Middleby Marshall Conveyor Oven, PS 360WB
Conveyor Oven Performance Test

Application of ASTM Standard
Test Method F 1817-97

FSTC Report 5011.98.63

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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.
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Specific appreciation is extended to Middleby Marshall, Inc. for supplying the Food Service Technology Center with the Model PS360WB Gas Conveyor Oven for controlled testing in the appliance laboratory.

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Legal Notice

Contents

List of Figures and Tables

Figures

Tables

Executive Summary

The Middleby Marshall model PS 360WB is a single deck, gas conveyor oven that boasts a wide 40-inch belt and a powerful 170,000 Btu/h burner. The PS 360WB oven uses air impingement for cooking food product and incorporates a combination of digital and analog controls.

The Food Service Technology Center (FSTC) tested the PS 360WB oven under the tightly controlled conditions of the American Society for Testing and Materials' (ASTM) Standard Test Method.[1] Oven performance is characterized by preheat energy consumption and duration, idle energy rate, cooking energy efficiency and production capacity.

The Middleby Marshall PS 360WB was set up and operated in accordance with the manufacturer's specifications, and operated consistently and reliably in all phases of the testing process.

Cooking energy efficiency and production capacity results are obtained from the cooking of standardized test pizzas under light load and heavy load testing scenarios. A summary of the test results is presented in Table ES-1.

Executive Summary

Table ES-1. Summary of Performance: Middleby Marshall single deck gas conveyor oven, Model PS 360WB.

Preheat and Idle Rate Tests	
Rated Energy Input Rate (Btu/h)	170,000
Measured Energy Input Rate (Btu/h)	170,700
Fan / Control Energy Rate (kW)	0.55
Preheat Time (min)	13.3
Preheat Energy (Btu)	30,900
Idle Energy Rate (Btu/h)	64,500
Light Load Pizza Efficiency Tests (6 pizzas)	
Cook Time (min)	3.6
Cooking Energy Efficiency (%)	12.8
Gas Cooking Energy Rate (Btu/h)	72,300
Electric Cooking Energy Rate (kW)	0.55
Heavy Load Pizza Efficiency and Production Capacity Tests (24 pizzas)	
Cook Time (min)	3.6
Cooking Energy Efficiency (%)	45.0
Cooking Energy Rate (Btu/h)	111,500
Electric Energy Rate (kW)	0.55
Production Capacity (pizzas/h)	282.4

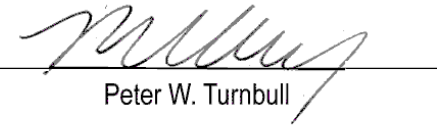
Executive Summary

The wide conveyor belt and high input rate of the Middleby Marshall PS 360WB allow for a higher production rate than narrower, lower powered single deck ovens. The cook time was a very quick 3.6 min, resulting in a production capacity of 282.4 test pizzas per hour.

This speed is not at a penalty to efficiency, as the PS 360WB oven's cooking efficiencies of 12.8% for light loads and 45.0% for heavy loads are among the highest for conveyor ovens of it's size tested at the FSTC to date.

FSTC Manager 

Donald R. Fisher

Senior Program Manager 

Peter W. Turnbull

1 Introduction

Conveyor ovens allow for the rapid cooking of food products with consistency and ease of operator use. Beyond the initial capital cost, conveyor ovens can be evaluated with regards to long-term operational cost and performance as characterized by cooking energy efficiency, idle energy consumption and production capacity.

With support from the Electric Power Research Institute (EPRI) and the Gas Research Institute (GRI), PG&E's Food Service Technology Center (FSTC) developed a uniform testing procedure to evaluate the performance of gas and electric conveyor ovens. This test procedure was submitted to the American Society for Testing and Materials (ASTM) and accepted as a standard test method (Designation F 1817-97) in 1997.[1] PG&E's *Development and Validation of a Uniform Testing Procedure for Conveyor Ovens* documents the developmental procedures and test results of several gas and electric conveyor ovens.[2]

The Middleby Marshall gas conveyor oven, model PS 360WB is a single deck, gas fired, conveyor oven with a 170,000 Btu/h input rate and a 40-inch conveyor belt width. The oven incorporates a combination of digital and analog controls. Conveyor belt speed is microprocessor controlled for timing accuracy. The PS 360WB was tested according to the ASTM procedure, and this report documents the results. The glossary in Appendix A provides a quick reference to the terms used in this report.

