Evaluation of 20 Ah Li Ion Cells

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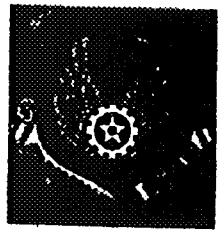
ABSTRACT

Lithium ion cells of 20 Ah capacity were fabricated by Bluestar Advanced Technology Corporation, Canada under a developmental contract from US Air Force. In this paper, we report our studies on the evaluation of these cells under various test conditions. These include generic test conditions such as discharges and charges at different temperatures to understand the rate-limiting processes in the discharge/charge processes as a function of temperature, and cycle life under standard cycling conditions (100 % DOD) at ambient temperature. In addition, tests are being done to ascertain the performance of the cells in the Mars 2001 Lander application, which includes pulse testing of the cells at 60 A and 40 A loads for 100 mS and 1 min., respectively at different states of charge and temperatures, and cycling at low temperature at partial depths of discharge.



EVALUATION OF 20 Ah LITHIUM ION CELLS (BLUESTAR)

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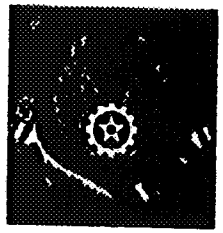
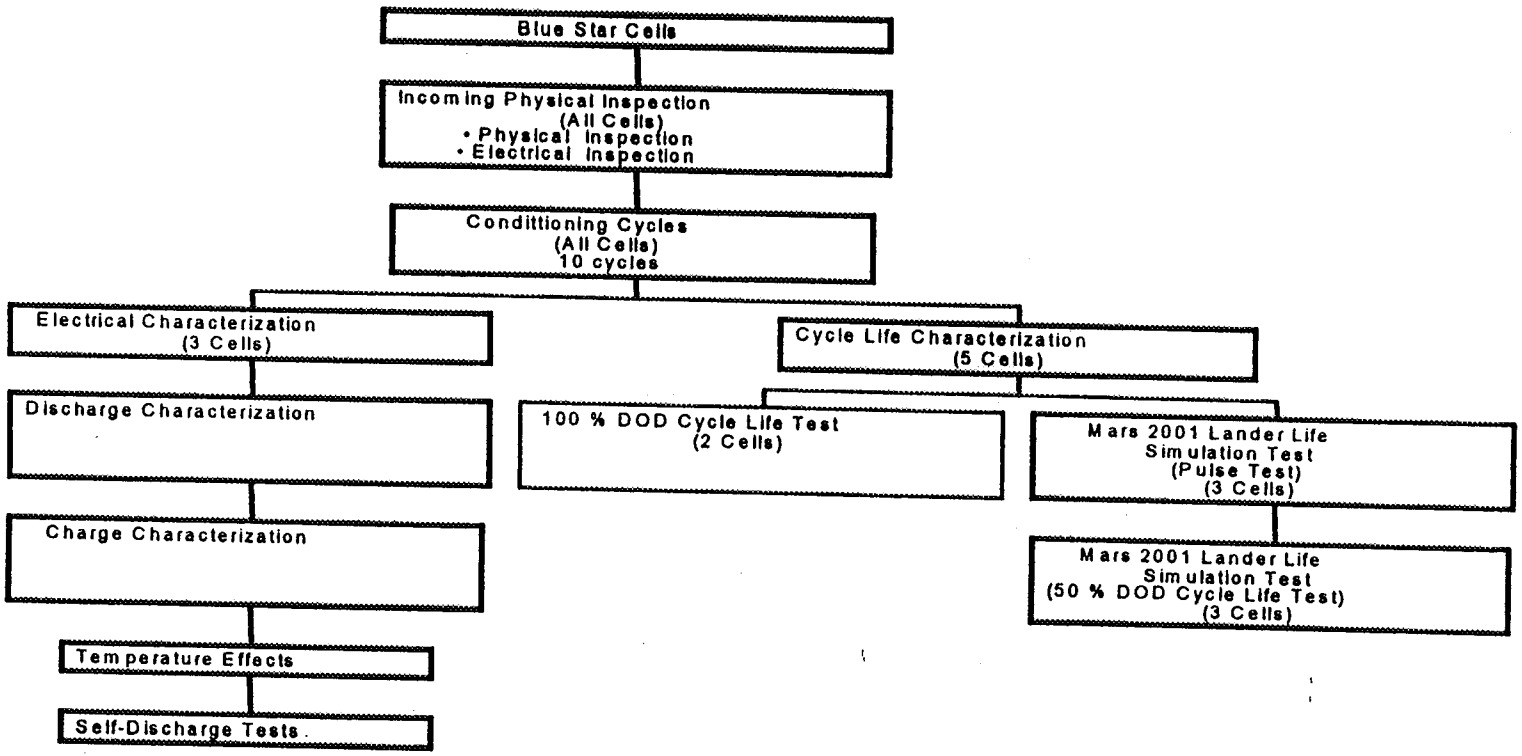
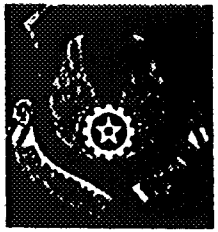


Blue Star Lithium-Ion Testing Flow Chart

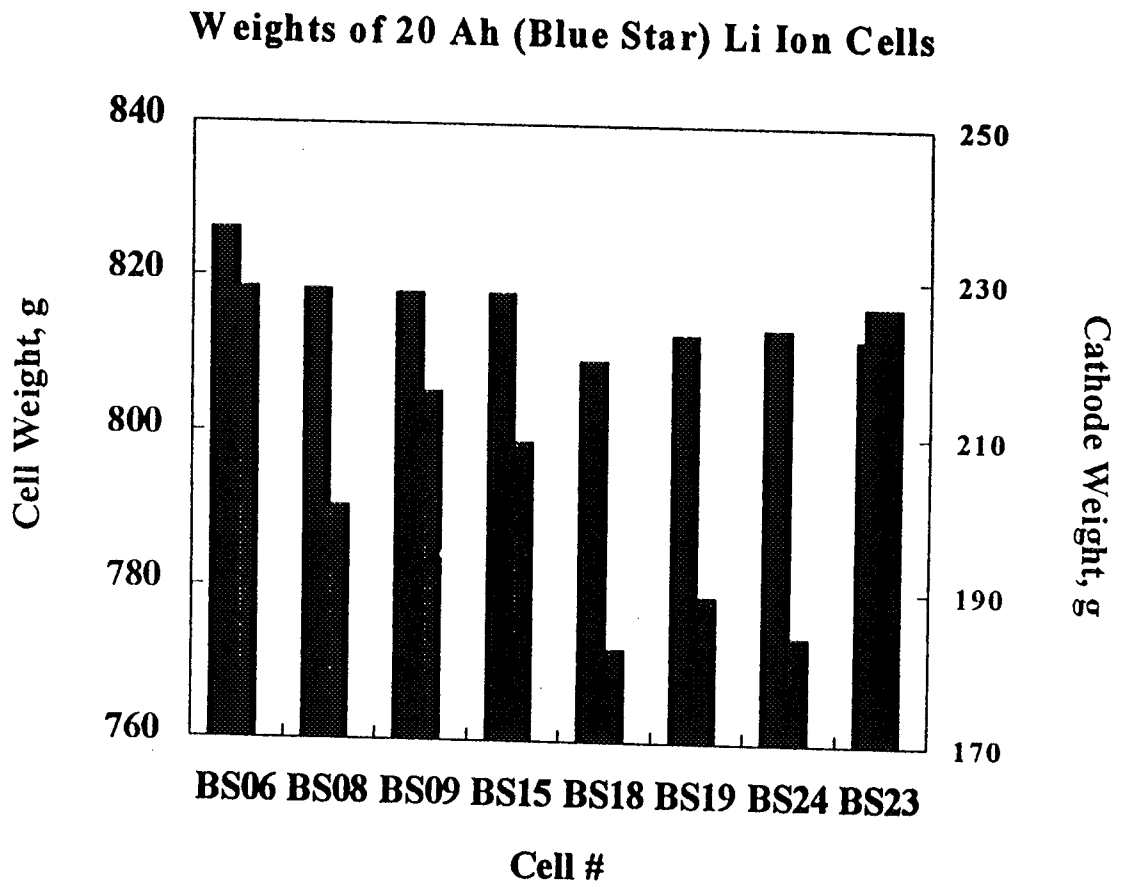




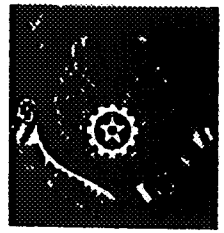
Characterization Tests

Temp.	Charge Rate			Discharge Rate		
	C/10	C/5	C/2	C/10	C/5	C/2
20°C	x			x		
	x				x	
	x					x
		x		x		
			x	x		
0°C	x			x		
	x				x	
	x					x
		x		x		
			x	x		
- 20°C	x			x		
	x				x	
	x					x
		x		x		
			x	x		
- 30°C	x			x		
	x				x	
	x					x
		x		x		
			x	x		
RT/-20°C	x			x		
(Charge at room temp. and discharge at -20° for 5 cycles0						
• Self-discharge at 20°C will be performed as described below.						
50°C	x			x		
	x				x	
	x					x
		x		x		
			x	x		
• Self-discharge at 50°C will be performed as described below.						

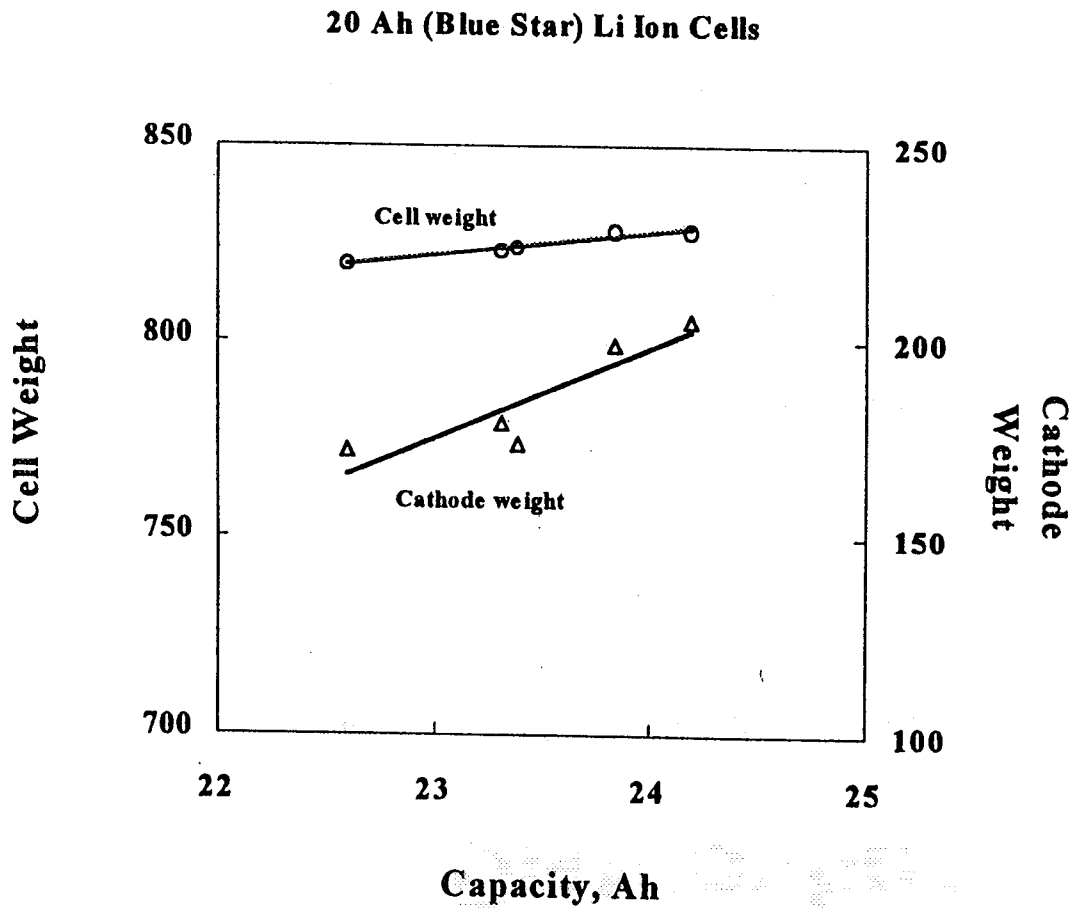
Weight Distribution



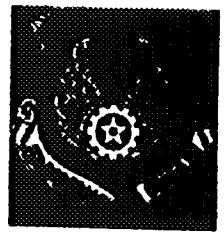
- **Cell weight more consistent among the cells compared to the cathode weight.**



