*Journal of Power Sources, 18* (1986) 155 - 160


# AN ADVANCED NICKEL–CADMIUM BATTERY CELL DESIGN

LEE MILLER

*Eagle-Picher Industries, Inc , P O Box 47, Joplin, MO 64802 (U S A )*

## Summary

An advanced Ni–Cd aerospace cell design is described based on incorporation of Ni–$H_2$ cell design technology. Test results demonstrate improved oxygen/hydrogen gas recombination rates and increased electrolyte levels. It is anticipated that these improvements will result in increased operational ranges and increased life.

## Introduction

An advanced Ni–Cd aerospace battery cell design is evolving as the result of the incorporation of Ni–$H_2$ battery cell design technology. High rate oxygen and hydrogen gas recombination capability with higher levels of electrolyte activation have been demonstrated. Improved performance and life are projected via an extended operational range and the use of inorganic separator materials

## Electrode stack design

The advanced electrode stack configuration is shown in Fig. 1. The first major design feature involves the use of two (2), half-thickness negative electrodes in a "back-to-back" configuration. Enhanced oxygen gas recombination is achieved by the application of a hydrophobic (to prevent electrolyte flooding), gas permeable membrane to their facing surfaces which are separated by a gas accessibility spacer material (Ni–$H_2$ design technology). Recombination performance dependency upon a specific porosity, organic separator material between the positive and negative electrodes is eliminated. Various more stable materials of inorganic composition should be accommodated, extending system life. In addition, separator flooding concerns are eliminated allowing higher electrolyte activation levels, also extending life.

The second major design feature involves the incorporation of a catalyzed gas recombination electrode. The gas electrode contacts the electrode stack edge surfaces and is connected electrically to the cell positive terminal. The design intent is to offer a mechanism for rapid hydrogen gas recombination

0378-7753/86/$3 50 

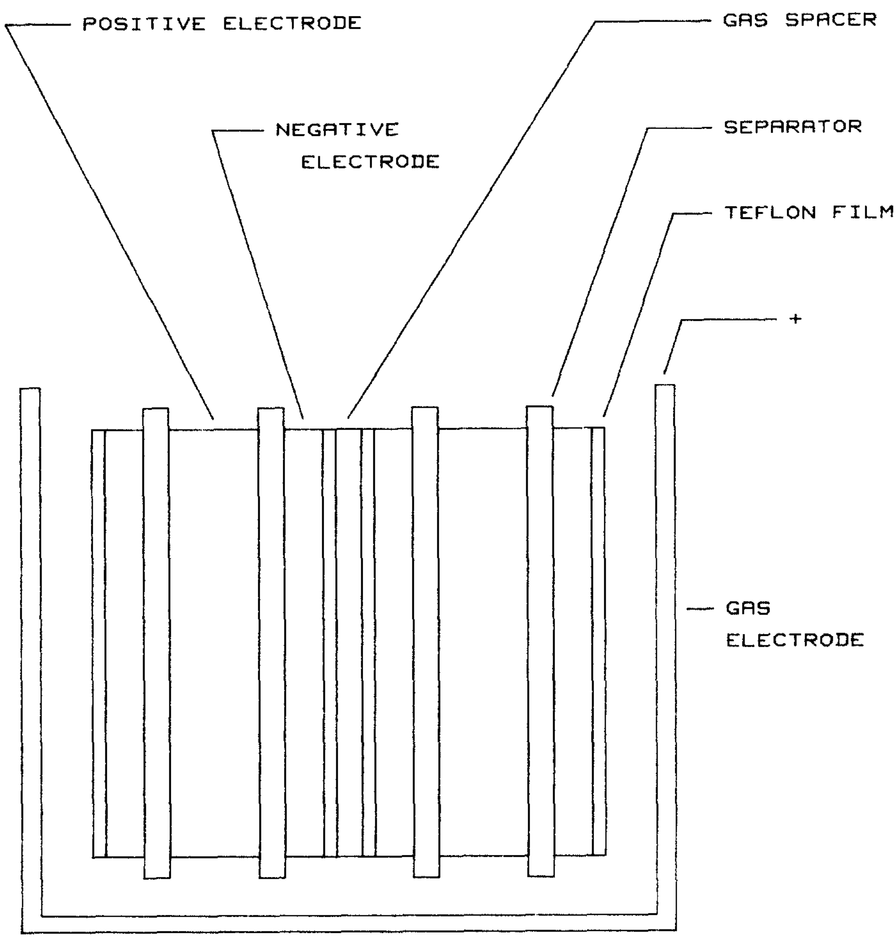


Fig 1 Sealed nickel–cadmium advanced electrode stack design

If a cell is subjected to sufficient operational or environmental stress to cause hydrogen gas generation (either deliberately to increase system performance or inadvertently), the gas would be rapidly recombined by the Ni–$H_2$ reaction described below

1. $H_2 + 2OH^- \longrightarrow [2H_2O + 2e^-]$

2. $2NiOOH + [2H_2O + 2e^-] \longrightarrow 2Ni(OH)_2 + 2OH^-$

Combined Reaction

3 $2NiOOH + H_2 \longrightarrow 2Ni(OH)_2$

## Testing

Testing of the above design concepts has been reported in a previous Battery Workshop [1]. The results of this effort may be summarized as follows.

