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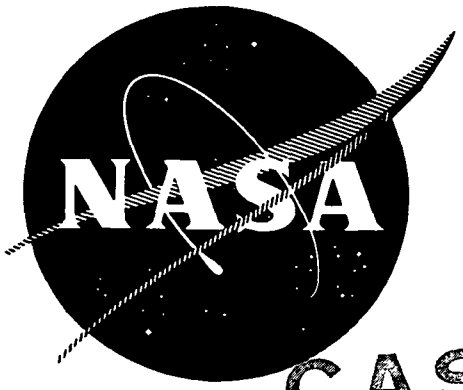

EVALUATION PROGRAM

for

SECONDARY SPACECRAFT CELLS

ACCEPTANCE TESTS
OF
EAGLE - PICHER
12.0 AMPERE-HOUR NICKEL-CADMIUM CELLS
WITH AUXILIARY ELECTRODES

prepared for
GODDARD SPACE FLIGHT CENTER
CONTRACT W12, 397

QUALITY EVALUATION LABORATORY
NAD CRANE, INDIANA

DEPARTMENT OF THE NAVY
NAVAL AMMUNITION DEPOT
CRANE, INDIANA 47522

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To: National Aeronautics and Space Administration, Goddard Space Flight Center (Code 716.2, Mr. T. J. Hennigan), Greenbelt, Maryland 20771

Subj: Report QEEL/C 71-366; Evaluation Program for Secondary Spacecraft Cells; Acceptance Tests of 12.0 Ampere-Hour Nickel-Cadmium Spacecraft Cells with Auxiliary Electrodes Manufactured by Eagle-Picher Company

Ref: (a) NASA P. O. No. W12-397

Encl: (1) Report QEEL/C 71-366

1. In compliance with reference (a), enclosure (1) is forwarded for information and retention.

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EVALUATION PROGRAM FOR SECONDARY SPACECRAFT CELLS

ACCEPTANCE TESTS OF EAGLE-PICHER 12.0 AMPERE-HOUR NICKEL-CADMIUM CELLS WITH AUXILIARY ELECTRODES

QEEL/C 71-366 8 DECEMBER 1971

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Enclosure (1)

REPORT BRIEF
EAGLE-PICHER COMPANY
12.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS
WITH AUXILIARY ELECTRODES

Ref: (a) NASA P. O. No. W12-397
(b) Acceptance Test Procedure for Nickel-Cadmium Cells: NAD 3052-TP304 Rev A, 14 May 1970

I. TEST ASSIGNMENT BRIEF

A. The purpose of this acceptance test program is to insure that all cells put into the life cycle program are of high quality by the removal of cells found to have electrolyte leakage, internal shorts, low capacity, or inability of any cell to recover its open circuit voltage above 1.150 volts after the cell short test.

B. The 24 cells were purchased by National Aeronautics and Space Administration, Goddard Spaceflight Center, from Eagle-Picher Company, Joplin, Missouri. The cells were rated at 12.0 ampere-hours and equipped with auxiliary electrodes. Testing on these cells was funded in accordance with reference (a).

II. SUMMARY OF RESULTS

A. The capacity of the 24 cells ranged from 14.6 to 16.8 ah. All the cells exceeded the rated capacity on all three capacity checks.

B. One cell (serial number 1) failed to recover to 1.150 volts after the cell short test.

C. During the overcharge tests, all cells but one failed the test at the c/10 rate after the first minute. Five cells (serial numbers 16, 17, 19, 20 and 21) had to be removed from the c/20 rate after 15 hours, one hour short of the requirement.

D. A special resistance test was conducted on the auxiliary electrodes of these cells. This test was designed to establish the resistance value necessary which would provide maximum signal power across the auxiliary electrode. The resistance value thus established was 10 ohms.

E. No electrolyte leakage was observed from any of the 24 cells.

III. RECOMMENDATIONS

A. Despite difficulties with overcharge tests it is mutually recommended by both Goddard Space Flight Center and this activity that these Eagle-Picher cells undergo life cycling tests to gain more knowledge of their overall performance.

RESULTS OF ACCEPTANCE TEST OF 12.0 AMPERE-HOUR NICKEL-CADMIUM SPACECRAFT CELLS WITH AUXILIARY ELECTRODES MANUFACTURED BY EAGLE-PICHER COMPANY

I. INTRODUCTION

A. On 16 March 1971 acceptance tests were begun on 24 cells manufactured by the Eagle-Picher Company, Joplin, Missouri. These tests were completed 26 April 1971.

