General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.

- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.

- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.

- This document is paginated as submitted by the original source.

- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

Produced by the NASA Center for Aerospace Information (CASI)

NASA CR-159906

(NASA-CR-159906) INITIAL EVALUATION TESTS OF GENERAL ELECTRIC COMPANY 26.5 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS WITH AUXILIARY ELECTRODES FOR THE TIROS-N AND NOAA-A (Naval Weapons Support Center, Crane, G3/44 43201

N79-15408

Unclas

INITIAL EVALUATION TESTS OF GENERAL ELECTRIC COMPANY 26.5 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS WITH AUXILIARY ELECTRODES FOR THE TIROS-N AND NOAA-A SATELLITES

prepared for

GODDARD SPACE FLIGHT CENTER

Contract S-53742AG

WEAPONS QUALITY ENGINEERING CENTER

NWSC Crane, Indiana

DEPARTMENT OF THE NAVY
NAVAL WEAPONS SUPPORT CENTER
WEAPONS QUALITY ENGINEERING CENTER
CRANE, INDIANA 47522

EVALUATION PROGRAM
FOR
SECONDARY SPACECRAFT CELLS
INITIAL EVALUATION TESTS
OF
GENERAL ELECTRIC COMPANY
26.5 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS
WITH AUXILIARY ELECTRODES
FOR THE
TIROS-N AND NOAA-A SATELLITES

WQEC/C 78-2

16 JANUARY 1978

PREPARED BY

J. D. HARKNESS
Project Manager

PREPARED UNDER THE DIRECTION OF

D. E. MAINS, Manager
Satellite & Shipboard Battery Branch

APPROVED BY

D. G. MILEY

REPORT BRIEF
INITIAL EVALUATION TESTS
OF
GENERAL ELECTRIC COMPANY
26.5 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS
WITH AUXILIARY ELECTRODES
FOR THE
TIROS-N AND NOAA-A SATELLITES

Ref: (a) NASA Purchase Order S-53742AG
(b) Initial Evaluation Test Procedure for Nickel-Cadmium Sealed Space Cells: NAD 3053-TP324; 10 Apr 1973

I. TEST ASSIGNMENT BRIEF

A. The purpose of this evaluation test program is to insure that all cells put into the life cycle program are of high quality by the screening of cells found to have electrolyte leakage, internal shorts, low capacity, or inability of any cell to recover its open-circuit voltage above 1.150 volts during the internal short test.

B. The ten cells were provided by the National Aeronautics and Space Administration, Goddard Space Flight Center (GSFC), to Crane for evaluation on life test. The cells were from the same lot as those procurred by RCA under NASA contract NAS 5-22330. These cells were manufactured by General Electric Company, Gainesville, Florida, according to the General Electric MCD 232A2222AA-82, Revision 13 (dated 10-15-76). This MCD responded to RCA's Specification 2285760, Revision H which reflected the requirements of GSFC Specification S-716-P-6, March 1971. The cells were identified by the manufacturer's catalog number 42B030AB10 (and/11 for auxiliary electrode cells) and were produced at the same time and are from the same lot (03) as those cells used for the TIROS-N and NOAA-A flight batteries. The nominal capacity of the cells was downgraded from 30 to 26.5 ampere-hours because of current density considerations. Testing was funded in accordance with reference (a).

C. Test limits specify those values at which a cell is to be terminated from charge or discharge. Requirements are referenced to as normally expected values based on past performance of aerospace nickel-cadmium cells with demonstrated life characteristics. A requirement does not constitute a limit for discontinuance from test.

II. SUMMARY OF RESULTS

A. No requirements or limits were exceeded during any portion of the testing.

B. Measurements of the cell containers, following test, indicated an average increase of .004 inches in the plate stack thickness.

C. There were no differences in the average end-of-charge voltages and capacity output between the cells with auxiliary electrodes and those without.

D. The average cell voltage at the end of one week open-circuit, during the charge retention test was 1.320 volts. Average capacity output was 27.4 ampere-hours following the open-circuit stand period.

