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INVESTIGATION OF LONG TERM STORAGE EFFECTS ON AEROSPACE NICKEL-CADMIUM CELL PERFORMANCE

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ABSTRACT

A study on evaluation of the long term storage effects on aerospace nickel-cadmium cells currently being performed at NASA/Goddard Space Flight Center (GSFC) is described. A number of cells of 6AH and 12AH capacities which have been stored in shorted condition for 8 to 9 years at the GSFC have been selected for this study. These cells will undergo electrical acceptance testing at the GSFC, and life cycling at the NASA Battery Test Facility at the Naval Weapons Support Center (NWSC) in Crane, Indiana; in addition, some cells from the study will undergo destructive analyses.

INTRODUCTION

Investigation of long term storage effects on aerospace nickel-cadmium cell performance is an important topic that has received relatively few interests because of the long time that is required. Although at the GSFC as well as at other facilities, there are many spare and test nickel-cadmium cells held in storage, uncertainties in the cell capabilities after years of storage have hindered their present usage. Another dilemma we face at the GSFC is the reliability of the cells at the time of launch. Cells for a flight project are procured and tested, and battery made well ahead of the launch date. Inevitably because launch delays arise, the question of battery capability with age is often asked. In the few studies done in this area of storage effects on nickel-cadmium cells [1-3], Thierfelder et al. recommends the maximum cell age of 3-1/2 years for maximum reliability in a 7-1/2 year mission [3]. In the above studies, tests that were performed were either accelerated tests or electrical characterization tests after certain periods of storage. Although these techniques may be useful because of the short duration needed in the cell age study, we find that these are not dependable. It has been our experience that the best way to gain a high degree of confidence with the cells is to perform real time testing on them.

The objective of this study is to investigate the effects of long term storage on aerospace nickel-cadmium cells through electrical acceptance testing, real time testing, and destructive analyses. The results from the study will be compared with previous data on these cells, namely from the initial acceptance data at the GSFC, and from the life cycling data at the

NWSC on the cells from the same lot. The study will use 12 General Electric (G.E.) 6AH nickel-cadmium cells (G.E. 42B006AB55/56) and 12 G.E. 12AH nickel-cadmium cells (G.E. 42B012AB20/21). These cells have been chosen because of their relative abundance in the Battery Lab at the GSFC, and also because of availability of the GSFC acceptance data and the NWSC life cycling data on them. These cells were stored shorted in the Battery Lab since 1976 and 1977. They were purchased for the International Ultraviolet Explorer (I.U.E.) Project, and are presently held as reserve cells for the mission. Specific information on these cells, the assembled battery, as well as the performance of the I.U.E. spacecraft is mentioned elsewhere [4-12].

TEST DESCRIPTION

Twelve cells have been selected from each of the I.U.E. 6AH and 12AH cell lots at the Battery Lab at the GSFC. Of the 12 cells within the lot, 2 cells will undergo destructive analysis per NASA Document X-711-74-279 [13]. The remaining 10 cells will be fabricated into two 5-cell packs, 1 of which will be tested at the GSFC/Battery Lab, and the other at the NWSC. Upon completion of the tests, 2 cells from each pack will go through destructive analysis. In all, 12 cells will undergo destructive analysis.

From each lot, one 5-cell pack will be subjected to the cell electrical characterization test at the GSFC that is similar to the acceptance test these cells underwent when they were first procured 8 to 9 years ago [14]. Table 1 shows the outline of the present electrical test. Direct comparisons between the original acceptance test data and the present characterization data from after storage will be made.

The remaining 5-cell packs from each lot will go through an acceptance test at the NWSC, and then a life test. The 6AH test pack will undergo geosynchronous orbit cycling (GEO), whereas the 12AH pack will operate at low-earth orbit cycling (LEO). The operating parameters for these orbits are shown in Table 2. These test parameters were deliberately chosen to operate under similar operating conditions as pack 231A for the 6AH pack and pack 8G for the 12AH pack at the NWSC [5-13]. These two I.U.E. packs, 231A and 8G, which are from the same lot as the cells being tested for this study, have been life cycled at the NWSC since 1978.

Prior to the start of life test, 2 preconditioning cycles will be performed on all cells. The first preconditioning cycle of C/10 charge for 24 hours at 20 C and a C/1.25 discharge with a cutout voltage of 0.75V for each cell will be followed by a second cycle of C/10 charge for 24 hours at 10 C and the same discharge profile as in the first preconditioning discharge.

