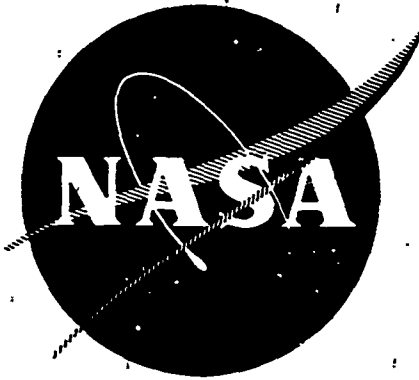


AD734694



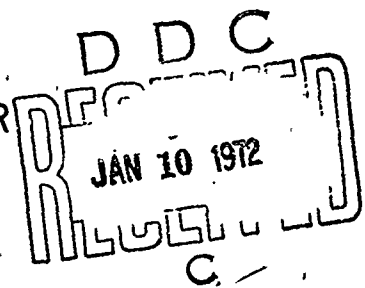
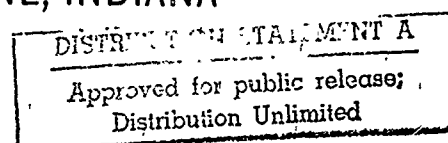
**EVALUATION PROGRAM**  
**for**  
**SECONDARY SPACECRAFT CELLS**

ACCEPTANCE TEST  
OF  
MC DONNELL - DOUGLAS  
ASTROPOWER DIVISION  
40.0 AMPERE-HOUR SILVER-ZINC CELLS

prepared for  
GODDARD SPACE FLIGHT CENTER  
CONTRACT W12,397

Reproduced by  
NATIONAL TECHNICAL  
INFORMATION SERVICE  
Springfield, Va. 22151

QUALITY EVALUATION LABORATORY  
NAD CRANE, INDIANA



DEPARTMENT OF THE NAVY

NAVAL AMMUNITION DEPOT

CRANE, INDIANA 47522

REPLY REFER TO:

3053-JDH:mm

8900

30 DEC 1971


From: Commanding Officer, Naval Ammunition Depot, Crane, Indiana  
To: National Aeronautics and Space Administration, Goddard Space  
Flight Center (Code 716.2, Mr. T. J. Hennigan), Greenbelt,  
Maryland 20771

Subj: Report QEEL/C 71-436; Evaluation Program for Secondary Spacecraft  
Cells; Acceptance Test of 40.0 Ampere-Hour Silver-Zinc Cells  
Manufactured by McDonnell-Douglas, Astropower Division

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

Encl: (1) Report QEEL/C 71-436

1. In compliance with reference (a), enclosure (1) is forwarded for  
information and retention.



D. G. MILEY

By direction

Copy to:  
Distribution List

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

Evaluation Program  
For  
Secondary Spacecraft Cells

ACCEPTANCE TEST  
OF  
MCDONNELL-DOUGLAS, ASTROPOWER DIVISION  
40.0 AMPERE-HOUR SILVER-ZINC CELLS

QEEL/C 71-436

26 NOVEMBER 1971

PREPARED BY

*J. D. Harkness*

J. D. HARKNESS

PREPARED UNDER THE DIRECTION OF

*D. E. Mains*

D. E. MAINS  
Manager, Space  
Satellite Cell Programs Branch

APPROVED BY

*D. G. Miley*

D. G. MILEY  
By direction

Enclosure (1)

REPORT BRIEF  
ASTROPOWER 40.0 AMPERE-HOUR SEALED SILVER-ZINC  
SECONDARY SPACECRAFT CELLS

Ref: (a) NASA, Purchase Order W12-397  
(b) NASA, ltr BRA/VBK/pad of 25 Sep 1961 w/BUWEPS first and  
FQ-1:WSK of 2 Oct 1961 to CO NAD Crane

I. TEST ASSIGNMENT BRIEF

A. Silver-zinc, 40 ampere-hour, Astropower cells, with an inorganic separator material, were constructed for NASA, Lewis Research Center, under Contract NAS 3-10928. NAD Crane received 64 of these cells for evaluation on the synchronous and Planetary Earth life-cycling orbits and on a wet-stand test. Prior to the placement of the cells on these programs, all the cells except one, serial number 29, which was dissected, analyzed and photographed so that it may be used as a base reference; were subjected to acceptance tests in which each cell was tested for seal quality, physical defects, and ampere-hour capacity as outlined in the acceptance test procedure furnished by NASA Goddard Space Flight Center (Appendix I). This report covers the acceptance test plan of the evaluation program in compliance with references (a) and (b).

