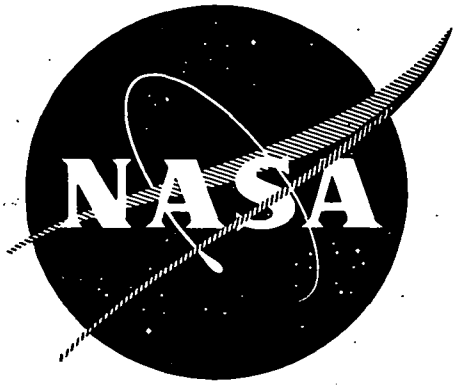


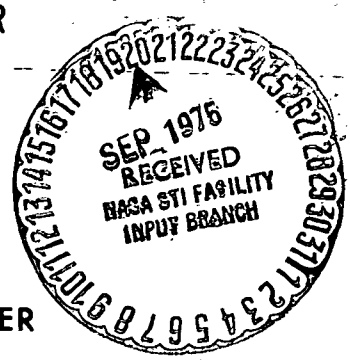
EVALUATION PROGRAM

for

SECONDARY SPACECRAFT CELLS

INITIAL EVALUATION TESTS
OF
GENERAL ELECTRIC COMPANY
12.0 AMPERE-HOUR, NICKEL-CADMIUM SPACECRAFT CELLS
FOR THE
INTERNATIONAL ULTRAVIOLET EXPLORER SATELLITE

prepared for
GODDARD SPACE FLIGHT CENTER
CONTRACT S-23404-G



WEAPONS QUALITY ENGINEERING CENTER

NAVAL AMMUNITION DEPOT, CRANE, INDIANA

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

EVALUATION PROGRAM FOR SECONDARY SPACECRAFT CELLS

INITIAL EVALUATION TESTS OF GENERAL ELECTRIC COMPANY 12.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS FOR THE INTERNATIONAL ULTRAVIOLET EXPLORER SATELLITE

WQEC/C 74-511 1 OCTOBER 1974

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Enclosure (1)

REPORT BRIEF

INITIAL EVALUATION TESTS OF GENERAL ELECTRIC COMPANY 12.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS FOR THE INTERNATIONAL ULTRAVIOLET EXPLORER SATELLITE

Ref: (a) NASA Purchase Order S-23404-G
(b) Initial Evaluation Test Procedure for Nickel-Cadmium Sealed Space Cells: NADC 3053-TP324 of 10 Apr 73

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 20 cells were manufactured for the National Aeronautics and Space Administration, Goddard Space Flight Center, under NASA contract NAS-5-23153, by General Electric Company, Gainesville, Florida, according to the Manufacturing Control Document (MCD) 232A2222AA-54, Revision 4. They were manufactured to Goddard Space Flight Center's specification number S-761-P-6. Ten cells were identified with the manufacturer's catalog number 42B012AB20-G3 and had no auxiliary electrodes. There were five cells each of catalog number 42B012AB21-G3 and 42B012AB21-G3-A which had auxiliary electrodes; but of two different designs. All the cells are rated at 12.0 ampere-hours, contain double ceramic seals, and were fitted with pressure gauge assemblies prior to testing. Testing was funded in accordance with reference (a).

C. Test limits specify those values in which a cell is to be terminated from a particular charge or discharge. Requirements are referred 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 test.

B. Cell, S/N 016, exhibited a high auxiliary electrode voltage during test. The cell was returned to Goddard Space Flight Center following completion of testing. The cell was X-rayed and no physical discrepancies were found. Also, the 0° C overcharge test was rerun and the cell did not exhibit a high auxiliary electrode voltage.

C. The cell containers had a convex contour, in which the average thickness of the cells were 0.008 inches thicker at the maximum thickness when compared to the minimum thickness, which was the edge of the containers. Following test, this value was 0.009 inches indicating an increase in the plate stack thickness although some cells did decrease in thickness.

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

E. The cells which have their auxiliary electrodes enclosed in non-woven nylon exhibited lower average end-of-charge electrode voltages than the other type cells, except during the charge efficiency test and the overcharge test at 35° C, in which the averages were the same.

F. The average cell voltage at the end of one week open-circuit, during the charge retention test, was 1.315 volts. Average capacity output was 13.5 ampere-hours following the open-circuit stand period.

