# Glowmaster 5.0 kW Induction Wok

Product Evaluation

FSTC Report 5011.98.52

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The information in this report is based on data generated at PG&E's Food Service Technology Center.

## 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.

PG&E's Food Service Technology Center is supported by the National Advisory Group which includes:

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Gas Research Institute (GRI)
International Facility Management Association (IFMA)
Marriott International
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National Restaurant Association
Underwriters Laboratories (UL)
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Specific appreciation is extended to Glowmaster Corporation, for supplying the Food Service Technology Center with a 5.0 kW induction wok for controlled testing in the appliance laboratory.

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# Executive Summary

This report documents the performance of the Glowmaster 5.0 kW induction wok, model GMI-WOK 300. The method used to test the wok was a derivative of the American Society of Testing and Materials (ASTM) *Standard Test Method for the Performance of Range Tops* (Designation F 1521 - 96). Wok performance is characterized by energy consumption, temperature response, cooking energy efficiency and production capacity. A summary of the cooking energy efficiency and production capacity test results are presented in
Table ES-1.

***Table ES-1***
***Summary of Induction Wok Test Results***

| | |
|---|---|
| Rated Energy Input Rate (kW): | 5.00 |
| Measured Energy Input Rate (kW): | 5.14 |
| Cooking Energy Efficiency (%): | 84.2 |
| Production Capacity (lb/h): | 117 |

Based on a 5-pound water heat-up test, the production capacity was 117 pounds per hour and energy efficiency was 84.2%. The 5-pound weight of water was chosen for the efficiency and production capacity tests based on the volume of the well that the wok rests in. The wok had a heat-up rate of 225°F per minute on the highest setting using oil as the medium.

The induction technology performed well with respect to the temperature response and energy efficiency. The unit has a high-watt density per surface area, which produces the quick temperature response usually associated with gas woks, while maintaining the higher cooking energy efficiency attributed to electric range tops.

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# 1 Introduction

## Background

Chinese ranges, commonly known as woks, have been around for thousands of years and are becoming increasingly more popular within today's culinary trends. Chinese ranges have maintained a similar design over the years, namely an intense heat source with a steel, aluminum, cast iron, cast aluminum or stainless steel container (also referred to as the wok) suspended over the heat source. These historic, culture-specific appliances have begun to evolve as commercial end users demand more efficient equipment and new technologies have become available. A recent development is the application of induction technology to Chinese ranges. One of the potential benefits of induction technology is that it has a high heat flux and fast response without compromising energy efficiency.

As interest in the commercial use of induction technology grew, several manufacturers expanded the commercial induction technology from single-unit cooktops to complete cooktop configurations and are now venturing into variations thereof, namely woks. The induction wok performance was evaluated by applying a standardized test method developed at the PG&E Food Service Technology Center (FSTC).

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

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

# Introduction

## Objectives

This report's objective is to foreshadow the development of a standardized test method for Chinese ranges/woks and to examine the operation and performance of the Glowmaster 5.0 kW induction wok within the context of developing a standard test method for this appliance. The scope of this testing was as follows:

- Verifying that the appliance is operating at the manufacturer's rated energy input.
- Characterizing the temperature response at high, medium and low settings.
- Determining the cooking energy efficiency at the full-input rate under different loading scenarios.
- Measuring the production capacity.

## Appliance Description and Operation

The Glowmaster 5.0 kW induction wok includes a single cooking unit that causes heat to be generated directly within the magnetic material comprising the cooking container or wok, 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 wok surface is a concave, smooth and continuous, ceramic bowl 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:** | Glowmaster Corporation |
| **Generic Appliance Type:** | Electric Induction Wok |
| **Model:** | GMI-WOK 300 |
| **Rated Energy Input:** | 5.0 kW |
| **Voltage:** | 208 V, three phase |
| **Dimensions:** | 16.67″ x 16.67″ x 8.30″ |
| **Construction Material:** | Ceramic bowl sealed flush with chrome nickel steel side panels |

# 2 Methods

## Input Rate

The induction wok was connected to a regulated 208 V, three phase power source. The input rate was measured with the unit operating at full input in order to verify that the wok was operating within ± 5.0% of the manufacturer's rated input. The input rate test was in accordance with ratified ASTM standard test methods for commercial food service equipment.

