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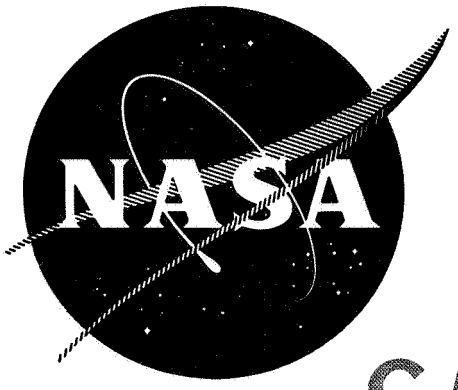

EVALUATION PROGRAM

for

SECONDARY SPACECRAFT CELLS

ACCEPTANCE TEST
OF
6.0 AMPERE-HOUR NICKEL CADMIUM
SECONDARY CELLS
(CERAMIC SEALS WITH NICKEL BRAZE)
MANUFACTURED BY
GENERAL ELECTRIC COMPANY

prepared for
GODDARD SPACE FLIGHT CENTER
CONTRACT W12,397

QUALITY EVALUATION LABORATORY

NAD CRANE, INDIANA

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

EVALUATION PROGRAM
FOR
SECONDARY SPACECRAFT CELLS

ACCEPTANCE TEST
OF
GENERAL ELECTRIC COMPANY
6.0 AMPERE-HOUR NICKEL-CADMIUM CELLS
(CERAMIC SEALS WITH NICKEL-BRAZE)

QE/C 71-45 8 February 1971

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Enclosure (1)

REPORT BRIEF
GENERAL ELECTRIC COMPANY
6.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS
(CERAMIC SEALS WITH ALL NICKEL BRAZE)

Ref: (a) NASA Purchase Order Number W12-397
(b) NASA ltr BRA/VBK/pad of 25 September 1961 w/BUWEPS first end FQ-1:WSK of 2 October 1961 to CO NAD Crane
(c) Acceptance Test Procedure for Nickel Cadmium Cells NAD 3022-TP308, 5 August 1970

I. TEST OBJECTIVES:

A. The purpose of the acceptance test phase of this program is to insure that all cells put into the life cycle program are of high quality by the removal 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 after the cell short test.

B. Forty-two cells having ceramic seals with all nickel braze were purchased from General Electric Company, Gainesville, Florida. These cells are rated at 6.0 ampere-hours. Thirty-seven of these were without pressure gauges, and five cells with pressure gauges.

C. The normal practice in manufacturing cells with ceramic seals is to utilize a braze alloy which contains some silver. During life cycling of the cells the silver tends to migrate across the ceramic insulation, thus causing shorting.

D. The cells which satisfactorily complete the acceptance test will be placed on life cycling test in an effort to further evaluate the performance of the cells with specific emphasis on the ceramic seal using the all nickel braze.

E. The evaluation of the nickel-cadmium cells at room ambient condition was conducted under the authorization of references (a) and (b).

II. RESULTS

A. The data substantiates the following summary of results:

1. The average capacity for the three capacity checks is 7.35, 7.61, and 7.35 ampere-hours, respectively.

2. The recovery voltage for two cells was less than 1.150 volts during the cell short test (cell serial number 019, 0.431 volt; cell serial number 037, 0.003). The average recovery voltage was 1.147 volts. It was determined by Goddard Space Flight Center, that cells 019, and 037 would not be subjected to life cycle testing.

3. The end-of-overcharge voltage averaged 1.425 volts for the c/20 rate, and 1.432 volts for the c/10 rate. Three cells were removed from the c/10 charge due to pressures over the 50 psig limit. These cells are identified in the following table. It was determined by Goddard Space Flight Center that cells 006 and 025 would be used in life cycle testing, but cell 019 would not be used.

Cell Serial No.	Pressure at Removal (PSIG)	Time on c/10 Chg prior to Removal (hours)
006	56	3
019	67	2
025	52	5

4. The internal resistance averaged 2.63 milliohms.

5. The capacity to 1.000 volt following the overcharge averaged 6.78 ampere-hours and ranged from 6.65 to 7.40 ampere-hours.

