DS-2 MARS MICROPROBE BATTERY

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NASA BATTERY WORKSHOP
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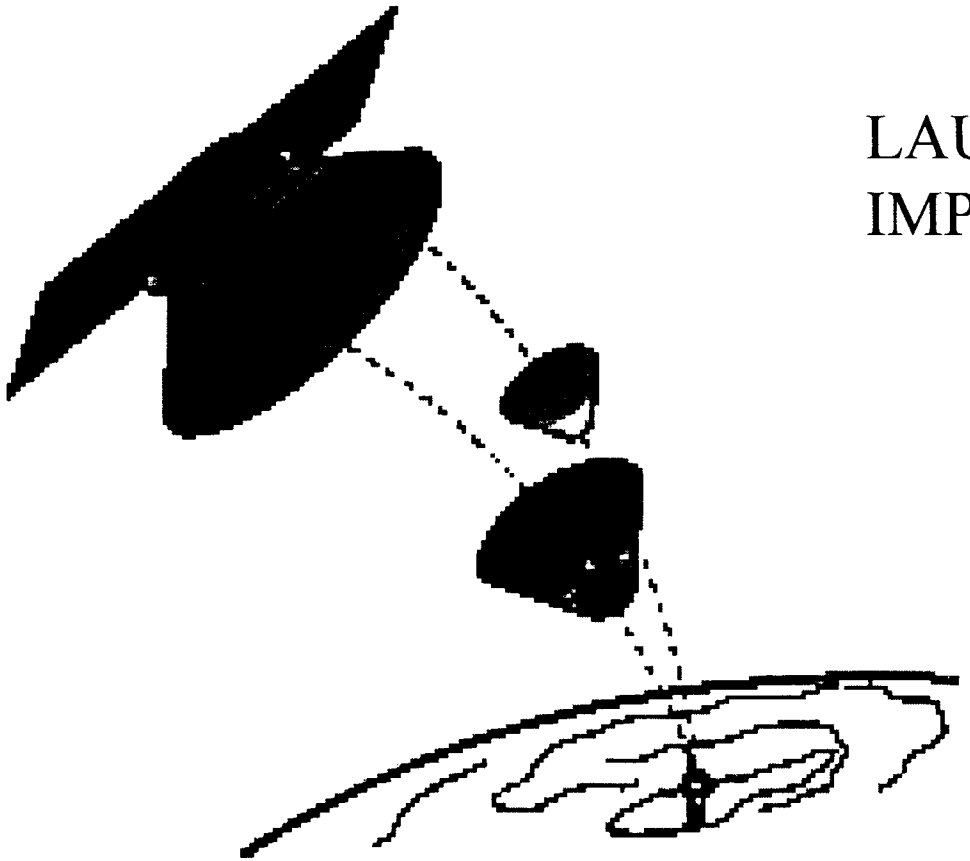
Electrochemical Technologies Group

OUTLINE

- DS-2 MISSION OVERVIEW
- DS-2 BATTERY PERF. REQUIREMENTS
- BATTERY TECHNOLOGY CHALLENGES
- CHEMISTRY SELECTION
- CELL DESIGN OVERVIEW
- PROBLEMS ENCOUNTERED
- PERFORMANCE RESULTS
- CONCULSIONS