Introduction

Objective

The objective of this report is to examine the operation and performance of the Middleby Marshall gas conveyor oven, model PS 360WB, under the controlled conditions of the ASTM Standard Test Method. The scope of this testing is as follows:

1. Accuracy of thermostat is checked at a setting of 475°F and the thermostat is adjusted if necessary.
2. Energy input rate is determined to confirm that the oven is operating within 5% of the nameplate energy input rate.
3. Preheat energy and time are determined.
4. Idle energy rate is determined at a thermostat set point of 475°F.
5. Cooking energy efficiency and production rate are determined during light and heavy load cooking tests using pizza as a food product.

Appliance Description

The PS 360WB oven is a stainless-steel, gas fired, single deck conveyor oven. When running, the oven draws heated air through a fan which forces it into the oven cavity through air distribution fingers above and below the stainless steel wire conveyor belt. The oven has a 40-inch wide by 55-inch long oven cavity and a 170,000 Btu/h input rate. An electronic temperature control with digital readout is mounted to the lower right front of the oven. On/Off switches for fan, oven heat and conveyor operation are also located in the same area. Conveyor speed is set using a tumbler-type switch and is microprocessor controlled.

Appliance specifications are listed in Table 1-1, and the manufacturer's literature is included in Appendix B.

Introduction

Table 1-1. Appliance Specifications.

Manufacturer	Middleby Marshall, Inc.
Model	PS 360WB
Generic Appliance Type	Conveyor Oven
Rated Input	170,000 Btu/h
Technology	Air Impingement
Construction	Stainless Steel Exterior
Controls	Electronic Temperature Control
	Microprocessor Controlled Conveyor Belt Speed
Belt Width	40”
Dimensions	90” X 58” X 45”

2 Methods

The PS 360WB oven was installed in accordance with the manufacturer's instructions and Section 9 of the ASTM standard test method.[1] The oven was positioned on a tiled floor under a 4-foot-deep canopy hood, with the lower edge of the hood 6 feet, 6 inches above the floor and the oven a minimum of 6 inches inside the vertical front edge of the hood. The exhaust ventilation operated at a nominal rate of 300 cfm per linear foot of hood.

Gas consumption was monitored using a positive displacement meter which generated a pulse for every 0.1 ft^3 of gas used. Power and energy were measured with a watt/watt-hour transducer that generated an analog signal for instantaneous power and a pulse for every 10 Wh used. Oven cavity temperature was monitored with a 24 gauge, type K fiberglass insulated thermocouple wire located in the center of the oven cavity and 2 inches above the belt. The transducer and thermocouples were connected to a computerized data acquisition unit that recorded data every 5 seconds. A voltage regulator, connected to the oven, maintained a constant voltage for all tests. Figure 2-1 shows the PS 360WB instrumented with the data aquisition system and voltage regulator.

Methods

Figure 2-1. The PS 360WB Instrumented for Testing.

Energy Input Rate and Thermostat Calibration

The energy input rate was determined by measuring the gas consumed by the oven from the time it was first turned on until the time when the burners first cycled off. The gas consumed and the time elapsed are used to calculate the maximum energy input rate. Thermostat calibration was verified by allowing the oven to operate with the thermostat set to the specified operating temperature of 475°F for a period of one hour, and then monitoring the oven cavity temperature for a period of thirty minutes.

Preheat and Idle Rate Tests

Preheat tests recorded the time and energy required for the oven to increase the cavity temperature from 75 ± 5°F to the operating temperature of 465°F. Recording began when the oven was first turned on and ended when the temperature in the oven cavity reached 465°F. Although the specified operating temperature is 475°F, research at PG&E's Food Service Technology Center has indicated that a conveyor oven is sufficiently preheated and ready to cook when the oven temperature is within 10°F of the oven set point (that is, 465°F when the thermostat is set to maintain 475°F).

After the oven was preheated, it was allowed to stabilize for one hour, and then idle energy consumption was monitored for a 2-hour period.

Light Load Pizza Efficiency Tests

Light load pizza tests are used to calculate cooking energy efficiency under partial loading conditions, as when the oven is cooking pizzas intermittently or at a rate below it's maximum capacity.

Cooking energy efficiency tests were performed with a uniform test pizza as the food product. Pizza crusts were 12-inch diameter, par-baked crusts weighing 0.9 ± 0.2 lb and having a moisture content of 36 ± 3% by weight. Pizza sauce was a simple, tomato based sauce with a moisture content of 87 ± 3% by weight. Pizza cheese was part-skim, low moisture, shredded mozzarella cheese with a moisture content of 50 ± 2% by weight. Ingredients were verified for proper moisture content by gravimetric moisture analysis.

