

Construction of Temperature Compensated Constant Voltage (VT) Curves for Super NiCd™ Cells

HUGHES

ELECTRON DYNAMICS DIVISION
COMMERCIAL / INDUSTRIAL SECTOR

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Abstract

Tests to establish current-voltage characteristics at selected temperatures for 9 ampere-hour Super Nickel-Cadmium™ cells were conducted at Hughes Industrial Electronics Company's Electron Dynamics Division (HIEC/EDD) under sponsorship of NASA Goddard Space Flight Center (NASA/GSFC) through their prime spacecraft contractors Fairchild Space (SMEX/SAMPEX) and TRW (TOMS-EP). Curves were constructed using techniques established by Webster, Ford, et al, at NASA/GSFC in the late 1960 - early 1970 time period for conventional nickel cadmium cells used on OAO and OSO spacecraft. The NASA/GSFC techniques were slightly modified by HIEC/EDD to fit the Super Ni-Cd situation.

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AGENDA

- I. Introduction**
 - Purpose of VT Determinations
 - Heritage - Use on OAO and OSO and current NASA spacecraft
- II. Technique for Generation of VT Curves**
 - Results from early NASA/GSFC Studies (Webster, Ford)
 - Use of Webster and Ford Techniques at HIEC/EDD
- III. Results**
 - Charge/Discharge Ratios
 - Characterization Tests
 - Plots of Recharge Ratio vs. Charge Voltage Limit
 - Voltage/Temperature Characteristics for Multiple Level Nickel-Cadmium Battery Charger
- IV. Discussions of Results**
 - Reasons for Differences in Super NiCd and Conventional NiCd Plots
 - Technique for Generation of Curves
- V. Conclusions**
 - Principle the same although curves may be slightly different for Super NiCd.
 - One set of curves can be used.

