

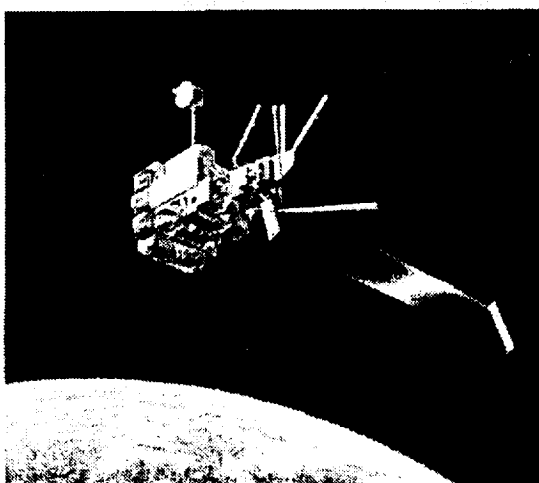
Battery Performance of ADEOS (Advanced Earth Observing Satellite) and Ground Simulation Test Results

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National Space Development Agency of Japan

1996 NASA Aerospace Battery Workshop

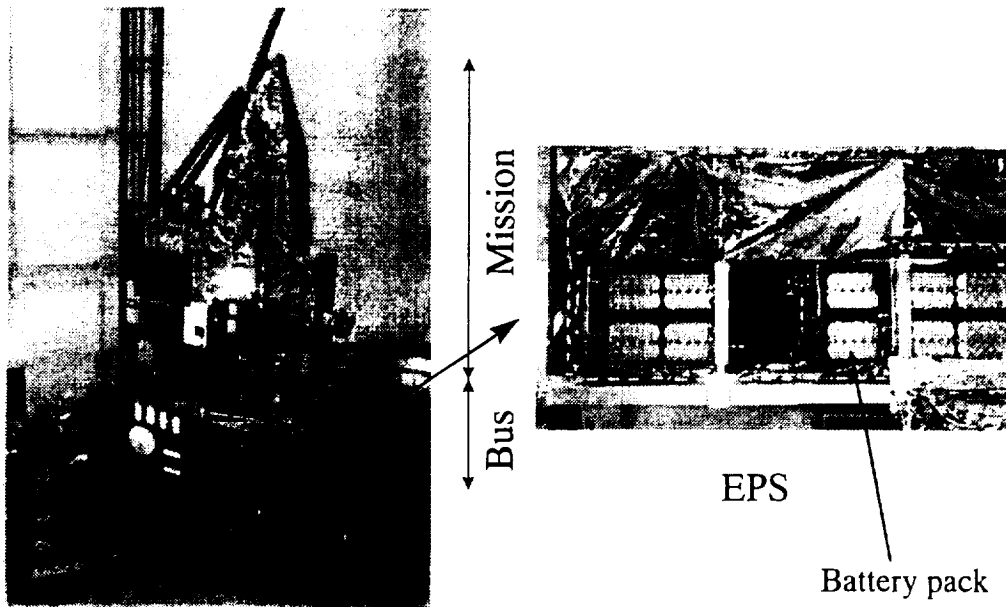
ADEOS

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.



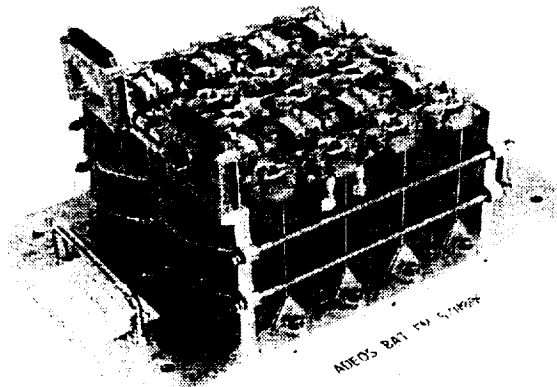
Shape : Module type with deployable paddle
Body: Approx. 4x4x5(m)
Solar Paddle: Approx. 3x26(m)
Weight : Approx. 3.5 ton(at lift-off)
Launch date: 8/17/1996
Launch Vehicle : H-II
Launch Site : Tanegashima Space Center
Orbit : Sun Synchronous Subrecurrent
Altitude: Approx. 800km
Inclination : Approx.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

