



Performance and Safety Characteristics of Sanyo NiCd Cells

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Introduction

- NiCd batteries are widely used for high drain applications like power tools and also in other portable equipment like cameras, PCs, etc.
- NASA and Dreamtime Holdings, Inc. worked together to have the capability of a High Definition TV (HDTV) on the ISS and Space Shuttle.
- The Sanyo HD camcorder was used on the STS 105 flight in July, 2001. The camcorder used two versions of a NiCd battery. One was a commercial off-the-shelf Sony BP90 battery pack that had Sanyo NiCd D cells. The other was a modified battery (FBP-90) made by Frezzi Energy, which also had the same Sanyo NiCd D cells.
- The battery has 10 NiCd D cells in series to form a 12 V pack with 5.0 Ah capacity.
- Our current study involved the performance and abuse tests on the Sanyo NiCd 5.0 Ah D cells.



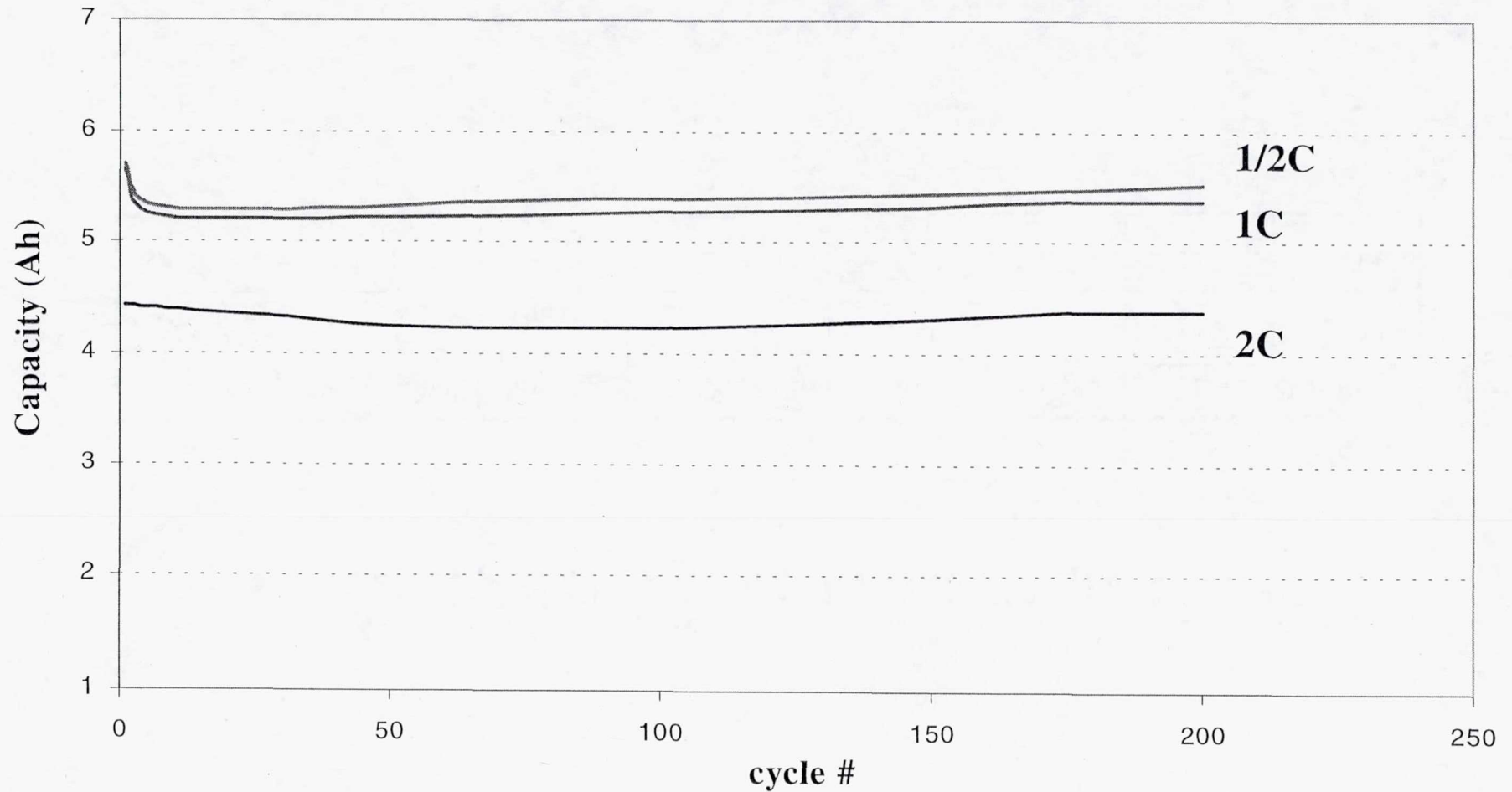
Specification of Sanyo NiCd D cells

Model	Nominal Voltage (V)	Nominal Capacity (mAh)	Dimensions (mm)		Weight (g)	Energy Density	
			Diameter	Length		Wh/L	Wh/Kg
KR-5000DEL	1.2	5000	33.0±0.3	60.0±0.4	150	117	40



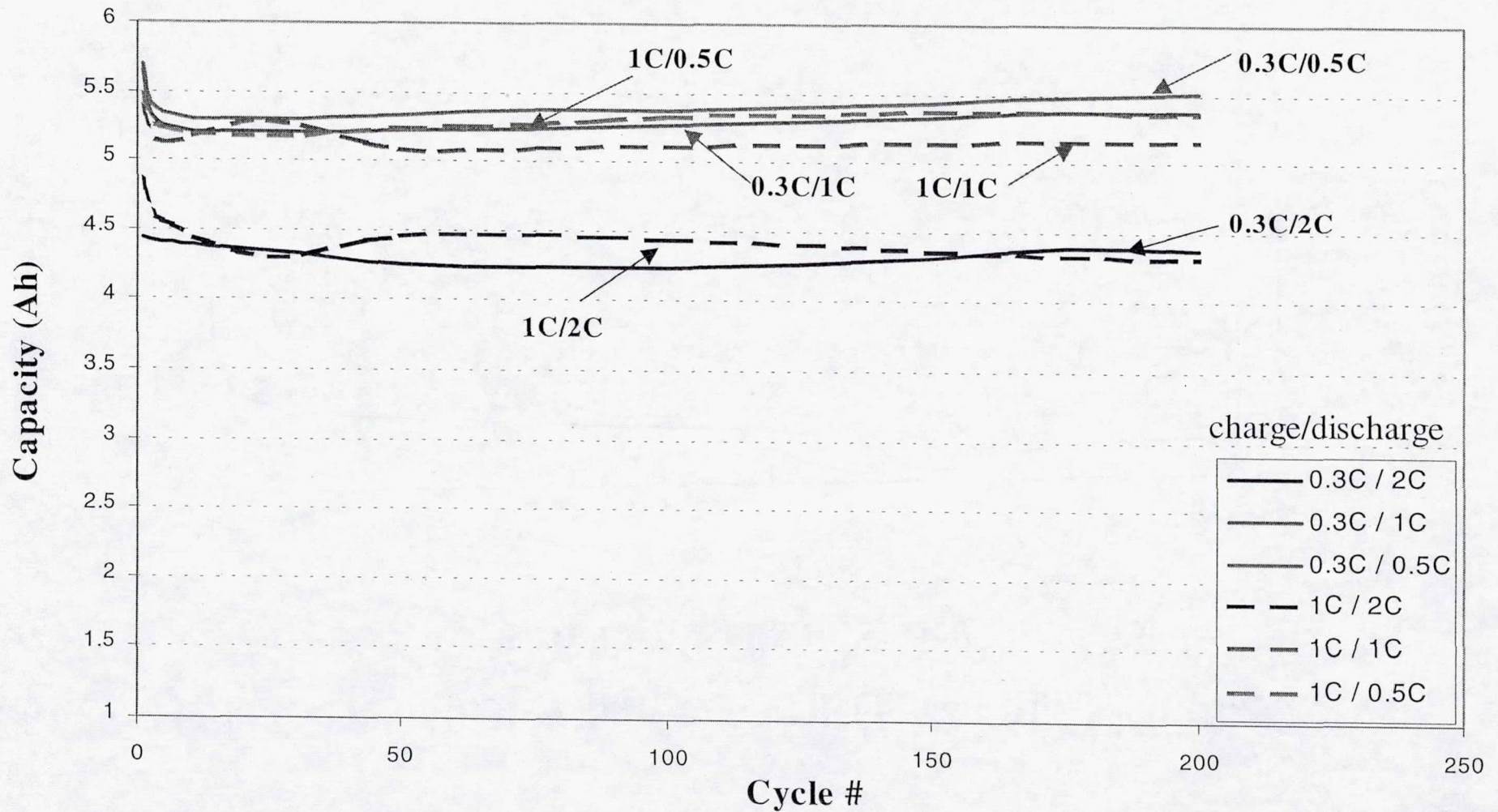
Performance Test

Cycle Life Test of NiCd D cell at Different Discharge rates
(Charge: 0.3C constant current)



