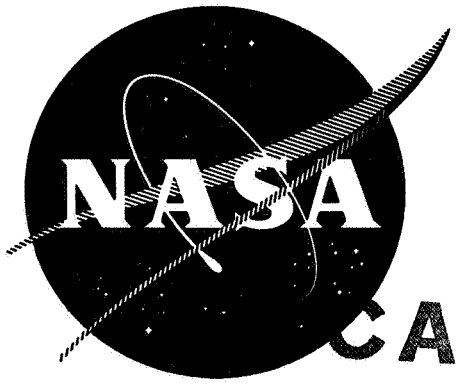




# EVALUATION PROGRAM

# for

# SECONDARY SPACECRAFT CELLS

ACCEPTANCE TEST
OF
MC DONNELL DOUGLAS, ASTROPOWER DIVISION
5.0 AMPERE–HOUR SILVER–ZINC CELLS

prepared for
GODDARD SPACE FLIGHT CENTER
CONTRACT W12–397


QUALITY EVALUATION LABORATORY

NAD CRANE, INDIANA

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

# EVALUATION PROGRAM
# FOR
# SECONDARY SPACECRAFT CELLS

## ACCEPTANCE TEST
## OF
## McDONNELL DOUGLAS, ASTROPOWER DIVISION
## 5.0 AMPERE-HOUR SILVER-ZINC CELLS

QE/C 69-656 15 AUGUST 1969

PREPARED BY

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APPROVED BY

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By direction

Enclosure (1)

# REPORT BRIEF
# ASTROPOWER 5.0 AMPERE-HOUR SEALED SILVER-ZINC SECONDARY SPACECRAFT CELLS

Ref: (a) National Aeronautics and Space Administration Purchase Order W12-397
(b) NASA ltr BRA/VBK/pad of 25 September 1961 w/BUWEPS first end FQ-1:WSK of October 1961 to CO NAD Crane

## I. TEST ASSIGNMENT

A. In compliance with references (a) and (b), 44 Astropower 5.0 ampere-hour cells, constructed for NASA Lewis under contract NAS 3-10924, were tested as outlined in the Acceptance Test Procedure for Astropower Inorganic Separator Cells of 27 May 1968. The acceptance test was designed to evaluate the cells for physical defects, seal quality, and ampere-hour capacity (full procedure in Appendix).

## II. RECOMMENDATIONS AND RESULTS

A. Rejection of all the cells is recommended because:

1. All the cells leaked an unknown quantity of electrolyte.

2. Twenty-five of the cells failed to deliver the required capacity of 5.5 ampere-hours.

QE/C 69-656

# RESULTS OF ACCEPTANCE TESTS OF 5.0 AMPERE-HOUR SEALED SILVER-ZINC SECONDARY SPACECRAFT CELLS MANUFACTURED BY THE ASTROPOWER DIVISION OF McDONNELL DOUGLAS

## I. INTRODUCTION

A. The Astropower Division of McDonnell Douglas has developed an inorganic separator material which they incorporated into the construction of 5.0 ampere-hour silver-zinc cells (one cell is shown in Photograph I). Forty-four cells were purchased by NASA, Lewis Research Center and tested at NAD Crane. Each cell was tested for seal quality, phyiscal defects, and ampere-hour capacity as outlined in the acceptance test procedure furnished by Goddard Space Flight Center (See Appendix). All the cells leaked electrolyte; also, 25 cells failed to deliver the required capacity. Based on these results no further tests were performed on these cells.

## II. CAPACITY TESTS

A. Each cell was required to deliver a minimum of 5.5 ampere-hours following the second charge at 350 milliamperes to 2.05 volts. Twenty-five cells failed to deliver 5.5 ampere-hours when discharged at 2.5 amperes to 1.0 volt.

B. The first and third discharges were performed at 1.0 ampere and 5.0 amperes, respectively, to 1.0 volt with all charges at 350 milliamperes to 2.05 volts.

C. The ampere-hours of charge and discharge for each of the three measurements are listed in Table I while a typical discharge curve for each of the three discharge rates is graphed in Figure 1.