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ADEOS uses 5 batteries, consists of 2 packs

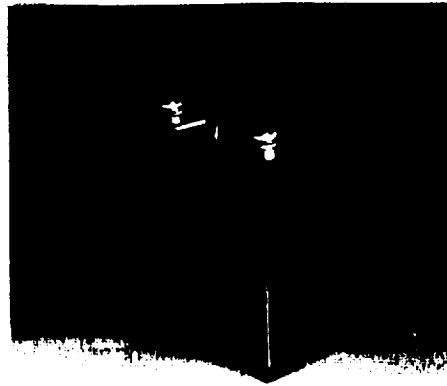


Weight : 19.3kg/pack(16cells)

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

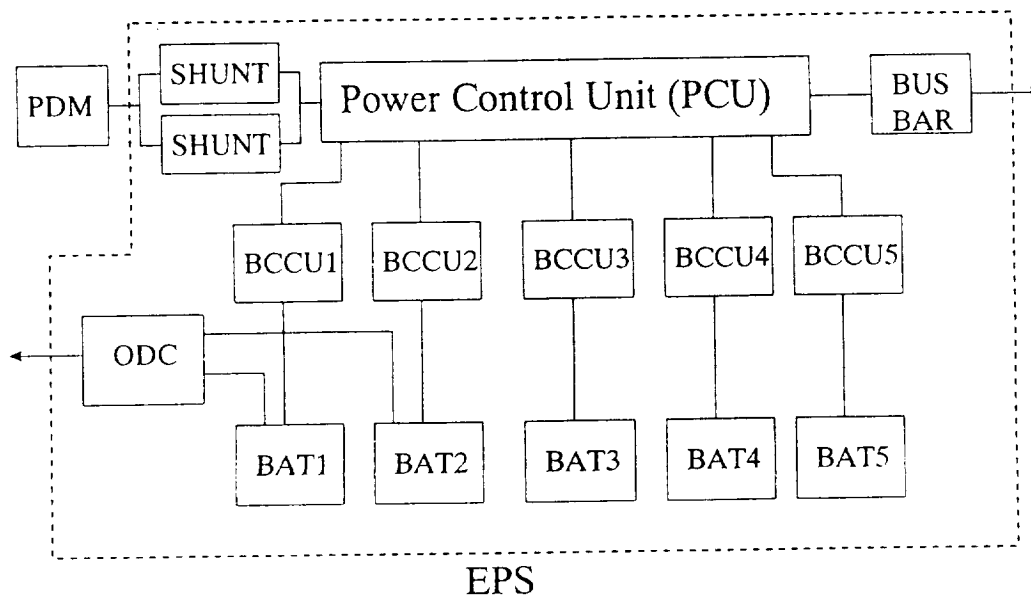
CELL MAJOR SPECIFICATIONS

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 ²
	Pressure Cycling	50,000cycles (0~3.5 kgf/cm ² G)



