Appliance Test Report SCGAT110808A

Imperial ICVG-1 *prototype*
Full-Size Gas Convection Oven Performance Test
Revision 0

Southern California Gas Company
Customer Programs Department

Issued Date: August 2011

Disclaimer

"The information and analysis contained in this report is based on data collected at the Energy Resource Center. The Gas Company has made reasonable efforts to ensure that all information is correct; however, the Gas Company makes no representation or warranty, express or implied, as to the accuracy, correctness or usefulness of any data or information in this report. Nothing contained in this report is intended to constitute a recommendation, endorsement, approval or guaranty of any product or service. The Gas Company shall not be responsible for errors or omissions in this report or for claims or damages relating to the use of this report, even if it has been advised of the possibility of such damages. All trademarks, methods, processes or other intellectual property contained in or described in this report are the property of their respective owners and the Gas Company makes no representation or warranty that their use will not infringe privately owned rights."

Legal Notice

“This report was prepared as a result of work sponsored by the California Public Utilities Commission (Commission). It does not necessarily represent the views of the Commission, its employees, or the State of California. The Commission, the State of California, its employees, contractors, and subcontractors make no warranty, express or implied, or assume no legal liability for the information in this report; nor does any party represent that the use of this information will not infringe upon privately owned rights. This report has not been approved or disapproved by the Commission nor has the Commission passed upon the accuracy of the information in this report."

Revision History

Revision No.	Date	Description	Author
0	August 16, 2011	Initial Release	Ricardo Vargas

THIS PAGE IS INTENTIONALLY LEFT BLANK

Table of Contents

THIS PAGE IS INTENTIONALLY LEFT BLANK

Executive Summary

The "Imperial" Model ICVG-1 *prototype*, a full-size gas-fired convection oven (Figure 1), was evaluated for energy performance at the Southern California Gas Company's (SCG) Commercial Food Service Testing Laboratory (FSTL). The oven was tested according to the specifications of The American Society for Testing and Materials' (ASTM) standard test method F 1496-99 (2005). To be considered energy efficient, a convection oven must achieve at least ***44% efficiency*** for the heavy-load cooking-energy efficiency test and an idle rate less than 13,000 Btu/h. The Imperial ICVG-1 *prototype* oven ***passed*** the standards as set forth. The test results for the Imperial ICVG-1 *prototype* (S/N 07131111) are as follows:

Figure 1
"Imperial" ICVG-1
gas convection oven

Table ES-1. Summary of ASTM Convection Oven Performance Results

Heavy-load cooking-energy efficiency (%)	**44**
Rated Energy Input Rate (Btu/h)	50,000
Measured Gas Energy Input Rate (Btu/h)	48,300
Preheat Time to 340°F (min)	13.1
Preheat Energy to 340°F (Btu)	11,000
Idle Energy Rate (*natural gas fuel*) at 350°F (Btu/h)	**9,900**
Idle Energy Rate (*combined gas & electric*) at 350°F (Btu/h)	11,400
Pilot Energy Rate (Btu/h)	N/A
Production Rate (lb/h)	82.3

The heavy-load cooking-energy efficiency test consisted of baking thirty russet potatoes per full-size sheet pans on five levels. As specified by the ASTM test method, cooking-energy efficiency is a measure of how much of the energy that an appliance consumes is actually delivered to the food product during the cooking process. Cooking-energy efficiency is therefore defined by the following relationship:

$$\text{Cooking Energy Efficiency} = \frac{\text{Energy to Food}}{\text{Energy to Appliance}}$$

Mission Statement - Commercial Food Service Equipment Testing

Recent advances in equipment design have produced commercial foodservice equipment that operates more efficiently, quickly, safely and conveniently. An energy efficient commercial equipment reduces energy consumption primarily through advanced technology and design.

The purpose of Southern California Gas Company's Energy Efficiency Commercial Food Service Equipment Testing Program is to provide energy efficiency measurement for cost effectiveness modeling in order to establish energy efficiency standards and ratings for commercial food service equipment. This measurement data is then utilized and integrated with typical equipment usage profiles for California Utility Customers participating in the Food Service Equipment Rebate Program.