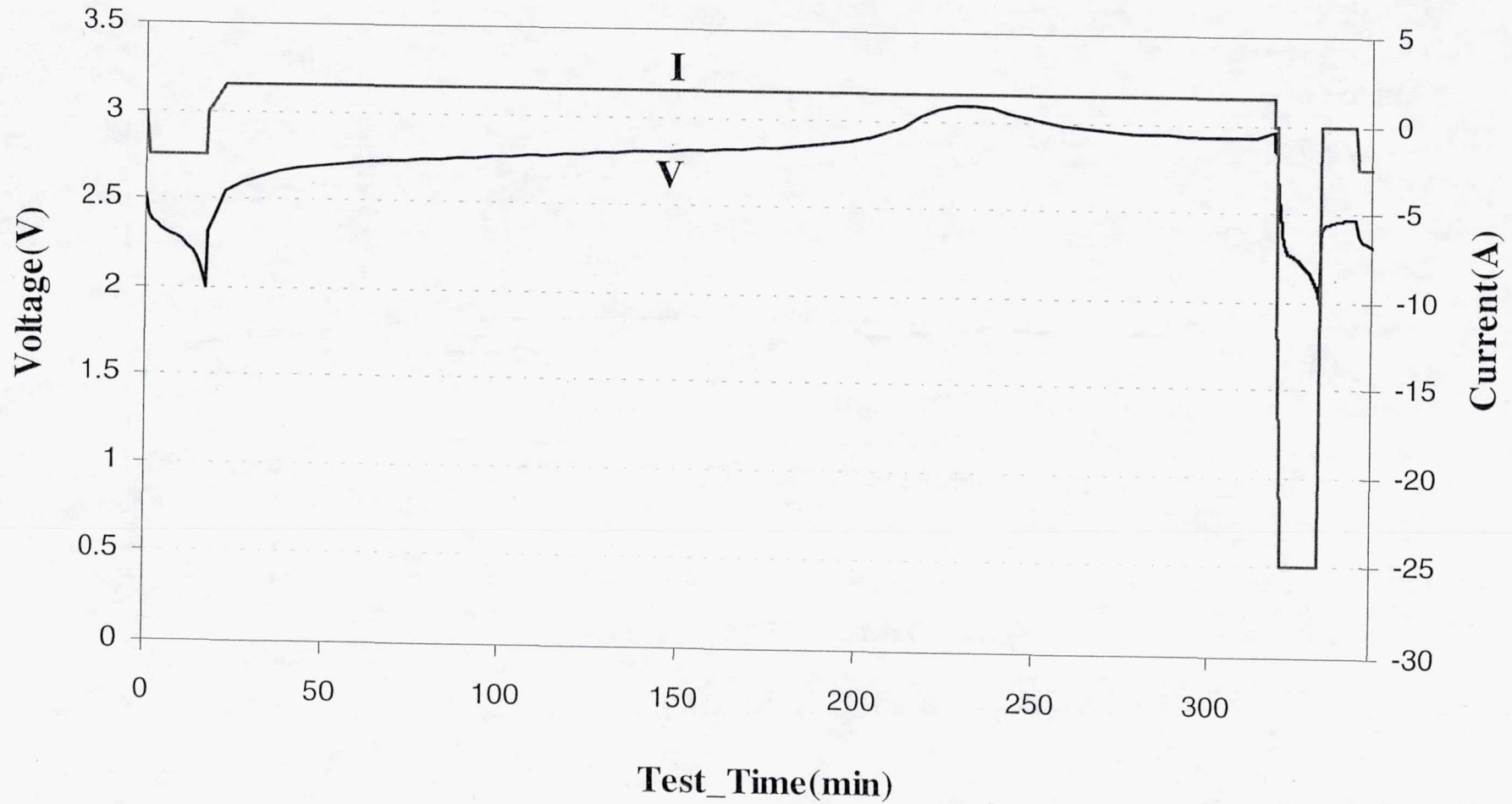


Cycle Life Test of NiCd D Cell at Various Charge/Discharge Rates



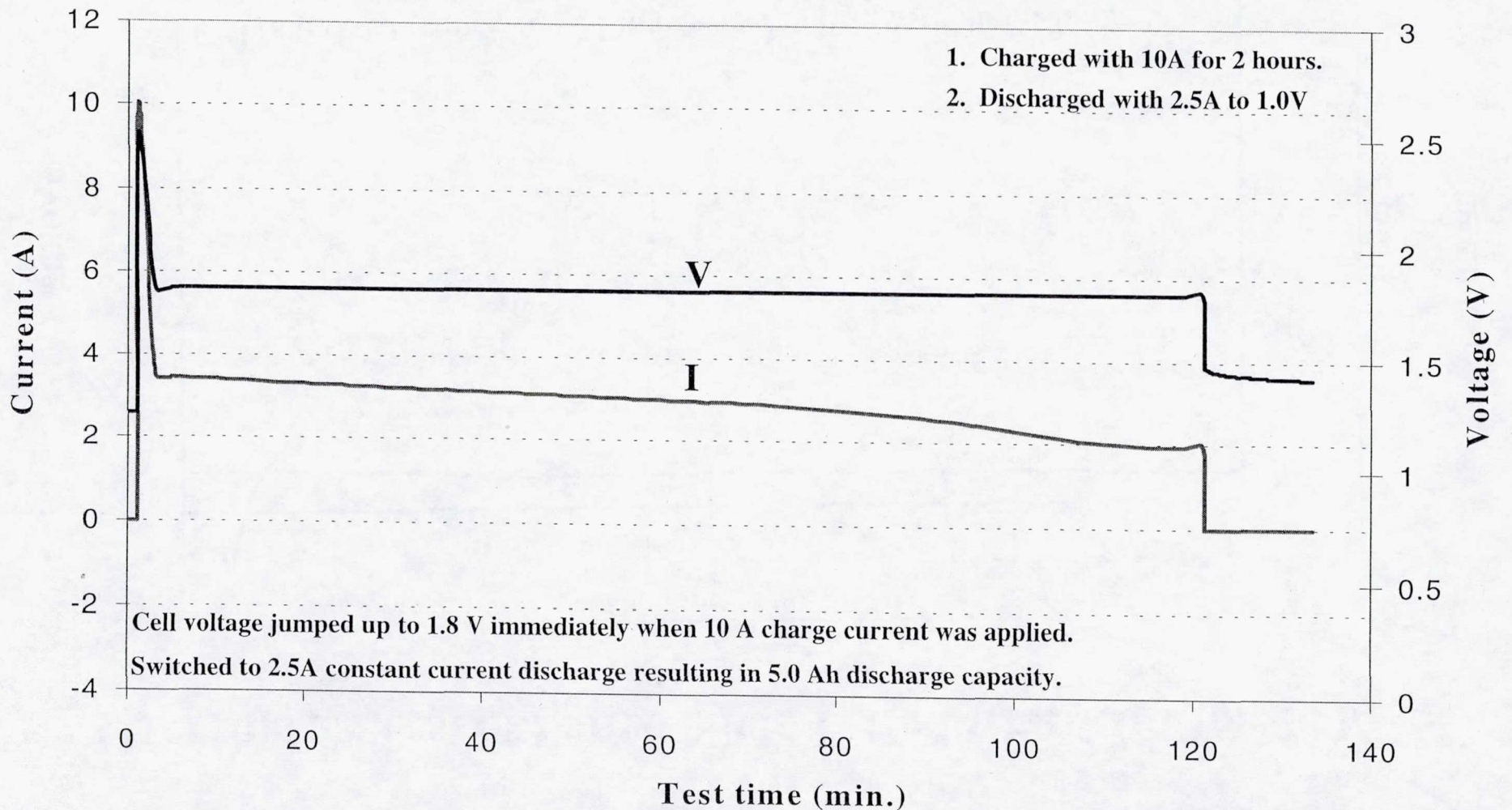


One Cycle of 0.3C Charge/5C Discharge Plot of Battery with Two Cells in Series



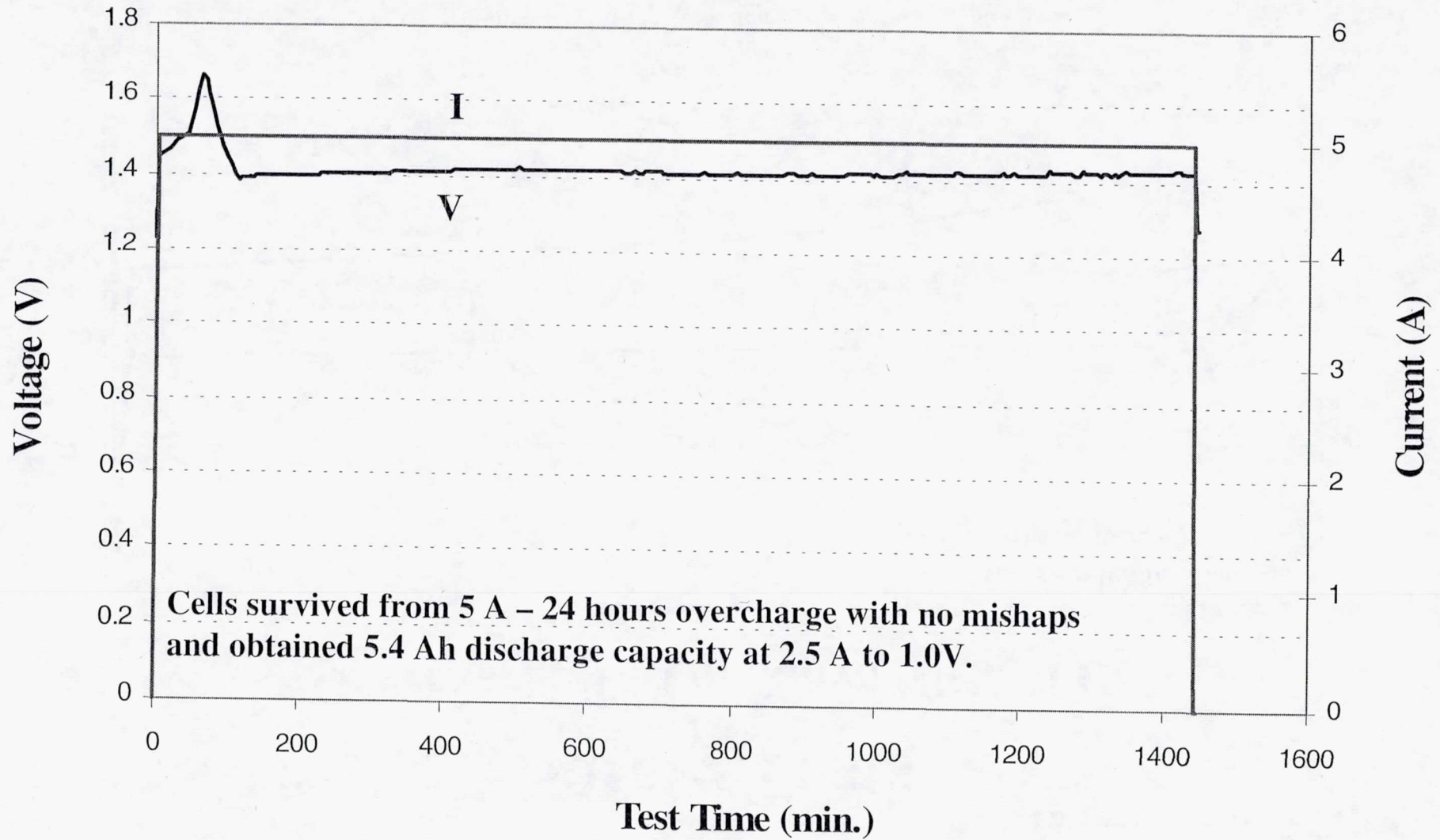