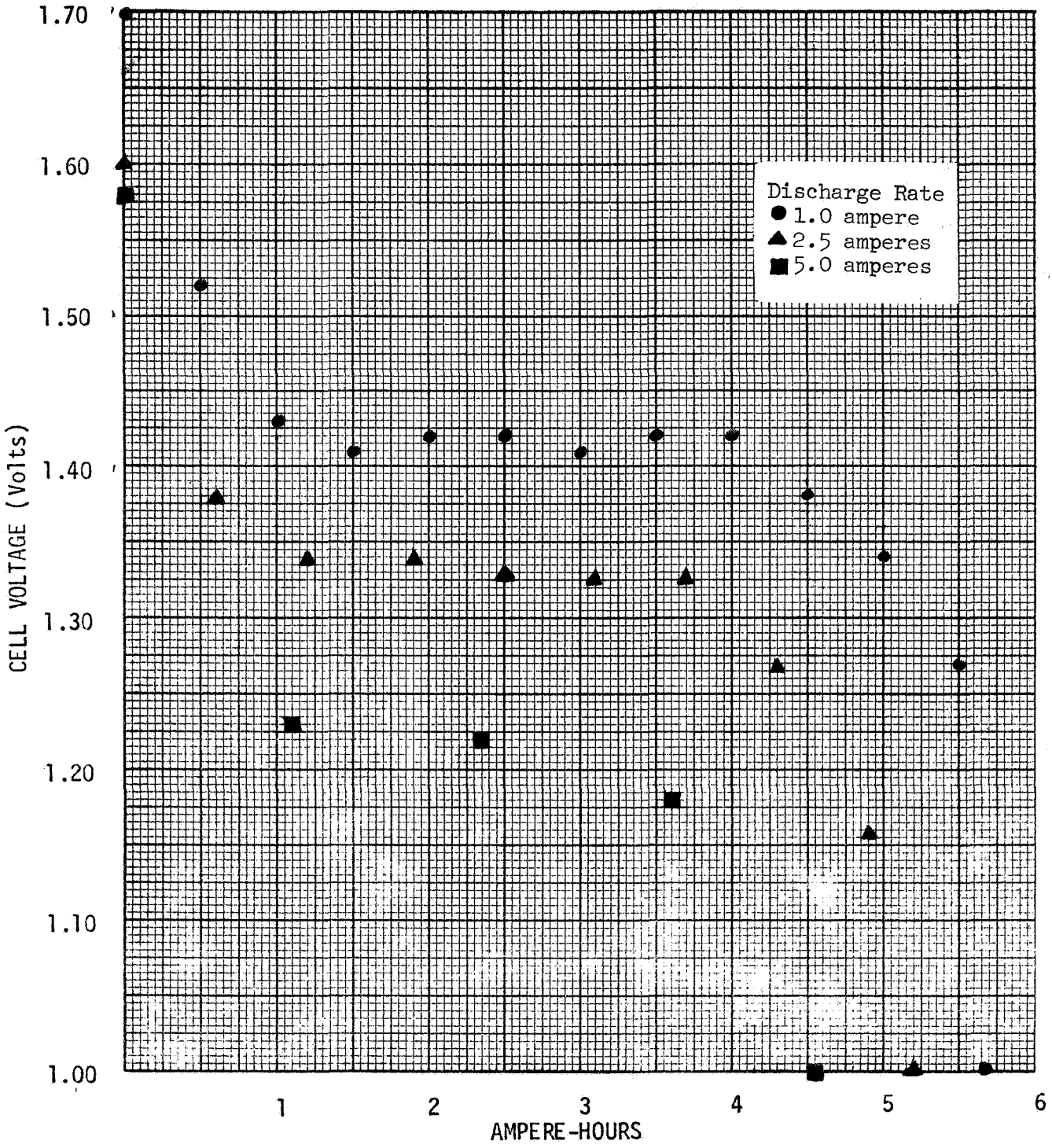
## III. CASE INSPECTION AND LEAK TESTS

A. The molded plastic case of each cell was visually inspected for defects. The terminals, fill port, and relief valve were checked by visual inspection and by phenolphthalein solution for leaks. Visual inspection revealed no defects in the cases before or after the capacity measurements. Prior to testing, 25 cells had visible leaks and an additional 17 had leaks detected by phenolphthalein. After the capacity check measurements, all the cells leaked, 34 visible and an additional 10 detectable by phenolphthalein solution.

