DS2 MARS MICROPROBE BATTERY

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JPL

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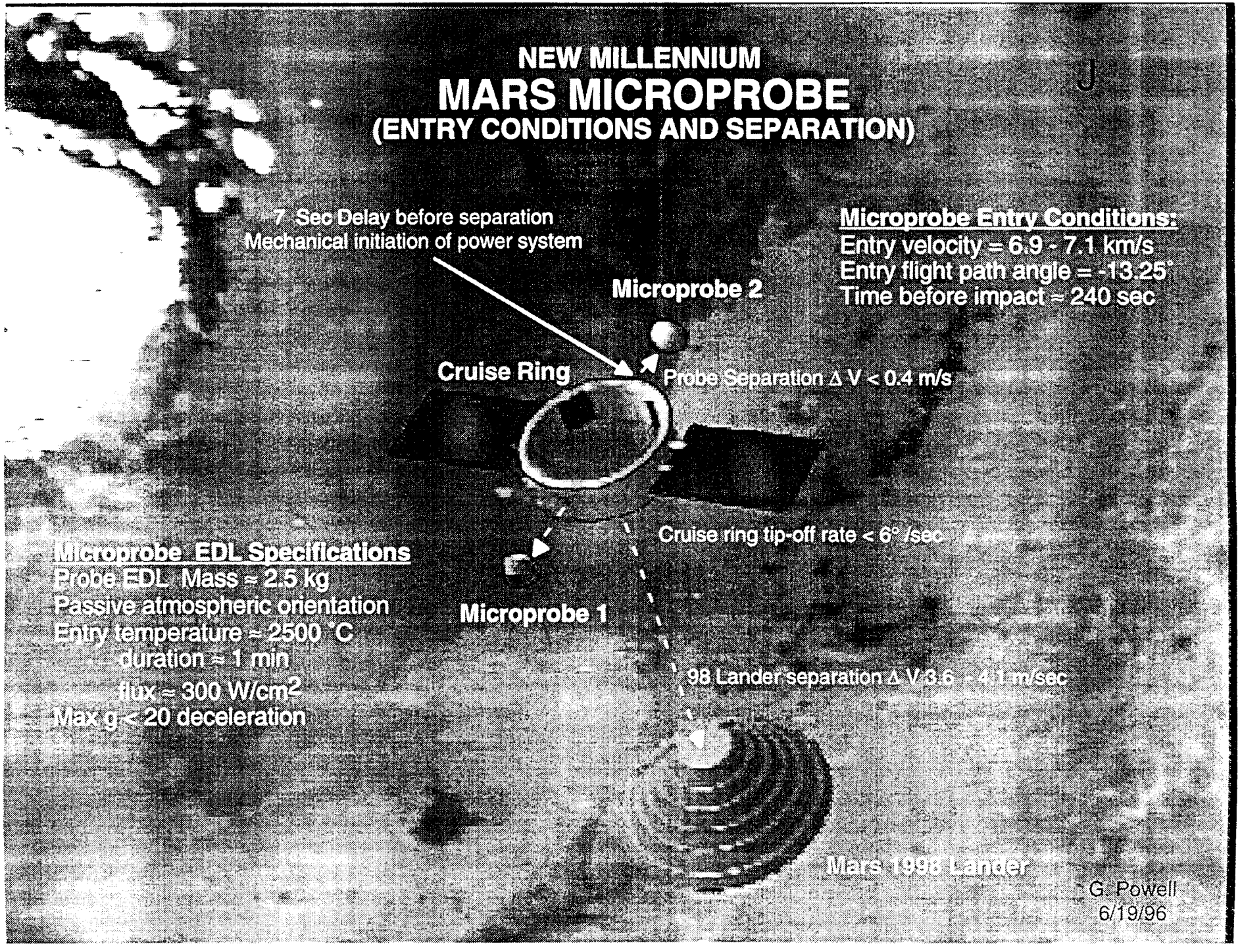
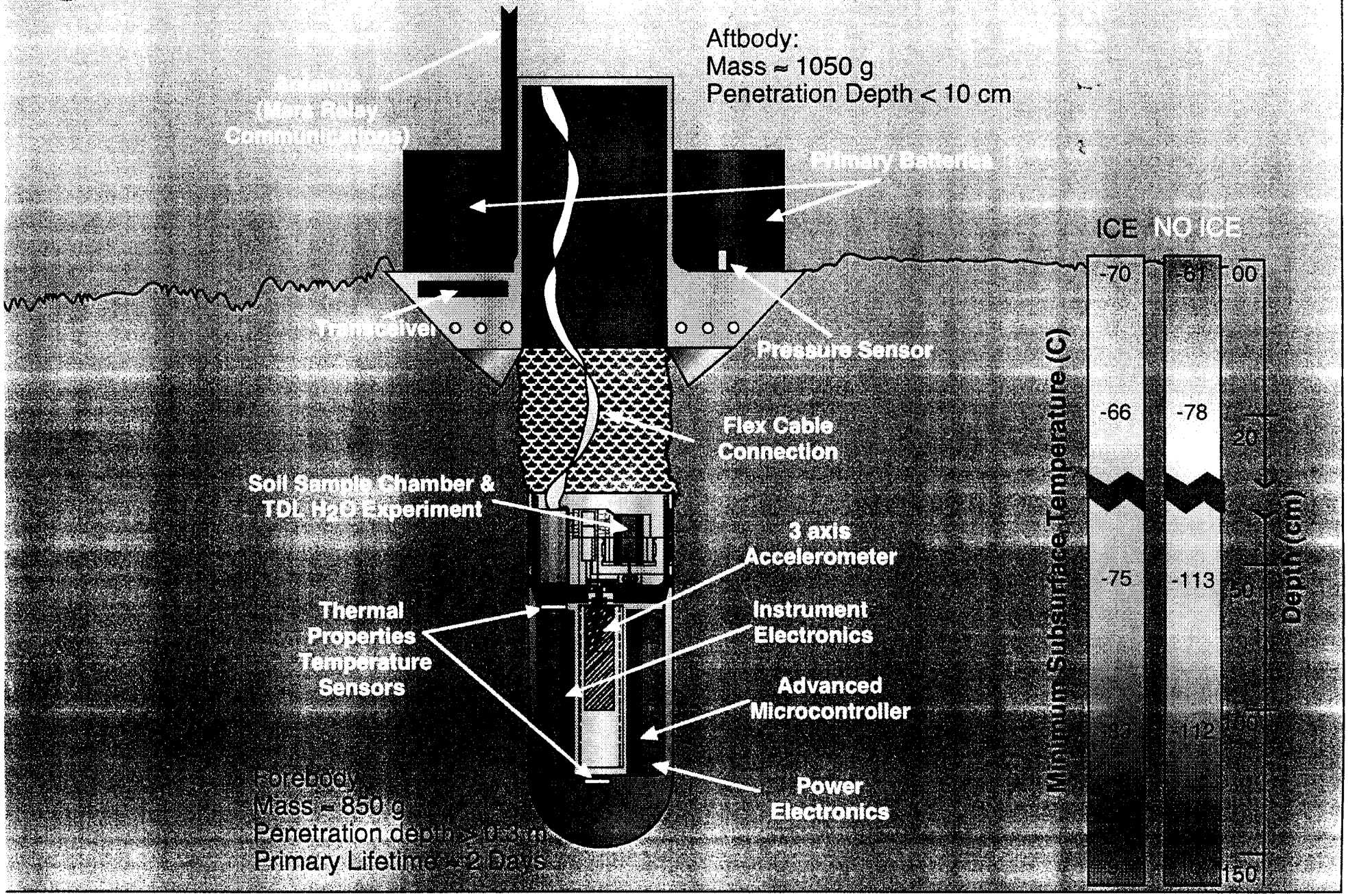
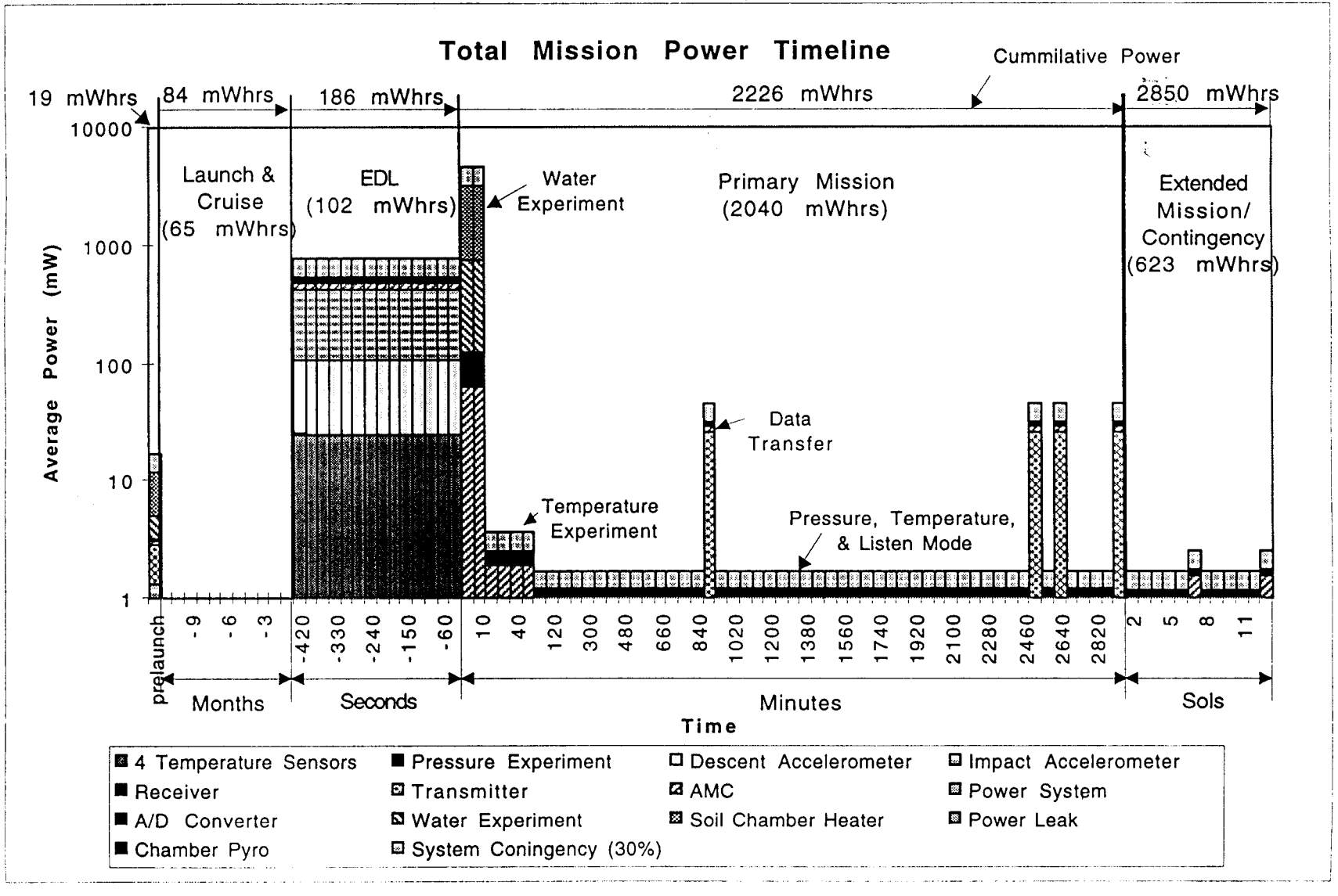
DS 2 MISSION

