Vulcan-Hart Induction Range Top

Application of ASTM Standard
Test Method F1521-94

FSTC Report 5011.95.29

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Acknowledgments

The establishment of a Food Service Technology Center reflects PG&E's commitment to the food service industry. The goal of the research project is to provide PG&E's customers with information to help them evaluate technically innovative cooking appliances and make informed equipment purchases regarding advanced technologies and energy sources. The project was the result of many people and departments working together within PG&E and the overwhelming support of the commercial equipment manufacturers who supplied the cooking appliances for testing.

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Specific appreciation is extended to Vulcan-Hart Corporation, for supplying the Food Service Technology Center with a 2.5 kW and a 5.0 kW induction range tops for controlled testing in the appliance laboratory.

Contents

Executive Summary

This study documents the performance of the Vulcan-Hart 2.5 kW induction range top, which is currently being superseded by a 3.0 kW induction range top, as determined by applying a revised version of the American Society for Testing and Materials' (ASTM) *Standard Test Methods for the Performance of Range Tops* (Designation F 1521-94). This report also covers the test method application to a similar 5.0 kW induction range top prototype, that is also not currently on the market. Range top performance is characterized by energy consumption, temperature response and uniformity, cooking energy efficiency, and production capacity. A summary of the cooking energy efficiency and production capacity test results is presented in Table ES-1.

Table ES-1
Summary of Induction Range Top Test Results

	2.5 kW	5.0 kW
Rated Energy Input Rate (kW)	2.5	5.0
Measured Energy Input Rate (kW)	2.56	4.82
Cooking Energy Efficiency (%)	80.0	84.1
Production Capacity (lb/h)	50.5	97.0

The range top's induction technology performed favorably, particularly with respect to the high and low heat-up temperature response. The 2.5 kW induction unit has a high limit safety that cuts the unit off when the surface reaches an unsafe temperature, but has an optional setting that maintains approximately 350°F. The low temperature setting has two variations, one for gradual temperature increase and another for rapid heat-up and then stabilization. The 5.0 kW unit has a dial temperature control that allows for only one minimum and maximum temperature response. Vulcan-Hart Corporation successfully incorporated the quick temperature response usually associated with gas range tops, while maintaining the higher cooking energy efficiency attributed to electric range tops.

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1 Introduction

Background

The range top is one of the most versatile and widely used pieces of equipment in a commercial kitchen and range tops continue to evolve as commercial end users demand more powerful and efficient equipment. An interesting development is the application of induction technology to electric range tops. One of the potential benefits of induction cooking is that heat can be evenly distributed into a large cooking surface, similar to a gas burner, without sacrificing the efficiency of electric resistance cooking.

Range top design continues to evolve as commercial end users demand more powerful and efficient equipment.

Residential induction range tops have been available for several years but the technology was not applied to commercial range tops. Interest in the commercial use of induction technology grew; an electric induction fryer was successfully introduced to the market and an induction griddle was developed. Now, two major equipment manufacturers have introduced commercial induction range tops to the market and these manufacturers as well as end users are anxious to know how well this technology performs, especially in comparison to existing technologies. Range top performance is evaluated by applying a standardized test method developed at the PG&E Food Service Technology Center (FSTC).

With cofunding from the Electric Power Research Institute (EPRI), the Gas Research Institute (GRI), and the National Restaurant Association, the FSTC developed a test method, called a uniform testing procedure (UTP), enabling evaluation of gas and electric range tops based on energy and performance indicators. This test method was submitted to the American Society for Testing and Materials (ASTM), and in May 1994, it was accepted as the *Standard Test Method for the Performance of Range Tops* (Designation F1521-94).[1] PG&E's *Development and Validation of a Uniform Testing Procedure for Range Tops* documents the development of the procedures, along with test results.[2] The test method has been applied to seven range tops: two electric, two gas, and three induction.[3,4,5,6,7]

Application of the standard test method determines cooking energy efficiencies and production capacities that correlate with "real-world" performance, providing end users with valuable information for purchasing and operating range tops. PG&E benefits from the study of range tops by being able to provide its customers with information on high-performance, energy-efficient commercial cooking equipment.

The FSTC is continually exploring possible areas for improvement to the ASTM standard test method. Through sensitivity testing and comparison of the results from one test to another, FSTC researchers developed a set of revisions, endorsed by the FSTC National Advisory Group that will be incorporated into a revised version of the ASTM standard test method. The testing detailed in this report is in accordance with these revisions.

The glossary in Appendix A is provided so that the reader has a quick reference to the terms used in this report.

Objectives

This report examines the operation and performance of the Vulcan-Hart 2.5 kW induction range top, under the controlled conditions of the revised ASTM standard test method. A 5.0 kW induction range top prototype, was also loaned to the FSTC for application of the UTP and both of these Vulcan-Hart induction units have been superseded by a 3.0 kW induction range top. Comparison of the two units gives an idea of how future models might perform. The scope of this testing is as follows:

- Verify that the appliance is operating at the manufacturer's rated energy input.
- Characterize the minimum and maximum temperature rise and temperature uniformity.
- Document the cooking energy efficiency at the full-input rate.
- Determine the production capacity.