## IV. WEIGHT AND DIMENSIONS

A. Each cell was weighed before and after the capacity measurements. The cell dimensions, initial weight, and final weight are tabulated in Table II.


PHOTOGRAPH 1




TYPICAL DISCHARGE CURVE

FIGURE 1

TABLE I
AMPERES IN AND OUT

| Serial Number | First Charge A.H. | First Discharge A.H. | Second Charge A.H. | Second Discharge A.H. | Third Charge A.H. | Third Discharge A.H. |
|---|---|---|---|---|---|---|
| 1-7 | 6.04 | 5.66 | 5.53 | 5.18* | 5.25 | 4.53 |
| 1-8 | 5.78 | 5.48 | 5.88 | 5.33* | 5.40 | 4.47 |
| 1-9 | 5.60 | 5.18 | 5.66 | 5.15* | 5.17 | 4.44 |
| 1-10 | 6.21 | 5.81 | 6.07 | 5.63 | 5.62 | 4.91 |
| 1-11 | 6.21 | 5.98 | 6.17 | 5.61 | 5.69 | 4.98 |
| 1-12 | 6.21 | 5.95 | 6.26 | 5.82 | 5.78 | 5.11 |
| 1-13 | 6.21 | 5.78 | 5.90 | 5.43* | 5.47 | 4.60 |
| 1-14 | 5.85 | 5.57 | 5.76 | 5.16* | 5.20 | 4.38 |
| 1-15 | 6.39 | 5.94 | 6.00 | 5.48 | 5.53 | 4.89 |
| 1-16 | 6.04 | 5.71 | 6.09 | 5.59 | 5.50 | 4.76 |
| 1-17 | 6.04 | 5.63 | 6.38 | 5.28* | 5.55 | 4.73 |
| 1-18 | 6.21 | 5.83 | 6.10 | 5.51 | 5.53 | 4.68 |
| 1-19 | 6.04 | 5.78 | 6.04 | 5.56 | 5.57 | 4.73 |
| 1-20 | 5.70 | 5.34 | 5.78 | 5.27* | 5.31 | 4.52 |
| 1-21 | 5.70 | 5.83 | 6.11 | 5.60 | 5.67 | 4.83 |
| 1-22 | 6.13 | 5.74 | 6.03 | 5.48* | 5.48 | 4.79 |
| 1-23 | 6.04 | 5.62 | 5.77 | 5.35* | 5.52 | 4.77 |
| 1-24 | 6.04 | 5.73 | 5.98 | 5.47* | 5.51 | 4.71 |
| 1-25 | 6.21 | 5.81 | 6.12 | 5.62 | 5.57 | 4.85 |
| 2-1 | 6.21 | 6.08 | 6.06 | 5.52 | 5.68 | 4.96 |
| 2-2 | 5.35 | 6.20 | 5.53 | 5.81 | 5.16 | 4.88 |
| 2-3 | 6.49 | 6.21 | 6.48 | 6.01 | 6.05 | 5.34 |
| 2-4 | 6.18 | 5.93 | 6.23 | 5.52 | 5.67 | 4.55 |
| 2-5 | 5.60 | 5.23 | 5.82 | 5.23* | 5.32 | 4.63 |
| 2-6 | 5.94 | 5.65 | 6.12 | 5.65 | 5.72 | 4.87 |
| 2-7 | 6.04 | 5.82 | 6.15 | 5.58 | 5.63 | 4.81 |
| 2-8 | 5.84 | 5.53 | 5.93 | 5.41* | 5.47 | 4.63 |
| 2-9 | 5.80 | 5.51 | 6.01 | 5.44* | 5.46 | 4.69 |
| 2-10 | 6.07 | 5.80 | 6.12 | 5.64 | 5.74 | 4.90 |
| 2-11 | 6.11 | 5.90 | 6.24 | 5.60 | 5.72 | 4.87 |
| 2-12 | 6.05 | 5.89 | 6.32 | 5.65 | 5.69 | 4.64 |
| 2-13 | 5.80 | 5.51 | 5.95 | 5.17* | 5.40 | 4.64 |
| 2-14 | 6.10 | 5.90 | 6.09 | 5.68 | 5.70 | 5.01 |
| 2-15 | 5.79 | 5.42 | 5.83 | 5.42* | 5.48 | 4.78 |
| 2-16 | 5.64 | 5.22 | 5.65 | 5.22* | 5.20 | 4.50 |
| 2-17 | 6.04 | 5.88 | 6.11 | 5.51 | 5.57 | 4.68 |
| 2-18 | 5.95 | 5.66 | 6.08 | 5.33* | 5.51 | 4.41 |
| 2-19 | 6.06 | 5.86 | 6.11 | 5.23* | 5.48 | 3.88 |
| 2-20 | 5.74 | 5.55 | 6.07 | 5.37* | 5.50 | 4.78 |
| 2-21 | 5.49 | 5.05 | 5.58 | 5.16* | 5.22 | 4.37 |
| 2-22 | 5.90 | 4.43 | 5.43 | 5.25* | 5.08 | 4.75 |
| 2-23 | 5.64 | 4.48 | 5.51 | 5.29* | 4.99 | 4.67 |
| 2-24 | 5.54 | 4.58 | 5.53 | 5.17* | 5.12 | 4.84 |
| 2-25 | 5.96 | 5.12 | 5.76 | 5.38* | 5.12 | 4.84 |

