MDESC-L&ES

NASA STANDARD 50 A.H. NICKEL CADMIUM BATTERY CELL

CELL-LEVEL PERFORMANCE HISTORY

PRESENTED: 1991 NASA AEROSPACE BATTERY WORKSHOP
OCTOBER 29 - 31, 1991

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NASA STANDARD 50 A.H. NICD CELL HISTORY

SYSNOPSIS: - CONCEPT, DESIGN & COMMITMENT FOR A NASA STANDARD NICKEL CADMIUM BATTERY CELL COALESCED 1975 - 1977

- NASA STANDARD 50 A.H. CELL FIRST MANUFACTURED 1977 - 1978

- SINCE THAT COMMITMENT:

  28 PLATE LOTS HAVE BEEN MANUFACTURED

  24 CELL LOTS HAVE BEEN BUILT, 23 OF WHICH WERE DELIVERED TO BUILD:

  23 FLIGHT BATTERIES AND 20 TEST/SPARE BATTERIES

  7 MISSIONS SUPPORTED:

	LAUNCH:
- LANDSAT 4	7/82
- LANDSAT 5	3/84
- EARTH RADIATION BUDGET SATELLITE (ERBS)	10/84
- GAMMA RAY OBSERVATORY (GRO)	3/91
- UPPER ATMOSPHERE RESEARCH SATELLITE (UARS)	9/91
- EXPLORER PLATFORM (EP)	(1/92)
- OCEAN TOPOGRAPHY EXPERIMENT / POSEIDON (TOPEX)	(5/92)

- SOLE SUPPLIER: GENERAL ELECTRIC BBD / GATES AEROSPACE BATTERIES

NASA STANDARD NICKEL CADMIUM BATTERY CELL:

DEFINING DOCUMENTS: (NASA)

GSFC 74 - 15000	SPECIFICATION FOR THE MANUFACTURING OF AERO-SPACE NICKEL-CADMIUM STORAGECELLS
NHB 8073.1	NASA SPECIFICATION FOR MANUFACTURING AND PERFORMANCE REQUIREMENTS OF NASA STANDARD AEROSPACE NICKEL-CADMIUM CELLS

EXECUTIVE DOCUMENTS: (GE/GAB)

232A2222AA-84	APPLICABLE QUALITY PLAN FOR NASA STANDARD NiCd CELLS (MASTER MCD)
232A2222AA-87	APPLICABLE QUALITY PLAN FOR NASA STANDARD NiCd CELLS (MASTER MCD)
232A2222AA-88	TEMPLATE FOR JOB-SPECIFIC MCD's

NASA STANDARD 50 A.H. BATTERY CELL

CELL VENDOR DESIGNATIONS:

50AB20	ORIGINAL NASA STANDARD 50 A.H. CELL WITH 2505 SEPARATOR
50AB21	ORIGINAL NASA STANDARD 50 A.H. CELL - SIGNAL ELECTRODE CELL (NOW OBSOLETE)
50AB25	NASA STANDARD 50 A.H. CELL DESIGN WITH 2536 SEPARATOR
50AB34	"ADOPTED" NASA STANDARD; ORIGINALLY 50AB29 (LOCKHEED HST CELLS) : - PASSIVATED, NON-CADMIUM TREATED POSITIVE PLATE - G.F.E. 2505 SEPARATOR (EAGLE PICHER STOCKPILE)
50AB35	NASA STANDARD 50 A.H. CELL DESIGN WITH G.F.E. 2505 SEPARATOR
50AB39	NASA STANDARD 50 A.H. CELL DESIGN WITH FREUDENBERG 2538 SEPARATOR

NASA STANDARD 50 A.H. BATTERY CELL

CURRENT DESIGN ELEMENTS:

- UNPASSIVATED POSITIVE PLATE (*)
- CADMIUM-TREATED POSITIVE PLATE (*)
- POSITIVE LOADING: 11.90 - 13.10 grams/dm^2

strip type FD03

- 16 POSITIVE PLATES PER CELL
- POSITIVE PLATE SURFACE AREA = 22.75 dm^2

- TEFLONATED NEGATIVE PLATES
- NEGATIVE PLATE LOADING: 15.10 - 16.30 grams/dm^2(**)
- 17 NEGATIVE PLATES PER CELL

strip type FD04

(*) - EXCEPT FOR 50AB34, AS NOTED BEFORE (FD05)
(**) - EXCEPT FOR 50AB34, WHICH IS LOADED 14.85 - 16.15 grams/dm^2(FD06)

- CELL HEIGHT = 6.447 " MAX (CELL BASE TO TOP OF CELL TERMINALS)
- CELL WIDTH = 4.956 " MAX
- CELL THICKNESS = 1.343 " MAX
- CELL WEIGHT = 2081 GRAMS MAX

- 31% POTASSIUM HYDROXIDE (KOH) AS ELECTROLYTE
- NYLON SEPARATOR (2505, 2536, 2538)

NASA STANDARD 50 A.H. BATTERY CELL

ACCEPTANCE TEST PROCEDURE

PARA. NO.	TITLE	REGIME	REQUIREMENT
3.0	SHORT	SHORT WITH 0.2 OHM RESISTORS	EOSV = 0.010V MAX
4.0, 8.0	74°F CAPACITY	CHARGE 24H @ 5 AMPS DISCHARGE @ 25 AMPS TO 1.00V RESISTIVE SHORT	V < 1.48V; P < 65 PSIG 3000 < CAP > 3900 A-M EOSV = 0.010V MAX
5.0	86°F CAPACITY	CHARGE 24H @ 5 AMPS DISCHARGE @ 25 AMPS TO 1.00V RESISTIVE SHORT	V < 1.47V; P < 65 PSIG CAP > 2400 A-M EOSV = 0.010V MAX
6.0	32°F OVRCHG	CHARGE 72H @ 2.5 AMPS DISCHARGE @ 25 AMPS TO 1.00V RESISTIVE SHORT	V < 1.53V; P < 75 PSIG CAP > 2700 A-M EOSV = 0.010V MAX
7.0	LOW RATE EFFICIENCY	CHARGE 20H @ 1.25 AMPS DISCHARGE @ 25 AMPS TO 1.00V RESISTIVE SHORT	CAP > 900 A-M
9.0	HIGH - RATE DISCHARGE	CHARGE 16H @ 5 AMPS DISCHARGE @ 150 AMPS FOR 30 SECONDS, THEN @ 25 AMPS TO 1.00V: RESISTIVE SHORT	EODV > 1.00V AFTER 30 SECONDS @ 150 AMPS 24 HOUR MAX SHORT
10.0	CHARGE RETENTION & IMPEDANCE	OPEN CIRCUIT FOR 24 HOURS MEASURE IMPEDANCE (HP 4328)	V > 1.17V AFTER 24 HOUR OPEN CIRCUIT 3 MILLIOHMS MAX

NASA STANDARD 50 A.H. BATTERY CELL: PLATE / CELL LOTS

PLATE LOT	NOTES	CELL LOT / DISPOSITION	LOT SIZE	MISSION USE
50AB20/21 LOT 1	-	50AB20/21 LOT 1	44 CELLS	50 A.H. QUAL BATTERY
50AB20/21 LOT 2	-	50AB20/21 LOT 2	101 CELLS	4 TEST BATTERIES
50AB20/21 LOT 3	-	50AB20/21 LOT 3	78 CELLS	2 TEST BATTERIES; 1 LANDSAT 4 FLIGHT BATTERY
50AB20/21 LOT 4	-	50AB20/21 LOT 4	52 CELLS	2 LANDSAT 4 FLIGHT BATTERIES
50AB20/21 LOT 5	-	50AB20/21 LOT 5	55 CELLS	2 LANDSAT 5 FLIGHT BATTERIES
50AB20/21 LOT 6	OVERLOADED	SCRAPPED	-	-
50AB20/21 LOT 7	-	50AB20/21 LOT 7	54 CELLS	1 LANDSAT 5 FLIGHT BATTERY; 1 LANDSAT SPARE BATTERY
50AB20/21 LOT 8A/8B	POSITIVE REJECTED, (PASSIVATED); 8B NEGATIVE USED FOR 50AB25 LOT 1 & 50AB20 LOT 13	-	-	-
50AB20/21 LOT 9	-	50AB20/21 LOT 9	92 CELLS	SCRAPPED. ERRATIC & HIGH VOLTAGE. CONTAMINATION?

NASA STANDARD 50 A.H. BATTERY CELL: PLATE / CELL LOTS

PLATE LOT	NOTES	CELL LOT / DISPOSITION	LOT SIZE	MISSION USE
50AB20/21 LOT 10	INSUFFICIENT MAT'L	-	-	-
50AB20/21 LOT 11	INSUFFICIENT MAT'L	-	-	-
50AB20/21 LOT 12	LOT 10 + LOT 11	50AB20/21 LOT 12	91 CELLS	2 ERBS FLIGHT BATTERIES; 1 ERBS CHARACTERIZATION BATTERY
	- LOT 11 POSITIVE - LOT 8 NEGATIVE	50AB20 LOT 13	21 CELLS	GSFC PRECHARGE EXPERIMENT
		50AB25 LOT 1	12 CELLS	2536 SEPARATOR QUAL TEST CELLS
50AB20 LOT 14	POSITIVE NOT CADMIUM TREATED	50AB20 LOT 14	78 CELLS	3 GRO TEST BATTERIES
50AB20 LOT 15A/15B	BAD 2505 SEPARATOR	50AB20 LOT 15 CHANGED TO 2536 SEPARATOR IN FLIGHT CELLS	7 CELLS	PRE-ACCEPT CELLS
50AB20 LOT 16	-	50AB20 LOT 16	7 CELLS 81 CELLS	PRE-ACCEPT CELLS 3 GRO FLIGHT SPARE BATTERIES
50AB20 LOT 17A/17B	-	50AB20 LOT 17	6 CELLS 83 CELLS	PRE-ACCEPT CELLS 3 GRO FLIGHT BATTERIES
50AB20 LOT 18A/ 18B/18C	OVERLOADED	SCRAPPED	-	-

