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EVALUATION PROGRAM FOR SECONDARY SPACECRAFT CELLS. INITIAL EVALUATION TESTS OF 20.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS MANUFACTURED BY GULTON INDUSTRIES, INCORPORATED

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Naval Ammunition Depot

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DEPARTMENT OF THE NAVY
NAVAL AMMUNITION DEPOT
QUALITY EVALUATION AND ENGINEERING LABORATORY
CRANE, INDIANA 47522

EVALUATION PROGRAM FOR SECONDARY SPACECRAFT CELLS

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QEEL/C 73-459 3 December 1973

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REPORT BRIEF
GULTON INDUSTRIES, INC.
20.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS

Ref: (a) NASA P.O. S-23404-G
(b) Initial Evaluation Test Procedure for Nickel-Cadmium Sealed Space Cells: NAD 3053-TP324, 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 on the cell short test.

B. The 32 cells were manufactured for the National Aeronautics and Space Administration, Goddard Space Flight Center, by Gulton Industries, Inc., Metuchen, New Jersey. The cells were manufactured in the same time frame and from the same plate lot as cells for OAO batteries, assemblies 36 and 37. They were manufactured to the "Nickel-Cadmium Storage Cells Power Supply Subsystem Orbiting Astronomical Observatory, Specification for," Grumman Specification AV-252CS-25F. (They are V020HS-type cells and the manufacturer's model number is 804325.) All cells, with the exception of G1, G2, and G3, deviated slightly from the manufacturing processes called for by the specification. Five cells (S/N G1 to G5) were designated as special cells because they differed from the manufacturing procedures used in the manufacturing of cells for Battery Assemblies 36 and 37. Five cells had auxiliary electrodes, and all cells were rated at 20.0 ampere-hours, contain double ceramic seals, and were received with pressure gauge assemblies. The 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. The capacity of the cells ranged from 24.0 to 28.0 ampere-hours during the three capacity checks.

B. The designated special cells (S/N G1 to G5) averaged approximately 5, 12 and 25 psia higher than the other cells during capacity tests 1, 2 and 3 respectively.

C. Twenty-three cells exceeded the voltage requirement of 1.480 volts during the C/10, 24-hour charge at room ambient temperature whereas all the cells exceeded this requirement when the charge was performed at 20°C temperature.

D. During the auxiliary electrode characteristic tests, maximum signal power was obtained with a 10-ohm resistor (5.20 milliwatts); but a 47-ohm resistor, approximately 72 percent of maximum power, was used as decided by Goddard Space Flight Center for the remainder of the test. This was because the 47-ohm resistor was used on previous cells of this type and also on flight batteries.

E. All cells recovered to a voltage in excess of 1.210 volts during the internal short test.

F. The average ampere-hours out during the charge efficiency test at 20°C was 7.9 which was 79 percent of capacity input.

G. Eight cells exceeded the voltage limit (1.560 volts for 2 hours continuous) during the 0°C overcharge test and all the other cells exceeded the voltage requirement of 1.520 volts. Of the eight cells that exceeded the voltage limit, one was a leaker and the other seven had a 6.5-hour open-circuit-stand in the middle of their charge. Average ampere-hours out following the charge was 24.1.

H. Average ampere-hours out during the 35°C overcharge test was 22.5.

I. Only two cells reached a pressure of 20 psia before their 1.550 voltage limit during the pressure versus capacity test and 17 cells did not reach 10 psia. Average ampere-hour input and output, for all cells, was 30.5 and 24.8 respectively. Eight cells indicated an increase in pressure of 1 to 3 psia, and one special cell (S/N G5) had an increase of 7 psia during the 1-hour OCV following charge. The other cells showed either slight or no decay during this period.

J. One cell, serial number 1656, indicated a leak at the base of the fill tube following test completion.

III. RECOMMENDATIONS

A. It is recommended that these cells, with the exception of cell S/N 1656 (which leaked), be placed into the life cycling program for comparison of performance with other cells which had no deviations from the specification during manufacture.