II. TEST CONDITIONS AND PROCEDURE

A. All acceptance tests were performed at an ambient temperature between 23° C and 27° C at existing relative humidity and atmospheric pressure, in accordance with reference (b) and consisted of the following:

1. Phenolphthalein Leak Test.
2. Three Capacity Checks.
3. Cell Short Test.
4. Phenolphthalein Leak Test.
5. Overcharge Tests, c/20 and c/10 Rates.
6. Special Resistance Test of Auxiliary electrodes (between c/20 and c/10 overcharge rates).
7. Internal Resistance.
8. Phenolphthalein Leak Test.

See Appendix I for detailed test procedure.

III. CELL IDENTIFICATION AND DESCRIPTION

A. The cells were identified by the manufacturer's serial numbers (1 through 25)--not consecutive.

B. The 12.0 ampere-hour cell is rectangular with an average height, width and length of 4.617, 2.993, and 0.913 inches, respectively. The average weight was 563.9 grams. Individual measurements and averages are listed in Table I.

C. The cell containers and the cell covers are made of stainless steel. The positive and negative terminals are insulated from the cell covers by ceramic seals and protrude through the cover as solder type terminals. The auxiliary electrode terminal consists of a stainless steel tab welded to the cell cover.

IV. RESULTS--The following data was condensed from Tables II through IV.

A. The average capacity for the three capacity checks was: 14.9, 16.4 and 15.8 ampere-hours respectively.

B. The average recovery voltage was 1.180 volts. One cell (serial number 1) failed to recover above 0.434 volts. See Table III.

C. End-of-Overcharge Voltage:

1. The voltage averaged 1.460 volts at the end of 16 hours, at the initial c/10 conditioning rate.

2. The voltage averaged 1.468 volts at the c/20 rate. However, this does not include five cells (serial numbers 16, 17, 19, 20 and 21) which reached the 1.500 voltage limit 1 hour short of the specified 16 hours.

3. All cells but one (serial number 23) reached the 1.500 voltage limit within 1 minute after the overcharge rate was increased to c/10.

D. Special Test for Determining the Resistance Giving Maximum Signal Power from the Auxiliary Electrode:

1. This test was conducted following the c/20 overcharge and prior to the c/10 overcharge on 9 of the 24 cells. See Appendix I for details. Table IV shows 10 ohms as the resistance value giving the maximum power in millivolts across the auxiliary electrode.

E. Internal Resistance Averaged:

1. 1.61 milliohms across the cell terminals.

2. 24.7 milliohms across the auxiliary electrode.

F. Leak Tests:

1. Each cell was subjected to three leak tests. No leakers were found for any of the 24 cells.

APPENDIX I

I. TEST PROCEDURE

A. Phenolphthalein Test:

1. The phenolphthalein leak test is a determination of the condition of the welds and ceramic seals on receipt of the cells. This test was performed prior to any other tests, with a phenolphthalein spray indicator solution of one-half of one percent concentration.

B. Capacity Tests:

1. The capacity test is a determination of the cell capacity at the c/2 discharge rate, where c is the manufacturer's rated capacity to a cutoff voltage of 1.00 volt per cell. The discharge was made after a 1-hour open circuit period following the 16-hour charge at the c/10 rate. A total of three capacity checks was made at this activity. The cells were discharged individually, but were recharged in series.

2. Based on experience with cells of other manufacturers, the following resistances were installed across the auxiliary electrodes for the respective capacity checks: first capacity check, infinite resistance (no resistor); second capacity check, 200 ohms; third capacity check, 300 ohms. Resistance characterization was conducted for the auxiliary electrodes during the overcharge tests--following the c/20 rate and just prior to the c/10 rate. These tests precisely determined the correct resistance for the auxiliary electrode.

C. Cell Short Test

1. The cell short test is a means of detecting slight shorting conditions which may exist because of imperfections in the insulating materials, or damage to element in handling or assembly.

2. Following completion of the third capacity discharge test, each cell was loaded with a 0.5 ohm, 3 watt resistor for 16 hours. At the end of 16 hours, the shorting resistors were removed and the cells were placed on open circuit stand for 24 hours. Any cell whose voltage did not recover to 1.150 volts or higher was considered as failing this portion of the acceptance test.

