FABRICATION & TESTING OF NEGATIVE-LIMITED SEALED NICKEL-CADMIUM CELLS

Report No. 732-015-3

Third Quarterly Report
1 January 1974 to 31 March 1974

Prepared by D.J. Gordy

28 May 1974

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Jet Propulsion Laboratory
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ABSTRACT

Negative-limited sealed nickel-cadmium cells are a possible means toward increasing the life of nickel-cadmium cells to about a decade or more. The purpose of this program is to design, construct, and test 100, 20 Ah and 100, 30 Ah negative-limited sealed cells. Fifty-two cells from each group will be selected and delivered to JPL. The remaining 48 cells of each group will be tested by Gould. The cell design was completed and hardware was ordered during the first quarter. Electrode fabrication was started in the first quarter and carried on through the second quarter. The fabrication and selection of the necessary electrodes has been completed during the third quarter. Cell construction has been completed and the preparatory cell cycling is underway. The preliminary testing to select the initial delivery cell has been started.

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I. INTRODUCTION

The sealed version of today's nickel-cadmium cell is a unique one. In terms of high-rate performance, over a wide range of ambient conditions, calendar life, cycle life, mechanical properties, etc., it is unsurpassed. In spite of its impressive performance features it has limitations where really long life (say 10 years) is required. Sealed nickel-cadmium cells with useful lives in this range are being actively pursued for aerospace applications, medical implantations, just to mention the prominent ones. In the past decade or so the nickel-cadmium cell has been developed to a point where it may be possible that gas loss from the cell is the most important life limiting phenomenon in the system.[1] The gassing that normally occurs in such cells, particularly on the positive electrode[2] during charge and overcharge can result in gas loss from the cell via diffusion. Also pressure and temperature fluctuation associated with the overcharge of the cell can damage its hermetic seals.

Gould Inc. has done work under subcontract with JPL in the past which was directed at minimizing the above-mentioned difficulties and thereby increase the life of the system to the desired level. An essentially 'non-gassing' negative-limited nickel-cadmium cell was developed.[4,5] The 'non-gassing' approach involved essentially three changes in the design of conventional nickel-cadmium batteries. These were:

1. Change the ratio of positive to negative active material in the cells so that the cells become negative-limited.
2. Use a grid material for the cadmium electrode that has a high overpotential for the hydrogen evolution reaction so that the onset of hydrogen gassing would be signaled by a relatively large voltage step.
3. Incorporation of a miniature electronic charge control device that will be used externally to each cell to end the charge using the voltage step as a signal.

During work on parts 1 and 2 (ref 4) the concept of a negative-limited 'non-gassing' nickel-cadmium battery was demonstrated by constructing and testing practical size experimental cells of approximately 25 Ah capacity. Thirty cells were constructed and tested (ref 5) for 500 cycles using an accelerated regime approximating a 90-minute orbit period. Three groups of 10 cells each were tested at 0°, 25°, and 40°C. The test program clearly showed that the negative-limited nickel-cadmium cell was a very promixing avenue leading to a practical, long-lived secondary cell.

The technology developed in the above-referenced program is being applied in the present work, which is made up of the following tasks:

- Cell design and hardware fabrication
- Component and cell construction
- Cell testing

for 100, 3 Ah and 100, 20 Ah aerospace type cells. Fifty-two cells of each size will be delivered to JPL. The remaining 48 cells will undergo varying tests including a 1000 cycle life test.

II. RESULTS AND DISCUSSION

A. Cell Design and Hardware Fabrication

1. Cell Design

The required physical dimensions of the cell components and hardware were established during the first quarter.

2. Hardware Fabrication

Stainless steel cans and covers were fabricated in the necessary sizes to accommodate the cell components. The covers were constructed with two ceramic seals; one of which was silver plated and will service the cadmium electrode. Provisions were made to attach pressure gauges and a rupture disc safety device to facilitate preliminary testing of the cells. These attachments will be removed from the initial delivery items, which will be sealed, but will remain on the cells retained for testing by Gould.

All exterior hardware items have been ordered and delivered. Screening of the cans and terminal connectors has been completed and an acceptable number have been certified to complete the necessary build.