Safety Tests

Overcharge Test of Sanyo NiCd D Cell



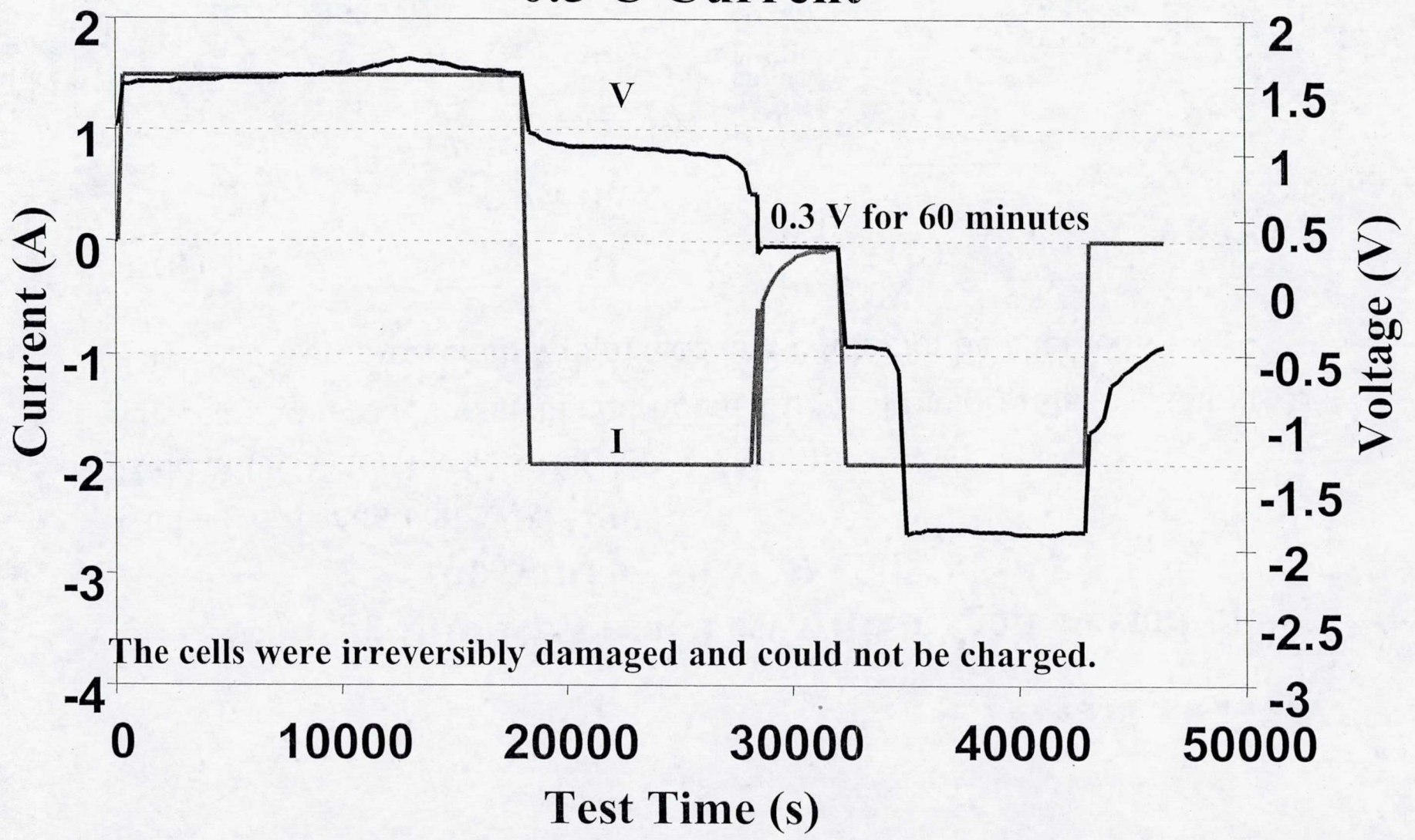


Overcharge Test of Sanyo NiCd D Cell with 5.0A for 24 hrs.



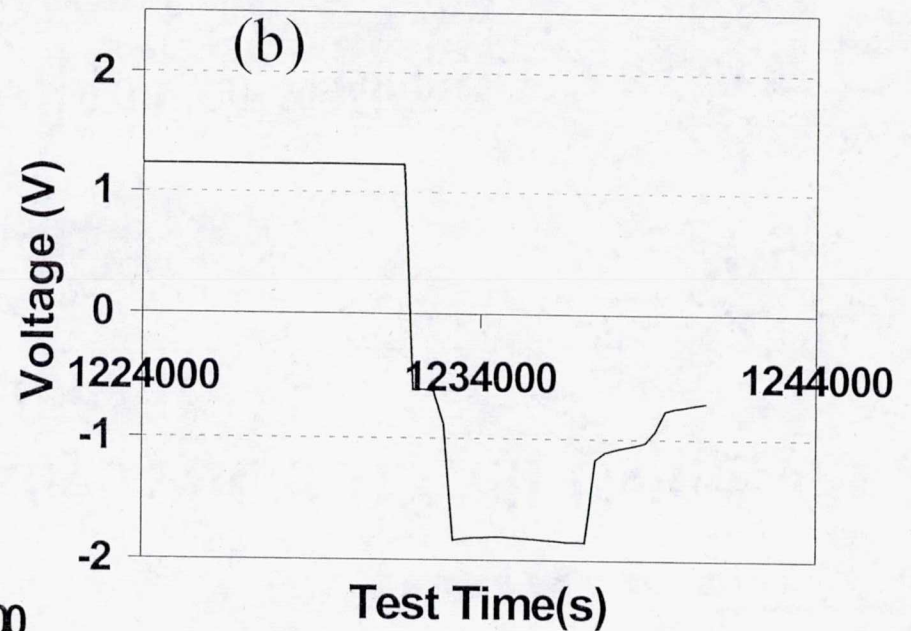
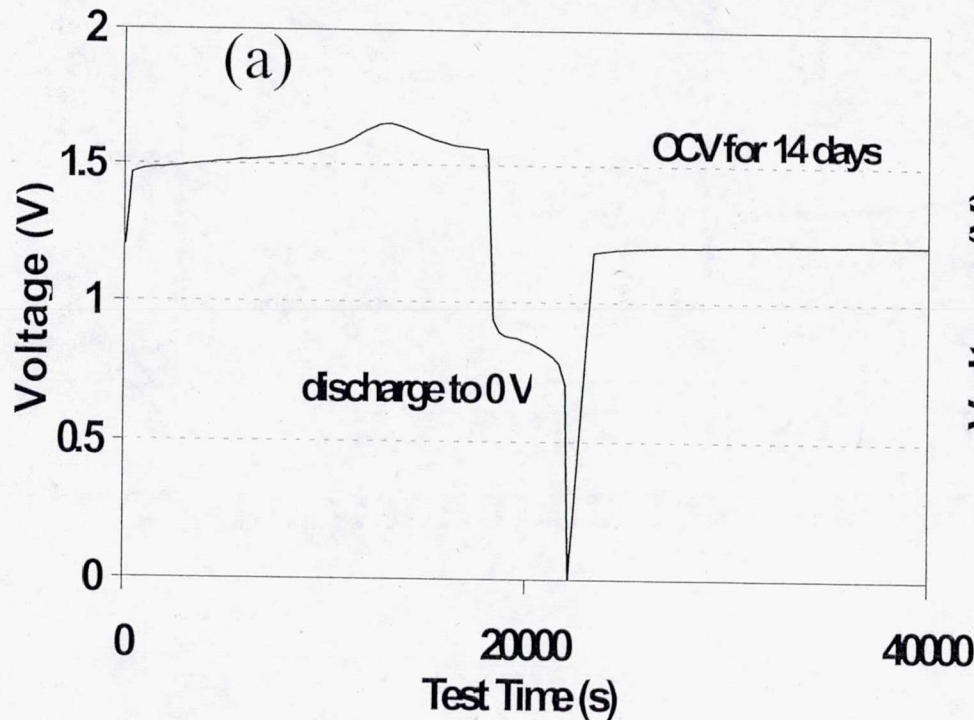