A group of 6 A h rated cells was constructed in three (3) design versions.

(i) Standard space cell design.

(ii) As (i) except incorporating a gas electrode.

(iii) As (i) except incorporating "back-to-back" negative electrodes (split negative).

Figure 2 graphically presents the results of a test designed to evaluate electrolyte activation level sensitivity. Clearly, the "back-to-back" negative electrode design version demonstrates a significantly improved tolerance to electrolyte activation level.

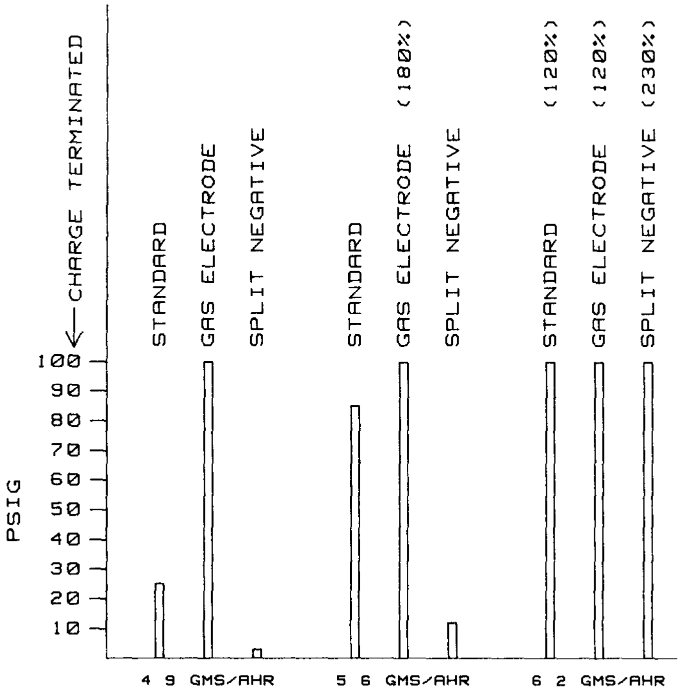


Fig 2 Overcharge pressure of oxygen *vs* electrolyte quantity Charge 250%, rate $C/10$, temperature 20 °C

Figure 3 graphically presents the results of a test designed to measure hydrogen gas recombination ability. The test temperature and charge rate were chosen to assure that the hydrogen overvoltage potential would be exceeded. Again, clearly, proper functioning of the gas electrode design version was demonstrated

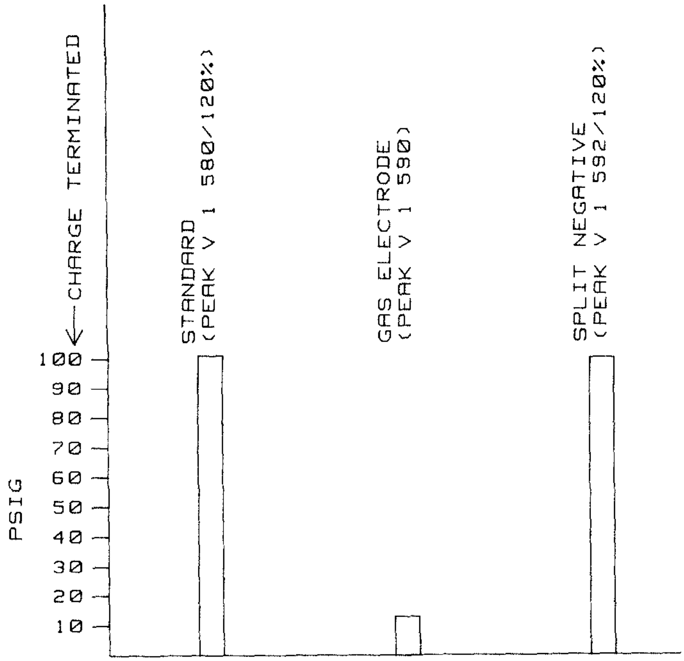


Fig 3 Overcharge pressure of hydrogen *vs* stack design Charge 200%, rate $C/10$, temperature 0 °C

