

1996-1997  
12/2/96

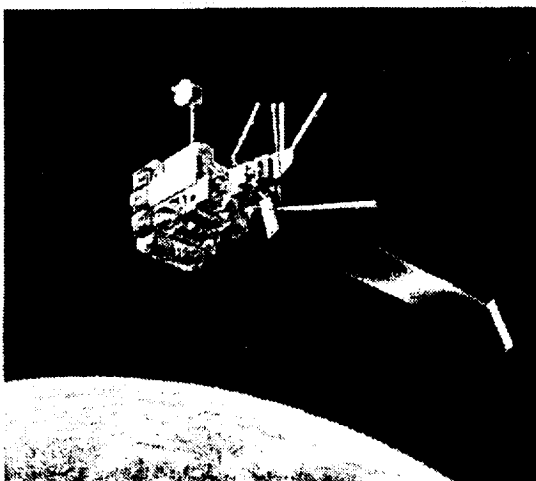
# Battery Performance of ADEOS (Advanced Earth Observing Satellite) and Ground Simulation Test Results

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1996 NASA Aerospace Battery Workshop

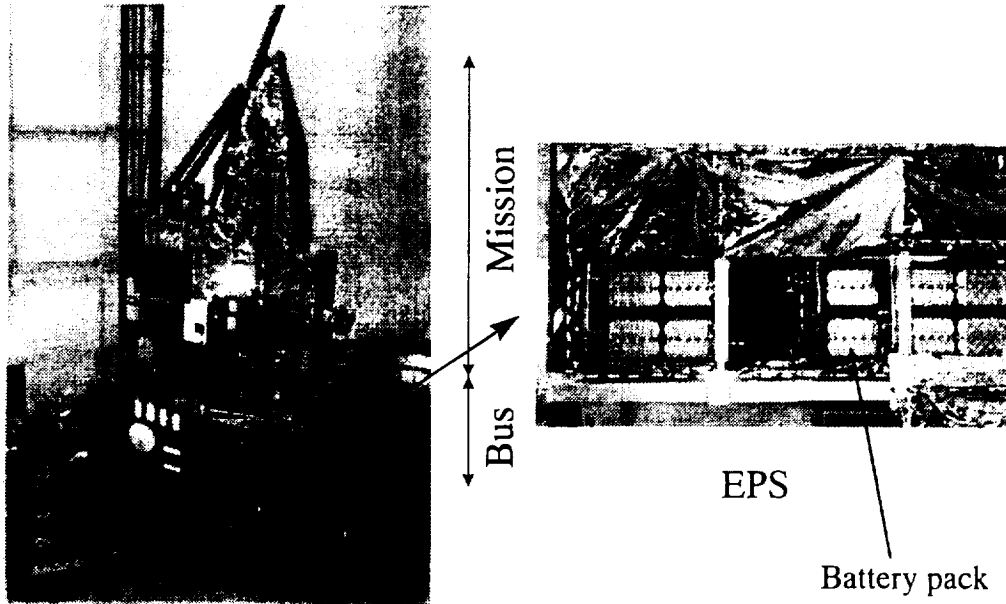
## ADEOS

The Advanced Earth Observing Satellite (ADEOS) is developed with the aim of establishment of platform technology for future spacecraft and inter-orbit communication technology for the transmission of earth observation data.