The pizzas were comprised of a pizza crust, pizza sauce and pizza cheese according to the following: 0.25 lb of pizza sauce spread uniformly on top of a pizza crust to within 0.5 inch of the edge, and 0.375 lb of pizza cheese spread uniformly over the pizza sauce. The pizzas were then placed on sheet pans and covered with plastic wrap. The pizzas were stabilized in a refrigerator for a minimum of 18 hours before testing to ensure temperature uniformity of 39 ± 1°F.

Pizza doneness requires a final pizza temperature of 195 ± 3°F. During temperature determination, the pizzas were placed on a piece of rigid polystyrene insulation that was covered with a sheet of waxed paper. The final pizza temperature was measured by placing six hypodermic-style thermocouple probes on the surface of the pizza, located 3 inches from the center of the pizza and equidistant from each other. The probes were allowed to penetrate the cheese and rest in the crust-sauce interface. The highest average temperature of the six probes during measurement was the final pizza temperature. For consistency and simplicity, the probes were attached to a lightweight plastic disc which held the relative position of each probe constant from pizza to pizza. Figure 2-2 shows the thermocouple probe structure in use.

Figure 2-2. Thermocouple Probe Structure in Use.

For purposes of testing, the oven cavity size of 40 inches by 55 inches is rounded down to the nearest foot, in this case to 3 feet by 4 feet. This dictated that 4 rows of 3 pizzas (12 total) were needed for each run of the light load test. For convenience, the pizzas were pre-weighed so only the final after-cook weight needed to be taken during the test. The pizzas were removed from the refrigerator and quickly loaded onto the conveyor belt so that no more than 1 minute elapsed before the cooking process began. Each row was placed on the conveyor with the middle pizza centered on the belt, and with the leading edge of the pizza adjacent to the entrance of the oven cavity. The other two pizzas were placed directly next to the middle one, such that the

extra conveyor width fell equally to each side of the pizza row, rather than on just one side or between the pizzas. After cooking, the center pizza from each row was chosen for final temperature determination. All pizzas were weighed after cooking for use in the energy efficiency calculations. Figure 2-3 shows a row of pizzas being loaded for a light load test.

Figure 2-3. Loading a Row of Pizzas for Testing.

Heavy Load Pizza Efficiency and Production Capacity Tests

The heavy load pizza tests are used to calculate cooking energy efficiency and production capacity when the oven is under maximum loading conditions.

The heavy load tests required preparation of 16 rows of 3 pizzas (48 total) for each test run. The pizzas were prepared, pre-weighed and stabilized as in the light load tests. The pizza rows are placed one after the other on the conveyor such that the leading edge of the new row of pizzas is directly next to the trailing edge of the previous row. Each individual row is placed on the conveyor in the same manner as in the light load test, with the middle pizza centered on the conveyor. All pizzas were weighed after cooking for use in the energy efficiency calculations.

Due to the large number of pizzas cooked during the heavy load tests, a minimum of three researchers were needed to conduct the tests smoothly- one for loading the pizzas onto the conveyor, one for removing the pizzas after cooking, and one for final temperature determination and final weighing.

Both light and heavy load tests were performed in triplicate to ensure that the reported cooking energy efficiency and production capacity results had an uncertainty of less than ±10%. The results from each test run were averaged, and the absolute uncertainty was calculated based on the standard deviation of the results.

The ASTM results reporting sheets appear in Appendix C, and the cooking energy efficiency data sheets appear in Appendix D.

3 Results

Energy Input Rate and Thermostat Calibration

The energy input rate was measured and compared with the manufacturer's nameplate value to ensure the oven was operating within its specified parameters. The maximum energy input rate was 170,700 Btu/h, 0.4% higher than the nameplate rate of 170,000 Btu/h, and within the 5% tolerance of the ASTM standard. The oven cavity temperature was monitored to verify that the oven was operating at 475 ± 5°F. At the thermostat set point of 475°F the oven cavity temperature averaged 468.6°F, which is below the operating window. The thermostat was adjusted to 483°F, which gave an average oven cavity temperature of 474.8°F, so the 483°F setting was used for all tests.

Preheat and Idle Rate Tests

Preheat Energy and Time

Time and energy were monitored starting from the time the blower and heat switches were turned on. Any time that elapsed before the igniting of the burners is included in the test. The oven has a soft-landing thermostat, so after 8.0 minutes and at a temperature of 435°F, the oven began to cycle off. This soft-landing extended the length of the preheat, but also prevented the oven from over-shooting the temperature set point. The preheat test ended at the specified temperature of 465°F, and consumed 30,900 Btu over a period of 13.3 min.