EXTERNAL VIEW OF Ni-Cd CELL

Simplified Block Diagram of the ADEOS EPS

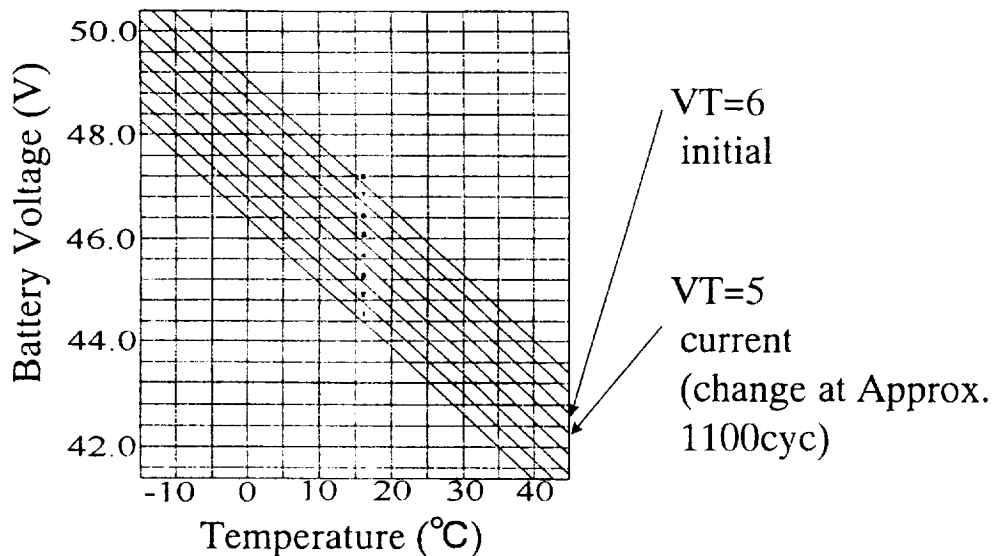


Cell	Ni-Cd 35Ah (Sanyo N35S)
Weight	19.3kg/pack(16cells)
Charge Scheme	V/T control
Charge Rate	0~10A±0.5A(usually) 0~12.5A±0.5A(4 battery operation)
Depth of Discharge	20%(usually), 60%(after launch) 25%(4 battery operation)
Operating Temp.	15°C
Mission Life	3 years (@LEO)

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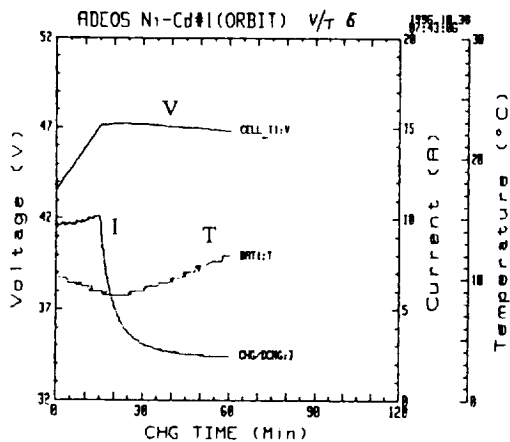
VT Curve

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



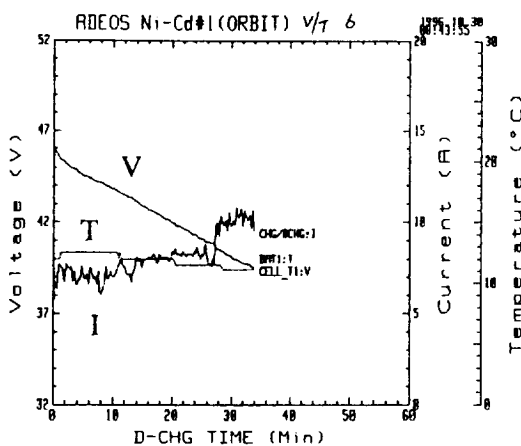
@1065Cycle
VT=6(initial)