D. Leak Test

1. The leak test is a means of detecting leakage of a seal or weld. The test was performed before and after the overcharge test sequence to determine and presence of leaks.

2. The cells were placed in a vacuum chamber and exposed to a vacuum of 40 microns of mercury or less for 24 hours. The cells were then removed from the vacuum chamber and sprayed with phenolphthalein. Pink or redish discolorations would indicate leakage.

E. Overcharge Test

1. The purpose of this test is basically threefold:

a. To determine the degree to which a pack of cells maintain a balanced voltage.

b. To determine the cells capability of reaching a point of chemical equilibrium--oxygen recombination with the negative (cadmium) plate.

c. To test the integrity of the seals as the pressure increases.

2. The overcharge tests were performed to determine the steady state voltage at specified rates. The test specified a series of constant current charges at c/10, c/20 and c/10 for a minimum of 16 hours at each charge rate. The first c/10 rate serves to establish a condition of overcharge.

3. The cells were monitored hourly throughout the test. Charging was to be discontinued on cells which exceeded 1.500 volts or 75 psig.

4. The special resistance characterization tests for the auxiliary electrodes were conducted following the c/20 overcharge and prior to the c/10 overcharge. The cells were maintained on charge at c/20 throughout the special resistance test. The tests were conducted on nine cells with pressure gauges and consisted of the following:

a. A decade resistance box was hooked across the auxiliary electrode of each cell (auxiliary electrode terminal to negative terminal) such that the resistance could be conveniently and precisely varied.

b. The pressure was maintained as close to ambient (0 psig) as possible throughout the test. No alteration of the c/20 charge rate was necessary for these cells to maintain this condition. The temperature was room ambient.

c. The sequence of resistance changes (ohms) were: 10,000, 5000, 2000;1000, 500, 200;100, 50, 20;10, 5, 2;1, 0.5, 0.2;and 0.1. A period of approximately 5 minutes was allowed for the equilibrium of the auxiliary electrode voltage to re-establish itself after each resistance change. This equilibrium was verified by observation of a strip chart recorder monitoring the auxiliary electrode voltage of each cell.

d. Data thus obtained was converted to power units in millivolts as illustrated at the foot of Table IV. The resistance value giving the maximum power of the auxiliary electrode signal is thus chosen for the auxiliary electrode resistance.

F. Internal Resistance:

1. Immediately following the overcharge test, the internal resistance was measured across the cell terminals and across the auxiliary electrodes (from auxiliary electrode terminal to negative terminal). These measurements were made with a Hewlett-Packard milliohmmeter (Model 4328A).

G. Leak Test:

1. Following the internal resistance measurements, the cells were still in a charged state. The cells were discharged at c/2 to 0.00 volt and shorted prior to the final leak test. The shorted cells were then placed in a vacuum chamber and the procedure described in paragraph I.D.2. was repeated.

TABLE I

SERIAL NUMBER	WEIGHT (Grams)	HEIGHT (Inches)	LENGTH (Inches)	WIDTH (Inches)	LEAK TESTS											
					Initial (Phenol Spray)				After Capacity Tests (Hi Vac & Phenol Spray)				After Overcharge Test (Hi Vac & Phenol Spray)			
					Terminals		Fill Tube	Other	Terminals		Fill Tube	Other	Terminals		Fill Tube	Other
					+	-			+	-			+	-		
1	563.6	4.591	0.902	2.994	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.	O.K.
2	564.8	4.629	0.896	2.995	"	"	"	"	"	"	"	"	"	"	"	"
3	565.1	4.611	1.016	2.984	"	"	"	"	"	"	"	"	"	"	"	"
4	562.2	4.630	0.995	2.995	"	"	"	"	"	"	"	"	"	"	"	"
5	564.0	4.615	0.905	3.000	"	"	"	"	"	"	"	"	"	"	"	"
6	567.8	4.628	0.904	2.994	"	"	"	"	"	"	"	"	"	"	"	"
7	562.0	4.635	0.900	2.995	"	"	"	"	"	"	"	"	"	"	"	"
8	564.8	4.625	0.904	2.995	"	"	"	"	"	"	"	"	"	"	"	"
9	566.3	4.623	0.903	2.993	"	"	"	"	"	"	"	"	"	"	"	"
10	565.0	4.635	0.900	2.994	"	"	"	"	"	"	"	"	"	"	"	"
11	564.0	4.623	0.905	2.992	"	"	"	"	"	"	"	"	"	"	"	"
12	563.2	4.616	0.904	2.998	"	"	"	"	"	"	"	"	"	"	"	"
13	562.5	4.641	0.904	2.992	"	"	"	"	"	"	"	"	"	"	"	"
14	562.2	4.600	0.898	3.000	"	"	"	"	"	"	"	"	"	"	"	"
15	563.4	4.608	0.898	2.994	"	"	"	"	"	"	"	"	"	"	"	"
16	562.7	4.627	0.897	2.997	"	"	"	"	"	"	"	"	"	"	"	"
17	563.5	4.614	0.901	2.990	"	"	"	"	"	"	"	"	"	"	"	"
19	563.9	4.628	0.926	2.987	"	"	"	"	"	"	"	"	"	"	"	"
20	564.4	4.632	0.905	2.994	"	"	"	"	"	"	"	"	"	"	"	"
21	564.3	4.612	0.910	2.990	"	"	"	"	"	"	"	"	"	"	"	"
22	562.6	4.621	0.903	2.992	"	"	"	"	"	"	"	"	"	"	"	"
23	564.5	4.624	0.928	2.985	"	"	"	"	"	"	"	"	"	"	"	"
24	564.7	4.620	0.905	2.993	"	"	"	"	"	"	"	"	"	"	"	"
25	562.6	4.628	0.905	2.995	"	"	"	"	"	"	"	"	"	"	"	"
Avg:	563.9	4.617	0.913	2.993												