- Launch Jan. 1999
- Impact Mars Dec. 1999
- Aftbody with batteries & telecom stays on surface
- Forebody penetrates, ~ 1 meter
- Drill scoops soil sample into chamber
- Heat vaporize & analyze for H_20
- Transmit water & other science data


NEW MILLENNIUM
MARS MICROPROBE
(ENTRY CONDITIONS AND SEPARATION)
J
7 Sec Delay before separation
Mechanical initiation of power system
Microprobe Entry Conditions:
Entry velocity = 6.9 - 7.1 km/s
Entry flight path angle = -13.25°
Time before impact ≈ 240 sec
Microprobe 2
Cruise Ring
Probe Separation Δ V < 0.4 m/s
Cruise ring tip-off rate < 6° /sec
Microprobe 1
98 Lander separation Δ V 3.6 - 4.1 m/sec
Microprobe EDL Specifications
Probe EDL Mass ≈ 2.5 kg
Passive atmospheric orientation
Entry temperature ≈ 2500 °C
duration ≈ 1 min
flux ≈ 300 W/cm2
Max g < 20 deceleration
Mars 1998 Lander
G. Powell
6/19/96


Aftbody:
Mass ≈ 1050 g
Penetration Depth < 10 cm
Primary Batteries
Pressure Sensor
Flex Cable Connection
Soil Sample Chamber & TDL H2O Experiment
3 axis Accelerometer
Thermal Properties Temperature Sensors
Instrument Electronics
Advanced Microcontroller
Power Electronics
Forebody
Mass ~ 850 g
Penetration depth > 0.3 m
Primary Lifetime ~ 2 Days
ICE
NO ICE
-70
-66
-75
-61
-78
-113
00
20
50
100
150
Minimum Subsurface Temperature (C)
Depth (cm)


Total Mission Power Timeline
Cummilative Power
19 mWhrs
84 mWhrs
186 mWhrs
2226 mWhrs
2850 mWhrs
Launch & Cruise (65 mWhrs)
EDL (102 mWhrs)
Water Experiment
Primary Mission (2040 mWhrs)
Extended Mission/ Contingency (623 mWhrs)
Data Transfer
Temperature Experiment
Pressure, Temperature, & Listen Mode
Average Power (mW)
10000
1000
100
10
1
prelaunch
-9
-6
-3
-420
-330
-240
-150
-60
10
40
120
300
480
660
840
1020
1200
1380
1560
1740
1920
2100
2280
2460
2640
2820
2
5
8
11
Months
Seconds
Minutes
Sols
Time
4 Temperature Sensors
Pressure Experiment
Descent Accelerometer
Impact Accelerometer
Receiver
Transmitter
AMC
Power System
A/D Converter
Water Experiment
Soil Chamber Heater
Power Leak
Chamber Pyro
System Coningency (30%)