Charge



C/D=1.31

Discharge

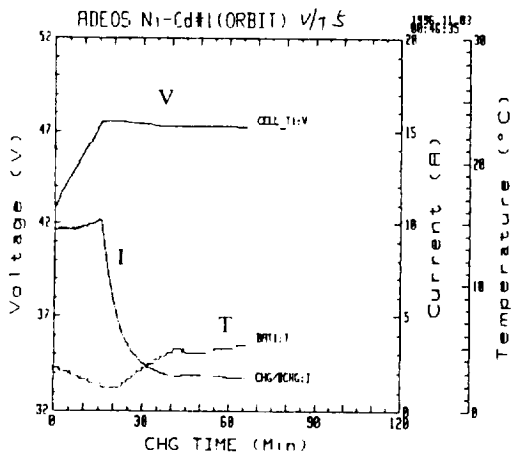


DOD=13.0 %

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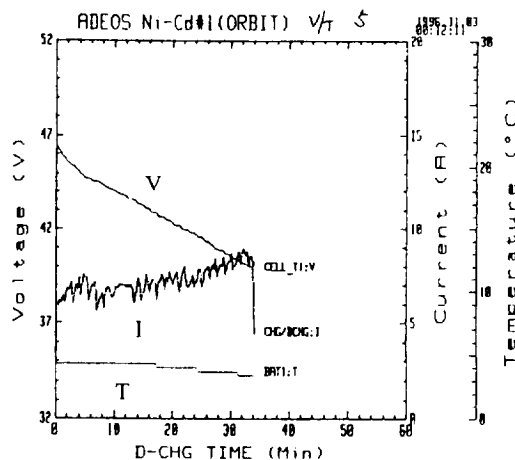
DOD is less than that of prediction(20%), so changed the VT level (from 6 to 5) to avoid the over charge.

Charge



C/D=1.20

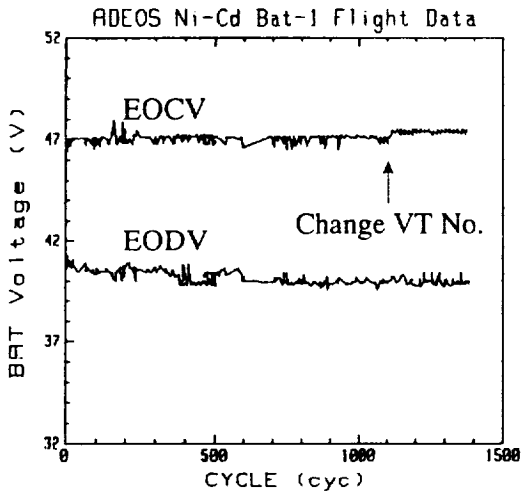
Discharge



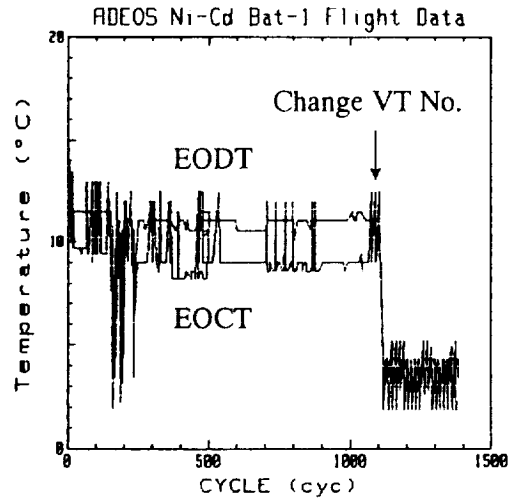
DOD=11.7 %

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EOCV and EODV

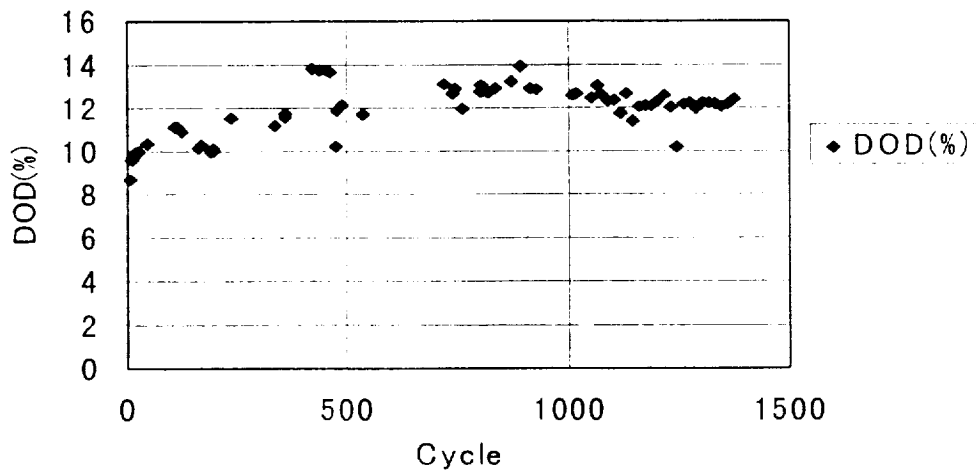


Temp.



