Nickel-Hydrogen Cell Testing Experience NASA/Goddard Space Flight Center

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OBJECTIVES

- Verify the Aerospace Cell Flight Worthiness
  - Quality, Reliability and Workmanship
- Elucidate the Aerospace Cell Thermal Behavior
- Develop the Aerospace Battery Assembly Design(s) and In-Orbit Battery Management Plan(s)
- Understand the Aerospace Cell Failure Mechanism(s)

TESTS

- LEO and GEO Life Cycling
  - Stress and Mission Profiles
- Calorimetric Analysis
- Destructive Physical Analysis
  - Component and Cell Levels
- Special Tests
  - Characterization, Pulse, Nickel Precharge Analysis, Gas Analysis, and Retest After Storage

AREAS FOR DISCUSSION

- Life Cycling Test Parameters
  - Charge Voltage and Recharge Ratio
- Nickel Precharge
  - Electrochemical Characterization, Gas Analysis and Plate Analyses

MISSION PROFILE CYCLING DATA

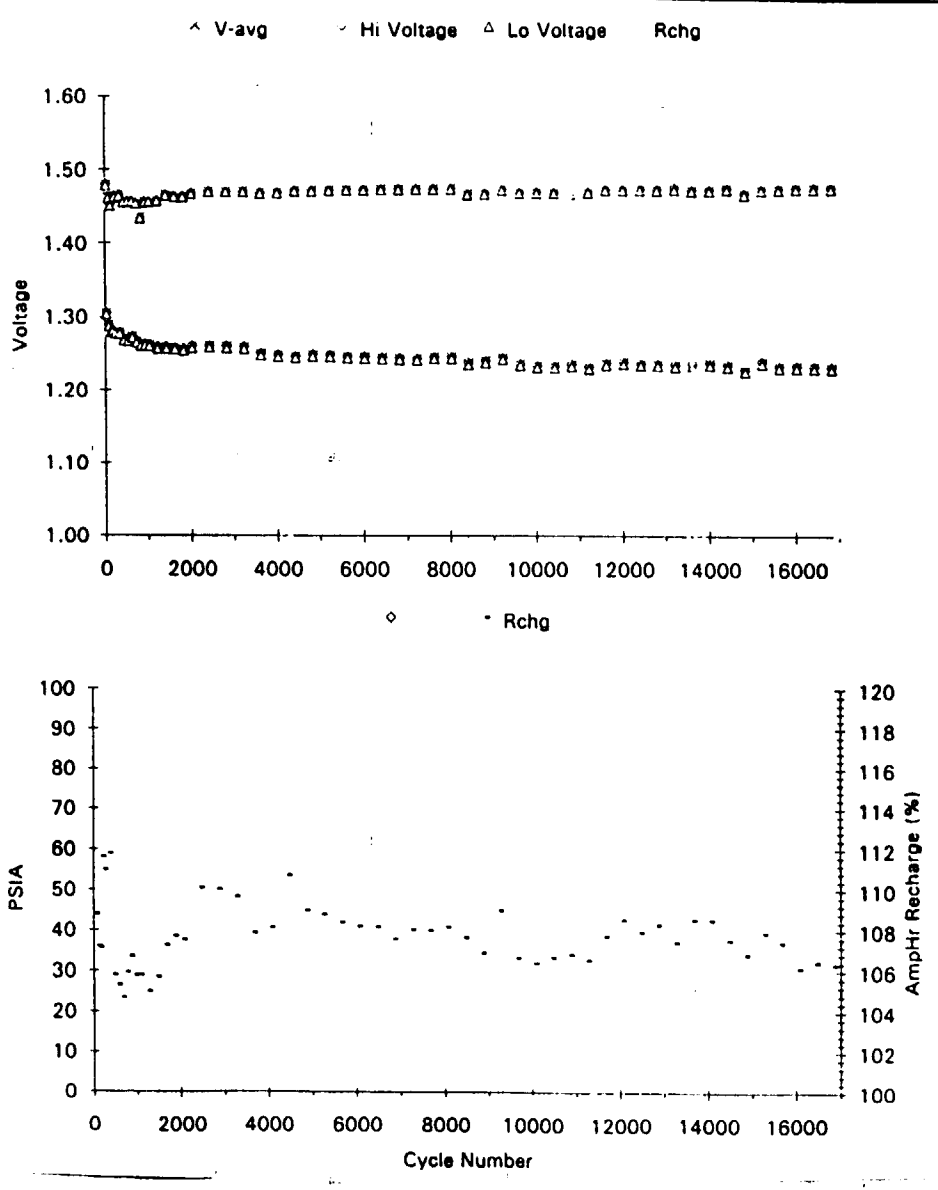
Pack #	Rated Ah	DOD %	Temp. C	VT V	C/D	EOD V	Cycle #	Status
3600H	93¶	11	-5	1.52	1.10	1.306	35000	cont.
3601H	93 ¶	11	-5	1.52	1.10	1.310	35000	cont.
EOSL	50	23	-5	1.52	1.06	1.243	22000	cont.
3050H	50	20	5	1.51	1.08	1.231	18000	cont.
GOES§	16	80‡	5	3.00	1.20	2.570	126	Discont.
EOST	160	26	5	1.54	1.06	1.220	4000	cont