## Temperature Response

To determine the heat-up temperature response of the Glowmaster induction wok, FSTC researchers placed two thermocouples in the center of the wok. One was placed ¾-inch from the bottom and the other thermocouple was spot welded to the bottom, center of the wok. The induction wok was turned on to the minimum control setting and time, temperature and energy were recorded over the next hour. After the wok was allowed to cool, the test was repeated at the medium setting and then the highest setting. For the temperature response test, 2 lb of vegetable oil was used as the heat-up medium, allowing the researchers to analyze the temperature profiles above 212°F, which is not possible with water as the testing medium.

## Cooking Performance Tests

A wok can be used for a variety of cooking styles; the most predominate being Asian cooking. Specifying a food product as a repeatable test medium is difficult since typical Asian cooking involves the rapid heating and stirring of thinly sliced and chopped vegetables and meat. Given the challenges of repeatability with food product, water was selected as a "gauge" for energy efficiency and productivity.

The amount of water for the heat-up test (energy efficiency) was not based on a pre-specified weight due to the diverse dimensions within this appliance category. In place of a pre-determined test weight, a dimensional level was established. By using a dimensional level versus a pre-specified weight, the test load was normalized to the wok design.

The test level was established with respect to the basic design of woks, a concave container which rests in/on a chamber or well. The wok is supported in the chamber by a continuous ring or by support points, a standard characteristic of the Chinese range/wok.

Therefore, the wok container was filled with water to the top portion of the chamber. In the case of the Glowmaster GMI-WOK 300 5.0 kW induction wok, a 5-lb weight is level with the top of the chamber (see Figure 2-1).

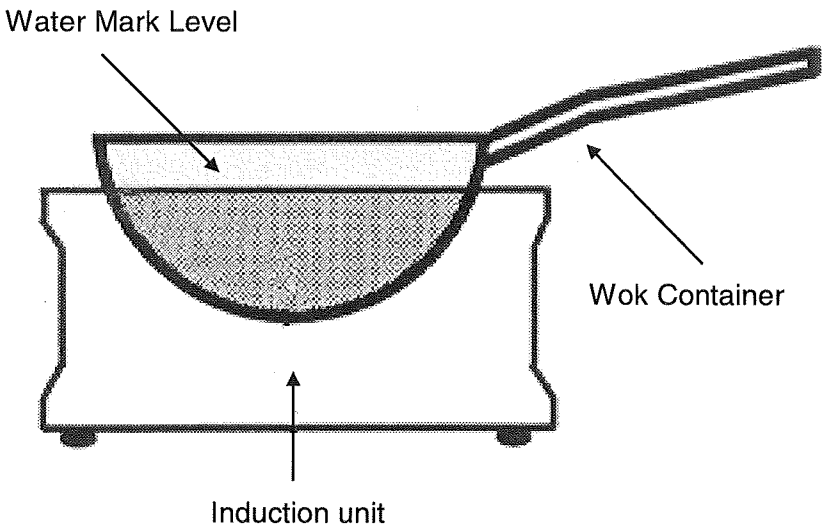



**Figure 2-1**
**Chinese range/wok testing level**

The cooking energy efficiency and production capacity were based on the sensible heat gain (heat-up) of water in a stainless steel wok, a temperature rise from 70°F to 200°F. Three cooking tests were performed at the full-input rate. This procedure specifies that the reported cooking energy efficiency and production capacity results have an uncertainty of less than ± 10.0%. The results from each test run are then averaged, and the absolute uncertainty calculated based on the standard deviation of the results.

The designated water level was derived from a series of sensitivity tests. The researchers conducted the energy efficiency test at water volumes of 5, 7 and 10 pounds. Each test was conducted in triplet, with a statistical uncertainty of less than ± 10.0%.