II. RESULTS

A. Leakage was detected in five cells prior to the capacity tests and in 19 cells after the capacity tests.

B. There was only one cell which failed to deliver a capacity of 40.0 ampere-hours (cell serial number 107--39.45 ampere hours). The average ampere-hours out on the first and second charge/discharge cycle were 42.41 and 42.18.

III. COMMENTS

A. NASA Goddard and NASA Lewis were informed that 30 percent of the cells were detected as leakers. They then decided that the top portion of the cells be re-potted at NAD Crane to correct this problem prior to the placement of the cells on the various test programs.

RESULTS OF ACCEPTANCE TESTS  
OF  
40.0 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 developed an inorganic separator material which they incorporated into the construction of 40.0 ampere-hour silver-zinc cells; (one cell is shown in Photograph I). NAD Crane received 64, HS-40-7 Series M type cells, fully formed as reported in the NASA technical report DAC-60989-F of November 1970 prepared by Astropower Laboratory, McDonnell Douglas Astronautics Company for evaluation on the synchronous and Planetary Earth life-cycling orbits and on a wet stand test. Prior to the placement of the cells on these programs, all the cells except one; serial number 29, which was dissected, analyzed and photographed so that it may be used as a base reference; were subjected to acceptance tests in which each cell was tested for real quality, physical defects and ampere-hour capacity, as outlined in the acceptance test procedure furnished by NASA, Goddard Space Flight Center (Appendix I).

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.

III. CAPACITY TESTS

A. The average ampere-hours input/output on the first charge/discharge cycle were 42.63 and 42.41, and on the second charge/discharge cycle they were 42.11 and 42.18. Only one cell (serial number 107) failed to deliver 40.0 ampere-hours during acceptance testing and that was during the second cycle when it delivered 39.45 ampere-hours. These results are listed in Table I.

IV. CASE INSPECTION AND LEAK TESTS

A. Visual inspection of the molded plastic case showed no defects before or after capacity tests. Prior to testing, visual inspection showed that five cells had leakage around their terminals and after the capacity tests 19 cells had leaks as detected by phenolphthalein solution. The results of these tests are listed in Table II in which only those cells that leaked are listed.

B. NASA Goddard and NASA Lewis were informed that 30 percent of the cells were detected as leakers. They then decided that the top portion of the cells were to be re-potted at NAD Crane prior to their placement on the various test programs (Photograph No. 2). By re-potting the cells, extension terminals were necessary and the addition of the extension terminals and potting compound increased the height of the cells approximately .500 inch and the weight approximately 58 grams.

