# RCA'S PLANNED TEST PROGRAM TO COMPARE THE PERFORMANCE AND LIFE OF NiCd CELLS CONTAINING PELLON 2536 IN CONTRAST WITH PELLON 2505 SEPARATOR MATERIAL

Stephen F. Schiffer
RCA Astro-Electronics
Princeton, N.J.

## ABSTRACT

RCA Astro-Electronics will be characterizing and life-testing two groups of hermetically-sealed aerospace nickel-cadmium cells to determine the effect, if any, of a separator change on cell performance. This test, designed to provide information for a specific low-earth-orbit satellite application, will also add to the overall data-base for cells with the new separator.

## INTRODUCTION

The most widely used separator material for hermetically-sealed aerospace nickel-cadmium cells, Pellon Corporation's Pellon 2505 ML, is no longer being produced. Manufacture of this non-woven fabric was discontinued by Pellon Corporation in 1976. The last of the "stockpile" of this material available at General Electric Battery Business Department (G.E.), a manufacturer of aerospace NiCd cells for RCA Astro-Electronics and others, will be committed by early 1985.

General Electric and Pellon Corporation have recommended an alternate material-Pellon 2536- as a substitute aerospace NiCd battery separator. At the 1983 NASA/GSFC Battery Workshop, Martin Milden of the Aerospace Corporation reported on the joint Government program to qualify the new separator material for aerospace NiCd cells (ref. 1). Cells have been procured for that program and testing will begin in 1985 at the Naval Weapons Support Center (NWSC), Crane, Indiana, to qualify the new material for aerospace applications.

It is also necessary to characterize existing cell designs with the new separator for specific mission requirements and compare these results to known data with Pellon 2505 ML. RCA-Astro uses 26.5 ampere-hour (nameplate) nickel-cadmium cells procured from G.E. (G.E. P/N 42B030AB10) in low-earth-orbit satellites for both NASA and U.S.A.F. programs. RCA has been funded by these customers to run characterization and life tests on the 26.5 Ah cells under their simulated mission conditions. This test is designed to determine the effects, if any, of the separator change on cell performance related to the power subsystems and charge controllers for these satellites.

Two groups of 11 cells each of one manufacturing lot, with separator being the only variable, have been procured from G.E. and will be tested side-by-side in the sequence listed below. The test is scheduled to begin in January, 1985.

TEST FLOW SEQUENCE

1. Acceptance testing at G.E.
2. Physical inspection, impedance measurements at RCA.
3. Conditioning (25°C).
4. Capacity determination (25°C, 10°C, 5°C, 0°C, -5°C)

   2 cycles at C/2 discharge, 1 cycle at C-rate discharge at each temperature.
5. Voltage recovery test.
6. Open circuit stand test.
7. Constant-current overcharge test

   Determine stabilized overcharge voltages at 0°, 5°, 10°, 25°, -5°C.
8. V-T charge control test (5°C, 10°C, 25°C)* 6 cycles each at each V-T limit at each temperature under low-earth-orbit cycling conditions. Charge at C/4 rate until voltage limit, then taper current for a total charge time of 69 minutes. Discharge at constant power, for 33' to 25% depth-of-discharge. After 6 cycles at each V-T limit at each temperature, measure capacity by discharging until the first cell in the group drops to 1.15 volts.

8a. V-T charge control test with C/5 charge rate, 25% depth-of-discharge, at 5°C

8b. V-T charge control test with C/4 charge, 15% depth of discharge at 5°C.

8c. V-T charge control test using 2 selected curves as in '8' above, at 0°C and at -5°C.

9. Simulated orbital life test @ 5°C, real-time cycling. V-T taper charge for 69 minutes, C/4 maximum charge rate. Constant power discharge for 33 minutes to 25% depth-of-discharge. Adjust V-T limits during cycling to provide 1.04 recharge ratio (subject to later adjustment if required).

## MATERIALS EVALUATION

The specified characteristics of the 2505ML separator and the 2536 separator are shown in Table 1.

One goal of this program is to determine whether any differences develop in the other cell components, as well as the separator, after electrical cycling.

Two dry sealed cells and two filled cells will be retained for future reference of starting material characteristics, one each containing the Pellon 2505ML and the second containing the Pellon 2536 separator.

Every 6 months during the life test, a cell will be removed from each test group and the charge and discharge voltage limits for the remaining cells will be adjusted accordingly.

