TEST SUMMARY FOR ADVANCED HYDROGEN CYCLE NICKEL–CADMIUM CELL

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Summary

To improve operational tolerances and mass, the H_2 gas-recombination design provisions of the Ni–H_2 system have been incorporated into the sealed Ni–Cd system. A cell design produced is capable of operating on the "H_2 cycle" *versus* the normal "O_2 cycle". Three test cells have now completed approximately 4300 LEO (90 min) cycles at 20% DOD. Performance remains stable although one cell exhibited a temporary pressure anomaly.

Introduction

This paper is intended as an updated test summary of a small group of cells which evolved from development efforts previously reported in the NASA/GSFC Battery Workshop [1].

Three 50 A h rated, aero-space type, Ni–Cd battery cells were equipped with standard, Ni–H_2 type, catalytic gas electrodes as shown in Fig. 1. These

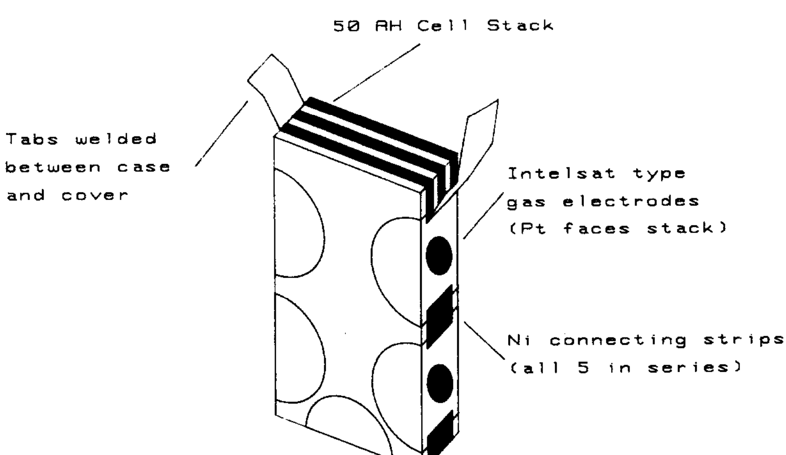

Fig. 1. Advanced Ni–Cd test cell assembly sketch.

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TABLE 1

Sealed nickel–cadmium gas electrode reactions

1. $H_2 + 2OH^- \rightarrow [2H_2O + 2e^-]$
2. $2NiOOH + [2H_2O + 2e^-] \rightarrow 2Ni(OH)_2 + 2OH^-$
Combined reaction:
3. $2NiOOH + H_2 \rightarrow 2Ni(OH)_2$

cells incorporated no discharged negative electrode capacity or "overcharge protection". Hydrogen gas evolution at the negative electrode during charge is expected and intended in this design.

By connecting (electrically) the cell case directly to the cell positive terminal, the evolved H_2 gas would be expected to be recombined rapidly by the reactions summarized in Table 1.

Design advantages

If the concept proves successful, it is believed the design will offer the advantages listed in Table 2. These advantages should allow the production of a sealed Ni–Cd cell design which can tolerate higher charge rates over a wider temperature range while offering a longer cycle life at a higher DOD.

In addition, a lower mass or improved specific energy should be achieved by elimination of the present weight associated with the negative electrode overcharge protection. This improvement relative to a current "O_2 cycle" cell design is summarized in Table 3.

TABLE 2

H_2 Cycle Ni–Cd cell design advantages

1. Increased operational tolerance.
2. Accommodate inorganic separator candidates.
3. Function with increased electrolyte quantities.
4. Lower operating pressures.
5. Higher specific energies.

Test summary

The three 50 A h rated cells were equipped with pressure gages and mounted in a thermal control system. Shorting straps were connected from the positive terminal of each cell to its case. The charge/discharge cycle was controlled automatically at a fixed time and constant current. Limited funds necessitated manual data acquisition which imposed the need for some data extrapolation to the actual end point.

Test parameters and major events are summarized in Table 4. In general, stable performance continues to be maintained.

TABLE 3

Light-weight 50 A h Ni–Cd cell deisgn

	O_2 Cycle (g)	H_2 Cycle (g)
Positive group	456	456
Negative group	633	508*
Electrolyte	223	223
Separator	18	18
Cell cover	25	25
Cell can	98	98
Total	1453 g	1328 g
Specific energy	45.4 W h kg^{-1}	49.7 W h kg^{-1}

*Assumptions:
1. Negative/positive ratio = 1.8:1.0.
2. Removed discharged negative capacity (overcharge protection) = 125 g (70% of excess capacity).

TABLE 4

Life test summary

Operational conditions:	
Charge:	60 min/10.0 A
Discharge:	36 min/16.0 A
Return:	1.04 factor
Temperature:	10 °C
Cycles to date:	4300
DOD:	Approx. 20%
Performance (Mean values, $\bar{x}$):	
I. Initial performance — (Approx. cycle 30)	
End-of-charge $\bar{x}$ = 1.68 V	
End-of-discharge $\bar{x}$ = 1.24 V	
End-of-charge pressure $\bar{x}$ = —20 in. of Hg	
II. Capacity measurement — (Approx. cycle 500)	
Measured capacity $\bar{x}$ = 59.0 A h	
III. Capacity measurement — (Approx. cycle 1500)	
Measured capacity $\bar{x}$ = 58.0 A h	
IV. Test anomaly — (Approx. cycle 2800)	
One cell pressure behaviour (end-of-charge)	
Approx. cycle	*Pressure*
2800	—21 in. of Hg
2930	64 psi
3050	81 psi
3180	33 psi
3310	—18 in. of Hg
V. Current performance — (Approx. cycle 3360)	
End-of-charge $\bar{x}$ = 1.67 V	
End-of-discharge $\bar{x}$ = 1.23 V	
End of-charge pressure $\bar{x}$ = —22 in. of Hg	

The capacity measurements were performed via reconditioning cycles from a fully charged state.

Because of pressure recovery, no examination of the one anomalous cell has yet been performed to determine the cause of its performance difference. It is suspected that in these "first build" test cells, a high resistance may have temporarily developed in the catalytic electrode-to-positive-electrode circuit.

The test data were only tabulated to approximately cycle number 3360 because a large group of cells from another program was introduced into the thermal control system. A higher test temperature required by the large group of cells precluded a direct comparison with the earlier cycle data.

Conclusion

Testing is continuing on a small group of "H_2 cycle", sealed Ni–Cd cells with successful results. To date, 4300 LEO cycles have been achieved at a 20% DOD.

The goal is to demonstrate concept feasibility leading to the production of an advanced, sealed, Ni–Cd cell design offering improved operational tolerance and lower mass.

Reference

1 L. Miller, An advanced Ni–Cd battery cell design, *Proc. 1985 Goddard Space Flight Center Battery Workshop, NASA Conf. Publ. 2434*, GSFC Greenbelt, MD, November 19 - 21, 1985.