B. On 24 October 1973, three 5-cell battery packs (4E, 4F and 4G) began life-cycle test.

RESULTS OF INITIAL EVALUATION TESTS OF 20.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS MANUFACTURED BY GULTON INDUSTRIES, INC.

I. TEST CONDITIONS AND PROCEDURE

A. All evaluation tests were performed at room ambient (R.A.) 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. Auxiliary electrode characterization test.

4. Internal short test.

5. Charge efficiency test, 20°C.

6. Overcharge tests, 0°C and 35°C.

7. Pressure versus capacity test.

8. Phenolphthalein leak test.

See Appendix I for summary of test procedure.

II. CELL IDENTIFICATION DESCRIPTION

A. The cells were manufactured in the same time frame and from the same plate lot as cells for OAO batteries assemblies 36 and 37. They were manufactured to the "Nickel-Cadmium Storage Cells Power Supply Subsystem Orbiting Astronomical Observatory, Specification for," Grumman Specification No. AV-252CS-25F. They are V020HS type cells and the manufacturer's model number is 804325. Cells, serial numbers G1 to G5, were designated as special cells because the manufacturing process differed from the battery assemblies 36 and 37 cell build as follows during formation:

Cell	Last Formation Cycle EOD Voltage	Virgin Cycle	Precharge Technique	O_2 Vented	224cc of O_2/AH Precharge AH
G1*	-0.2v	Yes	Vent O_2 to 710 ML	710 ML	3.16
G2*	-0.2v	Yes	Vent O_2 to 710 ML	710 ML	3.16
G3*	-0.2v	Yes	Vent O_2 to 710 ML	710 ML	3.16
G4	-0.2v	No	Charge 16 hrs @ 3.1 amps	390 ML	1.74
G5	-0.2v	No	Charge 16 hrs @ 3.1 amps	210 ML	0 94

The other cells, which were manufactured identically to the battery assemblies 36 and 37, had deviations from the specification as follows:

1. Cells discharged to -0.2 volts during last formation discharge.

2. No virgin cycle before setting precharge.

3. 1050 ML of gas vented during precharge, 4.7 AH (224cc of O_2/AH).

B. The cells were identified by the manufacturer's serial number and 5 cells had nickel auxiliary electrodes. The cells were placed in 8-cell pack configurations for testing and the pack numbers were 503X to 506X. All the cells were received with pressure gauge assemblies.

C. The cell containers and cover 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. The 20.0 ampere-hour cell is rectangular with average physical dimensions as follows:

Overall Height (in.)	Length (in.)	Width (in.)
6.884	0.901	2.986

III. RESULTS--THE FOLLOWING WAS CONDENSED FROM TABLES I THROUGH VI

A. Leak Tests--one cell (S/N 1656) indicated a leak at the base of its fill tube following test.

*Manufactured as per Grumman Specification No. AV-252CS-25F.

B. Average Capacity (ampere-hours, AH):

Type of Charge	AH Out
C/20, 48 hrs. RA	26.5
C/10, 24 hrs. RA*	25.8
C/10, 24 hrs. 20°C**	25.1

* 23 cells exceeded 1.480 volts requirement.
** All cells exceeded 1.480 volts requirement.

C. Average Internal Resistance Measurements (milliohm):

Measurement Taken	Resistance
30 min. before end-of-charge (Cycle 1)	3.93
1 hr. after start-of-discharge (Cycle 2)	4.24
2 hrs. after start-of-discharge (Cycle 2)	4.35

D. Maximum power was obtained with a 10-ohm resistor during the resistance characteristic test on the auxiliary electrode cells, although a 47-ohm resistor was used throughout the tests as instructed by Goddard Space Flight Center. This was because flight batteries and other cells of this type used this resistance value.

E. During the internal short test the 24-hour average cell voltage following a 16-hour short period was 1.231 volts.

F. Average ampere-hours out during the charge efficiency test at 20°C was 7.9 which was 79 percent of capacity input.

G. Eight cells exceeded the voltage limit (1.560 volts for 2 hours continuous) during the 0°C overcharge test and the other cells exceeded the voltage requirement of 1.520 volts. Of the eight cells that exceeded the voltage limit, one was a leaker and the others had an open-circuit-stand of 6.5 hours in the middle of their charge. Average capacity out following charge was 24.1 ampere-hours.