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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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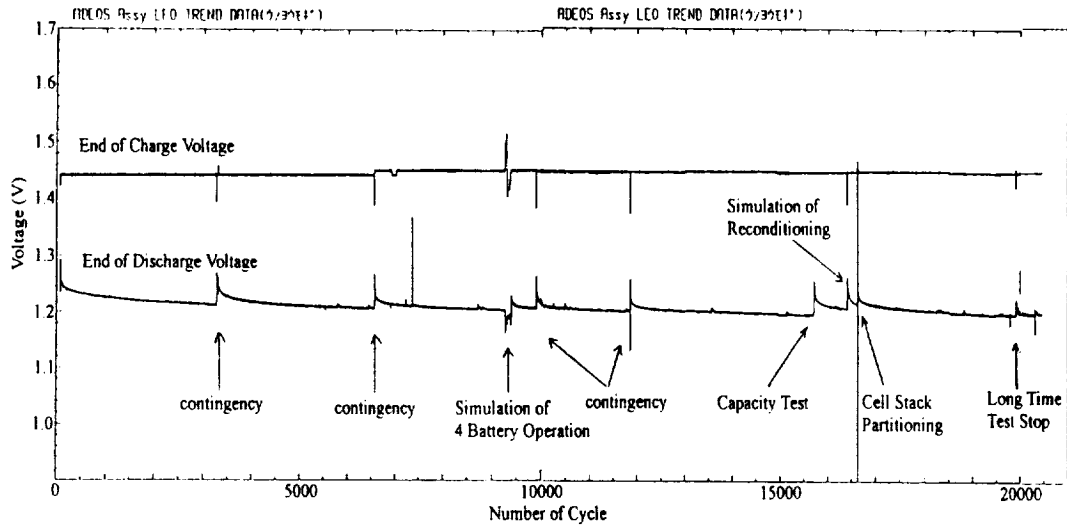
Cycle Test

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

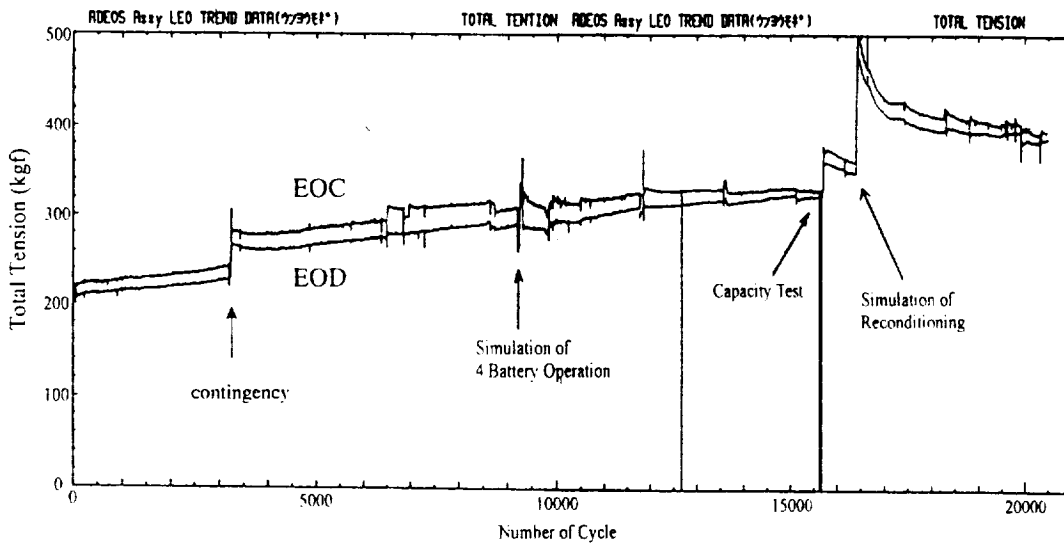
Capacity Test (at 15700cycle)