G. The 24-hour average cell voltage following a 16-hour short period, for the cells without auxiliary electrodes and those with auxiliary electrodes was 1.220 and 1.215 volts respectively.

H. All the cells 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 voltages at this pressure were 18.5 and 1.490 volts respectively. A few cells, of each type, exhibited pressure decay in the range of 1 to 5 psia during the last 30 minutes of the 1-hour open-circuit stand. Average capacity out was 14.6 ampere-hours.

III. RECOMMENDATIONS

A. Manufacturing processes and controls should be such to prevent swelling of the plate stack, thereby preventing cell case distortion.

B. It is recommended that these cells be placed on life test simulating that which the flight batteries will experience in orbit.

RESULTS OF INITIAL EVALUATION TESTS OF GENERAL ELECTRIC COMPANY 12.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS FOR THE INTERNATIONAL ULTRAVIOLET EXPLORER SATELLITE

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 I for summary of test procedure.)

II. CELL IDENTIFICATION AND DESCRIPTION

A. Ten cells were manufactured without auxiliary electrodes while the other 10 have auxiliary electrodes; but with two different types of electrode separator design. The cells were identified by the manufacturer's catalog and serial numbers as follows:

Manufacturer's Number		Auxiliary Electrode Design
Catalog	Serial	
42B012AB20-G3	1-10	None
42B012AB21-G3	11-15	Non-Woven Nylon/Nylon Mesh
42B012AB21-G3-A	16-19, 21	Non-Woven Nylon

The cells were fitted with pressure gauge assemblies and placed in temporary pack configurations for initial testing (Packs 516X and 517X).

B. The 12.0 ampere-hour cell is rectangular with an average weight and physical dimensions as follows:

Weight (g)	Overall Height (In)	Length (In) Pre-Test Minimum	Length (In) Pre-Test Maximum	Length (In) Post-Test Maximum	Width (In)
555.3	4.562	0.882	0.890	0.891	2.989

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 protrude through the cover as solder-type terminals.

D. Each cell has teflonated, negative electrodes (TFE-II) and a 10 percent reduction in their positive plate loading. The electrodes of these cells were teflonated prior to the electrochemical cleaning test (ECT). Each cell contains 51 cubic centimeters of potassium hydroxide.

E. The auxiliary electrode is a teflon coated (one side only, next to cell case), sintered, nickel plaque located along the narrow edge of the negative terminal side of the cell, 0.3 centimeter below the top of the plate stack. The tab is welded between the cell cover and the case. Its physical area is approximately 10 square centimeters (1.9 cm x 5.1 cm). The AB21-G3 type cells have non-woven nylon next to the back side of their auxiliary electrode and a nylon mesh on the gas side. The AB21-G3-A type cells have non-woven nylon on both sides of their auxiliary electrode.

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

A. Cell, S/N 016, exhibited a high auxiliary voltage during test. The cell was returned to Goddard Space Flight Center following test.

The cell was X-rayed and no discrepancies were found. Also, the 0° C overcharge test was rerun and the cell did not exhibit a high auxiliary electrode voltage.

B. The cell containers had a convex contour, in which the average thickness of the cells was 0.008 inches thicker at the maximum thickness when compared to the minimum thickness, which was the edge of the container. Following test, this value was 0.009 inches indicating an increase in the plate stack thickness although some cells did decrease in thickness.

C. There were no differences in the average end-of-charge (EOC) voltages and capacity output in ampere-hours (ah), between the cells with auxiliary electrodes and those without. One cell, S/N 005, indicated high voltage and low pressure; but this was due to a leak in its pressure gauge assembly. Following is a listing of these averages excluding those values of cell, S/N 005.

Charge	Volts	ah Out
c/20 for 48 hours at 25° C	1.429	14.9
c/10 for 24 hours at 25° C	1.436	14.8
c/10 for 24 hours at 20° C	1.453	14.6
c/10 for 24 hours at 20° C*	1.453	13.5
c/40 for 20 hours at 20° C**	1.372	3.7
c/20 for 60 hours at 0° C	1.473	14.2
c/10 for 24 hours at 35° C	1.399	15.0

* Charge retention test.
** Charge efficiency test, 6 ah input.