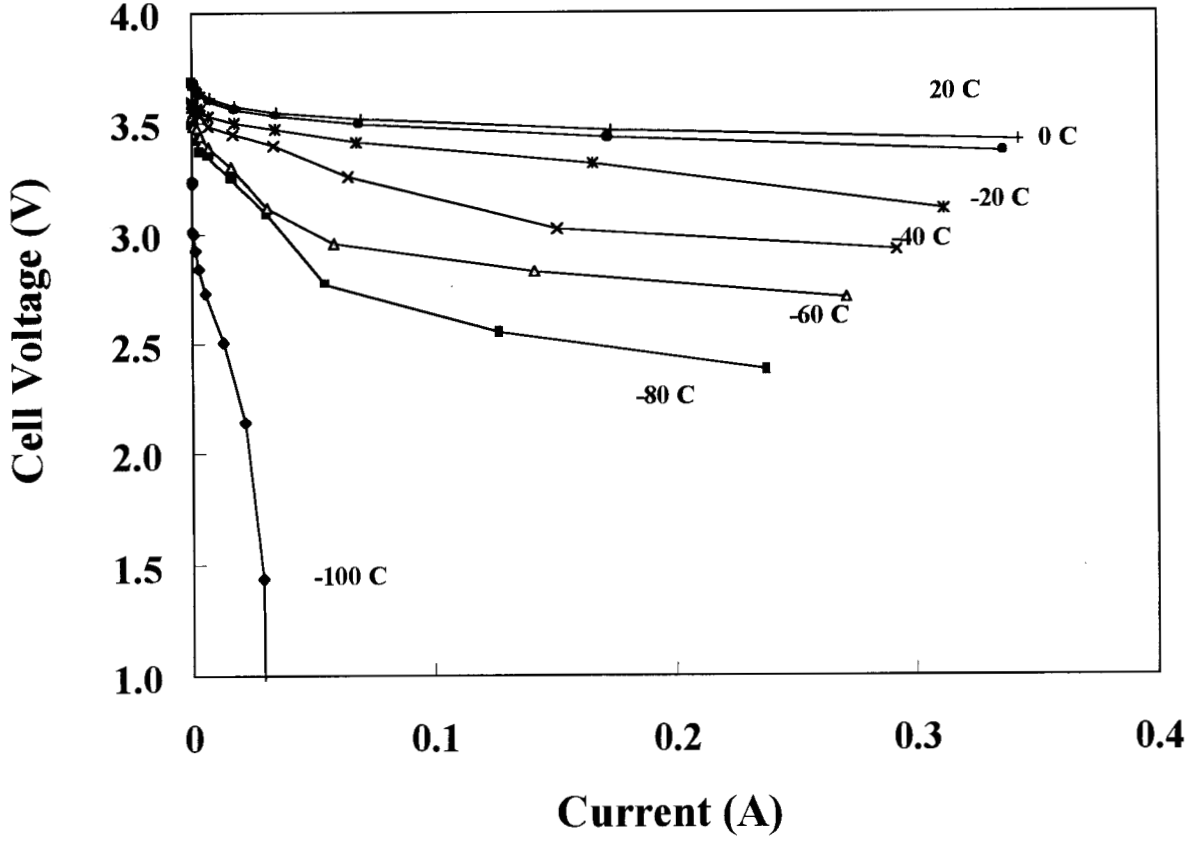
DS 2 BATTERY OBJECTIVES

- Develop battery that will meet DS-2 power requirements under specified operational, environmental, and life requirements.
- Deliver Flight Hardware Cells, Spares, and documentation packages to project.
- Ensure that all operations from cell farication to battery delivery are carried out safely.