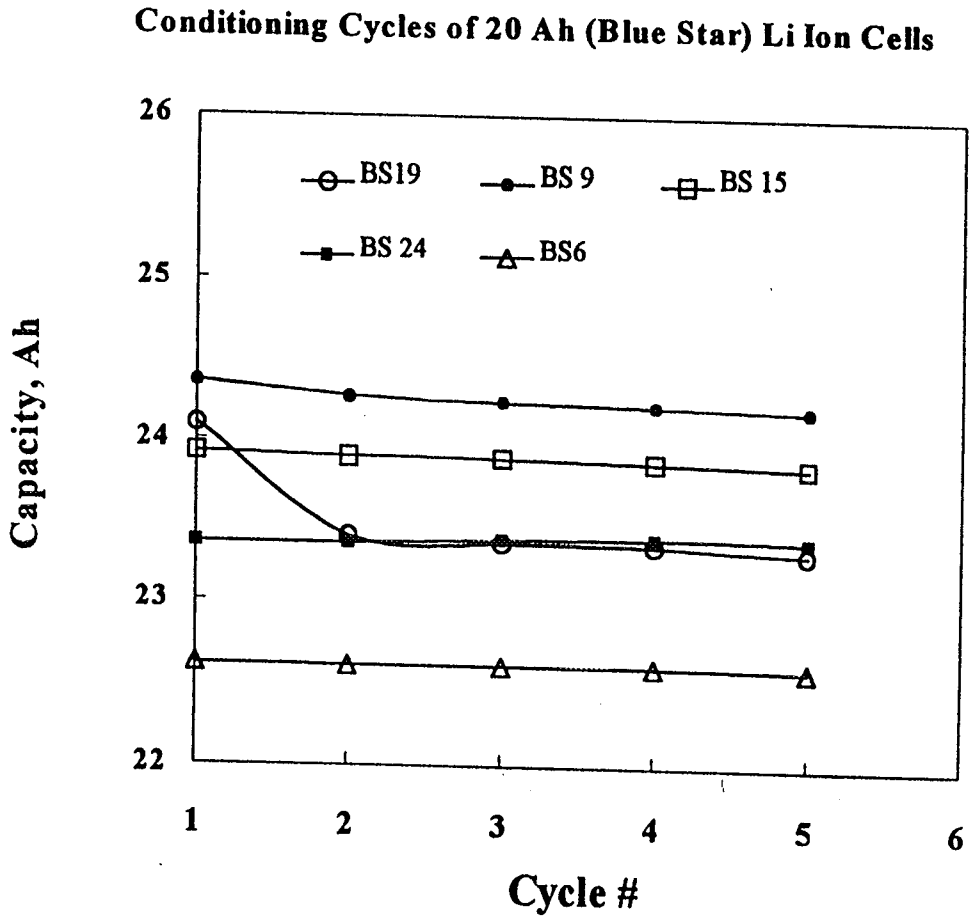
Weight vs. Capacity



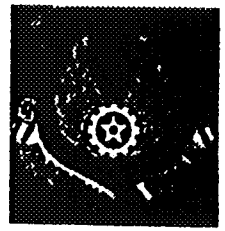
- **Capacity increase with increasing cathode weight.**



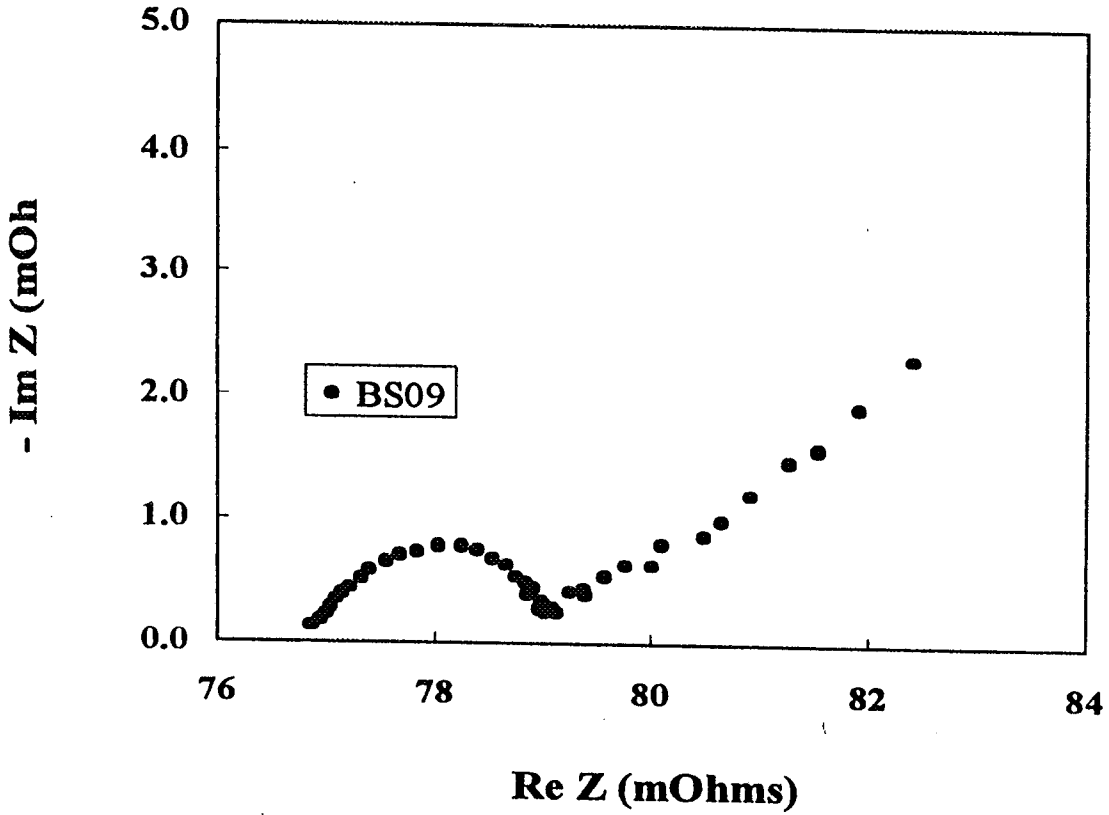
Conditioning Cycles



- **Cell capacity around 23 Ah**

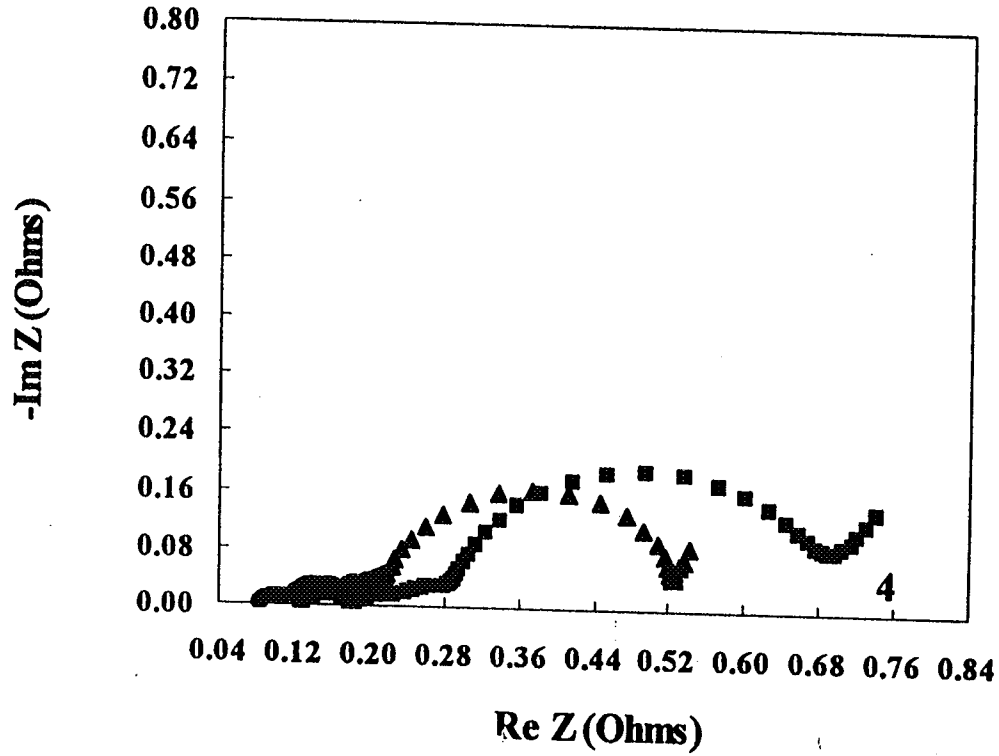


AC IMPEDANCE OF 20 Ah CELL

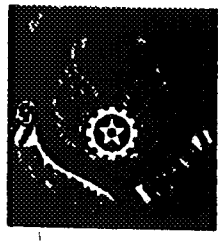


- Impedance reflective of a slow charge transfer process followed by diffusion.

EIS of JPL Experimental Li Ion Cells

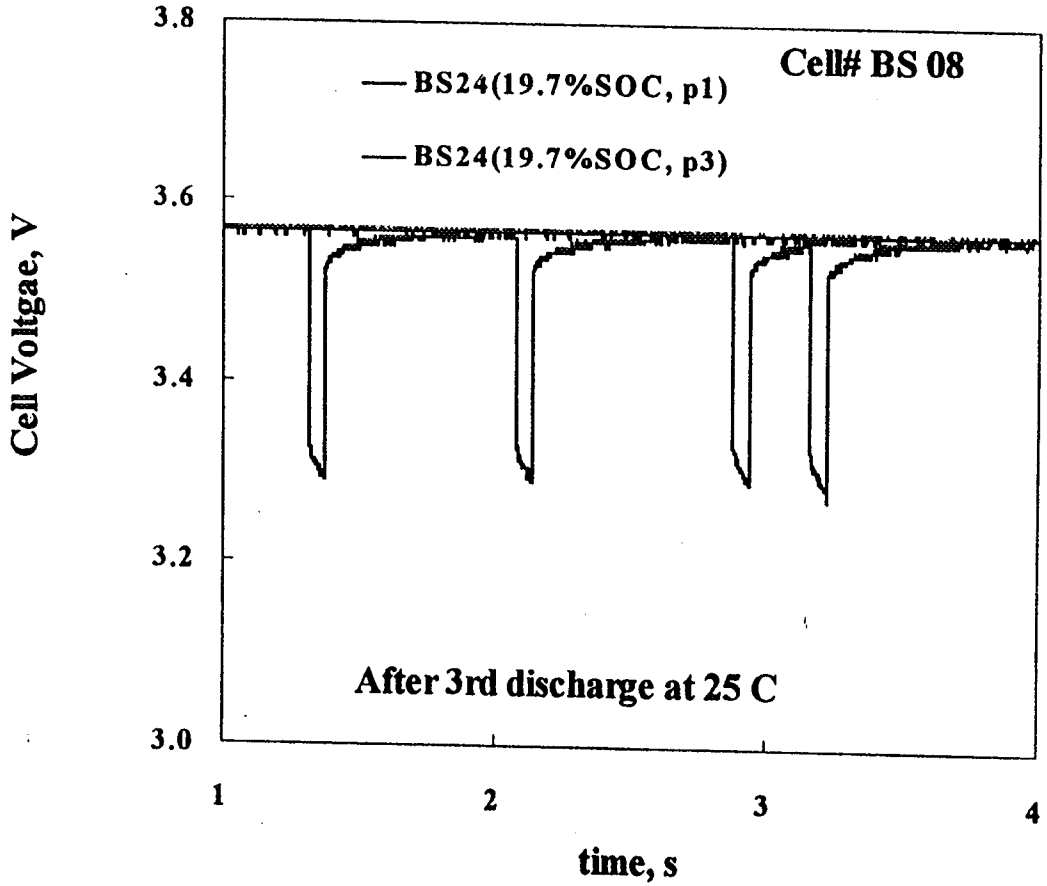


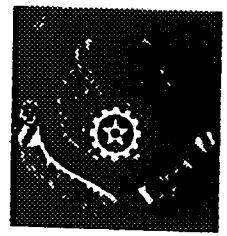
- **Cathode impedance dominant portion of the total cell Impedance.**



