short



Summary for safety tests

Number of 1.8Ah cells tested	Number of 1.8Ah cells passed	Number of 2.0Ah cells tested	Number of 2.0Ah cells passed	Safety test
2	2	2	2	High rate (3C) charge to 4.2V
2	2	2	2	1C rate overcharge to 4.5V
2	0	2	0	1C overcharge to 5.0V
2	2	2	2	High rate (3C) discharge to 2.7V
2	0	2	0	1C overdischarge to 0V and reverse 150% of 1C capacity
2	2	2	2	65°C heating test
2	0 Venting at 80°C	2	0 Venting at 150°C	Exposure at temperature higher than 65°C
2	2	2	2	Vacuum test
2	2	2	2	Drop test
1	1	1	1	Vibration test at 0.1 g ² /Hz level
2	0	2	0	Short circuit: internal & external

Acknowledgment

Thanks Samsung for supplying the li-ion cell samples.