## Test Setup and Instrumentation

The induction wok was placed 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 induction wok and the edge of the hood (see Figure 2-2).

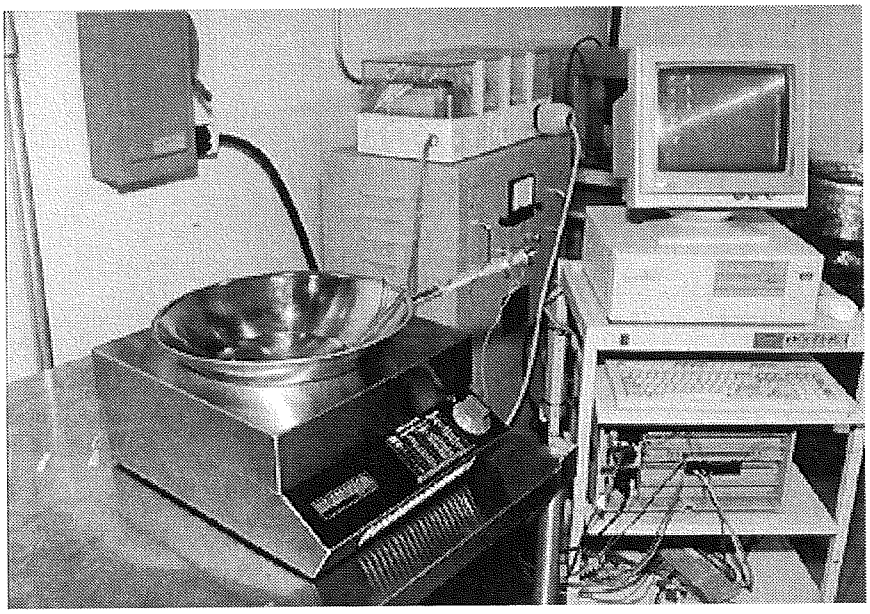


**Figure 2-2**
**Glowmaster induction wok undergoing a test**

Electric energy consumption was measured with a calibrated watt-hour meter with a 10-watt-hour resolution. The induction wok's response was measured with K-type thermocouples, spot welded to the bottom in the center of the wok and ¾-inch above the bottom center. Water temperature was also measured by suspending a Fluke resistance temperature device (RTD), model 2180A, ¾-inch above the bottom of the wok.

The cooking container used for testing was a Demeyere brand wok supplied by Glowmaster. The wok consists of five layers of laminated materials. From the inside out; stainless steel, aluminum, aluminum alloy, aluminum and magnetic stainless steel with a total weight of 3.3 lb and a weighted specific heat of 0.15 Btu/lb × °F. All data were logged using a Fluke Helios data logger and recorded on a PC. Voltage was maintained at 208V with a Staco voltage regulator.

# 3 Results

## Input Rate

Researchers measured the Glowmaster GMI-WOK 300 5.0 kW unit's energy input rate at 5.14 kW, which is 2.8 % higher than the nameplate rate, but within the acceptable ± 5.0 % specified by ASTM test methods.

## Temperature Response

The temperature control panel of the 5.0 kW unit has a dial with numbers ranging from *1* to *10*, with *1* being the lowest setting and *10* the highest. The FSTC researchers applied the temperature response test procedure at low (*1*), medium (*5*) and high (*10*) control settings for a representative sample of control settings. Results for the low-, medium- and high-temperature settings are shown in Figure 3-1. The wok had a heat-up rate of 225°F per minute on the highest setting using oil as the medium.