6. There was no evidence of any leakers out of the 42 cells tested.

III. CONCLUSIONS

A. From the results of this test it can be concluded that:

1. The ceramic seals used by the General Electric Company are satisfactory as evidenced by no leakers out of the 42 cells tested.

2. The capacity of the 42 cells was in the range of 6.90 to 7.85 ampere-hours.

3. Forty of the 42 cells were accepted for Life Cycle Test, on the basis of the acceptance test results.

RESULTS OF ACCEPTANCE TEST OF 6.0 AMPERE-HOUR NICKEL-CADMIUM SECONDARY SPACECRAFT CELLS (CERAMIC SEALS WITH ALL NICKEL BRAZE) MANUFACTURED BY GENERAL ELECTRIC COMPANY

I. INTRODUCTION

A. On 4 August 1970, acceptance tests were begun on 42 cells manufactured by General Electric Company, Gainesville, Florida. These tests were completed on 16 September 1970.

II. TEST CONDITIONS

A. All acceptance tests were performed at an ambient temperature between 23° C and 27° C at existing relative humidity and atmospheric pressure in accordance with reference (c).

B. All charging and discharging was done at constant current (± 5 percent). Cells were charged in series but discharged individually.

III. CELL IDENTIFICATION AND DESCRIPTION

A. The cells were identified by the manufacturer's serial numbers which were from 003 to 052 although not consecutively.

B. The 6.0 ampere-hour cells are rectangular with an average height (base to top of positive terminal), length and width of 3.535, 0.831, 2.131 inches, respectively. The average weight for cells with gauges is 576.0 grams. The average weight for cells without gauges is 250.5 grams. The individual cell dimensions and weight are given in Table I.

C. The cell containers, and the cell covers are made of stainless steel. Both terminals are insulated from the cell cover by ceramic seals and protrude through the cover as solder type terminals. The ceramic seals use a nickel braze instead of a braze material containing silver to eliminate the problem of silver migration across the ceramic insulation.

D. The cells were supplied in a discharged condition.

IV. TEST RESULTS

A. There were no signs of leakage on any of the 42 cells subjected to the leak test.

B. Capacity Test:

1. The capacity test is a determination of the cell capacity at the c/2 discharge rate, to a cutoff of 1.000 volt per cell. The discharge was made after a 1-hour open circuit period following the 16-hour charge at the c/10 rate. The cells were discharged in series to 1.000 volt per cell. At this voltage, (1.000 V per cell) each cell was manually switched to open circuit while the remaining cells continued to discharge to the 1.000 volt limit.

2. The individual cell capacities to 1.000 volt are given in Table I. Characteristic 2-hour rate discharge curves for high, average and low capacity cells are shown in Figure 1.

C. Cell Short Test:

1. The cell short 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 test, each individual cell was loaded with a 0.5-ohm, 3-watt resistor and allowed to stand 16 hours with the resistors acting as a shorting device. At the end of 16 hours, the resistors were removed and the cells were placed on open circuit stand for 24 hours. Any cell whose voltage did not recover to 1.150 volts or higher was considered as failing this portion of the acceptance testing.

3. Table I indicates two of the 42 cells failed to recover to the 1.150 volt level. These two cells will not be placed on life cycle test, as determined by Goddard Space Flight Center.

D. High Vacuum Leak Test:

1. The leak test is a means of detecting leakage of a seal or weld. This test was performed before and after the overcharge test to determine the presence and location of leaks.

2. None of the 42 cells tested failed these leak tests.

E. Overcharge Test:

1. The purpose of this test is basically threefold:

a. To determine the degree to which a pack of cells maintain a balanced voltage.

b. To determine the cells capability of reaching a point of chemical equilibrium--oxygen recombination with the negative (cadmium) plate.

c. To test the integrity of the seals as the pressure increases.

2. The cells were monitored hourly throughout the test. Charging was to be discontinued on cells which exceeded 1.500 volts. No cells were removed from the charging sequence. However, three cells were removed due to pressure that exceeded the 50 psig limit. Table I shows length of time on charge and pressure of these cells when removed from c/10 overcharge. The characteristic 16-hour overcharge is shown in Figure 2.

F. Internal Resistance Measurement:

1. Immediately following the overcharge test, the internal resistance of each cell was measured with a Hewlett-Packard milliohmmeter (Model 4328A).