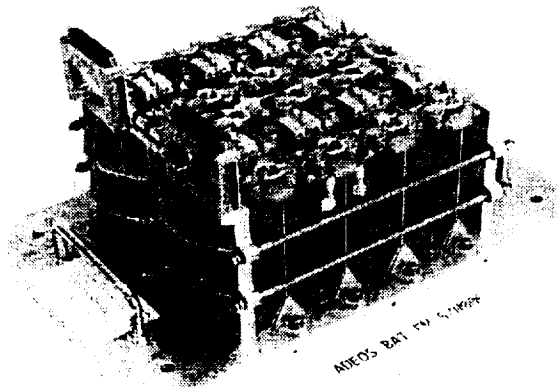
**Shape :** Module type with deployable paddle  
**Body:** Approx. 4x4x5(m)  
**Solar Paddle:** Approx. 3x26(m)  
**Weight :** Approx. 3.5 ton(at lift-off)  
**Launch date:** 8/17/1996  
**Launch Vehicle :** H-II  
**Launch Site :** Tanegashima Space Center  
**Orbit :** Sun Synchronous Subrecurrent  
**Altitude:** Approx. 800km  
**Inclination :** Approx. 98.6 deg.  
**Period :** Approx. 101 min.

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ADEOS uses 5 batteries, consists of 2 packs

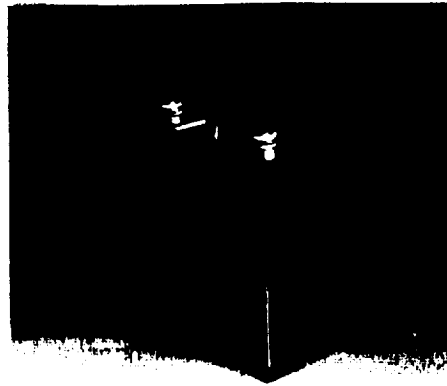


Weight : 19.3kg/pack(16cells)

Volume : 276(T) × 264(W) × 175(H)mm/pack

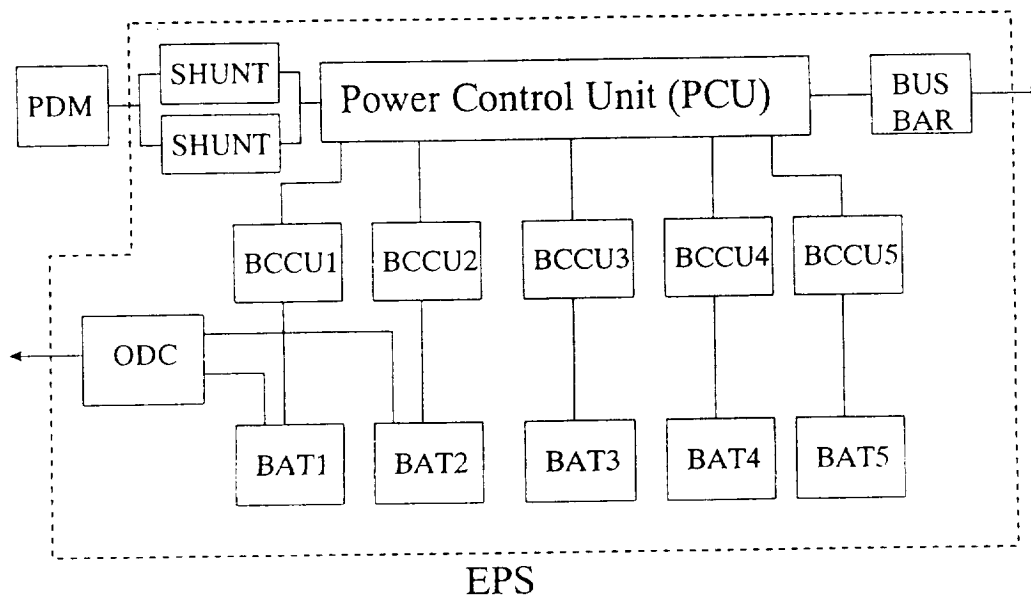
CELL MAJOR SPECIFICATIONS

Rated Capacity		35 AH
Mission	GEO	10Years, 1,000cycles
	LEO	3Years, 20,000cycles
Weight		max. 1050g
Energy Density		40WH/kg
Mechanical Strength	Burst Pressure	3.5 kg f/cm <sup>2</sup>
	Pressure Cycling	50,000cycles (0~3.5 kgf/cm <sup>2</sup> G)