OverDischarge Test on Sanyo NiCd D Cell Using 0.5 C Current



Over-Discharge Into Reversal Test with a Wait Period on the Sanyo NiCd D Cell

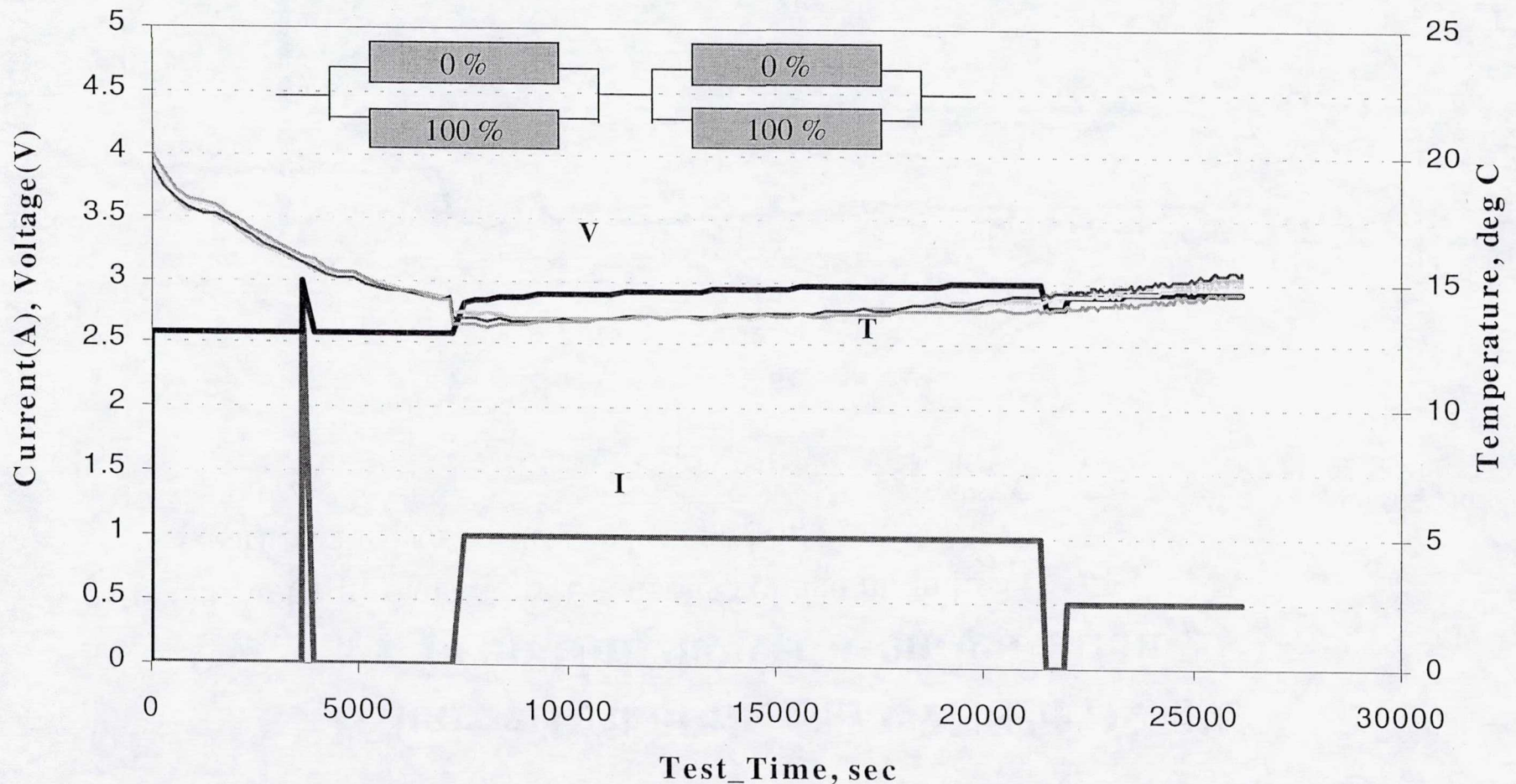
- Cells overdischarged to 0 V (a)
- Held at OCV for 14 days (OCV > 1.2V) (a)
- Discharged into reversal an additional 150% of the original capacity (b)
- The cells were irreversibly damaged and could not be charged.





Charge Test of the Sanyo NiCd D Cell in an Unbalanced Configuration

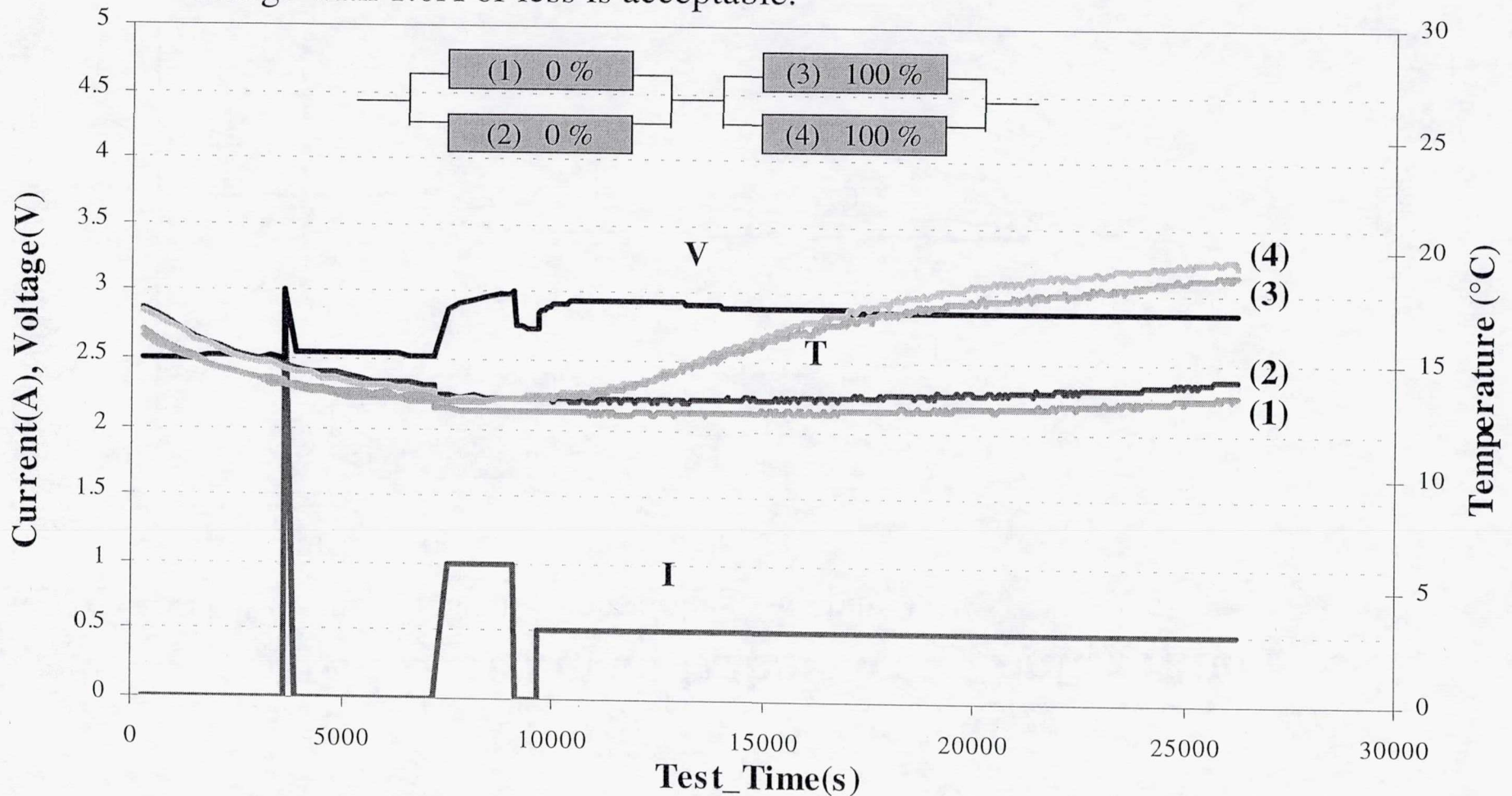
- 3A charge causes instantaneous voltage jump to 3.0V
- Charge with 1.0A or less is acceptable.





Charge Test of the Sanyo NiCd D cells in an Unbalanced Configuration

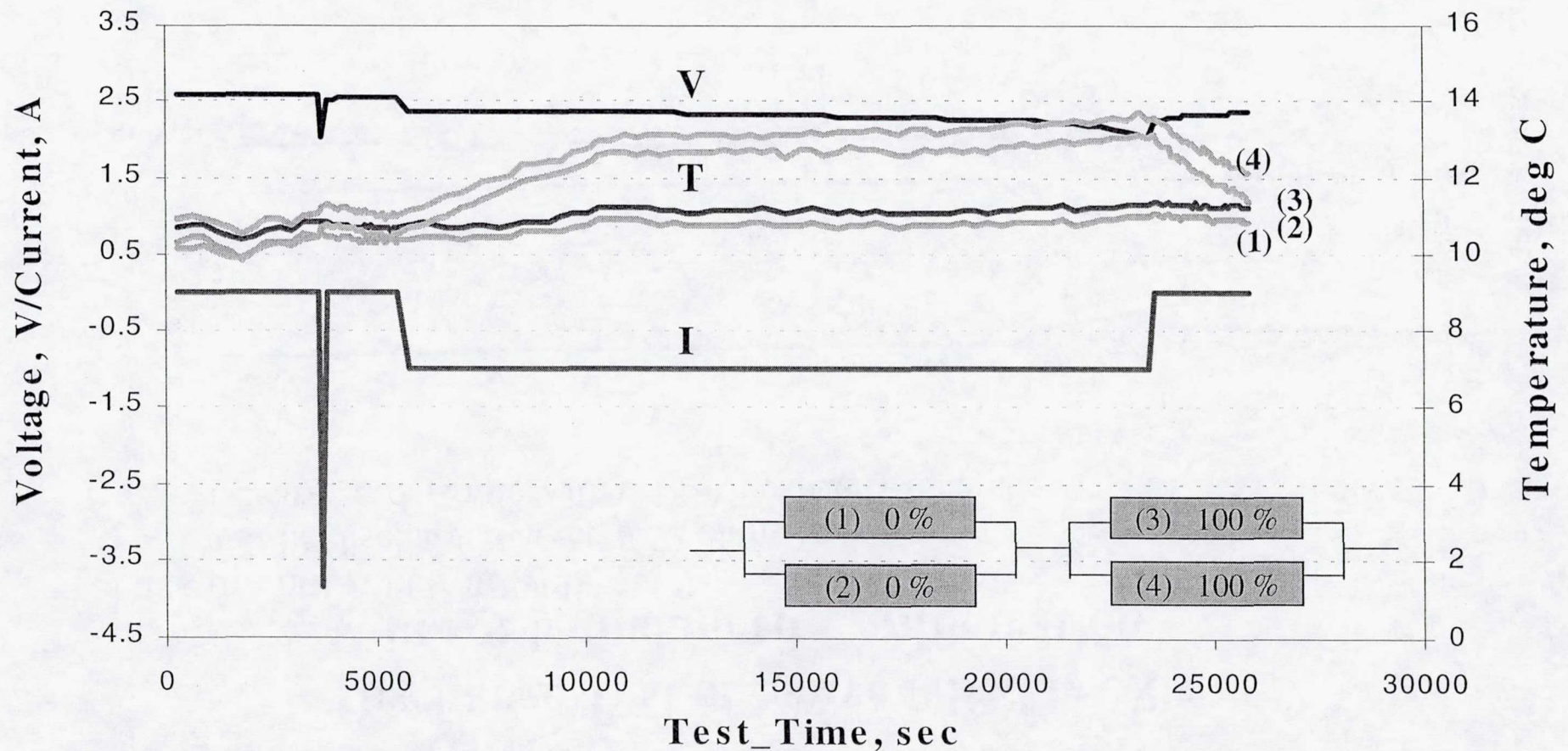
- 3.0A charge causes instantaneous voltage jump to 3.0V
- Charge with 1.0A or less is acceptable.