NM DS-2 MISSION OVERVIEW



LAUNCH : JAN. 1999

IMPACT MARS: DEC. 1999

DS2 MISSION OBJECTIVES

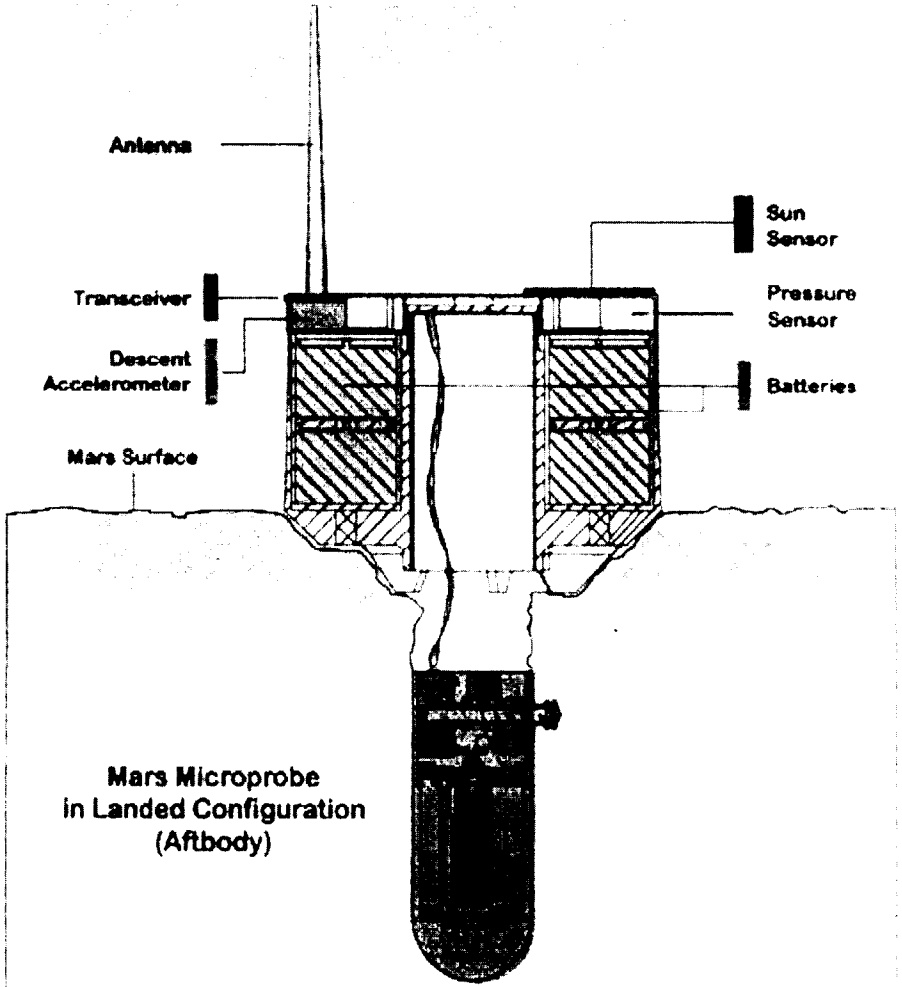
TECHNICAL OBJECTIVES

- Demonstrate key technologies which enable future network science missions (e.g., multiple landers, penetrators, or spacecraft)
- Demonstrate a passive atmospheric entry.
- Demonstrate highly integrated microelectronics which can withstand both low temperatures and high decelerations.
- Demonstrate in-situ, surface and subsurface science data acquisition

- **Scientific Objectives**

- Determine if ice is present below the Martian surface
- Measure the local atmospheric pressure
- Characterize the thermal properties of the Martian subsurface soil
- Estimate the vertical temperature gradient of the Martian soil

DS-2 AFTBODY


Antenna
Sun Sensor
Transceiver
Pressure Sensor
Descent Accelerometer
Batteries
Mars Surface
Mars Microprobe
In Landed Configuration
(Aftbody)

DS-2 MARS MICROPROBE BATTERY REQUIREMENTS

- Two 4 cell batteries
- Battery Voltage: 6-14 V
- Battery Capacity: 550 mAh at -80°C
  2 Ah at 25° C
- Shelf Life: 2.5 Years
- Operating Temp.: -60 C and below
- Shock Impact: 80,000 g