Idle Energy Rate

The oven was allowed to stabilize for one hour following the preheat test with the thermostat set to 483°F. Thereafter, the energy consumption was monitored over a 2-hour period. The idle energy rate was calculated to be 64,500 Btu/h, which is 38% of the oven's rated input.

Results

Test Results

The oven's preheat curve is shown in Figure 3-1. The rated energy input, preheat energy, and idle rate test results are summarized in Table 3-1.

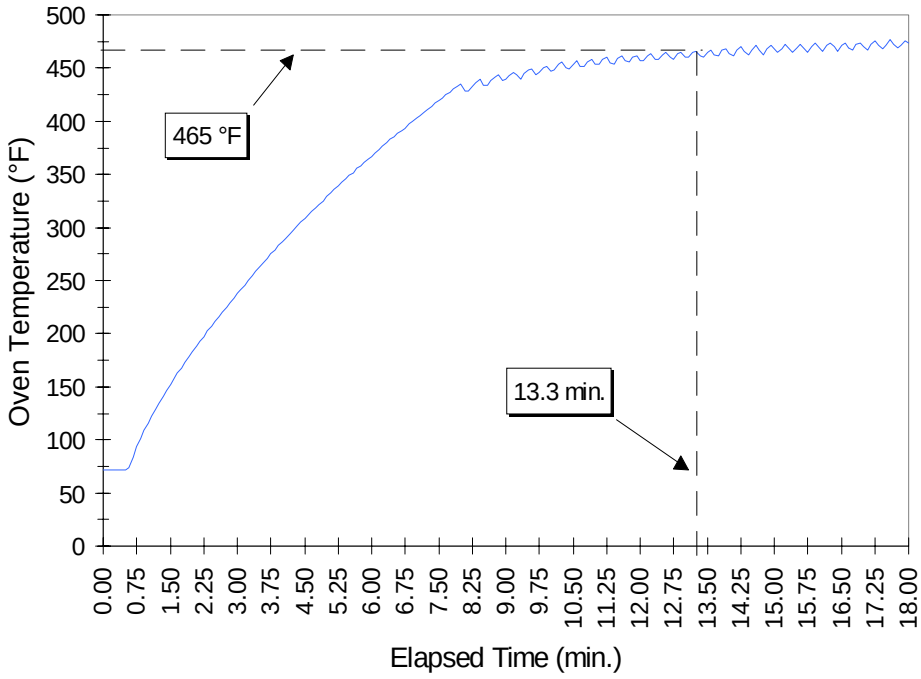


Figure 3-1.
Preheat Characteristics.

Table 3-1. Input, Preheat, and Idle Rate Test Results.

Rated Energy Input Rate (Btu/h)	170,000
Measured Energy Input Rate (Btu/h)	170,700
Preheat	
Time (min)	13.3
Energy (Btu)	30,900
Idle Energy Rate	
Energy Rate (Btu/h)	64,500

Results

Cooking Tests

The oven was subjected to two cooking tests: light load pizza and heavy load pizza. The gas consumption, electric energy consumption, elapsed cook time, oven cavity temperature, and ambient temperature were monitored for the duration of each test at five second intervals. During final pizza temperature determination, the readings of the temperature probes were also recorded at five second intervals.

Light Load Pizza Efficiency Tests

The light load tests were used to determine the oven's performance under partial load conditions. PS 360WB oven completed the test in 7.3 minutes, while delivering 12.8% cooking efficiency at a production rate of 49.3 pizza/h.

Heavy Load Pizza Efficiency and Production Capacity Tests

The heavy load tests were used to determine the oven's performance when operating the oven at it's maximum capacity. The PS 360WB oven completed the heavy load test in 5.1 minutes, while delivering 45.0 % cooking efficiency and a 282.4 pizza/h production capacity.

Test Results

Cooking energy efficiency is defined as the quantity of energy consumed by the pizzas expressed as a percentage of energy consumed by the oven during the cooking test. The mathematical expression is therefore:

$$\text{Cooking Energy Efficiency \%} = \frac{E_{pizza}}{E_{oven}} \times 100\%$$

Results

Energy imparted into the pizza is calculated using the measured values of initial and final pizza temperature, initial and final pizza weight, the specific heat of the pizza (based on the average specified pizza), and the heat of vaporization of water at 212°F.

Energy consumed by the oven is determined by adding gas and electric energy use during the test. Appendix D lists the physical properties and measured values of each test run. Using the detailed equations provided in Section 11 of the conveyor oven ASTM Standard Test Method, the cooking energy efficiencies can be readily calculated. Table 3-2 summarizes the PS 360WB oven's performance under the ASTM test method.