H. Average ampere-hours out following the overcharge at 35°C was 22.5.

I. Two cells reached a pressure of 20 psia before their 1.550 voltage limit during the pressure versus capacity test and 17 cells did not reach a pressure of 10 psia. Average ampere-hour input and output, for all cells, was 30.5 and 24.8 respectively. Eight cells indicated an increase in pressure of 1 to 3 psia, and one special cell (S/N G5) had an increase of 7 psia during the 1-hour OCV following charge. The other cells showed either slight or no decay during this period.

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 #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 (R.A.), Cycle 0, with a test limit of 1.52 volts or pressure of 100 psia.

b. C/10, 24 hours, R.A., 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 terminal 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. 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.

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 65 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 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.

I. 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.

TABLE I

SERIAL NUMBER	WEIGHT * (Grams)	OVERALL HEIGHT (Inches)	LENGTH (Inches)	WIDTH (Inches)	PHENOLPHTHALEIN LEAK TESTS											
					Initial				Following Hi Vac				Following Test Completion			
					Terminals		Fill Tube	Other	Terminals		Fill Tube	Other	Terminals		Fill Tube	Other
					+	-			+	-			+	-		
567	1284.1	6.892	.892	2.990												
568	1274.8	6.895	.897	2.482												
574	1276.4	6.885	.888	3.000												
578	1274.1	6.895	.898	2.980												
585	1279.2	6.895	.910	2.982												
G1 (PU)	1268.7	6.877	.896	2.982		NO	LEAKS			NO	LEAKS					
G2 (PU)	1267.3	6.877	.925	2.980												
G3 (PU)	1268.6	6.853	.882	2.990												
G4 (PV)	1262.2	6.885	.892	3.013												
G5 (PV)	1265.2	6.860	.920	2.975												
1635	1258.2	6.880	.895	2.980												
1638	1260.2	6.889	.883	2.982												
1656	1253.7	6.873	.918	2.985											L (BASE)	
1707	1263.6	6.895	.890	2.985												
1709	1255.9	6.893	.900	2.980												
1721	1256.2	6.912	.898	2.960												
1724	1267.6	6.888	.918	2.988												
1725	1260.5	6.873	.902	2.980												
1726	1258.8	6.905	925	2.987												
1727	1258.1	6.890	.910	2.977												
1728	1265.2	6.895	.895	2.993												
1738	1262.6	6.887	.890	2.977												
1743	1270.0	6.880	.920	2.975												
1746	1264.1	6.887	.892	2.982												
1748	1262.3	6.895	.890	3.000												
1749	1263.8	6.877	.888	2.977												

TABLE I

SERIAL NUMBER	WEIGHT * (Grams)	OVERALL HEIGHT (Inches)	LENGTH (Inches)	WIDTH (Inches)	PHENOLPHTHALEIN LEAK TESTS											
					Initial				Following Hi Vac				Following Test Completion			
					Terminals		Fill Tube	Other	Terminals		Fill Tube	Other	Terminals		Fill Tube	Other
					+	-			+	-			+	-		
1751	1253.1	6.885	.925	2.982												
1752	1267.7	6.878	.918	3.018												
1753	1268.5	6.875	.905	2.985		No	Leaks			No	Leaks					
1754	1268.2	6.872	.895	2.990												
1756	1270.5	6.890	.890	2.995												
1757	1263.2	6.878	.897	2.998												
*	ALL WEIGHTS W/ GAUGE ASSEMBLY															
**	GLASS BROKEN ON GAUGE															