EXTERNAL VIEW OF Ni-Cd CELL

Simplified Block Diagram of the ADEOS EPS

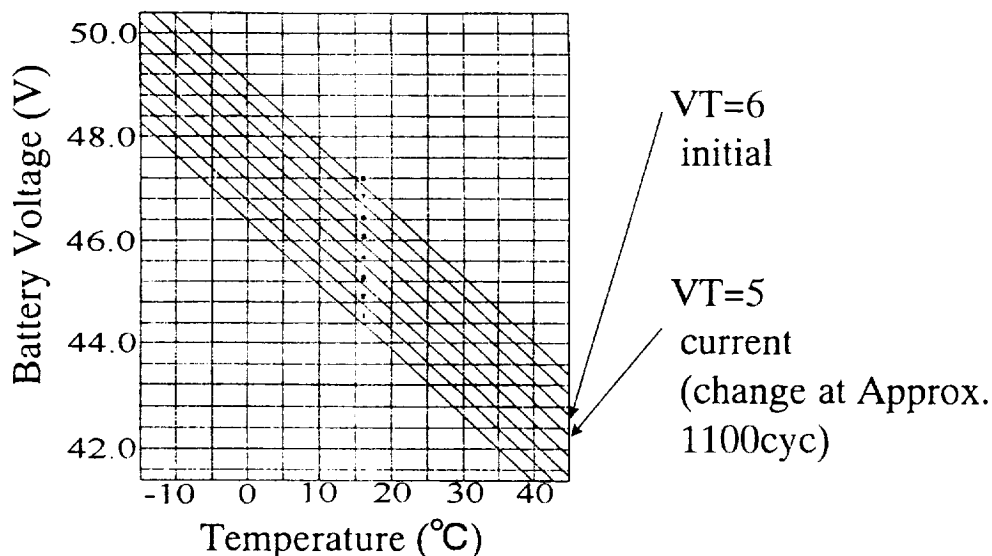


Cell	Ni-Cd 35Ah (Sanyo N35S)
Weight	19.3kg/pack(16cells)
Charge Scheme	V/T control
Charge Rate	0~10A±0.5A(usually) 0~12.5A±0.5A(4 battery operation)
Depth of Discharge	20%(usually), 60%(after launch) 25%(4 battery operation)
Operating Temp.	15°C
Mission Life	3 years (@LEO)

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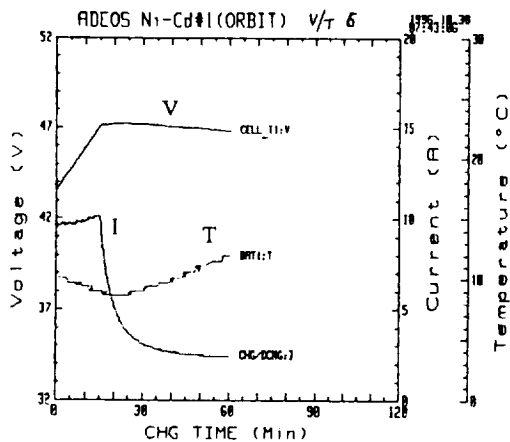
VT Curve

ADEOS has 8 VT curves.  
Initial No. is 6.



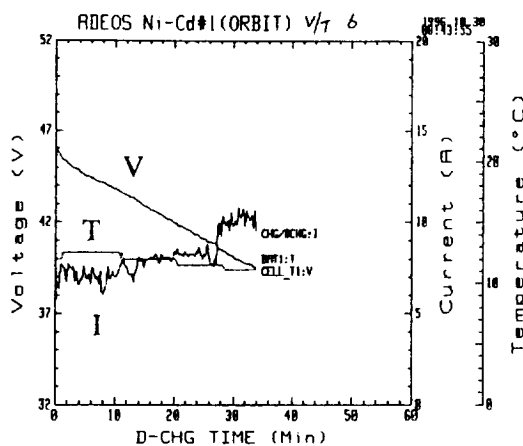
@1065Cycle  
VT=6(initial)