Appliance Description and Operation

The 2.5 kW and the 5.0 kW induction range tops include a single cooking unit that causes heat to be generated directly into the magnetic material comprising the cooking container by means of an induced electromagnetic field. The amount of heat generated in the cooking container is controlled by varying the strength of the magnetic field. The cooktop surface is a smooth and continuous, ceramic glass plate allowing for easy cleaning. Because the surface is not directly heated during operation, it remains relatively cool, gaining only residual heat from the cooking container. Appliance specifications are presented in Table 1-1 and the manufacturer's specification sheet is in Appendix B.

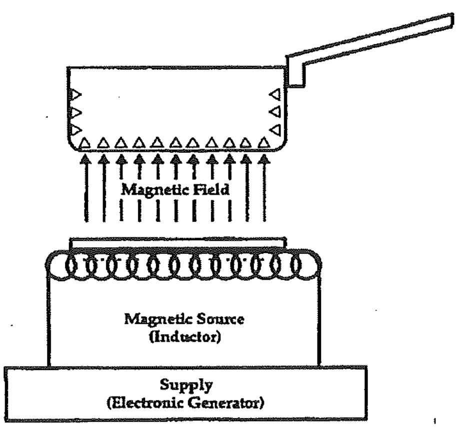

Table 1-1.
Appliance Specifications

Manufacturer:	Vulcan-Hart Corporation
Generic Appliance Type:	Electric Induction Cooktop
Rated Energy Input:	2.5 kW
Voltage	208 V, single phase
Dimensions:	18″ wide by 24″ deep by 14″ high
Construction Material:	Ceramic glass sealed flush with stainless steel side panels, control panel, and removable top

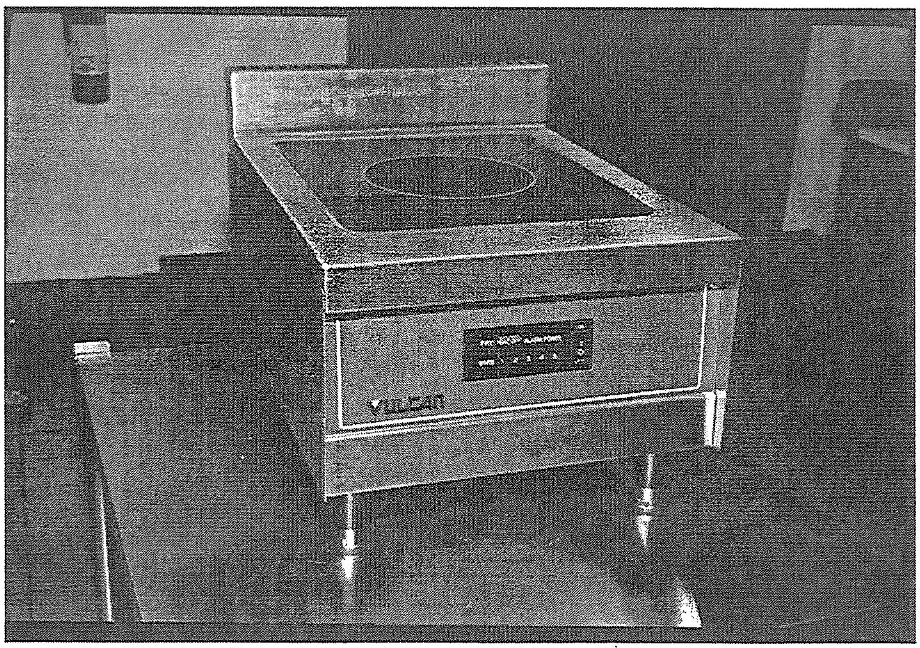

Figure 1-1
Vulcan-Hart 2.5 kW unit

2 Methods

Input Rate

The induction range top was connected to a regulated 208 V, single phase power source and the energy input rate test was performed. In accordance with the ASTM test method, the input rate was measured with the unit operating at full input in order to verify that the range top was operating properly, within ± 5.0% of the manufacturer's rated input.

Temperature Response and Uniformity

To determine the heat-up temperature response of the range top, FSTC researchers attached 17 thermocouples to a 1/4-inch-thick, 12-inch-diameter carbon steel plate, as detailed in section 10.4 of the ASTM test method. The range top was turned on to the minimum control setting and time, temperature, and energy were recorded over the next hour. After the plate was allowed to cool, the test was repeated at the highest setting.

Temperature uniformity of the range top was determined by recording the 17 individual temperatures on the plate surface at the end of each of the one-hour heat-up temperature response tests. The temperature uniformity was then expressed as the standard deviation of these 17 temperature points and was reported along with the average of the temperatures.

For a detailed discussion of temperature response and uniformity, refer to the FSTC report 1022.95.20, *Development and Validation of a Uniform Testing Procedure for Range Tops.*

Cooking Performance Tests

A range top can be used to cook food in several different ways; however, it is often used to heat up quantities of food in pots. In keeping with this scenario, the cooking energy efficiency and production capacity are based on the sensible heat gain (heat up) of water in a pot, a temperature rise from 70°F to 200°F. Three cooking tests were performed at full-input rate in accordance with section 10.5 of the ASTM test method. The results from each test run were averaged, and the absolute uncertainty was calculated based on the standard deviation of the results. This procedure ensures that the reported cooking energy efficiency and production capacity results have an uncertainty of less than ± 10.0%.