The equipment performance is determined by applying the American Society for Testing and Materials (ASTM) standard test method for performance. The ASTM standard test method is considered the industry standard for quantifying the efficiency and performance for cooking equipment.

Scope

The scope of this test is to evaluate the performance of the "Imperial" ICVG-1 *prototype* gas-fired convection oven, by using ASTM F 1496-99 (2005) "*Standard Test Method for Performance of Convection Ovens*" for the test procedure and evaluation criteria.

In order to evaluate the oven's energy consumption and cooking performance, the following were performed:

- Verify energy rating
- Verify thermostat calibration
- Determine energy input rate, preheat energy consumption and time
- Determine pilot energy consumption [1]
- Verify cooking uniformity [1]
- Verify cake browning [1]
- Determine cooking rate uncertainty
- Determine production rate uncertainty
- Report findings

Appliance and test overview

The "Imperial" ICVG-1 *prototype* is a natural gas-fired, full size oven rated at 50,000 Btu/h. The oven is equipped with two swing-out doors, one solid and the other with a double glazed window. The electric power requirements for the oven are 120 Volts AC single-phase 5 amps. The inner cavity measured 24.00 inches in height, 29.0 inches in width and 24.25 inches in depth for a total cavity volume of 16,880 cubic inches. The oven's cavity can accommodate up to five (5) steel wire racks spaced evenly. The oven's controls include on/off switches for oven "ON", oven cool down, fan speed and cavity lights. The controls also include two large analog dials, one for cavity temperature and the other for cooking timer. The prototype oven was

[1] Was not performed

equipped with fiberglass door seal and revised flue stack at the rear. A temporary label was affixed behind the temperature dial to indicate temperature settings.

The test consisted of taking fresh whole U.S. Number 1 Russet potatoes with an initial temperature of 75 ± 5°F and cooking them until their internal temperature reached 205°F. During cooking, the internal temperature of randomly selected potatoes was monitored using thermocouples that were inserted into their core until the temperature averaged 205°F on all the instrumented potatoes. Weight measurements were taken before and after cooking to determine cooking energy efficiency and production rate.

The gas volume, pressure and temperature were monitored and recorded as well as the ambient air temperature and pressure. Type K thermocouples were used to monitor the ambient, oven cavity and inner potato temperature. Electrical power measurements were also monitored and recorded. A Logic Beach Inc's HyperLogger™ data logger was used to monitor and record all data. See section "Testing Equipment Inventory" for more detail regarding the testing equipment.

Comments, Deviations and Exceptions

Comments:

The oven submitted for testing was a prototype oven.

Imperial personnel were present and witnessed all testing procedures at SCG's FSTL.

The heating values for each test were obtained from the SCG's MCS Gas Analysis daily reports.

Pilot energy consumption was not measured since the oven is equipped with an electronic pilot-less ignition system.

Deviations:

Testing procedures and results are limited to the heavy-load cooking scenario.

Tests for cooking uniformity and browning uniformity were not performed.

Exceptions:
None

Testing equipment inventory

Energy efficiency testing is conducted at SCG's Commercial Food Service Testing Laboratory located at the Energy Resource Center (ERC) in Downey California. The laboratory can provide utility services such as natural gas, water, electricity, sewer and fume exhaust for a variety of tests.

The testing equipment is mounted onto a mobile test bench providing the flexibility of movement within the test lab or for in the field use. The mobile test bench holds a data logger, various pressure and energy transducers. The data logger provides up to 24 channels of analog input with 13-bit analog to digital conversion, and sampling rates in excess of 150 samples per second. The bench mounted pressure transducers monitor barometric ambient pressure and natural gas pressure before and after the gas meter. The electrical transducers are capable of measuring different voltage and phase setups. A magmeter allows measurement of water flow. An analog gas meter fitted with an electronic counter is used to measure gas consumption. See Tables TEI 1-1 and 1-2 for inventory and specifications on testing equipment.