E. The 24-hour average cell voltage following a 16-hour short period, was 1.249 volts.

III. RECOMMENDATIONS

A. It is recommended that these cells be placed on life test simulating that which the spacecrafts will require of the flight batteries.

B. In January 1978, two 5-cell packs (Pack 26G and 26H) began life testing on a 1.68-hour orbit (1.12-hour charge) with a voltage limit control (1.457 V/C) at 10°C and a depth-of-discharge of 20 and 25%.

RESULTS OF INITIAL EVALUATION TESTS OF GENERAL ELECTRIC COMPANY 26.5 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS WITH AUXILIARY ELECTRODES FOR THE TIROS-N AND NOAA-A SATELLITES

I. TEST CONDITIONS AND PROCEDURE

A. All evaluation tests were performed at room ambient (RA) pressure and temperature (25°C ± 2°C), with discharges at the 2-hour rate, and in accordance with reference (b), unless otherwise specified, and consisted of the following:

1. Phenolphthalein leak tests (2).

2. Three capacity tests, third at 20°C, with internal resistance measurements during second charge/discharge.

3. Charge retention test, 20°C.

4. Internal short test.

5. Charge efficiency test, 20°C.

6. Overcharge tests, 0° and 35°C.

7. Phenolpthalein leak test.

(See Appendix I for summary of test procedure.)

II. CELL IDENTIFICATION AND DESCRIPTION

A. The cells were identified by the manufacturer's serial numbers, catalog numbers and RCA's number as follows:

Manufacturer's Number		RCA's Number
Catalog	Serial	
42AB030AB10-G1	02250260-09 to 62, not inclusive, -L03	2285760-1
42AB030AB11-G1	02250260-84 and 91-L03	2285760-2

The cells were placed in a temporary pack configuration for initial testing (Pack 26F). Each cell was individually restrained and there were no pressure gauges.

B. The 26.5 ampere-hour cell is rectangular with an average weight and physical dimensions as follows:

Weight (g)	Height (In.)	Overall Length (in.) Edge	Pre-Test Center	Post-Test Center	Width (In.)
1084.1	7.672	.915	.919	.923	3.005

C. The cell containers and covers are made of stainless steel. The positive and negative terminals are insulated from the cell cover by ceramic seals and protude through the cover as solder-type terminals. (See Appendix II for detailed cell description and manufacturer's test data.)

III. RESULTS - The following was condensed from Tables I through V:

A. All the cell containers, except 3, had a convex contour, in which the thickness was greater in the center of the can than at the edge of the container. Following test, the thickness at the center was greater, on all the cells, than it was before test.

B. Average end-of-charge voltages and capacity output in ampere-hours (ah) were as follows:

Charge	Volts	ah Out
C/20 for 48 hours at 25°C	1.450	33.1
C/10 for 24 hours at 25°C	1.457	32.3
C/10 for 24 hours at 20°C	1.463	31.4
C/10 for 24 hours at 20°C*	1.462	27.4
C/40 for 20 hours at 20°C**	1.373	9.85
C/20 for 60 hours at 0°C	1.494	29.3
C/10 for 24 hours at 35°C	1.422	33.3

*Charge retention test
**Charge efficiency test, 13.25 ah input.

C. Average Internal Resistance Measurements (milliohms):

Measurement Taken	Resistance
30 Min. before end of charge (cycle 1)	2.66
1 Hr. after start of discharge (cycle 2)	2.82
2 Hrs. after start of discharge (cycle 2)	2.71