NASA STANDARD 50 A.H. BATTERY CELL: PLATE / CELL LOTS

PLATE LOT	NOTES	CELL LOT / DISPOSITION	LOT SIZE	MISSION USE
50AB29 LOT 5	FROM 2536 TO G.F.E. 2505	50AB34 LOT 1	73 CELLS	3 GRO SPARE / TEST BATTERIES
50AB20 LOT 19A/B	POS. SCRAPPED	50AB35 LOT 1	81 CELLS	3 GRO FLIGHT BATTERIES
50AB20 LOT 20	NEG. SCRAPPED			
50AB35 LOT 2A/2B	-	50AB35 LOT 2	83 CELLS	3 UARS FLIGHT BATTERIES
50AB20 LOT 15	REBUILT USING 2536	50AB25 LOT 2	77 CELLS	COMPLETED CELL ATP, DELIVERED TO GSFC COLD STORAGE
50AB35 LOT 3	JPL TEST CELLS	STOP WORK ORDER	-	-
50AB29 LOT 4	FROM 2536 TO G.F.E.	50AB34 LOT 2	4 CELLS	GSFC KOH FILL AMOUNT
50AB29 LOT 6	2505	50AB34 LOT 3	13 CELLS	EXPERIMENT
50AB35 LOT 4A/4B	-	50AB35 LOT 4	107 CELLS	3 EP FLIGHT BATTERIES; 1 EP SPARE BATTERY
50AB35 LOT 2A/2B	-	50AB35 LOT '2A'	7 CELLS	GAB 2538 SEPARATOR LIFE
		50AB25 LOT '3'	7 CELLS	TEST CELLS PLUS CONTROL
		50AB39 LOT '1'	7 CELLS	CELLS
50AB35 LOT 5A/5B	INSUFFICIENT MATERIAL	-	-	-
50AB35 LOT 6A/6B/6C	-	50AB35 LOT 6	112 CELLS	3 TOPEX FLIGHT BATTERIES 1 TOPEX SPARE BATTERY

NASA STANDARD 50 A.H. BATTERY CELL: SIGNIFICANT ANOMALIES

50AB20 LOT 9

- WENT THROUGH ATP 3 TIMES BEFORE FINAL REJECTION
- CELLS EXHIBITING ERRATIC AND HIGH VOLTAGES AT ROOM TEMPERATURE
- MULTIPLE KOH ADJUSTMENTS FOR HIGH PRESSURE
- REPEATED, EXCESSIVE SHORTDOWNS
- DESTRUCT CELLS SHOW LOSS OF OVERCHARGE PROTECTION
- CONTAMINATION ?

50AB20 LOT 13 / 50AB25 LOT 1

- SEVERAL PERIODS OF EXCESSIVE SHORTDOWNS
- LOT 13 CELLS BUILT WITH 2505 LOT 30158, PIECE LR037 (GIDEP ALERT)
- CELLS WITH BOTH TYPES OF SEPARATOR WERE RETURNED FROM NWSC WITH OVERCHARGE PROTECTION VIRTUALLY GONE

50AB20 LOT 14

- NO CADMIUM TREATMENT OF POSITIVE PLATE
- SHARPLY REDUCED CAPACITY AT 95°F
- EOCV AT ROOM TEMPERATURE ~30mV LOWER THAN NORMAL

50AB20 LOT 17

- 17 FULLY-CHARGED CELLS WERE FURTHER CHARGED @ 25 AMPS FOR 42 MINUTES BEFORE BEING DISCOVERED (SHOULD HAVE BEEN DISCHARGING)
- EXTENSIVE INVESTIGATION CLEARED CELLS FOR FLIGHT USE

50AB34 LOT 1 / 50AB35 LOT 1

- BOTH LOTS REQUIRED ADDITIONAL PRECHARGING

NASA STANDARD 50 A.H. BATTERY CELL: TYPICAL PLATE SUMMARY

50AB35 LOT 6 (TOPEX)

DATA	POSITIVE		NEGATIVE		
PLATE LOT	6A	6B	6A	6B	6C
POST #	05103	05104	04801	04602	04601
SPIRALS	1 - 7	1 - 7	1 - 7	1 - 6	1,3 - 7
AVERAGE LOADING (gm/dm2)	12.58	12.64	15.68	15.60	15.44
AVERAGE PLATE THICKNESS (mills)	27.56	27.60	32.17	31.80	31.93
SAMPLE PLATE WEIGHT (grams)	38.48	38.31	45.04	44.98	44.90
100% PLATE WEIGHT (grams)	38.55	38.34	45.22	45.08	45.01
ANTI-POLAR MASS (gm/dm2)	0.65	0.63	NA	NA	NA
STRESS GROWTH (mills)	1.19	1.17	-	-	-
STRESS RATING	-	-	3.35	2.83	3.08
NICKEL ATTACK (%)	28.27	29.73	NA	NA	NA
PLATE POROSITY (%)	31.93	32.47	33.41	32.73	33.32
SAMPLE ECT (A-M)	3902	4052	7278	7403	7469
100% ECT (A-M)	3946	4024	7343	7417	7486
N/P RATIO	-	-	1.860	1.851	1.851
CAPACITY STABILITY PERCENT	100.75	100.70	85.13	80.2	79.2

ALSO: DATES OF PROCESSING, THEORETICAL CAPACITY FROM HYDRATE LOADING, PERCENT OF THEORETICAL FROM 100% ECT (UTILIZATION), % COBALT.

NASA STANDARD 50 A.H. BATTERY CELL: TYPICAL TEST DATA

50AB35 LOT 4 (EXPLORER PLATFORM) PRE-ATP:

R: = RANGE; X: = AVERAGE; EOCV = END-OF-CHARGE VOLTAGE; EOCP = END-OF-CHARGE PRESSURE (PSIG); CAP = CAPACITY IN AMP MINUTES; 16HRV, 20HRV, 32HRV = VOLTAGE AT 16, 20, 32 HOURS INTO CHARGE

3.0 FORMATION CYCLES - EOCV

CYCLE		GR1	GR2	GR3	GR4	GR5
1	R:	1.438 - 1.443	1.435 - 1.440	1.437 - 1.443	1.431 - 1.435	1.433 - 1.439
	X:	1.44057	1.43729	1.44024	1.43281	1.43630
2	R:	1.442 - 1.449	1.435 - 1.443	1.437 - 1.443	1.441 - 1.446	1.433 - 1.442
	X:	1.44590	1.43857	1.43995	1.44348	1.43804
3	R:	1.436 - 1.451	1.437 - 1.447	1.431 - 1.442	1.437 - 1.447	1.435 - 1.446
	X:	1.44471	1.44148	1.43614	1.44238	1.44091
4	R:	1.440 - 1.447	1.434 - 1.443	1.433 - 1.441	1.437 - 1.443	1.432 - 1.444
	X:	1.44333	1.43786	1.43648	1.43924	1.43857

4.0 NEGATIVE PRECHARGE - 30 VENTS + 13 PSI [MINUTES TO VENT]

TOTAL VENT TIME	R:	2933 - 4687	3506 - 5279	3502 - 5014	3397 - 5621	3396-4356
	X:	3788	4117	4026	4032	3846
AVG VENT TIME:		124.1	134.9	131.9	132.1	126.0

6.0 PRESSURE STABILIZATION

EOCV	R:	1.451 - 1.457	1.439 - 1.449	1.442 - 1.448	1.441 - 1.449	1.437 - 1.448
	X:	1.45400	1.44390	1.44452	1.44500	1.44365
EOCP	R:	23 - 50	25 - 46	7 - 49	19 - 40	21 - 50
	X:	39.7	35.3	34.9	31.4	35.9
CAP	R:	3400 - 3525	3450 - 3575	3425 - 3575	3550 - 3750	3450 - 3650
	X:	3455	3505	3496	3661	3538

ALL CELLS ADJUSTED TO 160 mL

NASA STANDARD 50 A.H. BATTERY CELL: TYPICAL TEST DATA

50AB35 LOT 4 PRE-ATP (cont.)

7.0 ROOM TEMPERATURE OVERCHARGE

		GR1	GR2	GR3	GR4	GR5
EOCV	R:	1.448 - 1.461	1.440 - 1.453	1.444 - 1.453	1.445 - 1.458	1.445 - 1.454
	X:	1.45452	1.44685	1.44900	1.45176	1.44909
EOCP	R:	11 - 36	12 - 36	9 - 41	9 - 30	9 - 35
	X:	26.0	23.9	25.9	21.3	20.2
CAP	R:	3450 - 3575	3425 - 3550	3400 - 3500	3475 - 3600	3400 - 3575
	X:	3512	3490	3443	3546	3472

9.0 BURN-IN CYCLES: - CAPACITY (A-M)

CYCLE						
1	R:	3496 - 3650	3445 - 3554	3443 - 3539	3477 - 3593	3473 - 3604
	X:	3569	3499	3482	3514	3520
2	R:	3433 - 3550	3298 - 3398	3375 - 3496	3412 - 3524	3384 - 3564
	X:	3483	3353	3425	3463	3449
3	R:	3338 - 3450	3284 - 3399	3302 - 3439	3372 - 3489	3325 - 3495
	X:	3387	3334	3360	3419	3393
4	R:	3282 - 3411	3219 - 3332	3206 - 3478	3283 - 3421	3258 - 3448
	X:	3336	3267	3286	3331	3333
5	R:	3306 - 3418	3226 - 3340	3277 - 3404	3310 - 3454	3278 - 3447
	X:	3350	3276	3332	3358	3347
6	R:	3286 - 3409	3218 - 3356	3239 - 3370	3262 - 3406	3253 - 3392
	X:	3338	3287	3297	3307	3307
7	R:	3251 - 3378	3281 - 3410	3209 - 3333	3241 - 3389	3221 - 3377
	X:	3307	3335	3278	3295	3283
8	R:	3233 - 3393	3251 - 3390	3255 - 3388	3373 - 3529	3259 - 3424
	X:	3304	3309	3318	3427	3325
9	R:	3242 - 3367	3210 - 3340	3206 - 3338	3202 - 3360	3228 - 3374
	X:	3294	3257	3268	3257	3298
10	R:	3211 - 3389	3187 - 3317	3196 - 3326	3234 - 3408	3216 - 3356
	X:	3282	3242	3261	3290	3291

NASA STANDARD 50 A.H. BATTERY CELL: TYPICAL TEST DATA

50AB35 LOT 4 PRE-ATP (cont.)