TABLE II
CAPACITY CHECK DATA

SERIAL NUMBER	FIRST CAPACITY CHECK (a)						SECOND CAPACITY CHECK (b)						THIRD CAPACITY CHECK (c)					
	END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE		
	CELL (Volts)	AUX ELECT (Volts)	PRESS *	CAPAC-ITY (ah)	AUX ELECT (Volts)	PRESS *	CELL (Volts)	AUX ELECT (Volts)	PRESS *	CAPAC-ITY (ah)	AUX ELECT (Volts)	PRESS *	CELL (Volts)	AUX ELECT (Volts)	PRESS *	CAPAC-ITY (ah)	AUX ELECT (Volts)	PRESS *
1	1.429	.787	-24	14.6	.545	-22	1.470	.555	+17	16.4	.325	0	1.462	.641	20	15.8	.462	+3
2	1.440	.208		14.9	.096		1.481	.515		16.5	.200		1.423	.591		16.2	.324	
3	1.433	-.028	0	14.9	1.170	0	1.457	.508	+10	16.3	.222	-11	1.454	.598	11	16.0	.323	-12
4	1.436	1.459		14.7	1.167		1.471	.537		16.4	.272		1.466	.586		16.1	.373	
5	1.443	.824	-22	15.0	.571	-22	1.480	.555	+12	16.2	.317	-11	1.477	.623	11	15.9	.408	-9
6	1.442	.807	-25	15.2	.671	-30	1.474	.905	+16	16.4	.705	-8	1.475	.928	15	15.6	.673	-3
7	1.438	.719		15.1	.600		1.480	.901		16.8	.673		1.478	.918		15.9	.642	
8	1.433	.815	-23	15.0	.640	-28	1.473	.909	+9	16.8	.712	-12	1.469	.926	11	16.0	.659	-10
9	1.435	.763		14.9	.606		1.461	.895		16.5	.673		1.459	.914		15.5	.656	
10	1.432	.780	-23	14.8	.631	-29	1.474	.911	+6	16.5	.682	-18	1.474	.931	8	15.7	.653	-12
11	1.434	.839	-10	14.5	.572	-12	1.478	.547	+10	16.2	.268	-6	1.466	.625	11	15.7	.352	-4
12	1.432	.765		14.7	.536		1.472	.489		16.4	.242		1.461	.552		15.9	.337	
13	1.428	.827	-23	14.6	.517	-28	1.460	.501	+8	16.0	.279	-16	1.450	.590	13	15.6	.365	-11
14	1.437	.718		14.8	.533		1.488	.494		16.2	.220		1.465	.549		15.7	.286	
15	1.438	.861	-2	14.7	.572	-4	1.462	.498	+9	15.7	.214	-7	1.449	.575	9	15.0	.284	-8
16	1.438	.799	-23	14.9	.649	-24	1.508	.512	+11	16.6	.245	-7	1.493	.555	6	16.0	.289	-4
17	1.444	.758		14.9	.597		1.497	.509		16.5	.264		1.481	.575		15.7	.295	
19	1.439	.776	-28	14.9	.641	-28	1.501	.544	+10	16.5	.282	-21	1.489	.615	9	16.0	.326	-15
20	1.438	.685		15.0	.586		1.479	.455		16.4	.229		1.467	.548		16.2	.286	
21	1.437	.753	-27	14.9	.624	-27	1.487	.508	+5	16.5	.273	-22	1.483	.565	5	16.0	.327	-18

