APPENDIX 5A. AHAM DATA SUBMITTAL

TABLE OF CONTENTS

LIST OF FIGURES

APPENDIX 5A. AHAM DATA SUBMITTAL

5A.1 INTRODUCTION

This appendix presents the shipments and incremental cost data submitted to the U.S. Department of Energy (DOE) by the Association of Home Appliance Manufacturers (AHAM) in support of the engineering analysis for this rulemaking. See chapter 5 of the technical support document (TSD) for details of the engineering analysis for which these data were used.

5A.2 AHAM MICROWAVE OVEN DATA SUBMITTAL

AHAM submitted the following microwave efficiency and standby test data and report to DOE on October 23, 2006.

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October 23, 2006

Mr. Michael Rivest
Managing Director
Navigant Consulting, Inc.
1801 K Street, NW, Suite 500
Washington, D.C. 20006- 1301

Subject: AHAM Test Data on Microwave Ovens

Summary:

The Association of Home Appliance Manufacturers is the trade association representing the manufacturers of over 95% of the microwave ovens sold in the U.S. To assist the Department of Energy in its rulemaking for Microwave Ovens (MWOs), AHAM commissioned the independent testing at Intertek/ETL of 22 randomly selected MWOs (provided by 7 different manufacturers). The ovens represented a broad spectrum of units presently in the market place, and varied by size, power rating, components, and features.

The tests were conducted using the DOE test procedures prescribed in 10 CFR Part 430 Appendix I, which references IEC Standard 705-1988 with Amendment 2-1993. The results of the tests are shown in the file embedded below. Each unit was tested 3 times. The average Energy Factor of the 3 runs for each unit is highlighted in yellow in the embedded file.

[File reproduced at the end of this letter]

The test results show that there is a very narrow range in energy efficiency between the least and most efficient unit (54.8% minimum to 61.8% maximum - less than a 13% spread). Using the annual useful cooking energy output of 79.8kWh/yr, as determined by DOE in its September 8, 1998 rulemaking, this range in efficiencies results in a difference of only about 16 kWh/yr (which is about $1.60/yr) between the least and most efficient unit.

The September 8, 1998 Final Rule on cooking products states that, “DOE has determined that there would be no significant conservation of energy for … microwave ovens, and standards would not be economically justified.”[a] **We believe the test data and information provided herein confirms that an efficiency standard for MWOs is still not warranted.**

DOE considered many design options for microwave ovens in its 1998 rule, and after extensive analysis, it was determined that no design options were technology feasible or economically justifiable. There have been no technological or economic breakthroughs since the previous determination which would change the previous conclusion.

Factors and Features Impacting Efficiency:

There are many factors that impact the efficiency of MWOs, and many different features that are driven by the demands of the marketplace. These features determine the need for components that consume electrical energy or absorb microwave energy during operation. Common components that affect the energy efficiency are shown in the table below:

Turntable motor	Waveguide & cavity	Magnetron tube
Stirrer motor	Glass turntable	High Voltage Transformer
Cavity lamp	Turntable roller	High Voltage Diode
Fan motor	Turntable hub	High Voltage Capacitor
Display, relays, & electronics	Stirrer blade	

Many of the components listed above may impact the energy consumption differently, depending upon the specific oven features and application. For example, an Over-The-Range (OTR) oven may require a larger cooling fan motor than a counter-top oven. This is because the ambient air at the OTR air inlet is at an elevated temperature due to the range beneath being in operation.

Wattage of the cavity lamp is another example. The consumer desires brightly illuminated oven cavities. Increasing the wattage of the lamp by only 10 watts could lower the efficiency of an oven by about 0.5%. Some manufacturers may choose higher wattage lamps for product differentiation.

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[a] 63 Fed. Reg. 48,038 (Tuesday, September 8, 1998).

Manufacturers do not optimize the efficiency of their designs around the DOE test procedure, which calls for a simplified method of heating one liter of water in the center of the oven. Rather, ovens are designed to heat various sizes, shapes, and types of food most efficiently and evenly. Again, consumer needs are the key drivers on MWO design.

For example, designers often use a stirrer to improve cooking performance as determined by Consumer Union testing in categories such as thermal uniformity and defrosting. The stirrer is a rotating device used to vary how the electromagnetic field is applied to the food in the oven cavity. As the stirrer sweeps through its rotation, the magnetron's frequency and efficiency also change. The net effect is to improve cooking performance for the consumer, in exchange for a small decrease in oven efficiency.