¶ 15Ah discharge

§ CPV

‡ Max.

Mission Profile Cycling Trend Plot for 50Ah Pack 3050H 20% DOD and 5C



STRESS CYCLING DATA

Pack #	Rated Ah	DOD %	Temp. C	VT V	C/D	EOD V	Cycle #	Status
5009M	48	60	10	1.56	1.06	1.215	23000	cont.
EOS	50	60	10	1.55	1.08	1.156	18000	Discont.◊
EOS 1	50	60	10	1.56	1.07	1.154	14000	cont.
LAND	50	60	10	1.55	1.07	1.158	14000	Discont.◊
BUTL∏	19	40	20	33.4	1.10	23.00	12000	Discont.◊
HST	93* ¶	60	10	1.60	1.10	1.101	9000	cont.
3023T§†	23	60	10	3.10	1.08	2.280	2000	cont.

¶ 15Ah discharge

* Derated to 75Ah

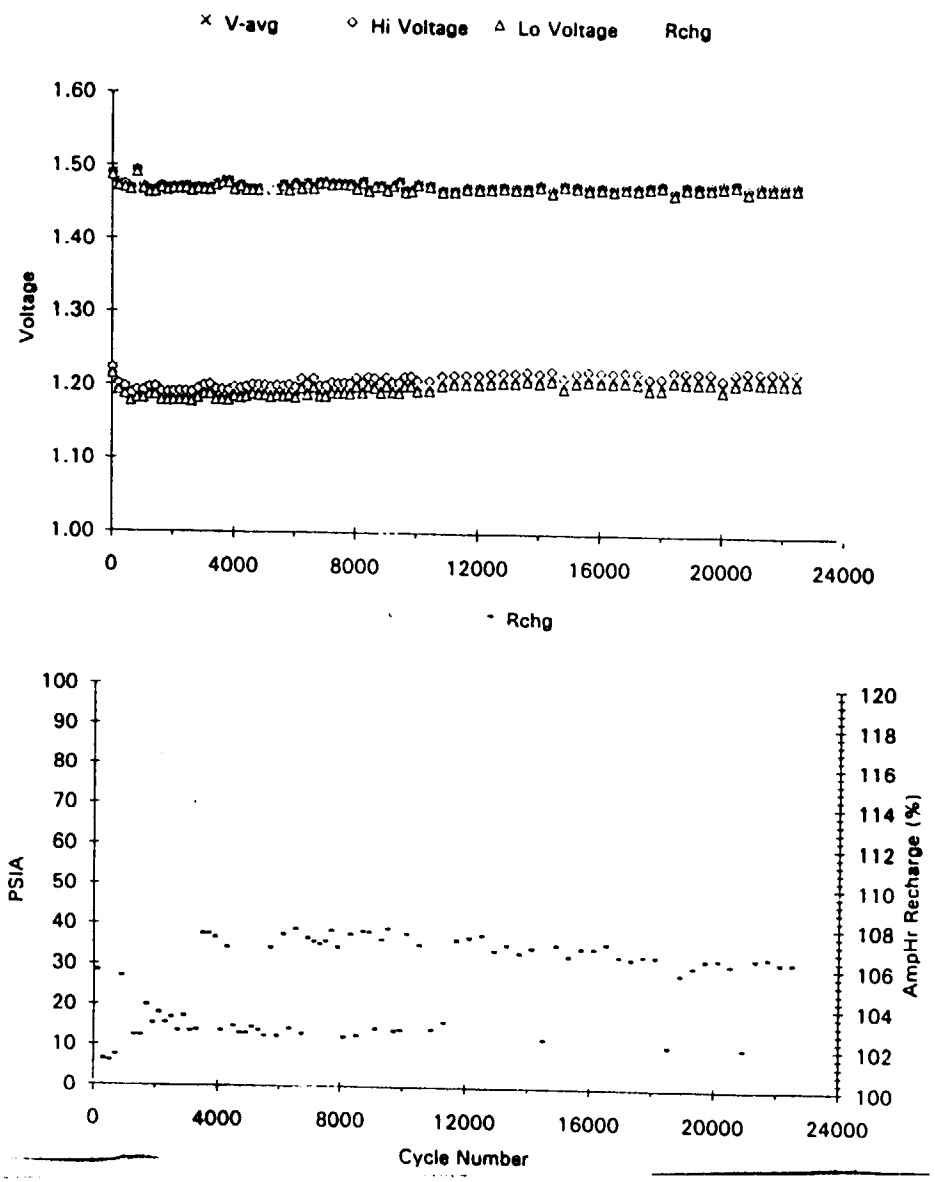
∏ SPV

§ CPV

† 38 months of wet storage

◊ Goal Achieved

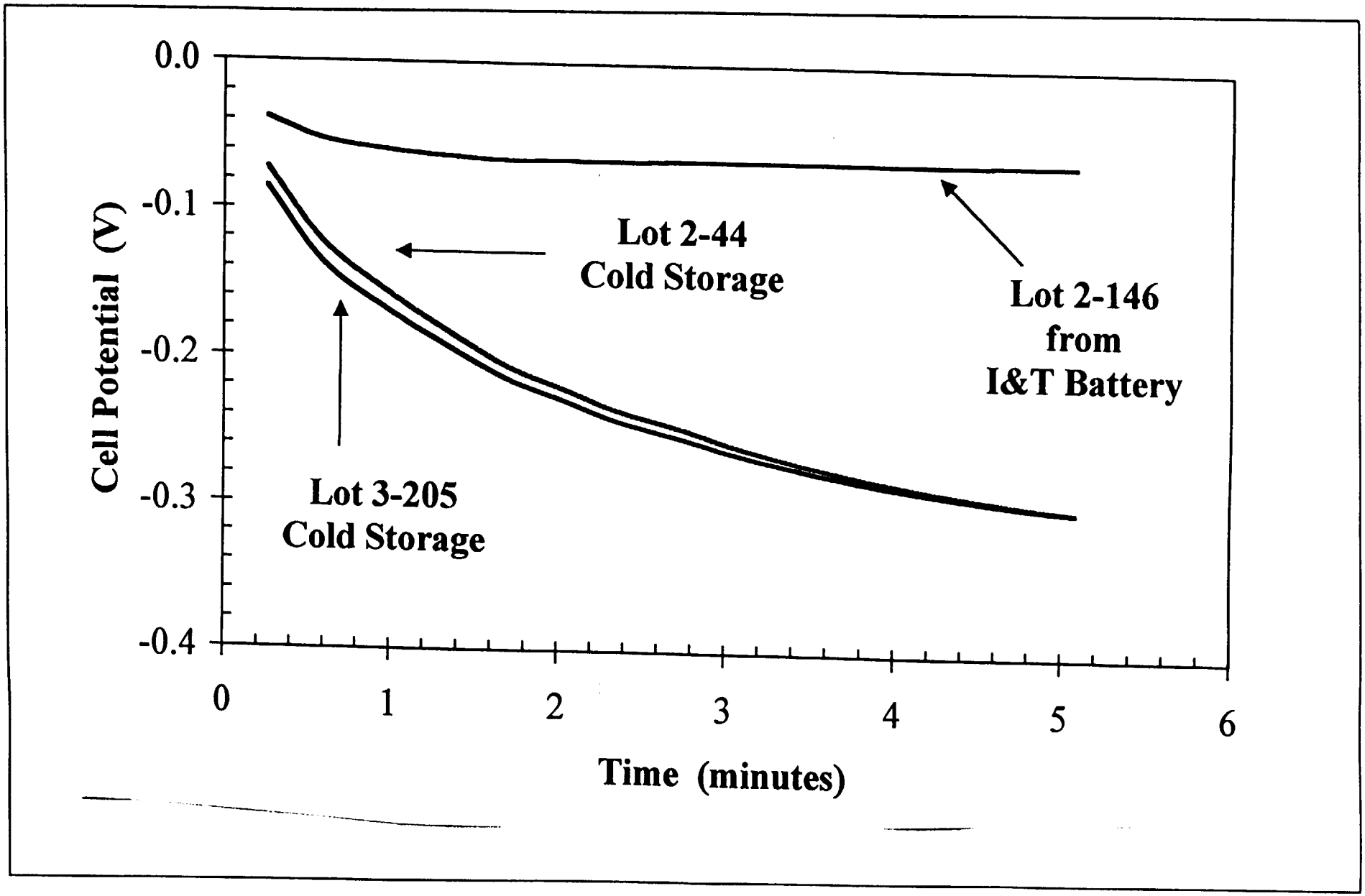
Stress Cycling Trend Plot for 48Ah Pack 5009M 60% DOD and 10C