#### V. PHYSICAL AND WEIGHT MEASURES

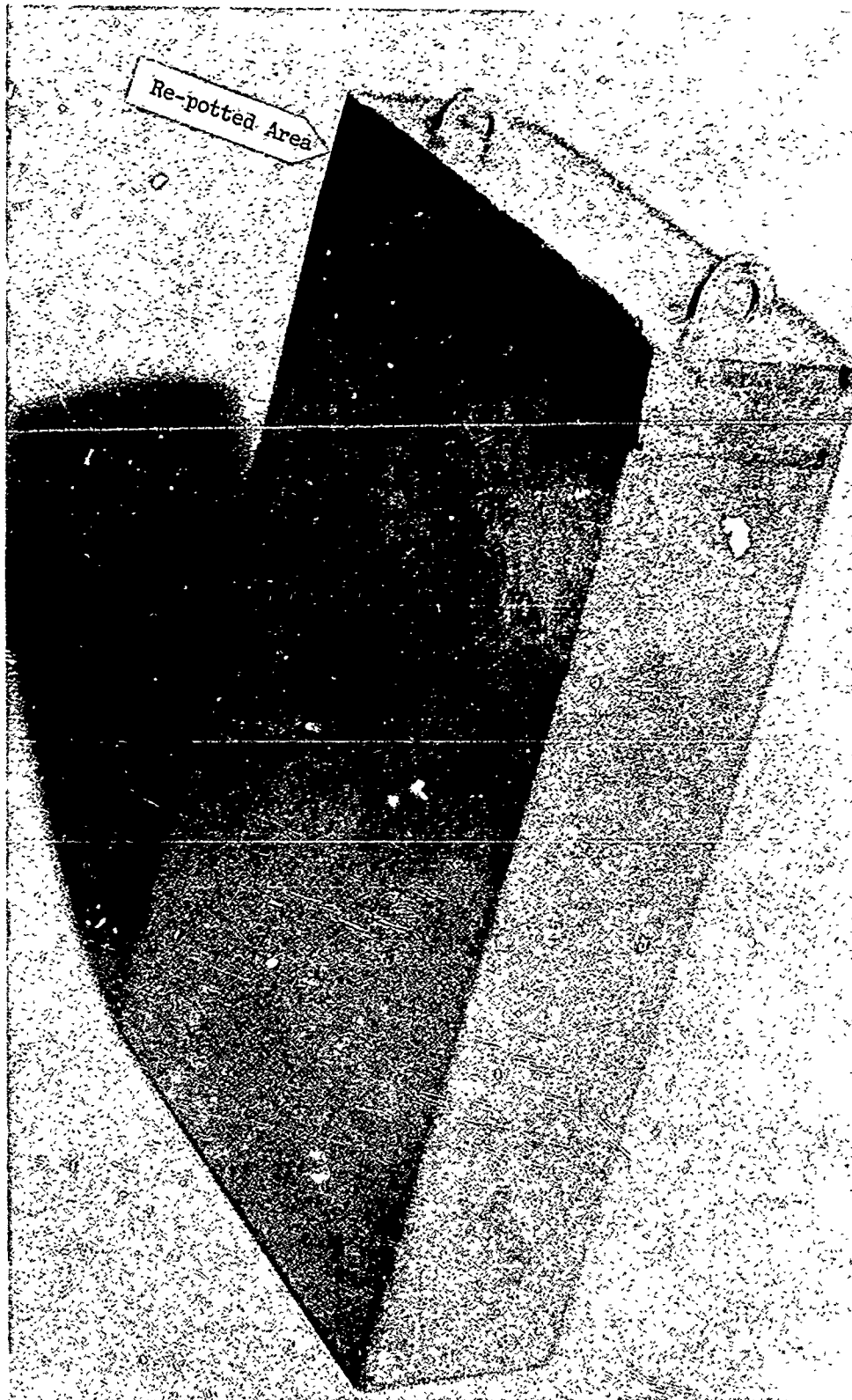
A. Each cell was weighed before and after the capacity tests prior to re-potting. The cell dimensions, initial weight, and final weight are recorded in Table III.



Shown here is a new 40 ampere-hour, silver-zinc cell (manufactured by Astropower of McDonnell Douglas) as received, prior to testing at NAD Crane.

PHOTOGRAPH 1

QEEL/C 71-436



This is a 40 ampere-hour, silver-zinc cell (manufactured by Astropower of McDonnell Douglas) after re-potting upon completion of acceptance testing.