10.0 ROOM TEMPERATURE OVERCHARGE

		GR1	GR2	GR3	GR4	GR5
EOCV	R:	1.447 - 1.465	1.439 - 1.453	1.437 - 1.459	1.447 - 1.461	1.433 - 1.454
	X:	1.45881	1.44340	1.44686	1.45281	1.44596
EOCP	R:	16 - 45	17 - 50	16 - 45	16 - 44	17 - 45
	X:	32.0	31.0	32.0	30.2	30.3
CAP	R:	3375 - 3500	3375 - 3475	3350 - 3450	3475 - 3625	3325 - 3475
	X:	3433	3416	3386	3538	3388

11.0 86°F CAPACITY SCREENING

		GR1	GR2	GR3	GR4	GR5	GR6	GR7
EOCV	R:	1.408 - 1.417	1.417 - 1.426	1.409 - 1.420	1.412 - 1.419	1.426 - 1.434	1.411 - 1.423	1.418 - 1.427
	X:	1.41313	1.42094	1.41378	1.41558	1.42883	1.41880	1.42308
EOCP	R:	(-1) - 10	2 - 10	2 - 12	1 - 9	3 - 11	0 - 17	1 - 11
	X:	5.3	5.6	7.3	5.7	7.7	8.3	5.8
CAP	R:	3198 - 3445	3256 - 3408	3131 - 3348	3145 - 3293	3278 - 3462	3240 - 3402	3241 - 3403
	X:	3336	3314	3242	3201	3383	3302	3337

12.0 32°F OVERCHARGE SCREENING

32HRV	R:	1.509 - 1.517	1.514 - 1.521	1.511 - 1.525	1.513 - 1.519	1.520 - 1.524	1.521 - 1.535	1.514 - 1.521
	X:	1.51338	1.51719	1.51644	1.51600	1.52208	1.52860	1.51792
EOCV	R:	1.501 - 1.507	1.498 - 1.507	1.498 - 1.508	1.502 - 1.508	1.505 - 1.509	1.505 - 1.513	1.501 - 1.507
	X:	1.50400	1.50450	1.50306	1.50467	1.50667	1.50935	1.50483
EOCP	R:	16 - 45	12 - 37	21 - 46	20 - 48	18 - 52	11 - 52	7 - 44
	X:	32.3	25.6	34.2	33.8	35.4	31.9	26.1
CAP	R:	3200 - 3434	3222 - 3361	3140 - 3241	3108 - 3238	3153 - 3340	3140 - 3315	3208 - 3349
	X:	3331	3284	3191	3175	3284	3221	3275

NASA STANDARD 50 A.H. BATTERY CELL: TYPICAL TEST DATA

50AB35 LOT 4 ATP:

4.0 1st 74°F CAPACITY TEST

		GR1	GR2	GR3	GR4	GR5	GR6	GR7
16HRV	R:	1.451 - 1.456	1.459 - 1.463	1.457 - 1.467	1.455 - 1.459	1.463 - 1.468	1.460 - 1.467	1.468 - 1.472
	X:	1.45431	1.46044	1.46194	1.45792	1.46558	1.46315	1.46967
20HRV	R:	1.449 - 1.458	1.455 - 1.460	1.458 - 1.468	1.463 - 1.477	1.463 - 1.467	1.458 - 1.472	1.463 - 1.471
	X:	1.45469	1.45713	1.46194	1.46783	1.46483	1.46615	1.46625
EOCV	R:	1.448 - 1.456	1.456 - 1.460	1.456 - 1.466	1.457 - 1.464	1.461 - 1.466	1.456 - 1.469	1.462 - 1.469
	X:	1.45431	1.45719	1.45989	1.45983	1.46375	1.46365	1.46500
EOCP	R:	13 - 37	19 - 39	26 - 55	27 - 47	23 - 48	21 - 54	18 - 50
	X:	29.9	29.9	41.2	35.7	38.6	37.6	34.4
CAP	R:	3485 - 3595	3517 - 3658	3318 - 3670	3482 - 3592	3593 - 3670	3498 - 3642	3610 - 3700
	X:	3543	3555	3572	3509	3623	3556	3656

5.0 86°F CAPACITY

EOCV	R:	1.422 - 1.432	1.422 - 1.429	1.419 - 1.430	1.420 - 1.424	1.419 - 1.431	1.417 - 1.434	1.424 - 1.432
	X:	1.42844	1.42513	1.42344	1.42125	1.42500	1.42520	1.427920
EOCP	R:	4 - 16	5 - 14	6 - 17	5 - 14	6 - 14	4 - 19	5 - 15
	X:	11.1	9.3	12.1	9.3	9.6	10.6	9.8
CAP	R:	3252 - 3360	3279 - 3432	3313 - 3463	3218 - 3339	3301 - 3403	3202 - 3364	3321 - 3430
	X:	3312	3324	3375	3256	3354	3263	3372

6.0 32°F OVERCHARGE

32HRV	R:	1.520 - 1.527	1.521 - 1.528	1.518 - 1.530	1.520 - 1.525	1.522 - 1.527	1.525 - 1.535	1.521 - 1.527
	X:	1.52519	1.52456	1.52328	1.52258	1.52450	1.52895	1.52358
EOCV	R:	1.510 - 1.516	1.503 - 1.510	1.503 - 1.513	1.508 - 1.511	1.509 - 1.515	1.510 - 1.518	1.508 - 1.514
	X:	1.51375	1.50788	1.50894	1.50983	1.51142	1.51345	1.51075
EOCP	R:	15 - 51	16 - 41	27 - 53	21 - 57	23 - 59	14 - 55	24 - 52
	X:	35.3	29.9	40.7	37.9	40.0	36.6	34.5
CAP	R:	3265 - 3427	3301 - 3411	3230 - 3354	3177 - 3279	3301 - 3426	3225 - 3395	3213 - 3377
	X:	3358	3368	3307	3215	3374	3302	3309

NASA STANDARD 50 A.H. BATTERY CELL: TYPICAL TEST DATA

50AB35 LOT 4 ATP (cont.)

7.0 LOW RATE EFFICIENCY

		GR1	GR2	GR3	GR4	GR5	GR6	GR7
EOCV	R:	1.373 - 1.376	1.374 - 1.375	1.374 - 1.377	1.375 - 1.376	1.375 - 1.376	1.375 - 1.376	1.375 - 1.377
	X:	1.37419	1.37419	1.37578	1.37508	1.37550	1.37580	1.37600
CAP	R:	877 - 902	859 - 874	896 - 915	904 - 923	847 - 862	901 - 914	901 - 919
	X:	885	867	906	915	855	906	911

8.0 2nd 74°F CAPACITY TEST

16HRV	R:	1.453 - 1.458	1.458 - 1.462	1.458 - 1.466	1.455 - 1.460	1.461 - 1.465	1.461 - 1.470	1.463 - 1.469
	X:	1.45575	1.45981	1.46111	1.45792	1.46317	1.46620	1.46542
20HRV	R:	1.451 - 1.459	1.458 - 1.463	1.455 - 1.466	1.458 - 1.467	1.462 - 1.468	1.461 - 1.474	1.461 - 1.469
	X:	1.45619	1.45994	1.46000	1.46150	1.46500	1.46760	1.46392
EOCV	R:	1.452 - 1.460	1.456 - 1.461	1.452 - 1.463	1.456 - 1.465	1.459 - 1.465	1.453 - 1.464	1.458 - 1.466
	X:	1.45756	1.45825	1.45711	1.45917	1.46258	1.45855	1.46117
EOCP	R:	17 - 45	24 - 41	30 - 55	29 - 51	31 - 53	25 - 60	26 - 51
	X:	34.8	32.3	43.6	38.2	44.3	42.0	37.3
CAP	R:	3706 - 3773	3669 - 3757	3679 - 3795	3640 - 3744	3688 - 3776	3729 - 3797	3720 - 3799
	X:	3730	3706	3726	3678	3739	3769	3757

NASA STANDARD 50 A.H. BATTERY CELL: TYPICAL DPA RESULTS

DESTRUCT CELL CHEMICAL ANALYSIS RESULTS (ALL VALUES IN AMP-HOURS)