Test Setup and Instrumentation

The range was installed under a 4-foot-deep canopy hood that was 6 feet 6 inches above the floor. The hood operated at a nominal exhaust rate of 300 cfm per linear foot of hood. There was at least 6 inches of clearance between the front edge of the range top and the edge of the hood. All test apparatus were installed in accordance with Section 9 of the ASTM standard.

Electric energy consumption was measured with a calibrated watt-hour meter with a 10-watt-hour resolution. Range top temperature rise and uniformity were measured with K-type thermocouples strain-gage-welded to a steel plate. Water temperature was measured using a Fluke resistance temperature device (RTD), model 2180A. The cooking container used for testing was a Spring Brigade Complet brand, steel plated, 12⅝-in diameter, 13½-qt, sauce pot, model 8475-60 and weighing 12.0 lb, with a lid weighing 1.7 lb. The cooking container is described in section 6.3 of the revised ASTM test method. Each test load consisted of 20.0 lb of water. All data were logged using a Fluke Helios data logger and recorded on a PC. Voltage is maintained at 208V with a Staco voltage regulator.

3 Results

Input Rate

Researchers measured the Vulcan-Hart 2.5 kW unit's energy input rate to be at 2.56 kW, which is 2.4% higher than the nameplate. The 5.0 kW unit measured 4.82 kW, which is 3.6% lower than the nameplate. Both units operated within the specified ± 5.0% of the nameplate rate.

Temperature Response and Uniformity

The temperature control panel of the 2.5 kW unit has a *warm* setting, settings from *1* to *5*, with 1 being the low setting and 5 the high, and a *fry* setting. Section 10.4 of the ASTM test method specifies that the range top be tested at the minimum and maximum control settings; however, the induction unit has two possible minimum settings, low (1) and *warm*, and two possible maximum settings, high (5) and *fry*. The FSTC researchers applied the test procedure at all four of the control settings for comparison. Results from these tests are shown in Figure 3-1 as the low, *warm*, high, and *fry* curves.

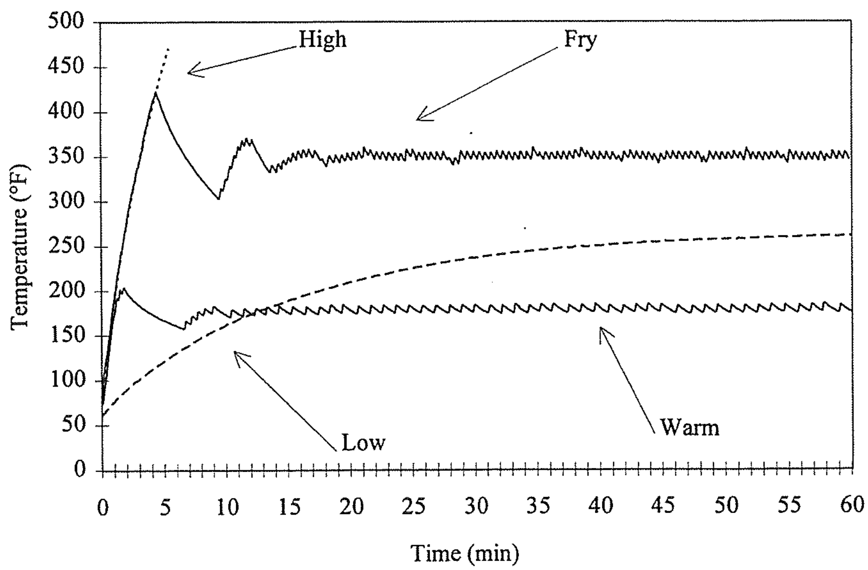

Figure 3-1
2.5 kW temperature response

The four curves generated by the temperature response test illustrate the function of each of the four control settings. The researchers discovered, during the maximum control setting test, that the induction range top has a high temperature safety cut-off point that terminates the power source. The range top shut down within the first five minutes after reaching almost 500°F. Both the *warm* and the *fry* settings cause the magnetic source to modulate, which produces a steady, non-increasing temperature in the cooking container. This is a control feature that is unique to the induction range. If a cooking container is placed on a non-thermostatic device such as an electric element or a gas burner, it is difficult to stabilize the temperature of the cooking container because the container will continue to heat up until it reaches some equilibrium. Using the induction range *warm* or *fry* setting, a chef could melt butter or fry fish and walk away for a moment without worrying about the pan scorching the food.

Temperature response comparisons of the Vulcan-Hart 2.5 kW induction unit with a standard resistance-element electric unit and a standard gas star-burner unit that were tested at the FSTC[3,5] show that after five minutes at the maximum setting, the 2.5 kW unit had reached almost 500°F, the standard gas unit was at 500°F, and the standard resistance-element was at 250°F. For the minimum temperature response test, the primary issue is not how fast the unit can respond, but how low the operating temperature is at the minimum setting. At the end of the one-hour test period, the resistance-element had reached slightly over 300°F, the standard gas unit was at 210°F, and induction unit was at a temperature of 150°F. The results of the Vulcan-Hart 2.5 kW induction range top reflect both speed and flexibility, exhibiting the quick temperature response characteristics usually attributed to standard gas range tops, while allowing the user to operate at a lower temperature setting than either the gas or electric elements.