D. Average Internal Resistance Measurements (milliohms):

Measurement Taken	Resistance
30 Min before end of charge (Cycle 1)	2.53
1 Hr after start of discharge (Cycle 2)	2.49
2 Hrs after start of discharge (Cycle 2)	2.47

E. The cells which have their auxiliary electrodes enclosed in non-woven nylon exhibited lower average end-of-charge electrode voltages than the other type cells, except during the charge efficiency test and the overcharge test at 35° C, in which the averages were the same.

F. The auxiliary electrode characteristic test was performed on two cells (type AB21-G3) with the non-woven nylon and the nylon mesh electrode covering. Maximum signal power was obtained with a 500-ohm resistance; but a 300-ohm resistance was used throughout the tests as instructed by the Goddard Space Flight Center's Technical Officer.

G. The average cell voltage at the end of one week open-circuit, during the charge retention test, was 1.315 volts.

H. The 24-hour average cell voltage following a 16-hour short period, for the cells without auxiliary electrodes and those with auxiliary electrodes was 1.220 and 1.215 volts respectively.

I. All the cells 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 voltages at this pressure were 18.5 and 1.490 volts respectively. A few cells, of each type, exhibited pressure decay in the range of 1 to 5 psia during the last 30 minutes of the 1-hour open-circuit stand. Average capacity out was 14.6 ampere-hours.

APPENDIX I

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 #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 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).

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 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.

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 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 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 1.56 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 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 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 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.

-A821-63-4 — -A821-63 — 6 — A820-63 —

SERIAL NUMBER	WEIGHT (Grams)	HEIGHT (Inches)	LENGTH (Inches)			WIDTH (Inches)	PHENOLPHTHALEIN LEAK TESTS								
							INITIAL			POST HI VAC			POST TEST		
							Terminals		Other	Terminals		Other	Terminals		Other
			MINIMUM	MAXIMUM (Pre-Test)	MAXIMUM (Post-Test)		+	-		+	-		+	-	
001	553.4	4.561	.884	.892	.890	2.989									
002	552.7	4.570	.883	.892	.890	2.989				-					
003	555.2	4.568	.880	.891	.892	2.986									
004	555.6	4.554	.884	.890	.892	2.995									
005	554.5	4.560	.880	.890	.888	2.990	NONE			NONE					Gauge Assembly
006	553.8	4.563	.879	.888	.893	2.982									
007	555.7	4.555	.883	.888	.892	2.985									
008	553.6	4.563	.884	.890	.892	2.983									
009	554.2	4.556	.884	.890	.894	2.991									
010	554.3	4.565	.884	.890	.890	2.990									
011	557.3	4.555	.881	.885	.885	3.000									
012	553.3	4.568	.879	.888	.885	2.992									
013	557.3	4.556	.881	.892	.898	2.982	NONE			NONE			NONE		
014	556.4	4.564	.880	.892	.890	2.988									
015	555.1	4.559	.881	.884	.892	2.992									
016	555.4	4.568	.880	.888	.891	2.992									
017	556.4	4.560	.881	.893	.892	2.993									
018	555.9	4.559	.885	.890	.890	2.979	NONE			NONE			NONE		
019	558.6	4.562	.882	.890	.891	2.991									
021	555.9	4.568	.883	.890	.891	2.992									