DS 2 BATTERY TECHNOLOGY NEEDS

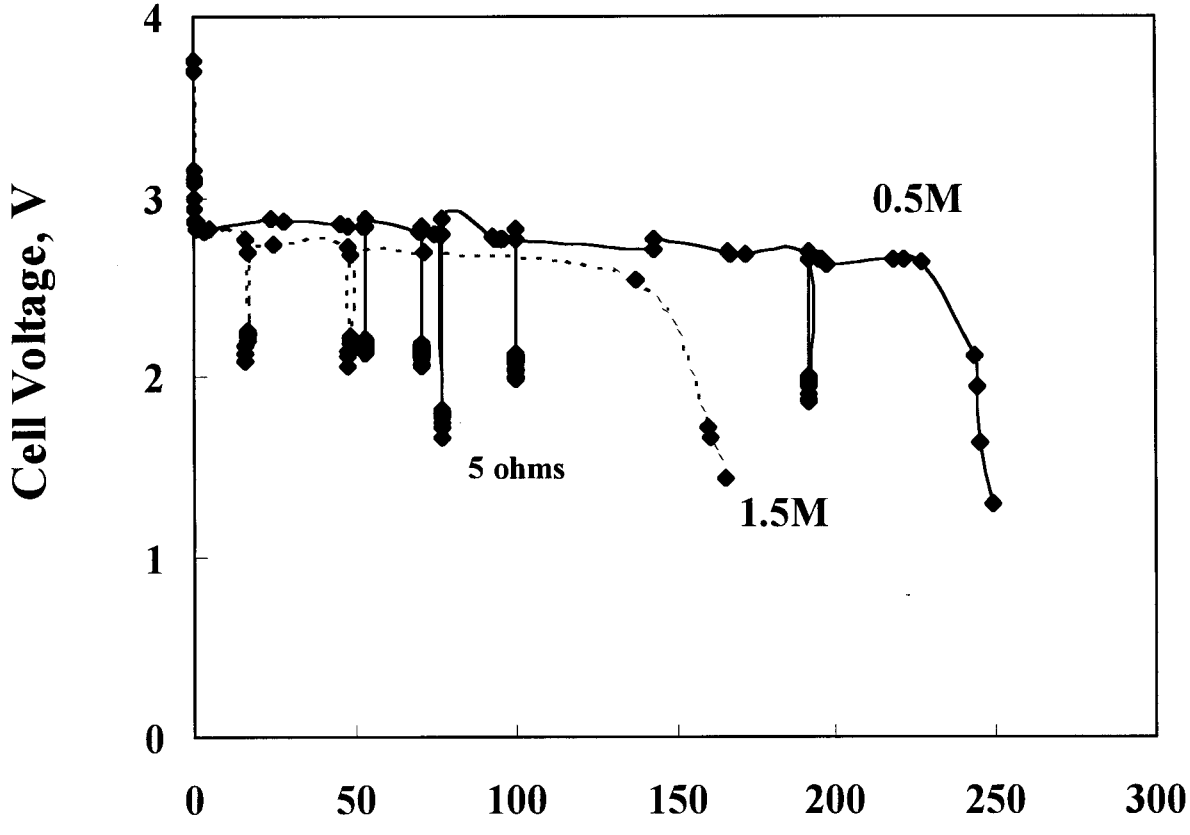
- **Operate at temperatures as low as -80°C.**
- **Withstand 80,000 g impact.**
- **Minimal voltage delay during operating at temperatures below -60°C, after 12 months of storage.**
- **3 year life**

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



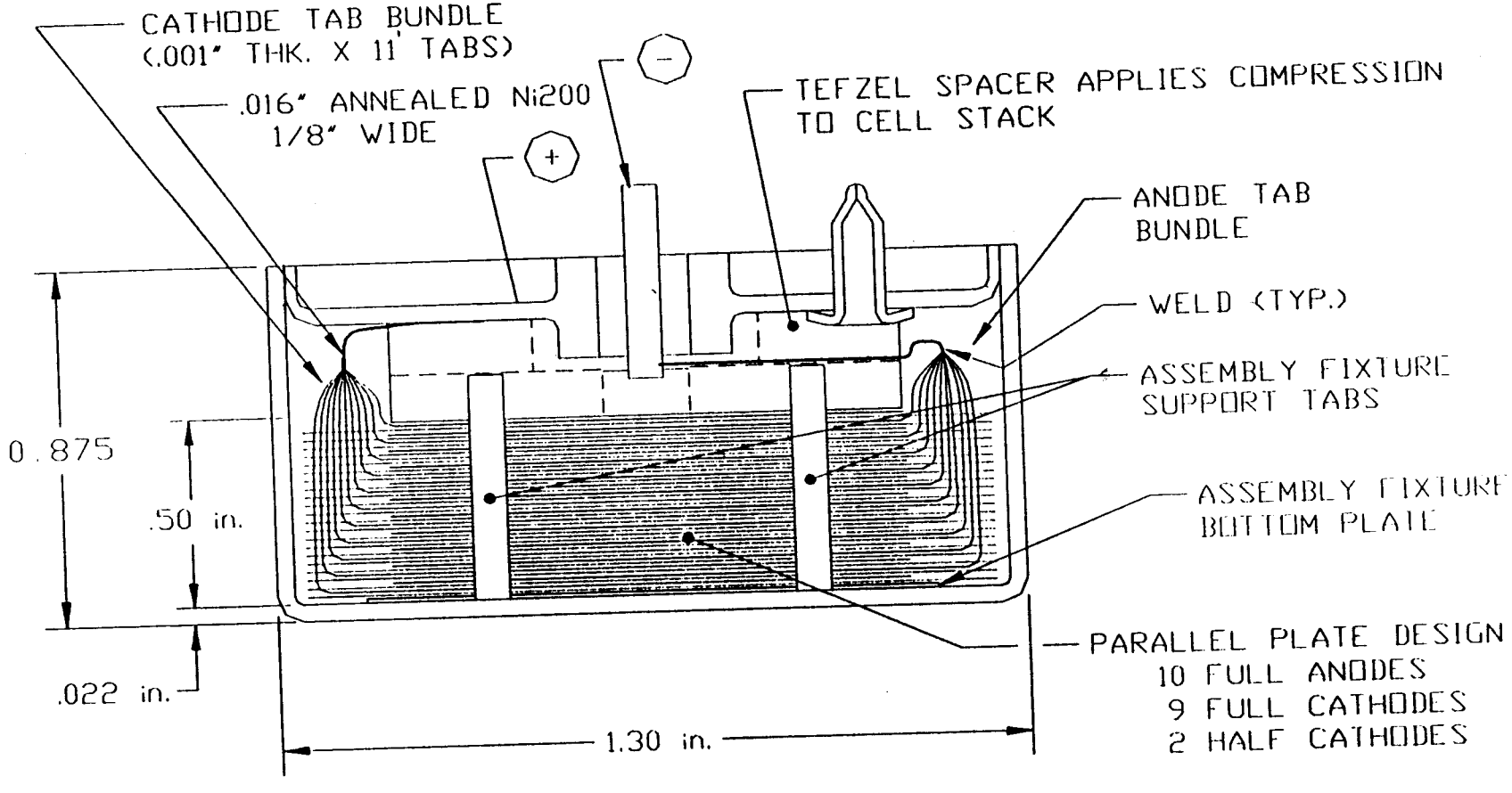
Yardney
TECHNICAL PRODUCTS, INC.