Charge



C/D=1.31

Discharge

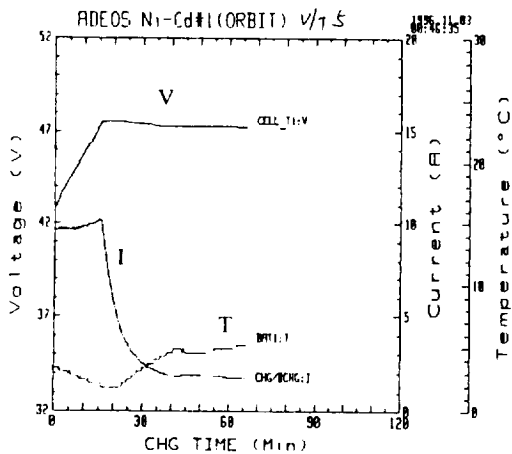


DOD=13.0 %

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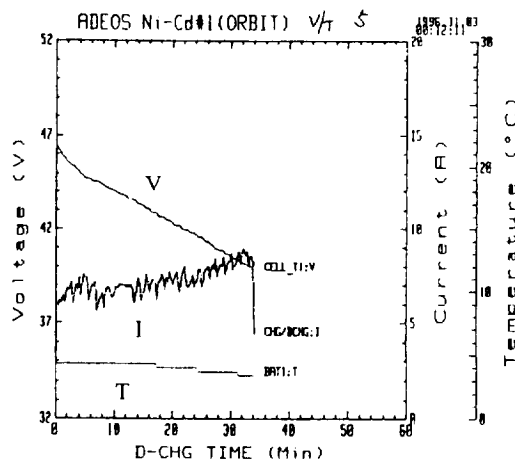
DOD is less than that of prediction(20%), so changed the VT level (from 6 to 5) to avoid the over charge.