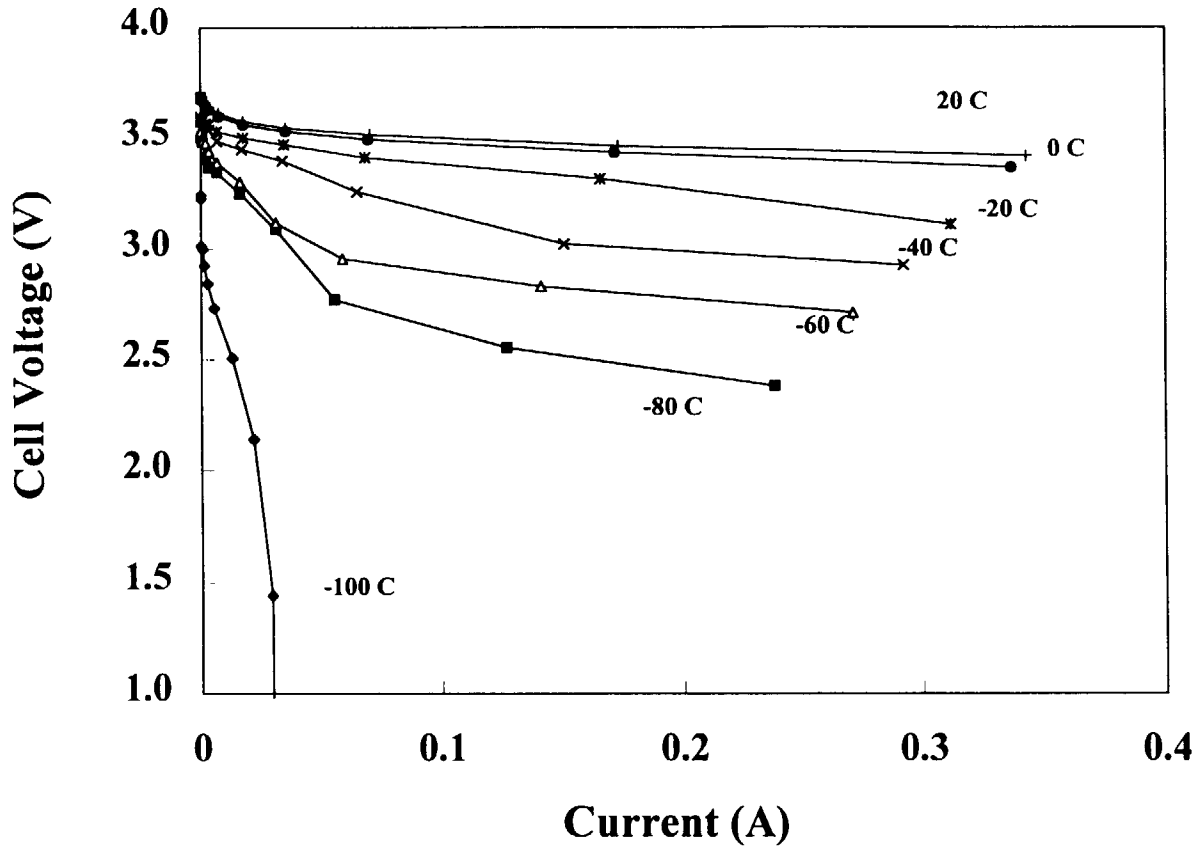
Technology Challenges

- Ultra Low Temperature Operation(-80C)
- High Impact Shock Capability
- Minimal Voltage Delay at -60 C and below
- Three Year Shelf Life

Technical Approach

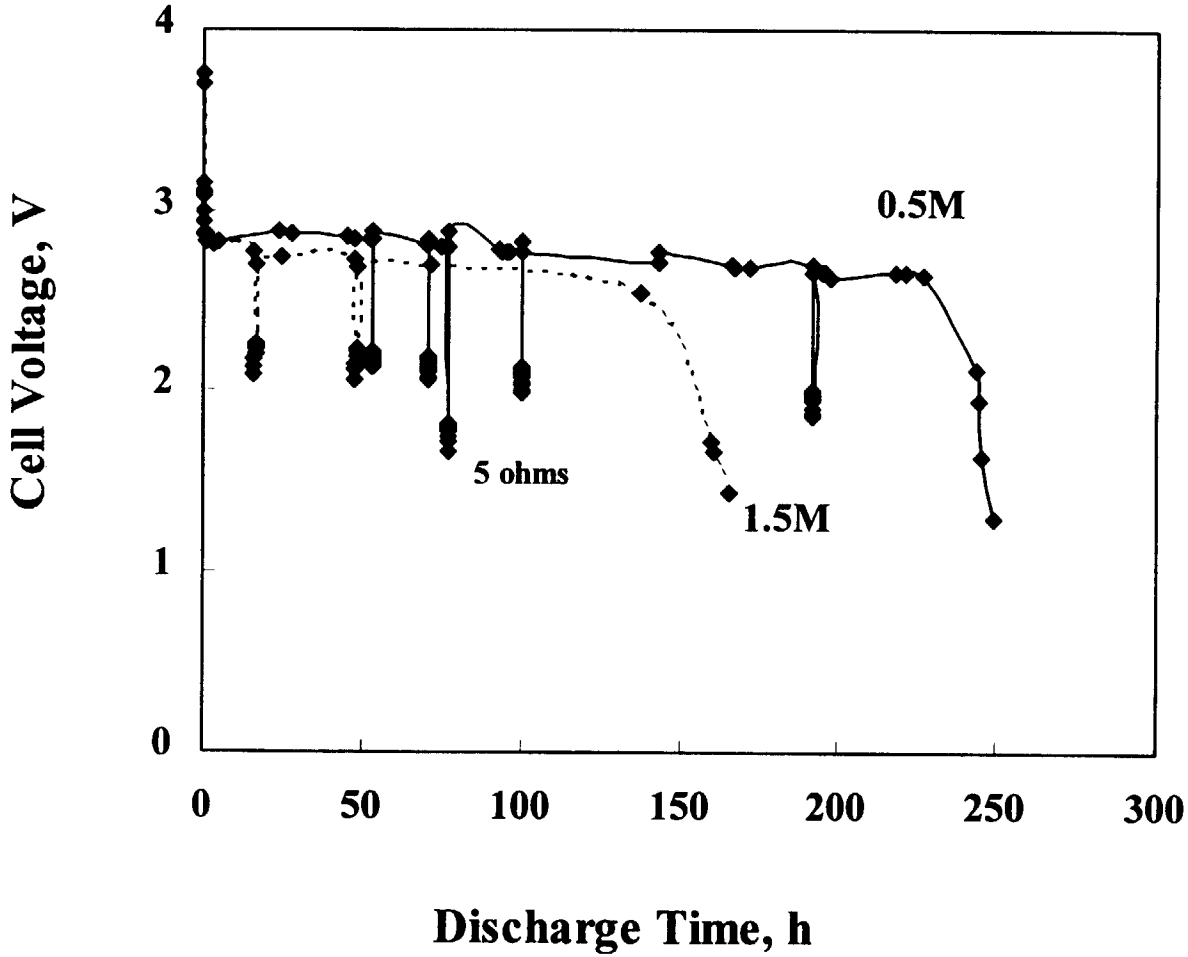
- **Select Cell Chemistry**
- **Award Contract for Cell Fabrication**
- **Demonstrate Electrical Performance at -80C**
- **Demonstrate Impact Resistance**
- **Demonstrate Life (Microcal)**
- **Demonstrate Safety**
- **Deliver Quality Cells to Project**