Table 3-2. Cooking Energy Efficiency and Production Capacity Test Results.

	Light Load Pizza	Heavy Load Pizza
Number of pizzas	6	24
Test Time (min)	7.3	5.1
Gas Cooking Energy Rate (Btu/h)	72,300	111,500
Electric Cooking Energy Rate (kW)	0.55	0.55
Energy Efficiency (%)	12.8	45.0
Production Rate (pizzas/h)	49.3	-
Production Capacity (pizzas/h)	-	282.4

4 Conclusions

The Middleby Marshall single deck gas conveyor oven, model PS 360WB, performed very well under the stringent conditions of the ASTM standard test method. The oven cooked consistent pizzas which were evenly done at every position along the conveyor, and the controls were simple and intuitive. For cleaning, the crumb pans and end panels are easily removed.

The cook time of 3.6 minutes was faster than any conveyor oven tested at the FSTC to date.

The PS 360WB's high input rate of 170,000 Btu/h allowed the oven to cook the test pizzas very quickly. The cook time of 3.6 minutes was faster than any conveyor oven tested at the FSTC to date. This resulted in a very high 282.4 pizza/h production capacity from just a single deck.

The quick speed did not come at the expense of energy use. The PS 360WB oven's idle energy rate of 64,500 Btu/h was 38.0% of the rated input, which is a lower percentage than that of a smaller Middleby Marshall conveyor oven previously tested at the FSTC. The cooking energy efficiency numbers of 12.8% for light loads and 45.0% for heavy loads are among the highest of all conveyor ovens of it's size tested at the FSTC to date.

With it's wide conveyor belt and high input rate the Middleby Marshall PS 360WB gas conveyor oven is suitable for heavy duty use demanding high throughput with consistent product quality and simplicity of operation.

5 References

1. American Society for Testing and Materials. 1997. *Standard Test Method for the Performance of Conveyor Ovens.* ASTM Designation F 1817-97, in *Annual Book of ASTM Standards,* Philadelphia: American Society for Testing and Materials.

2. Pacific Gas and Electric Company. Publication Pending. *Development and Validation of a Uniform Testing Procedure for Conveyor Ovens*.

Appendixes

A Glossary

Conveyor Oven
An appliance that carries the food product on a moving conveyor into and through a heated chamber. The chamber may be heated by gas or electric forced convection, radiants, or quartz tubes. Top and bottom heat may be independently controlled.

Conveyor Speed
Time required for a single point on the conveyor belt to travel through the oven cavity.

Cook Time
Time required for an entire pizza to travel through the oven cavity, measured from the time when the leading edge of the pizza enters the oven cavity, to the time when the trailing edge of the pizza exits the oven cavity.

Cooking Energy Efficiency
Energy Efficiency
Quantity of energy imparted to the specified food product expressed as a percentage of energy consumed by the conveyor oven during the cooking event.

Cooking Energy Rate
Cooking Energy Consumption Rate
Average rate of energy consumption (Btu/h or kW) during the cooking energy efficiency test. Refers to all loading scenarios (heavy,light).

Energy Input Rate
Rate at which a conveyor oven consumes energy (Btu/h or kW).

Idle Energy Rate
Idle Rate
The conveyor oven's rate of energy consumption (kW or Btu/h), when empty, required to maintain it's cavity temperature at the specified thermostat set point.

Maximum energy input rate
Measured Energy Input
Measured Peak Energy Input Rate
Peak Rate of Energy Input Rate
Peak rate at which a conveyor oven consumes energy (Btu/h or kW).

Oven Cavity
That portion of the conveyor oven in which food products are heated or cooked.

Pilot Energy Rate
Rate of energy consumption (Btu/h) by a conveyor oven's continuous pilot (if applicable).

Preheat Energy
Amount of energy consumed (Btu/h or kWh) by the conveyor oven while preheating it's cavity from ambient temperature to the specified thermostat set point.

Preheat Time
Time (min.) required for the conveyor oven cavity to preheat from ambient temperature to the specified thermostat set point.

Glossary

Production Capacity

Maximum rate (lb(kg)/h) at which a conveyor oven can bring the specified food product to a specified "cooked" condition.

Production Rate

Rate (lb(kg)/h) at which a conveyor oven can bring the specified food product to a specified "cooked" condition.

Uncertainty

measure of systematic and precision errors in specified instrumentation or measure of repeatability of a reported test result.