Cell Design Features

- CYLINDRICAL CELL CONSTRUCTION
- COVER WITH IMPROVED GLASS-TO-METAL
- PARALLEL PLATE ELECTRODE CONFIGURATION PERPENDICULAR TO CYLINDRICAL AXIS
- TEFZEL SPACER PROVIDES PROPER STACK COMPRESSION
- CATHODES SUBSTRATES RADIATE HEAT RADIALLY TO CELL CASE
- GALLATE ELECTROLYE PROVIDES 40% OF AMBIENT TEMP. CAPACITY AT -80°C
- SHEET FABRICATION METHOD IMPROVES EFFICIENCY OF THIN CATHODES

Final 2 Ahr Cell Design

VERTICAL CROSS-SECTION OF THE FINAL
2 Ah CELL DESIGN



SEE ACKNOWLEDGEMENT

DS-2 MARS MICROPROBE BATTERY

Battery Description

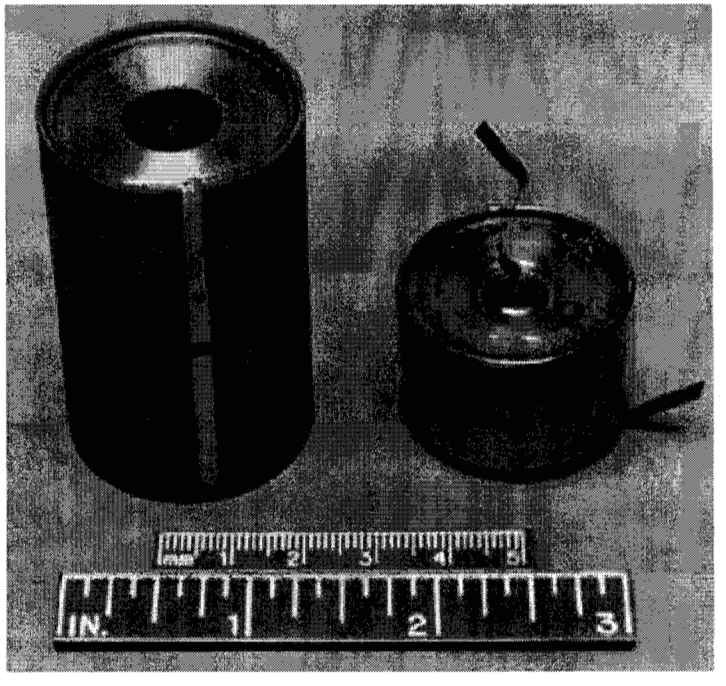
Lithium-Thionyl Chloride Chemistry
Primary Battery
Two 4 cell batteries
Battery Voltage: 6-14 V
Battery Capacity: 550 mAh at -80°C
2 Ah at 25° C
Shelf Life: 2.5 Years
Shock Impact: 80,000 g