DS 2 BATTERY
Li-$SOCL_2$ SYSTEM



DS 2 BATTERY
Li-SOCL$_2$ CHEMISTRY DEVELOPMENT

Dsicharge curves of D-size Li-SOCl$_2$ Cell at -80°C at 120 ohm



Ds-2 Microprobe Battery

- Parallel Plate Configuration Perpendicular to to cyl. Axis
- $LiGaCl_4/SOCl_2$ Electrolyte
- Thin Electrodes
- Tefzel Spacer to Provide Stack Compression

INDUSTRIAL PARTNER: YARDNEY TECHNICAL PRODUCTS

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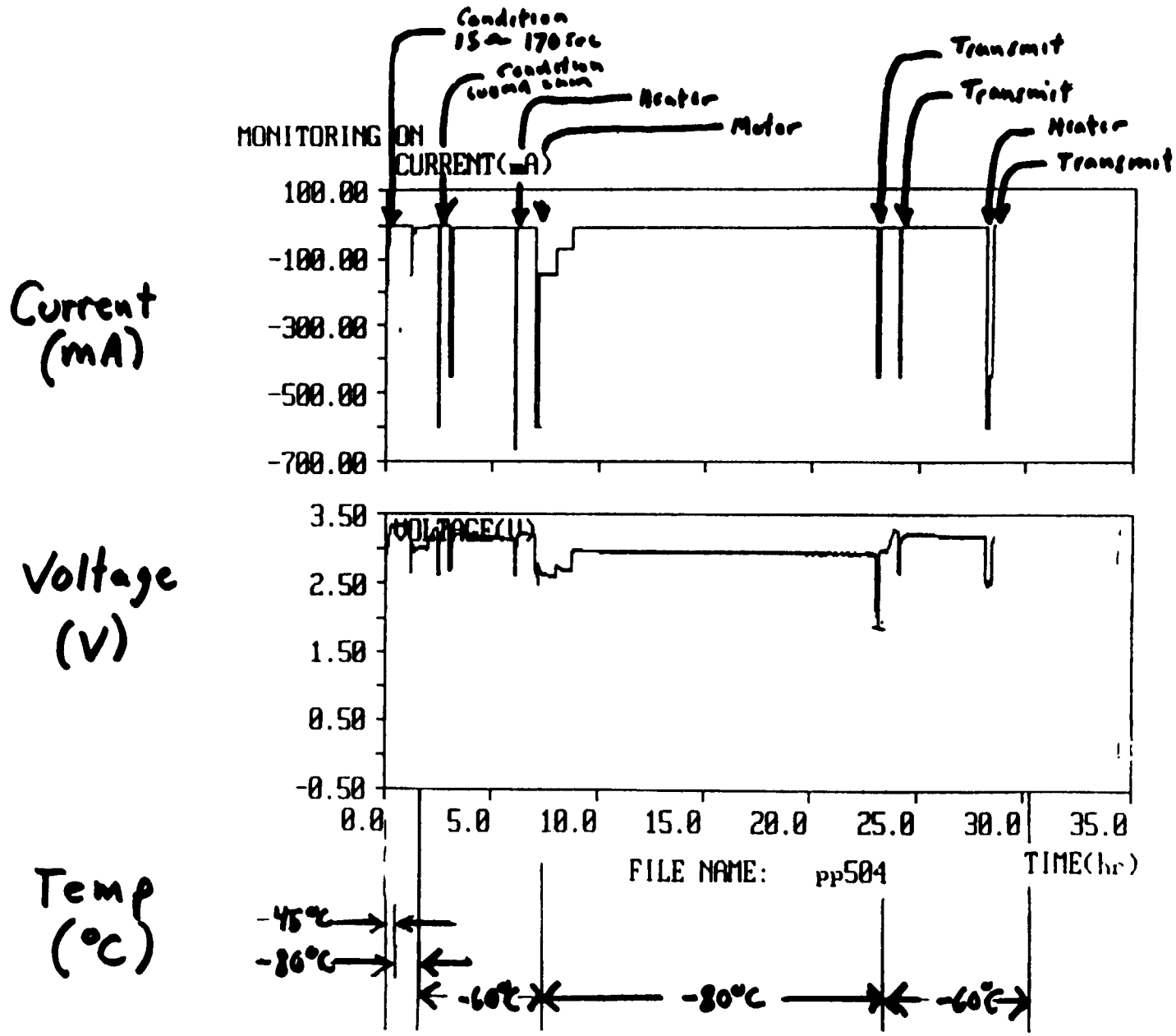
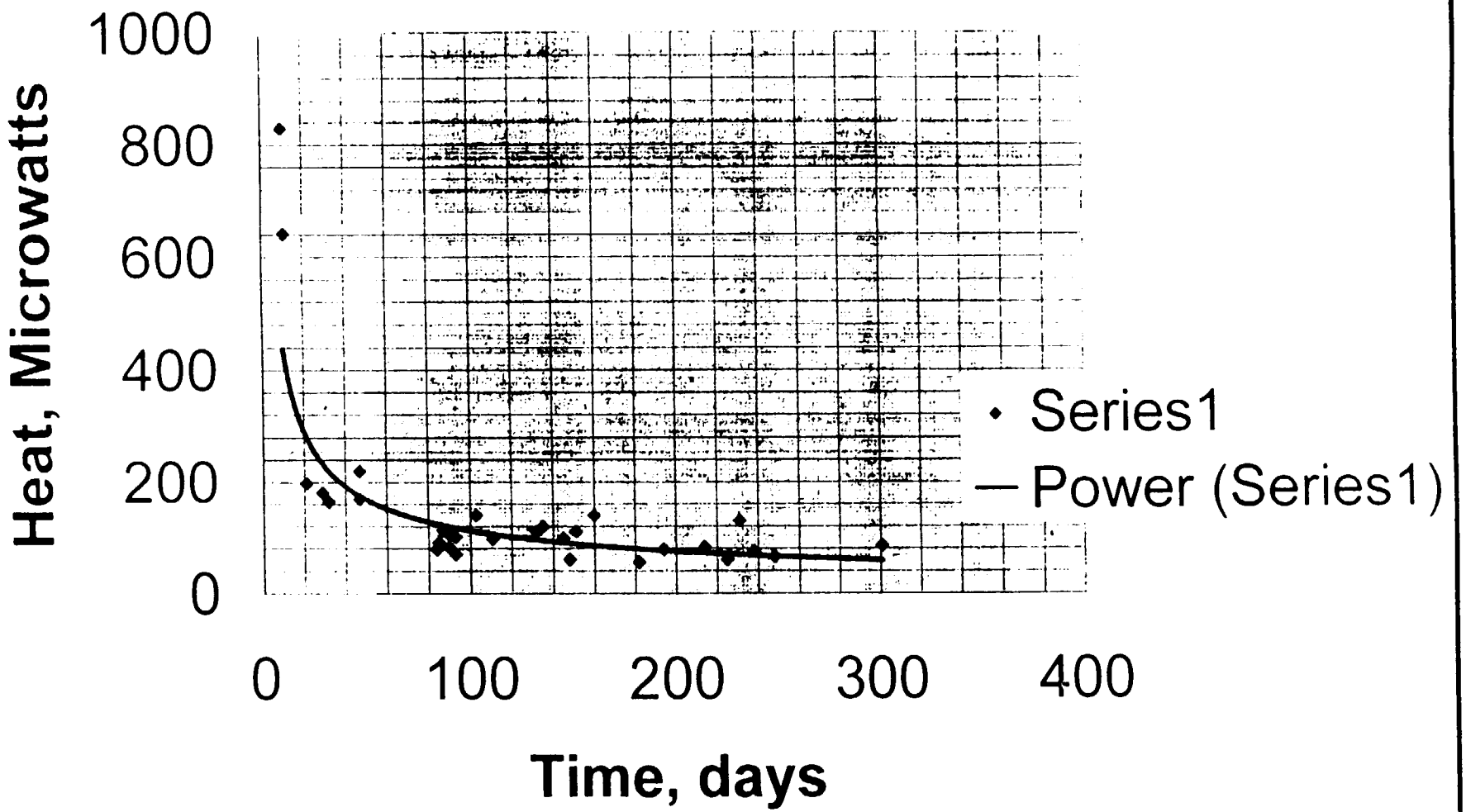
PROFILE TEST