Discharge Test on Sanyo NiCd D Cells in an Unbalanced Configuration with 1A Current

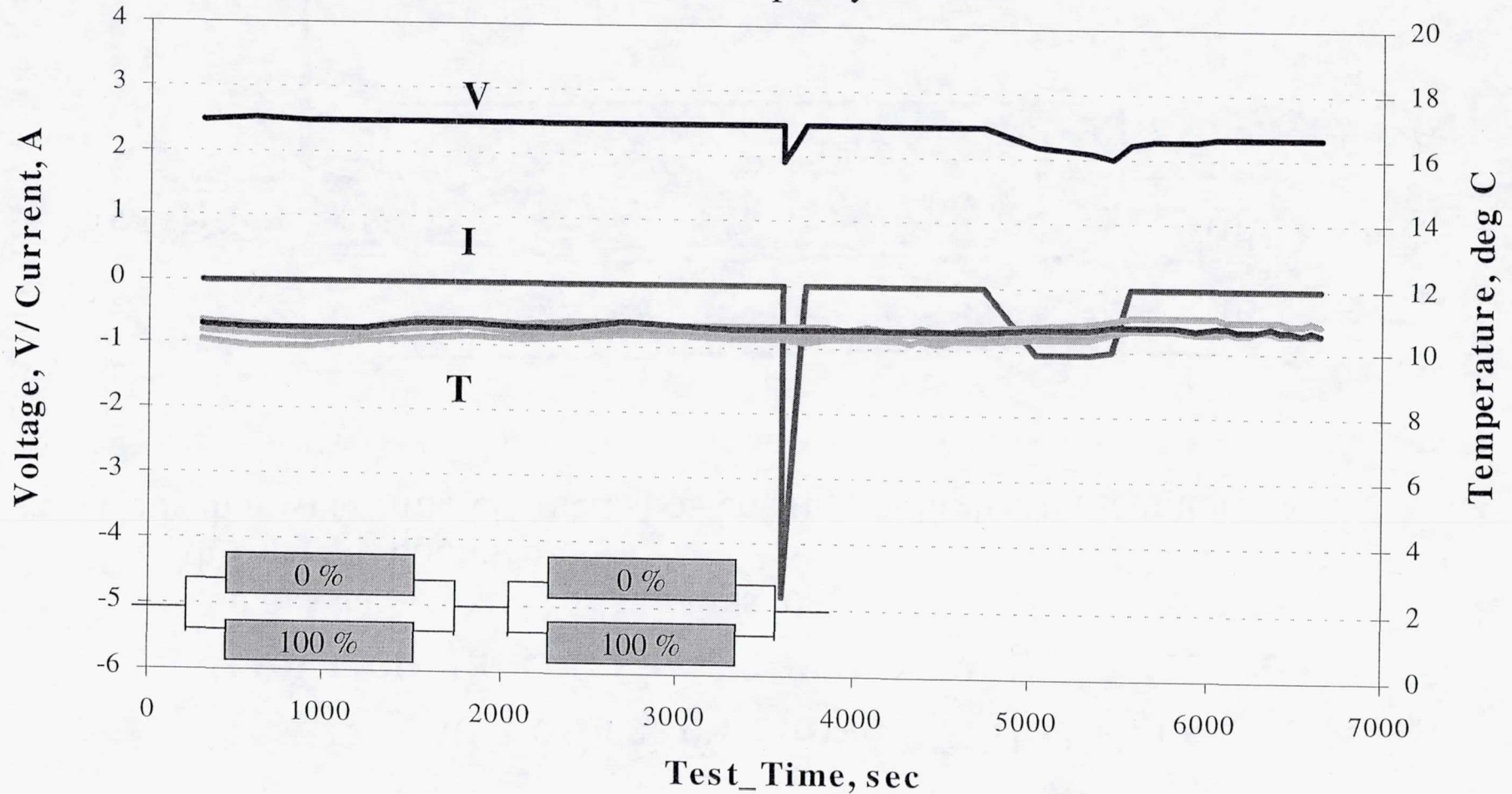
- Can't be discharged at the 0.52 ohms load
- 5.1 Ah capacity obtained
- Cells that were fully charged showed slightly higher temperature





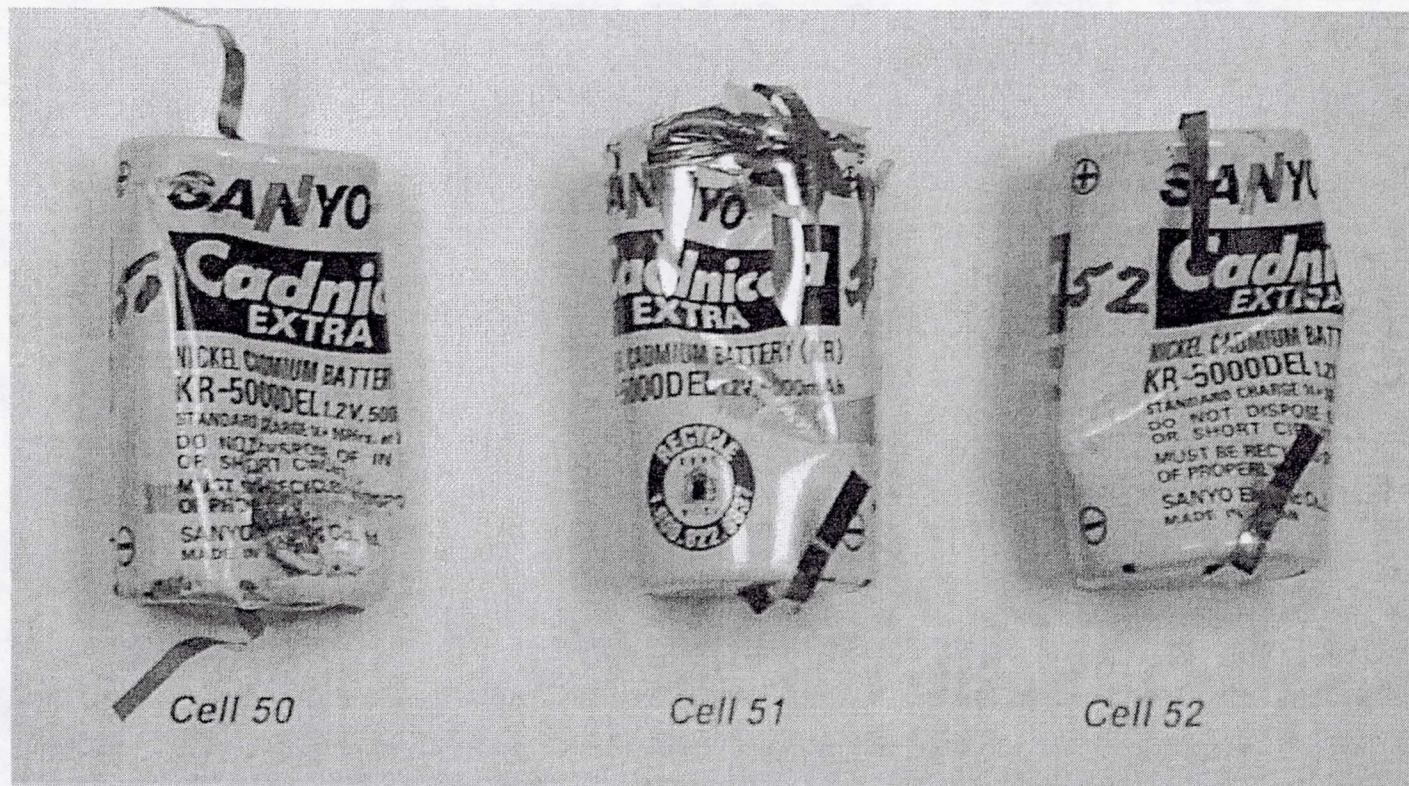
Discharge Test of Sanyo NiCd D cells in An Unbalanced Configuration

- Pack did not function well
 - Can't be discharged at the 0.52 ohms load
 - Discharge at 1 A rate with 0.18 Ah capacity obtained