D. The average cell voltage at the end of one week open-circuit, during the charge retention test, was 1.320 volts.

E. The 24-hour average cell voltage following a 16-hour short period, was 1.249 volts.

EDING PAGE BLANK NOT FILMED

TABLE I

MEASUREMENT AND LEAK TEST DATA

SERIAL NUMBER	WEIGHT (Grams)	HEIGHT (Inches)	LENGTH (Inches)			WIDTH (Inches)	PHENOLPHTHALEIN LEAK TESTS								
							INITIAL			POST HI VAC			POST TEST		
			EDGE	CENTER (Pre-Test)	CENTER (Post-Test)		Terminals		Other	Terminals		Other	Terminals		Other
							+	-		+	-		+	-	
09	1088.9	7.675	.935	.940	.945	3.000									
11	1082.9	7.655	.931	.928	.933	3.003									
13	1085.2	7.675	.913	.912	.916	3.008									
25	1080.9	7.685	.912	.921	.925	3.000									
26	1082.7	7.669	.912	.913	.919	3.010									
55	1081.8	7.676	.909	.909	.915	3.010		No Leaks			No Leaks			No Leaks	
58	1082.1	7.690	.909	.915	.916	3.011									
62	1081.1	7.670	.905	.913	.921	3.001									
84 *	1090.4	7.665	.911	.916	.920	3.003									
91 *	1085.3	7.657	.912	.920	.923	3.004									

* - Auxiliary electrode cells

ORIGINAL PAGE IS OF POOR QUALITY

ORIGINAL PAGE IS OF POOR QUALITY

TABLE II
Capacity Data

SERIAL NUMBER	Capacity Test 1						Capacity Test 2						Capacity Test 3 (20°C)					
	END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE		
	CELL (Volts)	AUX ELECT (Volts)	PRESS* (PSIA)	CAPAC-ITY (ah)	AUX ELECT (Volts)	PRESS* (PSIA)	CELL (Volts)	AUX ELECT (Volts)	PRESS* (PSIA)	CAPAC-ITY (ah)	AUX ELECT (Volts)	PRESS* (PSIA)	CELL (Volts)	AUX ELECT (Volts)	PRESS* (PSIA)	CAPAC-ITY (ah)	AUX ELECT (Volts)	PRESS* (PSIA)
8	1.449	.404		33.9	-.076		1.458	.468		32.9	.003		1.465	.465		31.6	.106	
91	1.450	.462		32.8	-.045		1.458	.507		31.9	.040		1.465	.497		30.5	.133	
09	1.449			33.4			1.457			32.4			1.463			31.6		
11	1.450			32.8			1.457			32.4			1.463			31.6		
13	1.448			32.8			1.455			31.9			1.461			31.0		
25	1.449			32.8			1.456			32.4			1.461			31.6		
26	1.449			32.8			1.456			32.4			1.462			31.6		
55	1.449			32.8			1.456			32.4			1.461			31.6		
58	1.448			32.8			1.457			31.9			1.462			31.0		
62	1.454			33.9			1.461			32.4			1.466			32.1		

*- not applicable

MQEC/C 78-2

9ND-NADC (SP 11/73)

TABLE III
INTERNAL RESISTANCE AND SHORT TEST DATA

GND-NADC (SP 11/73)

SERIAL NUMBER	INTERNAL RESISTANCE (MILLIOHMS)			INTERNAL SHORT TEST		
	END-OF-CHARGE	ONE HOUR AFTER START-OF-DISCHARGE	TWO HOURS AFTER START-OF-DISCHARGE	AFTER 16 HR SHORT	AFTER 24 HOUR OCV STAND	
				CELL	CELL	PRESS*
84	2.5	2.6	2.4	.110	1.251	
91	2.7	3.1	2.7	.111	1.251	
09	2.8	2.9	3.2	.109	1.250	
11	2.7	3.0	2.6	.113	1.249	
13	2.8	3.1	2.6	.104	1.249	
25	2.7	2.7	2.6	.104	1.249	
26	2.7	3.0	2.9	.112	1.248	
55	2.6	2.6	3.0	.103	1.248	
58	2.6	2.7	2.3	.099	1.249	
62	2.5	2.5	2.8	.099	1.247	
* -	not applicable					