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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)	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)
001	1.428	N/A	43	14.9	N/A	10	1.436	N/A	73	14.8	N/A	20	1.453	N/A	81	14.7	N/A	29
002	1.434	N/A	34	15.2	N/A	5	1.441	N/A	43	15.3	N/A	5	1.457	N/A	52	14.9	N/A	10
003	1.428	N/A	46	14.8	N/A	5	1.435	N/A	78	14.8	N/A	10	1.452	N/A	86	14.7	N/A	20
004	1.431	N/A	38	15.0	N/A	9	1.438	N/A	65	15.1	N/A	11	1.456	N/A	76	14.9	N/A	20
005	1.429	N/A	35	15.1 *	N/A	4	1.436	N/A	64	15.0	N/A	8	1.470	N/A	29	14.9	N/A	7
006	1.427	N/A	39	14.8	N/A	6	1.434	N/A	79	14.5	N/A	11	1.451	N/A	88	14.4	N/A	24
007	1.426	N/A	43	14.8	N/A	6	1.433	N/A	84	14.6	N/A	10	1.449	N/A	93	14.6	N/A	17
008	1.432	N/A	32	15.0	N/A	4	1.439	N/A	57	14.8	N/A	6	1.457	N/A	68	14.6	N/A	14
009	1.427	N/A	40	14.9	N/A	5	1.436	N/A	75	14.5	N/A	8	1.452	N/A	87	14.4	N/A	18
010	1.430	N/A	35	14.9	N/A	5	1.436	N/A	49	14.8	N/A	6	1.452	N/A	56	14.6	N/A	10
011	1.429	.562	35	14.8	.177	4	1.437	.622	42	14.8	.304	5	1.458	.635	55	14.7	.214	9
012	1.429	.548	36	15.0	.135	5	1.435	.620	63	15.0	.217	12	1.453	.617	74	14.8	.186	21
013	1.430	.481	30	14.9	.056	5	1.437	.576	47	15.1	.186	6	1.457	.597	62	14.8	.253	9
014	1.432	.482	27	15.0	.153	4	1.438	.605	52	15.1	.246	5	1.456	.597	60	14.9	.307	10
015	1.429	.474	26	14.8	.127	6	1.435	.560	40	14.8	.227	8	1.452	.561	46	14.6	.248	11
016	1.429	.410	12	14.9	.094	0	1.433	.495	24	14.8	.153	0	1.450	.491	33	14.6	.223	0
017	1.429	.384	28	14.9	.061	3	1.435	.469	53	14.8	.146	5	1.452	.452	60	14.6	.150	9
018	1.430	.401	27	15.0	.042	6	1.435	.451	46	14.8	.138	7	1.452	.443	57	14.6	.087	9
019	1.430	.377	35	14.9	.117	10	1.437	.451	80	14.6	.044	14	1.452	.452	79	14.4	.073	19
021	1.427	.335	40	14.7	.061	4	1.434	.407	79	14.6	.102	10	1.450	.401	86	14.4	.054	17
* - Reversed -.155 volts																		

UL — A820-G3 — A821-G3 — A820-G3-4 —

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9-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 HOUR OCV STAND	
				CELL	CELL	PRESS
001	2.5	2.5	2.7	.004	1.217	9
002	2.4	2.5	2.4	.006	1.222	1
003	2.6	2.5	2.7	.005	1.222	3
004	2.5	2.5	2.5	.005	1.218	5
005	2.5	2.5	2.4	.005	1.216	12
006	2.5	2.4	2.4	.005	1.222	0
007	2.4	2.3	2.4	.007	1.225	5
008	2.4	2.4	2.4	.005	1.218	1
009	2.6	2.6	2.5	.005	1.221	1
010	2.5	2.4	2.4	.006	1.214	1
011	2.5	2.4	2.4	.004	1.216	1
012	2.5	2.5	2.5	.005	1.216	5
013	2.4	2.4	2.5	.006	1.213	2
014	2.5	2.5	2.5	.008	1.211	2
015	2.5	2.5	2.4	.007	1.215	2
016	2.6	2.7	2.5	.008	1.211	0
017	2.7	2.4	2.5	.007	1.215	1
018	2.8	2.5	2.5	.008	1.214	4
019	2.6	2.5	2.3	.005	1.216	7
021	2.5	2.8	2.5	.005	1.218	0