2. The internal resistance for each cell is shown in Table I. The resistance values ranged from 2.49 to 2.80 milliohms for an average of 2.63 milliohms.

TABLE I

Cell Serial No.	Weight (Grams)	Height (In.)	Length (In.)	Width (In.)	Capacity Checks A.H. No. 1	No. 2	No. 3	Cell Short Test	Overcharge (Volts) C/20	C/10	Internal Resistors (Milliohms)	C/2 Discharge Following Overcharge
003	250.4	3.545	0.825	2.127	7.40	7.50	7.30	1.204	1.431	1.436	2.56	6.95
004	250.6	3.530	0.828	2.128	7.40	7.55	7.35	1.172	1.430	1.430	2.54	6.95
007	249.9	3.527	0.830	2.130	7.40	7.25	6.90	1.184	1.421	1.416	2.75	6.65
009	250.3	3.534	0.820	2.130	7.40	7.45	7.25	1.197	1.422	1.418	2.58	6.80
010	249.8	3.530	0.830	2.140	7.40	7.55	7.30	1.212	1.418	1.414	2.60	7.00
011	250.2	3.528	0.834	2.134	7.45	7.50	7.35	1.202	1.420	1.415	2.71	6.95
012	249.7	3.535	0.825	2.130	7.40	7.45	7.25	1.196	1.421	1.417	2.63	6.95
013	249.7	3.530	0.825	2.130	7.40	7.45	7.30	1.195	1.422	1.419	2.58	6.95
014	249.6	3.530	0.825	2.135	7.40	7.40	7.30	1.165	1.426	1.427	2.54	6.90
016	250.3	3.545	0.825	2.130	7.40	7.55	7.30	1.202	1.431	1.436	2.65	6.95
018	249.8	3.544	0.825	2.130	7.40	7.45	7.40	1.185	1.436	1.441	2.67	7.00
020	249.3	3.532	0.825	2.130	7.35	7.40	7.05	1.201	1.425	1.426	2.62	6.80
021	249.9	3.530	0.825	2.130	7.40	7.50	7.45	1.196	1.429	1.428	2.57	7.00
023	250.1	3.540	0.825	2.128	7.40	7.45	7.20	1.205	1.428	1.427	2.50	6.90
024	250.3	3.535	0.825	2.140	7.40	7.55	7.55	1.210	1.423	1.422	2.70	7.00