The 5.0 kW induction range top had a dial temperature control setting that allowed for a single minimum and maximum temperature response. The high setting for the 5.0 kW unit reached almost twice the temperature range (800°F) as did the 2.5 kW unit, within the same amount of time, while still maintaining the high temperature safety cut-off point. The low setting on the 5.0 kW range top had a very low, stable temperature throughout the test period that stabilized after 10 minutes and remained at about 120°F. The average temperature response curves for the 5.0 kW unit are plotted in Figure 3-2. A comparison of the two units' high and low temperature settings are plotted in Figures 3-3 and 3-4, respectively.

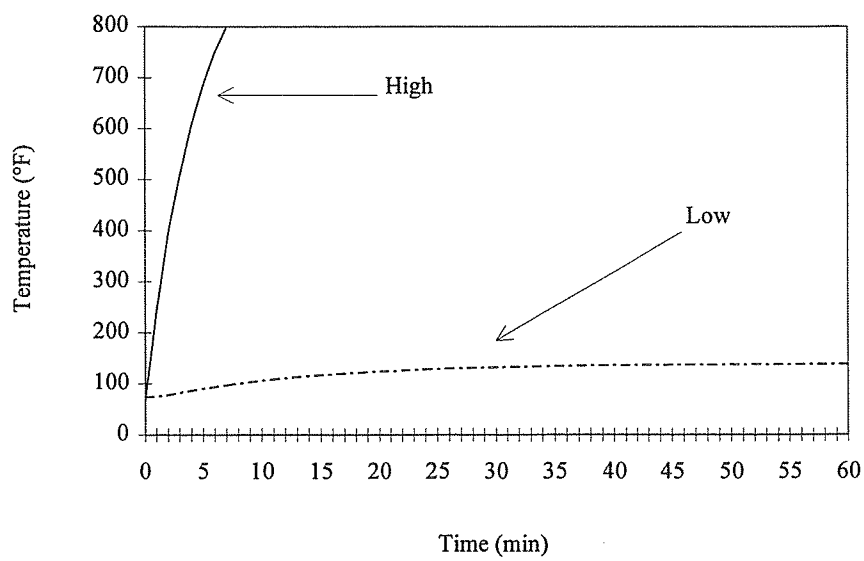

Figure 3-2
5.0 kW temperature response

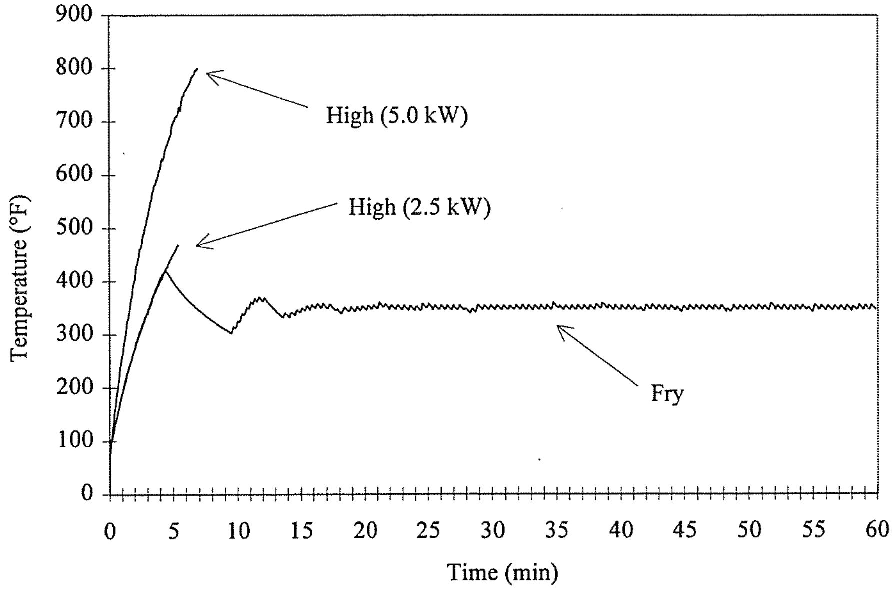

Figure 3-3
High temperature response comparison

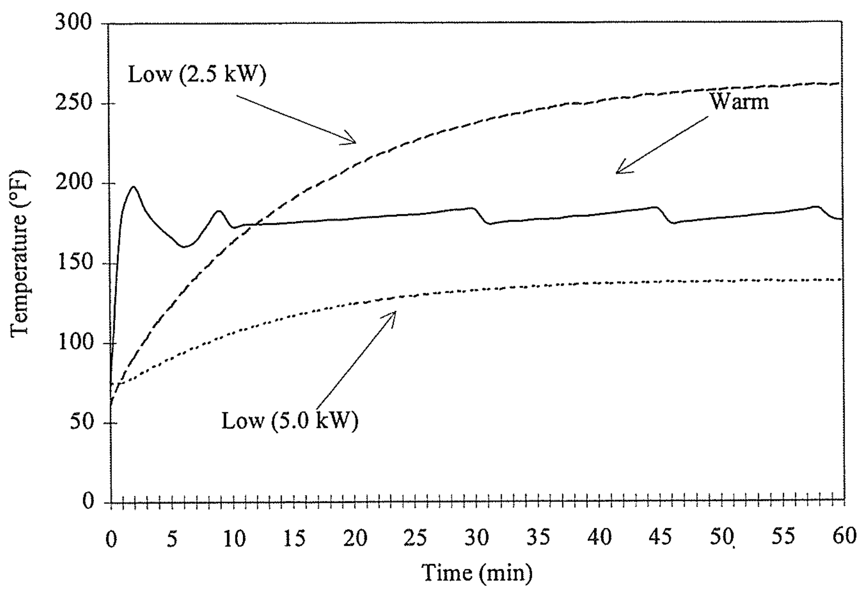

Figure 3-4
Low temperature response comparison