Cells removed from the life test will be tested as follows, with the data compared to early-life data:

Measure AC impedance
Determine overcharge voltage values
Determine full capacity at 10°C
Perform voltage recovery test at 25°C
Perform 72 hour stand test at 10°C
Perform electrolyte leak check and internal resistance test

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* V-T charge control is voltage-limited battery charging with pre-selected voltage limits. The battery is charged at a constant current until a pre-determined voltage(temperature-dependent) is reached. The voltage is limited at that value and the charging current tapers as charging continues.

Determine negative electrode precharge
and excess negative capacity

The cells shall then be physically dissected and the internal components examined. As a minimum, the following characteristics will be checked:

Positive and negative electrode thickness
Separator degradation and cadmium penetration
Positive and Negative flooded capacity

Materials from the dry sample cells will be used as a basis for comparison for these material tests.

## CONCLUSIONS

This test will provide timely data to establish V-T charge control limits and power-balance predictions for RCA's specific low-earth-orbit satellite applications. It will also provide a direct comparison under low-earth-orbit test conditions of charge and discharge characteristics and, eventually of life, of identical cells containing Pellon 2536 separator in contrast with Pellon 2505 ML, for which there is a sizable data base.

With the testing scheduled to begin in January, 1985, sufficient data should be available in advance of Flight use of these cells to provide confidence in their behavior.

## REFERENCES

(1) Milden, M.J.: Separator Qualification for Aerospace Nickel-Cadmium Cells. Presented at the 1983 NASA Goddard Space Flight Center Battery Workshop.

(2) Milden, M.J. and Harkness, J.: Separator Qualification for Aerospace Nickel-Cadmium Cells. Proceedings of the 19th Intersociety Energy Conversion Engineering Conference, 1984 pp. 108-110.

Table 1. BRIEF COMPARISON OF NiCd SEPARATOR (Ref. 2)

| ITEM | 2505ML | (2536 TENTATIVE) |
| --- | --- | --- |
| GENERAL DESCRIPTION | STABILIZED ZINC CHLORIDE BONDED NYLON | HOT INERT GAS BONDED NYLON |
| WEIGHT | 60+8 $g/m^2$ | 80+7 $g/m^2$ |
| THICKNESS (UNDER 7.28 $KG/CM^2$ | 0.007-.010 INCH | 0.007-0.009 INCH* |
| TENSILE STRENGTH | | |
| (MACHINE DIRECTION) | 3 LBS. | 5 LBS. MINIMUM |
| (CROSS DIRECTION) | 5 LBS. | 5 LBS. MINIMUM |
| ELECTROLYTE RETENTION(31% KOH) | 400% MINIMUM | 300% MINIMUM* |
| SHRINKAGE (31% KOH, 70°C, 200 HRS) | 1% MAXIMUM | 1% MAXIMUM |
| WETABILITY (31% KOH) | 5 MINUTES MINIMUM | 5 MINUTES MINIMUM |

*FROM GE SPECIFICATION A50-PB-168

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# BRIEF COMPARISON OF NICD SEPARATOR