B Appliance Specifications

Appendix B includes the product literature for the Middleby Marshall gas conveyor oven, model PS 360WB.

Middleby® Marshall
CONVEYORS OF EXCELLENCE

AIA File No.:_____

Item No.:_____

PS360WB

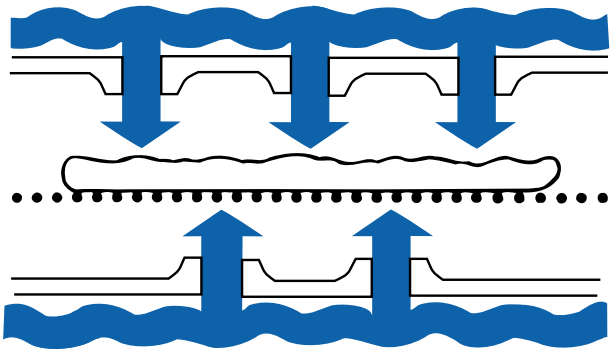
Direct Gas Fired Conveyor Oven

PS360WB Single Unit

PS360WB-D Double Unit

Principle

Middleby Marshall PS Series Conveyor ovens bake both faster and at a lower temperature than other ovens. Patented vertical columns of hot air move heat aerodynamically instead of using high temperatures. The streams of hot air remove the boundary layers of cool heavy air which tend to insulate the product. This gives very rapid baking without burning. All Middleby ovens are designed to cook a multitude of products including pizza, seafood, bagels, ethnic foods and more.



General Information

PS360WB conveyor ovens feature a 54.5" cooking chamber, a 40" wide conveyor belt, and a patented “Jet Sweep” impingement process that delivers constant heat to the chamber. All ovens feature microprocessor controlled bake time/conveyor speed. Eight adjustable jet fingers per chamber and front-loading window are standard. Ovens have stainless steel front, sides and top. All ovens include extra fan belt, installation kit, and 4' AGA flex hose. Heating is controlled in 8" adjustable zones. Top and bottom are independently adjustable. The conveyor drive is reversible. Conveyor belt provides automatic delivery when product is finished. Front loading window with cool handle design allows product with different bake times to be cooked consistently regardless of loading.

Special Features

PS360WB units are stackable two high. Split belt option also available upon request.

Conserves Energy

Middleby ovens provide very efficient heat transfer to product. Energy is conserved as air is recycled from heater to product, with minimum flue or vent loss.

Cleanability

PS360WB ovens are designed for easy cleaning. Removable parts include: crumb pans, end panels, air fingers and a folding conveyor belt assembly for easy removal.

Easily Serviced

Control compartment is designed for quick and easy access. All electrical controls are door mounted.

Warranty

All PS360WB models have a one year parts and labor warranty. Oven start-up and demonstration are included at no additional charge (USA only).

Ventilation

For installation under a ventilation hood only.

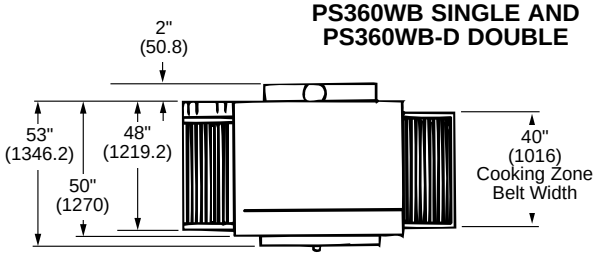
Middleby® Marshall
A MIDDLEBY COMPANY
1400 Toastmaster Drive
Elgin, Illinois 60120 USA
(847) 741-3300 Fax: (847) 741-0015
www.middleby.com

Middleby Marshall Model PS360WB Direct Gas Fired Conveyor Oven

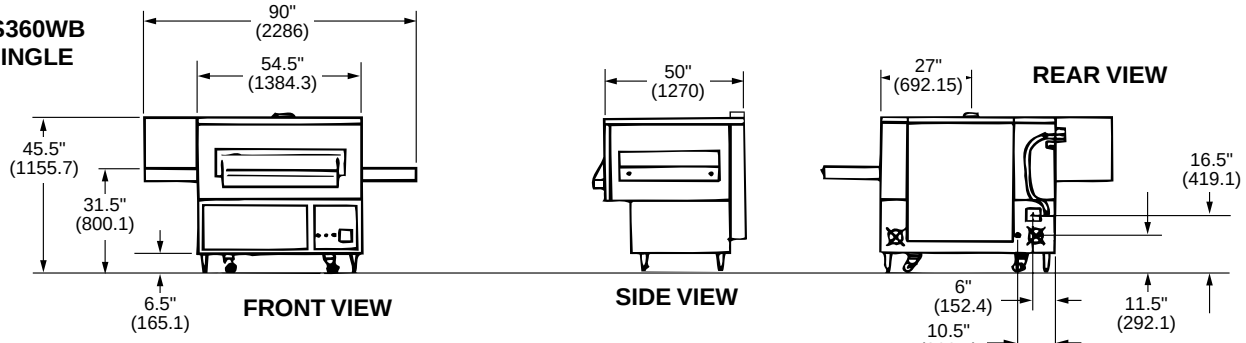
Baking chamber opening: 3.875" (98.42 mm).
Scale .25" (6.35 mm) = 1' (304.8 mm) approx.