Design Options:

In DOE's March 15, 2006 Framework Document, several design options are listed for microwave ovens as possible considerations to improve energy efficiency. We offer the following comments on those design options:

- Add insulation – This is not a practical option, as it would not improve the Energy Factor. The DOE test is only about 45 seconds in duration and the temperature of the oven walls does not increase during use, thus no significant energy would be saved by adding insulation. It is likely that the net result would not even be measurable.

- Reflective surfaces – Manufacturers are already using surface finishes to optimize efficiency. If DOE is referring to the possibility of adding metallic plates inside the oven cavity to adjust cavity impedance to the highest oscillation impedance of the magnetron, this is best accomplished by better oven design without such metallic plates.

- More efficient fan – A typical fan only draws about 30 watts, resulting in less than 2% of the total energy consumed during the DOE test. Therefore, improving the fan efficiency by going to more expensive motors would at best improve the energy factor by less than 0.5%. Thus more efficient fans motors are not economically justified.

- Improve efficiency of magnetron – The magnetron tube is the heart of the MWO. As such, considerable engineering effort has already gone into optimizing their efficiency, and there is very little difference in available technologies. Virtually all magnetrons are the same. A review of magnetron manufacturers' specifications shows that the typical efficiency is about 73%, with only a plus or minus 2% variance. Thus, there is no available technology for improvement.

- Improve efficiency of the power supply – There are two types of high voltage power supplies that are used in MWOs. The predominant type is the inductive capacitance transformer, known as the LC power supply, which has an efficiency of about 82%. The other type is the inverter type, which is more expensive, and has an efficiency of about 84%. (General purpose transformers have higher efficiencies, but the need for stable output power in MWOs requires the use of special transformers which have inherently lower efficiencies.)

  Three of the units tested utilized an inverter type power supply, whereas all others used the more typical LC transformer. Even though inverter power supplies are slightly more efficient than LC types, the Energy Factors of the 3 units with an inverter were right around the median of all the units tested. They ranged around 56% to 59%, with the average of the 3 units being 58%.

Therefore, the use of an inverter as a design option does not necessarily improve efficiency. We see no cost effective opportunity for improving the efficiency of the power supply.

- Eliminate or improve ceramic stirrer cover – Virtually no residential solo-function microwave ovens still use a ceramic stirrer. Almost all MWOs use a polypropylene or mica film, which are low energy loss materials resulting in less losses than the ceramic type. Thus this design option has already been optimized.

- Modify wave guide – We are not aware of any improvement to the wave guide that would result in any significant increase in energy efficiency. Losses associated with the wave guide are typically less than 0.5% of the overall energy consumption.

- Dual magnetrons – This would not be an effective way to improve energy efficiency since magnetrons require energy to heat the magnetron heater. This energy is not converted to microwave energy, and thus is wasted. Thus, the more magnetrons used, the more wasted energy is consumed, not to mention the additional cost of extra magnetrons.

Standby Power:

Standby power was measured on all the ovens tested, in accordance with IEC Standard 62301-2005, *Household electrical appliances – Measurement of standby power*. The measurements ranged between 1.5 and 5.8 watts, with an average of 2.9 watts. Each watt of standby power is approximately 8.7 kWh/yr, which amounts to about 85 cents/yr. Even if DOE limited the standby power of MWOs to 2 watts, it would only result in less than a dollar per year savings on average per unit.

There are three major types of displays used in microwave ovens today. They are LED (light emitting diodes), VFD (vacuum fluorescent display) and LCD (liquid crystal display). Typically, LCD without back-lighting uses the least amount of energy while VFD uses the most. Energy consumed by LCD would depend on whether back-lighting is present or not. And if present, the number of LEDs used for back-lighting is a major factor in energy consumption.

For LEDs, the number of segments, color and operating temperature has an impact on its energy consumption. The size of the display (number of digits and icons) also affects the energy consumed by the display. For VFDs, the size of display is a major factor in its energy consumption.

The type of display used, its size, and type of back-lighting, etc., all have a direct impact on the product's appeal to the consumer. Thus, while an LCD without back-lighting may be most energy efficient, it may not have as much consumer appeal as a VFD, which is typically the best from a legibility perspective.

Manufacturers (driven by consumer/market desires) want the flexibility to produce microwave ovens using the various displays described above in order to provide products with market differentiation, in turn meeting the diverse needs of consumers. This is the reason for the variance in the test results for measured standby power. Therefore, AHAM recommends that standby power not be considered as a separate prescriptive requirement.

Conclusion:

All the ovens we tested were within a relatively narrow efficiency range without any current energy standards in effect. The tests indicated a range in efficiencies that results in a difference of only about 16 kWh/yr (which is about $1.60/yr) between the least and most efficient unit. This narrow range of efficiencies is a result of optimization of current cost effective design options and market competition to produce high quality microwave ovens at low prices for the consumer, while still being able to offer ample product features and differentiation.