NICKEL PRECHARGE ANALYSIS

- Electrochemical Characterization of cell
  - Reconditioning, Capacity at 0, 10 and 20C, and Charge Retention
  - Cell Reversal at C/40 Rate on Selected Cells
- C/2 Discharge of the Cell to 0.1V at 10C
- Gas Analysis
- Chemical Analysis of Positive Plate - Total Precharge
- Electrochemical Analysis of Positive Plate - Electrochemical Precharge

Voltage Profile of 50Ah Cell During Cell Reversal at C/40 Rate



NICKEL PRECHARGE‡ - DATA

History	Activ-ation	DPA	Rated Ah	Meas. Ah	Gas Anal.	Nickel Precharge (Ah) Total	Nickel Precharge (Ah) Electrochem.
Cell from I&T Battery Lot 2 - S/N 146	5/95	12/98	50	62.5	Vac.	4.47 7.2%	0.71 1.1%
Cold Storage Lot 3 - S/N 205	1/96	12/98	50	63.7	Vac.	9.7 15.2%	1.00 1.6%
Cold Storage Lot1 - S/N 41	11/97	9/98	160	186	Vac.	27.3 14.7%	8 4.3%
Cold Storage¶ Lot 10 - S/N 515	6/98	2/99	93*	84.2	Vac.	13.2 15.7%	1.4 1.7%

‡ Calculation based on the measured capacity to 1V

* 15Ah discharge

¶ Dry storage for about two years prior to cell activation.

CONCLUSIONS

- Test Data Complies with the Mission requirements
  - Validate the Flight Worthiness of Batteries
- Nominal Stress and Mission Profile Cycling Performance
  - Charge Voltage as High as 1.60V and Recharge Ratio greater than 1.05 are Acceptable
- Electrochemical Signatures alone do not Provide Conclusive Proof for Nickel Precharge
  - Recommend Gas and Positive Plate Analyses for further Confirmation

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