	35 LOT 6	35 LOT 4	35 LOT 2	35 LOT 1	20 LOT 17	20 LOT 14	20 LOT 12	20 LOT 7	20 LOT 4	20 LOT 1	
TOTNEG	134.64	137.97	133.91	135.70	136.26	130.58	145.54	163.18	152.55	151.82	POST-PCG
TOTPCG	25.59	26.32	23.39	24.33	26.73	21.23	26.14	24.49	29.77	36.47	
OXYGEN PCG	17.06	23.22	17.12	18.44	20.34	19.10	21.11	18.50	RVN:12.50	RVN:12.33	
RESIDUAL PCG	8.53	3.10	6.27	5.89	6.39	2.13	5.03	5.99			
AVN	31.18	30.90	34.16	27.73	28.45	34.86	36.74	37.96	30.68	23.87	
POS 0.5	59.48	62.97	59.95	64.82	62.03	61.98	62.85	57.49	61.70	60.73	
POS 0.0	71.59	71.85	71.71	71.43	73.50	71.58	72.93	65.66	70.79	67.71	
TOTPOS	81.66	78.98	79.36	85.73	83.79	79.64	81.46	77.36	INC	INC	
	35 LOT 6	35 LOT 4	35 LOT 2	35 LOT 1	20 LOT 17	20 LOT 14	20 LOT 12	20 LOT 7	20 LOT 4	20 LOT 1	
TOTNEG	136.82	138.27	135.80	140.28	135.91	135.91	143.60	156.17	153.27	154.96	POST-ATP
TOTPCG	26.00	27.37	28.41	29.17	31.44	26.69	24.83	27.86	35.96	35.29	
OXYGEN PCG	18.32	21.18	20.95	23.19	25.17	23.36	20.95	23.00	RVN:15.67	RVN:15.50	
RESIDUAL PCG	7.68	6.19	7.46	5.98	6.27	3.33	3.88	4.86			
AVN	24.35	28.39	27.84	25.56	24.85	30.10	40.72	32.17	25.43	22.98	
POS 0.5	64.18	64.19	63.24	64.75	61.44	61.43	58.07	60.48	59.83	64.96	
POS 0.0	79.63	73.31	72.76	75.83	72.85	73.28	70.36	72.86	64.55	70.29	
TOTPOS	82.92	81.37	78.92	83.59	84.31	76.91	78.95	83.73	INC	INC	
FINAL FILL AM'T (cc's)	160	160	161.8	158 - 161	163	162	160	165	165	170	

TIPS ON INTERPRETING THE DATA

32HRV	- VOLTAGE 32 HOURS INTO CHARGE
EOCV	- END OF CHARGE VOLTAGE
EOCP	- END OF CHARGE PRESSURE
CAP	- CAPACITY TO 1.0 VOLT IN AMP-MINUTES (A-M)
PCG	- PRECHARGE
ATP	- ACCEPTANCE TEST PROCEDURE
DPA	- DESTRUCT PHYSICAL ANALYSIS
AVN	- OVERCHARGE PROTECTION
P/A	- PRE-ACCEPT CELL
R/A	- CELL RETURNED TO VENDOR FOR ANALYSIS
F/A	- FAILURE ANALYSIS

FOR:	WHEN THE DATA READS:	IT MEANS:
50AB20 LOT 16 AND LOT 17	1.509 / 1.507	PRE-ACCEPT DATA / FLIGHT CELL DATA
50AB20 LOT 13 (NASA PRECHARGE EXPERIMENT)	15.6 / 13.1 / 7.4	NORMAL PCG / 50% OVERPCG / 50% UNDER PCG
50AB34 LOT 3 (NASA KOH FILL EXPERIMENT)	3511 / 3602 / 3571	NORMAL KOH FILL / KOH UNDER-FILL / KOH OVER-FILL (161.5 / 148 / 174.5 cc's) (0.85 / 0.77 / 0.93 fill index)

NASA STANDARD 50 A.H. BATTERY CELL: PLATE PACK DATA

CELL LOT	INTER-ELECTRODE SPACING (mills)	PACK WEIGHT (grams)	TEFLONATION (gm/dm2)	FINAL KOH FILL AMOUNT (cc's)
50AB20/21 LOT 1	9.21	1336	0.226	170
LOT 2	9.52	1345	0.300	170
LOT 3	9.03	1321	0.358	170
LOT 4	9.21	1331	0.446	165
LOT 5	8.90	1339	0.358	172
LOT 7	8.97	1342	0.520	165
LOT 9	9.12	1372	0.176	150 - 153
LOT 12	8.76	1365	not avl	160
50AB20 LOT 13	9.02	not avl	not avl	166
50AB25 LOT 1	9.02	1313	0.286	150 - 160
50AB20 LOT 14	8.76	1347	0.325	162
LOT 15	8.98	1354	0.200	160
LOT 16	8.68	1355	0.297	150 / 153
LOT 17	8.82	1359	0.259	160 / 163
50AB34 LOT 1	8.97	1380	not recorded	163
50AB35 LOT 1	8.94	1350	0.218	158 - 161
LOT 2	9.12	1354	0.219	162
50AB25 LOT 2	8.98	1354	0.200	157
50AB34 LOT 2	not avl	not avl	not recorded	161
LOT 3	not avl	not avl	not recorded	161.5 / 148 / 174.5
50AB35 LOT 4	8.67	1375	0.177	160
50AB35 LOT 2a	9.12	1354	0.219	166
50AB25 LOT 3	9.12	1354	0.219	162
50AB39 LOT 1	9.12	1354	0.219	166
50AB35 LOT 6	8.23	1386	0.284	158 - 160

NASA STANDARD 50 A.H. BATTERY CELL: PLATE DATA

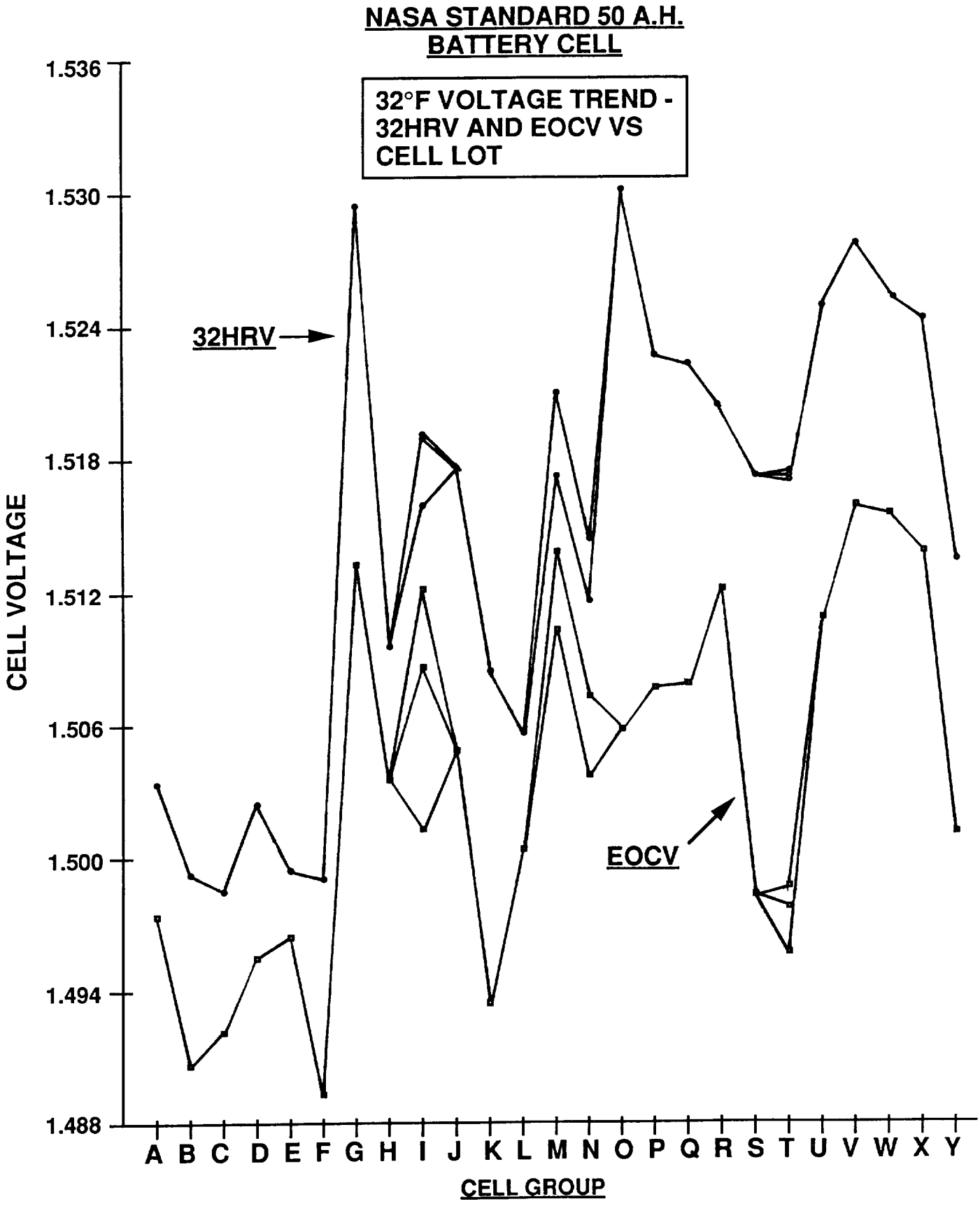
PLATE LOT	POSITIVE LOADING (gm/dm2)	100% ECT POS. CAPACITY (A-M)	N/P RATIO
50AB20/21 LOT 1	12.69	3864	1.843
LOT 2	12.53	3880	1.864
LOT 3	12.63	3647	1.845
LOT 4	12.79	3784	1.843
LOT 5	12.96	3777	1.820
LOT 6	13.09	3958	-
LOT 7	12.80	3797	1.840
LOT 8	12.13	3791	-
LOT 9	13.17	4014	1.776
LOT 10	12.32	3846	1.966
LOT 11	12.16	3873	2.015
LOT 12	-	-	-
50AB20 LOT 13	12.16	3873	1.830
50AB25 LOT 1	12.16	3873	1.830
50AB20 LOT 14	12.70	3791	1.897
50AB20 LOT 15	12.56	3881	1.880
LOT 16	12.74	3738	1.967
LOT 17	12.84	3974	1.837
LOT 18A/18C	13.08	4039	-
LOT 19	not avl	-	-
LOT 20	12.65	-	-
50AB34 LOT 1	12.50	4055	1.840
50AB35 LOT 1	-	3782	1.977
LOT 2A/2B	12.76	3756	1.963
LOT 3	not recorded	not recorded	-
50AB34 LOT 2	12.70	3888	1.901
LOT 3	12.46	3966	1.935
50AB35 LOT 4A/4B	12.51	3802	1.967
50AB35 LOT 5	12.69	NA	NA
LOT 6A/B/C	12.61	3994	1.851