Table TEI 1-1. Testing Equipment Inventory

Description	Manufacturer	Model	Quantity
Data Logger	Logic Beach	HLP-10	1
Barometric Pressure Transducer	Omega	EWS-BP-A	1
Differential Pressure Transducer	Dwyer	607-9	1
Thermocouple	Omega	Type K	12
Gas Meter	American Meter	DTM 200A	1
Energy Transducer	Hawkeye	8036	1
Magmeter	Omega	FMG-3000	1

Table TEI 1-2. Testing Equipment Specifications

Description	Measures	Signal output	Measurement range
Data Logger	Data input	Data	Varies
Barometric Pressure Transducer	Pressure	4 - 20mA	10.20 – 15.72 psia
Differential Pressure Transducer	Pressure	4 - 20mA	0 – 25 in.-H_2O
Thermocouple	Degree Fahrenheit	± 2 Volts	-328 – 2282°F

Testing Equipment Inventory *(continued)*

Table TEI 1-2 Testing Equipment Specifications (continued)			
Description	**Measures**	**Signal output**	**Measurement range**
Gas Meter	Cubic feet	On / Off pulse	0 or 1 V
Energy Transducer	Current, Voltage	Modbus	2400 A (max) 120 – 480 VAC
Magmeter	Water flow	4 - 20mA	0 – 21 gpm

The mobile testing bench is equipped with additional testing equipment. The additional testing equipment is listed as miscellaneous testing equipment in Table TEI 2-1.

Table TEI 2-1 Miscellaneous Testing Equipment			
Description	**Manufacturer**	**Model**	**Function**
Power supply	Omega	U24y101	Converts 120VAC to 24VDC at 1 Amp max.
Power supply	Idec	PS5R	Converts 120VAC to 24VDC at 0.3 Amp max.
Digital multimeter	Fluke	189	Measures Voltage, resistance, current & temperature
Digital manometer	Testo	512	Measures gauge pressure (0 – 29 psig, 0.5% of fsv.)
Pressure gauge	Ashcroft	-	Measures gauge pressure (0 – 15 in.-H_2O)
Bench scale	A&D	FG-60KAL	Weight measurement (150 lbs. x 0.01 lbs.)