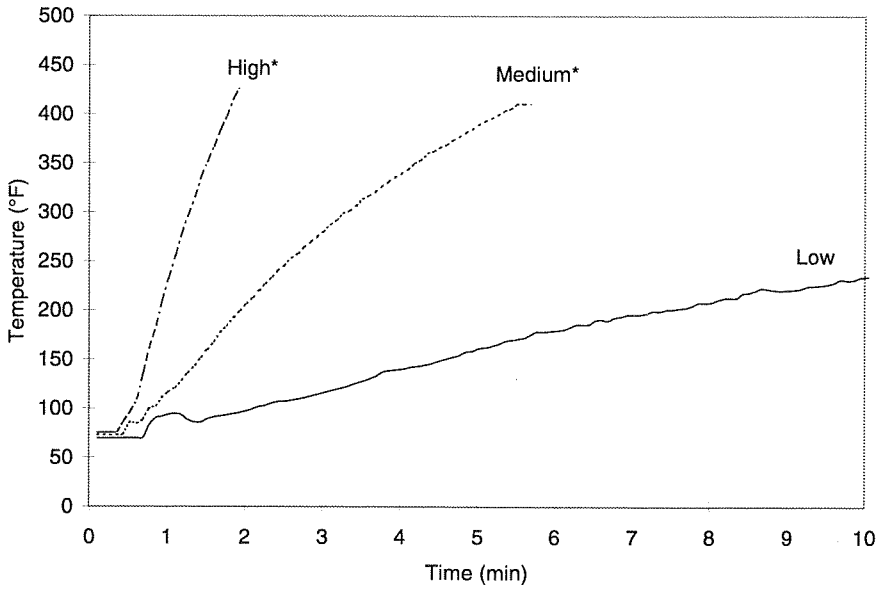



**Figure 3-1 Temperature response for low, medium and high settings**

* Note: The high and medium temperature response plot shows the results to approximately 400°F, at which point the FSTC researchers terminated the test to avoid reaching the flash point of the oil.

# Results

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 a one-hour test period the induction unit was at a temperature of 356°F.

The results from the Glowmaster 5.0 kW induction wok test exhibit the quick temperature response characteristics usually attributed to standard gas woks. As the graph in Figure 3-1 displays, the controls for the Glowmaster GMI-WOK 300 5.0 kW induction wok are responsive and representative of their numeral designation. The induction wok has remarkable control of the heating source with virtually no delay in applying heat to the cooking process.

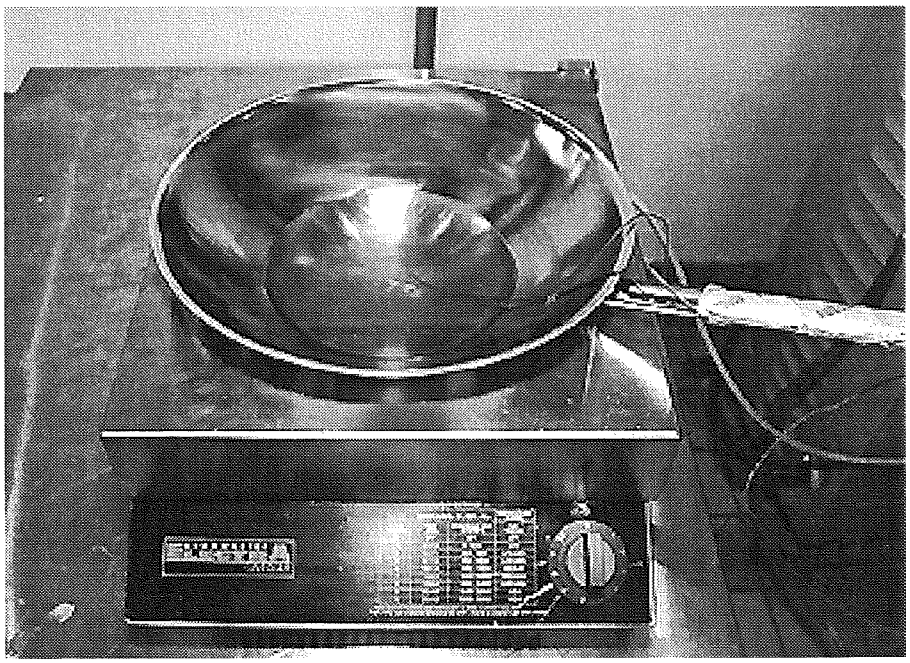


**Figure 3-2**
**Wok set-up with thermocouples for temperature response test**

# Results

## Cooking Performance Tests

Three test runs were performed at full-input rate for water weights of 5, 7 and 10 lb to determine cooking energy efficiency and production capacity. The results are reported in Table 3-1.

