THERMAL BEHAVIOR OF AN EXPERIMENTAL 2.5-kWh LITHIUM/IRON SULFIDE BATTERY

C.C. Chen, T.W. Olszanski, and H.F. Gibbard

October 1981

Prepared for the U.S. Department of Energy under Contract W-7405-ENG-48
DISCLAIMER

This document was prepared as an account of work sponsored by the United States Government. While this document is believed to contain correct information, neither the United States Government nor any agency thereof, nor the Regents of the University of California, nor any of their employees, makes any warranty, express or implied, or assumes any legal responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by its trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof, or the Regents of the University of California. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof or the Regents of the University of California.
THERMAL BEHAVIOR OF AN EXPERIMENTAL 2.5-kWh LITHIUM/IRON SULFIDE BATTERY

C.C. Chen, T.W. Olszanski, H.F. Gibbard

Subcontract Prepared For

Lawrence Berkeley Laboratory
University of California
Berkeley, CA 94720

By

Gould, Inc.
40 Gould Center
Rolling Meadows, Illinois 60008

October 1981

This work was supported by the U.S. Department of Energy under Contract No. W-7405-ENG-48 with Lawrence Berkeley Laboratory through subcontract 4505810 and under Contract No. W-31-109-ENG-38 with Argonne National Laboratory through Subcontract No. 31-109-38-5006.
THERMAL BEHAVIOR OF AN EXPERIMENTAL 2.5-kWh LITHIUM/IRON SULFIDE BATTERY

C.C. Chen, T.W. Olszanski, H.F. Gibbard

Gould Inc.
40 Gould Center
Rolling Meadows, Illinois 60008

High temperature lithium/iron sulfide batteries are currently under development for electric vehicle applications at Gould Inc. The preferred battery temperature range during operation and idle periods is 400 to 500°C. Thermal management is thus an essential part of battery design; the battery requires a thermal insulation vessel to minimize heat loss and heating and cooling systems to control temperature. Studies have been performed on the thermal energy generation and the gross thermal energy balance in the battery systems [1, 2, 3]. However, information is not available on the dynamic thermal response of the system which is required for the engineering design of thermal control systems. The present paper reports results of temperature measurements performed on a 2.5-kWh battery module, which was built to gain information for the design of larger systems.

Figure 1 shows the construction of the module, which consists of ten 200-Ah cells. Two movable plates, at either end of the stainless-steel case, were employed to constrain the cells against a fixed center partition. All cell surfaces, with the exception of cell lids, were wrapped with a thin mica sheet and Fiberfrax felt. These materials serve as electrical insulation and electrolyte absorber. However, their low thermal conductivity significantly impairs heat transfer from the cells. Stainless-steel cooling tubes are attached on two opposite side walls of the case, and strip heaters are fastened to all four sides. Thermocouples were used to record the temperature at 25 locations while the battery was at several operating conditions.

Figure 2 shows the temperature at three representative locations, while the battery was heated to 475°C with a heater power of 300W. The temperatures at other locations in the battery were observed to be between curves 1 and 3 in the figure. Temperature differences between thermocouple locations were relatively constant, except near the beginning and end of the heating period. This indicated that heat was transferred quasi-steadily from the heaters to the cells. The rate of temperature increase was 18.5°C per hour, with a maximum temperature difference of 60°C.

During idle periods the temperature in the battery was uniform to within 10°C. At a mean battery temperature of 475°C, the measured heat loss through the vessel walls was 81 W.
The effect of the cooling system on the battery temperature was also tested. The results of temperature measurements during a 30-minute time period at a 600 SCFH air flow rate are shown in Figures 3 and 4. The actual cooling rate decreased from 1.5 to 0.92 kW while the battery and supporting hardware cooled down over this test period. The battery temperature declined relatively slowly as compared to the surface temperature of the cooling tubes as shown in Figure 3, which indicates a large thermal resistance between the cells and the cooling system. The average battery temperature dropped about 20°C after 30 minutes of cooling, but the temperature gradient in the battery increased significantly. The shape of the temperature profile clearly shows the effect of heat conduction along the partition plate as well as the end plates.

The results of these heating and cooling tests show the need for more direct means of heat removal from the cells. Although the cooling system functioned at the desired cooling rate, it produced unacceptably large thermal gradients within the battery module. This study has produced valuable and necessary data for the design of the temperature control systems for full-scale lithium/iron sulfide batteries.

Acknowledgement

This work was supported by the U.S. Department of Energy under Contract No. W-7405-ENG-48 with Lawrence Berkeley Laboratory through subcontract 4505810 and under Contract No. W-31-109-ENG-38 with Argonne National Laboratory through subcontract number 31-109-38-5006.

References

Figure 1
Ten - Cell (2.5kWh) Battery Design

Figure 2
Variation of Battery Temperature During 300 Watt Heating Test

Figure 3
Variation of Battery Temperature During a 30 Minute Cooling Test

Figure 4
Effect of Cooling on Battery Temperature Distribution
This report was done with support from the Department of Energy. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Department of Energy to the exclusion of others that may be suitable.