Pulses at 60 A at 25°C

Pulsing of Blue Star 20 Ah Cell at 60 A (120 mS)





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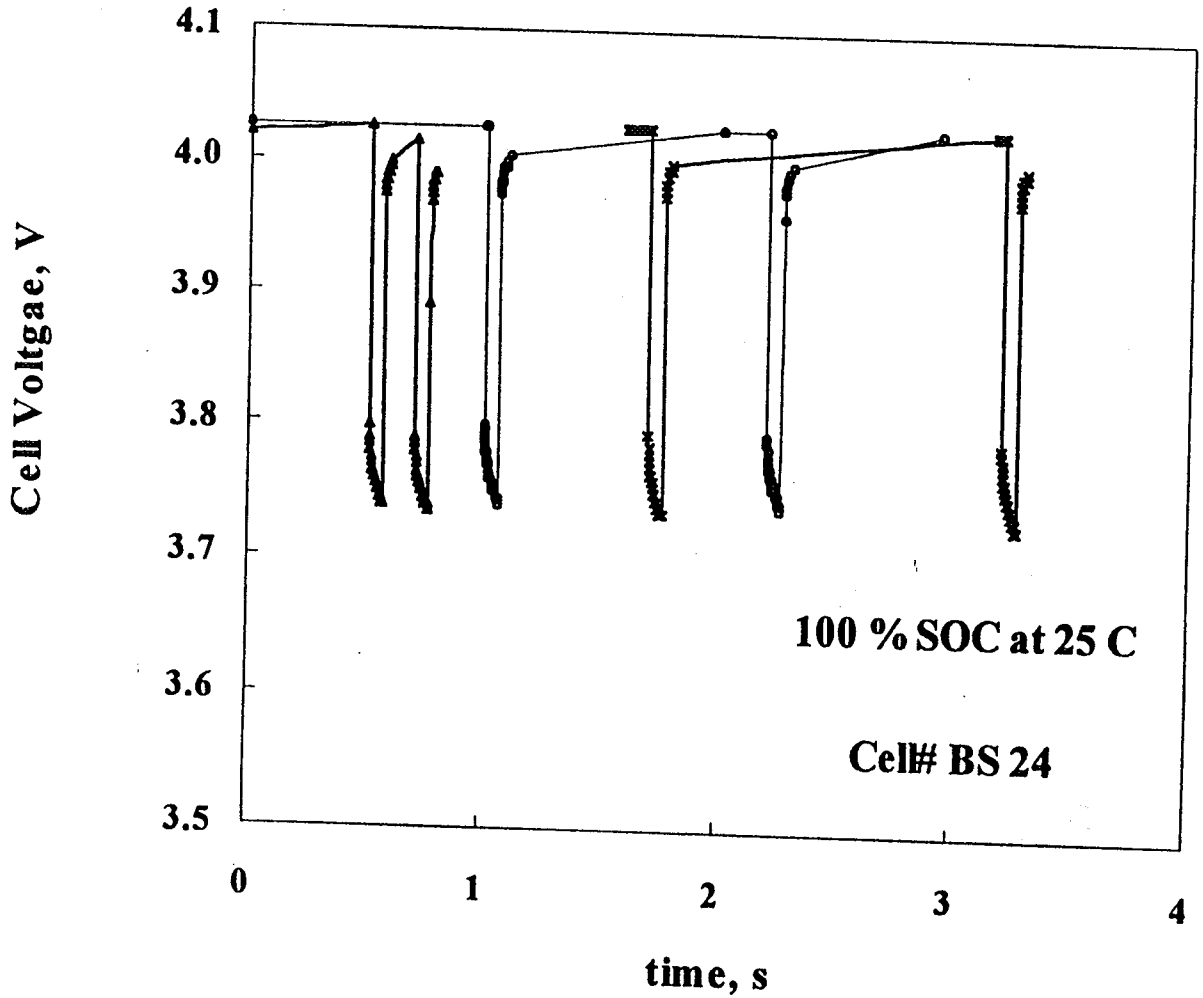
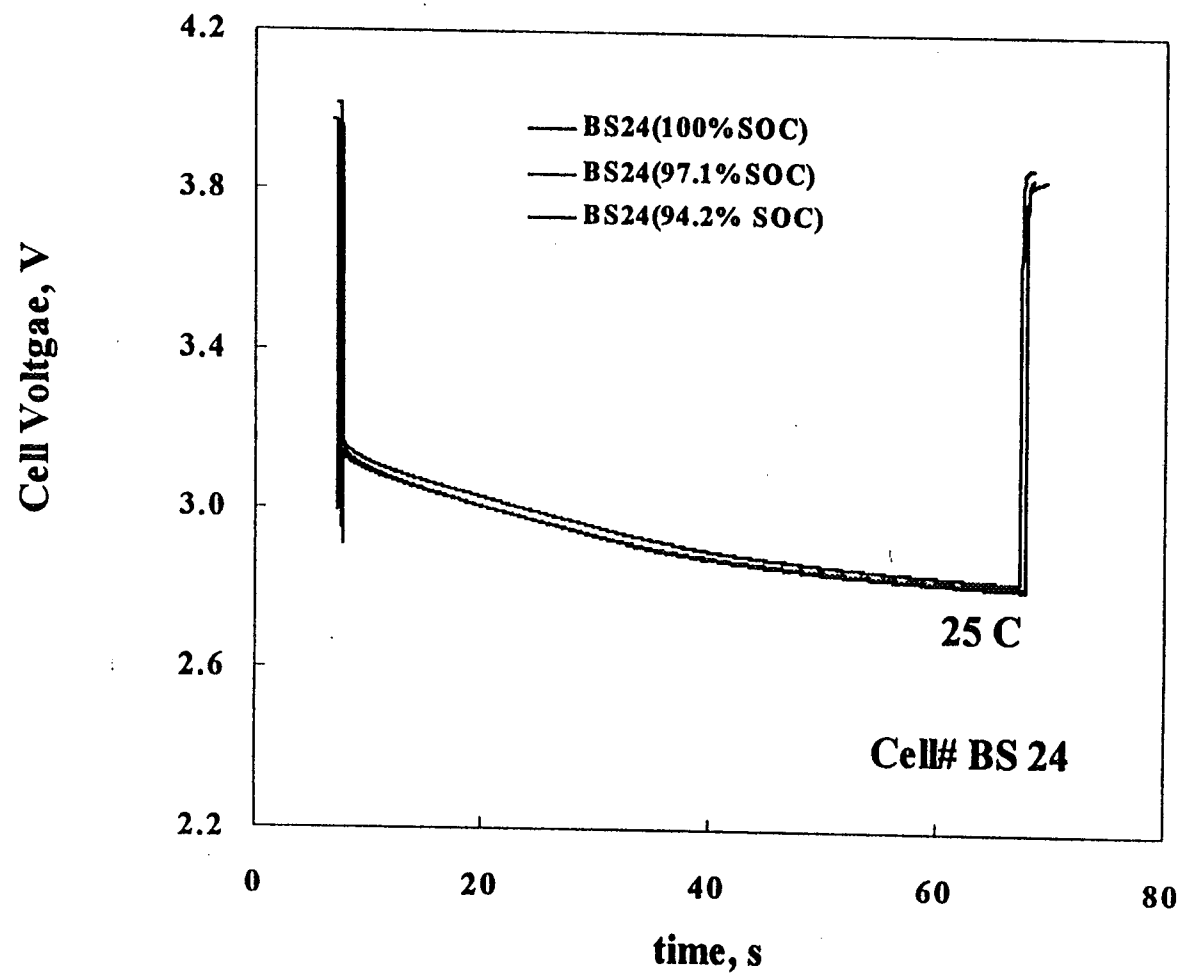
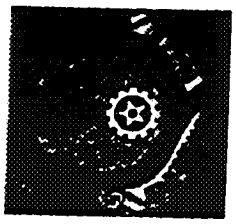
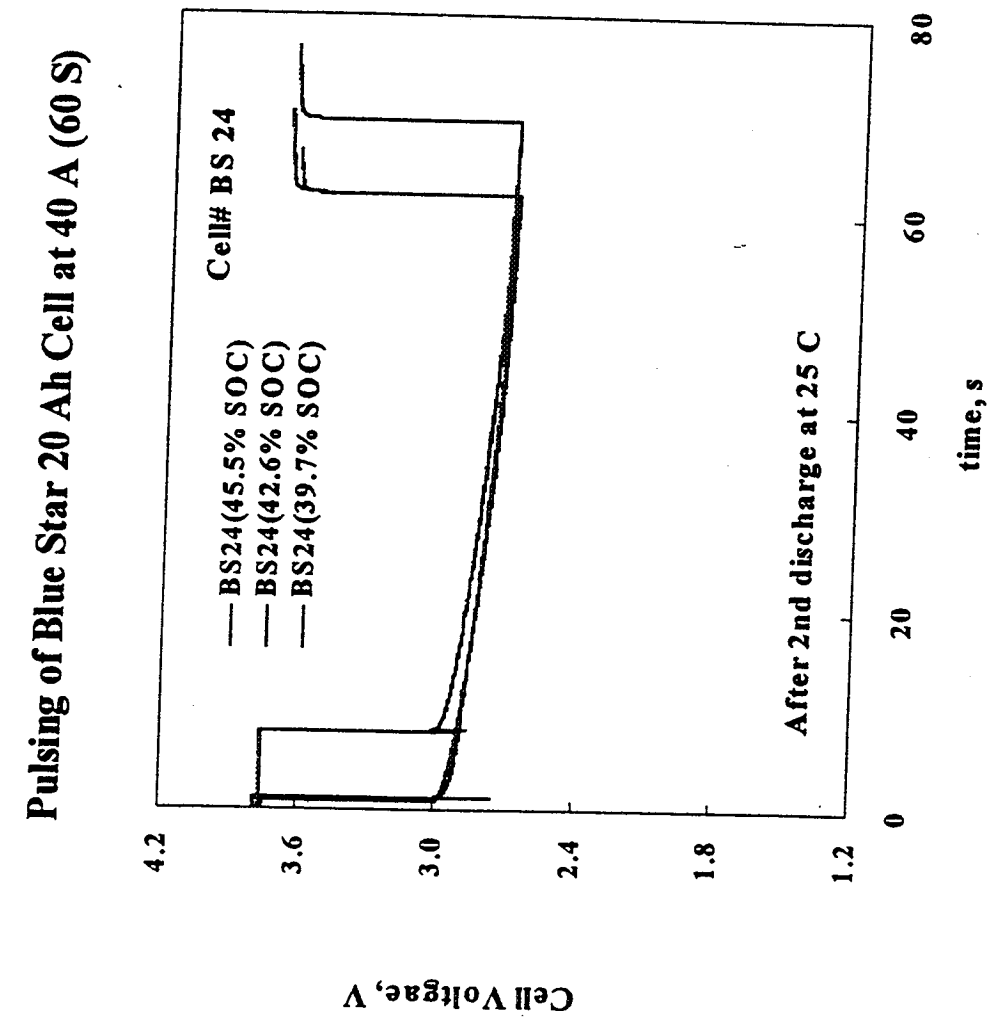