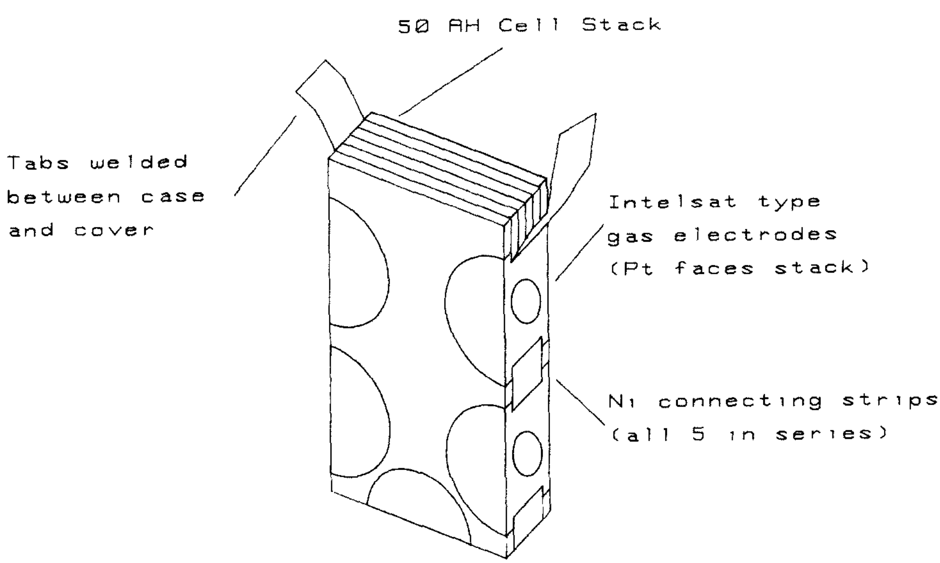


Fig 4 Advanced Ni–Cd test cell assembly

More recent testing was initiated with a small group (3 each) of current production 50 A h rated cells. All three (3) cells incorporated the same gas electrode design configured as depicted in Fig. 4 To ensure hydrogen gas generation, discharged excess negative electrode capacity or overcharge protection was not incorporated in these cells.

Figure 5 graphically presents the results of a test designed to assess hydrogen gas recombination rate capabilities. Doubling the charge rate (from $C/10$ to $C/5$), surprisingly, did not increase the maximum pressure achieved. It would appear that a relatively small catalytic gas electrode area is capable of managing high gas generation rates

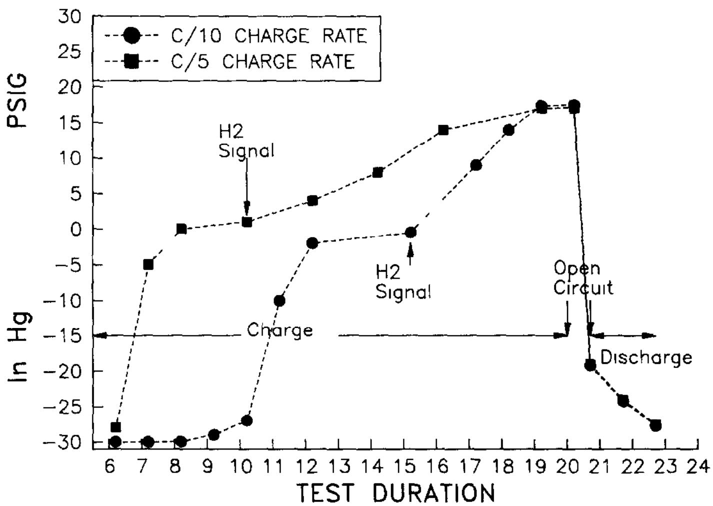


Fig 5 Hydrogen pressure for two charge rates, 50 A h rated Ni–Cd cells, test temperature 10 °C, duration 24 h

## Conclusion

The evolution of an advanced Ni–Cd aerospace battery cell design continues to prove very promising. High oxygen/hydrogen gas recombination rates (currently up to a $C/5$ charge rate) and increased electrolyte activation level tolerance (currently up to 5.6 g/A h of positive capacity) have been demonstrated.

A superior performance, extended life battery cell offering the advantages listed in Table 1 should soon be available for mission applications

TABLE 1

Sealed nickel–cadmium advanced electrode stack design advantages

| | |
|---|---|
| 1 | Greater overcharge tolerance relative to both $O_2$ and $H_2$ gas evolution |
| 2 | Significantly decreased maximum electrolyte quantity sensitivity promoting longer cycle life |
| 3 | Improved cell performance via extended operational range |
| 4 | Allows consideration of more stable, longer life, inorganic separator materials |
| 5 | Enhanced cell reversal tolerance |

## References

1 L Miller, Advanced sealed nickel–cadmium design, *Proc 1976 Goddard Space Flight Center Battery Workshop, X-711-77-28*, GSFC Greenbelt, MD, November 1976