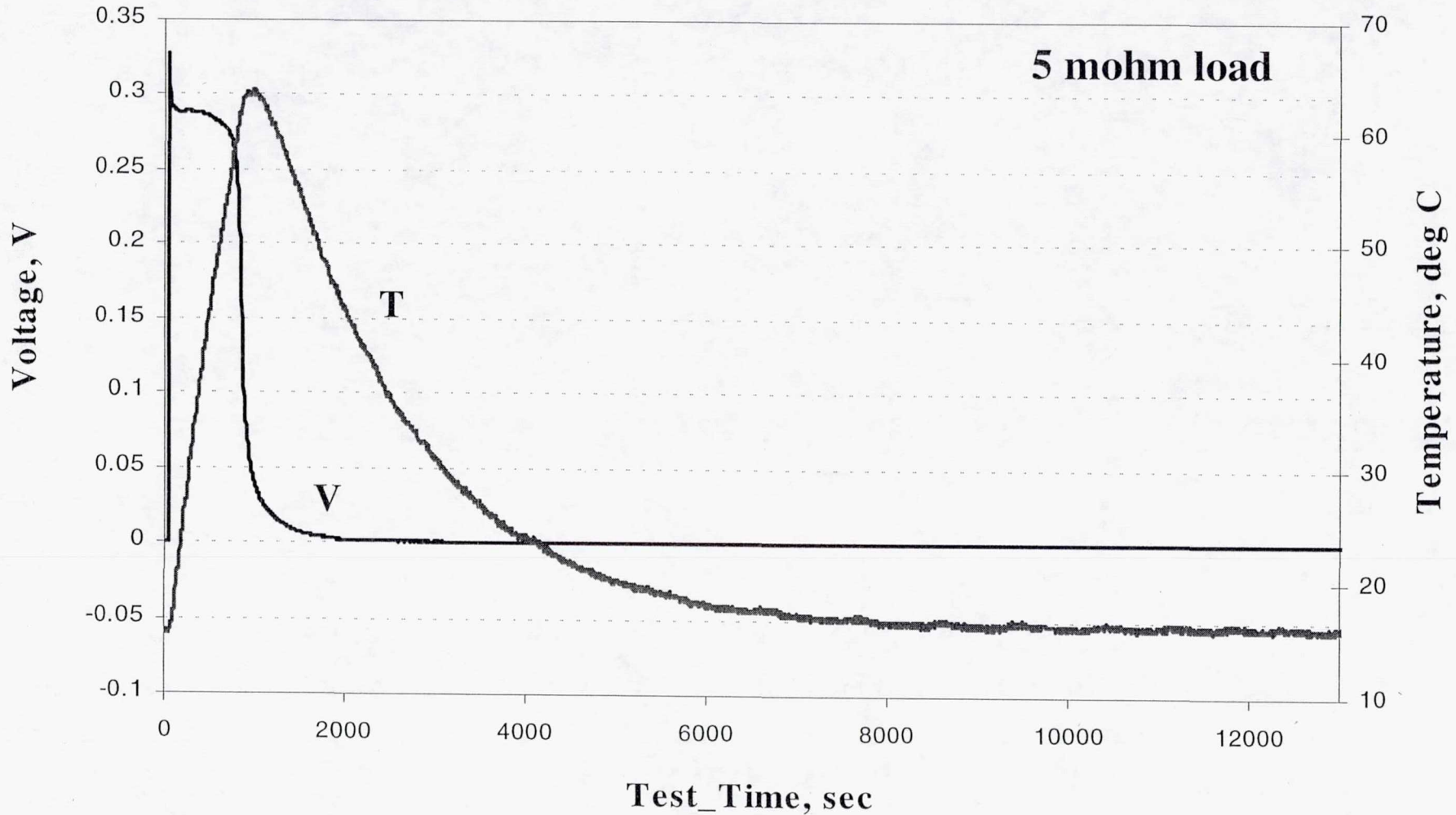
Internal Short

- Cells show good OCV even when they are severely deformed.
- No violent explosion when the cells were crushed completely



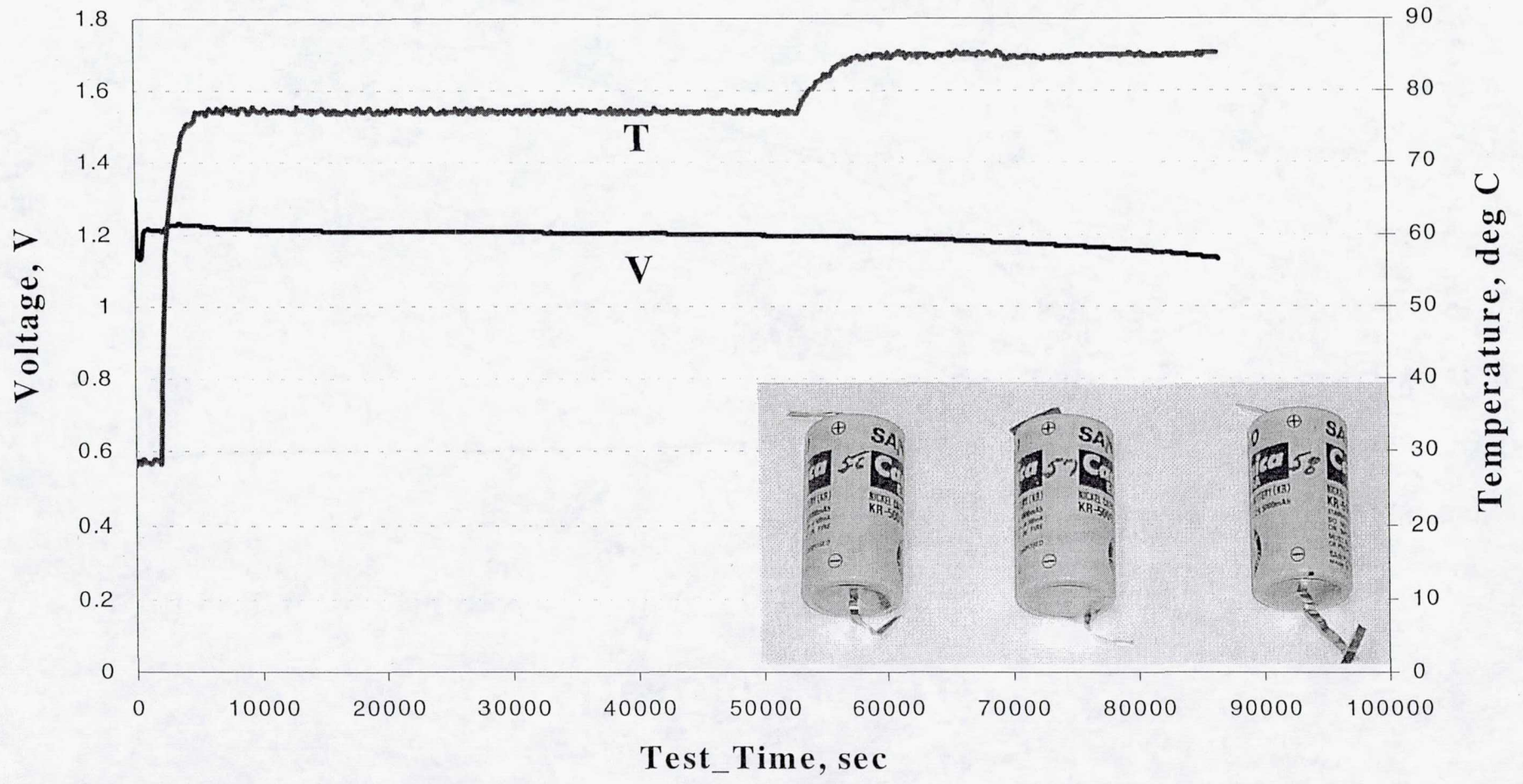
External Short Test of the Sanyo NiCd D Cell

- No mishaps



High Temperature Exposure of Sanyo NiCd D Cell at 80 °C

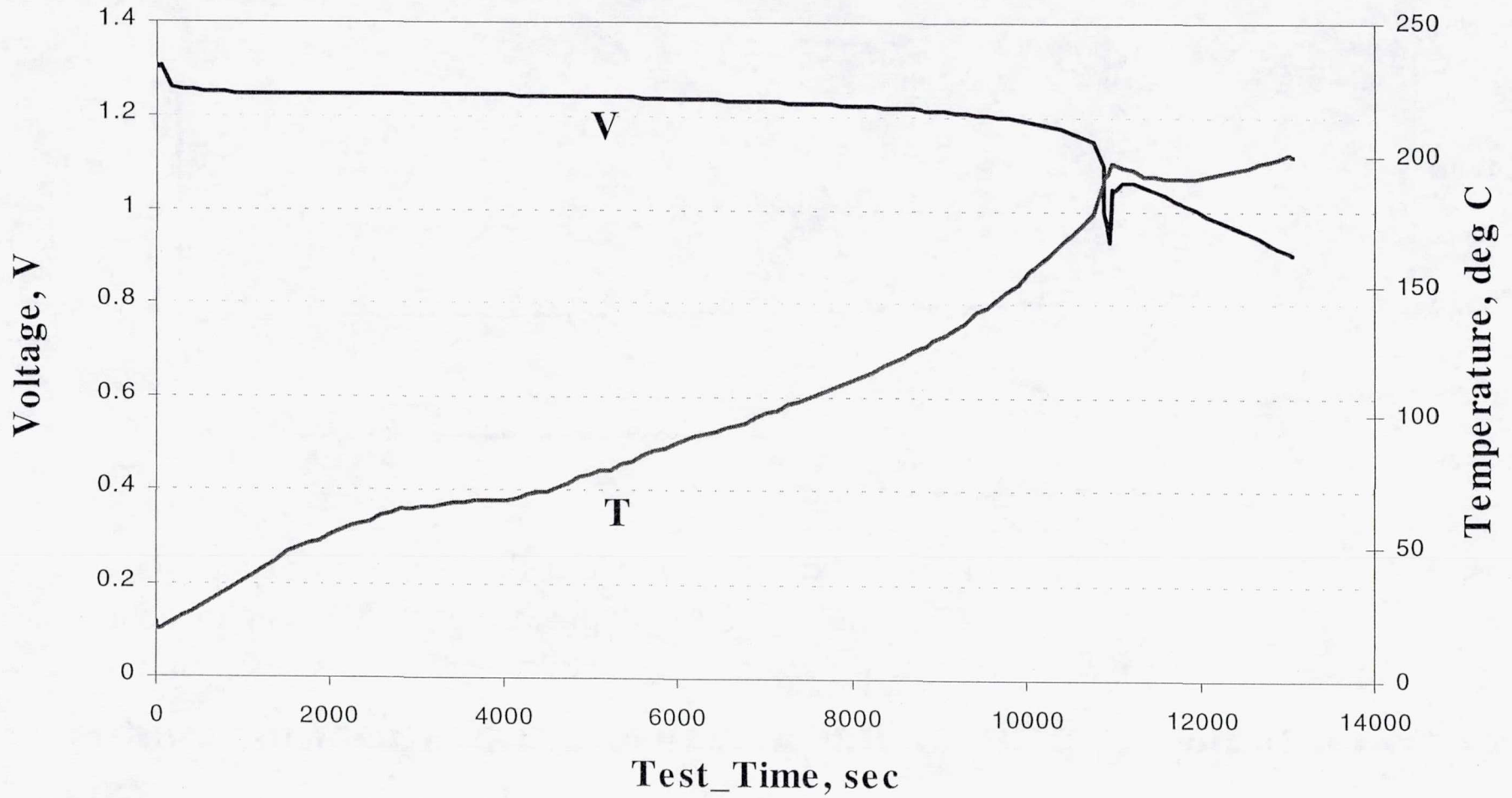
- No mishaps with exposure to 80 °C for over 3 hours.
- No weight changes before and after the exposure
- Cells delivered 4.8Ah capacity after 3 hrs exposure at 80 °C

