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INITIAL EVALUATION TESTS OF GENERAL ELECTRIC COMPANY 50.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS FOR THE LANDSAT-D SATELLITE PROGRAM

prepared for

GODDARD SPACE FLIGHT CENTER

Contract S-57075AG

WEAPONS QUALITY ENGINEERING CENTER
NWSC Crane, Indiana

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

IN REPLY REFER TO:
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To: National Aeronautics and Space Administration, Goddard Space Flight Center (711), Greenbelt MD 20771

Subj: Report WQEC/C 80-104; Initial Evaluation Tests of General Electric Company 50.0 Ampere-Hour Nickel-Cadmium Spacecraft Cells for the LANDSAT-D Satellite Program

Ref: (a) NASA Purchase Order S-57075AG

Encl: (1) Report WQEC/C 80-104

1. In compliance with reference (a), enclosure (1) is forwarded for information and retention.

MORRIS L. ROBERTSON
By direction

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NAVAL WEAPONS SUPPORT CENTER
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CRANE, INDIANA 47522

EVALUATION PROGRAM
FOR
SECONDARY SPACECRAFT CELLS

INITIAL EVALUATION TESTS
OF
GENERAL ELECTRIC COMPANY
50.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS
FOR THE
LANDSAT-D SATELLITE PROGRAM

WQEC/C 80-104

09 APR 1980

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Enclosure (1)

REPORT BRIEF
INITIAL EVALUATION TESTS
OF
GENERAL ELECTRIC COMPANY
50.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS
FOR THE
LANDSAT-D SATELLITE PROGRAM

Ref: (a) NASA Purchase Order S-57075AG
(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 eight cells were provided by the National Aeronautics and Space Administration, Goddard Space Flight Center (GSFC), to NAVWPNSUPPCEN Crane for evaluation on a near-earth orbit test regime. The cells were manufactured by the General Electric Company, under NASA Contract NAS-5-23844, according to General Electrics' Manufacturing Control Document (MCD) 232A2222AA-84. (See Appendix I for a detailed cell description.) The cells were identified by the manufacturer's catalog numbers 42B050AB20/21 - G1 and G2. The AB21 type cell has an auxiliary electrode and the G2 type cell was received with a gauge assemble. Pressure transducer assemblies were placed on a total of 5 cells including that cell with the gauge assembly. The cells are rated at 50.0 ampere-hours and contain dual, nickel-braze ceramic seals. 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. Measurement of the cell containers, following test, indicated ar increase of .005 inches in the one auxiliary electrode type cell's plate stack.

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

Charge	Volts	PSIA	ah Out
c/20 for 48 hrs @ 25° C	1.444	30	63.6
c/10 for 24 hrs @ 25° C	1.452	61	62.2
c/10 for 24 hrs @ 20° C	1.468	73	60.5
c/10 for 24 hrs @ 20° C*	1.462	75	56.4
c/40 for 20 hrs @ 20° C**	1.373	11	18.8
c/20 for 60 hrs @ 0° C	1.493	64	60.9
c/10 for 24 hrs @ 35° C	1.393	30	59.3

*Charge retention test
**Charge efficiency test, 25.0 ah input

C. Three pressure transducer cells exceeded the pressure requirement of 65 psia during their c/10 charge at 25°C.

D. Three cells exceeded the voltage requirement of 1.480 volts during their first c/10 charge at 20°C. Their peak voltages were 1.480 to 1.482 volts. Also, 4 of the 5 pressure transducer cells exceeded the pressure requirement of 65 psia during this charge and their second c/10 charge at 20°C.

E. The average cell voltage at the end of 1 week open-circuit during the charge retention test, was 1.308 volts. One cell's voltage was below the requirement of being within 5 millivolts of the average voltage.

F. The average ampere-hours out, during the charg efficiency test, was 18.8 which corresponds to an efficiency of 75%.

G. During the 0°C overcharge test, 3 cells exceeded the pressure requirement of 65 psia. One cell (S/N 006) reached the voltage requirement of 1.520 volts. Peak voltages were 1.502 (S/N 023) to 1.520 volts (S/N 006).

H. The cells, with pressure transducers, reached a pressure of 20 psia before reaching the voltage limit of 1.550 volts during the pressure versus capacity test. The average ampere-hours in and voltage at this pressure were 73.5 ah and 1.504 volts respectively. The cells exhibited a pressure decay of 2 psia during the last 30 minutes of the 1 hour open-circuit stand period. Average capacity out was 61.9 ampere-hours.

III. RECOMMENDATIONS

A. Although high cell pressures were observed during the c/10 charges at 25°C and 20°C, it is recommended that these cells be placed on a near-earth orbit life test.