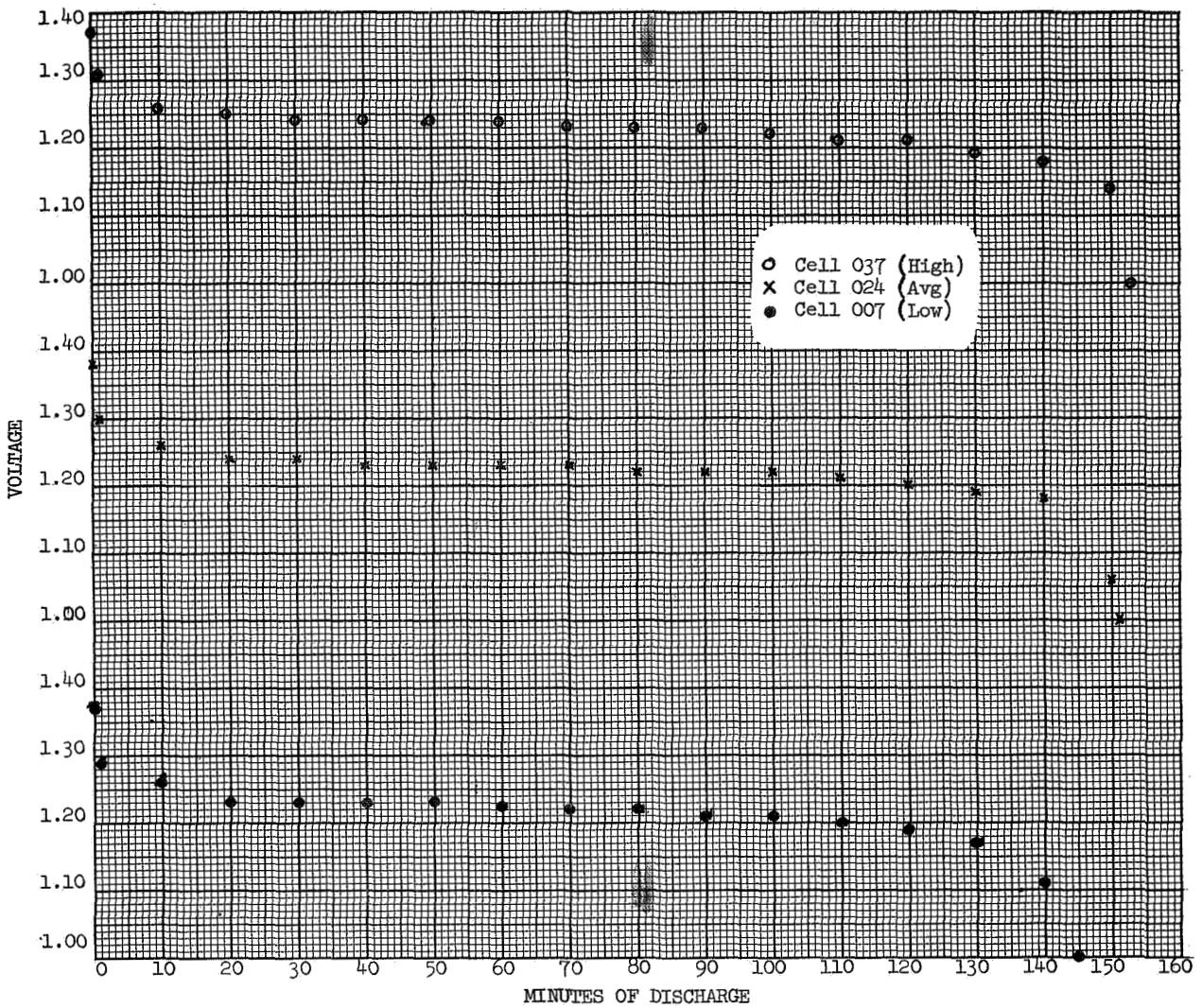
TABLE I (Contd)

Cell Serial No.	Weight (Grams)	Height (In.)	Length (In.)	Width (In.)	Capacity Checks A.H. No. 1	No. 2	No. 3	Cell Short Test	Overcharge (Volts) C/20	C/10	Internal Resistors (Milliohms)	C/2 Discharge Following Overcharge
026	250.3	3.550	0.828	2.130	7.40	7.55	7.40	1.210	1.425	1.424	2.56	7.00
027	250.1	3.545	0.829	2.132	7.40	7.55	7.50	1.211	1.424	1.424	2.49	7.00
028	250.1	3.525	0.841	2.130	7.40	7.45	7.40	1.216	1.432	1.434	2.63	7.00
029	250.3	3.530	0.825	2.132	7.45	7.55	7.50	1.214	1.431	1.435	2.57	7.05
031	249.9	3.536	0.825	2.141	7.40	7.60	7.40	1.210	1.430	1.438	2.60	7.00
032	250.1	3.525	0.834	2.129	7.40	7.75	7.55	1.214	1.423	1.432	2.66	7.25
034	251.0	3.540	0.840	2.128	7.10	7.80	7.55	1.215	1.419	1.424	2.53	7.05
035	250.5	3.530	0.832	2.128	7.30	7.85	7.60	1.210	1.416	1.417	2.54	7.10
036	250.3	3.528	0.840	2.129	7.25	7.65	7.45	1.210	1.416	1.417	2.59	7.00
037	251.2	3.536	0.830	2.134	7.40	7.85	7.65	0.003	1.418	1.419	2.59	7.25
038	250.4	3.550	0.840	2.128	7.15	7.70	7.45	1.209	1.416	1.417	2.57	7.00
039	249.9	3.535	0.835	2.132	7.15	7170	7.55	1.206	1.418	1.419	2.52	7.05
040	250.7	3.550	0.830	2.129	7.35	7.55	7.35	1.209	1.421	1.424	2.59	6.80
041	251.2	3.536	0.829	2.130	7.25	7.65	7.40	1.213	1.422	1.427	2.66	6.75
042	250.3	3.528	0.830	2.128	7.05	7.80	7.55	1.214	1.423	1.431	2.61	7.00