NASA STANDARD 50 A.H. BATTERY CELL: 95°F/86°F CAPACITY

CELL LOT	95°F EOCV	95°F CAPACITY (A-M)	86°F EOCV	86°F CAPACITY (A-M)
50AB20/21 LOT 1	1.38842	3204		
LOT 2	1.39383	3286		
LOT 3	1.39230	3274		
LOT 4	1.39500	3445		
LOT 5	1.39202	3211		
LOT 7	1.39955	3434		
(3rd try) LOT 9	1.41401	3339		
LOT 12	1.39309	2695		
50AB20 LOT 13	1.38575/1.39075/1.39280	2503 / 2557 / 2658		
50AB25 LOT 1	1.40467	2903		
50AB20 LOT 14	1.38075	2118		
LOT 15	1.38833	2741		
LOT 16	1.40129 / 1.41133	3239 / 3349		
LOT 17	1.38340	2584	1.44011	3541
50AB34 LOT 1			1.41511	3342
50AB35 LOT 1			1.42376	3617
LOT 2			1.43813	3622
50AB25 LOT 2			1.42975	3467
50AB34 LOT 2			1.41225	3304
LOT 3			1.40825/1.40750/1.41050	3174 / 3107 / 3163
50AB35 LOT 4			1.42522	3320
50AB35 LOT 2a			1.41357	3344
50AB25 LOT 3			1.41829	3360
50AB39 LOT 1			1.42043	3368
50AB35 LOT 6			1.44246	3543