B. On 4 March 1980, two 4-cell packs (Packs 50C and 50D) began life test on a 1.48-hour orbit (1.00-hour charge with a voltage limit control at 20°C). Pack 50C's depth-of-discharge is 25% and 50D's is 40%.

RESULTS OF INITIAL EVALUATION TESTS OF GENERAL ELECTRIC COMPANY 50.0 AMPERE-HOUR NICKES-CADMIUM SPACECRAFT CELLS FOR THE LANDSAT-D SATELLITE PROGRAM

I. TEST CONDITIONS AND PROCEDURE

A. All evaluation tests were performed at room ambient (RA) pressure and temperature (25° ± 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. Auxiliary electrode characterization test.

4. Charge retention test, 20° C.

5. Internal short test.

6. Charge efficiency test, 20° C.

7. Overcharge tests, 0° and 35° C.

8. Pressure versus capacity test.

9. Phenolphthalein leak test.

(See Appendix II for summary of test procedure.)

II. CELL IDENTIFICATION AND DESCRIPTION

A. The cells were identified by the manufacturer's serial numbers (02680305-006 to 041 non-inclusive - L01) and catalog numbers 42B050AB20/21 - G1 and G2. AB21 designates the cell (S/N 006) as having an auxiliary electrode and G2 designated the cell (S/N 033) as having a gauge assembly. Pressure transducer assemblies were placed on a total of 5 cells including that cell with the gauge assembly. The cells were placed in a temporary pack (561x) configuration for initial testing. Each cell was individually restrained.

B. The 50.0 ampere-hour cell is rectangular with an average weight and physical dimensions as follows:

Weight (g)	Height (in.)	Thickness (in.) (Pre/Post-Test) Edge	Center	Width (in.)
2022.8*	5.882	1.333	1.337	4.947

*Does not include those cells with pressure transducers.

C. The cell containers and covers are made of stainless steel. The positive and negative terminals are insulated from the cell cover by dual, nickel-braze, ceramic-to-metal seals and protrude through the cover as solder-type terminals.

D. Cell serial number 041 contains a standard Aerospace type auxiliary electrode.

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

A. Measurement of the cell containers, following test, indicated an increase of .005 inches in one cell's (S/N 041) plate stack thickness.

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

Charge	Volts	PSIA	ah Out
c/20 for 48 hrs @ 25° C	1.444	30	63.6
c/10 for 24 hrs @ 25° C	1.452	61	62.2
c/10 for 24 hrs @ 20° C	1.468	73	60.5
c/10 for 24 hrs @ 20° C*	1.462	75	56.4
c/40 for 20 hrs @ 20° C**	1.373	11	18.8
c/20 for 60 hrs @ 0° C	1.493	64	60.9
c/10 for 24 hrs @ 35° C	1.393	30	59.3

*Charge retention test
**Charge efficiency test, 25.0 ah input

C. The average internal resistance at the end-of-charge (Cycle 1) was 2.4 milliohms and at the end-of-discharge (Cycle 2) it was 2.1 milliohms.

D. Three pressure transducer cells exceeded the pressure requirement of 65 psia during their c/10 charge at 25°C.

E. Three cells exceeded the voltage requirement of 1.480 volts during their first c/10 charge at 20°C. Their peak voltages were 1.480 to 1.482 volts. Also, 4 of the 5 pressure transducer cells exceeded the pressure requirement of 65 psia during this charge and their second c/10 charge at 20°C.

F. The average cell voltage at the end of 1 week open-circuit, during the charge retention test, was 1.308 volts. One cell's (S/N 033) voltage was below the requirement of being within 5 millivolts of the average voltage.

G. The 24-hour average cell voltage following the 16-hour shunt period, during the internal shunt test, was 1.219 volts.

H. The average ampere-hours out, during the charge efficiency test, was 18.8 which corresponds to an efficiency of 75%.

I. During the 0°C overcharge test, 3 cells exceeded the pressure requirement of 65 psia. One cell (S/N 006) reached the voltage requirement of 1.520 volts. Peak voltages were 1.502 (S/N 023) to 1.520 volts (S/N 006).

J. The cells, with pressure transducers, reached a pressure of 20 psia before reaching the voltage limit of 1.550 volts during the pressure versus capacity test. The average ampere-hours in and voltage at this pressure were 73.5 ah and 1.504 volts respectively. The cells exhibited a pressure decay of 2 psia during the last 30 minutes of the 1-hour open-circuit stand period. Average capacity out was 61.9 ampere-hours.

K. The auxiliary electrode characteristic test was performed on cell S/N 041. Maximum signal power was obtained with a resistance of 50-ohms. A 200-ohm resistance was used throughout the remainder of the tests, as instructed by the Goddard Space Flight Center's Technical Officer.