Pulses at 40 A at 25°C



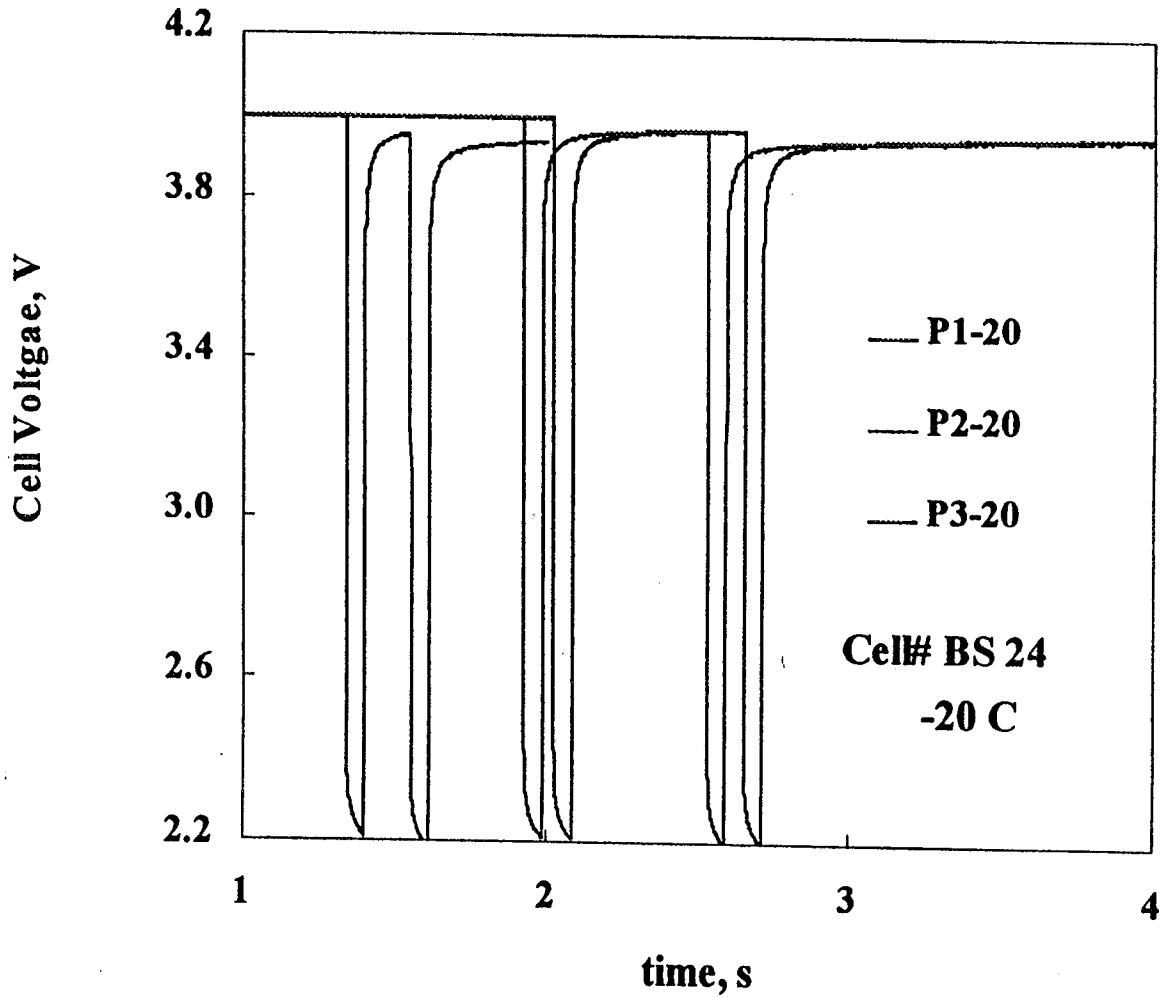


Pulses at 40 A at 25°C

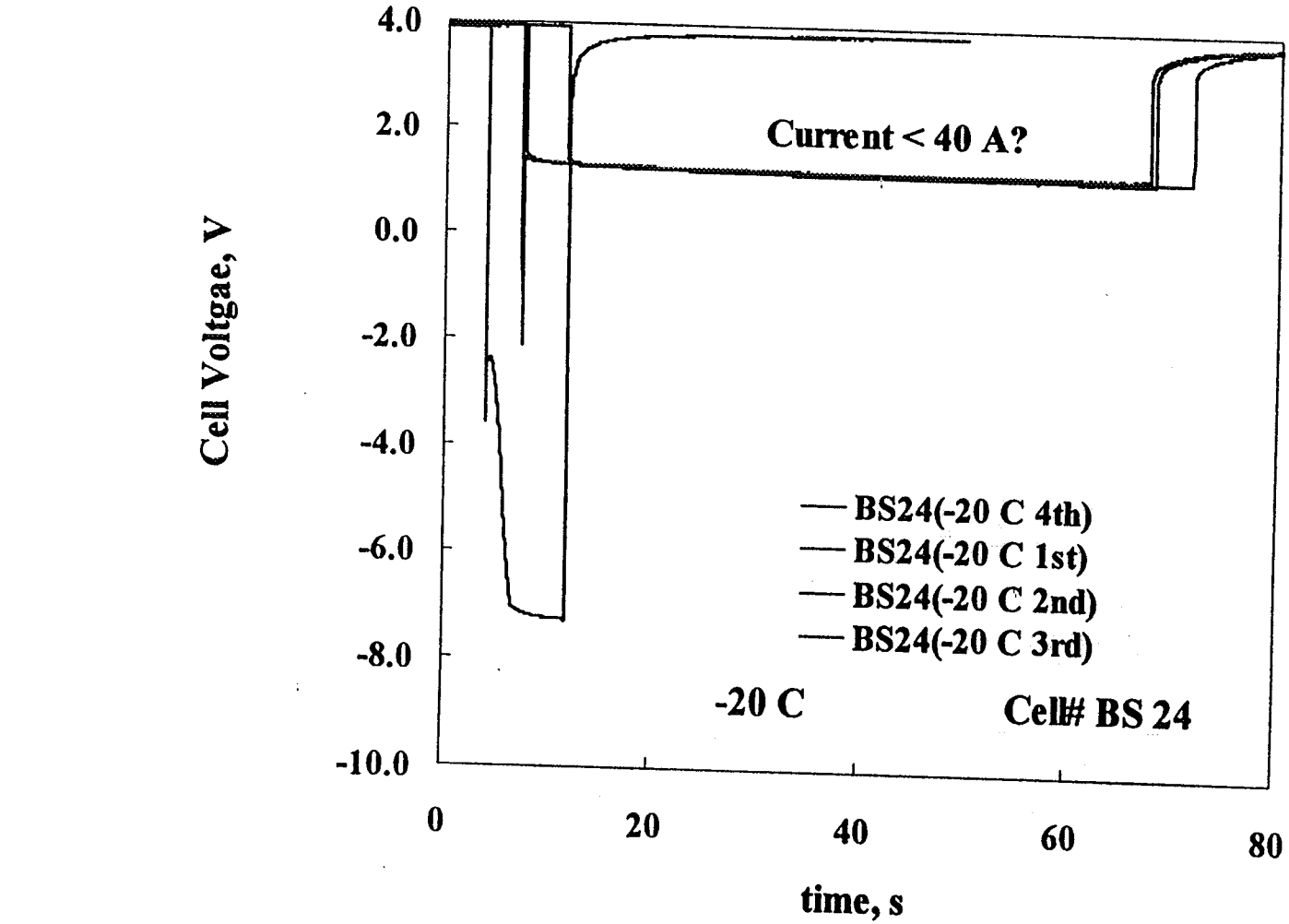


Pulses at 60 Aat -20°C

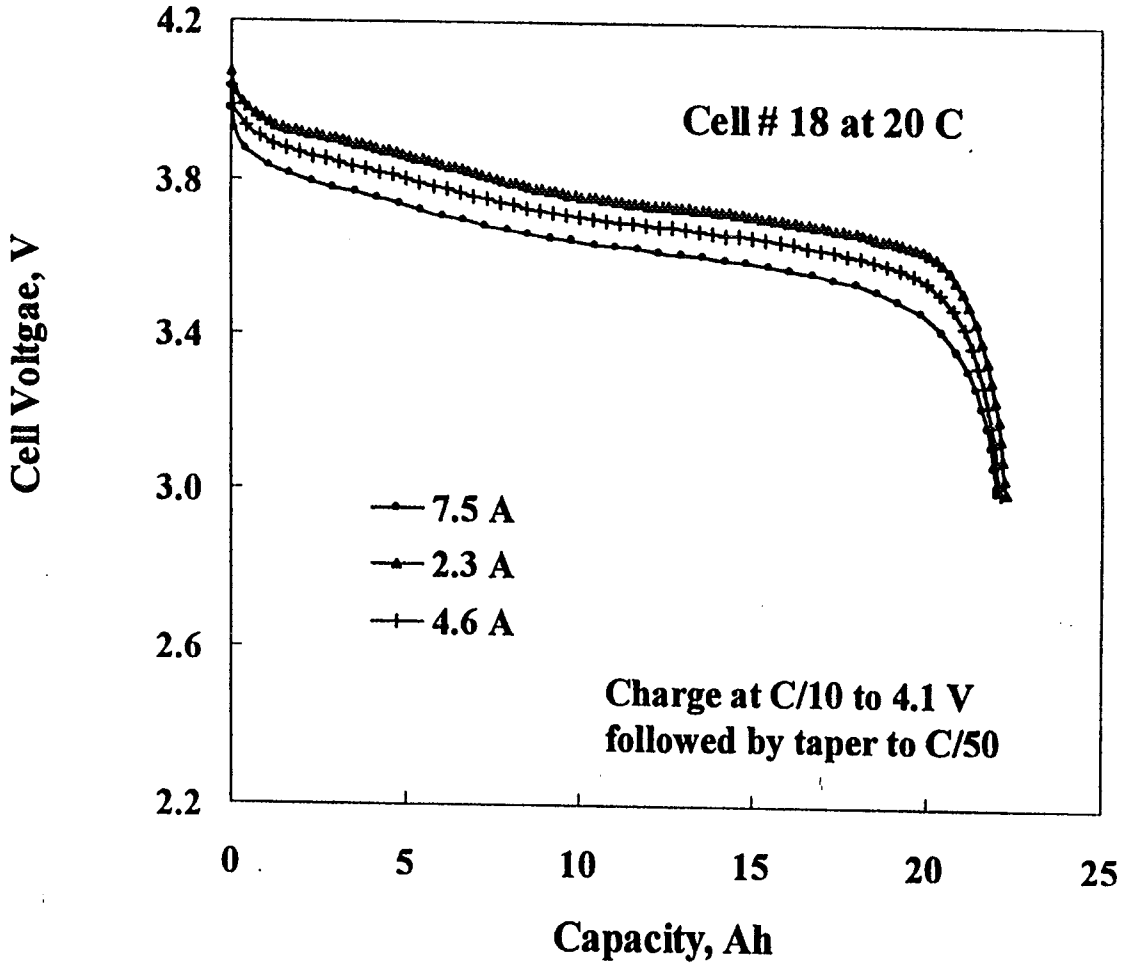
Pulsing of Blue Star 20 Ah Cell at 60 A (120 mS)