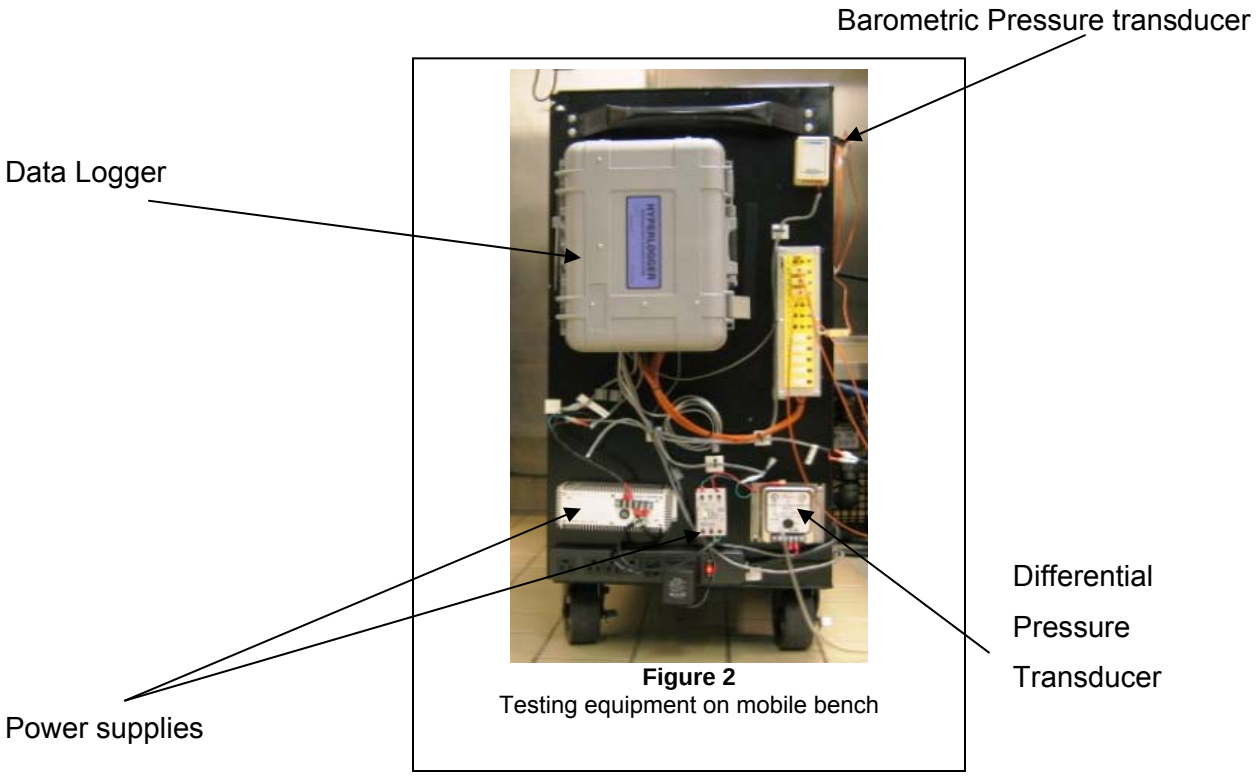


Figure 2
Testing equipment on mobile bench

Testing Equipment Inventory - Photos

Energy transducer

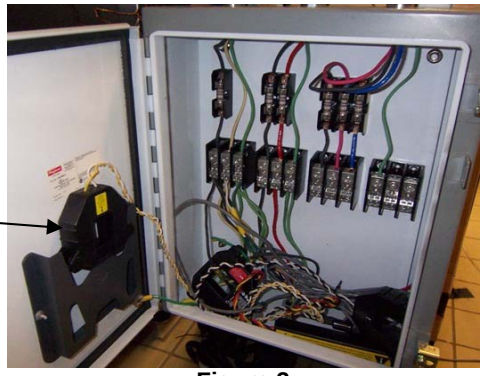


Figure 3
Fuse box and energy transducers

Pressure gauge

Figure 4
Gas meter and pressure gauge

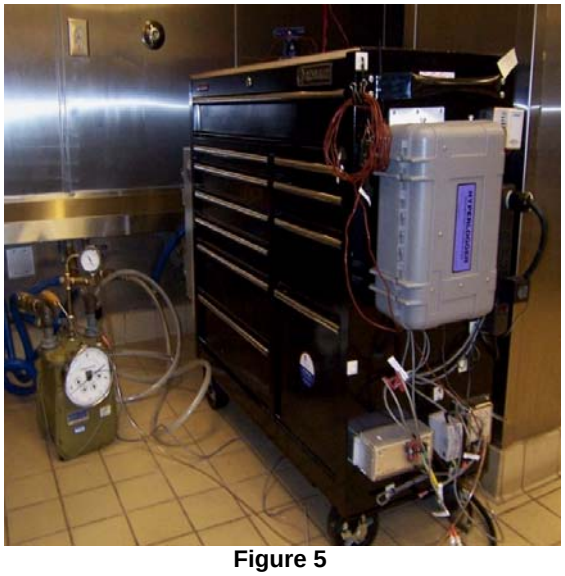


Figure 5
Gas meter & mobile testing bench

THIS PAGE IS INTENTIONALLY LEFT BLANK

Performance of Convection Ovens
RESULTS SUMMARY
ASTM F 1496-99 (2005) (11)

Manufacturer	Imperial
Model	ICVG-1 (*prototype)*
Date	August 8, 2011
Oven serial number	07131111

1. Appliance Type – Full-Size Convection Oven (11.1)

Fuel type:	Natural gas
Oven rating:	50,000 Btu/h
Physical dimensions	
Size of oven:	34.00 H x 38.00 W x 38.00 D in.
Size of oven cavity:	24.00 H x 29.00 W x 24.25 D in.
Oven cavity volume:	16,880 $in.^3$

Controls:

All the oven's controls lie on a panel just right of the double swing-out doors. At the top of the panel reside two switches for fan speed (High/Low), and oven On and Cool Down, below is a cavity light switch. Below, an "Oven Ready" indicator lamp and an oven temperature dial, with a temporary temperature label with markings at 200°F, 275°F, 350°F and MAX. At the bottom of the panel, a one-hour timer dial with 10-minute division markings.

Description of operational characteristics:

With the thermostat control dial set at slightly over 350°F, the average temperature at the center of the oven was determined to be 338.5°F. The thermostat was readjusted to 360°F, which yielded a cavity temperature of 346.7°F within the limit of ± 5°F set forth in the ASTM F 1496-99 (2005) test method section 11.2.