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TABLE II
CAPACITY CHECK DATA

SERIAL NUMBER	FIRST CAPACITY CHECK (a)						SECOND CAPACITY CHECK (b)						THIRD CAPACITY CHECK (c)					
	END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE			END-OF-CHARGE			END-OF-DISCHARGE		
	CELL (Volts)	AUX ELECT (Volts)	PRESS *	CAPAC-ITY (ah)	AUX ELECT (Volts)	PRESS *	CELL (Volts)	AUX ELECT (Volts)	PRESS *	CAPAC-ITY (ah)	AUX ELECT (Volts)	PRESS *	CELL (Volts)	AUX ELECT (Volts)	PRESS *	CAPAC-ITY (ah)	AUX ELECT (Volts)	PRESS *
22	1.440	.781	-28	15.0	.119	-29	1.497	.600	+14	16.5	.344	-17	1.488	.654	+8	15.7	.400	-12
23	1.429	.832		14.8	.154		1.453	.450		16.5	.366		1.439	.559		15.3	.433	
24	1.437	.769		15.0	.117		1.479	.539		16.4	.254		1.463	.585		15.7	.311	
25	1.433	.797	-27	14.9	.116	-29	1.472	.528	+11	16.5	.269	-22	1.458	.615	+7	15.7	.352	-15
Avg.				14.9						16.4						15.8		

* Negative values are interpreted as inches of mercury vacuum, while positive values are psig.

(a) The first capacity check was run with no resistor (open) across the auxiliary electrodes.
(b) The second capacity check was run with 200-ohm resistors across the auxiliary electrodes.
(c) The third capacity check was run with 300-ohm resistors across the auxiliary electrodes.

TABLE III

SERIAL NUMBER	CELL SHORT TEST Recovery Voltage after 24 Hours (Volts)	END OF CHARGE VOLTAGE AT: c/10 CONDITIONING RATE			c/20 CONDITIONING RATE			c/10 CONDITIONING RATE			INTERNAL RESISTANCE MEASUREMENT (Milliohms)	
		CELL (Volts)	AUX ELECT (Volts)	PRESS *	CELL (Volts)	AUX ELECT (Volts)	PRESS *	CELL (Volts)	AUX ELECT (Volts)	PRESS *	CELL	AUX ELECT
1	0.434	1.447	.810	−9	1.477	.904	1	**			1.58	22.1
2	1.218	1.464	.385		1.484	.482		**			1.73	22.8
3	1.218	1.451	.877	6	1.437	.867	1	**			1.53	32.8
4	1.220	1.463	.461		1.468	.551		**			1.50	23.8
5	1.217	1.475	.864	−8	1.497	.629	−3	**			1.50	27.5
6	1.209	1.432	.870	−8	1.490	.929	+6	**			1.70	24.0
7	1.217	1.435	.444		1.488	.459		**			1.60	25.6
8	1.217	1.427	.825	−11	1.473	.903	0	**			1.60	22.5
9	1.192	1.436	.420		1.454	.549		**			1.60	20.7
10	1.209	1.433	.803	−11	1.487	.884	+11	**			1.80	21.3
11	1.216	1.463	.878	+2	1.479	.920	7	**			1.61	24.0
12	1.209	1.451	.437		1.445	.492		**			1.57	26.7
13	1.207	1.440	.871	+1	1.442	.886	−3	**			1.58	24.6
14	1.203	1.458	.436		1.465	.513		**			1.55	25.0
15	1.215	1.461	.893	+1	1.452	.847	−8	**			1.76	27.8
16	1.216	1.480	.437	+3	***	***	+3	**			NOT RECORDED	
17	1.218	1.502	.526					**				
19	1.226	1.493	.572	−1			+3	**				
20	1.217	1.465	.442					**				
21	1.222	1.475	.427	−4			+1	**				