| ITEM | 2505ML | (2536 TENTATIVE) |
|---|---|---|
| GENERAL DESCRIPTION | STABILIZED ZINC CHLORIDE BONDED NYLON | HOT INERT GAS BONDED NYLON |
| WEIGHT | $60+8\ g/m^2$ | $80+7\ g/m^2$ |
| THICKNESS (UNDER 7.28 $KG/CM^2$ | 0.007-.010 INCH | 0.007-0.009 INCH* |
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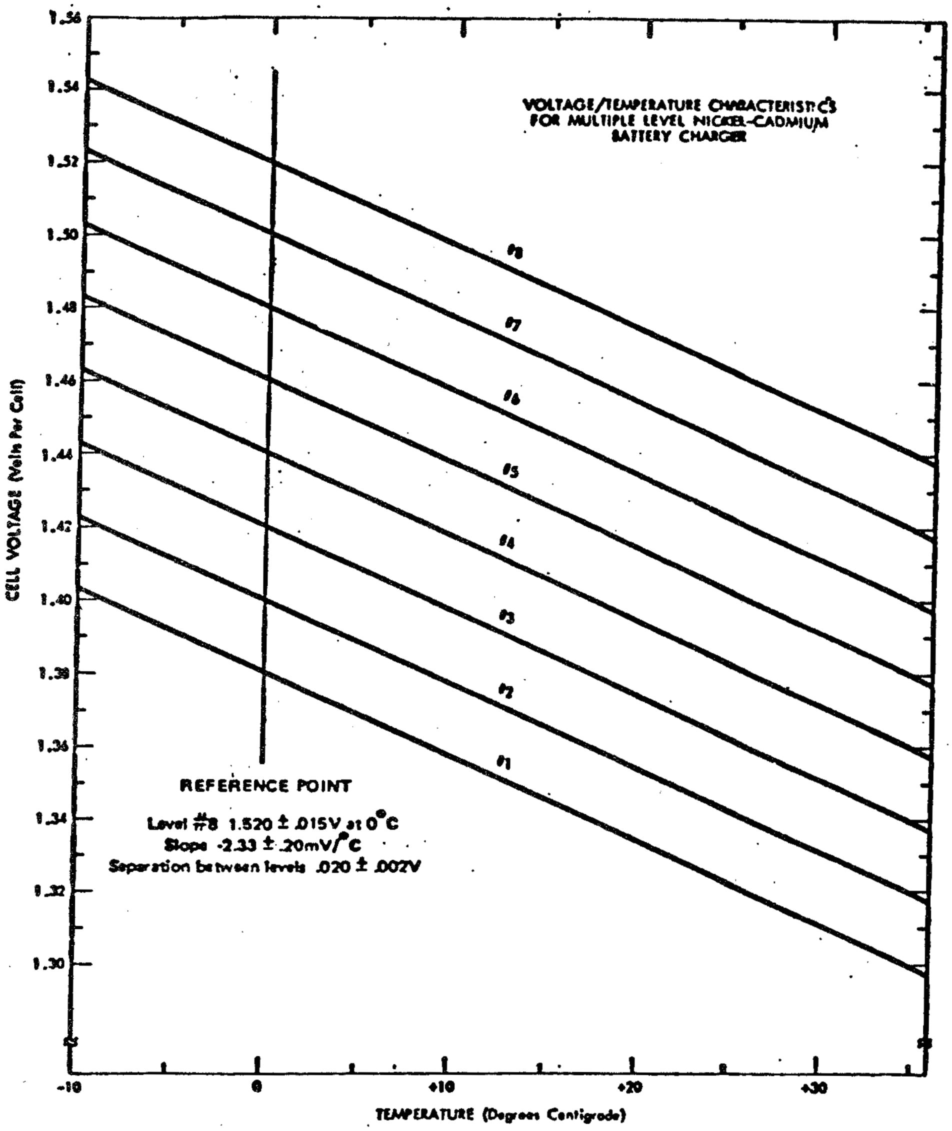
# TYPICAL V-T LIMIT CURVES




**Cell Voltage Limit versus Temperature**

ELECTRICAL TESTS, PRE-LIFE CYCLING
(11 CELLS OF EACH SEPARATOR TYPE)

- IMPEDANCE
- CONDITIONING
- CAPACITY DETERMINATION
  25°C, 10°C, 5°C, 0°C, -5°C
- VOLTAGE RECOVERY TEST @ 25°C
- OPEN CIRCUIT STAND - 72 HOURS @ 10°C
- CONSTANT CURRENT OVERCHARGE
  25°C, 10°C, 5°C, 0°C, -5°C
- V/T LIMIT CHARGE CONTROL EVALUATION
  25°C, 10°C, 5°C
  6 CYCLES AT EACH LIMIT, 69' CHARGE, 33' DISCHARGE
  25% DOD. 2 CHARGE RATES - C/4, C/5.
  CAPACITY DETERMINATION AFTER EACH 6 CYCLES.
  ADDITIONAL TESTS AT 0°C, -5°C.

## LIFE-CYCLING

- REAL-TIME, LOW-EARTH-ORBIT, 5°C
- V-T TAPER CHARGE FOR 69 MINUTES, C/4 MAX. CHARGE RATE
- CONSTANT-POWER DISCHARGE FOR 33 MINUTES TO 25% DOD
- RECHARGE RATIO: 1.04
- REMOVE ONE CELL EVERY 6 MONTHS FOR ANALYSIS
- TEST FOR THREE YEARS OR UNTIL VOLTAGE < 1.0 VOLT/CELL

## POST-CYCLING TESTS

- REMOVE ONE CELL EVERY 6 MONTHS
  - MEASURE AC IMPEDANCE
  - DETERMINE OVERCHARGE VALUES
  - DETERMINE FULL CAPACITY AT 10°C
  - PERFORM VOLTAGE RECOVERY TEST AT 25°C
  - PERFORM 72 HOUR STAND TEST AT 10°C
  - DETERMINE NEGATIVE ELECTRODE PRECHARGE AND EXCESS NEGATIVE CAPACITY
  - ELECTROLYTE LEAK CHECK
  - DISSECT

## POST DISSECTION ANALYSIS

- POSITIVE AND NEGATIVE ELECTRODE THICKNESS
- SEPARATOR DEGRADATION AND CD PENETRATION
- POSITIVE AND NEGATIVE FLOODED CAPACITY