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

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

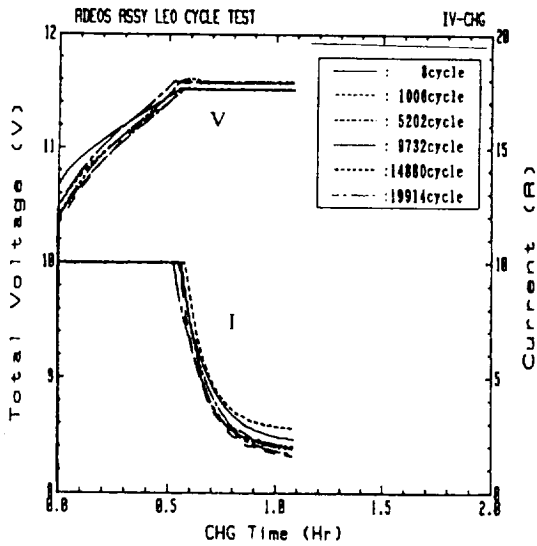


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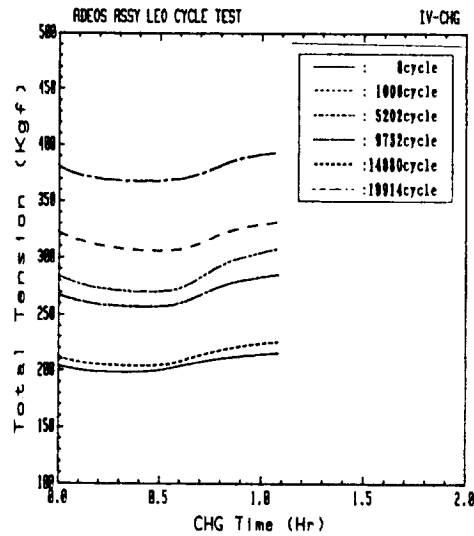


$$100\text{kgf}(\text{total tension})=0.813\text{kgf}/\text{cm}^2(\text{face pressure})$$