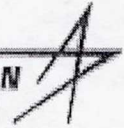




Heat-to-Vent Test

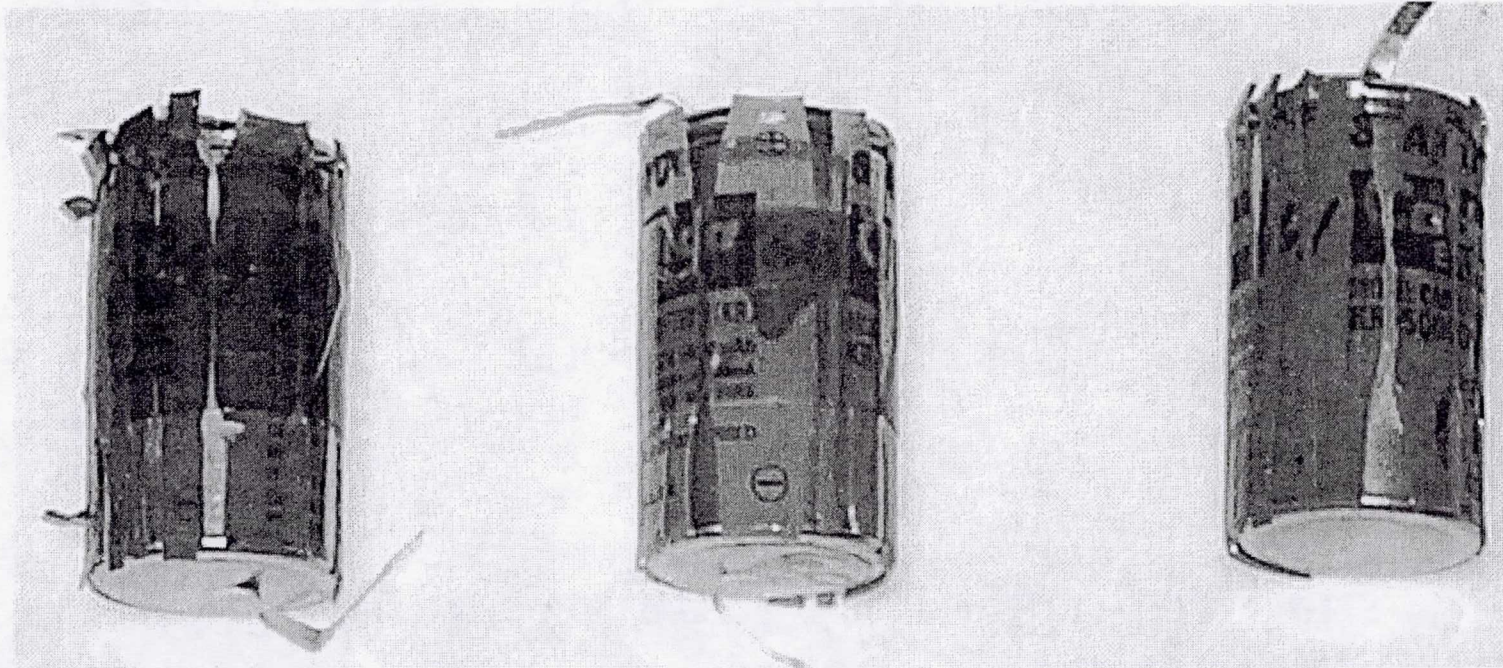
- Cell skin temperature and voltage profiles



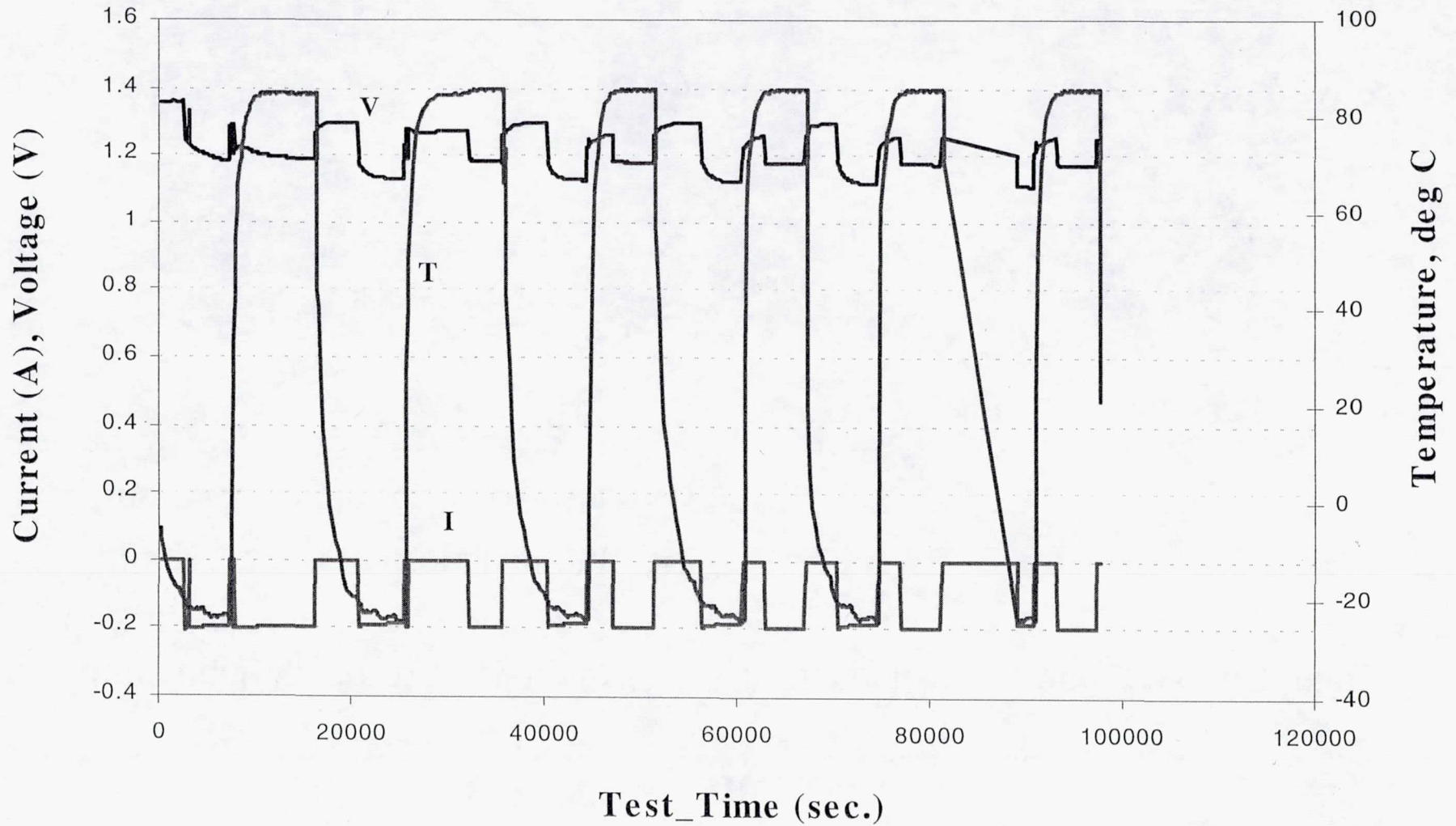


Heat-to-Vent Test

- Cells functioned normally up to 130 °C. The cells were under 6 ohms load during the test.
- Voltage started to drop at about 150 °C.
- Minor electrolyte leakage observed