- A820-63 -
- A821-63 -
- A821-63-A -

TABLE IV
CHARGE RETENTION TEST DATA

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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)
001	1.453	N/A	86.	1.361	N/A	12	1.317	N/A	12	13.5	N/A	9
002	1.457	N/A	59	1.363	N/A	2	1.318	N/A	1	13.8*	N/A	1
003	1.453	N/A	90.	1.362	N/A	4	1.316	N/A	3.	13.4*	N/A	3
004	1.457	N/A	83.	1.362	N/A	5	1.317	N/A	5	13.6*	N/A	5
005	1.476	N/A	28.	1.360	N/A	11	1.317	N/A	13.	13.8*	N/A	12
006	1.450	N/A	93.	1.362	N/A	3	1.315	N/A	1.	13.6*	N/A	1
007	1.449	N/A	98.	1.360	N/A	4	1.314	N/A	3.	13.6*	N/A	5
008	1.456	N/A	70.	1.363	N/A	2	1.317	N/A	1	13.3	N/A	1
009	1.453	N/A	92	1.362	N/A	3	1.316	N/A	2.	13.5	N/A	2
010	1.452	N/A	62	1.363	N/A	3	1.316	N/A	2.	13.5	N/A	2
011	1.459	.637	57	1.362	.178	2	1.312	.002	2	13.4	-.069	2
012	1.455	.606	76	1.360	.192	6	1.311	.002	5	13.4	-.152	5
013	1.457	.626	69	1.361	.123	3	1.313	.005	2	13.5	-.109	2
014	1.457	.602	66	1.361	.075	3	1.314	.002	2	13.7	-.167	2
015	1.453	.472	53	1.361	.016	6	1.314	.003	5	13.5	-.109	5
016	1.450	.496	37	1.361	.147	0	1.312	.002	0	13.6	-.198	0
017	1.451	.455	62	1.361	.082	3	1.312	.002	1	13.6	-.105	1
018	1.452	.458	61.	1.361	.157	7	1.313	.003	4	13.6	-.036	4
019	1.452	.465	83	1.362	.215	11	1.314	.003	8	13.5	-.169	8
021	1.449	.421	89	1.361	.206	4	1.313	.002	1	13.4	-.099	0
* - Reversed; -.074 to -.197 volts.												

AB20-63

-4821-63-4

-4821-63

TABLE V
Charge Efficiency and Overcharge Data

SERIAL NUMBER	Charge Efficiency (20°C) END-OF-CHARGE CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	END-OF-DISCHARGE CAPACITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)	Overcharge Test (0°) END-OF-CHARGE CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	END-OF-DISCHARGE CAPACITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)	Overcharge Test (35°C) END-OF-CHARGE CELL (Volts)	AUX ELECT (Volts)	PRESS (PSIA)	END-OF-DISCHARGE CAPACITY (ah)	AUX ELECT (Volts)	PRESS (PSIA)
001	1.374	N/A	9	3.68	N/A	9	1.472	N/A	71	14.0	N/A	35	1.400	N/A	21	15.1	N/A	5
002	1.372	N/A	1	3.74 *	N/A	3	1.475	N/A	47	14.2	N/A	20	1.400	N/A	9	15.3	N/A	4
003	1.372	N/A	2	3.74	N/A	2	1.471	N/A	78	14.0	N/A	35	1.400	N/A	17	14.9	N/A	14
004	1.372	N/A	5	3.74 *	N/A	6	1.474	N/A	75	14.2	N/A	40	1.399	N/A	18	15.0	N/A	9
005	1.372	N/A	14	3.68	N/A	13	1.526	N/A	19	14.3	N/A	15	1.403	N/A	22	15.3	N/A	17
006	1.371	N/A	1	3.70	N/A	1	1.470	N/A	76	14.1	N/A	41	1.400	N/A	22	14.9	N/A	6
007	1.371	N/A	5	3.70	N/A	5	1.467	N/A	81	14.0	N/A	38	1.400	N/A	24	14.9	N/A	7
008	1.371	N/A	1	3.70	N/A	1	1.475	N/A	55	14.1	N/A	22	1.404	N/A	16	15.1	N/A	4
009	1.372	N/A	2	3.70	N/A	2	1.471	N/A	94	14.1	N/A	47	1.400	N/A	38	15.1	N/A	17
010	1.371	N/A	1	3.70	N/A	1	1.473	N/A	47	14.3	N/A	18	1.402	N/A	22	15.1	N/A	5
011	1.372	.022	1	3.68 *	.008	1	1.477	.513	57	14.0	.128	14	1.401	.397	15	15.4	.189	5
012	1.372	.020	5	3.74 *	.004	5	1.478	.522	70	14.3	.219	29	1.399	.413	23	15.0	.193	9
013	1.371	.021	2	3.68	.009	2	1.478	.501	73	14.3	.181	22	1.397	.356	13	15.0	.172	5
014	1.372	.021	1	3.68 *	-.010	1	1.476	.480	54	14.3	.184	20	1.398	.399	16	15.1	.055	5
015	1.373	.022	5	3.68 *	.010	5	1.474	.419	58	14.1	.158	17	1.397	.340	19	14.8	.173	9
016	1.371	.021	0	3.70	.014	0	1.471	1.074	41	14.4	.510	5	1.393	1.190	6	14.6	.207	0
017	1.372	.024	1	3.70	.031	1	1.472	.367	52	14.3	.180	16	1.396	.400	18	14.8	.061	5
018	1.372	.021	3	3.70	.031	3	1.473	.380	52	14.3	.156	14	1.396	.385	18	14.8	.063	8
019	1.372	.017	8	3.70	.000	8	1.474	.409	74	14.3	.182	30	1.398	.396	28	15.0	.142	12
021	1.372	.018	1	3.70	-.009	1	1.472	.371	83	14.2	.128	33	1.399	.502	41	14.9	.245	8
* - Reversed on discharge, -.046 to -.205 volts.																		