Charge



C/D=1.20

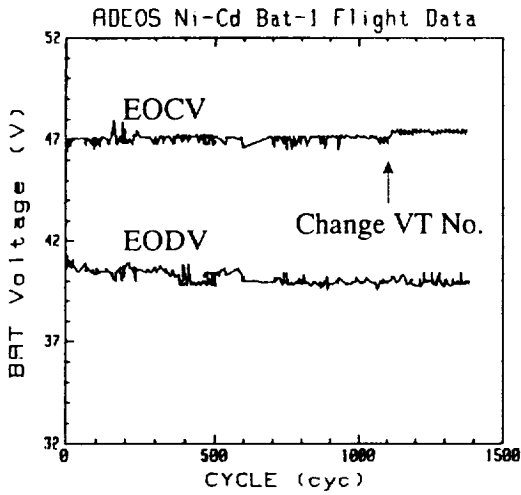
Discharge



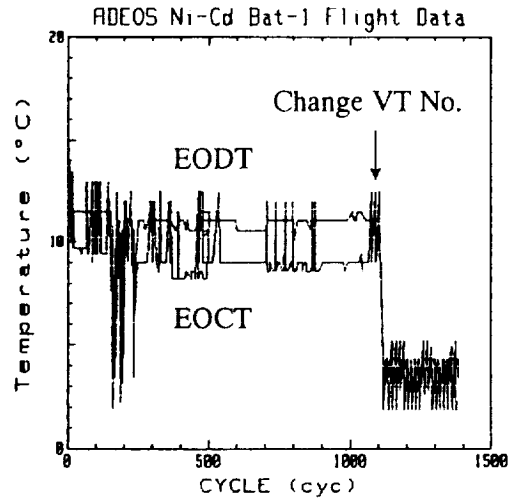
DOD=11.7 %

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EOCV and EODV

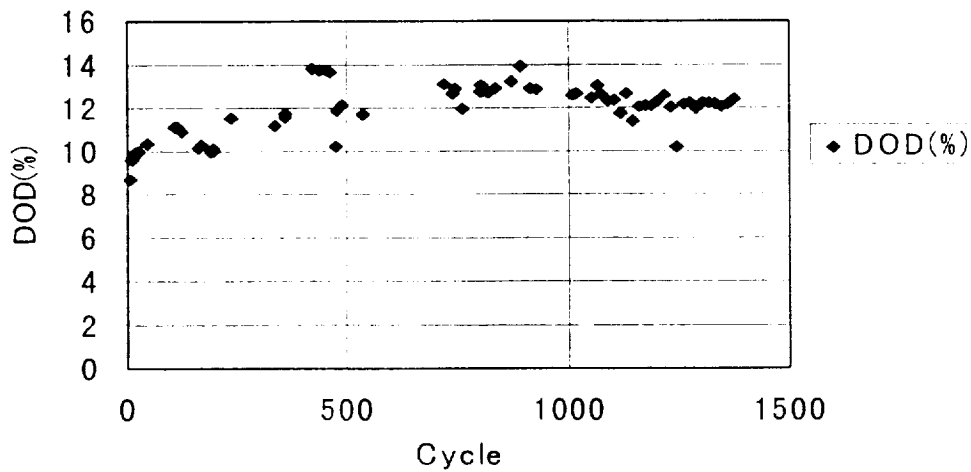


Temp.



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DOD Trend of ADEOS BAT#1



8/1996

11/1996

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We started the simulation test to evaluate the life cycle of ADEOS battery at April 1992.

**Test material** 16 cell stack (ADEOS EM cell)  
**Required cycle** 15700cyc ( 3 years @LEO )  
**Others** measuring the tension of tie rod  
using strain gauge

### Test Type

Normal cycle test  
Contingency (simulate the reduce of solar array power)  
4 battery Operation(simulate 1battery failure)  
Capacity test after 15700cyc  
Reconditioning

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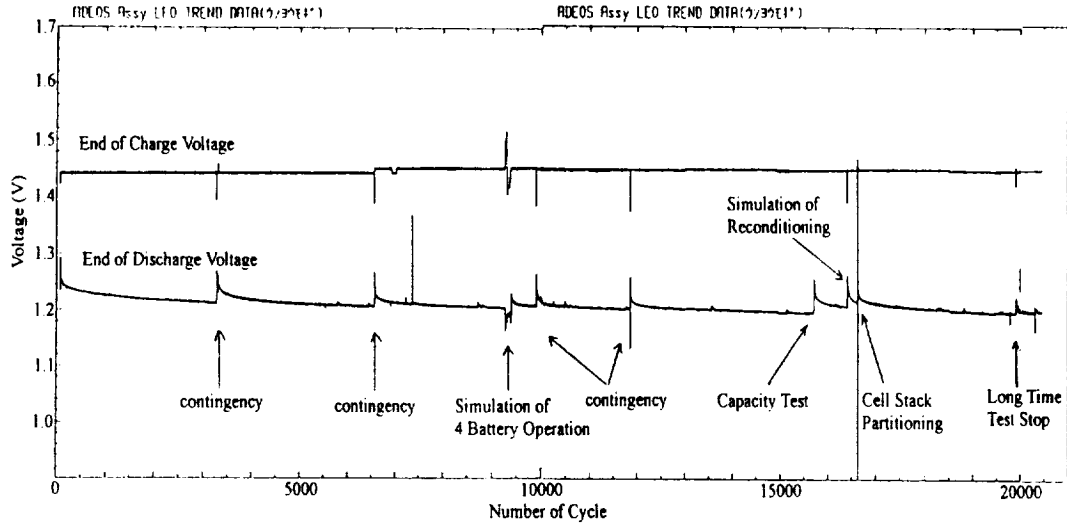
### Cycle Test