Efficiency standards for microwave ovens are not justified, as very little energy savings would result. The cost and risk of modifying today's well-performing products with questionable design options should not be underestimated. Microwave ovens are much more efficient than conventional cooking products, and their use should be encouraged, not discouraged by adding cost to the products for very little overall energy savings benefit.

Therefore, we recommend that a "No Standard, Standard" be re-established for these products and that significant resources not be expended to conduct unnecessary analyses. Sufficient data and precedent exists to support and affirm DOE's previous conclusion that standards for MWOs are not justified. DOE and industry resources would be better spent on expediting other rulemakings.

Thank you for the opportunity to provide this information. Please feel free to contact me with any questions that you might have.

Sincerely,

Lawrence R. Wethje

Lawrence R. Wethje, P.E.
Vice President, Technical Services

Figure 5A.2.1 AHAM Standby Power Test Data

Client: AHAM
Project No.: 3100653
Microwave Oven Re-Testing: 09/20-22/06
Tested per IEC 705-1988 and Amendment 2-1993

Unit No.	Rated Volume (ft3)	Humidity Sensor (Y/N)	Rated Watts	Mw , (g)	Mc, (g)	T0, (oC)	T1, (oC)	T2, (oC)	t, (Sec.)	Win	Watts @ 20 Sec.	P, (Watts)	EF, (%)	SP,** (Watts)
1	0.8	N	800	1000	515	20.8	10.0	19.5	52	18.9	1292	753.6	58.3	1.5
				1000	515	19.6	10.4	19.7	52	18.8	1286	749.7	58.3	
				1000	515	19.9	10.0	19.1	52	18.8	1292	725.8	56.2	
												Average:	***57.6***	
2	1.5	N	1200	1005	515	19.5	10.4	19.9	35	18.4	1875	1147.3	61.2	3.0
				1000	515	21.9	11.7	21.3	35	18.4	1876	1140.7	60.8	
				995	515	20.8	10.5	20.2	35	18.3	1872	1146.8	61.3	
												Average:	***61.1***	
3	1.6*	N	1000	1000	515	18.9	9.8	20.0	42	20.0	1730	1028.7	59.5	3.9
				1000	515	19.5	10.1	20.3	42	20.1	1735	1025.5	59.1	
				1000	515	19.9	10.4	20.3	42	19.7	1705	991.3	58.1	
												Average:	***58.9***	
4	1.6*	Y	1000	1000	515	19.5	10.1	19.9	42	19.6	1696	981.3	57.9	4.2
				1000	515	20.7	10.5	20.2	42	19.7	1704	961.6	56.4	
				995	515	20.5	10.5	20.3	42	19.4	1678	969.9	57.8	
												Average:	***57.4***	
5	1.2	N	1000	1000	515	20.7	10.8	20.4	42	19.1	1604	953.8	59.5	1.8
				1000	515	19.3	10.1	19.8	42	19.1	1602	972.4	60.7	
				1000	515	19.2	9.9	19.8	42	19.1	1607	993.4	61.8	
												Average:	***60.7***	
6	1.6	Y	1200	1000	515	19.1	10.1	20.1	35	19.6	1946	1209.2	62.1	3.7
				1005	515	19.2	10.1	20.1	35	19.6	1951	1213.9	62.2	
				1000	515	21.1	10.8	20.8	35	19.6	1950	1192.4	61.1	
												Average:	***61.8***	
7	1.2	Y	1300	1000	515	19.2	9.8	18.8	32	17.6	1988	1171.9	59.0	2.0
				995	515	20.4	10.2	19.4	32	17.6	1986	1183.6	59.6	
				1000	515	20.8	10.8	19.8	32	17.5	1984	1163.4	58.6	
												Average:	***59.1***	
8	1.6	N	1250	1000	515	21.3	11.0	20.4	34	18.7	2010	1145.6	57.0	2.2
				1000	515	19.6	10.6	19.9	34	18.8	2010	1149.3	57.2	
				1000	515	20.0	10.7	19.9	34	18.8	2010	1131.6	56.3	
												Average:	***56.8***	
9	2.2	Y	1250	1005	515	18.7	9.3	18.6	34	18.8	2008	1149.7	57.3	2.9
				995	515	19.3	9.8	19.3	34	18.7	2006	1164.0	58.0	
				1000	515	19.2	9.7	19.3	34	19.1	2009	1183.5	58.9	
												Average:	***58.1***	