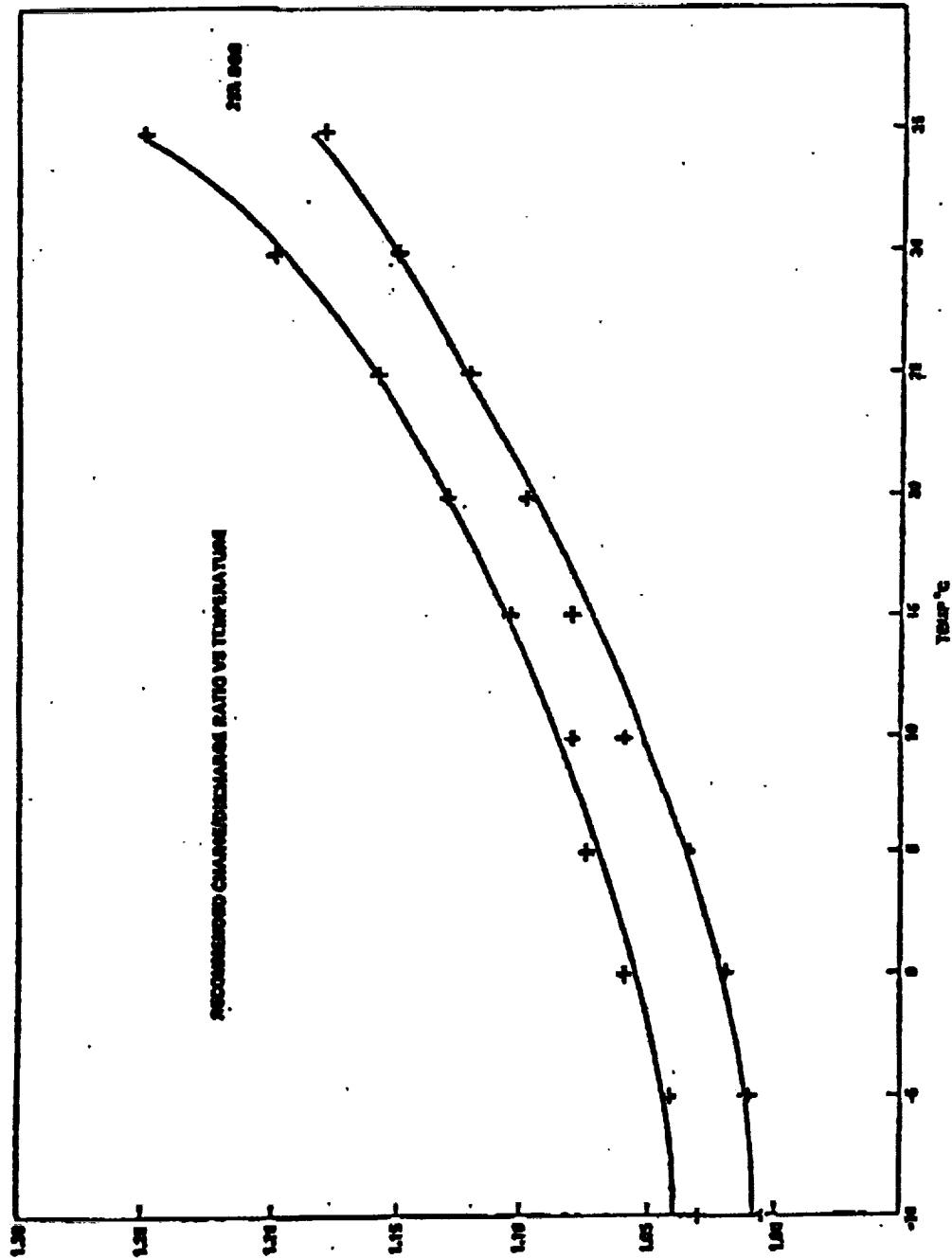
Procedure for Generation of Curves

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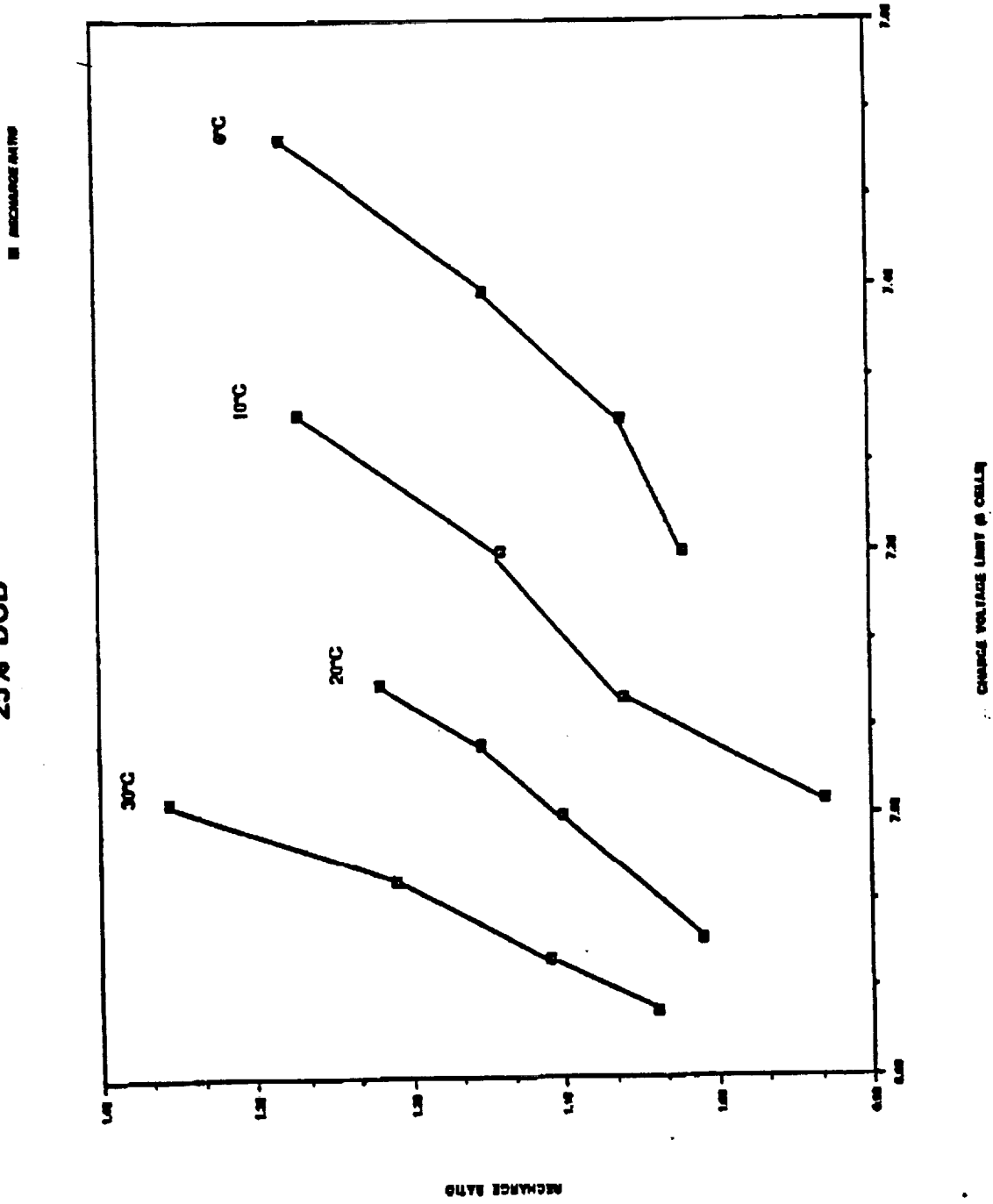
- **Select % Recharge from Figure 1.**
- **Select % DOD's (e.g., 25%) characteristic recharge ratio and voltage limit from Figure 2.**
- **Put % return on curve at appropriate temperature - Drop perpendicular to abscissa for voltage reading.**
- **To verify plot on cell voltage vs. temperature scale, compare with past curves (Figure 3).**
(Set level 8 at $1.520 \pm .015$ at 0°C , $0.020 \pm .002$ per level)
- **Level 8 limit may not be used.**
- **Level 7 for max. DOD expected.**
(Curves 1 & 2 allow operation with loss of cell)
- **Operate 1 level lower than expected at BOL.**
(Level 3 at 10% DOD, Level 5 at higher DOD)