TABLE III

SERIAL NUMBER	CELL SHORT TEST Recovery Voltage after 24 Hours (Volts)	END OF CHARGE VOLTAGE AT: c/10 CONDITIONING RATE			c/20 CONDITIONING RATE			c/10 CONDITIONING RATE			INTERNAL RESISTANCE MEASUREMENT (Milliohms)	
		CELL (Volts)	AUX ELECT (Volts)	PRESS *	CELL (Volts)	AUX ELECT (Volts)	PRESS *	CELL (Volts)	AUX ELECT (Volts)	PRESS *	CELL	AUX ELECT
22	1.222	1.493	.611	+2	1.477	.590	0	**			NOT RECORDED	
23	1.153	1.447	.521		1.414	.544		1.464				
24	1.218	1.475	.570		1.484	.540		**				
25	1.219	1.468	.551	+1	1.482	.598	+1	**				
Avg.	1.180	1.460			1.468						1.61	24.7

* Negative values are interpreted as inches of mercury vacuum, while positive values are psig.
** These cells all reached the voltage limit within 1 minute from the time the overcharge rate was increased.
*** Cells were removed from charge after 15 hours due to high cell voltage.

TABLE IV
SPECIAL RESISTANCE TEST DATA ON THE AUXILIARY ELECTRODES

SERIAL NO.	1		3		5		6		8		10		11		13		15		AVERAGE	
OHMS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	PRESS	VOLTS	MILLIWATTS
10,000	0.904	+1	0.867	+1	0.929	-3	0.927	+7	0.902	0	0.882	+12	0.924	+2	0.891	-2	0.846	-7	0.897	0.081
5,000	0.858	+1	0.833	+1	0.898	-4	0.904	+7	0.867	0	0.832	+12	0.847	+2	0.868	-2	0.792	-7	0.855	0.146
2,000	0.779	+1	0.751	+1	0.826	-4	0.835	+7	0.873	0	0.735	+12	0.766	+2	0.794	-2	0.678	-7	0.772	0.298
1,000	0.687	+1	0.660	+1	0.736	-4	0.752	+7	0.701	0	0.649	+12	0.688	+2	0.716	-2	0.591	-7	0.690	0.476
500	0.581	+1	0.561	+1	0.636	-3	0.635	+7	0.613	+1	0.565	+12	0.601	+2	0.614	-2	0.511	-7	0.591	0.699
200	0.445	+1	0.434	+1	0.503	-3	0.478	+7	0.502	+1	0.447	+12	0.478	+2	0.477	-2	0.410	-7	0.464	1.080
100	0.357	+1	0.531	+1	0.412	-2	0.386	+7	0.416	+1	0.368	+12	0.386	+2	0.384	-2	0.329	-7	0.377	1.430
50	0.284	+1	0.281	+1	0.338	-2	0.308	+7	0.342	+1	0.301	+12	0.306	+2	0.307	-1	0.258	-8	0.303	1.840
20	0.204	+1	0.210	+1	0.258	-2	0.223	+7	0.260	+1	0.221	+11	0.214	+2	0.221	-1	0.183	-8	0.222	2.460
10	.		.		.		0.163	+7	0.202	+1	0.162	+11	0.154	+2	0.164	-1	0.134	-8	0.163	2.660
5	.		.		.		0.109	+6	0.145	0	0.110	+11	0.100	+2	0.108	-1	0.088	-8	0.110	2.420
2	.		.		.		0.055	+6	0.082	0	0.057	+11	0.051	+2	0.052	-2	0.045	-8	0.057	1.620
1	0.032	+1	0.041	+1	0.013	-2	0.029	+6	0.046	0	0.032	+11	0.029	+1	0.028	-2	0.025	-8	0.031	0.961
0.5	.		.		.		0.015	+6	0.023	-1	0.017	+11	0.016	+1	0.015	-2	0.014	-8	0.011	0.242
0.2	.		.		.		0.007	+5	0.010	-2	0.008	+10	0.008	+1	0.006	-2	0.006	-8	0.005	0.125
0.1	.		.		.		0.003	+5	0.005	-2	0.004	+10	0.005	+1	0.006	-3	0.003	-9	0.003	0.090

$$\text{POWER} = \frac{V^2}{R} \text{ Watts } 10^3 \frac{\text{Milliwatts}}{\text{Watt}} : \text{Milliwatts}$$

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