<b>Temp.</b>	15°C
<b>Charge</b>	10.0A(1/3.5C), 66 min.
<b>taper</b>	@ 23.02V(1.439V/cell) (change VT level after 6478cycle) @ 23.15V(1.447V/cell)
<b>Discharge</b>	12.0A(1/2.9C), 35 min.
<b>DOD</b>	20 %
<b>C/D</b>	less than 1.15

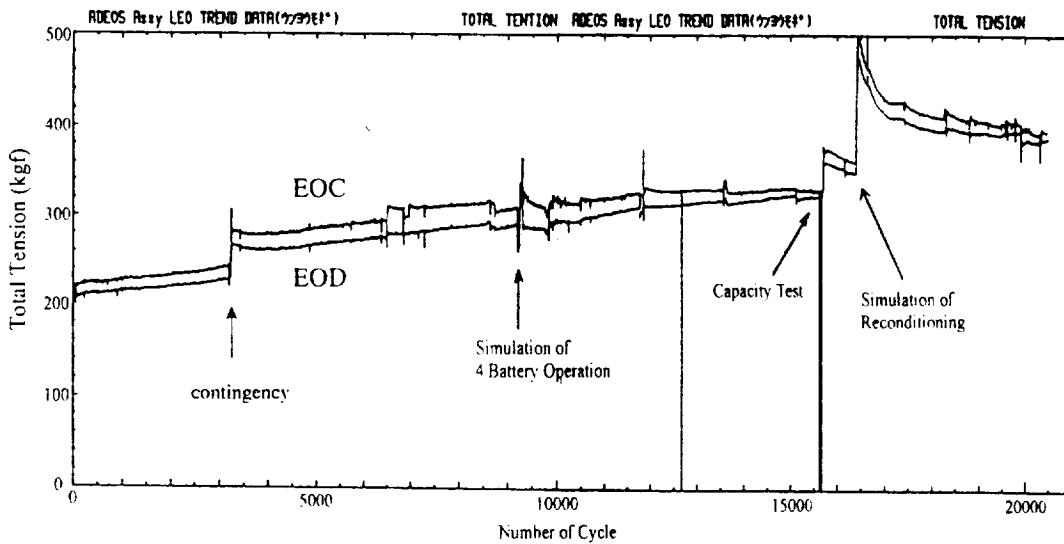
### Capacity Test (at 15700cycle)

<b>Temp.</b>	15°C
<b>Charge</b>	3.5A(1/10C), 16 hours
<b>Discharge</b>	17.5A(1/2C), any cell at 1 Volt

This plot is overlapped by 16 cells.  
Each cell shows the same level of voltage.



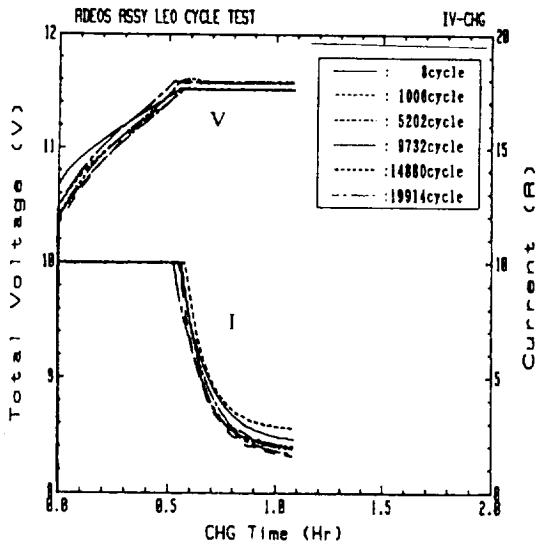
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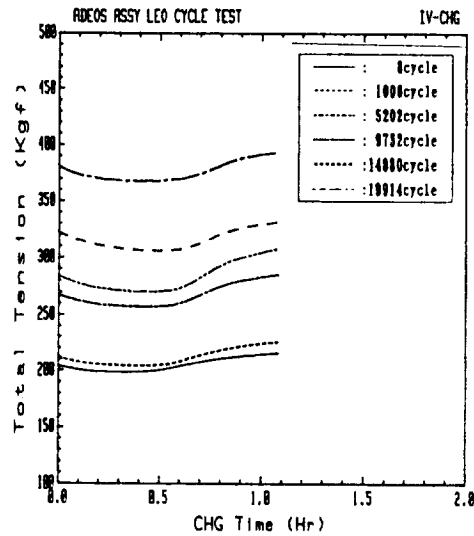
$$100\text{kgf}(\text{total tension})=0.813\text{kgf}/\text{cm}^2(\text{face pressure})$$



