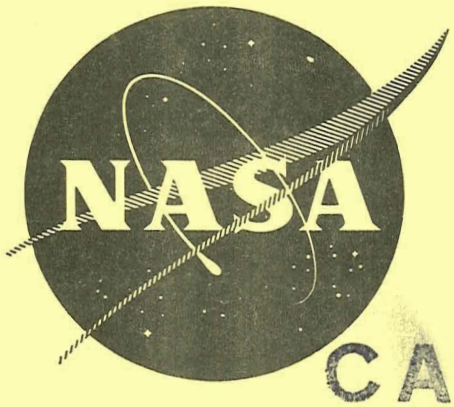

EVALUATION PROGRAM

for

SECONDARY SPACECRAFT CELLS

ACCEPTANCE TESTS
OF
100 AMPERE-HOUR NICKEL-CADMIUM CELLS
MANUFACTURED BY
GULTON INDUSTRIES

prepared for
GODDARD SPACE FLIGHT CENTER

CONTRACT W12, 397

QUALITY EVALUATION LABORATORY

NAD CRANE, INDIANA

DEPARTMENT OF THE NAVY
NAVAL AMMUNITION DEPOT
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Subj: Report QE/C 71-283; Evaluation Program for Secondary Spacecraft Cells; Acceptance Tests of 100.0 Ampere-Hour Nickel-Cadmium Spacecraft Cells Manufactured by Gulton Industries

Ref: (a) NASA P. O. No. W12,397

Encl: (1) Report QE/C 71-283

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EVALUATION PROGRAM FOR SECONDARY SPACECRAFT CELLS

ACCEPTANCE TESTS OF GULTON INDUSTRIES 100.0 AMPERE-HOUR NICKEL-CADMIUM CELLS

QE/C 71-283 20 JULY 1971

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Enclosure (1)

QE/C 71-283

REPORT BRIEF
GULTON INDUSTRIES
100.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS

Ref: (a) NASA, Langley Research Center, P. O. No. L-32,102
(b) Acceptance Test Procedure for Nickel-Cadmium Cells: NAD 3022-TP 304, Rev A, 14 May 1970

I. TEST ASSIGNMENT BRIEF

A. The purpose of this acceptance test 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 1.200 volts after cell short tests.

B. The 23 cells were purchased by National Aeronautics and Space Administration, Langley Research Center, from Gulton Industries, Metuchen, New Jersey. These cells were rated at 100.0 ampere-hours. Five of these cells were equipped with auxiliary electrodes. Testing on these cells was funded in accordance with reference (a).

II. SUMMARY OF RESULTS

A. The capacity of the 23 cells ranged from 48.3 to 125.0 ah. Ten cells delivered less than rated capacity on one or more of the three capacity checks.

B. Five cells failed to recover to 1.200 volts as established by the procedure for the cell short tests.

C. Electrolyte leakage was not observed for any of the 23 cells.

III. RECOMMENDATIONS

A. From the results of this acceptance test, it was recommended that these 100.0 ampere-hour cells not be placed on life cycling. This recommendation was based on low capacity of 10 cells and on the failure of five cells to meet the specified recovery voltage during the short tests. It was further noted by National Aeronautics and Space Administration, Langley Research Center, that cells of the same lot as those tested at NAD Crane contained excessive carbonates based on their data. Thus it was mutually agreed that the 23 cells be returned to National Aeronautics and Space Administration, Langley Research Center, for carbonate removal by flushing with electrolyte prior to beginning any life cycling tests on these cells.

RESULTS OF ACCEPTANCE TESTS OF 100.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS MANUFACTURED BY GULTON INDUSTRIES

I. INTRODUCTION

A. On 7 November 1970 acceptance tests were begun on 23 cells manufactured by Gulton Industries, Metuchen, New Jersey. These tests were completed 11 February 1971.

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 (b) and consisted of the following:

1. Phenolphthalein Leak Test.
2. Three Capacity Tests.
3. Two Cell Short Tests.
4. Phenolphthalein Leak Test.
5. Overcharge Test, c/20 rate and c/10 rate.
6. Internal Resistance.
7. Phenolphthalein Leak Test.

III. CELL IDENTIFICATION AND DESCRIPTION

A. The cells were identified by the manufacturer's serial numbers (14 through 53)--not consecutive.

B. The 100.0 ampere-hour cell is rectangular with an average height, width, and length of 7.308, 7.604 and 1.415 inches, respectively. The average weight was 4121.4 grams for cells without auxiliary electrodes and 4162.0 grams for cells with auxiliary electrodes. Figure 1 is a photograph of the Gulton Industries 100.0 ampere-hour cell.

