Full as AD-741704

(NASA-CR-126659) EVALUATION PROGRAM FOR SECONDARY SPACECRAFT CELLS; ACCEPTANCE TESTS OF GENERAL ELECTRIC 4.5 AMPERE-HOUR
D.E. Christy (Naval Ammunition Depot)
29 Mar. 1972 11 p CSCL 10A G3/03

N72-24039

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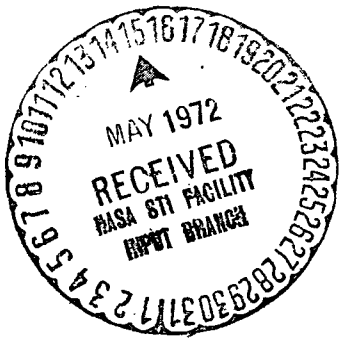
# EVALUATION PROGRAM

# for

# SECONDARY SPACECRAFT CELLS

## ACCEPTANCE TESTS
## OF
## GENERAL ELECTRIC
## 4.5 AMPERE-HOUR NICKEL-CADMIUM CELLS
## NIBUS TYPE

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

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# EVALUATION PROGRAM FOR SECONDARY SPACECRAFT CELLS

## ACCEPTANCE TESTS OF GENERAL ELECTRIC 4.5 AMPERE-HOUR NICKEL-CADMIUM CELLS NIMBUS TYPE

QEEL/C 72-128 29 MARCH 1972

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Enclosure (1)

# REPORT BRIEF
# GENERAL ELECTRIC COMPANY
# 4.5 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS
# NIMBUS TYPE

Ref: (a) NASA P. O. No. S-23404-G
(b) Acceptance Test Procedure for Nickel-Cadmium Cells: NAD 3022-TP308, 1 Sep 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 1.150 volts after the cell short test.

B. The 11 cells were purchased by National Aeronautics and Space Administration. Goddard Space Flight Center, from General Electric Company, Gainesville, Florida. The cells were rated at 4.5 ampere-hours and tested in accordance with reference (a).

## II. SUMMARY OF RESULTS

A. The capacity of the 11 cells ranged from 5.36 to 6.26 ah. All the cells exceeded the rated capacity on all three capacity checks.

B. One cell (serial number 53-57) failed to recover to 1.150 volts after the cell short test.

C. During the overcharge tests, the cell voltages ranged from 1.413 to 1.461 volts.

D. No electrolyte leakage was observed from any of the 11 cells.

## III. RECOMMENDATIONS

A. It is mutually recommended by Goddard Space Flight Center and this activity that these General Electric, NIMBUS cells undergo life cycling tests. It is further recommended that these tests include the cell (serial number 53-57) which showed a low recovery voltage on the short test.

# RESULTS OF ACCEPTANCE TEST OF 4.5 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS MANUFACTURED BY GENERAL ELECTRIC FOR THE NIMBUS PROGRAM

## I. INTRODUCTION

A. Testing was begun on 18 January 1972 and completed on 4 February 1972.

## II. TEST CONDITIONS AND PROCEDURE

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. Cell Short Test.
4. Phenolphthalein Leak Test.
5. Overcharge Tests, c/20 and c/10 Rates.
6. Internal Resistance.
7. Phenolphthalein Leak Test.

See Appendix I for detailed test procedure.

## III. CELL IDENTIFICATION AND DESCRIPTION

A. The cells were identified by the manufacturer's serial numbers (46-172R through 53-57--not consecutive). See Table I for a complete listing of serial numbers

B. The cells are cylinderical and the covers and containers are made of stainless steel. The positive terminal is insulated from the cover by a ceramic seal and protrudes through the cover as a solder type terminal. The negative terminal is a stainless steel tab to which the negative lead is soldered. There are three such tabs, any one of which may serve as the negative terminal. In addition, the bottom of the stainless steel container is slightly rounded

(dome shaped) in a convex manner. At the center of the dome is a threaded stud designed to afix the cell to a heat sinking fixture when installed in the NIMBUS satellite.