Charge characteristics at 8,1006,5202,9732,14880,19914cyc



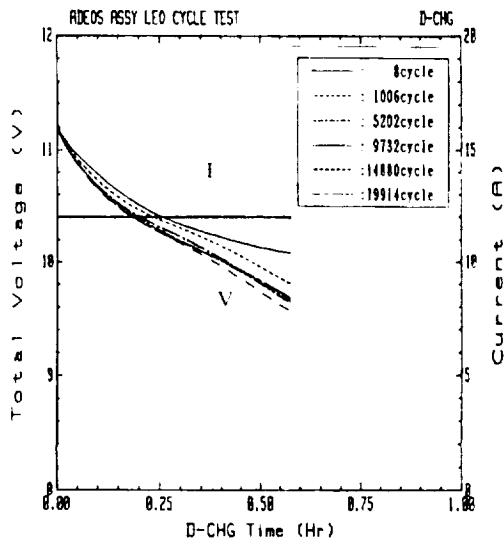
Voltage and Current



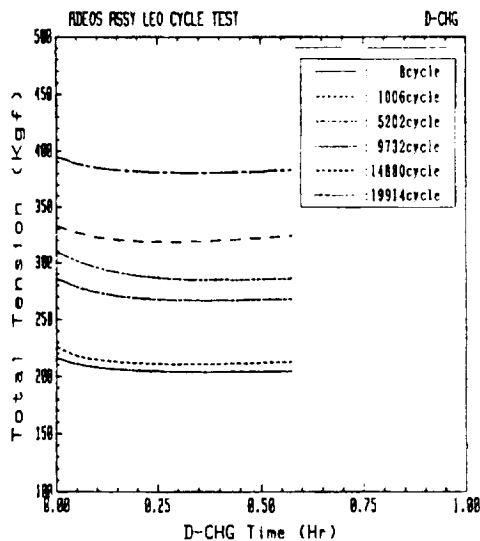
Total tension

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Discharge characteristics at 8,1006,5202,9732,14880,19914cyc



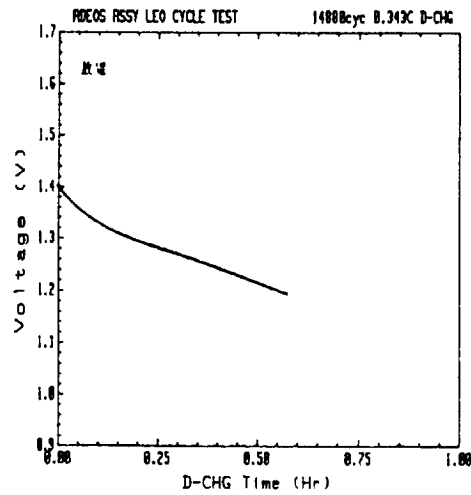
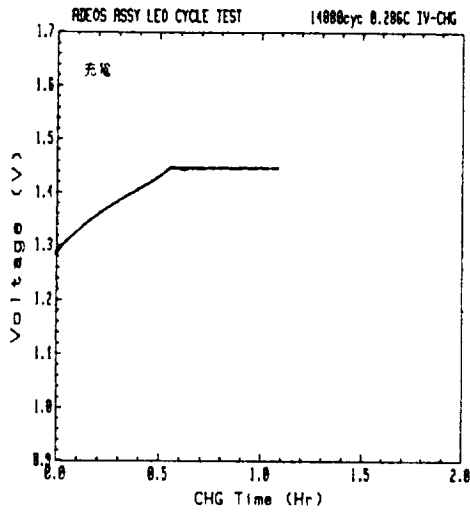
Voltage and Current