2. Apparatus (11.2)

√ Check if testing apparatus conformed to specifications in Section 6.

3. Thermostat Calibration (11.4)

As-Received:

Oven temperature control setting (°F)	350
Oven cavity temperature (°F)	346.7
Oven temperature control setting (°F)	N/A
Oven cavity temperature (°F)	N/A

4. Energy Input Rate (11.5)

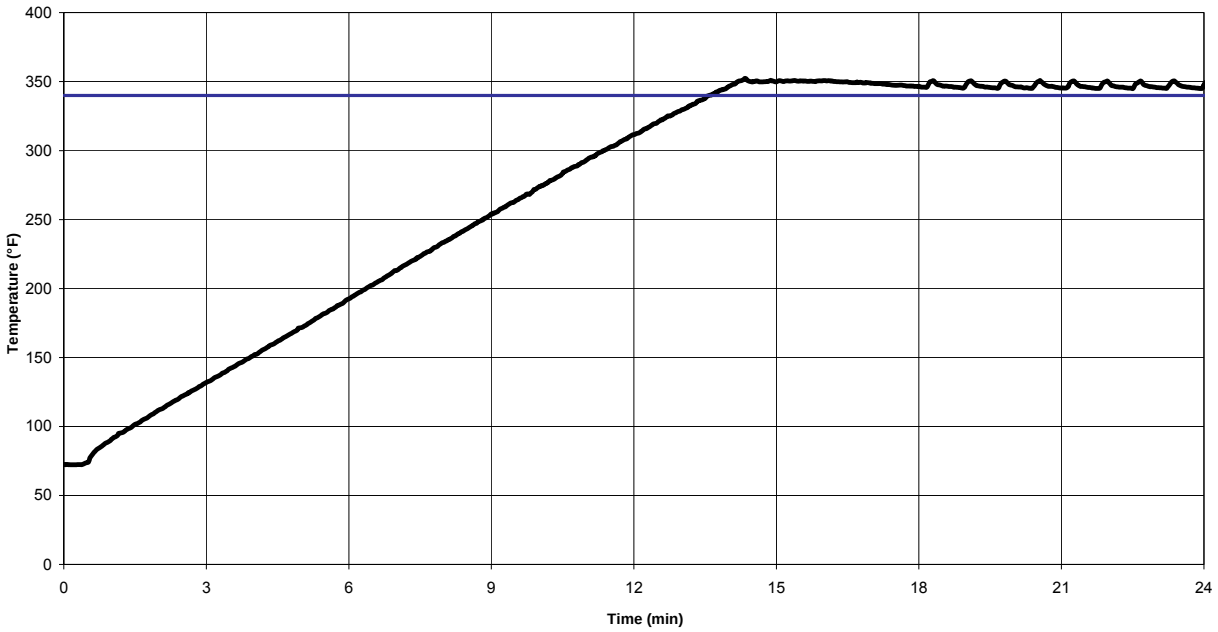
Test voltage (V)	116.5
Higher heating value of natural gas (Btu/ft^3)	1,033
Measured gas input rate (Btu/h)	48,300
Rated (Btu/h)	50,000
Percent difference between measured and rated (%)	3.4
Oven's fan and control energy rate (kW)	0.495

5a. Preheat Energy and Time (11.6)

Test Voltage (V)	116.4
Higher heating value of natural gas (Btu/ft^3)	1,033
Starting temperature of oven cavity (°F)	73.9
Energy consumption of natural gas (Btu)	11,000
Electric energy consumption (kWh)	0.109
Duration (min)	13.1
Preheat rate (°F/min)	20.3

5b. Preheat Curve (11.6 - Continued)

Preheat Curve
Imperial ICVG-1



6. Pilot Energy Rate (if applicable) (11.7)

See Comments, Deviations and Exceptions

Gas heating value (Btu/ft^3)	N/A
Pilot energy rate (Btu/h)	N/A (Electronic Spark Ignition)

7. Idle Energy Rate (11.8)

Test Voltage (V)	116.5
Higher heating value of natural gas (Btu/ft^3)	1,025
Idle energy rate at 350°F – *natural gas only* (Btu/h)	**9,900**
Idle energy rate at 350°F – *gas & electric* (Btu/h)	11,400
Electric energy rate at 350°F (kW)	0.433