C. The cell containers, and the cell covers are made of stainless steel. Both terminals are insulated from the cell covers by ceramic seals and protrude through the cover as screw type terminals. The positive and negative terminals are on opposite ends of the cell.

IV. RESULTS-- The following data was condensed from Table I. For details on procedure, see Appendix I.

A. The average capacity for the three capacity checks was:

1. Cells without auxiliary electrodes: 112.7, 106.0, and 94.3 ampere-hours respectively.

2. Cells with auxiliary electrodes: 121.3, 115.3 and 108.3 ampere-hours respectively.

3. Ten of the 23 cells delivered less than rated capacity on one or more of the capacity checks. These ten cells had no auxiliary electrodes. The capacities ranged from 48.3 to 125.0 ampere-hours for all 23 cells.

B. The average recovery voltages for the two short tests (see paragraph I.C of Appendix I for complete description) were:

1. 24-hour open circuit following dead short:

a. Without auxiliary electrodes: 1.227 volts.

b. With auxiliary electrodes: 1.032 volts.

2. Dead Short; c/10 chg. 5 minute; 24-hour open circuit:

a. Without auxiliary electrodes: 1.232 volts.

b. With auxiliary electrodes: 0.565 volts. Five of the 23 cells failed to recover to the 1.200 volts limit on one or both of the short tests.

C. The end-of-overcharge voltage averaged:

1. Cells without auxiliary electrodes: 1.416 volts at c/20 and 1.422 volts at c/10.

2. Cells with auxiliary electrodes: 1.389 volts at c/20 and 1.376 volts at c/10. One cell, without auxiliary electrode (serial number 52), was removed from the c/10 charge due to pressure over the 30 psig limit.

D. The internal resistance averaged:

1. Cells without auxiliary electrodes: 0.570 milliohms.

2. Cells with auxiliary electrodes: 0.964 milliohms. The internal resistance of the third electrodes averaged 5.8 milliohms.