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)
567	1.458	.963**	17	27.6	-.074	12	1.446	.490	22	25.5	-.141	6	1.458	.692	61	25.0	.051	11
568	1.456	.427	9	27.6	-.035	6	1.443	.595	21	26.0	-.127	6	1.462	.706	38	25.5	.011	6
574	1.455	.478	10	27.2	-.104	5	1.434*	.716	40	25.2	-.013	6	1.460	.752	58	24.7	.102	10
578	1.453	.429	11	26.8	-.068	7	1.437	.516	18	25.2***	-.252	7	1.454	.724	55	24.3	.051	7
585	1.452	.420	8	26.8	-.090	4	1.437	.634	27	25.1	-.132	4	1.458	.731	50	24.7	-.005	5
C1 (P4)	1.464	N/A	21	26.2	N/A	3	1.460*	N/A	39	25.6	N/A	4	1.469	N/A	84	25.0	N/A	15
C2 (P4)	1.462		16	26.0		2	1.452*		29	25.9		4	1.469		73	25.2		12
C3 (P4)	1.461		20	26.3		4	1.454*		35	26.0		4	1.472		82	25.0		17
C4 (P4)	1.460		15	26.8		5	1.451*		30	26.7		5	1.472		59	25.8		14
C5 (P4)	1.457		18	26.3		2	1.449*		34	26.0		3	1.467		85	25.2		14
1635	1.455		9	27.6		8	1.442		17	25.9		3	1.461		58	25.1		8
1639	1.455		9	27.2		3	1.446		17	25.6		3	1.462		57	24.7		7
1656	1.459		9	28.0		4	1.453		17	26.3		3	1.472		38	25.9		7
1707	1.459		10	26.0		2	1.445		15	26.3		5	1.464		32	25.8		7
1709	1.454		8	25.6		4	1.449		15	25.7		3	1.466		22	25.8		3
1721	1.464		12	25.8		2	1.457*		23	25.9		4	1.468		35	25.6		7
1724	1.456		11	25.3		5	1.468*		20	25.7		5	1.472		39	25.3		7
1725	1.449		12	25.2		5	1.469*		23	25.6		5	1.474		43	24.7		10
1726	1.450		12	25.3		5	1.468*		22	26.1		7	1.472		41	25.4		8
1727	1.451		11	25.5		4	1.470*		20	26.2		5	1.473		38	25.4		9
1728	1.454		12	27.0		5	1.483*		21	27.5		10	1.505		39	25.0		20
1738	1.452		10	24.8		4	1.474*		17	25.3		5	1.479		27	25.0		3
1743	1.449		11	25.7		4	1.471*		27	26.2		5	1.475		57	26.3		12
1746	1.447		11	25.3		3	1.473*		23	26.1		5	1.478		48	24.6		12
1748	1.452		12	26.5		5	1.471*		22	25.4		5	1.477		46	24.5		8
1749	1.452	~	11	27.2	~	5	1.470*	~	24	25.7	~	5	1.475		49	24.8		8

9ND-NAIDC (SP 11/73)

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)
1751	1.453	N/A	12	27.5	N/A	5	1.475*	N/A	17	26.4	N/A	5	1.479	N/A	35	25.2	N/A	8
1752	1.454	↓	13	27.2	↓	5	1.475*	↓	23	25.8	↓	6	1.480	↓	40	25.0	↓	9
1753	1.451		12	26.0		5	1.471*		24	24.9		5	1.474		48	24.0		8
1754	1.453		13	27.3		5	1.473*		25	26.0		5	1.479		34	25.3		6
1756	1.455		10	26.8		5	1.474*		20	25.6		5	1.477		42	24.4		10
1757	1.460		10	27.2		4	1.475*		21	25.8		4	1.479		37	25.2		12

* CELLS EXCEEDING 1.48 VOLTS DURING CHARGE
** AUX. ELECTRODE RESISTOR OFF.
*** CELL REVERSED, S/N 578 (-.25V)
**** ALL CELLS EXCEEDED 1.48 VOLTS DURING CHARGE
N/A - NOT APPLICABLE