9ND-NADC (SP 11/73)

- 4821-63-4 - 4821-63 - 13 - 4820-63

WDEC/C 74-511

TABLE VI

PRESSURE VS. CAPACITY TEST DATA

AB21-63 Cells — AB21-63-14 Cells

Serial No.	011	012	013	014	015		016	017	018	019	021					
Start-of-Charge, Press.	2	5	2	3	2		0	2	5	9	2					
AH in to 5 PSIA	11.4	N/A	14.7	11.4	13.7		17.8	15.6	N/A	N/A	14.8					
Cell (volts)	1.424		1.436	1.425	1.434		1.499	1.450			1.442					
Aux (volts)	.153		.177	.131	.220		.926	.256			.250					
AH in to 10 PSIA	17.8	14.7	18.3	17.1	16.7		18.1	17.4	16.5	13.3	16.5					
Cell (volts)	1.455	1.435	1.466	1.462	1.442		1.502	1.486	1.461	1.434	1.459					
Aux (volts)	.292	.221	.250	.323	.245		1.002	.338	.327	.197	.300					
AH in to 15 PSIA	18.7	18.1	19.1	19.1	18.8		18.5	17.9	17.4	17.0	17.4					
Cell (volts)	1.472	1.465	1.489	1.485	1.476		1.501	1.500	1.483	1.469	1.480					
Aux (volts)	.342	.288	.286	.370	.304		1.213	.376	.377	.292	.352					
AH in to 20 PSIA	19.4	18.9	19.8	19.6	19.1		19.0	18.3	18.0	17.8	18.0					
Cell (volts)	1.493	1.483	1.500	1.500	1.488		1.497	1.504	1.502	1.493	1.498					
Aux (volts)	.402	.316	.330	.407	.320		1.214	.403	.413	.339	.382					
AH in to V/L (1.55V)	N/A	N/A	N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A					
Aux (volts)																
Press (PSIA)																
30 Min OCV, Cell	1.407	1.401	1.412	1.410	1.401		1.406	1.404	1.403	1.401	1.404					
Aux (volts)	.435	.338	.419	.278	.239		.394	.388	.361	.336	.369					
Press (PSIA)	23	23	25	25	24		20	25	23	26	24					
1 hour OCV, Cell	1.396	1.392	1.398	1.398	1.391		1.394	1.393	1.393	1.393	1.394					
Aux (volts)	.428	.362	.423	.400	.337		.562	.365	.331	.327	.383					
Press (PSIA)	21	23	24	25	23		15	22	21	25	23					
EOD AH out	14.6	14.4	14.9	14.9	14.6		14.9	14.7	14.6	14.6	14.6					
Aux (volts)	.305	.278	.299	.164	.211		.407	.186	.159	.272	.293					
Press (PSIA)	9	11	8	8	7		0	5	8	13	9					