Technology Challenges

Ultra Low Temperature Operation
High Impact Shock Capability

Industrial Partner

Yardney Technical Products



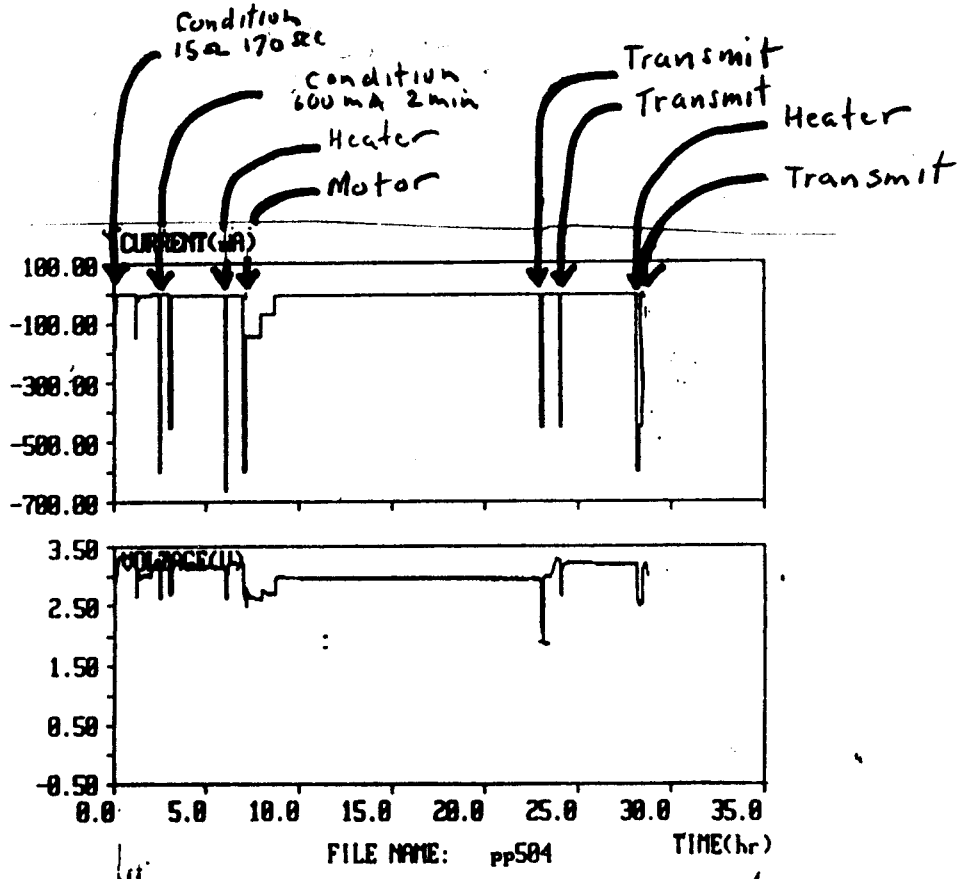
D Cell, DS-2 Cell

IMPACT TESTING

OVERVIEW

TEST NO.	DATE	CELL TYPE	NO CELLS	PROBE TYPE	AOA	HIGHLIGHT
36	3/13/97	OLD	4	21	10 degrees	All got GTM cracks and leaks, 3 functioned
38	4/4/97	OLD	2	11	NA	Both got GTM cracks and leaks, both functioned
42	5/29/97	OLD	8	11	+2	All got GTM cracks and leaks, 1 opened, 7 functioned
50	8/28/97	NEW	8	11	-15	No cracks, no leaks, 1 rented, 1 bulged, 7 functioned
53	10/29/97	NEW	7	11	+2	No cracks, no leaks, 7 functioned

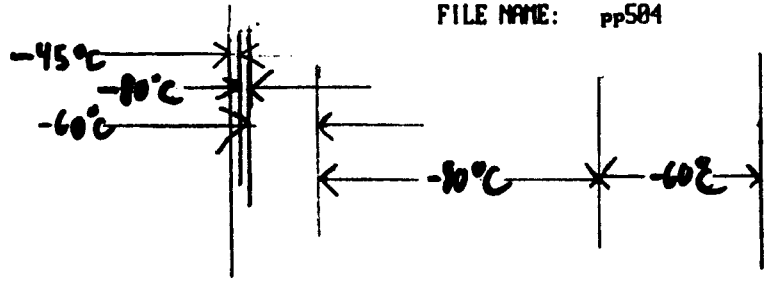
PROFILE TEST



Current (mA)