TABLE I (Contd)

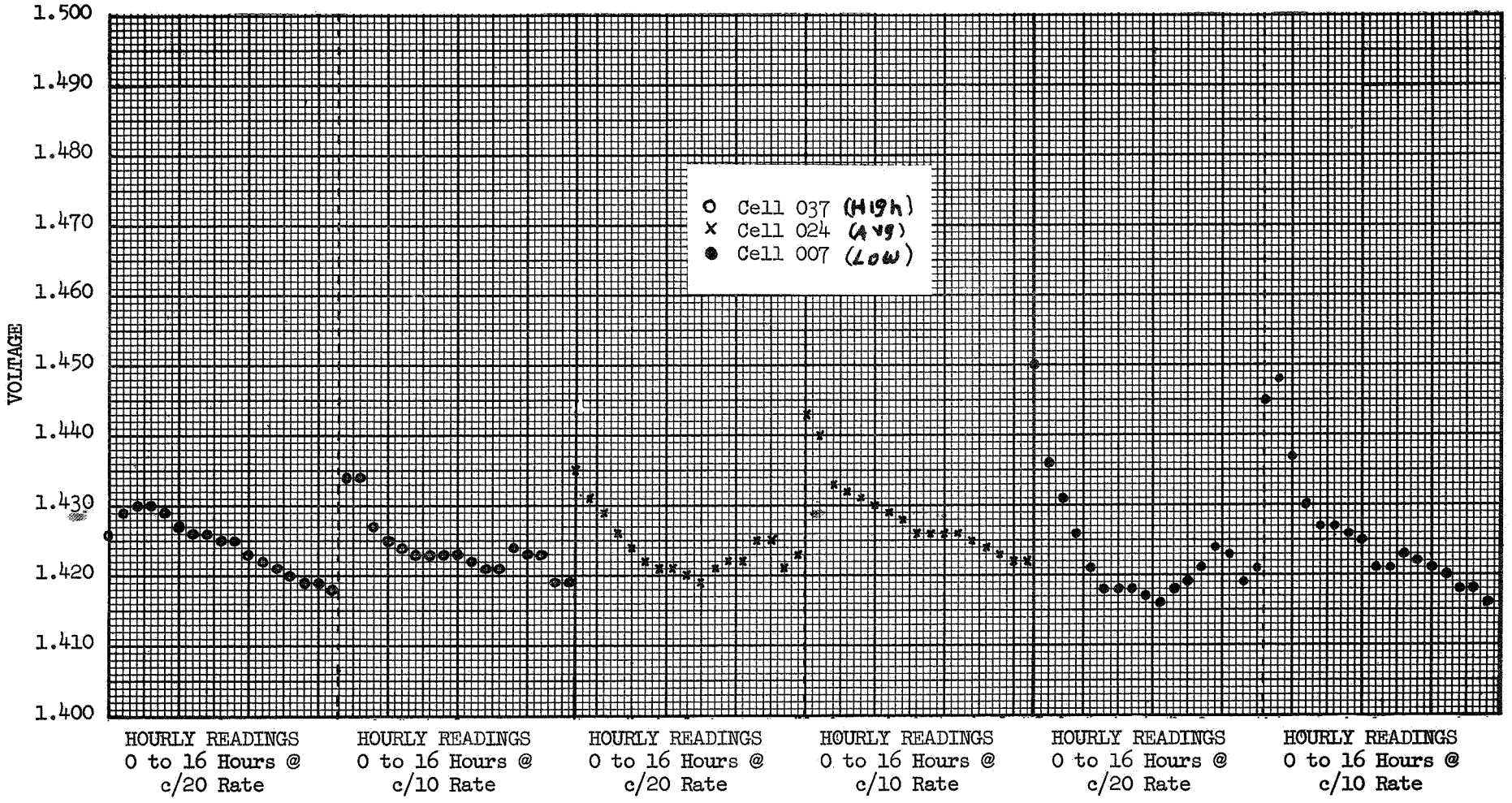
Cell Serial No.	Weight (Grams)	Height (In.)	Length (In.)	Width (In.)	Capacity Checks A.H. No. 1	No. 2	No. 3	Cell Short Test	Overcharge (Volts) C/20	C/10	Internal Resistors (Milliohms)	C/2 Discharge Following Overcharge
044	250.9	3.535	0.825	2.133	7.05	7.65	7.40	1.188	1.422	1.430	2.72	6.75
045	251.9	3.526	0.830	2.129	7.20	7.60	7.40	1.192	1.419	1.422	2.66	6.95
046	251.0	3.530	0.829	2.129	7.30	7.55	7.30	1.200	1.420	1.420	2.67	6.75
048	250.4	3.525	0.829	2.135	7.35	7.55	7.30	1.225	1.408	1.407	2.69	6.85
050	251.4	3.544	0.836	2.128	7.55	7.70	7.40	1.200	1.417	1.416	2.58	6.90
051	250.7	3.529	0.835	2.132	7.40	7.60	7.40	1.199	1.423	1.426	2.67	6.95
052	251.5	3.540	0.829	2.130	7.10	7.60	7.45	1.201	1.423	1.428	2.55	6.75
Avg.	250.5	—										
006	575.9	3.538	0.836	2.131	7.40	7.60	7.10	1.170	1.455	1.475*	2.61	7.05
015	576.5	3.532	0.831	2.132	7.50	7.55	6.90	1.194	1.445	1.455	2.80	7.05
019	573.7	3.535	0.832	2.131	7.25	7.60	7.00	0.431	1.449	1.478**	2.72	6.95
025	578.2	3.538	0.836	2.132	7.55	8.00	7.55	1.208	1.444	1.462***	2.64	7.30
030	575.6	3.535	0.839	2.131	7.50	7.95	7.50	1.211	1.441	1.456	2.79	7.40
Avg.	576.0	3.535	0.831	2.131	7.35	7.61	7.35	1.147	1.425	1.432	2.63	6.78