Pulses at 40 Aat -20°C

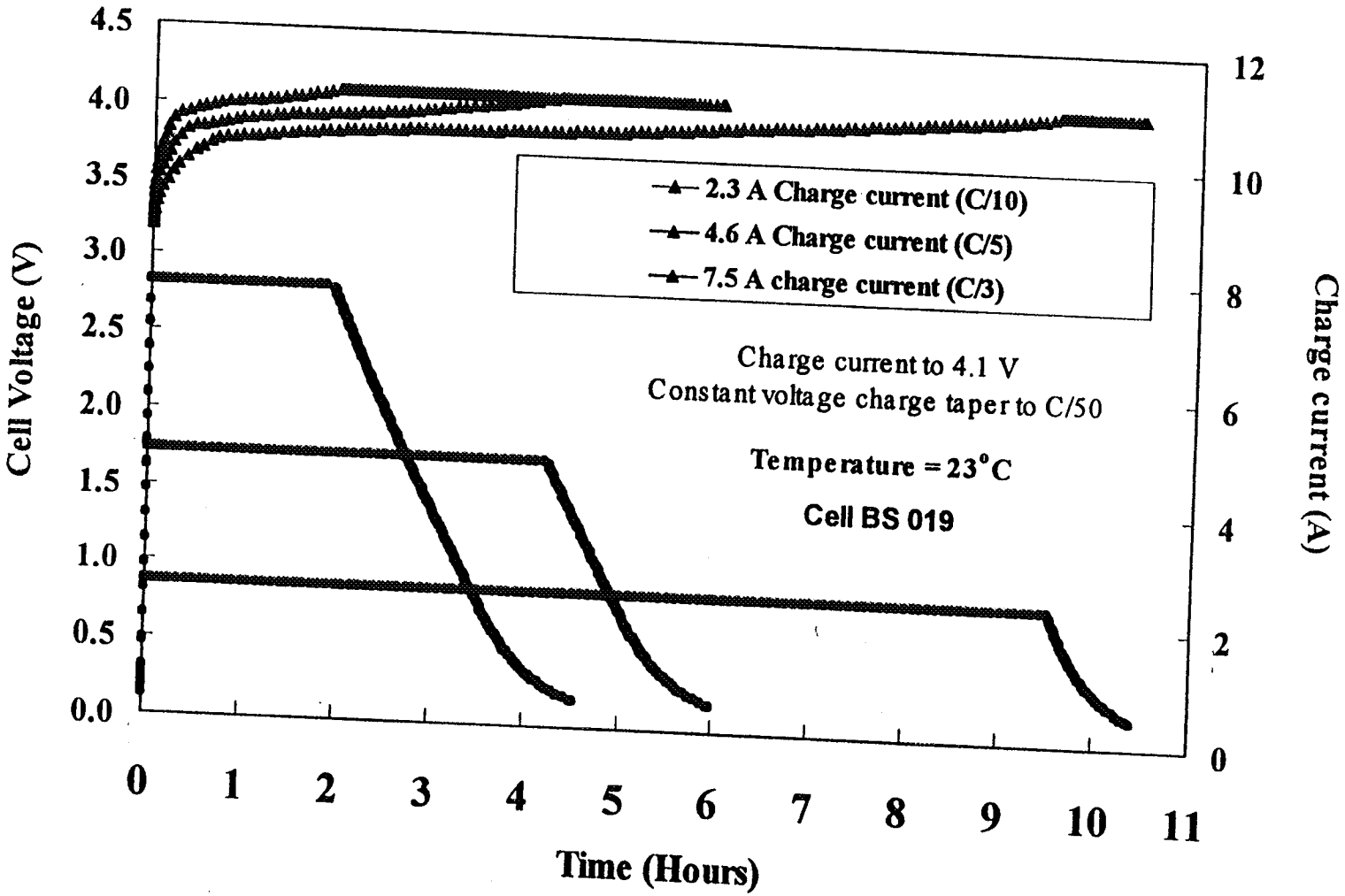


Discharge at 25°C

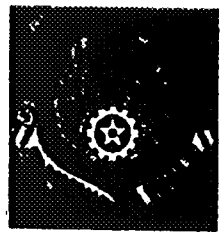


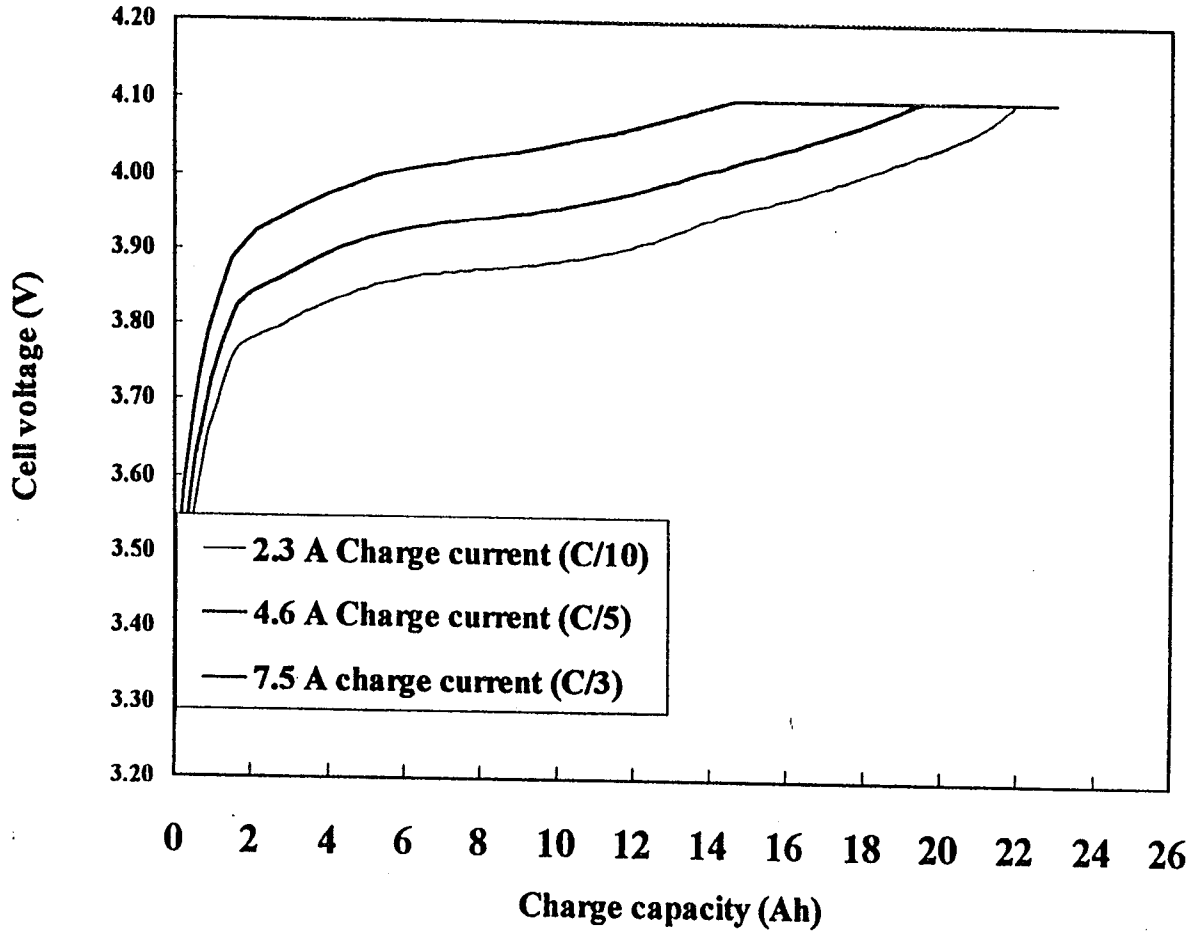
- Nearly 100 % utilization at C/3 discharge rate.

Charge at 25°C



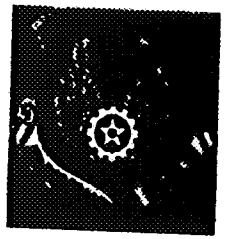
Charge at 25°C

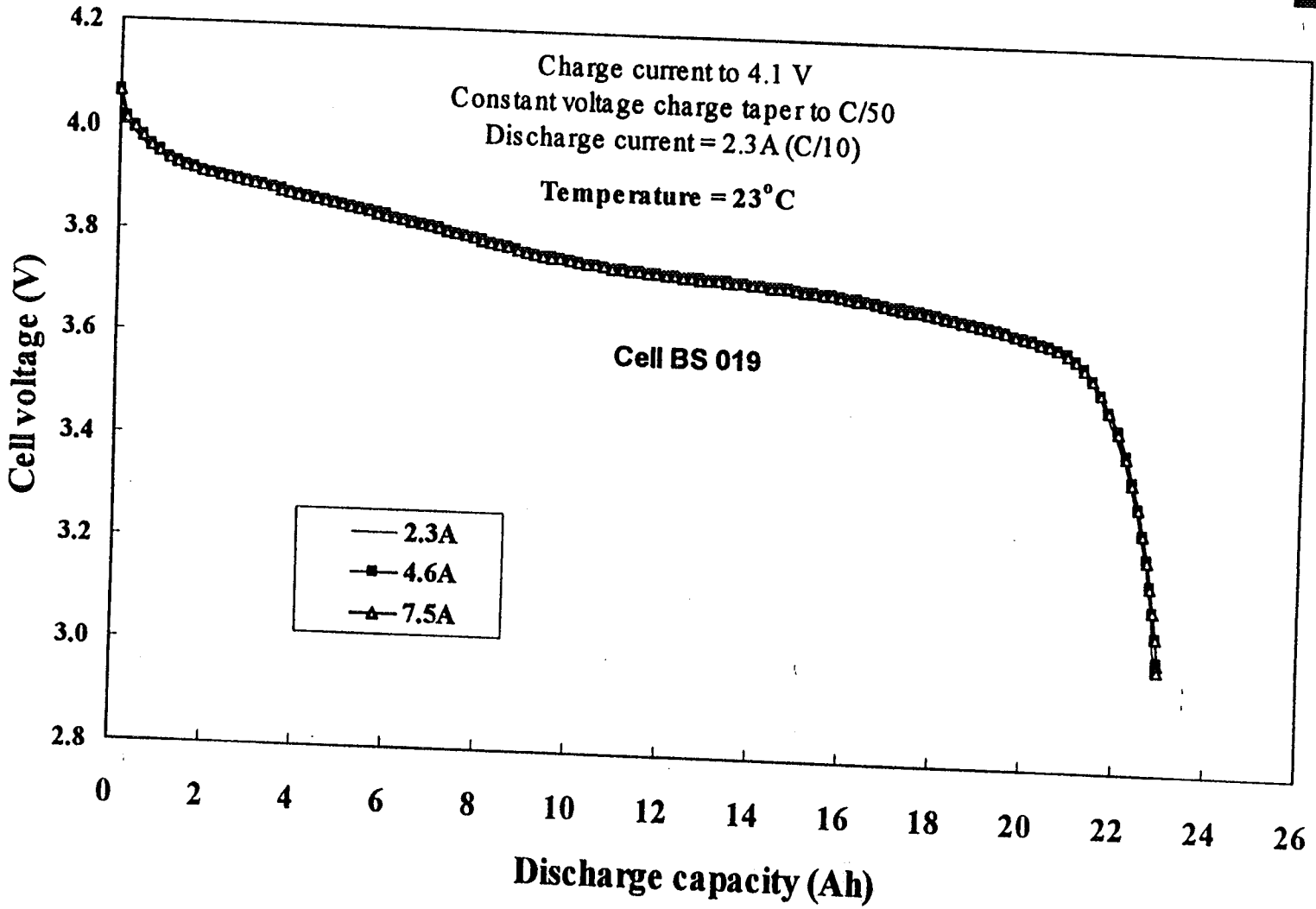




- **Above 2/3 capacity in constant current mode at highest rate tested, i.e., C/3/**