NOTE: All Figures In Parentheses Are In Millimeters Unless Otherwise Specified

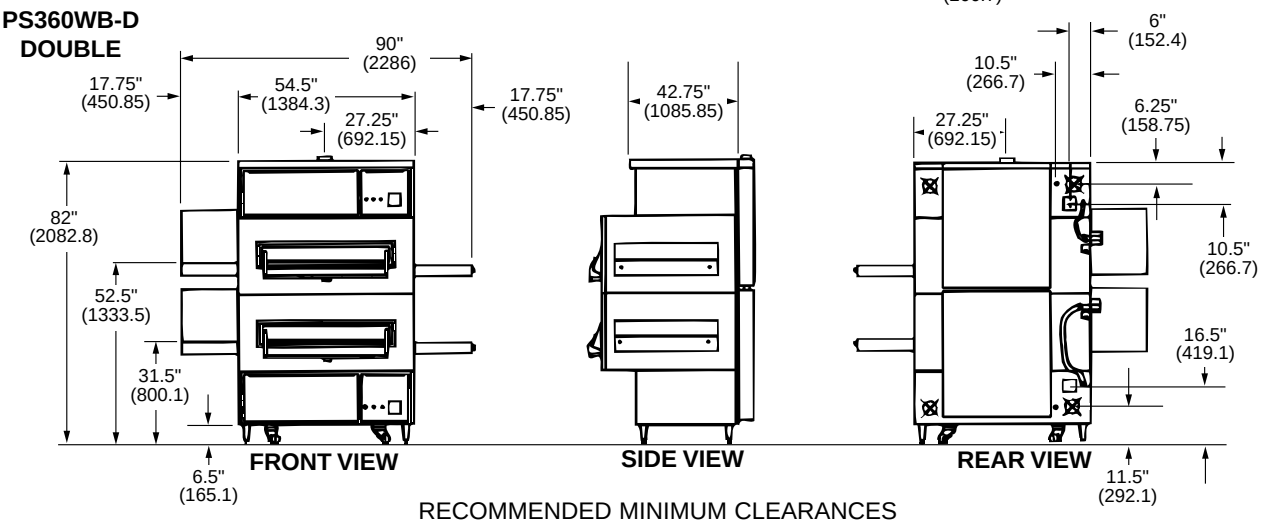
TOP VIEW OF BOTH THE PS360WB SINGLE AND PS360WB-D DOUBLE



PS360WB SINGLE



PS360WB-D DOUBLE



RECOMMENDED MINIMUM CLEARANCES

Rear of Oven to Wall	Left Conveyor Extension to Wall	Right Conveyor Extension to Wall (control panel side)
1" (25.4)	0"	0"

GENERAL INFORMATION

	Heating Zone	Bake Chamber	Belt Width	Height	Width	Depth	Max. Operating Temp.	Bake Time Range	Ship Wt. (lbs.)	Ship Cube per cavity
PS360WB Single	54.5" (1384.3)	15.14 sq. ft. (1.406 sq. m)	40" (101.6)	45.5" (1155.7)	90" (2286)	55" (1397)	550° (287°C)	2 min., 40 sec. to 29 min., 50 sec.	1500	126.3 ft.^{3}
PS360WB Double	109" (2768.6)	30.28 sq. ft. (2.813 sq. m)	40" (101.6)	82" (2082.8)	90" (2286)	55" (1397)	550° (287°C)	2 min., 40 sec. to 29 min., 50 sec.	3000	126.3 ft.^{3}

GAS SUPPLY PROVIDED BY CUSTOMER

	Min. Gas Pipe Size	Gas Valves (full flow gas shut-off valve)	Req'd Supply Gas Pressure*	Power
Natural Gas 1 or 2 ovens	2" (508) NPT	.75" (19.05) ID each oven	6" (15mbar) to 14" (35mbar) water column	170,000 BTU/HR (50kW) per cavity
Propane Gas 1 or 2 ovens	1.5" (38.1) NPT	.75" (19.05) ID each oven	6" (15mbar) to 14" (35mbar) water column (CE Max 50mbar)	170,000 BTU/HR (50kW) per cavity