*Table 3-1*
*Cooking Energy Efficiency and Production Capacity Results*

| | Wok Loading (pounds of water) | | |
|---|---|---|---|
| | **5** | **7** | **10** |
| **Cooking Energy Efficiency (%)*** | 84.2 | 81.3 | 80.0 |
| Uncertainty (%) | 3.7 | 0.5 | 1.1 |
| **Production Capacity (lb/h)*** | 117 | 103 | 109 |

*Measured at full-energy input.

Cooking energy efficiency is defined as the quantity of energy consumed by the water expressed as a percentage of energy consumed by the wok during the cooking event. The mathematical expression is therefore:

$$\text{Cooking Energy Efficiency (\%)} \quad \frac{E_{water}}{E_{wok}} \times 100$$

Energy imparted into the heated water is calculated by separating its various components. Since products must be cooked in the stainless-steel wok, the energy input to the wok is factored into the total energy equation.

It was anticipated that as the weight of water increased, the efficiency would decrease slightly. This was reflected by the results. The production capacity tests indicate a slight trend that decreasing the amount of water results in slightly increased production capacity rates. Using 5 lb of water, the wok performed very well. The production capacity and efficiency were at the highest level, 117 lb/h and 84.2 %, respectively. As a side note, the 5-lb test weight corresponded to the proposed water level testing mark for this design of wok.

# 4 Conclusions

Induction technology has eliminated the additional time and energy 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 induction wok is that energy savings inherently occur when the cooking container is removed. The unit automatically goes into "stand-by" mode when the wok container is removed from the magnetic field, no longer consuming energy and will "stand-by" until the user reactivates the wok unit. Standard gas woks continue to consume energy until the user manually turns the gas off.

The Glowmaster GMI-WOK 300 5.0 kW induction wok proved to be a powerful and efficient cooking unit. The Glowmaster wok has incorporated the quick temperature response, usually associated with gas appliances, while maintaining a higher energy efficiency traditionally attributed to electric appliances. It is estimated that the performance of the 5.0 kW induction wok would match or exceed that of a 60,000 Btu/h gas "wok" burner.

# 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. *Vulcan-Hart Induction Range Top: Application of ASTM Standard Test Method.* Report 5011.95.29 prepared for Products and Services Department. San Francisco, California: Pacific Gas and Electric Company.

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

# A Glossary

***Cooking Energy***

Energy consumed by the wok as it is used to cook at 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 wok during 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.