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

A. The average capacity for the three capcity checks was: 5.78, 6.02 and 5.74 ampere-hours, respectively.

B. The average recovery voltage was 1.192 volts which excluded cell 53-57; this cell only recovered to 0.106 volt within 24 hours from a dead short.

C. End-of-Overcharge Voltage:

1. The voltage averaged 1.445 volts at the end of 16 hours, at the initial c/10 conditioning rate.

2. The voltage averaged 1.438 volts at the end of 16 hours at the c/20 rate. There were no cells which reached the 1.500 voltage limit.

3. The voltage averaged 1.445 volts at the end of 16 hours at the c/10 rate. No cells exceeded the 1.500 volt limit.

D. Internal resistance averaged 8.2 milliohms across the cell terminals.

E. Leak Tests:

1. Each cell was subjected to three leak tests. No leakers were found for any of the 11 cells.

# APPENDIX I

I. TEST PROCEDURE

A. Phenolphthalein 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/2 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.

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 0.5 ohm, 3 watt resistor for 16 hours. At the end of 16 hours, the shorting 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 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 discoloration 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--oxygen 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 the condition of overcharge.

3. The cells were monitored hourly throughout the test. Charging was to be discontinued on cells which exceed 1.500 volts.

F. Internal Resistance:

1. Immediately following the overcharge test, the internal resistance was measured across the cell terminals. These measurements were made with a Hewlett-Packard milliohmmeter (Model 4328A).

G. Leak Test:

1. Following internal resistance measurements, the cells were still in a charged state. The cells were discharged at c/2 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 Para. I.D.2 was repeated.

TABLE I



| SERIAL NUMBER | LEAK TESTS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Initial (Phenol Spray) | | | | After Capacity Tests (Hi Vac & Phenol Spray) | | | | After Overcharge Test (Hi Vac & Phenol Spray) | | | |
| | Terminals | | Fill Tube | Other | Terminals | | Fill Tube | Other | Terminals | | Fill Tube | Other |
| | + | - | | | + | - | | | + | - | | |
| 46-172 R | ok | ok | ok | ok | ok | ok | ok | ok | ok | ok | ok | ok |
| 47-187 R | " | " | " | " | " | " | " | " | " | " | " | " |
| 48-135 R | " | " | " | " | " | " | " | " | " | " | " | " |
| 51-14 | " | " | " | " | " | " | " | " | " | " | " | " |
| 51-26 | " | " | " | " | " | " | " | " | " | " | " | " |
| 51-27 | " | " | " | " | " | " | " | " | " | " | " | " |
| | | | | | | | | | | | | |
| 51-53 | ok | ok | ok | ok | ok | ok | ok | ok | ok | ok | ok | ok |
| 52-56 | " | " | " | " | " | " | " | " | " | " | " | " |
| 52-93 | " | " | " | " | " | " | " | " | " | " | " | " |
| 52-160 | " | " | " | " | " | " | " | " | " | " | " | " |
| 53-57 | " | " | " | " | " | " | " | " | " | " | " | " |