Temperatures were recorded from the 17 thermocouple locations on the steel plate. The average temperatures of each thermocouple were plotted onto a diagram of the plate surface, which indicates the uniformity of the cooking surface. Temperature uniformity plots for the low, warm, high, and fry settings are shown in Figures 3-5 to 3-8, respectively. The 5.0 kW high temperature uniformity plots are shown in Figures 3-9 and 3-10. A summary of temperature response and uniformity for the 2.5 kW and the 5.0 kW units are shown in Table 3-1.

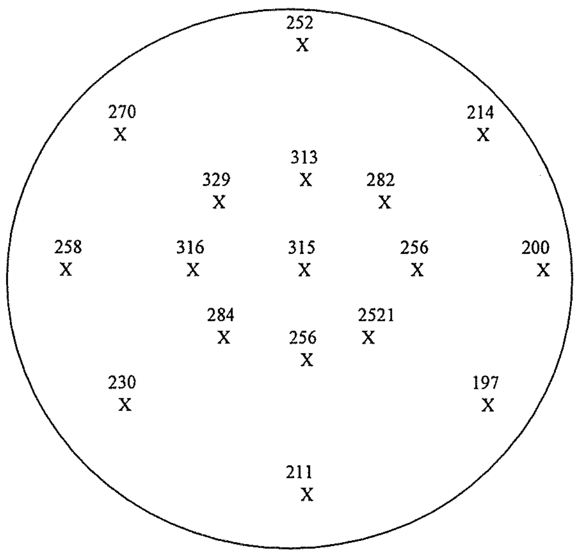

Figure 3-5
2.5 kW low temperature uniformity

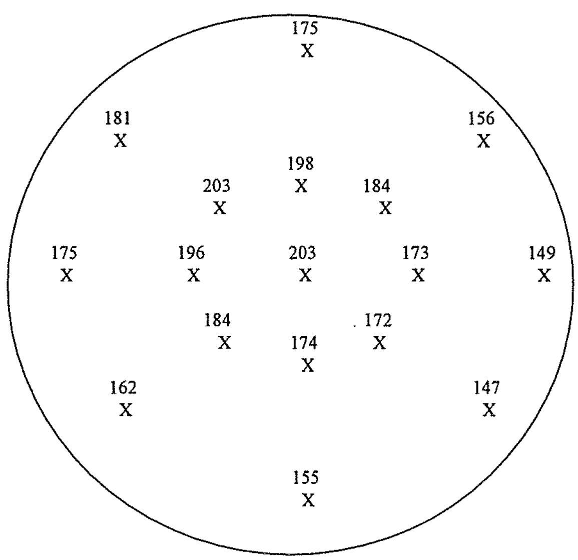

Figure 3-6
2.5 kW warm temperature uniformity

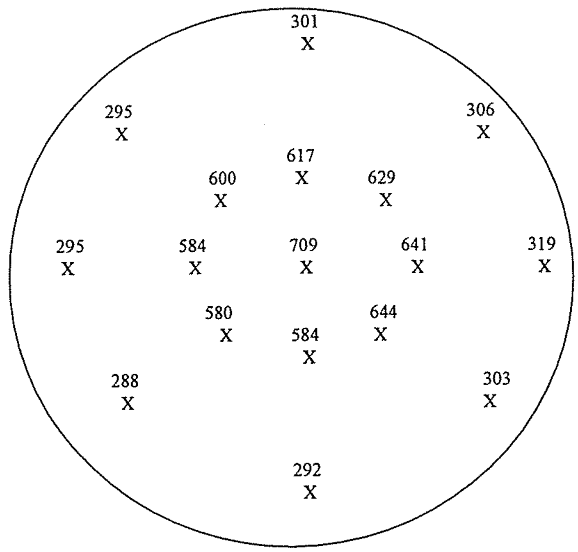

Figure 3-7
2.5 kW high temperature uniformity*

*Note: The 2.5 kW high temperature uniformity plot shows the results after five minutes, at which point the high limit safety feature was activated. Therefore, the one-hour test period was not completed.