NASA STANDARD 50 A.H. BATTERY CELL: 32°F CAPACITY

CELL LOT	32°F 32HRV	32°F EOCV	32°F EOCP [PSIG (-inHg)]	32°F CAPACITY (A-M)
50AB20/21 LOT 1	1.50328	1.49740	52.5	3220
LOT 2	1.49931	1.49067	49.8	3065
LOT 3	1.49852	1.49225	44.2	3187
LOT 4	1.50258	1.49566	44.0	3278
LOT 5	1.49941	1.49650	44.3	2919
LOT 7	1.49909	1.48940	53.9	3023
(3rd try) LOT 9	1.52937	1.51341	16.1	3419
LOT 12	1.50956	1.50369	25.2	3417
50AB20 LOT 13	1.51600/1.51900/1.51920	1.50125/1.50850/1.51220	9.4 / 5.3 / 7.6	3502 / 3631 / 3534
50AB25 LOT 1	1.51758	1.50492	21.9	3718
50AB20 LOT 14	1.50839	1.49335	(-1.3)	3255
LOT 15	1.50567	1.50033	32.0	3112
LOT 16	1.51714 / 1.52098	1.51029 / 1.51400	13.3 / 21.3	3547 / 3544
LOT 17	1.51160 / 1.51429	1.50380 / 1.50733	5.4 / 15.1	3090 / 3133
50AB34 LOT 1	1.53015	1.50576	10.3	3488
50AB35 LOT 1	1.52285	1.50780	47.6	3636
LOT 2	1.52212	1.50801	50.0	3439
50AB25 LOT 2	1.52041	1.51213	32.4	3353
50AB34 LOT 2	1.51725	1.49800	11.0	3598
LOT 3	1.51700/1.51750/1.51725	1.49775/1.49875/1.49575	13.8 / (-7.8) / 31.3	3632 / 3547 / 3542
50AB35 LOT 4	1.52492	1.51094	36.4	3320
50AB35 LOT 2a	1.52771	1.51600	75.0	3718
50AB25 LOT 3	1.52543	1.51557	56.6	3687
50AB39 LOT 1	1.52429	1.51386	60.0	3716
50AB35 LOT 6	1.51374	1.50096	38.1	3387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32HRV AND EOCV VS
CELL LOT
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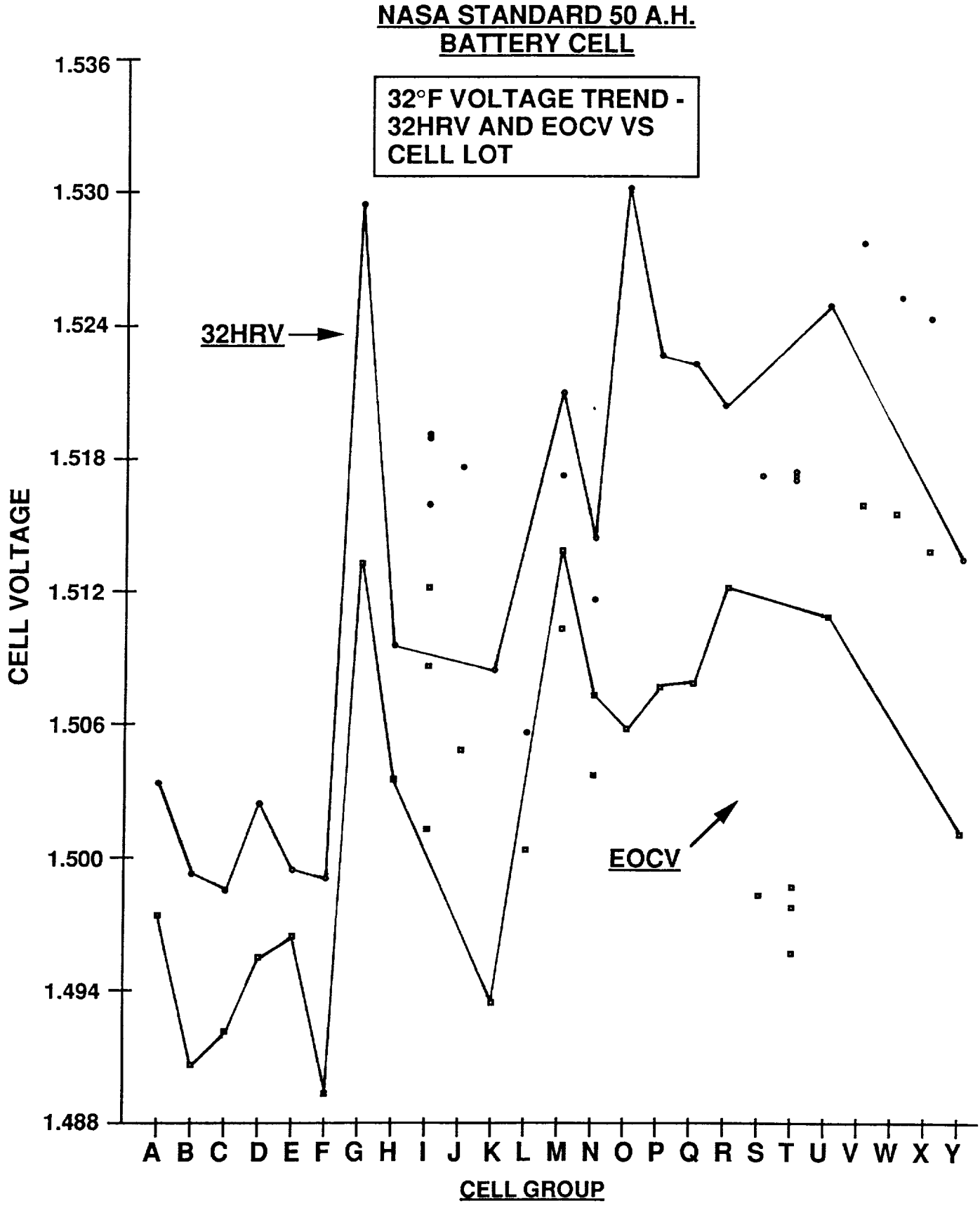
1.530
1.524
1.518
1.512
1.506
1.500
1.494
1.488
CELL VOLTAGE
32HRV
EOCV
A B C D E F G H I J K L M N O P Q R S T U V W X Y
CELL GROUP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32HRV AND EOCV VS
CELL LOT
32HRV
EOCV
CELL VOLTAGE
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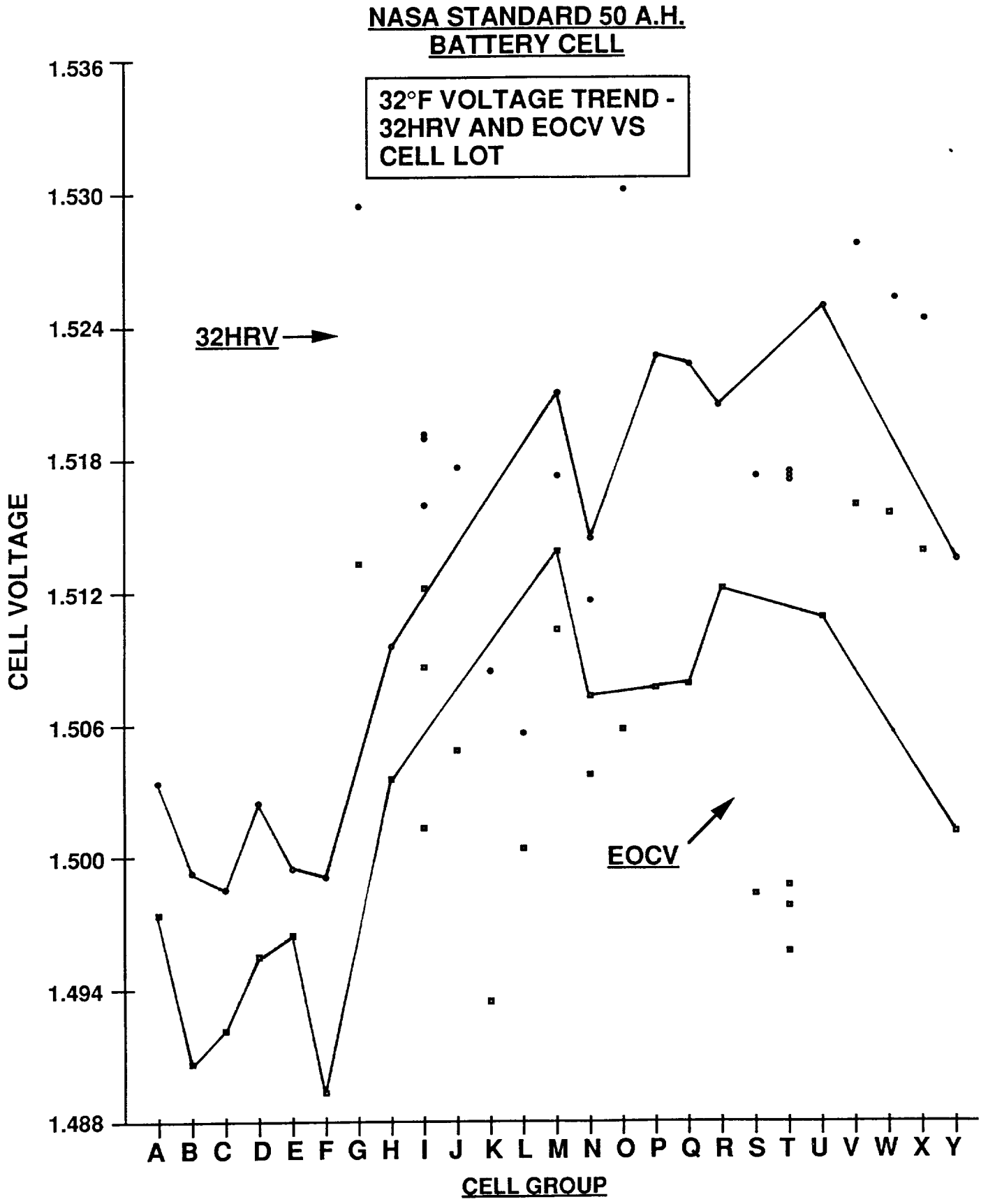
1.530
1.524
1.518
1.512
1.506
1.500
1.494
1.488
A B C D E F G H I J K L M N O P Q R S T U V W X Y
CELL GROUP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32HRV AND EOCV VS
CELL LOT
32HRV
EOCV
CELL VOLTAGE
1.536
1.530
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1.512
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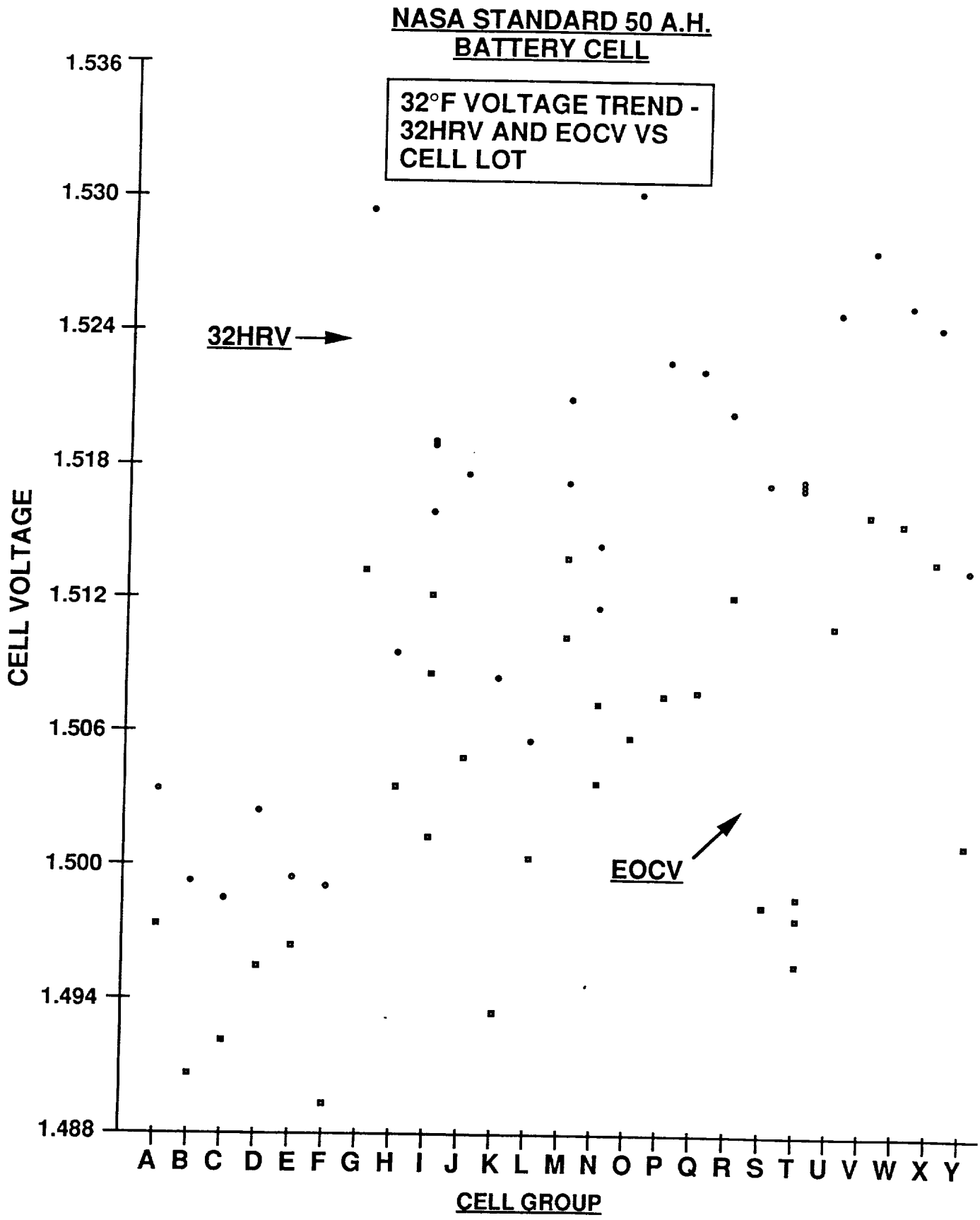
1.500
1.494
1.488
A B C D E F G H I J K L M N O P Q R S T U V W X Y
CELL GROUP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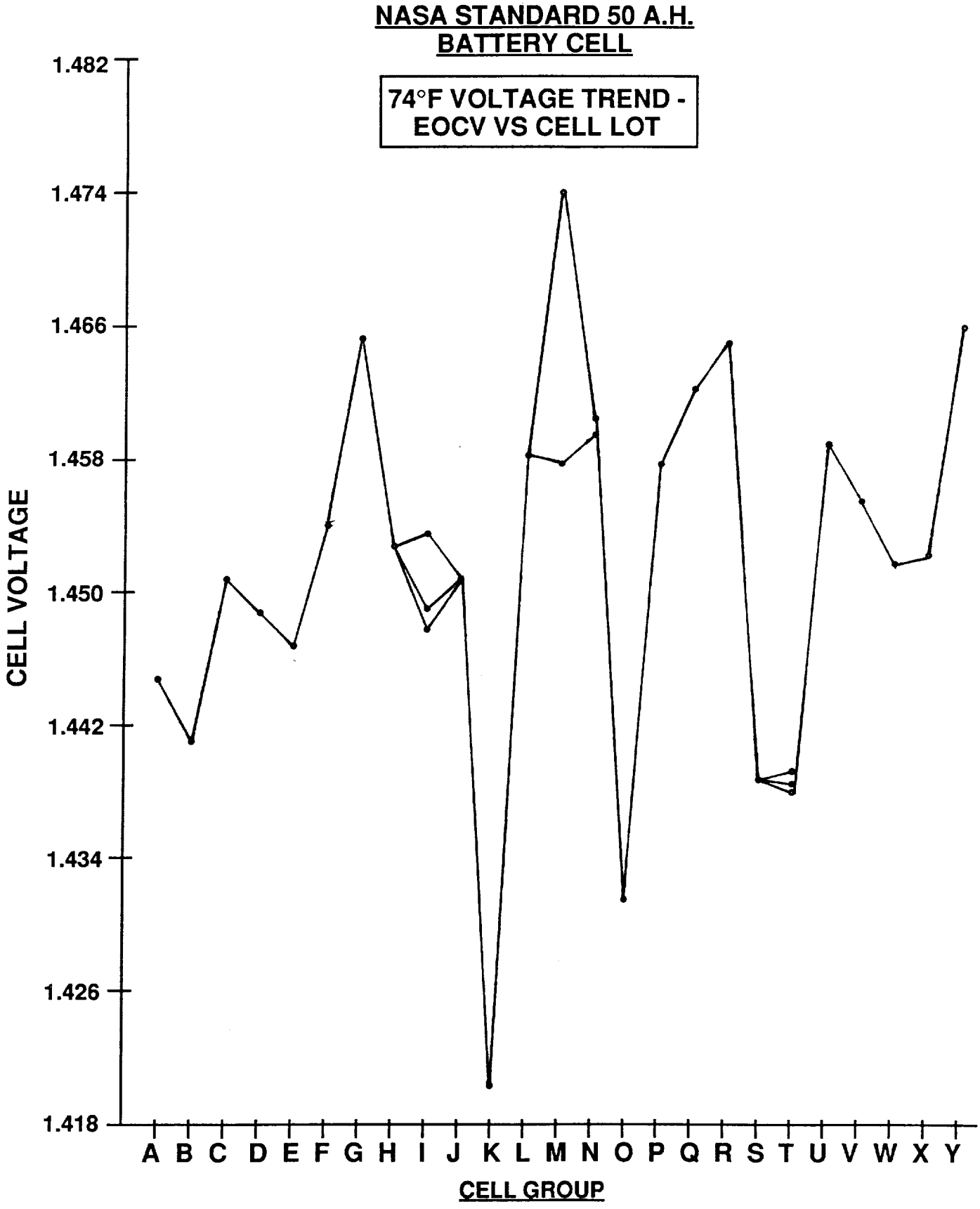
BATTERY CELL
32°F VOLTAGE TREND -
32HRV AND EOCV VS
CELL LOT
1.536
1.530
1.524
1.518
1.512
1.506
1.500
1.494
1.488
CELL VOLTAGE
32HRV
EOCV
A B C D E F G H I J K L M N O P Q R S T U V W X Y
CELL GROUP