- Meets profile with conditioning

MICROCAL SUMMARY



o MAX LOSS RATE ≃ 100 μW = 26.9 μA = 0.2 AH/yr

PROBLEMS ENCOUNTERED

- IMPACT SENSITIVITY
- CRACKING OF SEALS
- VOLTAGE DELAY

IMPACT TESTING
Problems Encountered

TEST	DATE	# Cells	CELL TYPE	PROBLEM
36	3/13/97	4	Old Design	Electrolyte Leak GTM Cracks Three Cells Functioned
38	4/4/97	2	Old Design	Electrolyte Leak GTM Cracks Two Cells Functioned
42	5/29/97	8	Old Design	Electrolyte Leak GTM Cracks Seven Cells Functioned
50	8/28/97	8	New Design	One Cell Vented, One Cell Bulged, Seven Cells Functioned
53	10/29/97	7	New Design	No Problems

SEAL PROBLEM

PROBLEMS

- RADIAL CRACKS(1-3) WERE OBSERVED IN THE GLASS TO METAL SEALS IN 34 OF 48 CELLS

- FOURTEEN CELLS SHOWED NO CRACKS ON INSPECTION

- CIRCUMFERENTIAL TOOL MARKS OBSERVED IN SOME SEALS

CORRECTIVE ACTIONS

PRE WELD FILL TUBE

IMPROVED HEAT SINKING DURING CASE TO COVER WELD

CHANGE SEAL DIMENSIONS TO REDUCE STRESS

VOLTAGE DELAY PROBLEM

PROBLEM

- Voltage delay in excess of 50 seconds was seen at temperatures lower than -45 C

CORRECTIVE SOLUTION

- Dry the Electrodes to Reduce Water Contamination
- Assemble the Cells within a Week of Electrode Manufacturing
- Ensure Electrolyte Purity (Iron, Water Content)
- Provide second depassivation pulse after landing

DS-2 BATTERY ADDITIONAL TESTS SATIFIED

- **ENVIRONMENTAL**
  - **Thermal cycling, -30 to + 75oC.**
  - **Quasi-static acceleration, 100g for 60 sec.**
  - **Random vibration**
- **SAFETY**
  - **Discharge and Reversal at 114 mA, and at 25 and -80oC.**
  - **Shorting across 0.020 Ohms.**

DS-2 BATTERY ACCOMPLISHMENTS

- Demonstrated low temp (to -80°c) capability.
- Demonstrated capability to withstand shock.
- Demonstrated functionality for mission profile at low temp after shock.
- Demonstrated acceptably low self discharge for 2 year mission life.
- Delivered hardware and documentation.

DS-2 BATTERY CONCLUSIONS

- **Can withstand shock (to 80, 000 g).**
- **Can meet discharge profile post shock at Mars temps.**
- **Self discharge rate moderate but not excessive (0.2 Ah/year max).**
- **Can meet environmental requirements and tolerate electrical abuse.**

DS-2 BATTERY ACKNOWLEDGMENTS

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