***Chinese Range or 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.

***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 wok as it is used to cook at full energy input rates.

***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.

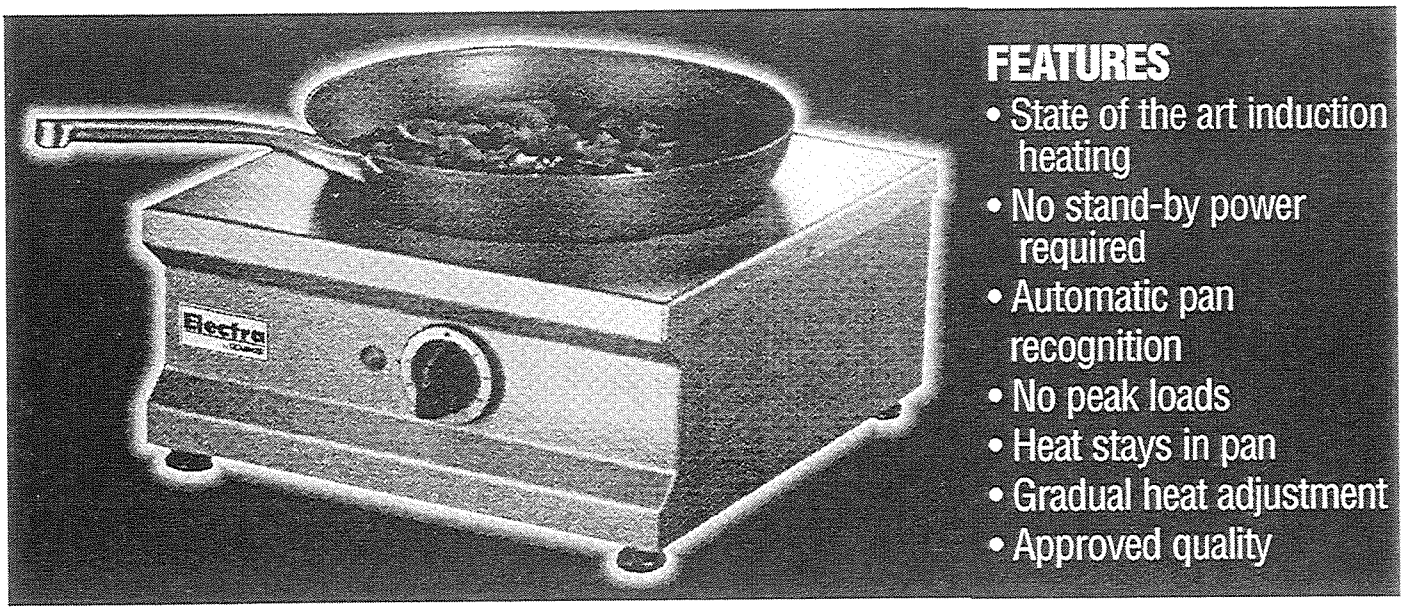
***Temperature Response***

The temperature rise measured in the test medium during the test period in accordance with the heat-up temperature response test.

# B Glowmaster 5.0 kW Induction Wok Specifications

# Cooking the new way with the Induction Wok GMI-WOK300 from GLOWMASTER™

## Superior quality, ready within minutes.




**FEATURES**

- State of the art induction heating
- No stand-by power required
- Automatic pan recognition
- No peak loads
- Heat stays in pan
- Gradual heat adjustment
- Approved quality

## Induction cooking for the new eating experience.

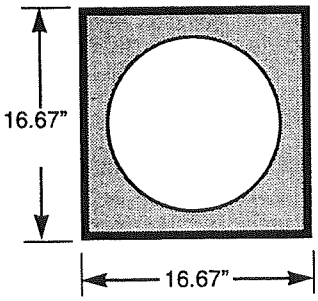
Nutritious and carefully prepared foods straight from the induction wok:

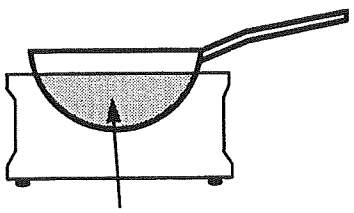
- Sautés (fish, meat, game)
- Quick fried dishes (beef stroganoff, liver, sliced meat, poultry, etc.)
- Instant correction of seasoning (including convenience food)
- Àla minute dishes

This new no heat technique permits fast table-side cooking for catering or special oriental food weeks, either at trade shows or in fairgrounds, for snack bars, fast food counters, cafeterias and so on.

- Available in 3.5 Kw and 5Kw configurations
- 12.5 inch diameter/3.5Kw/5Kw.

## SPECIFICATIONS




**Induction Characteristics:**

- Absolutely reliable technique
- Electric bill down by 70%
- Cooks up to three times faster
- Automatic pan recognition
- No peak loads
- Heats only when required, quickly and finely adjustable
- Cooking without waste heat
- Easy to clean and hygienic

**GMI-WOK 300**

| | |
|---|---|
| WIDTH | 16.67" |
| LENGTH | 16.67" |
| HEIGHT | 8.3" |
| DIAMETER | 12.5" FOR WOK |
| WEIGHT | 35.2 LBS |

**REQUIREMENTS**

| MODEL | GMI-WOK 300 | |
|---|---|---|
| POWER | 3.5Kw | 5.0Kw |
| VOLTAGE | 208-220/1N | 208-220/3N |
| CURRENT | 15A | 15A |
| PLUG | 20A/L6-20P | 20A/L15-20P |

**GLOWMASTER CORPORATION**

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