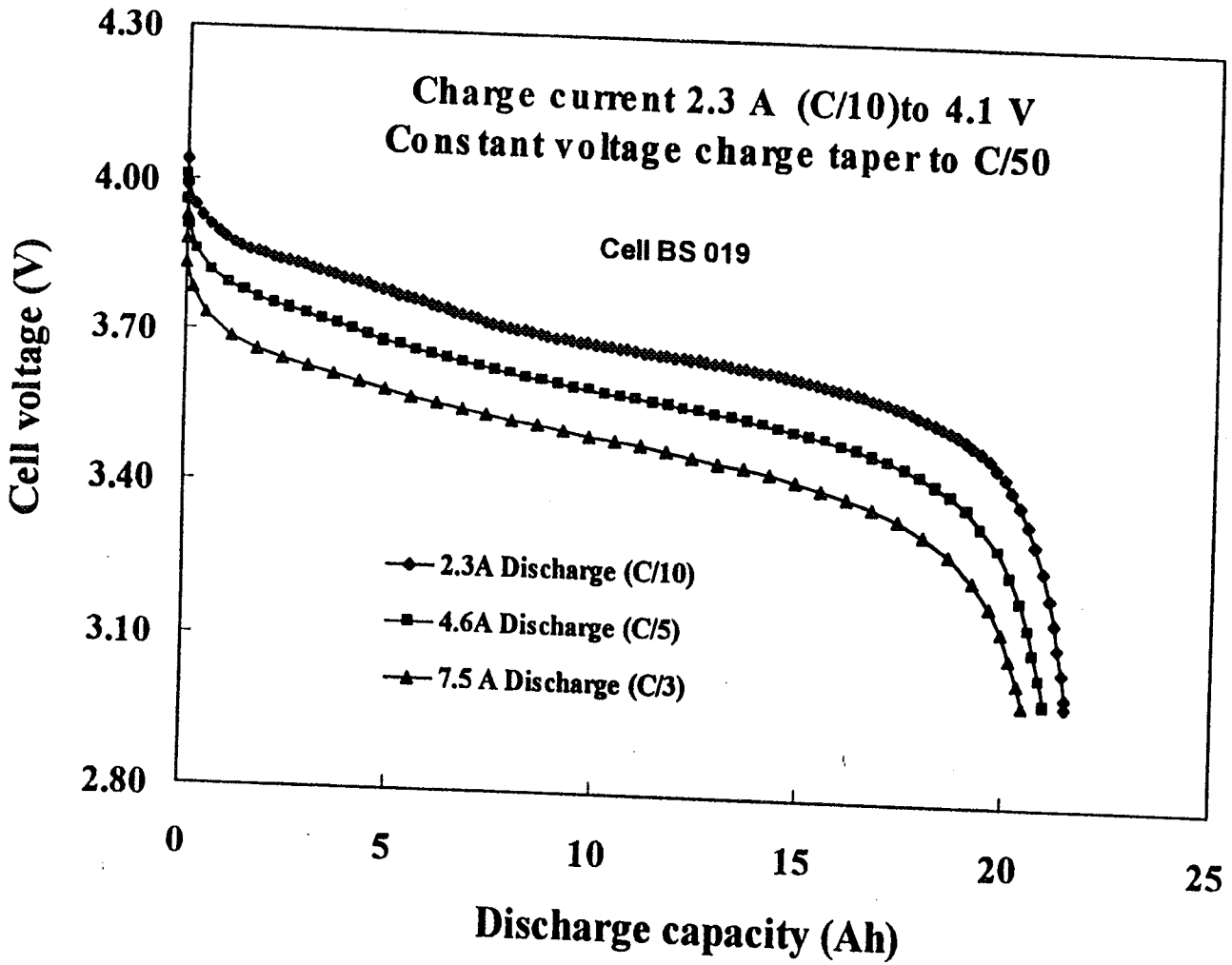
Charge at 25°C





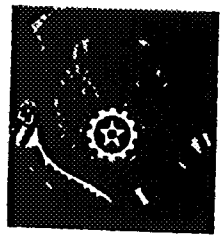
- **Nearly 100 % charge input in 3 hours of charging.**

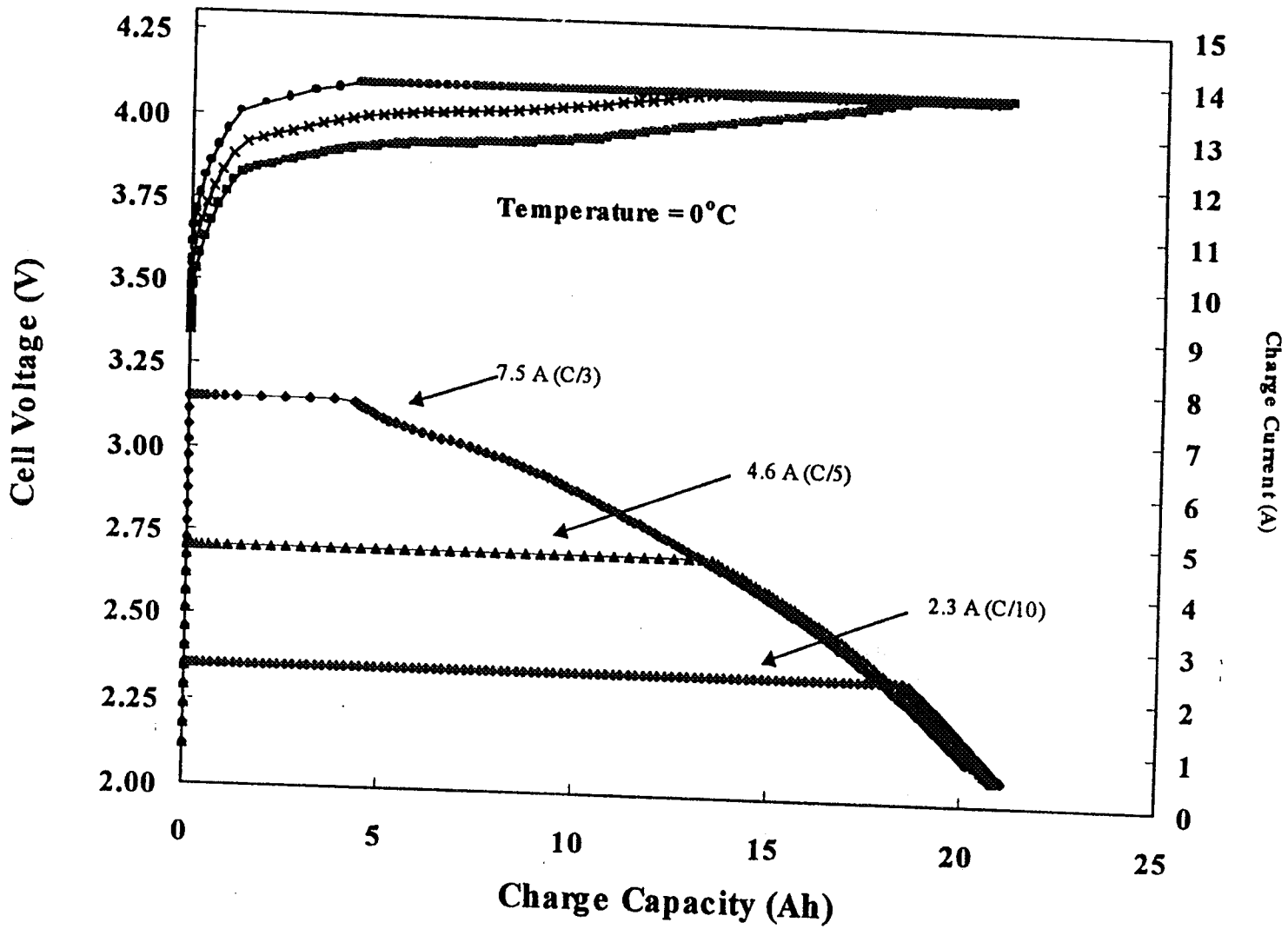
Discharge at 0°C



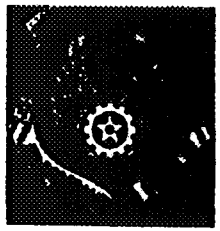
- Nearly 90 %capacity realized at C/3 discharge rate at 0 °C