ORIGINAL PAGE IS
OF POOR QUALITY

TABLE IV
CHARGE RETENTION TEST DATA

SERIAL NUMBER	END-OF-CHARGE			24 HR. OCV			1 WEEK OCV			END-OF-DISCHARGE		
	CELL (VOLTS)	AUX. ELECT. (VOLTS)	PRESS.* (PSIA)	CELL (VOLTS)	AUX. ELECT. (VOLTS)	PRESS.* (PSIA)	CELL (VOLTS)	AUX. ELECT (VOLTS	PRESS.* (PSIA)	CAPAC-ITY (AH)	AUX. ELECT. (VOLTS)	PRESS.* (PSIA)
84	1.464	.472		1.362	.100		1.321	.006		27.9	-.086	
91	1.463	.502		1.362	.051		1.322	.004		27.3	-.101	
09	1.462			1.363			1.319			27.3		
11	1.462			1.362			1.319			27.3		
13	1.460			1.362			1.318			26.7		
25	1.460			1.362			1.319			27.3		
26	1.461			1.362			1.319			27.9		
55	1.460			1.363			1.320			27.3		
58	1.463			1.363			1.321			27.3		
62	1.465			1.365			1.321			27.9		

* - not applicable

TABLE V

Charge Efficiency and Overcharge Data

SERIAL NUMBER	Charge Efficiency (20°C)						Overcharge Test (0°)						Overcharge Test (35°C)					
	END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE		
	CELL (Volts)	AUX ELECT (Volts)	PRESS* (PSIA)	CAPACITY (ah)	AUX ELECT (Volts)	PRESS* (PSIA)	CELL (Volts)	AUX ELECT (Volts)	PRESS* (PSIA)	CAPACITY (ah)	AUX ELECT (Volts)	PRESS* (PSIA)	CELL (Volts)	AUX ELECT (Volts)	PRESS* (PSIA)	CAPACITY (ah)	AUX ELECT (Volts)	PRESS* (PSIA)
84	1.373	.038		10.2	-.025		1.494	.421		31.1	.028		1.422	.341		34.6	.037	
91	1.374	.035		10.2	.009		1.494	.443		30.0	.149		1.422	.378		33.6	.024	
09	1.373			10.2			1.492			28.9			1.421			33.1		
11	1.373			9.7			1.494			28.9			1.424			33.1		
13	1.373			9.7			1.493			28.4			1.420			32.6		
25	1.373			9.7			1.493			28.9			1.420			33.1		
26	1.373			9.7			1.494			28.9			1.419			32.6		
55	1.373			9.7			1.491			28.9			1.420			33.1		
58	1.374			9.7			1.493			28.9			1.425			33.1		
62	1.373			9.7			1.497			30.0			1.426			33.6		

*- Not Applicable

ORIGINAL PAGE IS OF POOR QUALITY

APPENDIX I

I. TEST PROCEDURE

A. Phenolphthalein Leak Tests:

1. This test is a determination of the condition of the welds and ceramic seals on receipt of the cells and following the last discharge of the cells (Cycle # 7).

2. The cells were initially checked with a one-half of one percent phenolphthalein solution applied with a cotton swab and then placed in a vacuum chamber and exposed to a vacuum of 40 microns of mercury or less for 24 hours. Upon removal they were rechecked for leaks and then received a final check following test completion. The requirement is no red or pink discoloration which indicates a leak.

B. Capacity Tests:

1. The capacity test is a determination of the cells' capacity at the C/2 discharge rate to 0.75 volt per cell, where C is the manufacturer's rated capacity. This type discharge follows all charges of this evaluation test.

2. The charges for the capacity tests are as follows:

a. C/20, 48 hours, room ambient (RA), Cycle 0, with a test limit of 1.52 volts or pressure of 100 psia.

b. C/10, 24 hours, RA, Cycle 1, with a test limit of 1.52 volts or 100 psia pressure and a requirement of maximum voltage (1.48) or pressure (75 psia).

c. C/10, 24 hours, 20°C, Cycle 2, with the same limits and requirements as the charge of Cycle 1.

C. Internal Resistance:

1. Measurements are taken across the cell terminals 1/2 hour before the end-of-charge (EOC) on Cycle 1, and 1 and 2 hours after the start-of-discharge of Cycle 2. These measurements were made with a Hewlett-Packard milliohmmeter (Model 4328A).