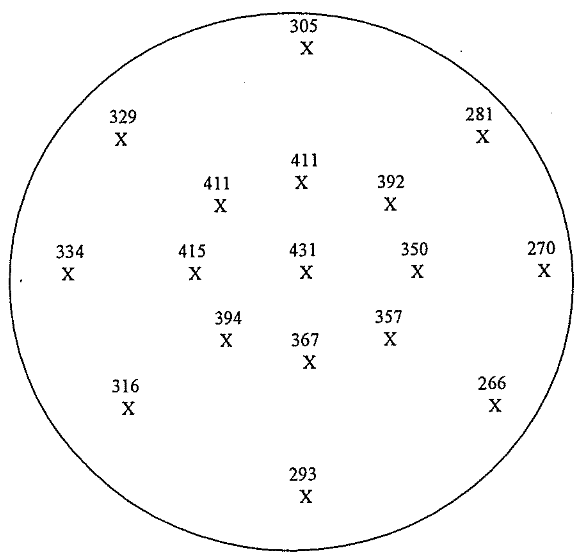

Figure 3-8
2.5 kW fry temperature uniformity

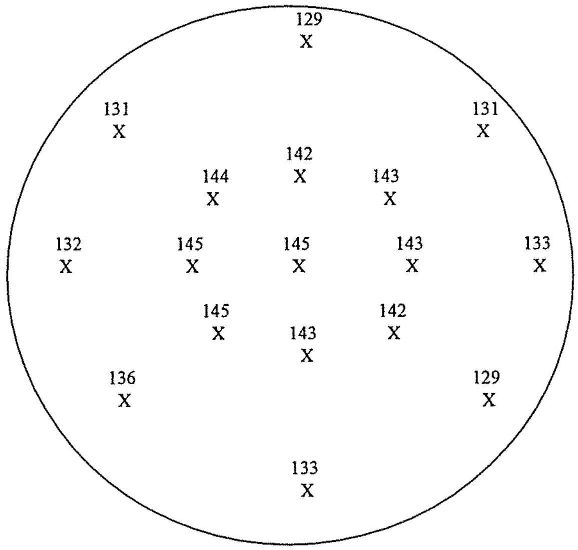

Figure 3-9
5.0 kW low temperature uniformity

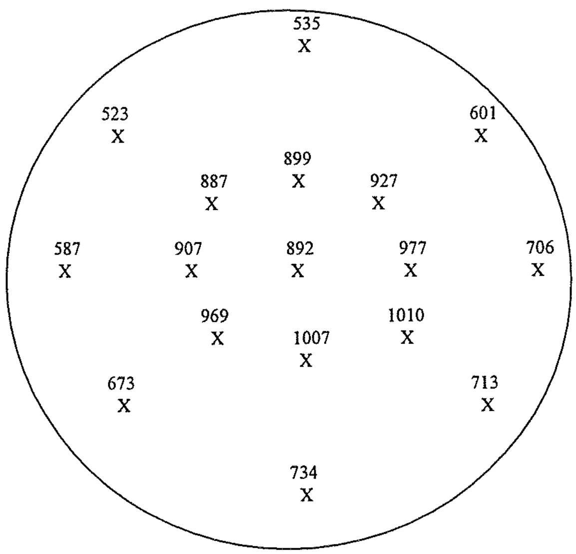

Figure 3-10
5.0 kW high temperature uniformity *

*Note: The 5.0 kW high temperature uniformity plot shows the results after five minutes, at which point the high limit safety feature was activated. Therefore, the one-hour test period was not completed.

Table 3-1.
Summary of Temperature Response and Uniformity

	Average Temperature (°F)	Standard Deviation
2.5 kW Temperature Settings		
Warm	175.7	17.9
Low	260.8	41.8
High*	469.9	167.9
Fry	345.8	52.4
5.0 kW Temperature Settings		
Low	137.9	6.4
High*	796.8	171.1

*Note: The average high temperature results are after five minutes, at which point the high limit safety feature was activated. Therefore, the one-hour test period was not completed.

Cooking Performance Tests

Three test runs were performed at full-input rate in accordance with section 10.5 of the revised ASTM test method to determine cooking energy efficiency and production capacity. The performance results of a standard 2.0 kW resistance unit is compared to those of the 2.5 kW and the 5.0 kW induction range tops. The results are reported in Table 3-2.

Table 3-2.
Cooking Energy Efficiency and Production Capacity

	induction 2.5 kW	induction 5.0 kW	resistance 2.0 kW
Cooking Energy Efficiency			
Full-Energy Input Rate (%):	80.0	84.1	80.4
Uncertainty (%):	1.1	1.9	6.2
Production Capacity			
Full-Energy Input Rate (lb/h):	50.5	97.0	38.9

The cooking energy efficiency results show that the induction range top maintained a similar efficiency as the standard electric unit. The input rate increased

25.0% from the 2.0 kW standard unit to the 2.5 kW induction range top and the productivity increased by 29.8%. There was a 100.0% increase in the input rate between the 2.5 kW and the 5.0 kW units that resulted in a 92.0% productivity increase.

In Figure 3-11, production rate is plotted against input rate and efficiency. This shows the correlation between an increase in input rates and an increase in productivity. Knowing the energy input rate required to achieve a desired production rate is helpful in estimating the cost of operation.