Thermal Cycling of Sanyo NiCd D Cells



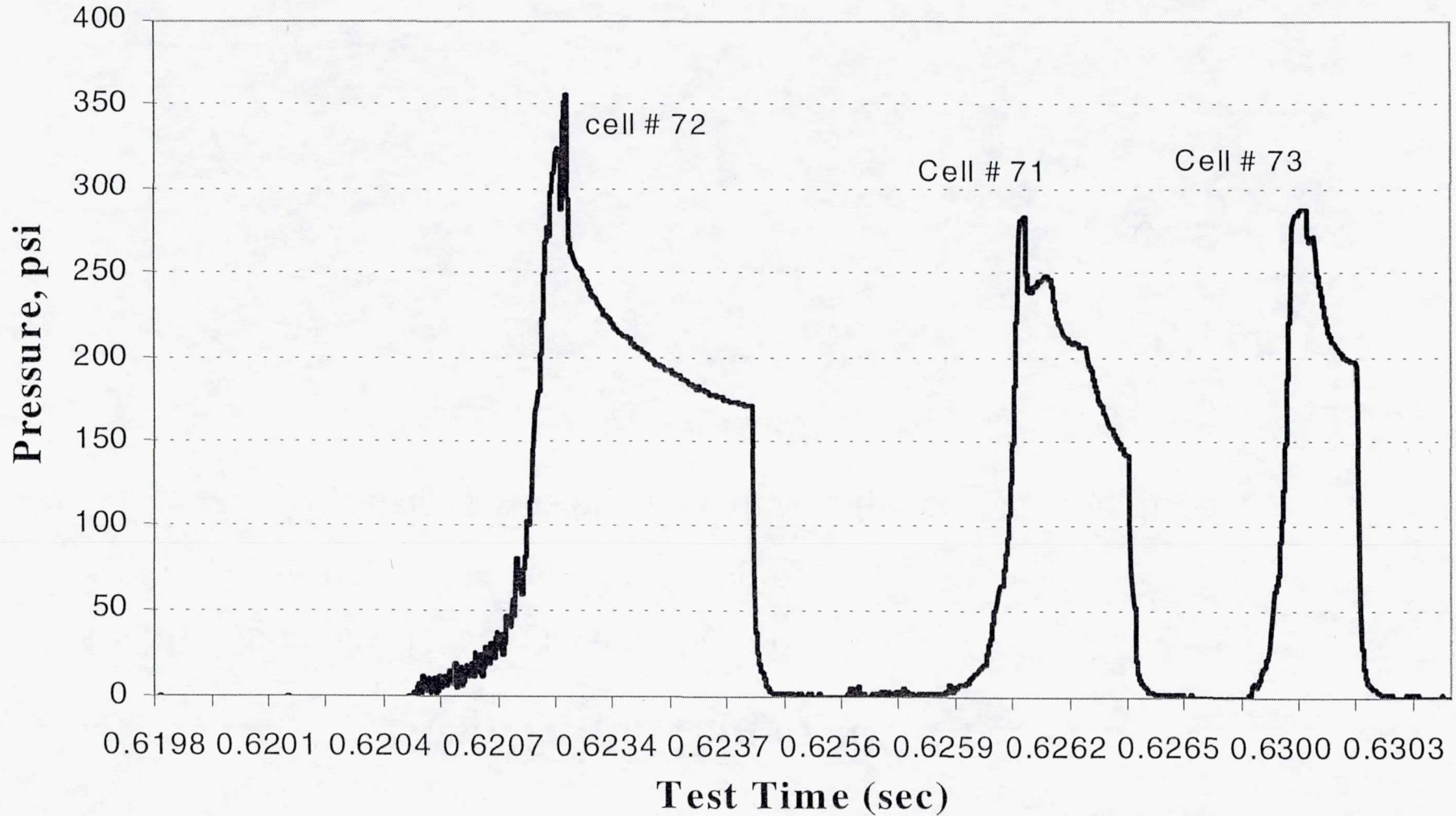
Drop Test of Sanyo NiCd D Cell

- Minimum physical damage to the cells
- No performance change after dropping
 - 5.3 Ah capacity was obtained during the post charge/discharge cycle



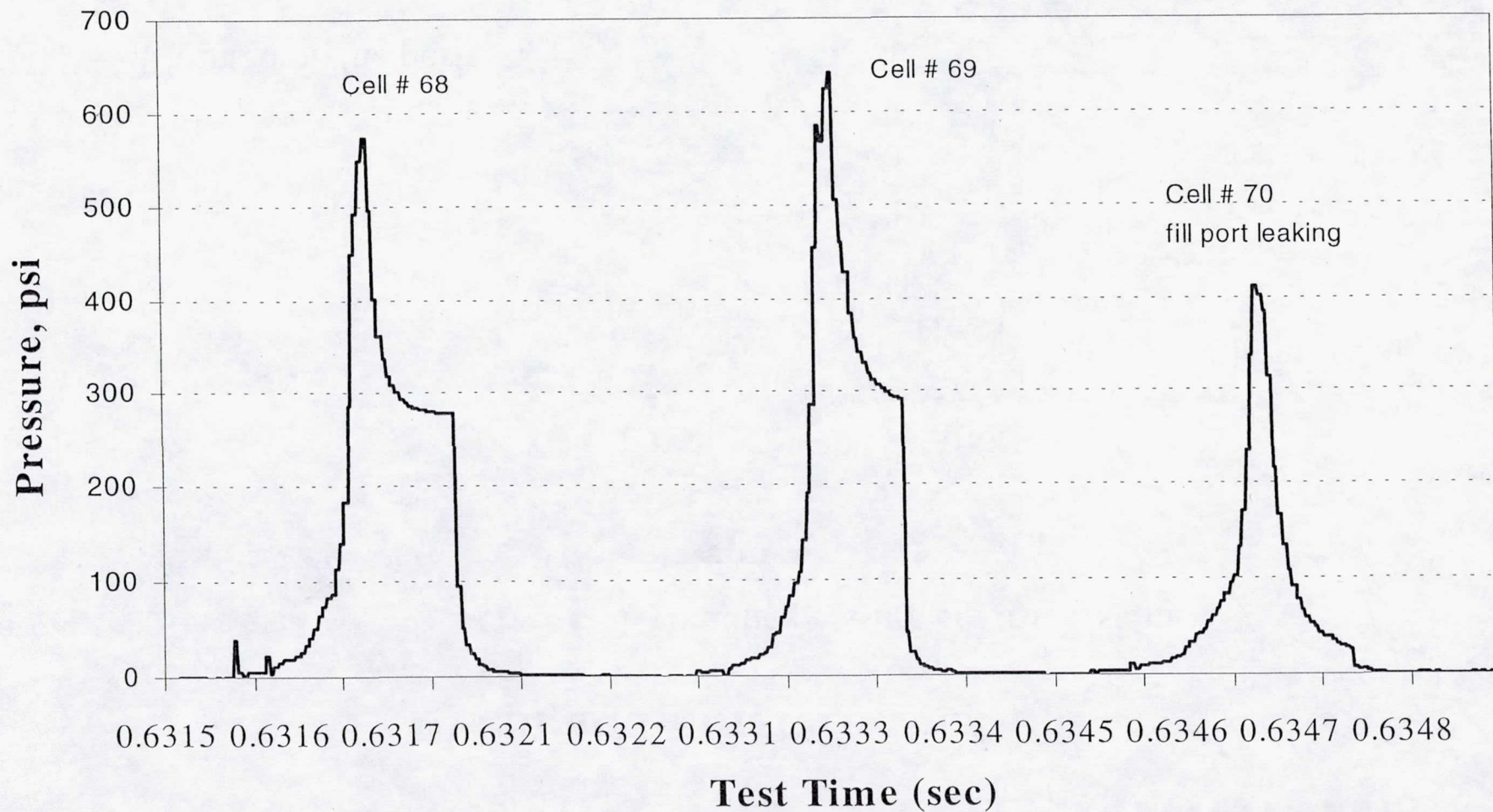
Vent Pressure Test of Sanyo NiCd D Cell

- Cell vented at > 280 psi

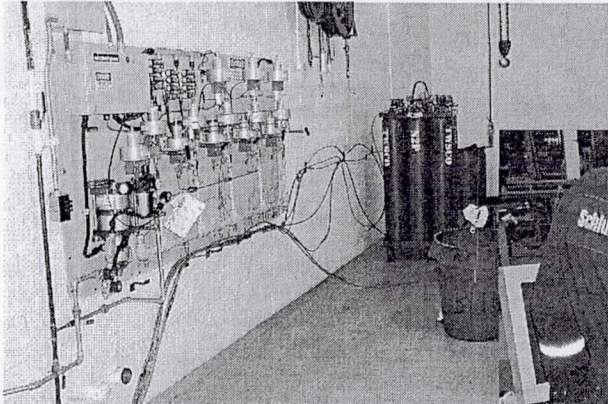


Burst Pressure Test of Sanyo NiCd D Cell

- Vent covered by epoxy
- Vent occurred through epoxy covered vent holes. Cell did not burst.



Vent and Burst Test Set-ups



Hydraulic pressure control system



Data acquisition system

Cell vented on the ports



Epoxy on the vent

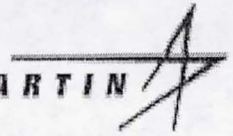




Vibration Test of Sanyo NiCd D Cell

Vibration tests in X, Y, and Z axes for 15 min. respectively with following vibration spectrum:

Frequency:	Level:
20-80 HZ	+3 dB/octave
80-350 Hz	0.1g ² /Hz
350-2000 Hz	-3 dB/octave



Conclusion

- The best combination of charge/discharge current rate is 0.3C for charge and 1/2C for discharge within 200 cycles. No significant changes in capacity were observed in 200 cycles. The cell also showed capability of 5C (25.0A) high rate discharge.
- In overcharge and overdischarge tests, all tested cells passed the tests without venting.
- In imbalance tests, the battery pack could be charged and discharged only at relatively low current. At charge current of 1.0A or less, the imbalanced cells in the battery pack displayed relatively high temperatures during charge or discharge.
- The cells functioned normally during internal short and no mishap occurred during external short.
- Cells passed exposure tests at 80 °C and no leakage till 150 °C during heat-to-vent tests.



(Continued)

- The cell vent operated at 280 psi and no burst of the can occurred even at 570 psi.
- Cells passed vacuum, drop, and vibration tests.