D. Special Charge Retention Test, 20°C:

1. This test is to establish the capacity retention of each cell following a 7-day open-circuit-stand in a charge mode.

2. The cells are charged at C/10 for 24 hours with a test limit of 1.52 volts or 100 psia pressure. They then stand on open-circuit for 7 days, with the requirement that the open-circuit voltage of each cell, following this period, is within +5 millivolts of the average cell voltage. The cells are then discharged and 80 percent capacity out of that obtained in Cycle 3 is required.

E. Internal Short Test:

1. This test is a means of detecting slight shorting conditions which may exist because of imperfections in the insulating materials, or damage to element in handling or assembly.

2. Following completion of the third capacity discharge, the cells are shunted with a 0.5-ohm, 3-watt resistor for 16 hours. At the end of 16 hours the resistors are removed and the cells stand on open-circuit-voltage (OCV) for 24 hours. A minimum voltage of 1.15 is required at the end of the 24 hours.

F. Charge Efficiency Test, 20°C:

1. This test is a measurement of the cells' charge efficiency when charged at a low current rate.

2. The cells are charged at C/40 for 20 hours with a test limit of 1.52 volts or 100 psia pressure. They are then discharged and the requirement is that the minimum capacity out equals 55 percent of capacity in during the preceding charge.

G. Overcharge Test #1, 0°C:

1. The purpose of this test is to determine the degree to which the cells will maintain a balanced voltage, and to determine the cells' capability to be overcharged without overcharging the negative electrode.

2. The cells are charged at C/20 for 60 hours. The test limits are cell voltages of 1.56 or greater for a continuous time period of 2 hours or pressures of 100 psia. The requirement is a voltage of 1.520 or a pressure of 75 psia. The cells are then discharged and 85 percent capacity out of that obtained in Cycle 3 is required.

H. Overcharge Test #2, 35°C:

1. This test is a measurement of the cells' capacity at a higher temperature when compared to its capacity at 20°C. This test also determines the cells' capability of reaching a point of pressure equilibrium; oxygen recombination at the negative plate at the same rate it is being generated at the positive plate.

2. The cells are charged C/10 for 24 hours with a test limit of 1.52 volts or 100 psia pressure and a requirement of 1.45 volts or 75 psia pressure. The cells are then discharged and 55 percent capacity out of that obtained in Cycle 3 is required.

APPENDIX II

CELL DESCRIPTION AND MANUFACTURER'S TEST DATA

2.0 Cell Information

2.1 Cell History and Description

These cells designated 42B030AB10 (and /11 for signal electrode cells) from lot 03 manufactured to General Electric MCD 232A2222AA-82 Revision 13 (dated 10-15-76). The MCD responded to RCA Specification 2285760 Revision H which reflected the requirements of GSFC Specification S716-P-6 March 1971. The cells completed precharge 10-20-76 and were tested to GE pre-acceptance electrical tests P24B-PB238 and Acceptance test P24APB222.

2.2 Cell Design

	Positives	Negatives
Number of plates	11	12
Post Number	31060	90915
Nominal Thickness		
(mils)	026-028	031-032
(mms)	.066-071	.078-081
Hydrate loading gm/dm^2	13.4±.6	15.96±.65
Plate Area dm^2	1.098	1.098

Separator 188B5070AR - Pellon 2505 bagged around positives.
Electrolyte 162A8090 - 86cc of 31% KOH.
Seals 152B540CF - GE Tube Division Ceramic/metal Type
Case 152B5402 - 025 mil 304L Stainless Steel
Negative Plates - Teflon Coated per P5C-PB106.

2.3 Manufacturers Test Data

	Positive		Negative
Formation Capacity (avg.) AH	34.15		59.27
Negative/Positive Ratio		1.74	
Precharge (O_2 Removed) AH			13.12
Precharge measured (AH)			7.28
24°C Capacity AH (1)	33.1		
15°C Capacity AH (2)	30.2		
0°C Capacity AH (3)	27.9		
Flooded Cell Capacity AH	38.35		63.32

(1) Charge at 2.65 A for 24 hours.

(2) Charge at 1.5 A for 48 hours.

(3) Charge at 1.325 A for 72 hours.