E. The capacity to 1.000 volt following the overcharge averaged:

1. Cells without auxiliary electrode: 116.2 ampere-hour.

2. Cells with auxiliary electrode: 114.3 ampere-hour.

F. There was no evidence of any leakers out of the 23 cells tested.

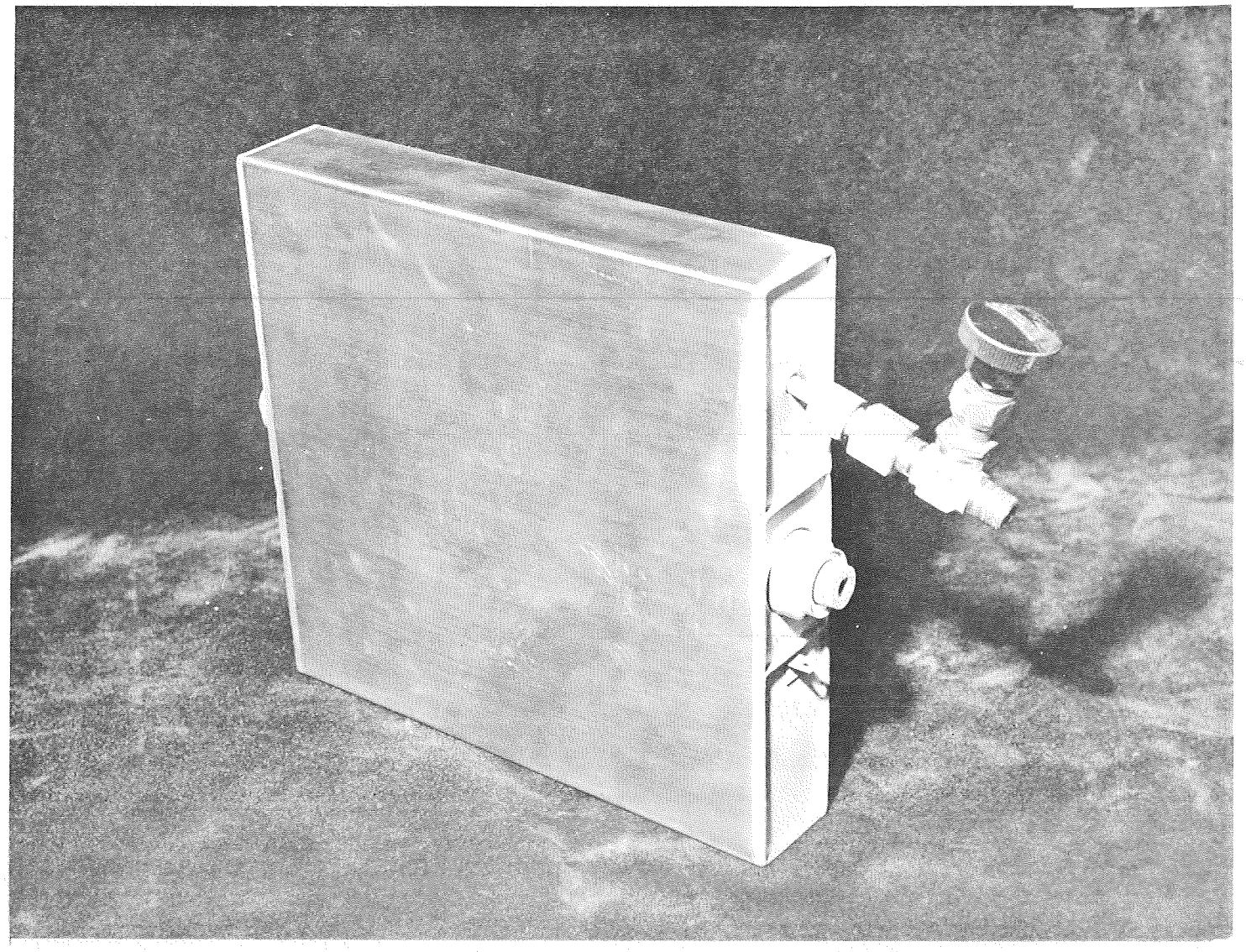

FIGURE 1

TABLE I
GULTON 100.0 AMPERE-HOURS CELLS
WITHOUT AUXILIARY ELECTRODES

CELL SN	WEIGHT (IN GRAMS)	HEIGHT (INCHES)	LENGTH (INCHES)	WIDTH (INCHES)	CAPACITY CHECKS (AMPERE-HOURS) 1	2	3	CELL SHORT TEST (VOLTS) 1	2	OVERCHARGE (VOLTS) c/20	c/10	INTERNAL RESISTANCE (MILLIOHMS)	C/1 DISCHARGE FOLLOWING OVERCHARGE
14	4098.1	7.305	1.423	7.615	121.7	116.7	106.7	1.188	1.240	1.426	1.445	0.620	123.3
15	4112.8	7.312	1.425	7.621	115.0	113.3	105.1	1.210	1.243	1.421	1.439	0.659	121.7
16	4124.3	7.305	1.413	7.617	111.7	106.7	98.3	1.215	1.244	1.421	1.441	0.522	115.0
17	4133.2	7.312	1.421	7.610	121.7	118.3	108.3	1.204	1.241	1.422	1.441	0.640	121.7
18	4132.5	7.316	1.419	7.616	125.0	120.0	111.7	1.171	1.241	1.428	1.439	0.481	133.3
19	4115.9	7.317	1.411	7.521	111.7	110.0	98.3	1.232	1.214	1.410	1.405	0.620	108.3
20	4112.3	7.311	1.413	7.619	111.7	110.0	105.0	1.238	1.230	1.408	1.413	0.595	121.7
22	4126.7	7.317	1.412	7.616	110.0	106.7	96.7	1.246	1.214	1.414	1.417	0.479	113.3
23	4139.6	7.320	1.411	7.613	111.7	115.0	110.0	1.221	1.212	1.420	1.419	0.490	125.0
24	4124.1	7.316	1.422	7.610	105.0	103.5	91.7	1.251	1.229	1.417	1.426	0.542	121.7
26	4120.8	7.306	1.411	7.520	113.3	108.3	98.3	1.239	1.241	1.414	1.416	0.739	110.0
27	4124.2	7.321	1.411	7.611	111.7	108.3	96.7	1.237	1.238	1.413	1.421	0.678	116.7
28	4101.5	7.302	1.411	7.609	111.7	106.7	96.7	1.235	1.237	1.416	1.423	0.525	111.7
29	4121.4	7.305	1.417	7.610	113.0	106.7	100.0	1.238	1.243	1.419	1.426	0.499	120.0
33	4131.9	7.307	1.416	7.608	116.7	108.3	100.0	1.240	1.241	1.422	1.430	0.655	126.7
50	4120.3	7.305	1.406	7.628	105.0	88.3	66.7	1.237	1.220	1.407	1.401	0.500	101.7
52	4137.4	7.316	1.422	7.610	106.7	80.0	48.3	1.245	1.229	1.406	1.394	0.530	96.7
53	4108.7	7.306	1.411	7.520	108.3	81.7	58.3	1.243	1.227	1.412	1.399	0.490	103.3
AVG	4121.4	*	*	*	112.7	106.0	94.3	1.227	1.232	1.416	1.422	0.570	116.2