TABLE III
INTERNAL RESISTANCE AND SHORT TEST DATA

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
567	3.5	3.7	4.5	.103	1.230	8
568	3.7	4.0	4.2	.094	1.225	6
574	3.7	3.9	4.3	.070	1.227	6
578	3.8	3.8	4.6	.110	1.228	7
585	3.4	3.8	4.3	.064	1.225	5
G1 (PW)	3.5	3.3	3.9	.182	1.239	4
G2 (PW)	3.8	3.7	4.1	.078	1.233	3
G3 (PW)	4.5	3.5	3.5	.085	1.232	5
G4 (PV)	4.4	3.8	3.5	.085	1.232	5
G5 (PV)	4.2	4.2	4.7	.074	1.235	3
1635	4.8	3.6	4.3	.105	1.232	4
1638	3.7	4.1	4.5	.090	1.228	4
1656	3.3	4.1	4.4	.051	1.226	6
1707	3.9	3.9	4.5	.074	1.224	2
1709	3.4	3.5	4.6	.040	1.211	4
1721	4.2	3.9	4.6	.054	1.220	5
1724	3.5	5.0	4.3	.062	1.230	5
1725	4.8	4.5	4.3	.067	1.234	6
1726	4.6	5.1	4.6	.057	1.228	7
1727	3.8	4.8	4.4	.059	1.229	5
1728	5.1	4.8	5.0	.070	1.224	13
1738	3.7	4.8	4.6	.045	1.224	6
1743	3.8	4.8	5.1	.072	1.238	6
1746	3.4	4.8	5.0	.082	1.239	6
1748	3.9	4.1	4.2	.068	1.240	6
1749	3.0	4.6	4.4	.071	1.240	5
1751	3.9	4.7	4.2	.058	1.237	6
1752	4.2	4.6	4.4	.063	1.238	6
1753	4.0	4.8	4.0	.057	1.239	5
1754	4.2	4.5	4.2	.031	1.234	5
1756	4.1	5.0	4.3	.082	1.240	6
1757	3.8	4.1	3.8	.070	1.239	5

TABLE IV
Charge Efficiency and Overcharge Data

SERIAL NUMBER	Charge Efficiency (20°C)						Overcharge Test (0°C)						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)
567	1.367	.151	9	7.1	-.191	9	1.512	N.A.	28	24.8	N.A	10	1.410	633	38	23.9	N.A	10
568	1.367	.166	7	7.0	-.150	7	1.516	↓	15	25.7	↓	8	1.407	.625	24	23.4	↓	8
574	1.367	.172	8	7.3	-.236	8	1.512		23	25.0		8	1.413	.618	33	24.2		7
578	1.368	.171	8	7.1	-.202	8	1.507		25	24.8		10	1.412	.653	33	23.6		8
585	1.366	.156	6	7.1	-.139	5	1.510		23	25.7		6	1.409	.608	29	23.8		6
G1 (PV)	1.370	N/A	7	7.8	N/A	6	1.518	N/A	52	24.0	N/A	24	1.391	N/A	59	19.6	N/A	9
G2 (PV)	1.368	↓	6	7.7*	↓	6	1.518	↓	36	25.7	↓	11	1.394	↓	48	21.8	↓	7
G3 (PV)	1.368		7	7.7		7	1.518		46	24.5		17	1.396		62	21.7		10
G4 (PV)	1.368		7	7.5*		7	1.523		47	25.0		21	1.396		62	21.7		12
G5 (PV)	1.369		5	7.1*		5	1.513		61	24.8		30	1.394		72	21.4		16
1635	1.367		7	7.3		5	1.518		27	25.3		10	1.411		39	23.6		9
1638	1.367		6	7.1		5	1.514		25	24.8		7	1.415		40	23.9		5
1656	1.368		6	6.7		6	1.565		15	25.3		15	1.419		34	25.4		18
1707	1.368		6	7.7		6	1.517		22	26.7		10	1.391		25	22.4		7
1709	1.367		4	7.6		5	1.526		19	26.7		8	1.387		19	21.3		6
1721	1.368		7	7.4		6	1.524		27	26.0		10	1.390		34	21.0		8
1724	1.370		6	8.3		6	1.563		36	24.3		24	1.401		63	22.0		17
1725	1.370		7	8.4		7	1.563		34	23.5		23	1.400		68	21.2		19
1726	1.370		8	8.3		8	1.570		41	24.0		30	1.400		66	22.2		21
1727	1.370		7	8.4		7	1.570		48	23.8		40	1.400		65	22.4		29
1728	1.370		14	8.3		14	1.580		74	21.9		62	1.412		73	25.0		43
1738	1.370		6	7.8		6	1.562		35	24.2		30	1.404		46	22.4		21
1743	1.369		8	8.8		8	1.557		33	23.8		24	1.399		73	21.7		17
1746	1.370		6	8.8		6	1.555		27	23.1		16	1.399		63	20.9		13
1748	1.372		7	8.8		7	1.553		37	22.4		24	1.407		80	21.7		22
1749	1.372	↓	7	9.0	↓	7	1.560	↓	54	22.3	↓	39	1.407	↓	93	22.4	↓	33