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



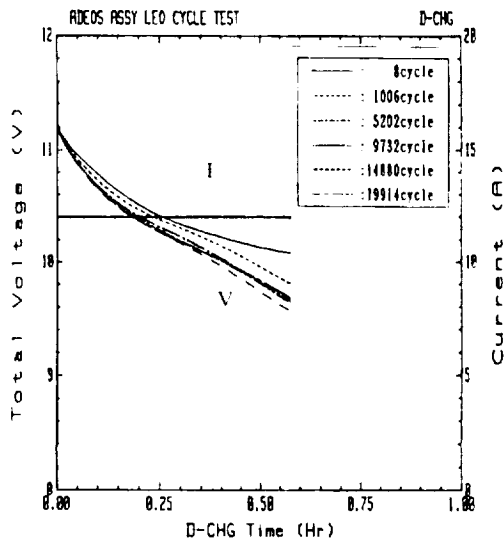
Voltage and Current



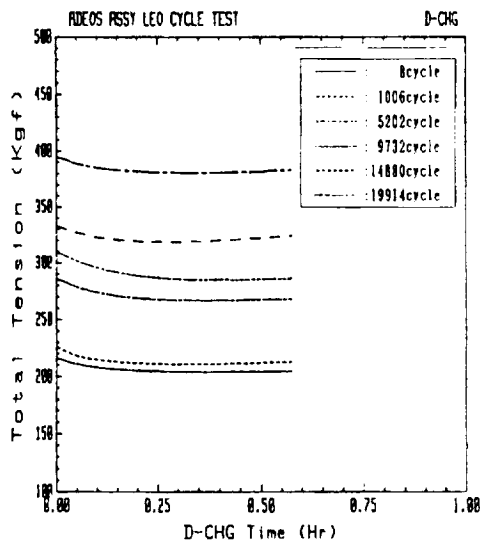
Total tension

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



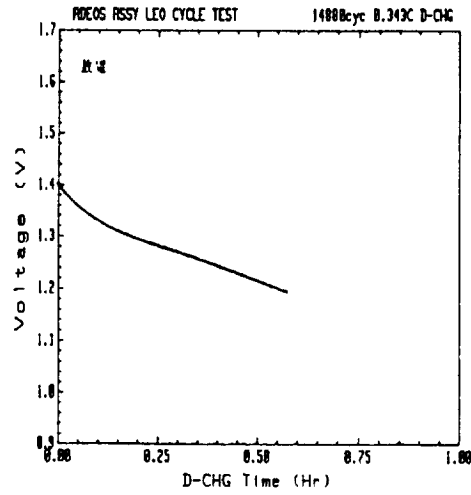
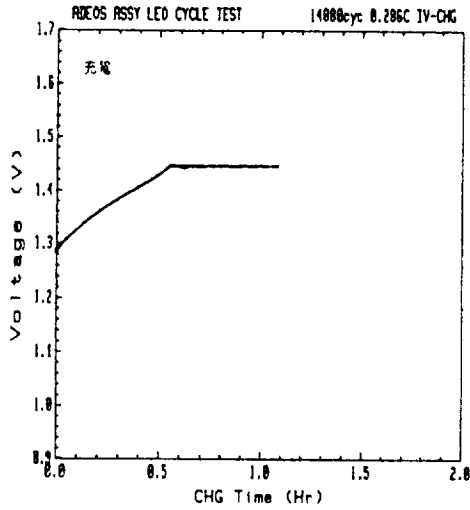
Voltage and Current



Total tension

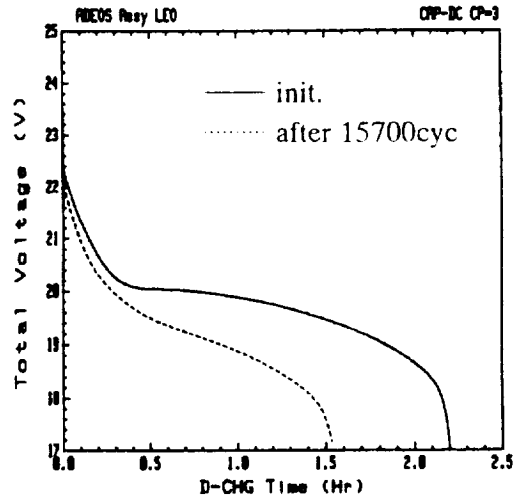
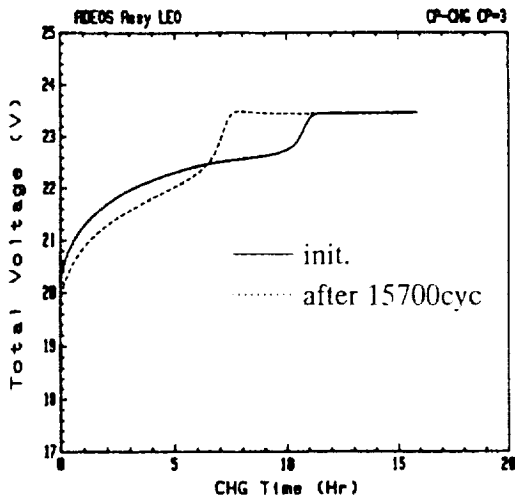
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This plot is overlapped by 16 cells at 14880cyc.
Each cell shows the same level of voltage.



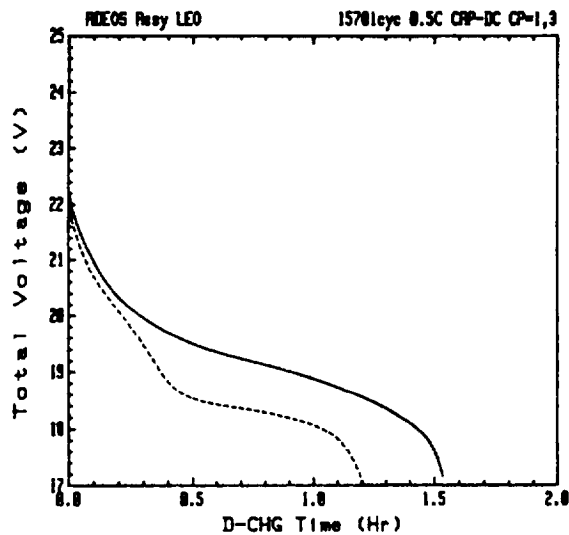
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Capacity initial : 38.93Ah
after 15700cyc: 27.12Ah



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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).