Total tension

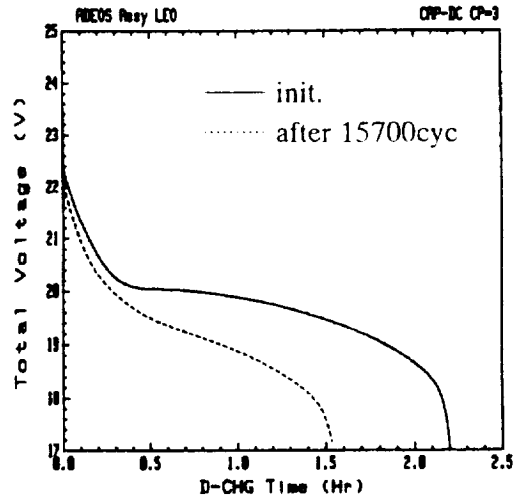
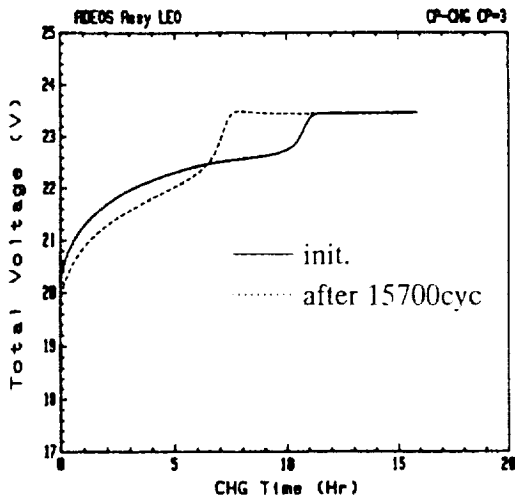
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This plot is overlapped by 16 cells at 14880cyc.  
Each cell shows the same level of voltage.



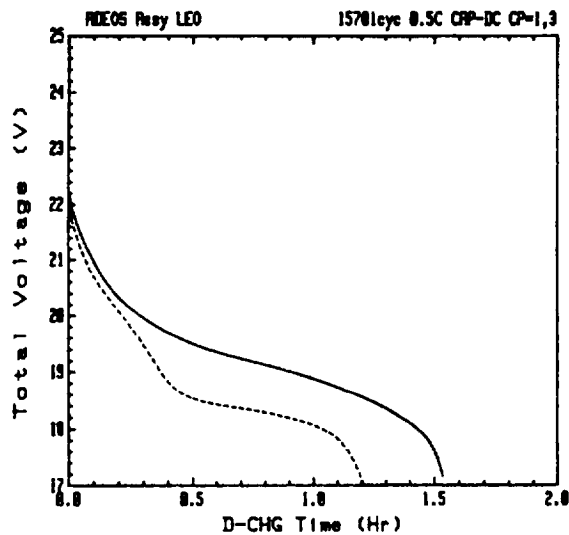
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Capacity initial : 38.93Ah  
after 15700cyc: 27.12Ah



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@15700cycle



----- Residual Capacity Test  
 ——— Full-charge Capacity Test

Memory Effect

about 0.8V/16cells  
 0.05V/cell

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### ADEOS Flight Data

Each battery shows good performance.  
 DOD is fluctuated from 10 to 15%.  
 Temperature is controlled from 0 to 15°C.

### ADEOS Simulation Data

Test result satisfied the required 15700 cycle.  
 Each cell's voltage dispersion is little.  
 Capacity at 15700cyc was 27.12Ah.  
 Test is continued over 22000 cycle(@11/1996).