GND-NADC (SP 11/73)

TABLE IV
Charge Efficiency and Overcharge Data

SERIAL NUMBER	Charge Efficiency (20°C)						Overcharge Test (0°C)						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)
1751	1.371	N/A	7	9.0	N/A	7	1.564	N/A	60	22.6	N/A	51	1.407	N/A	84	23.3	N/A	39
1752	1.372	↓	7	8.8	↓	7	1.567	↓	64	22.0	↓	51	1.409	↓	87	23.3	↓	41
1753	1.372		7	8.7		6	1.547		33	22.4		19	1.403		82	21.0		20
1754	1.371		7	8.4		6	1.557		60	23.5		45	1.405		93	22.4		37
1756	1.373		7	8.5		7	1.556		34	22.2		27	1.405		89	22.1		27
1757	1.372		7	9.0		7	1.536		70	21.5		60	1.414		89	23.7		45
N.A	= NOT AVAILABLE																	
*	CELL REVERSED G2 (-.15) G4 (-.06) G5 (-.19)																	
**	ALL CELLS EXCEEDED 1.52 VOLTS DURING CHARGE, CELL S/N V656 REMOVED FROM CHARGE DUE TO																	
	HIGH VOLTAGE AND LEAK TEST OF CELL INDICATED A LEAK AT BASE OF FILL TUBE.																	
	CELLS WITH S/N 1724 THRU 1757 RECEIVED 64 HRS OF CHARGE WITH AN C.C.V OF 6.5 VRS																	
	IN THE MIDDLE OF CHARGE. CELL S/N 1726, 1727, 1728, 1735, 1751, 1752, 1757 OFF BECAUSE																	
	OF HIGH VOLTAGE.																	
N/A	= NOT APPLICABLE																	

9ND-MADC (SP 11/73)

OEEL/C 73-459

TABLE V
PRESSURE VS. CAPACITY TEST DATA

Serial No.	567	568	574	578	585	C1 (PA)	C2 (PA)	C3 (PA)	C4 (PA)	C5 (PA)	1635	1638	1656	1707	1709	1721
Start-of-Charge, Press.	7	7	6	7	5	3	3	4	4	2	7	3	15	5	3	5
AH in to 5 PSIA	N/A	N/A	N/A	N/A	N/A	26.7	26.7	26.7	8.3	30.8	N/A	26.7	N/A	N/A	28.3	N/A
Cell (volts)						1.490	1.488	1.484	1.430	1.550		1.498		N/A	1.492	N/A
Aux (volts)																
AH in to 10 PSIA	29.8			29.5		30.0										30.0
Cell (volts)	1.550			1.550		1.555										1.536
Aux (volts)	.139			.156												
AH in to 15 PSIA																
Cell (volts)																
Aux (volts)																
AH in to 20 PSIA																
Cell (volts)																
Aux (volts)																
AH in to V/L (1.55V)	29.8	30.0	29.3	29.5	30.0	29.7	30.3	30.3	31.0	30.8	29.7	29.7	29.7	30.7	31.3	30.5
Aux (volts)	.134	.168	.161	.156	.150											
Press (PSIA)	10	9	9	11	8	11	8	7	8	6	8	7	17	9	7	11
30 Min OCV, Cell	1.400	1.402	1.399	1.402	1.404						1.400	1.402	1.400			
Aux (volts)	.207	.286	.195	.260	.161											
Press (PSIA)	10	9	8	11	8	13	10	10	10	13	8	7	17	10	10	11
1 hour OCV, Cell	1.395	1.397	1.394	1.397	1.398	1.387	1.392	1.391	1.393	1.394	1.395	1.397	1.395	1.393	1.392	1.391
Aux (volts)	.192	.241	.185	.235	.137											
Press (PSIA)	10	8	8	9	7	13	10	10	8	13	8	6	17	9	7	10
EOD AH out	25.0	25.0	25.0	25.0	25.0	25.5	25.0	25.0	25.2	25.0	25.0	25.0	25.0	25.2	25.0	25.0
Aux (volts)	.714	.070	.063	.039	.060											
Press (PSIA)	7	5	6	7	5	7	5	7	7	6	7	5	15	6	6	7