FIGURE 1



Recommended Charge/Discharge Ratio versus Temperature

FIGURE 2
25% DOD



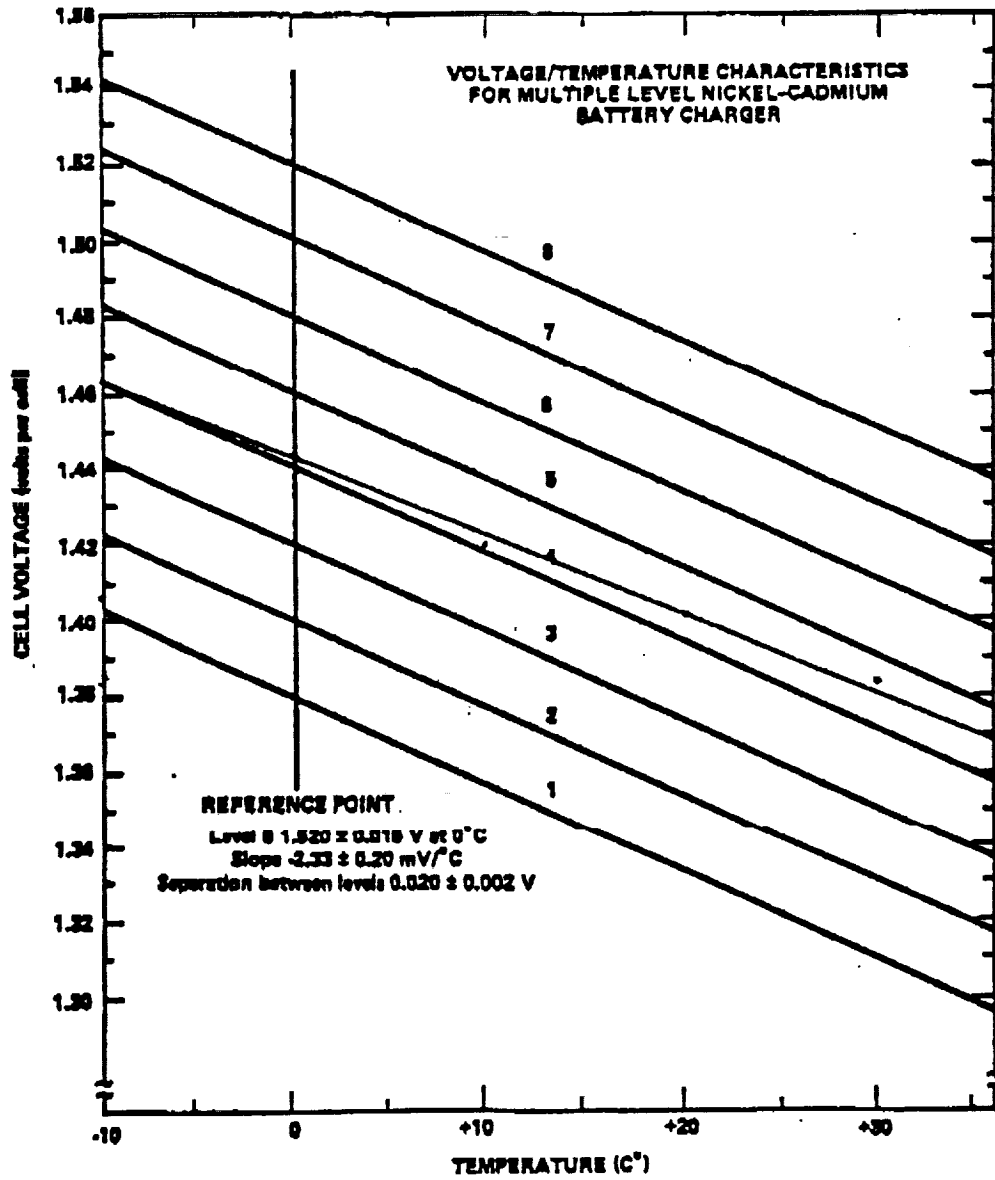


Figure 3 - Cell Voltage Limit versus Temperature

TABLE 1
SMEX CHARACTERIZATION TEST
CHARGE/ DISCHARGE RATIOS

EOC VOLTS	0°C DOD				10°C DOD				20°C DOD				30°C DOD			
	10%	25%	40%		10%	25%	40%		10%	25%	40%		10%	25%	40%	
	6.7															
6.75														1.0806		
6.8									0.8944					1.1744		
6.85														1.3324	1.0391	0.9889
6.9					0.9993				1.1072	1.0101				1.5594	1.1075	
6.95									1.2377						1.2133	1.0637
7.0	0.8895				1.0478	0.9299			1.4024	1.0994	1.0244				1.3558	
7.05										1.1538						1.2169
7.1	1.2063				1.1890	1.0616	0.9397			1.2204	1.1088					
7.15																1.4691
7.2	1.055	1.0168	1.0091		1.4805	1.1403	1.0638				1.1899					
7.25														1.2418		
7.3	1.1764	1.0621	1.0426		1.8630	1.2709	1.1282									
7.35																
7.4		1.1495	1.0934				1.2033									
7.45																
7.5		1.2818	1.1634													

**BATTERY CELL CHARACTERIZATION TEST
DATA SUMMARY**

Test Cond	Date 1993	Cycle No.	DISCHARGE				CHARGE				C/D Ratio			
			DoD %	EOH Temp. °C	EOH Curr. A	EOH Volts V	EOD Volts V/Cell	Output Ah	EOC Temp. °C	EOC Curr. A		EOC Volts V	EOC Volts V/Cell	Input Ah
1	2-25	6	10	14	1.797	23.0580	1.281	0.90	1.0	0.275	25.8980	1.439	1.13	1.256
2	2-26	5	25	24	4.490	22.301	1.239	2.25	1.8	0.818	26.4270	1.468	2.60	1.156
3	2-26	15	25	14	4.499	22.018	1.223	2.25	1.2	1.291	26.829	1.49	2.97	1.32
4	2-27	8	40	-14	7.193	21.687	1.205	3.61	-1.4	0.75	26.434	1.469	3.76	1.042
5	3-4	5	40	34	7.200	21.905	1.217	3.61	1.6	2.033	27.158	1.509	4.32	1.197
6	3-5	12	10	103	1.799	23.094	1.283	0.91	10.5	0.525	25.853	1.436	1.36	1.495
7	3-6	8	25	103	4.500	22.217	1.234	2.25	10.0	0.568	25.636	1.424	2.45	1.089
8	3-6	6	25	113	4.456	22.1810	1.232	2.24	11.0	1.24	26.0810	1.449	2.82	1.259
9	3-6	6	25	123	4.481	22.1180	1.229	2.25	12.0	1.837	26.2510	1.458	3.15	1.4
10	3-7	5	40	113	7.192	21.6860	1.205	3.60	10.9	0.887	25.8550	1.436	4.03	1.119
11	3-7	5	40	123	7.194	21.6680	1.204	3.61	12.0	2.282	26.4100	1.467	4.45	1.233
12	3-7	5	40	133	7.193	21.6490	1.203	3.60	13.0	3.119	26.5850	1.477	4.84	1.344
13	3-8	5	50	163	9.001	21.3930	1.189	4.50	13.3	3.587	26.7210	1.485	5.85	1.300
14	3-8	8	10	203	1.811	22.7036	1.261	0.90	19.7	0.199	24.7600	1.376	1.04	1.156
15	3-8	5	25	213	4.493	22.082	1.227	2.25	20.2	0.789	25.2015	1.400	2.56	1.138
16	3-9	5	40	223	7.194	21.603	1.200	3.61	21.0	1.320	25.4662	1.415	4.16	1.152
17	3-9	5	40	213	7.203	21.591	1.199	3.60	20.0	3.313	26.189	1.455	4.93	1.369