* Failed to deliver required capacity of 5.5 ampere-hours.

TABLE II
PHYSICAL INFORMATION

| Serial Number | Height (Inches) | Depth (Inches) | Width (Inches) | Weight Initial (Grams) | Weight Final (Grams) | Leakers Initial* | Leakers Final* |
|---|---|---|---|---|---|---|---|
| 1-7 | 3.343 | 1.036 | 2.282 | 231.3 | 231.1 | P | VP |
| 1-8 | 3.341 | 1.041 | 2.280 | 230.2 | 230.1 | P | P |
| 1-9 | 3.346 | 1.067 | 2.279 | 231.3 | 231.1 | P | VP |
| 1-10 | 3.333 | 1.034 | 2.283 | 230.2 | 230.1 | P | P |
| 1-11 | 3.344 | 1.036 | 2.281 | 230.4 | 230.2 | P | P |
| 1-12 | 3.339 | 1.072 | 2.276 | 230.0 | 229.7 | VP | VP |
| 1-13 | 3.345 | 1.034 | 2.281 | 231.6 | 231.4 | | P |
| 1-14 | 3.336 | 1.036 | 2.282 | 231.1 | 230.9 | P | VP |
| 1-15 | 3.342 | 1.036 | 2.282 | 231.7 | 231.5 | P | P |
| 1-16 | 3.346 | 1.034 | 2.281 | 230.6 | 230.5 | P | P |
| 1-17 | 3.347 | 1.033 | 2.282 | 230.3 | 230.1 | P | P |
| 1-18 | 3.347 | 1.034 | 2.281 | 230.8 | 230.5 | P | P |
| 1-19 | 3.343 | 1.035 | 2.280 | 230.9 | 230.7 | P | P |
| 1-20 | 3.342 | 1.036 | 2.277 | 230.4 | 230.3 | P | VP |
| 1-21 | 3.345 | 1.038 | 2.281 | 231.4 | 231.3 | P | VP |
| 1-22 | 3.344 | 1.050 | 2.278 | 230.0 | 229.8 | P | VP |
| 1-23 | 3.341 | 1.051 | 2.281 | 231.8 | 231.5 | P | VP |
| 1-24 | 3.338 | 1.036 | 2.284 | 231.1 | 231.0 | P | VP |
| 1-25 | 3.345 | 1.036 | 2.281 | 230.1 | 230.1 | P | P |
| 2-1 | 3.346 | 1.042 | 2.281 | 229.5 | 229.3 | VP | VP |
| 2-2 | 3.336 | 1.072 | 2.283 | 229.3 | 228.3 | VP | VP |
| 2-3 | 3.343 | 1.041 | 2.286 | 231.2 | 231.2 | VP | VP |
| 2-4 | 3.334 | 1.069 | 2.279 | 228.0 | 227.5 | VP | VP |
| 2-5 | 3.343 | 1.030 | 2.288 | 230.7 | 230.7 | VP | VP |
| 2-6 | 3.342 | 1.037 | 2.286 | 231.0 | 231.0 | VP | VP |
| 2-7 | 3.343 | 1.092 | 2.280 | 229.0 | 229.0 | VP | VP |
| 2-8 | 3.346 | 1.050 | 2.283 | 230.6 | 230.7 | VP | VP |
| 2-9 | 3.345 | 1.032 | 2.286 | 229.8 | 229.8 | VP | VP |
| 2-10 | 3.337 | 1.035 | 2.285 | 230.1 | 230.0 | VP | VP |
| 2-11 | 3.345 | 1.094 | 2.280 | 229.3 | 229.1 | | VP |
| 2-12 | 3.341 | 1.085 | 2.282 | 227.9 | 228.0 | VP | VP |