NASA STANDARD 50 A.H. BATTERY CELL: 2nd 74°F CAPACITY

	CELL LOT	74°F EOCV	74°F EOCP (PSIG)	74°F CAPACITY (A-M)
A	50AB20/21 LOT 1	1.44484	33.9	3756
B	LOT 2	1.44103	34.1	3569
C	LOT 3	1.45081	44.1	3618
D	LOT 4	1.44886	34.0	3623
E	LOT 5	1.44680	27.7	3430
F	LOT 7	1.45406	51.2	3668
G	(6th try) LOT 9	1.46527	18.6	3803
H	LOT 12	1.45277	25.9	3597
I	50AB20 LOT 13	1.44892/1.44775/1.45340	12.8 / 8.5 / 10.0	3666 / 3559 / 3657
J	50AB25 LOT 1	1.45083	21.0	3478
K	50AB20 LOT 14	1.42013	2.2	3545
L	LOT 15	1.45833	26.0	3402
M	LOT 16	1.45771 / 1.47405	21.4 / 35.4	3654 / 3728
N	LOT 17	1.45940 / 1.46035	12.4 / 22.3	3687 / 3767
O	50AB34 LOT 1	1.43149	9.6	3907
P	50AB35 LOT 1	1.45764	48.0	3789
Q	LOT 2	1.46235	45.5	3730
R	50AB25 LOT 2	1.46501	43.0	3741
S	50AB34 LOT 2	1.43875	11.8	3901
T	LOT 3	1.43850/1.43925/1.43800	19.3 / 1.8 / 40.0	3897 / 3928 / 3873
U	50AB35 LOT 4	1.45893	39.0	3731
V	50AB35 LOT 2a	1.45557	41.3	3687
W	50AB25 LOT 3	1.45171	41.1	3715
X	50AB39 LOT 1	1.45229	48.0	3682
Y	50AB35 LOT 6	1.46612	43.2	3763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BATTERY CELL
74°F VOLTAGE TREND -
EOCV VS CELL LOT
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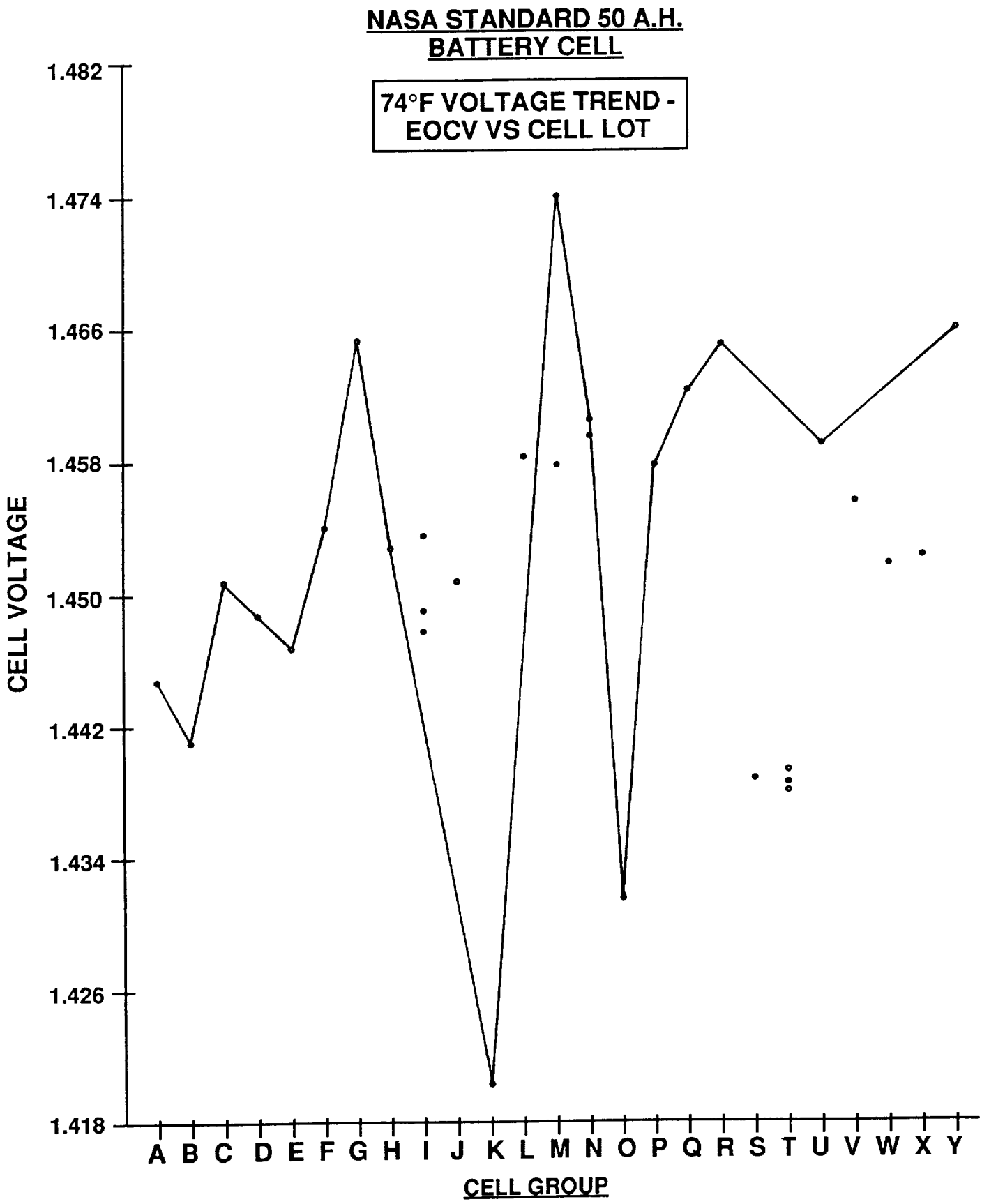
1.474
1.466
1.458
1.450
1.442
1.434
1.426
1.418
A B C D E F G H I J K L M N O P Q R S T U V W X Y
CELL GROUP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74°F VOLTAGE TREND -
EOCV VS CELL LOT
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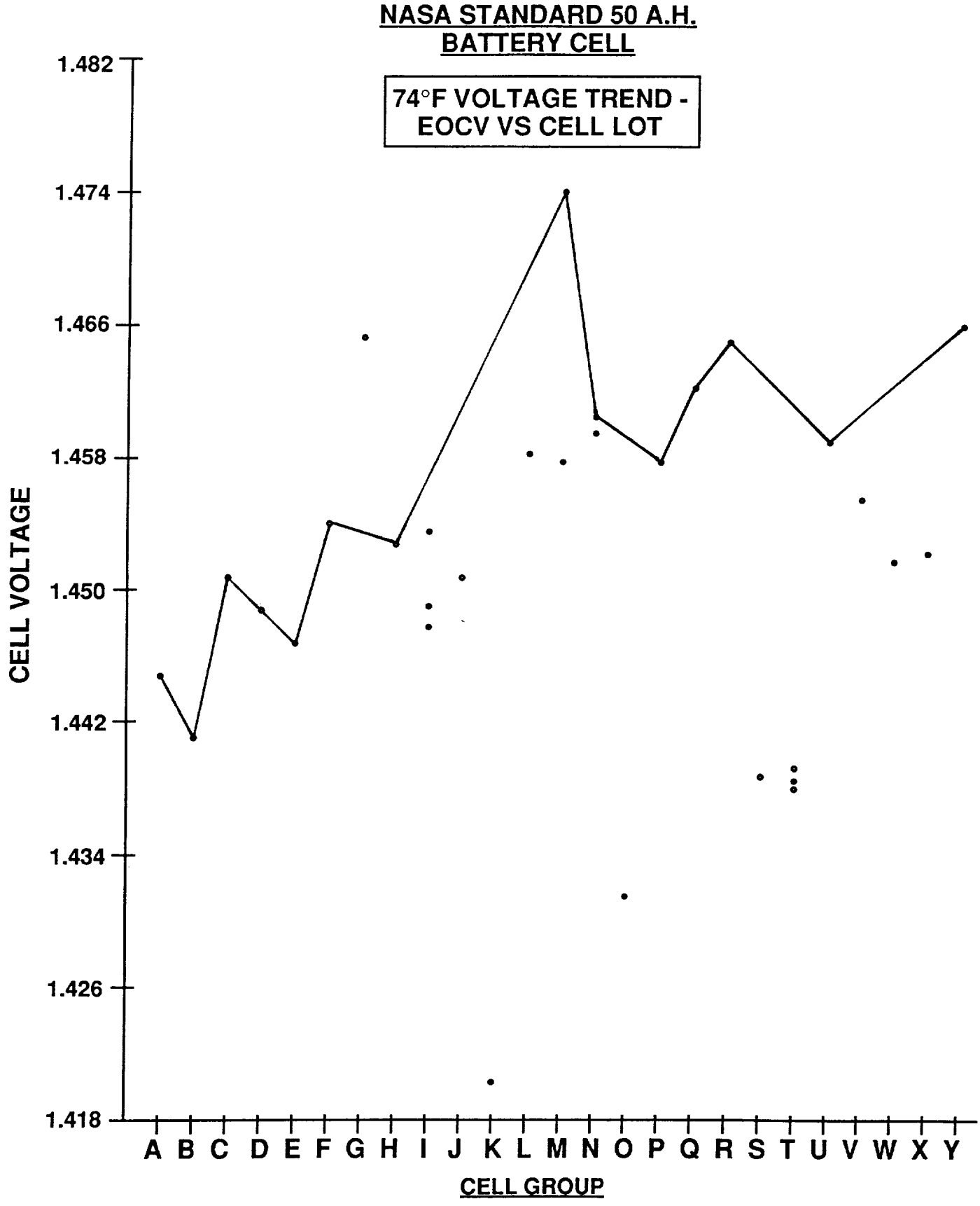
1.450
1.442
1.434
1.426
1.418
CELL VOLTAGE
A B C D E F G H I J K L M N O P Q R S T U V W X Y
CELL GROUP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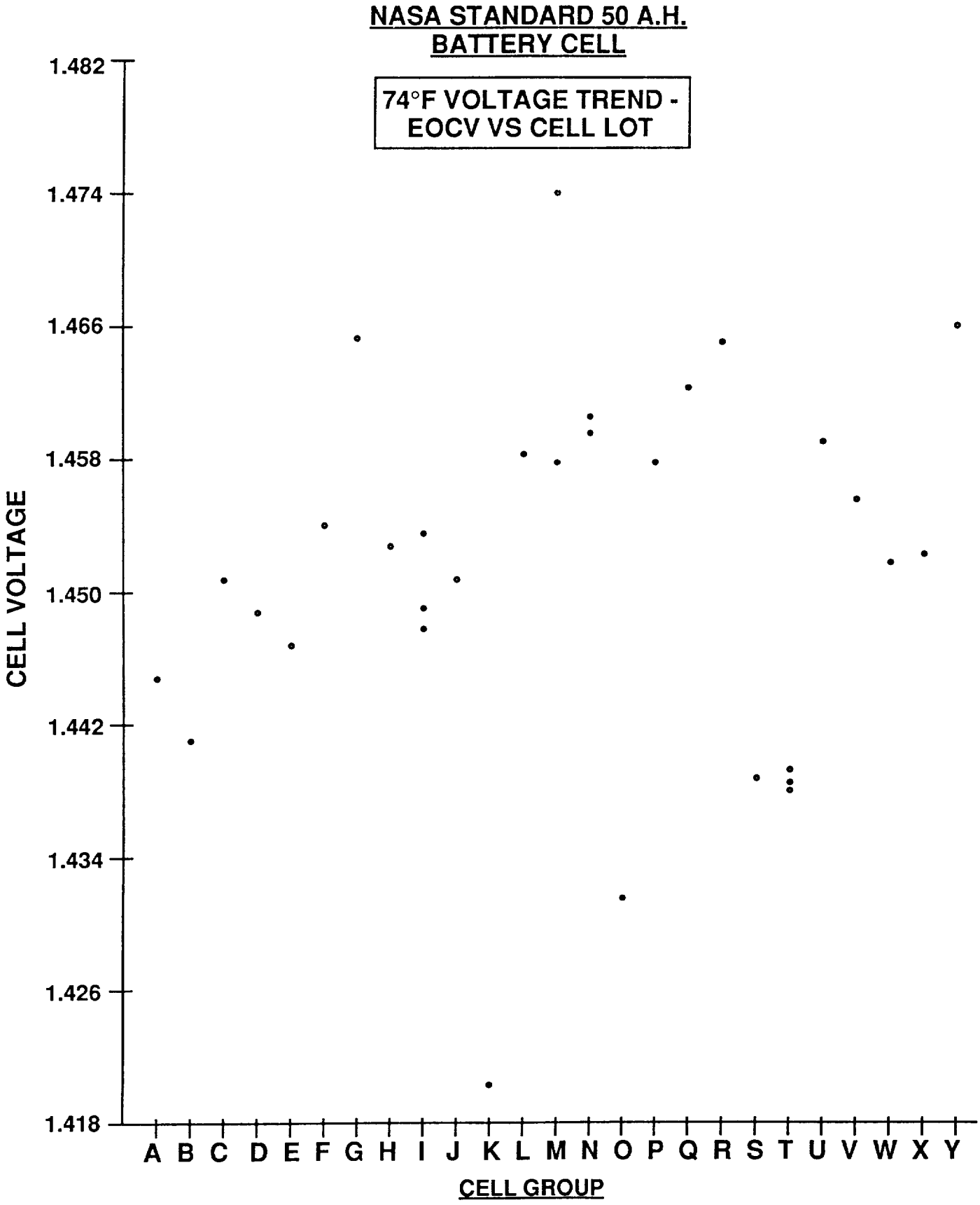
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EOCV VS CELL LOT
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1.434
1.426
1.418
A B C D E F G H I J K L M N O P Q R S T U V W X Y
CELL GROUP