PHOTOGRAPH 2



TABLE I  
CAPACITY TESTS

| SERIAL<br>NUMBER | FIRST CYCLE      |                 | SECOND CYCLE     |                 |
|------------------|------------------|-----------------|------------------|-----------------|
|                  | AH <sub>in</sub> | AH <sub>o</sub> | AH <sub>in</sub> | AH <sub>o</sub> |
| 24               | 42.70            | 43.00           | 42.00            | 41.45           |
| 25               | 42.38            | 42.70           | 43.48            | 42.85           |
| 26               | 42.00            | 42.45           | 43.45            | 42.80           |
| 27               | 42.00            | 42.50           | 42.75            | 42.05           |
| 28               | 42.12            | 42.50           | 42.90            | 42.15           |
| 29               | dissected        |                 |                  |                 |
| 32               | 42.65            | 42.85           | 43.40            | 42.70           |
| 33               | 42.00            | 42.50           | 42.98            | 42.25           |
| 34               | 42.00            | 42.50           | 42.75            | 42.00           |
| 36               | 42.00            | 42.45           | 42.75            | 41.90           |
| 37               | 42.00            | 42.35           | 42.75            | 41.90           |
| 38               | 42.00            | 42.15           | 42.00            | 42.38           |
| 39               | 42.00            | 42.40           | 42.00            | 42.30           |
| 40               | 43.20            | 43.40           | 42.65            | 43.35           |
| 41               | 44.03            | 44.15           | 43.30            | 44.10           |
| 42               | 43.45            | 43.60           | 42.75            | 43.55           |
| 46               | 42.40            | 42.55           | 42.18            | 42.90           |
| 49               | 43.40            | 43.60           | 42.95            | 43.60           |
| 51               | 42.63            | 42.85           | 42.03            | 43.05           |

NOTE: Cycles 1 & 2 = 9A to 1.0V + 3A to 1.0V

TABLE I (Cont)

| SERIAL<br>NUMBER | FIRST CYCLE      |                 | SECOND CYCLE     |                 |
|------------------|------------------|-----------------|------------------|-----------------|
|                  | AH <sub>in</sub> | AH <sub>o</sub> | AH <sub>in</sub> | AH <sub>o</sub> |
| 52               | 42.25            | 42.35           | 42.00            | 42.95           |
| 53               | 42.83            | 42.90           | 42.35            | 43.05           |
| 54               | 44.38            | 42.65           | 42.20            | 42.70           |
| 55               | 44.38            | 42.75           | 42.00            | 42.75           |
| 56               | 43.15            | 41.45           | 42.00            | 42.70           |
| 57               | 43.20            | 41.60           | 42.00            | 42.45           |
| 58               | 44.38            | 42.85           | 42.00            | 42.65           |
| 59               | 45.00            | 43.30           | 42.30            | 42.70           |
| 60               | 44.38            | 42.65           | 42.30            | 42.70           |
| 61               | 45.38            | 43.70           | 42.00            | 42.65           |
| 62               | 44.38            | 42.85           | 42.00            | 42.55           |
| 63               | 44.38            | 42.90           | 42.00            | 42.65           |
| 64               | 44.38            | 44.85           | 43.13            | 43.15           |
| 65               | 44.38            | 44.95           | 43.23            | 43.25           |
| 66               | 43.08            | 42.65           | 42.53            | 42.60           |
| 67               | 43.85            | 41.90           | 42.00            | 42.10           |
| 68               | 42.90            | 42.55           | 42.40            | 42.50           |
| 69               | 44.38            | 44.90           | 43.40            | 43.60           |
| 70               | 43.08            | 42.65           | 42.43            | 42.40           |
| 71               | 44.38            | 44.15           | 43.10            | 43.05           |

TABLE I (Cont)