| 2-13 | 3.343 | 1.064 | 2.283 | 230.2 | 230.2 | VP | VP |
| 2-14 | 3.344 | 1.090 | 2.282 | 231.9 | 232.0 | VP | VP |
| 2-15 | 3.345 | 1.038 | 2.288 | 230.8 | 230.8 | VP | VP |
| 2-16 | 3.340 | 1.034 | 2.285 | 229.3 | 229.2 | VP | VP |
| 2-17 | 3.338 | 1.055 | 2.281 | 229.8 | 229.3 | VP | VP |
| 2-18 | 3.335 | 1.076 | 2.272 | 225.3 | 224.8 | VP | VP |
| 2-19 | 3.339 | 1.085 | 2.283 | 230.6 | 230.6 | VP | VP |
| 2-20 | 3.345 | 1.081 | 2.282 | 229.2 | 229.2 | VP | VP |
| 2-21 | 3.344 | 1.049 | 2.286 | 229.8 | 229.9 | VP | VP |
| 2-22 | 3.343 | 1.067 | 2.282 | 229.7 | 229.8 | VP | VP |
| 2-23 | 3.341 | 1.092 | 2.282 | 231.0 | 231.1 | VP | VP |
| 2-24 | 3.336 | 1.032 | 2.287 | 231.1 | 231.2 | VP | VP |
| 2-25 | 3.345 | 1.065 | 2.286 | 231.2 | 231.3 | VP | VP |
| Average | 3.342 | 1.052 | 2.282 | 230.3 | 230.1 | | |

* V = Visual
* P = Phenolphthalein

# APPENDIX

# Acceptance Test Procedure for Astropower Inorganic Separator Cells of 27 May 1968

1.0 Inspect cell terminals and relief valve for corrosion or leaks.

2.0 Inspect case and epoxy for cracks or defects.

3.0 Check that all electrode and separator stacks are on bottom of case.

4.0 Weigh each cell to within one gram.

5.0 Discharge each cell with a 0.5 ohm resistor to 1.0 volt.

6.0 Charge at 350 milliamperes constant current to 2.05 volts, each cell. Record cell voltage at 1 minute and every 30 minutes thereafter. Record ampere-hours in.

7.0 Discharge at 1.0 ampere constant current to 1.0 volt each cell. Record cell voltage at 1 minute and every 15 minutes thereafter. Record ampere-hours out.

8.0 Repeat paragraphs 6.0 and 7.0 twice, but with the second and third constant current discharges at 2.5 and 5.0 amperes, respectively.

9.0 Ampere-hours out on the second discharge are to be greater than 5.5 ampere-hours. If not, return the low cells to the manufacturer.

10.0 Inspect cell terminals and relief valve for corrosion or leaks.

11.0 Discharge each cell with a 0.5 ohm resistor to 1.0 volt.

12.0 Weigh each cell to within one gram.

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