TABLE II
CAPACITY CHECK DATA

QEEL/C 72-128

| SERIAL NUMBER | FIRST CAPACITY CHECK | | | | | | SECOND CAPACITY CHECK | | | | | | THIRD CAPACITY CHECK | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | END-OF-CHARGE | | | END-OF-DISCHARGE | | | END-OF-CHARGE | | | END-OF-DISCHARGE | | | END-OF-CHARGE | | | END-OF-DISCHARGE | | |
| | CELL (Volts) | AUX ELECT (Volts) | PRESS * | CAPAC-ITY (ah) | AUX ELECT (Volts) | PRESS * | CELL (Volts) | AUX ELECT (Volts) | PRESS * | CAPAC-ITY (ah) | AUX ELECT (Volts) | PRESS * | CELL (Volts) | AUX ELECT (Volts) | PRESS * | CAPAC-ITY (ah) | AUX ELECT (Volts) | PRESS * |
| 46-172R | 1.448 | — | — | 5.92 | — | — | 1.450 | — | — | 5.74 | — | — | 1.436 | — | — | 5.78 | — | — |
| 47-187R | 1.421 | | | 5.62 | | | 1.424 | | | 5.69 | | | 1.418 | | | 5.36 | | |
| 48-105R | 1.457 | | | 5.85 | | | 1.454 | | | 5.90 | | | 1.439 | | | 5.69 | | |
| 51-14 | 1.442 | | | 5.92 | | | 1.451 | | | 6.03 | | | 1.439 | | | 5.90 | | |
| 51-20 | 1.442 | | | 5.96 | | | 1.455 | | | 6.08 | | | 1.442 | | | 5.92 | | |
| 51-27 | 1.445 | | | 5.85 | | | 1.453 | | | 6.03 | | | 1.442 | | | 5.90 | | |
| | | | | | | | | | | | | | | | | | | |
| 51-53 | 1.423 | | | 5.69 | | | 1.443 | | | 6.12 | | | 1.437 | | | 5.81 | | |
| 52-56 | 1.420 | | | 5.69 | | | 1.434 | | | 6.08 | | | 1.424 | | | 5.63 | | |
| 52-93 | 1.442 | | | 5.69 | | | 1.432 | | | 6.08 | | | 1.422 | | | 5.63 | | |
| 52-160 | 1.420 | | | 5.64 | | | 1.435 | | | 6.19 | | | 1.424 | | | 5.67 | | |
| 53-57 | 1.419 | | | 5.69 | | | 1.436 | | | 6.26 | | | 1.425 | | | 5.85 | | |
| | | | | | | | | | | | | | | | | | | |
| Average | 1.433 | | | 5.78 | | | 1.442 | | | 6.02 | | | 1.432 | | | 5.74 | | |



* Negative values are interpreted as inches of mercury vacuum, while positive values are psia.

TABLE III

QEEL/C 72-128

| SERIAL NUMBER | CELL SHORT TEST Recovery Voltage after 24 Hours (Volts) | END OF CHARGE VOLTAGE AT: c/10 CONDITIONING RATE | | | c/20 CONDITIONING RATE | | | c/10 CONDITIONING RATE | | | INTERNAL RESISTANCE MEASUREMENT (Milliohms) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | CELL (Volts) | AUX ELECT (Volts) | PRESS * | CELL (Volts) | AUX ELECT (Volts) | PRESS * | CELL (Volts) | AUX ELECT (Volts) | PRESS * | CELL | AUX ELECT |
| 46-172 R | 1.191 | 1.448 | — | — | 1.442 | — | — | 1.447 | — | — | 7.6 | — |
| 47-181 R | 1.196 | 1.424 | | | 1.413 | | | 1.423 | | | 7.2 | |
| 48-135 R | 1.187 | 1.459 | | | 1.442 | | | 1.447 | | | 7.7 | |
| 51-14 | 1.201 | 1.446 | | | 1.436 | | | 1.442 | | | 7.7 | |
| 51-26 | 1.191 | 1.452 | | | 1.439 | | | 1.446 | | | 8.1 | |
| 51-27 | 1.197 | 1.451 | | | 1.444 | | | 1.452 | | | 8.2 | |
| | | | | | | | | | | | | |
| 51-53 | 1.190 | 1.461 | | | 1.446 | | | 1.449 | | | 9.1 | |
| 52-56 | 1.186 | 1.440 | | | 1.441 | | | 1.445 | | | 9.2 | |
| 52-93 | 1.189 | 1.439 | | | 1.436 | | | 1.449 | | | 8.5 | |
| 52-160 | 1.187 | 1.444 | | | 1.440 | | | 1.445 | | | 8.5 | |
| 53-57 | 0.106 | 1.434 | | | 1.442 | | | 1.447 | | | 8.8 | |
| | | | | | | | | | | | | |
| Average | 1.192 ** | 1.445 | | | 1.438 | | | 1.445 | | | 8.2 | |

** Excludes cell 53-57

* Negative values are interpreted as inches of mercury vacuum, while positive values are psig.

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