| SERIAL<br>NUMBER | FIRST CYCLE |        | SECOND CYCLE |        |
|------------------|-------------|--------|--------------|--------|
|                  | $AH_{1n}$   | $AH_o$ | $AH_{1n}$    | $AH_o$ |
| 72               | 43.13       | 43.50  | 42.00        | 42.20  |
| 73               | 42.90       | 41.85  | 42.00        | 42.15  |
| 74               | 42.05       | 42.15  | 42.38        | 41.80  |
| 75               | 40.75       | 40.65  | 41.25        | 40.65  |
| 76               | 40.75       | 40.70  | 41.10        | 40.75  |
| 77               | 41.70       | 41.00  | 42.20        | 41.90  |
| 78               | 42.35       | 42.25  | 42.65        | 42.50  |
| 79               | 42.35       | 42.30  | 42.75        | 42.65  |
| 102              | 42.05       | 41.85  | 41.40        | 41.15  |
| 103              | 40.75       | 40.80  | 41.13        | 40.55  |
| 104              | 40.75       | 40.80  | 40.75        | 40.25  |
| 105              | 40.75       | 40.85  | 41.08        | 40.45  |
| 106              | 41.10       | 40.90  | 40.35        | 40.60  |
| 107              | 40.75       | 40.95  | 39.00        | 39.45  |
| 108              | 41.63       | 41.60  | 40.38        | 40.85  |
| 109              | 42.33       | 42.25  | 41.28        | 41.75  |
| 110              | 42.33       | 42.35  | 41.13        | 41.40  |
| 111              | 42.68       | 42.50  | 41.00        | 41.75  |
| 112              | 41.60       | 41.65  | 40.75        | 41.05  |

TABLE I (Cont)

| SERIAL<br>NUMBER       | FIRST CYCLE |        | SECOND CYCLE |        |
|------------------------|-------------|--------|--------------|--------|
|                        | $AH_{in}$   | $AH_o$ | $AH_{in}$    | $AH_o$ |
| 113                    | 42.33       | 42.30  | 40.80        | 41.15  |
| 114                    | 42.75       | 42.75  | 41.38        | 41.70  |
| 115                    | 41.10       | 41.05  | 40.38        | 40.75  |
| 116                    | 40.12       | 40.45  | 42.23        | 41.90  |
| 117                    | 41.75       | 41.65  | 43.50        | 43.05  |
| 118                    | 41.75       | 41.70  | 43.50        | 42.73  |
| Average of<br>63 cells | 42.63       | 42.41  | 42.11        | 42.18  |

QEEL/C 71-436

TABLE II

LEAKAGE TESTS\*

| SERIAL<br>NUMBER | INITIAL<br>TERMINAL |     | FINAL<br>TERMINAL |     |
|------------------|---------------------|-----|-------------------|-----|
|                  | POS                 | NEG | POS               | NEG |
| 25               |                     |     |                   | P   |
| 26               | V                   | V   | P                 | P   |
| 29               | V                   |     |                   |     |
| 32               |                     |     |                   | P   |
| 38               |                     |     | P                 |     |
| 39               |                     |     | P                 |     |
| 40               |                     |     | P                 |     |
| 41               |                     |     | P                 |     |
| 46               |                     |     | P                 |     |
| 49               |                     |     |                   | P   |
| 53               |                     |     |                   | P   |
| 55               | V                   |     | P                 |     |
| 60               | V                   |     | P                 |     |
| 75               |                     |     | P                 | P   |
| 76               |                     |     | P                 |     |
| 106              |                     |     | P                 |     |
| 107              |                     | V   |                   | P   |
| 108              |                     |     |                   | P   |
| 110              |                     |     |                   | P   |
| 113              |                     |     | P                 |     |

\*only those cells which leaked are listed.