B. Electrode Fabrication

1. Cadmium Electrodes

Electrodeposited cadmium electrodes which earlier work (ref 4,5) indicated were best suited for use in negative-limited sealed cells have been prepared and those suitable for cell construction have been selected.

These electrodes were prepared using a laboratory version of a proprietary production process whereby cadmium active mass is deposited on a 5 Ag 7-4/0 expanded silver screen (Exmet Corp). These electrodes are 2.25 x 1.75 in. and 5.50 x 3.50 in. in size. They are 0.014 - 0.016 in. thick and have an average $Cd(OH)_2$ loading of 0.89 g/in.^{2} Electrical formation steps associated with the manufacturing process were employed to screen the electrode capacities to assure that electrodes of closely balanced capacities were assembled into cells. In addition, all electrodes were carefully examined for physical defects.

2. Nickel Electrodes

Nickel electrodes of a type identical in construction, except for thickness, to those previously used (ref 4,5) have been constructed. Inco type 287 powder was first dried in a vacuum oven for one hour at 210°C. After removal from the oven, the powder was cooled in a dry room. The powder was then placed in a set of standard sieves and processed on a Ro-Tap shaker for 15 minutes. The 1.04 g/cc (Scott Densiometer, the -37μ fraction) fraction was stored in a dry room until used. A portion of the powder was sprinkled into a 6 x 12 in. mold containing a 20 x 20 mesh, 7 mil wire-woven nickel screen. The powder was removed from the mold and sintered in a vacuum furnace for 30 minutes at 1675°F.

Plaques thusly prepared were first marked to the appropriate sizes for the electrodes used in the 20 Ah and 3 Ah cells. These electrodes were then coined and current collectors were welded on. The thickness of the plaques prior to impregnation was 62.6 mils with a standard deviation of 0.8 mils. The sample size was 480.

The plaques have undergone impregnation using one of Gould's private processes. The loading was 1.925 g/cc of nickel active mass.

The electrodes prepared in this way were shown to be extremely uniform (ref 4). For the purpose of the present work it is sufficient to screen electrode weights and thicknesses to assure the desired level of uniformity. Formed electrodes were carefully inspected and rejected if physical defects like blisters were apparent.

C. Cell Assembly and Preparation

1. Cell Assembly

Cell assembly has been completed on both the 20 Ah and 3 Ah size cells. These cells were constructed using 18 mil pellon separator between electrodes and a wrap of the same separator around the final pack both vertically and horizontally. In addition 36 mils (2 layers) of separator was placed along each edge (both sides and bottom) of the cell pack to give extra insulation from the metal cell can. Terminal connections have been made, and the covers have been welded in place. Currently, the cells are undergoing a 100% leak test. To-date, approximately 40% of the 20 Ah cells have completed this testing.

2. Cell Preparation

Cells which have passed the leak testing were filled (flooded) with 30% ± 0.1% KOH and subjected to a preparatory cycling. This cycling consists of charging the cells at the C/12.5 rate and discharging them at the C/8 rate to 100% DOD. One group of 10 cells has completed these 'prep-cycles'. The average capacity (formation capacity) of this group of cells was 22.77 Ah; the standard deviation was ± 0.35 Ah, the group size was 10, the $\sum_x$ was 227.64 and the $\sum_{x^2}$ was 5,183.07.

After these preliminary cycles the cells were then sealed by placing the pressure sensing device and rupture type safety device in place.

D. Preliminary Tests To Select Delivery Cells

Preliminary testing to select the initial delivery cells has begun, but no information is available at this time. This testing is conducted at 25°C and the regime consists of 33 cycles. The first 30 cycles are at the 1C charge and discharge rates. The DOD is 25% of the rated capacity. The final three cycles are at 100% DOD and are conducted at the C/12.5 charge rate and the C/8 discharge rate. Capacity measurements made during the last three cycles, along with pressure data, will be used to match and select the initial delivery items.

III. CONCLUSIONS

During the third quarter of the program the following tasks have been completed or are in progress:

1. Hardware specifications have been confirmed and hardware construction completed.
2. Electrode fabrication and selection have been completed.
3. Cell assembly has been completed, and hardware testing and cell preparation is continuing.
4. Preliminary testing to select the initial delivery items is underway.

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