* Cell SN 006 removed electrically from C/10 overcharge after 3 hrs. charge due to high pressure (56 PSIG)
** Cell SN 019 removed electrically from C/10 overcharge after 2 hrs. charge due to high pressure (67 PSIG)
*** Cell SN 025 removed electrically from C/10 overcharge after 5 hrs. charge due to high pressure (52 PSIG)



CHARACTERISTIC 2-HOUR RATE DISCHARGE CURVES
(High, Average, and Low)
GE 6.0 AMPERE-HOUR NICKEL-CADMIUM CELLS
(CERAMIC SEALS WITH NICKEL BRAZE)

FIGURE 1



CHARACTERISTIC 16-HOUR OVERCHARGE CURVES
GE 6.0 AMPERE-HOUR NICKEL-CADMIUM CELLS
(CERAMIC SEALS WITH NICKEL BRAZE)

FIGURE 2

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Gulton Industries, Battery & Power Sources Division, 212 Durham Avenue, Metuchen, New Jersey 08840

Honeywell, Inc., Livingston Electronic Laboratory (Librarian), Montgomeryville, Pennsylvania 18936.

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Life Systems, Inc. (Dr. Richard A. Wynveen, Pres.), 23715 Mercantile Road, Cleveland, Ohio 44122

Arthur D. Little, Inc. (Dr. James D. Birkett), Acorn Park, Cambridge, Massachusetts 02140

Lockheed Aircraft Corporation (Bldg. 157, Dept. 62-25, Mr. Robert E. Corbett), P. O. Box 504, Sunnyvale, California 94088

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P. R. Mallory and Co., Inc. (Dr. Per Bro), Northwest Industrial Park, Burlington, Massachusetts 01801

P. R. Mallory and Co., Inc. (Library), P. O. Box 1115, Indianapolis, Indiana 46206

Marathon Battery Company (Mr. Lou Belove), Kemble Avenue, Cold Spring, New York 10516

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Portable Power Sources Corporation (Mr. Leon Schulman), 166 Pennsylvania Avenue, Mt. Vernon, New York 10552

Power Information Center, University City Science Institute, Room 2210, 3401 Market Street, Philadelphia, Pennsylvania 19104

Prime Battery Corporation, 15600 Cornet Street, Santa Fe Springs, California 90670

RAI Research Corporation, 225 Marcus Boulevard, Hauppauge, New York 11787

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

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