8. Cooking Energy Efficiency, Cooking Energy Rate, and Production Rate (11.9) [2]

Heavy-Load:

Test voltage (V)	116.5
Higher heating value of natural gas (Btu/ft^3)	1,019
Cooking time (min)	52.9
Production rate (lb/h)	82.3
Energy to food (Btu)	17,300
Cooking energy rate (Btu/h)	45,000
Electric cooking energy rate (kW)	0.438
Energy per pound of food cooked (Btu/lb)	547
Cooking energy efficiency (%)	**43.6**

Medium-Load: *See Comments, Deviations and Exceptions*

Test voltage (V)	
Higher heating value of natural gas (Btu/ft^3)	
Cooking time (min)	
Production rate (lb/h)	
Energy to food (Btu/lb)	
Cooking energy rate (Btu/h)	
Electric energy rate (kW)	
Energy per pound of food cooked (Btu/lb)	
Cooking energy efficiency (%)	

Light-Load: *See Comments, Deviations and Exceptions*

Test voltage (V)	
Higher heating value of natural gas (Btu/ft^3)	
Cooking time (min)	
Production rate (lb/h)	
Energy to food (Btu/lb)	
Cooking energy rate (Btu/h)	
Electric energy rate (kW)	
Energy per pound of food cooked (Btu/lb)	

[2] Test results based on the average of three (3) iterations

Cooking energy efficiency (%)	

9. Cooking Uniformity (Frozen Macaroni & Cheese) (11.10)

See Comments Deviations and Exceptions

Test voltage (V)	
Higher heating value of natural gas (Btu/ft^3)	

Rack	Average Rack Temperature (°F)
1 (Top)	
2	
3	
4	
5 (Bottom)	

Cooking time (min)	
Production capacity (lb/h)	
Energy to food (Btu/lb)	
Cooking energy rate (Btu/h)	
Electric energy rate (kW)	
Cooking energy efficiency (%)	

10. Browning Uniformity (White Sheet Cakes) (11.11)

See Comments Deviations and Exceptions

Test voltage (V)	
Higher heating value of natural gas (Btu/ft^3)	
Initial cake temperature (°F)	
Final cake temperature (°F)	
Initial cake weight (lb)	
Final cake weight (lb)	
Sheet cake cook time (min)	
Sheet cake cooking energy (Btu)	
Electric energy (kWh)	

THIS PAGE IS INTENTIONALLY LEFT BLANK

Performance of Convection Gas Ovens
UNCERTAINTY RESULTS FOR COOKING ENERGY EFFICIENCY
Annex A1.

Make:	Imperial
Model:	ICVG-1
Equipment Type:	Full-size convection oven
Calculations from:	ASTM F 1496-99 (2005) Annex A1
Results Evaluated:	Cooking Energy Efficiency (%)

A. Iteration results

1. Iteration 1	X_1 =	43.8
2. Iteration 2	X_2 =	42.7
3. Iteration 3	X_3 =	44.3
4. Iteration 4	X_4 =	
5. Iteration 5	X_5 =	

B. Uncertainty results

Average **Xa_n =**	43.6
Standard deviation **S_n =**	0.819
Absolute Uncertainty **U_n =**	2.03
% Uncertainty **$\%U_n$ =**	4.66

Performance of Convection Gas Ovens
UNCERTAINTY RESULTS FOR PRODUCTION RATE
Annex A1.

Make:	Imperial
Model:	ICVG-1
Equipment Type:	Full-size convection oven
Calculations from:	ASTM F 1496-99 (2005) Annex A1
Results Evaluated:	Production Rate (lb/h)

C. Iteration results

1. Iteration 1	X_1 =	83.4
2. Iteration 2	X_2 =	81.8
3. Iteration 3	X_3 =	81.6
4. Iteration 4	X_4 =	
5. Iteration 5	X_5 =	

D. Uncertainty results

Average **Xa_n =**	82.3
Standard deviation **S_n =**	0.987
Absolute Uncertainty **U_n =**	2.45
% Uncertainty **$\%U_n$ =**	2.98

Signatures: The undersigned has performed stated tests and has verified that the results recorded were the actual results observed.

SCG's Tester:

(signature) (date)

Ricardo Vargas

(print name)