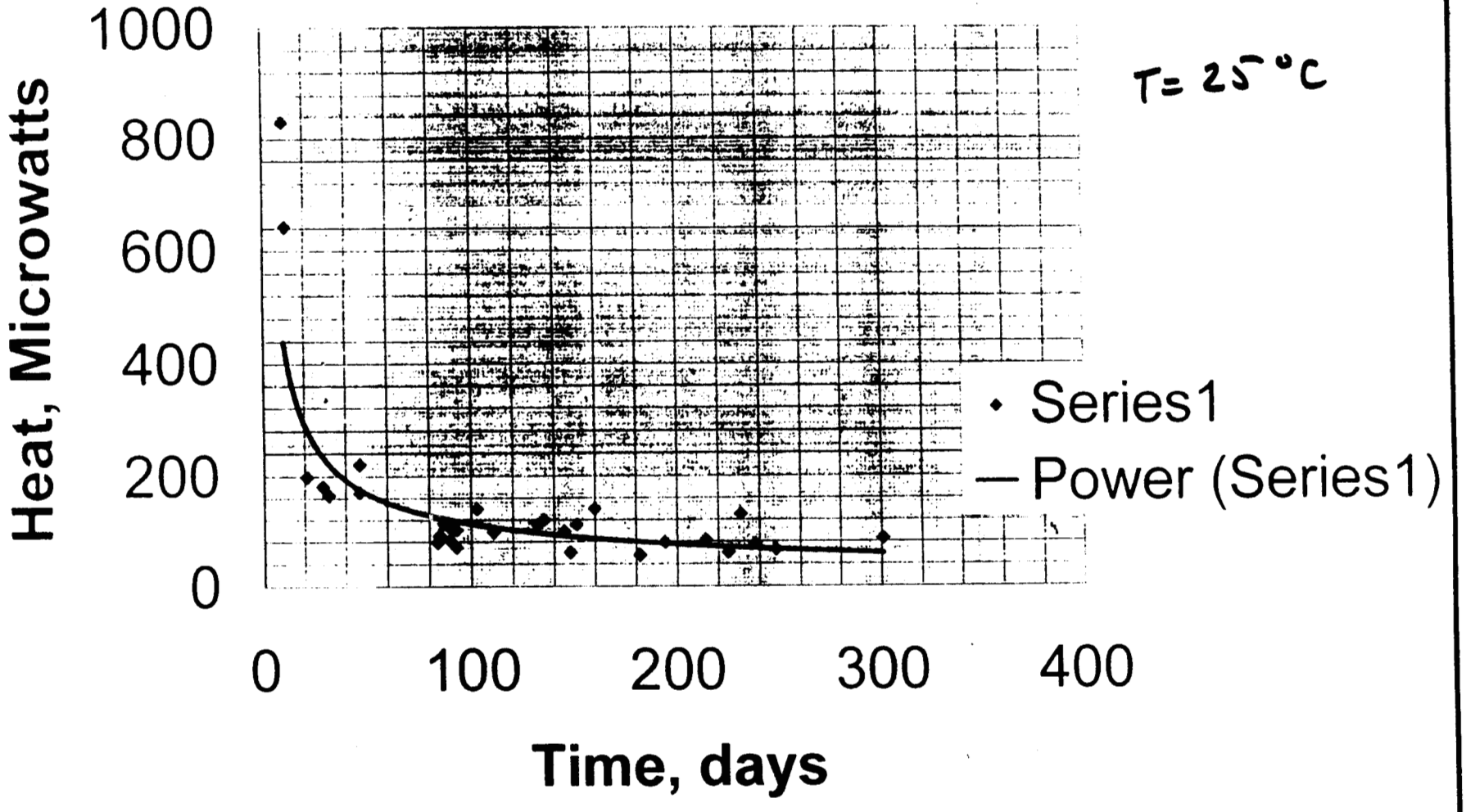
Voltage (V)

Temp (°C)



o MEETS PROFILE WITH CONDITIONING

MICROCAL SUMMARY



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

FLIGHT/QUALIFICATION CELL LOT INSPECTION FINDINGS & SEAL PROBLEM

- CELLS SHOWED NORMAL OPEN CIRCUIT VOLTAGES(3.66+/- 0.01V)
- CELL IMPEDANCES WERE FOUND TO BE IN THE RANGE OF PRIOR GOOD CELLS
- CELLS WEIGHTS AND DIMENSIONS MET SPECIFICATIONS
- 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

PFR # Z46474 BATTERY GLASS TO METAL SEAL CRACK

CORRECTIVE ACTIONS

- CHANGE SEAL DIMENSIONS
- PRE-WELD FILL TUBE
- IMPROVED HEAT SINK FOR WELDING

VOLTAGE DELAY

PROBLEM:

VOLTAGE DELAYS IN EXCESS OF
50 SECONDS

SOLUTION:

- REDUCE WATER CONTAMINATION OF ELECTRODES DURING CELL ASSEMBLY
- PROVIDE SECOND DEPASSIVATION PULSE AFTER LANDING BUT BEFORE HIGH LOAD OPERATION

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
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 ACKNOWLEDGMENTS

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