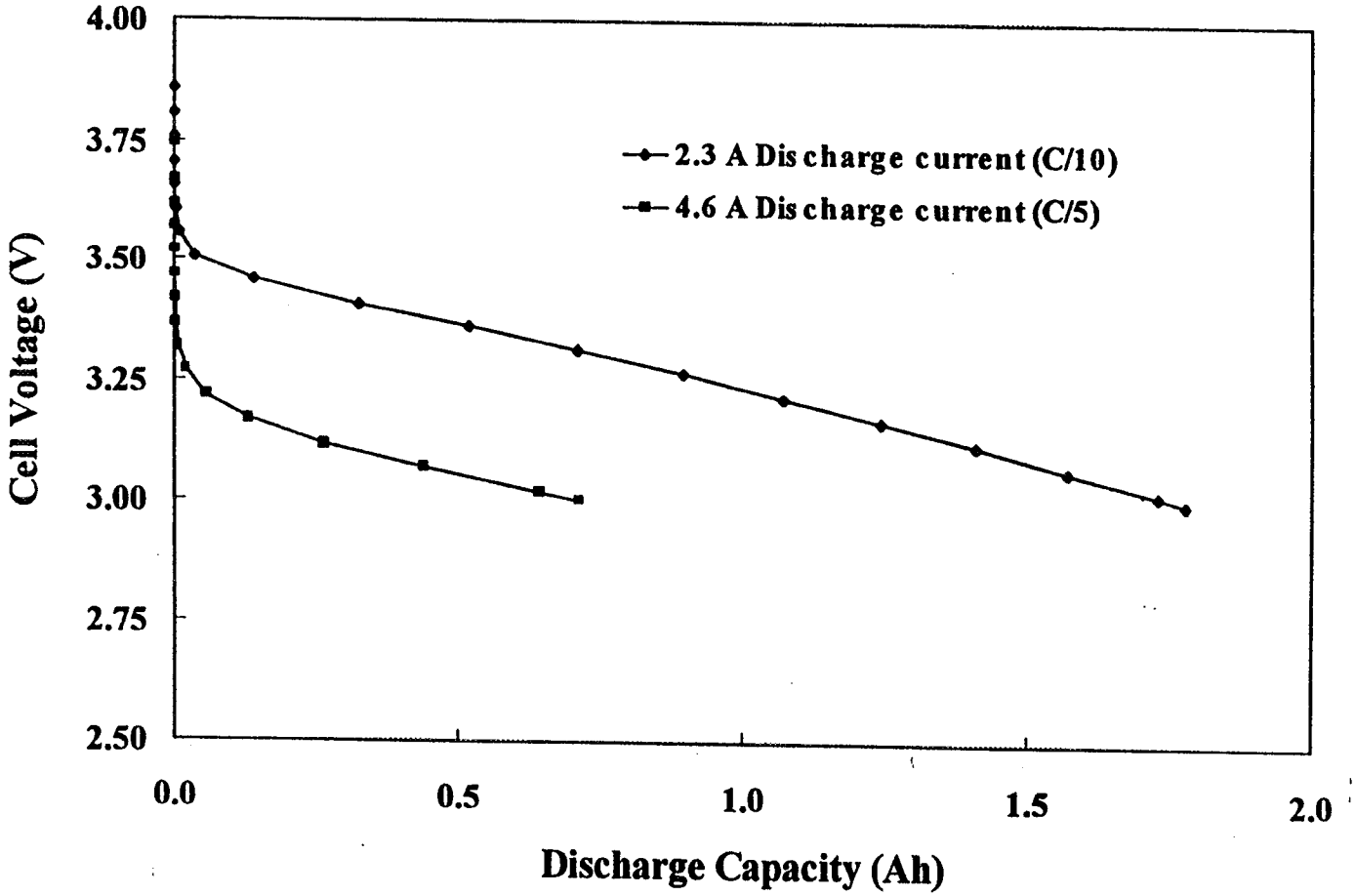
Charge Profiles at 0°C



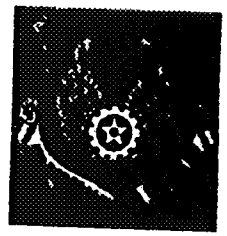


Discharge at -20°C

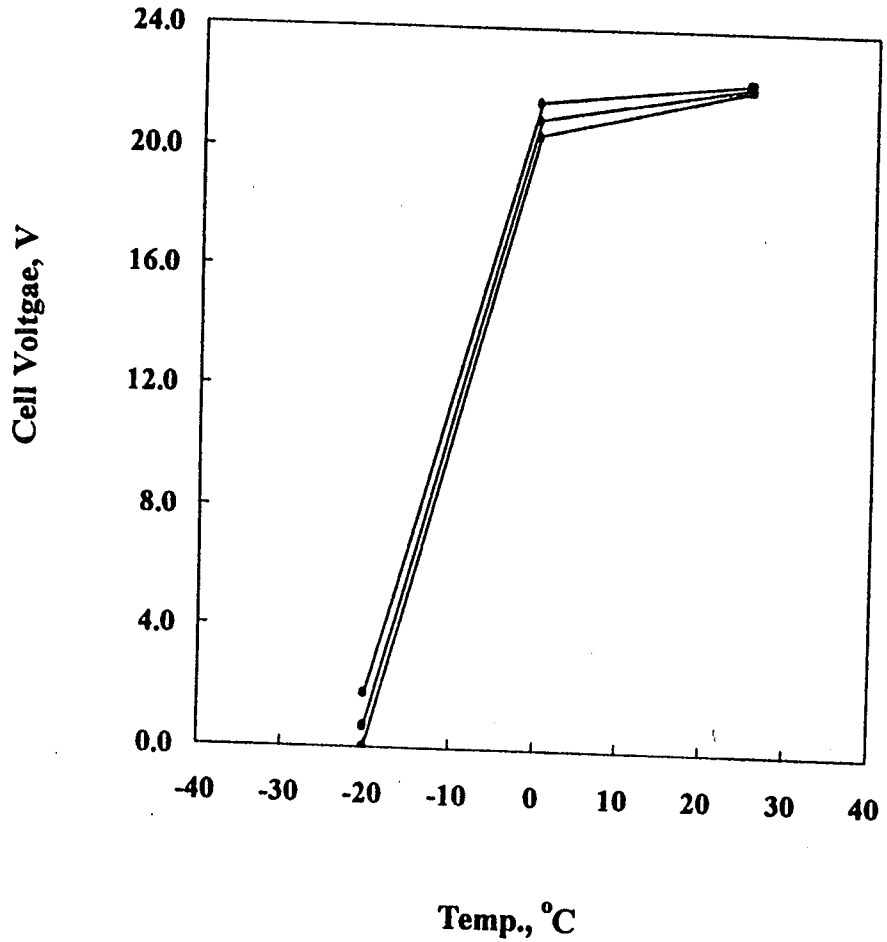




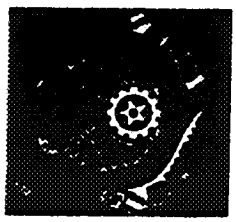
- **Poor Performance at -20°C**



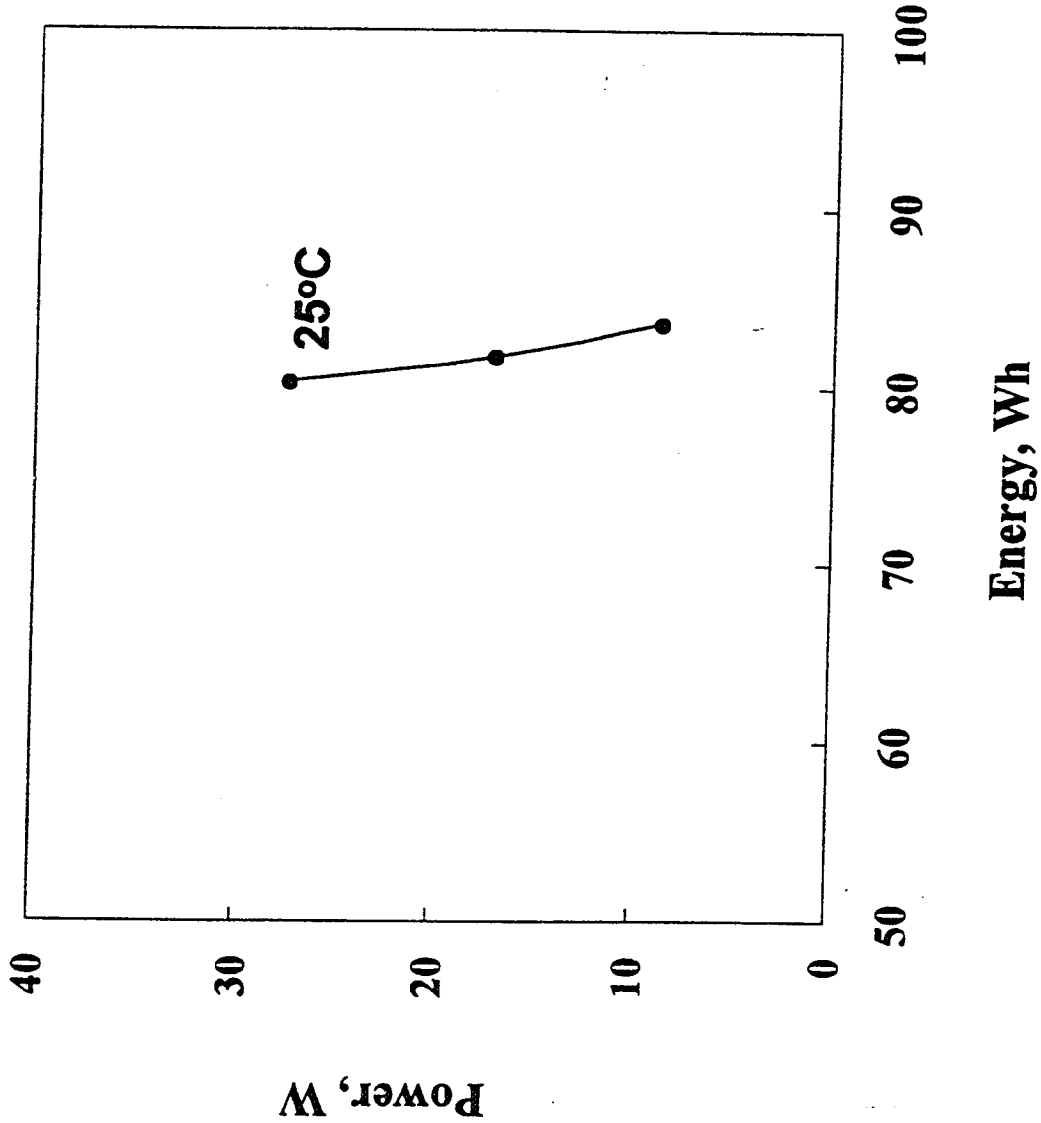
Capacity vs. Temperature



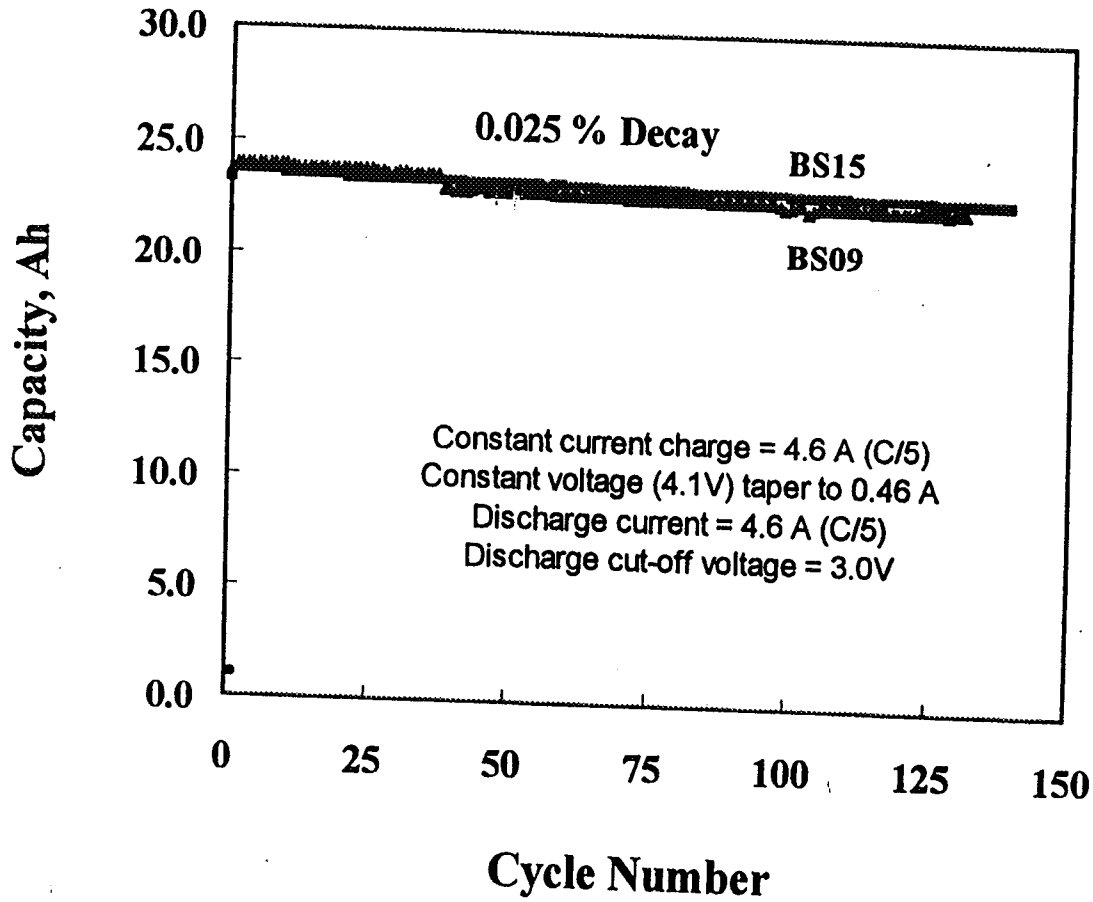
- Poor performance at -20°C



Ragone Plot

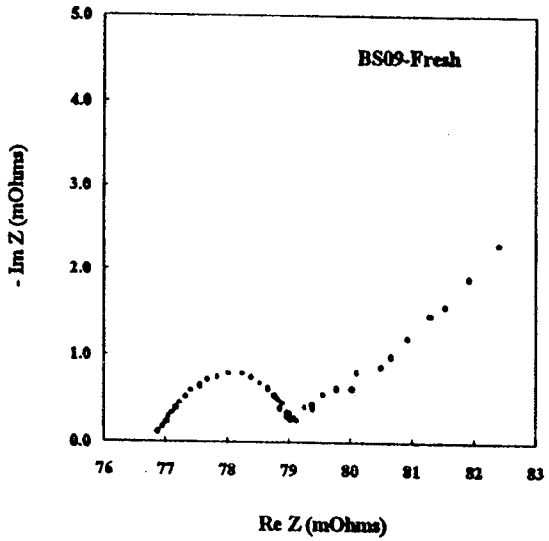


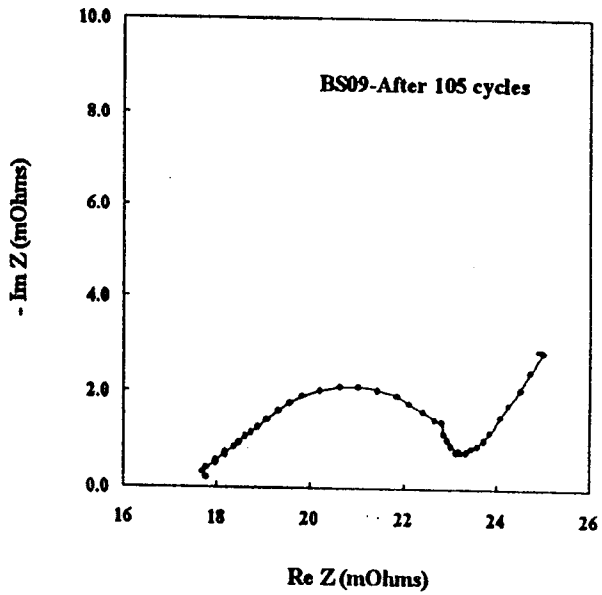
Cycling (100% DOD) at 25°C



- **Capacity fade 0.025 % per cycle.**

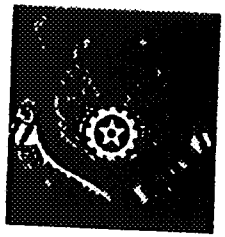
EIS During Cycling

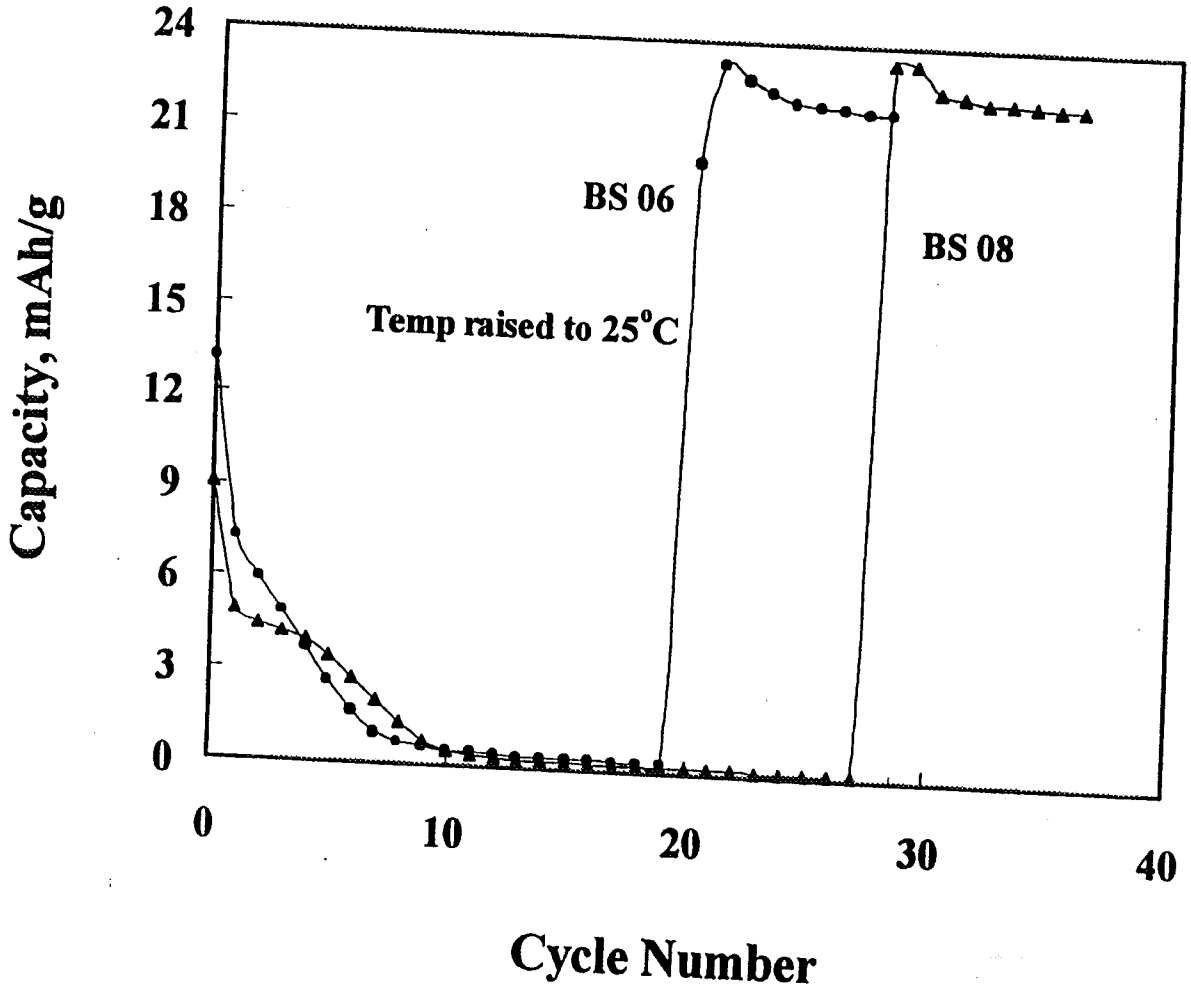




- Marginal increase in the charge transfer (Faradaic) impedance
- Additional charge transfer polarization.
- Decrease in the series (Ohmic) resistance.

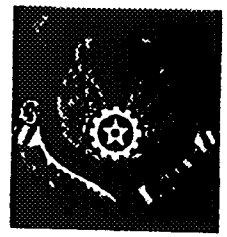
Cycling at 50% DOD at -20°C- Mars 2001 Lander

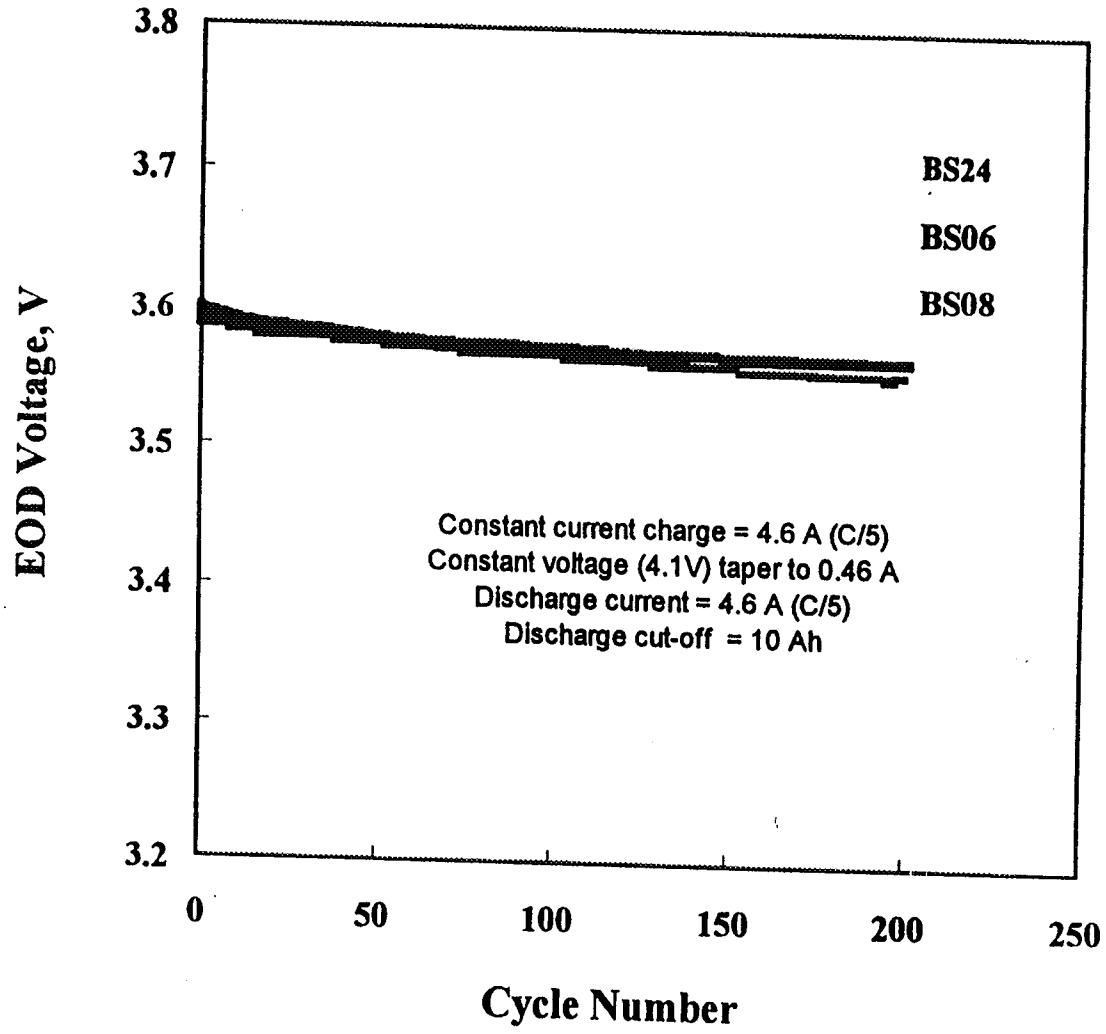