TABLE VI
AB20-63 Cells PRESSURE VS. CAPACITY TEST DATA

Serial No.	001	002	003	004	005	006	007	008	009	010						
Start-of-Charge, Press.	10	4	5	6	12	2	4	2	5	2						
AH in to 5 PSIA	N/A	9.8	N/A	N/A	N/A	13.3	11.5	15.6	N/A	13.3						
Cell (volts)		1.402				1.434	1.429	1.448		1.435						
Aux (volts)		N/A				N/A	N/A	N/A		N/A						
AH in to 10 PSIA	N/A	17.1	15.6	16.7	N/A	16.5	15.6	17.0	15.6	17.4						
Cell (volts)		1.452	1.442	1.448		1.461	1.449	1.470	1.448	1.481						
Aux (volts)		N/A	N/A	N/A		N/A	N/A	N/A	N/A	N/A						
AH in to 15 PSIA	17.1	18.4	17.8	18.1	14.7	17.0	17.0	17.4	17.0	17.8						
Cell (volts)	1.453	1.468	1.461	1.464	1.432	1.472	1.468	1.480	1.468	1.493						
Aux (volts)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A						
AH in to 20 PSIA	18.4	19.1	18.7	18.9	18.4	17.8	17.4	18.1	17.9	18.1						
Cell (volts)	1.471	1.484	1.477	1.478	1.471	1.495	1.477	1.498	1.492	1.499						
Aux (volts)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A						
AH in to V/L (1.55V)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A						
Aux (volts)																
Press (PSIA)																
30 Min OCV, Cell	1.393	1.402	1.396	1.399	1.397	1.400	1.393	1.403	1.401	1.405						
Aux (volts)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A						
Press (PSIA)	23	24	25	23	22	25	23	23	26	24						
1 hour OCV, Cell	1.387	1.393	1.389	1.391	1.390	1.391	1.385	1.393	1.392	1.395						
Aux (volts)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A						
Press (PSIA)	23	24	25	23	22	25	21	22	25	23						
EOD AH out	14.1	14.7	14.2	14.6*	14.4*	14.5*	14.3*	14.6	14.6	14.7						
Aux (volts)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A						
Press (PSIA)	15	11	11	12	15	8	7	5	10	6						

* - Reversed, -.032 to -.098 volts

9ND-NADC (SP 11/73)

TABLE VII (AB21-63 Cells)

SPECIAL RESISTANCE CHARACTERISTIC DATA ON THE AUXILIARY ELECTRODES

GSD-NADC (SP 11/73)

SERIAL NO.	011		012								AVERAGE	
OHMS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	MILLIWATTS
10,000	.834	17	.835	20							.834	.070
5,000	.798	17	.813	20							.806	.130
2,000	.701	17	.724	20							.713	.254
1,000	.585	17	.620	20							.603	.364
500	.454	17	.470	20							.462	.427
200	.286	17	.297	20							.291	.423
100	.188	17	.197	20							.193	.372
50	.115	17	.127	20							.121	.293
20	.057	17	.065	19							.061	.186
10	.033	16	.034	19							.033	.109
5	.019	16	.018	19							.018	.065
2	.008	16	.008	19							.008	.032
1	.004	16	.002	19							.003	.009
0.5	.002	16	.002	19							.002	.008
0.2	.002	16	.001	19							.001	.005
0.1	.001	16	.001	18							.001	.010

Note: All pressures in PSIA.

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

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Southwest Research Institute (Library), P. O. Drawer 28510, San Antonio, Texas 78228

Spectrolab, Inc. (Dr. Harvey Seiger), 12484 Gladstone Avenue, Sylmar, California 91342

TRW Systems, Inc. (Dr. W. R. Scott, M-1/1208), One Space Park, Redondo Beach, California 90278

TRW Systems, Inc. (Dr. Herbert P. Silverman, R-1/2094), One Space Park, Redondo Beach, California 90278

TRW, Inc. (Librarian, TIM 3417), 23555 Euclid Avenue, Cleveland, Ohio 44117

Union Carbide Corporation, Development Laboratory, P. O. Box 6056, Cleveland, Ohio 44101

Union Carbide Corporation, Consumer Products Division, (Dr. Ralph Brodd), P. O. Box 6116, Cleveland, Ohio 44101

Union Carbide Corporation, Consumer Products Division (Dr. Robert Powers), P. O. Box 6116, Cleveland, Ohio 44101

Utah Research and Development Co., Inc. (Mr. William Boyd), 1820 South Industrial Road, Salt Lake City, Utah 84104

United Aircraft Corporation (Library), 400 Main Street, East Hartford, Connnecticut 06108

Director (Dr. E. Y. Weissman), Inorganic-Electrolytic R&D, Wyandotte Corporation, Wyandotte, Michigan 48192

Yardney Electric Corporation, Power Sources Division, 3850 Olive Street, Denver, Colorado 80207

Yardney Electric Corporation (Mr. William Ryder), 82 Mechanic Street, Pawcatuck, Connecticut 02891

Mr. Robert H. Park, Main Street, Brewster, Massachusetts 02631