APPENDIX 5B. MICROWAVE OVEN STANDBY POWER TESTING REGRESSION METHODOLOGY

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5B.1 INTRODUCTION

The U.S. Department of Energy (DOE) considered alternate testing methods to determine standby power over a shorter period than 12 hours that were highly representative in order to reduce the test burden on manufacturers. Thus, DOE developed an algorithm by which the standby power consumption and line voltage are measured as the clock is cycled through all the possible digit combinations (in terms of active elements) and then a regression analysis is performed to quantify the impact of the number of lit elements (by digit) and voltage on power consumption. The results are then integrated across the number of minutes that each active element combination is "on" through the course of the 12 hours.

5B.2 METHODOLOGY

The test method would require that the tester enter the following 18 clock combinations at 15 second intervals into the microwave oven clock display: 1:11, 1:17, 1:14, 1:15, 1:16, 1:18, 1:41, 1:51, 1:01, 1:55, 7:55, 4:55, 5:55, 6:55, 8:55, 11:55, 12:55, and 10:55. For each programmed time, the average line voltage and standby power consumption over a 15-second period are measured. The tester also determines, for each clock time displayed, the total number of active elements. For the purpose of calculating the active number of elements for each digit displayed on the microwave oven display, DOE developed the following simplified lookup table.

Table 5B.2.1 Active Element Lookup Table

Digit Displayed	Number of Active Elements
Blank / None	0
0	6
1	2
2	5
3	5
4	4
5	5
6	6
7	3
8	7
9	6

The results are then used as inputs to the regression analysis, as shown for illustrative purposes with example data in Table 5B.2.2 below. The regression uses five input factors: the number of active elements for each digit (AE1 through AE4, assuming a four-digit display) and

the average line voltage in volts alternating-current (VAC), while the standby power consumption in watts (W) is the output.

Table 5B.2.2 Sample Regression Table

Clock Time	Average Voltage (VAC)	Number of Active Elements by Digit				Average Standby Power (W)
		1st	2nd	3rd	4th	
1:11	119.718	0	2	2	2	1.16308
1:17	119.8	0	2	2	4	1.22024
1:14	119.8128	0	2	2	4	1.22018
1:15	119.5997	0	2	2	5	1.23941
1:16	119.7364	0	2	2	6	1.2659
1:18	119.7421	0	2	2	7	1.28572
1:41	119.7179	0	2	4	2	1.21773
1:51	119.9457	0	2	5	2	1.24857
1:01	119.9266	0	2	6	2	1.2708
1:55	119.8723	0	2	5	5	1.32908
7:55	119.8025	0	4	5	5	1.38373
4:55	119.7811	0	4	5	5	1.3812
5:55	119.6811	0	5	5	5	1.40734
6:55	119.7248	0	6	5	5	1.43133
8:55	119.758	0	7	5	5	1.45239
11:55	119.7374	2	2	5	5	1.38162
12:55	119.6646	2	5	5	5	1.46521
10:55	119.6489	2	6	5	5	1.48858

The regression results consist of six coefficients: AE1-AE4, voltage, and the intercept. A sample Microsoft Excel regression result is shown below in Table 5B.2.3.

Table 5B.2.3 Sample Regression Output

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.998071
R Square	0.996146
Adjusted R	0.99454
Standard E	0.009197
Observatio	18

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regressior	5	0.26235	0.05247	620.3353	4.78E-14
Residual	12	0.001015	8.46E-05		
Total	17	0.263365			

	Coefficients	*tandard Erı*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 95.0%*	*Jpper 95.0%*
Intercept	-2.989038	0.434515	-6.879024	1.7E-05	-3.935764	-2.042311	-3.935764	-2.042311
Volts	0.035709	0.00358	9.975633	3.68E-07	0.02791	0.043508	0.02791	0.043508
AE1	0.047066	0.003238	14.5357	5.57E-09	0.040011	0.054121	0.040011	0.054121
AE2	0.030723	0.001635	18.79208	2.88E-10	0.027161	0.034286	0.027161	0.034286
AE3	0.030894	0.001898	16.28024	1.52E-09	0.02676	0.035029	0.02676	0.035029
AE4	0.032807	0.00169	19.41726	1.97E-10	0.029126	0.036488	0.029126	0.036488

The five input factors are input into a small integration table which accounts for how many minutes each digit is displaying a given number of active elements per day. A sample integration table appears as Table 5B.2.4 below.

Table 5B.2.4 Sample Integration Table

Active Elements	Minutes the Number of Active Elements are on For a Given Digit per Day				Standby Energy Consumption	
	AE1	AE2	AE3	AE4		
2	360	240	240	144	0.913	Wh
3	0	0	0	0	0.000	Wh
4	0	240	240	288	1.367	Wh
5	0	480	720	432	3.661	Wh
6	0	360	240	432	2.743	Wh
7	0	120	0	144	0.808	Wh
				Voltage	28.292	Wh
				Intercept	-4.207	Wh
	Average			Daily Total	33.577	Wh
	1.399 W			Yearly	12.2557	kWh

The integration table then predicts the average standby power in W, the daily total watt-hours (Wh) consumed, and the yearly standby energy consumption in kilowatt-hours (kWh), assuming stable 120 VAC input power.