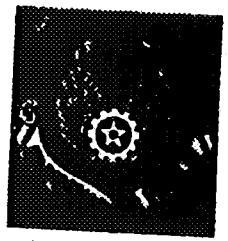
- Performance at -20°C inadequate.

Cycling at 50% DOD at 0°C- Mars 2001 Lander





- **Depression in the EOD Voltage : 0.2 mV/cycle.**

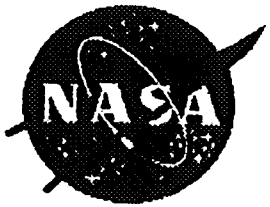


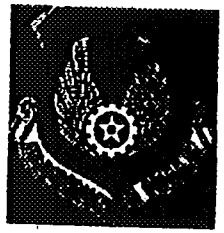
SUMMARY

- Bluestar 20 Ah cells have so far shown good cycle life characteristics both at 100 % and 50 % DOD, which encouraging from the Mars 2001 mission point of view.

- Charge and discharge characteristics are fairly good at moderate rates.

- Low temperature performance needs to be improved to enable the Mars Exploratory missions.





Acknowledgement

This work was carried out at the Jet Propulsion Laboratory, California Institute of Technology under contract with National Aeronautics and Space Administration and in collaboration with the Air Force Research Laboratory. The cells were fabricated by Bluestar under Air Force contract.