P--Phenolphthalein

V--Visual

TABLE III  
PHYSICAL AND WEIGHT MEASURES

| SERIAL<br>NUMBER | HEIGHT<br>(INCHES) | DEPTH<br>(INCHES) | WIDTH<br>(INCHES) | WEIGHT<br>INITIAL<br>(GRAMS) | WEIGHT<br>FINAL<br>(GRAMS) |
|------------------|--------------------|-------------------|-------------------|------------------------------|----------------------------|
| 24               | 5.930              | 1.350             | 3.600             | 875.3                        | 875.3                      |
| 25               | 5.946              | 1.355             | 3.600             | 886.5                        | 886.8                      |
| 26               | 5.925              | 1.356             | 3.604             | 886.1                        | 886.2                      |
| 27               | 5.925              | 1.349             | 3.603             | 890.0                        | 890.1                      |
| 28               | 5.928              | 1.352             | 3.604             | 893.5                        | 893.6                      |
| 29               | 5.915              | 1.356             | 3.607             | 890.5                        |                            |
| 32               | 5.941              | 1.355             | 3.610             | 890.3                        | 890.4                      |
| 33               | 5.938              | 1.346             | 3.607             | 889.8                        | 890.0                      |
| 34               | 5.924              | 1.347             | 3.600             | 889.2                        | 889.2                      |
| 36               | 5.933              | 1.348             | 3.610             | 888.9                        | 889.0                      |
| 37               | 5.932              | 1.361             | 3.600             | 888.2                        | 888.0                      |
| 38               | 5.952              | 1.360             | 3.600             | 891.3                        | 891.0                      |
| 39               | 5.932              | 1.356             | 3.600             | 892.4                        | 892.2                      |
| 40               | 5.935              | 1.345             | 3.600             | 886.9                        | 886.9                      |
| 41               | 5.928              | 1.350             | 3.600             | 889.5                        | 889.5                      |
| 42               | 5.960              | 1.352             | 3.596             | 891.2                        | 891.0                      |
| 46               | 5.932              | 1.357             | 3.600             | 890.2                        | 890.0                      |
| 49               | 5.936              | 1.356             | 3.600             | 888.8                        | 886.6                      |
| 51               | 5.950              | 1.355             | 3.592             | 891.2                        | 890.9                      |
| 52               | 5.925              | 1.356             | 3.595             | 896.0                        | 896.0                      |
| 53               | 5.939              | 1.359             | 3.594             | 890.7                        | 890.5                      |

TABLE III (Cont)

| SERIAL<br>NUMBER | HEIGHT<br>(INCHES) | DEPTH<br>(INCHES) | WIDTH<br>(INCHES) | WEIGHT<br>INITIAL<br>(GRAMS) | WEIGHT<br>FINAL<br>(GRAMS) |
|------------------|--------------------|-------------------|-------------------|------------------------------|----------------------------|
| 54               | 5.930              | 1.355             | 3.592             | 886.9                        | 886.6                      |
| 55               | 5.931              | 1.355             | 3.592             | 887.0                        | 886.8                      |
| 56               | 5.925              | 1.355             | 3.600             | 887.9                        | 887.6                      |
| 57               | 5.956              | 1.356             | 3.594             | 886.9                        | 886.7                      |
| 58               | 5.950              | 1.356             | 3.595             | 891.6                        | 891.2                      |
| 59               | 5.961              | 1.355             | 3.598             | 888.0                        | 887.7                      |
| 60               | 5.945              | 1.351             | 3.598             | 887.8                        | 887.5                      |
| 61               | 5.946              | 1.356             | 3.592             | 884.0                        | 883.9                      |
| 62               | 5.954              | 1.355             | 3.600             | 885.0                        | 884.9                      |
| 63               | 5.920              | 1.355             | 3.598             | 885.9                        | 885.7                      |
| 64               | 5.946              | 1.353             | 3.597             | 882.3                        | 882.0                      |
| 65               | 5.935              | 1.351             | 3.593             | 879.9                        | 879.6                      |
| 66               | 5.947              | 1.348             | 3.600             | 882.5                        | 882.2                      |
| 67               | 5.965              | 1.359             | 3.594             | 883.3                        | 882.8                      |
| 68               | 5.942              | 1.354             | 3.590             | 883.3                        | 883.1                      |
| 69               | 5.960              | 1.360             | 3.592             | 887.3                        | 887.0                      |
| 70               | 5.922              | 1.357             | 3.593             | 885.5                        | 885.2                      |
| 71               | 5.936              | 1.356             | 3.590             | 885.1                        | 884.8                      |
| 72               | 5.931              | 1.354             | 3.592             | 887.2                        | 887.0                      |
| 73               | 5.954              | 1.362             | 3.596             | 887.6                        | 887.5                      |
| 74               | 5.924              | 1.352             | 3.593             | 886.5                        | 886.5                      |