NASA STANDARD 50 A.H. BATTERY CELL: DPA CELL DATA

CELL LOT - S / N:	TOTAL NEGATIVE (AH)	OVERCHARGE PROTECTION (AH)	TOTAL PRECHARGE (AH)	SAMPLE POINT: PCG	ATP	OTHER
50AB20/21 L1-32	151.82	23.87	36.47	X		
L1-29	154.96	22.98	35.29		X	
LOT 2-51	154.96	33.02	29.91	X		
L2-102	148.44	32.04	30.23	X		
L2-68	153.03	25.56	37.61		X	
LOT 3-25	148.68	32.97	25.73	X		
L3-2	155.45	15.97	38.72		X	
LOT 4-25	152.55	30.68	29.77	X		
L4-53	153.27	25.43	35.96		X	
LOT 5-25	151.10	23.91	35.87	X		
L5-50	158.59	27.68	28.78		X	
LOT 7-54	163.18	37.96	24.49	X		
L7-55	156.17	32.17	27.86		X	
LOT 9-25	137.08	25.65	28.04	X		
L9-93	131.76	11.55	38.70		X	
L9-52	135.14	5.83	43.60		X	
L9-51	131.27	17.40	32.72			EXP
LOT 12-92	143.60	36.74	26.14	X		
L12-25	145.54	40.72	24.83		X	
(OVER) LOT 13-13	134.42	34.92	17.29	X		
(NORMAL) L13-5	132.64	3.34	38.86			R/A
(OVER) L13-16	132.64	6.40	36.64			R/A
(UNDER) L13-20	132.64	8.94	33.82			R/A
50AB25 L1-6	132.64	7.46	36.90			R/A
LOT 1-11	132.64	17.58	30.78			R/A

NASA STANDARD 50 A.H. BATTERY CELL: DPA CELL DATA

CELL LOT - S / N:	TOTAL NEGATIVE (AH)	OVERCHARGE PROTECTION (AH)	TOTAL PRECHARGE (AH)	SAMPLE POINT: PCG	ATP	OTHER
50AB20 LOT 14-79	130.58	34.86	21.23	X		
L14-78	135.91	30.10	26.69		X	
LOT 15-7	137.86	34.70	25.27	X		P/A
L15-6	127.30	7.98	39.35			R/A
LOT 16-24	136.26	33.99	24.68	X		P/A
L16-16	135.14	27.12	27.87			500~
L16-84	134.90	26.11	28.42			500~
L16-88	135.91	33.40	24.07	X		
L16-1	136.13	29.77	29.31		X	
LOT 17-90	139.73	33.65	26.52	X		P/A
L17-87	136.26	28.45	26.73	X		
L17-81	137.00	26.62	29.95			F/A
L17-69	135.91	24.85	31.44		X	
50AB34 LOT 1-16	142.82	33.13	22.41	X		
L1-15	139.55	27.06	27.87		X	
50AB35 LOT 1-81	135.70	27.73	24.33	X		
L1-32	140.28	25.56	29.17		X	
LOT 2-36	133.91	34.16	23.39	X		
L2-63	135.80	27.84	28.41		X	
50AB25 LOT 2-37	138.01	30.85	24.72	X		
50AB34 LOT 3-20	139.26	31.64	24.65	X		
50AB35 LOT 4-39	137.97	30.90	26.32	X		
L4-108	138.27	28.39	27.37		X	
LOT 6-27	134.64	31.18	25.59	X		
L6-103	136.82	24.35	26.00		X	

C-5

NASA STANDARD 50 A.H. NICKEL CADMIUM BATTERY CELL

SUMMARY OF PERFORMANCE STUDY:

1. THE NASA STANDARD 50 A.H. CELL IS AN EXCELLENT DESIGN WHEN THE CELL PRODUCTION PROCESS IS PROPERLY MANAGED BY BOTH SUPPLIER AND CONTRACTOR
   - EVIDENCED BY CONSISTENT CELL TEST RESULTS OBTAINED
   - EVIDENCED BY IN-FLIGHT PERFORMANCE
2. FINAL KOH AMOUNT MUST BE INTELLIGENTLY BALANCED AGAINST CELL VENDOR PRESSURE LIMITS
3. MELANGING OF TWO OR MORE POSTS IS A PROVEN TECHNIQUE
4. ADDITIONAL PRECHARGING IS A PROVEN TECHNIQUE
5. PRE-ACCEPT CELLS SEEM TO BE AN EXCELLENT PRECURSOR TO FLIGHT LOT PERFORMANCE

NASA STANDARD 50 A.H. NICKEL CADMIUM BATTERY CELL

SUMMARY OF PERFORMANCE STUDY:

6. HIGHLY LOADED POSITIVE PLATE SHOULD BE AVOIDED

7. POSSIBLE CELL PROBLEMS CAN BE DETECTED EARLY IN PRE-ATP

8. LONG AND REPEATED SHORTDOWNS SHOULD BE AVOIDED

9. EOCV HAS INCREASED AT BOTH 32°F AND 74°F

NASA STANDARD 50 A.H. NICKEL CADMIUM BATTERY CELL

CELL-LEVEL PERFORMANCE HISTORY

THIS RESEARCH WAS MADE POSSIBLE THROUGH THE HELPFULNESS, COOPERATION, AND EXTREME PATIENCE OF THE FOLLOWING INDIVIDUALS AND THEIR ORGANIZATIONS:

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