TABLE I

MEASUREMENT AND LEAK TEST DATA

SERIAL NUMBER	WEIGHT (Grams)	HEIGHT (Inches)	LENGTH (Inches)			WIDTH (Inches)	PHENOLPHTHALEIN LEAK TESTS								
							INITIAL			PRE HI VAC			POST TEST		
			MINIMUM EDGE	CENTER MAXIMUM (Pre-Test	CENTER MAXIMUM Post-Test)		Terminals +	Terminals -	Other	Terminals +	Terminals -	Other	Terminals +	Terminals -	Other
010	2033.3 *	5.886	1.332	1.333	1.333	4.949									
016	2038.0 *	5.8[illegible]	1.333	1.337	1.337	4.945									
023	2043.5 *	5.891	1.336	1.336	1.336	4.949									
025	2040.7 *	5884	1.337	1.341	1.341	4.949									
033	2369.0 **	5.880	1.327	1.332	1.332	4.948	NO	LEAKS		NO	LEAKS		NO	LEAKS	
006	2021.7	5.878	1.337	1.341	1.341	4.945									
015	2024.0	5.880	1.329	1.339	1.339	4.945									
041	2037.1 □	5.884	1.331	1.335	1.340	4.943									

* - cells with swaglok fittings

** - cell with pressure gauge

□ - cell with auxiliary electrode

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)
010	1.441		29	63.4		7	1.452		53	62.0		11	1.466		71	60.3		12
016	1.444		30	63.4		7	1.449		67	62.3		10	1.467		78	60.5		11
023	1.441		26	63.4		10	1.452		50	62.3		13	1.470		60	61.3		14
025	1.442		35	63.4		8	1.452		70	62.3		12	1.471		83	61.3		14
033	1.443		30	62.9		7	1.452		65	61.5		10	1.470		75	59.5		12
006	1.44x			64.1			1.457			62.8			1.471			61.3		
015	1.445			63.4			1.456			62.5			1.468			60.5		
041	1.446	.680		64.6	-.011		1.448	.686		61.8	.037		1.460	.666		59.5	-.111	

9ND-NADC (SP 11/73)

TABLE III
INTERNAL RESISTANCE AND SHORT TEST DATA

9ND-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 HOU OCV STAND	
				CELL	CELL	PRE
010	2.2	2.0	2.1	.217	1.225	
016	2.6	2.2	2.0	.126	1.203	9
023	2.4	2.3	2.1	.067	1.207	14
025	2.5	2.4	2.1	.133	1.203	11
033	2.5	2.3	2.0	.218	1.221	9
006	2.4	2.3	2.5	.226	1.225	
015	2.1	1.8	1.7	.165	1.225	
041	2.3	2.0	2.2	.245	1.244	

TABLE IV
CHARGE RETENTION TEST DATA

SERIAL NUMBER	END-OF-CHARGE			24 HR. OCV			1 WEEK OCV			END-Or-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)
010	1.469		76	1.364		12	1.309		11	56.3		10
016	1.465		79	1.362		11	1.312		10	57.0		10
023	1.462		60	1.357		17	1.309		14	56.8		14
025	1.462		84	1.357		13	1.308		12	56.8		11
033	1.458	.	76	1.353		11	1.302		10	56.3		9
006	1.463			1.350			1.306			56.8		
015	1.460			1.359			1.309			56.5		
041	1.460	.669		1.353	.059		1.311	.007		54.5	-.295	

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)	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)
010	1.373		9	18.8		9	1493		60	60.9		12	1.394		23	59.4		7
016	1.373		10	18.3		10	1.491		67	61.1		15	1.392		31	59.6		13
023	1.374		14	18.3		12	1.492		49	60.9		16	1.391		29	58.6		16
025	1.373		11	18.3		11	1.491		74	61.1		18	1.392		36	58.6		16
033	1.372		9	18.5		9	1.492		69	61.1		18	1.390		30	58.1		14
006	1.372			18.6			1.495			62.4			1.390			58.6		
015	1.373			18.3			1.494			61.1			1.396			60.9		
041	1.373	.054		21.8	-.186		1.499	.520		58.6	- 272		1.396	.646		60.4	.178	

TABLE VI
PRESSURE VS. CAPACITY TEST DATA

Serial No.	010	016	023	025	033											
Start-of-Charge, Press.	1	7	2	8	4											
AH in to 5 PSIA	64.6	NA	NA	NA	47.8											
Cell (volts)	460				1.435											
Aux (volts)	NA	NA	NA	NA	NA											
AH in to 10 PSIA	72.0	57.7	55.2	63.6	68.1											
Cell (volts)	1.493	1444	1.440	1.454	1.467											
Aux (volts)																
AH in to 15 PSIA	73.8	71.5	68.1	71.5	72.0											
Cell (volts)	1.512	1.484	1.466	1.481	1.497											
Aux (volts)																
AH in to 20 PSIA	74.5	73.5	72.0	72.8	74.5											
Cell (volts)	1.51F	1.503	1484	1.503	1.510											
Aux (volts)																
AH in to V/L (1.55V)	NA	NA	NA	NA	NA											
Aux (volts)																
Press (PSIA)																
30 Min OCV, Cell	1.412	1408	1.398	1.408	1.410											
Aux (volts)																
Press (PSIA)	24	24	22	24	26											
1 hour OCV, Cell	1.400	1.399	1.342	1.399	1.406											
Aux (volts)																
Press (PSIA)	21	23	19	23	25											
EOD AH out	62.1	62.0	60.8	62.1	62.3											
Aux (volts)																
Press (PSIA)	5	11	10	11	7											

