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26% Potassium Hydroxide Electrolyte for Long-Term Nickel–Hydrogen Geosynchronous Missions

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Nickel–hydrogen battery cells using 26% potassium hydroxide (KOH) electrolyte instead of the conventional 31% KOH have previously demonstrated longer life for low Earth orbit missions. However, the life increase has also been determined to be valid for high depth of discharge missions using nickel–hydrogen cells of similar design for 80% depth of discharge for 15 years or more in geosynchronous orbit. To use 26% KOH for geosynchronous applications, it was necessary to completely characterize the cells. Testing included initial capacity, storage, charge efficiency vs charge rate and temperature, cold temperature tolerance to −16°C, trickle charge efficiency, and self-discharge characterization. Results showed that the electrical performance differences between 31–26% KOH are minimal, and that the 26% KOH cells can be used to replace 31% KOH cells on geosynchronous spacecraft without change to either the battery or spacecraft configuration. In addition, data from long-term real-time synchronous testing have been reviewed, and an additional four cells with 26% KOH electrolyte have been placed in an accelerated synchronous test. These cells are capable of 80% depth of discharge for 15 years in synchronous orbit, including support for the additional demands of electric ion propulsion.

Introduction

THE use of 26% potassium hydroxide (KOH) electrolyte has been proposed for many years. Despite the obvious benefits,[1–6] use of 26% KOH electrolyte has been impeded by the lack of characterization data demonstrating its effectiveness for synchronous orbit use. This article describes the test results for six 160 A-h nickel–hydrogen cells activated with 26% KOH electrolyte. The results are then compared with similar data from cells activated with 31% KOH electrolyte. Cell performance characteristics measured are capacity, voltage on charge and on discharge, self-discharge, charge efficiency, low-temperature tolerance, transfer orbit performance, and storage.

Test Articles

The six-cell test program used single-stack, 160 A-h (576,000 C) cells, 11.43 cm (4.5 in.) diam. The cell[7] construction (Fig. 1) was back-to-back,[8] with a single layer of Zircar separator rather than the recirculating design with two layers of separator described in the reference. The positive electrodes are electrochemically impregnated using the alcohol[9] process. The 26% KOH was vacuum impregnated into the cells with the positive electrodes at approximately 60% state of charge.

Test Program

All six of the cells were activated with 26% KOH, and were activated and acceptance tested simultaneously with a lot of 30 flight cells containing 31% KOH. Two of the 26% KOH cells were centrifuged at 8 *g* for 30 min during the activation process to remove excess electrolyte. All of the cells received nickel electrode precharge[10] to prevent capacity losses during storage. In the figures that follow, where the plural cells are used, the plotted data represent averages; where the singular cell is used, the plotted data are for that single cell.

After activation, all of the cells were acceptance tested and characterized. Four of the cells, including both of the centrifuged cells, were subsequently subjected to characterization testing, while the other two cells were put into a storage test.

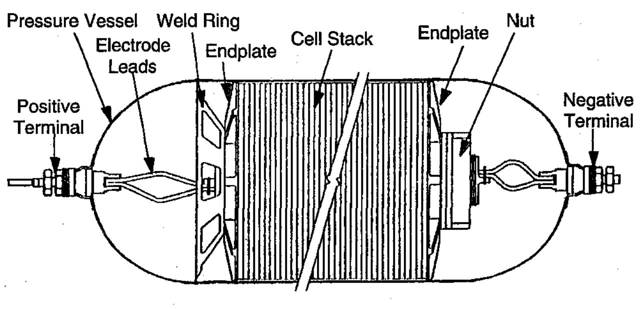
Test Results

Capacity

Production 160 A-h (576,000 C) nickel–hydrogen cells with 31% KOH range from 175 to 205 A-h (630,000–738,000 C), averaging 190 A-h (684,000 C) in capacity at 10°C. These values were obtained from a standard acceptance test (16-h charge at charge rate C/10, discharge at discharge rate C/2 to 1 V), prior to setting nickel electrode precharge. The six 26% KOH cells had capacities of 178–192 A-h (640,800–691,200 C), averaging 186 A-h (669,600 C).

Voltage Performance

Charge voltages for 26% KOH cells at C/20 (Fig. 2) are little affected by temperature except in the overcharge region (near full charge) where a temperature coefficient of −0.0028 V/°C was calculated. This coefficient is similar to that found for 31% KOH cells. Over most of the charge region the 26%



Stack Sequence: Neg Sep Pos Pos Sep Neg Gas
Neg: Negative Electrode- Teflon/Platinum/Etched Nickel Screen
Sep: Separator- Zirconia/Yttria Cloth
Pos: Positive Electrode- Nickel Hydroxide Based
Gas: Gas Distribution Screen- Polypropylene Screen

Fig. 1 Nickel–hydrogen cell.

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