N/A = NOT APPLICABLE

9ND-NADC (SP 11/73)

TABLE V
PRESSURE VS. CAPACITY TEST DATA

Serial No.	1724	1725	1726	1727	1728	1738	1743	1746	1748	1749	1751	1752	1753	1754	1756	1757
Start-of-Charge, Press.	5	4	3	3	5	3	2	2	5	2	4	3	3	2	4	3
AH in to 5 PSIA	N/A	23.3		29.0	28.3	26.7	29.0	28.3		30.0	6		21.7	30.0	25.0	23.3
Cell (volts)		1.456		1.497	1.502	1.483	1.490	1.489		1.520	1.403	1.511	1.444	1.504	1.458	1.448
Aux (volts)																
AH in to 10 PSIA						30.0	30.5	30.2		31.2	31.2		30.0	31.0		
Cell (volts)						1.550	1.543	1.524	1.528	1.550	1.550	1.549	1.524	1.542	1.537	1.528
Aux (volts)																
AH in to 15 PSIA									31.3			31.5			31.3	
Cell (volts)									1.550			1.550	1.538		1.550	
Aux (volts)																
AH in to 20 PSIA													31.3	31.8		
Cell (volts)													1.550	1.545		
Aux (volts)																
AH in to V/L (1.55V)	30.3	30.0	30.2	30.3	30.0	29.7	31.2	31.0	31.3	31.2	31.2	31.5	31.3		31.3	31.3
Aux (volts)																
Press (PSIA)									15	10	10	15	20		15	
30 Min OCV, Cell																
Aux (volts)																
Press (PSIA)	14	14	10	10	9	12	17	19	19	13	12	14	25	18	19	14
1 hour OCV, Cell																
Aux (volts)																
Press (PSIA)	12	12	9	9	9	9	15	17	16	12	11	12	21	16	18	13
EOD AH out	24.3	23.9	24.3	24.6	24.7	23.7	24.7	24.7	24.3	24.7	24.8	24.8	23.9	24.9	24.5	24.7
Aux (volts)																
Press (PSIA)	5	5	3	3	5	5	4	4	7	5	5	5	7	5	8	5

N/A = Not Applicable

9ND-NADC (SP 11/73)

TABLE VI

SPECIAL RESISTANCE CHARACTERISTIC DATA ON THE AUXILIARY ELECTRODES

GRD-NADC (SP 11/73)

SERIAL NO.	568		574		585						AVERAGE	
OHMS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	MILLIWATTS
10,000	.740	10	.768	13	.729	10					.746	.056
5,000	.767	10	.800	13	.756	10					.774	.120
2,000	.784	10	.816	13	.774	10					.791	.313
1,000	.787	10	.816	13	.778	10					.794	.630
500	.770	10	.764	13	.710	10					.748	1.119
200	.682	10	.658	13	.630	10					.657	2.158
100	.592	10	.532	13	.527	10					.550	3.025
50	.431	10	.437	13	.424	10					.431	3.715
20	.303	10	.332	13	.305	10					.313	4.898
10	.220	10	.247	13	.218	10					.228	5.198
5	.155	10	.155	13	.147	10					.152	4.621
2	.093	10	.089	13	.084	10					.089	3.961
1	.066	10	.056	13	.055	10					.059	3.481
0.5	.047	10	.037	13	.040	10					.041	3.362
0.2	.030	10	.024	13	.028	10					.027	3.645
0.1	.020	10	.019	13	.021	10					.020	4.000

Note: All pressures in PSIA.

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