NA - Not Applicable

TABLE VII

SPECIAL RESISTANCE CHARACTERISTIC DATA ON THE AUXILIARY ELECTRODES

Serial No.	041										AVERAGE	
[illegible]	VOLTS	PRESS	VOLTS	PRES	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	MILLIWATTS
10,000	.861	NA									.861	.741
5,000	.853										.853	.145
2,000	.811										.811	.329
1,000	.755										.755	.570
500	.685										.685	.938
200	.556										.556	1.546
100	.439										.439	1.927
50	.312										.312	1.947
20	.177										.177	1.566
10	.110										.110	1.210
5	.065										.065	.245
2	.031										.031	.481
1	.017										.017	.289
0.5	.010										.010	.200
0.2	.006										.006	.180
0.1	.004										.004	.160

Note: All pressures in PSIA.
NA. not applicable

$$\text{POWER} = \frac{V^2}{R} \text{ Watts} \times 10^3 \frac{\text{Milliwatts}}{\text{Watt}} : \text{Milliwatts}$$

APPENDIX I

CELL DESCRIPTION

APPENDIX I

CELL DESCRIPTION

Cell History and Description

Sixty-eight, Lot 1, 50 ah cells were purchased by the GSFC, under NASA Contract Number NAS-23844, from the General Electric Company. These cells were manufactured in accordance with General Electric's MCD 232A2222AA-84. The General Electric catalog number is 42B050AB20/21. Some of the pertinent cell design features and manufacturing data are as follows:

Number of Plates: 16 Positive
17 Negative

Plate Dimensions: Positive 4.723" x 4.670" x .027"
Negative 4.726" x 4.675" x .031"

Loading: Positive 12.69 gm/dm^2
Negative 16.21 gm/dm^2

KOH Quantity: 170 cc of 31% KOH

Precharge: 25.0 ah

Separator: Pellon 2505

Flouded cell tests: Average Positive 64.66 ah
Average Negative 120.68 ah

Dual, nickel-braze, ceramic-to-metal seals

APPENDIX II

TEST PROCEDURE

APPENDIX II

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 8).

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 (65 psia);

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

C. Special Resistance Characterization Tests for Auxiliary Electrode Cells:

1. The purpose of this test is to determine the resistance to be placed across the cell's auxiliary electrode and negative terminals which will provide maximum signal when the cell is fully charged.

2. The cells are charged at c/10 for 24 hours at the room ambient temperature following their initial charge/discharge cycle. Following this the cells are continued on charge with the current reduced, if necessary, to maintain the cell's voltage below 1.520 volts and to stabilize the pressure between 10-20 psia. Resistance values, between 10,000 ohms and 0.1 ohm are then placed between the

auxiliary electrode and the negative terminal. The cells are allowed a minimum of 5 minutes, at each resistance value, to obtain an equilibrium voltage across this resistance. This voltage value is then recorded and by calculation using the equation $P = E^2/R$ the resistance that produces maximum power is determined.

D. Internal Resistance:

1. Measurements are taken across the cell terminals 0.5 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 milliohmeter (Model 4328A).

E. 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 the same limits and requirements as the charge of cycle 1. 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 $\pm$ 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.

F. 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 charge retention test 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 mimimum voltage of 1.15 is required at the end of 24 hours.

G. 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.

H. 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 1.55 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 65 psia. The cells are then discharged and 85 percent capacity out of that obtained in cycle 3 is required.

I. Overcharge Test 2, 35° C:

1. This test is a measurement of the cell's 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 at 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 65 psia pressure. The cells are then discharged with a requirement that capacity out equals 55 percent capacity out as obtained in cycle 3.

J. Pressure Versus Capacity Test:

1. The purpose of this test is to determine the capacity to a pressure and the pressure decay during charge and open-circuit stand respectively.

2. Each cell is charged at c/2 to either a pressure of 20 psia or a voltage of 1.550. Recordings are taken on each cell when it reaches 5, 10, 15 and 20 psia pressure. The cells then stand OCV for 1 hour with 30-minute recordings and then are discharged, shorted out and leak tested.