TABLE III (Cont)

| SERIAL<br>NUMBER | HEIGHT<br>(INCHES) | DEPTH<br>(INCHES) | WIDTH<br>(INCHES) | WEIGHT<br>INITIAL<br>(GRAMS) | WEIGHT<br>FINAL<br>(GRAMS) |
|------------------|--------------------|-------------------|-------------------|------------------------------|----------------------------|
| 75               | 5.936              | 1.352             | 3.598             | 890.4                        | 890.3                      |
| 76               | 5.950              | 1.361             | 3.597             | 892.1                        | 891.8                      |
| 77               | 5.930              | 1.356             | 3.593             | 885.3                        | 885.3                      |
| 78               | 5.919              | 1.355             | 3.592             | 884.5                        | 884.3                      |
| 79               | 5.933              | 1.352             | 3.596             | 883.2                        | 883.2                      |
| 102              | 5.909              | 1.364             | 3.590             | 894.4                        | 894.7                      |
| 103              | 5.917              | 1.354             | 3.591             | 891.6                        | 891.6                      |
| 104              | 5.894              | 1.355             | 3.591             | 892.3                        | 892.3                      |
| 105              | 5.905              | 1.351             | 3.593             | 890.0                        | 890.0                      |
| 106              | 5.911              | 1.359             | 3.592             | 890.0                        | 889.7                      |
| 107              | 5.914              | 1.357             | 3.591             | 884.5                        | 884.8                      |
| 108              | 5.910              | 1.354             | 3.592             | 893.4                        | 893.4                      |
| 109              | 5.922              | 1.357             | 3.593             | 880.0                        | 880.1                      |
| 110              | 5.905              | 1.350             | 3.589             | 886.4                        | 886.3                      |
| 111              | 5.906              | 1.356             | 3.595             | 886.0                        | 886.0                      |
| 112              | 5.918              | 1.356             | 3.594             | 878.7                        | 878.8                      |
| 113              | 5.911              | 1.352             | 3.592             | 886.0                        | 886.1                      |
| 114              | 5.908              | 1.352             | 3.589             | 876.5                        | 876.7                      |
| 115              | 5.905              | 1.352             | 3.594             | 891.4                        | 891.3                      |
| 116              | 5.909              | 1.352             | 3.592             | 883.4                        | 883.2                      |
| 117              | 5.925              | 1.358             | 3.590             | 880.0                        | 880.0                      |
| 118              | 5.928              | 1.354             | 3.590             | 892.6                        | 892.6                      |



QEEK/C 71-436

APPENDIX I

ASTROPOWER HS 40-7 Ag Zn CELLS  
SERIES (M-)

ACCEPTANCE TESTS ON ALL CELLS:

1. Inspect cell terminals for corrosion or leaks.
2. Inspect cases for cracks or defects.
3. Weigh all cells within 5 grams.
4. Discharge all cells with 0.5 ohms to 1.0 volts.
5. Assemble cells in 10 cell groups with end plates and connecting rods.
6. Charge at 1.5 amperes to 2.00 volts, each cell. Record cell voltages on first minute of charge and every half hour thereafter. Record Ah in.
7. Discharge at 9.0 amperes constant current to 1.0 volts. Record cell voltages during first minute of discharge and 10-minute intervals thereafter. Record Ah out. After 9.0 ampere discharge continue discharge at 3.0 amperes to 1.0 volts. Record total Ah out for the 9.0 and 3.0 ampere discharges.
8. Repeat steps 6 and 7 once.
9. Ampere-hours out at end of second discharge to be greater than 38.0 Ah. If not, cells should not be used for Sync. Orbit or P.E. Orbiter battery tests.
10. Inspect cell terminals for corrosion and leaks.
11. Weigh all cells to within 5 grams.
12. Assemble cells in 10 cell groups with end plates and connecting rods. The 10 cells for each group shall have similar Ah inputs.
13. Repeat step 6 prior to initiating Synchronous Orbit and P.E. Orbiter Battery tests.