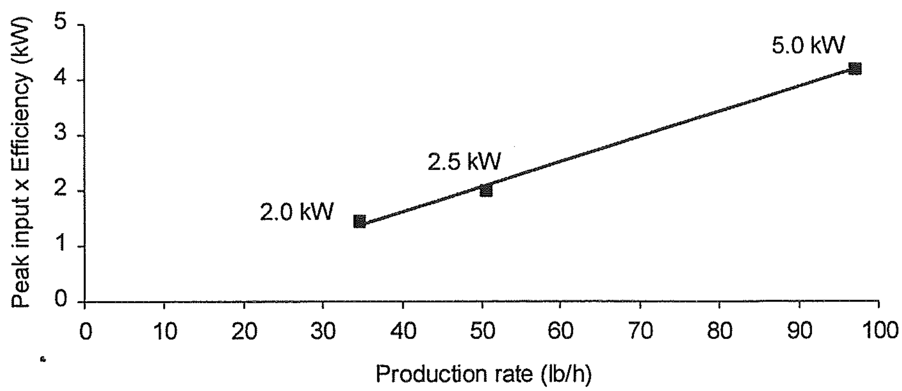

Figure 3-11
Range top cooking capacity comparison

4 Conclusions and Recommendations

The Vulcan-Hart 2.5 kW induction range top performed favorably when tested according to the revised ASTM standard test method for range tops. The induction unit had a faster heat-up temperature response as compared to the standard electric range tops. The cooking energy efficiency of the 2.5 kW induction range top was comparable with that of the standard resistance-element and the 5.0 kW unit. The production capacity shows that the increased input rate is generally proportional to the increased productivity.

Induction exhibits the positive performance attributes from standard gas and electric range tops.

Induction technology has eliminated the additional time and energy typically required during the preheat by directly heating the cooking container, as opposed to heating a surface that the cooking container sits on. Another characteristic of the range top, that provides potential energy savings, occurs when the cooking container is removed. The unit automatically goes into "stand-by" mode when the container is removed from the magnetic field no longer consuming energy and will "stand-by" until the user reactivates the range by the control panel. Many standard ranges will continue to consume energy until the user manually turns the power off.

The results showed that the new technology exhibits the positive performance characteristics from both standard gas and electric range tops. Vulcan-Hart Company has incorporated the quick temperature response, usually associated with gas range tops and maintained the higher efficiency attributed to electric range tops.

5 References

1. American Society for Testing and Materials. ASTM F 1521-94. *Standard Test Method for the Performance of Range Tops.* In *Annual Book of ASTM Standards*. Philadelphia: American Society for Testing and Materials. This test method can be purchased from the American Society for Testing and Materials, 100 Bar Harbor Drive, West Conshohocken, PA 19428-2959

2. Food Service Technology Center. 1995. *Development and Validation of a Uniform Testing Procedure for Range Tops.* Report 1022.95.20 prepared for PG&E Products and Services Department. San Francisco, California: Pacific Gas and Electric Company.

3. Food Service Technology Center. 1994. *Vulcan-Hart Model VR-4 Heavy-Duty Electric Range: Application of ASTM Standard Test Method.* Report 5011.94.7 prepared for Products and Services Department. San Francisco, California: Pacific Gas and Electric Company.

4. Food Service Technology Center. 1994. *Toastmaster Model RA36C1 Heavy-Duty Hot Top Electric Range: Application of ASTM Standard Test Method.* Report 5011.94.8 prepared for Products and Services Department. San Francisco, California: Pacific Gas and Electric Company.

5. Food Service Technology Center. 1994. *Montague Model V 136-5 Heavy-Duty Open Top Gas Range: Application of ASTM Standard Test Method.* Report 5011.94.4 prepared for Products and Services Department. San Francisco, California: Pacific Gas and Electric Company.

6. Food Service Technology Center. 1994. *Montague Model V 136-5 Heavy-Duty 30,000 Btu/h Open Top Gas Range: Application of ASTM Standard Test Method.* Report 5011.94.6 prepared for Products and Services Department. San Francisco, California: Pacific Gas and Electric Company.

References

7. Food Service Technology Center. *Garland 2.5 kW Induction Range Top: Application of ASTM Standard Test Method.* Report 5011.95.30 prepared for Consumer Energy Management Department. San Francisco, California: Pacific Gas and Electric Company.

A Glossary

Cooking Energy
Energy consumed by the range top as it is used to cook at half- and full-energy input rates.

Cooking Energy Efficiency
The quantity of energy input to the food, expressed as a percentage of the quantity of energy input to the range top during the half- and full-energy input rate cooking energy efficiency tests.

Energy Input Rate **(kW or kBtu/h)**
Energy Consumption Rate
Energy Rate
The rate (Btu/h or kW) at which an appliance will consume energy.

Range Top
A device for cooking food by direct or indirect heat transfer from one or more cooking units to one or more cooking containers.

Heating Value
Heating Content
The quantity of heat (energy) generated by the combustion of the fuel. For natural gas, this quantity varies depending on the constituents of the gas.

Pilot Energy Consumption **(kBtu)**
Pilot Energy Use
Standing or Constant Pilot Energy Consumption
Standing or Constant Pilot Energy Use
The rate of energy consumption by the standing or constant pilot(s) while the appliance is not being operated (i.e., when the thermostats or control knobs have been turned off).

Production Capacity
The production rate (lb/h) of the range top as it is used to cook at half- and full-energy input rates.

Glossary

Test Method

A definitive procedure for the identification, measurement, and evaluation of one or more qualities, characteristics, or properties of a material, product, system, or service that produces a test result.

Temperature Response

The temperature rise measured on the surface of a steel plate during the test period in accordance with the heat-up temperature-response test.