In the LEO cycling, duration of the test is planned for 1 year. Capacity check will be performed on the 12AH pack at the C/1.25 rate to a voltage limit of 0.75 V/cell on one of the cells at 6 months, and on two of the cells at 12 months. These cell(s) will be recharged at the C/1.25 rate to the voltage limit and tapered until 115% recharge is reached. Other cells will remain open-circuited during the check.

Like the LEO pack, the 6AH GEO pack will be cycled for 1 year. During every other solstice period, each period lasting 2 weeks, the packs will be reconditioned. In the first reconditioning cycle, the pack will be recharged at a float rate of C/60, followed by a discharge at C/1.5 rate until any cell reaches 0.75V, and then open-circuited for 5 days. Thereafter each reconditioning cycle will go through a 3-step charge.

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Table 1. TEST OUTLINE/SCHEDULE

Sequence Number	Test Condition Number	Test Description	Temperature (°c)	Current	Voltage Limits		Test Duration (hours)	
					Upper Limit (V)	Lower Limit (V)	Specified	Estimated
1	1	Conditioning Charge	25	C/20	1.51	0.80	48	—
2	2	Conditioning Discharge	25	C/2	1.51	0.80	—	3
		Resistive Drain	25	—	—	—	—	2
3	3	Conditioning Charge	25	C/10	1.51	0.80	24	—
4	2	Conditioning Discharge	25	C-2	1.51	0.80	—	3
		Resistive Drain/Temperature Stabilization	20	—		—	—	2
5	4	Capacity Charge	20	C/10	1.51	0.80	24	—
6	5	Capacity Discharge	20	C/2	1.51	0.80	—	3
		Resistive Drain	20	—	—	—	16	—
7	6	Charge Retention — Open Circuit	20	—	—	—	24	—
		Resistive Drain/Temperature Stabilization	10	—	—	—	—	2
8	7	Capacity Charge	10	C/20	1.53	0.80	48	—
9	8	Capacity Discharge	10	C/2	1.53	0.80	—	3
		Resistive Drain/Temperature Stabilization	0	—	—	—	—	2
10	9	Overcharge Charge	0	C/20	1.53	0.80	72	—
11	10	Overcharge Discharge	0	C/2	1.53	0.80	—	3
		Resistive Drain/Temperature Stabilization	10	—	—	—	—	2
12	11	Burn-in Charge #1	10	C/20	1.53	0.80	23	—
13	12	Burn-in Discharge #1	10	C/2	1.53	0.80	1	—
14	11	Burn-in Charge #2	10	C/20	1.53	0.80	23	—
15	12	Burn-in Charge #2	10	C/2	1.53	0.80	1	—
16	11	Burn-in Charge #3	10	C/20	1.53	0.80	23	—
17	12	Burn-in Discharge #3	10	C/2	1.53	0.80	1	—
18	11	Burn-in Charge #4	10	C/20	1.53	0.80	23	—
19	12	Burn-in Discharge #4	10	C/2	1.53	0.80	1	—
20	11	Burn-in Charge #5	10	C/20	1.53	0.80	23	—
21	12	Burn-in Discharge #5	10	C/2	1.53	0.80	1	—
22	11	Burn-in Charge #6	10	C/20	1.53	0.80	23	—
23	12	Burn-in Discharge #6	10	C/2	1.53	0.80	1	—
24	11	Burn-in Charge #7	10	C/20	1.53	0.80	23	—
25	12	Burn-in Discharge #7	10	C/20	1.53	0.80	1	—
26	11	Burn-in Charge #8	10	C/20	1.53	0.80	23	—
27	13	Burn-in Capacity Discharge	10	C/2	1.53	0.80	1	—
		Resistive Drain/Temperature Stabilization	20	—	—	—	—	2
28	4	Capacity Charge	20	C/10	1.51	0.80	24	—
29	5	Capacity Discharge	20	C/2	1.51	0.80	—	3
		Resistive Drain	20	—	—	—	—	2

Table 2. OPERATING PARAMETERS OF THE 6AH AND 12AH NICKEL CADMIUM CELL PACKS SCHEDULED TO BE LIFE CYCLED AT NWSC, CRANE, IN.

	6AH Pack	12AH Pack
Life cycling regime	GEO	LEO
Duration (year)	1	1
Temperature (°C)	10	0
Depth-of-Discharge (%)	80	40
Orbit	25 day Eclipse	90 min.
Charge	C/10	C/1.25
Discharge	Eclipse	C/1.25