10	0.7	N	700	1000	515	19.6	10.0	19.8	60	20.2	1216	685.4	56.4	2.1
				1000	515	21.8	11.8	21.3	60	20.3	1218	659.2	54.1	
				1000	515	21.7	11.8	21.4	60	20.0	1210	667.7	55.2	
												Average:	**55.2**	
11	0.7	N	700	1000	515	19.7	10.1	20.3	60	20.0	1192	716.3	60.1	2.0
				1000	515	21.6	11.4	21.4	60	19.6	1180	696.3	59.0	
				1000	515	21.7	11.1	21.0	60	19.6	1176	685.6	58.3	
												Average:	**59.1**	
12	1.6	N	1000	1000	515	21.8	11.3	21.0	42	19.8	1690	958.4	56.7	1.9
				1000	515	19.2	10.1	19.9	42	20.1	1712	984.5	57.5	
				1000	515	19.6	10.0	19.6	42	19.6	1668	957.0	57.4	
												Average:	**57.2**	
13	2.0	Y	1100	1000	515	18.5	9.1	19.2	38	20.9	1934	1121.2	58.0	3.6
				1000	515	19.1	9.9	20.1	38	20.9	1959	1135.8	58.0	
				1000	515	19.1	9.9	19.8	38	20.6	1909	1099.2	57.6	
												Average:	**57.8**	
14	0.9*	Not Listed	1000	1000	515	19.8	8.9	19.0	42	19.9	1670	998.2	59.8	2.0
				1000	515	21.7	11.3	21.1	42	20.3	1686	970.5	57.6	
				1000	515	21.0	10.4	20.4	42	20.2	1683	990.4	58.8	
												Average:	**58.7**	
15	1.1	N	1000	1000	515	18.9	9.7	20.0	42	19.7	1672	1038.7	62.1	1.8
				1000	515	19.1	10.1	20.3	42	19.7	1675	1029.8	61.5	
				1000	515	20.4	10.2	20.4	42	19.8	1676	1016.8	60.7	
												Average:	**61.4**	
16	0.8*	Y	800	1000	515	19.5	10.0	20.0	52	21.0	1421	809.6	57.0	5.7
				1000	515	21.7	11.2	21.1	52	20.6	1402	791.9	56.5	
				1000	515	21.6	11.0	20.8	52	20.6	1402	782.1	55.8	
												Average:	**56.4**	
17	1.2	N	1200	995	515	19.6	10.5	20.3	35	18.7	1878	1175.6	62.6	2.0
				1000	515	21.1	11.1	20.7	35	18.6	1874	1143.3	61.0	
				1000	515	21.0	10.6	20.2	35	18.6	1875	1138.1	60.7	
												Average:	**61.4**	
18	1.5	N	1000	**DAMAGED UNIT!!!!!**										-
												Average:		
19	1.5	Y	1000	1000	515	21.3	10.6	20.7	42	20.8	1740	1000.4	57.5	4.4
				1000	515	19.4	9.7	19.8	42	20.8	1745	1011.2	57.9	
				1005	515	20.0	10.5	20.3	42	20.8	1745	985.1	56.5	
												Average:	**57.3**	
20	1.0	N	1000	1000	515	19.4	9.2	18.8	42	19.9	1668	950.6	57.0	1.7
				1000	515	20.7	10.3	19.7	42	19.8	1669	926.3	55.5	
				1000	515	21.3	11.6	20.8	42	19.8	1668	911.8	54.7	
												Average:	**55.7**	
21	1.5*	Y	1100	1000	515	20.0	10.7	20.2	38	21.1	1936	1049.1	54.2	5.8
				1005	515	20.0	9.6	19.4	38	21.1	1941	1078.0	55.5	
				1000	515	20.1	10.0	19.6	38	20.8	1922	1051.8	54.7	
												Average:	**54.8**	
22	1.4*	N	950	1000	515	20.2	10.6	20.3	44	20.5	1630	924.1	56.7	2.6
				995	515	21.1	11.1	20.6	44	20.5	1628	894.3	54.9	
				1000	515	19.9	10.4	19.9	44	20.2	1623	904.0	55.7	
												Average:	**55.8**	

Legend:

P - is the microwave power output, in watts
Mw - is the mass of the water, in grams
Mc - is the mass of the container, in grams
T0 - is the ambient temperature, in degrees Celsius
T1 - is the initial temperature of the water, in degrees Celsius
T2 - is the final temperature of the water, in degrees Celsius
t - is the heating time, in seconds, excluding the magnetron filament heating-up time

Win - is the energy input, in watt-hours

EF - is the Energy Factor, or efficiency, in percent

SP - is the standby power, in watts

All tests were performed at 120 Vac, 60 Hz

** - Physical measurement performed by ETL*

*** - Measured with the microwave clock set to 12:00 and with door closed.*