Temperature Uniformity

The comparison of individual temperatures measured on the surface of a steel plate at the end of the test period in accordance with the heat-up temperature-response test.

B Test Results - Data Sheets

Test Results - Data Sheet for Range Top UTP

date: 1/25/96
ompany: Vulcan-Hart Corporation
fuel: electric
notes: 2.5 kW Induction Range Top

energy input rate:

	kW		nameplate	% diff
unit	2.56	unit	2.5	2.4

17 temperatures on plate at end of 1 hour of operation at minimum control setting:

low setting

	°F		°F		°F
1	314.7	7	329.1	13	229.7
2	256.2	8	312.6	14	258.0
3	252.1	9	282.2	15	269.6
4	255.8	10	200.0	16	252.1
5	283.6	11	196.9	17	214.0
6	315.9	12	211.3	*input rate:*	0.408 kW

average plate temperature (average of 17 temperatures): 260.8 °F

17 temperatures on plate at end of 1 hour of operation at minimum control setting:

warm setting

	°F		°F		°F
1	202.9	7	202.7	13	161.7
2	172.9	8	197.7	14	174.5
3	171.8	9	184.2	15	181.2
4	174.0	10	148.6	16	175.2
5	183.8	11	147.3	17	156.2
6	196.3	12	155.1	*input rate:*	0.279 kW

average plate temperature (average of 17 temperatures): 175.7 °F

17 temperatures on plate at end of 1 hour of operation at maximum control setting:

high setting*

	°F		°F		°F
1	709.4	7.0	600.0	13.0	288.0
2	640.9	8.0	617.4	14.0	295.2
3	644.3	9.0	629.0	15.0	294.8
4	583.5	10.0	319.4	16.0	301.3
5	580.1	11.0	302.7	17.0	306.3
6	584.3	12.0	292.4	*input rate:*	2.43 kW

average plate temperature (average of 17 temperatures): 469.9 °F

*(note: This temperature setting terminates after a high temperature safety-cut off point is activated.)

ompany: Vulcan-Hart Corporation

fuel: electric

page: 2

notes: 2.5 kW Induction Range Top

17 temperatures on plate at end of 1 hour of operation at maximum control setting:

fry setting

	°F		°F		°F
1	430.7	7.0	411.4	13.0	316.0
2	349.5	8.0	392.7	14.0	334.0
3	356.8	9.0	367.2	15.0	329.0
4	367.1	10.0	270.0	16.0	304.7
5	394.3	11.0	266.1	17.0	280.7
6	414.7	12.0	293.1		

input rate: 0.725 kW

average plate temperature (average of 17 temperatures): 345.8 °F

production rate:

full-energy input rate

	lb/h
test 1	50.2
test 2	50.7
test 3	50.7
production rate	50.5

run	1	2	3	average
pot wt	13.7	13.7	13.7	
H2O wt	20.0	20.0	20.0	
delta t	129.6	129.2	129.5	
time	23.9	23.7	23.7	
lb/h	50.2	50.7	50.7	50.5
% uncertainty				1.4
wh	1019.7	1009.1	1010.3	
avg kw	2560.0	2560.0	2560.0	
sens pot	177.6	177.0	177.4	
sens H2O	2592.4	2583.8	2590.4	
eff w/pot	79.6	80.2	80.3	80.0
% uncertainty				1.1

Test Results - Data Sheet for Range Top UTP

date: 11/30/95
ompany: Vulcan-Hart Corporation
fuel: electric

notes: 5.0 kW Induction Range Top

energy input rate:

	kW		nameplate	% diff
unit	4.8	unit	5.0	4.0

17 temperatures on plate at end of 1 hour of operation at minimum control setting:

	°F		°F		°F
1	145.0	7	143.5	13	135.7
2	142.5	8	142.0	14	132.3
3	142.4	9	143.0	15	130.6
4	142.7	10	133.2	16	128.7
5	145.0	11	128.5	17	131.3
6	145.1	12	132.7	*input rate:*	0.249 kW

average plate temperature (average of 17 temperatures): 137.9 °F

17 temperatures on plate at end of 1 hour of operation at maximum control setting:

	°F		°F		°F
1	891.7	7	887.3	13	673.3
2	977.4	8	899.0	14	586.5
3	1009.5	9	926.6	15	522.9
4	1006.6	10	705.8	16	535.2
5	968.5	11	712.9	17	601.2
6	907.2	12	734.2	*input rate:*	4.054 kW

average plate temperature (average of 17 temperatures): 796.8 °F

production rate:

full-energy input rate

	lb/h
test 1	97.3
test 2	96.1
test 3	97.7
production rate	97.0

ompany: Vulcan-Hart Corporation

fuel: electric

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notes: 5.0 kW Induction Range Top

run	1	2	3	average
pot wt	13.3	13.3	13.3	
H2O wt	20.0	20.0	20.0	
delta t	129.7	129.7	129.2	
time	12.3	12.5	12.3	
lb/h	97.3	96.1	97.7	97.0
% uncertainty				2.1
wh	1000.0	997.9	981.9	
avg kw	4.9	4.8	4.8	
sens pot	177.6	177.0	177.4	
sens H2O	2594.0	2594.0	2594.0	
eff w/pot	83.6	83.8	84.8	84.1
% uncertainty				1.9