TABLE I (CONT)
GULTON 100.0 AMPERE-HOURS CELLS
WITH AUXILIARY ELECTRODES

CELL SN	WEIGHT (IN GRAMS)	HEIGHT (INCHES)	LENGTH (INCHES)	WIDTH (INCHES)	CAPACITY CHECKS 1 A.H.	1 AUX E VOLT	2 A.H.	2 AUX E VOLT	3 A.H.	3 AUX E VOLT	CELL SHORT TEST (VOLTS) 1	2	OVERCHARGE (VOLTS) C/20 CELL	C/20 AUX E	C/10 CELL	C/10 AUX E	INTERNAL RESISTANCE (MILLIOHMS) CELL	AUX E	C/1 DISCHARGE FOLLOWING OVERCHARGE CAP.	AUX E VOLT
35	4165.8	7.317	1.422	7.600	121.7	.046	113.3	.089	103.3	.065	1.254	1.211	1.387	.303	1.379	.349	0.770	5.6	115.0	.033
38	4170.8	7.305	1.417	7.615	120.0	.021	111.7	0.54	110.0	.121	1.252	0.201	1.383	.307	1.374	.348	1.050	5.9	120.0	.032
39	4158.4	7.306	1.412	7.610	120.0	.017	111.7	.086	100.0	.085	1.250	1.211	1.382	.370	1.371	.483	0.980	6.2	101.7	-.006
40	4161.2	7.304	1.408	7.619	125.0	.021	123.3	.026	116.7	.023	1.203	0.084	1.395	.131	1.376	.276	1.020	5.9	118.3	.022
41	4153.9	7.300	1.412	7.607	120.0	.014	116.7	.015	111.7	.018	0.203	0.119	1.399	.159	1.382	.236	1.000	5.4	116.7	.015
AVG	4162.0	7.308	1.415	7.604	121.3	.024	115.3	.054	108.3	.042	1.032	0.565	1.389	.254	1.376	.388	0.964	5.8	114.3	.019

*Height, length and width data are averaged for all 23 cells.

APPENDIX I

I. TEST PROCEDURE

A. Phenolphthalein Leak Test:

1. The phenolphthalein leak test is a determination of the condition of the welds and ceramic seals on receipt of the cells. This test was performed prior to any other tests, with a phenolphthalein spray indicator solution of one-half of one percent concentration.

B. Capacity Tests:

1. The capacity test is a determination of the cell capacity at the c/1 discharge rate, where c is the manufacturer's rated capacity to a cutoff voltage of 1.00 volt per cell. The discharge was made after a 1-hour open circuit period following the 16-hour charge at the c/10 rate. A total of three capacity checks was made at this activity. The cells were discharged individually, but were recharged in series.

2. The five cells with auxiliary electrodes were loaded with 5.1 ohm resistors across the auxiliary electrodes. These resistors were installed prior to the start of the capacity checks and remained throughout the test.

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 cell was loaded with a 0.05 ohm, 10 watt resistor, for 8 hours, then dead shorted with bus wire for 16 hours. At the end of 16 hours, the dead short was removed and the cells were placed on open circuit stand for 24 hours. Any cell whose voltage did not recover to 1.200 volts or higher was considered as failing this portion of the acceptance test.

3. Upon completion of (I.C.2) above, the cells were again loaded with 0.05 ohm resistors for 8 hours, and dead shorted with bus wire for 16 hours. At the end of 16 hours, the bus wire was removed and the cells were charged for 5 minutes at the c/10 rate. At the end of 5 minutes the cells were placed on open circuit for 24 hours. Any cell whose voltage dropped below 1.200 volts was considered as failing this portion of the acceptance test.

D. Leak Test:

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

2. The cells were placed in a vacuum chamber and exposed to a vacuum of 40 microns of mercury or less for 24 hours. The cells were then removed from the vacuum chamber and sprayed with phenolphthalein. Pink or redish discolorations would indicate leakage.

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--ozygen recombination with the negative (cadmium) plate.

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

2. The overcharge tests were performed to determine the steady state voltage at specified rates. The test specified a series of constant current charges at c/10, c/20 and c/10 for a minimum of 16 hours at each charge rate. The first c/10 rate serves to establish a condition of overcharge.

3. The cells were monitored hourly throughout the test. Charging was to be discontinued on cells which exceeded 1.55 volts, 49° C, or 30 psig.

F. Internal Resistance:

1. Immediately following the overcharge test, the internal resistance was measured across the cell terminals and, where applicable, across the auxiliary electrodes (from auxiliary electrode terminal to negative terminal). These measurements were made with a Hewlett-Packard milliohmmeter (Model 4328A)

G. Leak Test:

1. Following the internal resistance measurements, the cells were still in a charged state. The cells were discharged at c/1 to 0.00 volt and shorted prior to the final leak test. The shorted cells were then placed in a vacuum chamber and the procedure described in paragraph I.D.2. was repeated.

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