ELECTRICAL RATINGS per cavity

Gas Fired Ovens	Voltage	Phase	HZ	Amps	Supply	Breakers
PS360WB	208 - 240	1	60	12	3 pole, 4 wire (2 hot, 1 neutral,1 ground)	per local codes
PS360WB (CE Listed)	220 - 230	1	50	2400 Watts	2 pole, 3 wire (1 hot, 1 neutral, 1 ground)	per local codes

Middleby® Marshall
CONVEYORS OF EXCELLENCE

Above specifications subject to change without notice.
* For CE gas supply applications, please consult factory for specifics.

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C Results Reporting Sheets

Manufacturer	Middleby Marshall, Inc.
Model	PS 360WB
Date:	July, 98

Section 11.1 Test Oven

Description of operational characteristics: The oven draws heated air through a fan which forces it into the oven cavity through air distribution fingers above and below the conveyor, which carries food into and through the oven. The oven has front mounted controls for all operating functions.

Section 11.2 Apparatus

The oven was installed in accordance with the manufacturer's instruction on a tiled floor under a 4-foot-deep canopy hood, with the lower edge of the hood 6 feet, 6 inches above the floor and a minimum of 6 inches inside the vertical front edge of the hood. The exhaust ventilation operated at a nominal rate of 300 cfm per linear foot of hood.

The oven was instrumented using a positive displacement gas meter, a watt/watt-hour transducer, and a 24 gauge, type K fiberglass insulated thermocouple wire (for oven cavity temperature measurement). A voltage regulator maintained a constant voltage for all tests and data was recorded at five second intervals by a computerized data acquisition unit. All test apparatus were installed in accordance with Section 9 of the ASTM test method.

Results Reporting Sheets

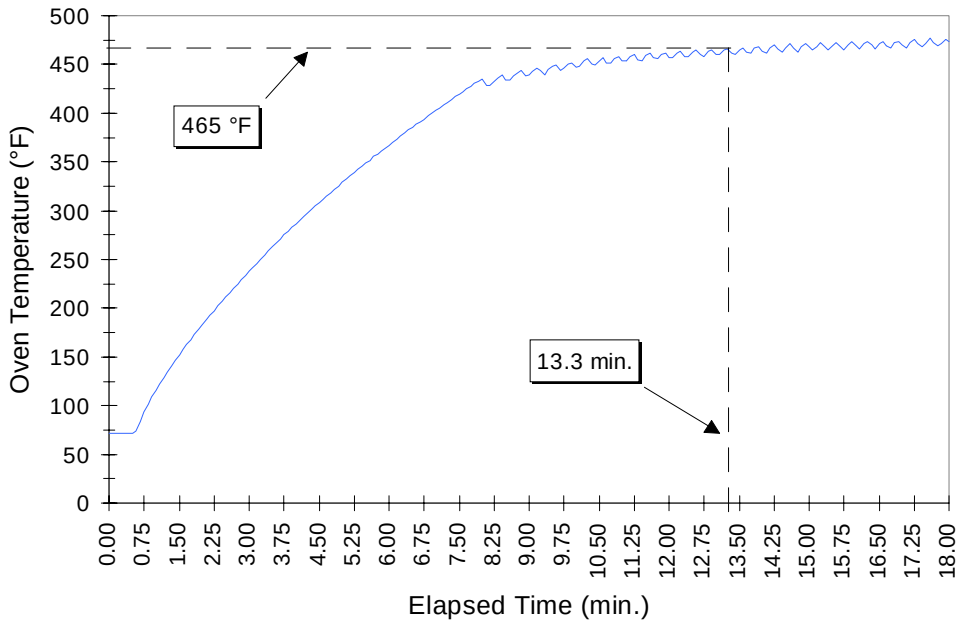
Section 11.4 Energy Input Rate

Test Voltage	208 V
Gas Heating Value	1026.8 Btu/ft^3
Rated	170,000 Btu
Measured	170,700 Btu
Percent Difference between Measured and Rated	0.4 %
Fan / Control Energy Rate (Gas Ovens Only)	0.55 kW

Section 11.5 Preheat Energy and Time

Test Voltage	208 V
Gas Heating Value	1026.5 Btu/ft^3
Energy Consumption	30,900 Btu
Time from 75°F to 465°F	13.3 min

Preheat Characteristics



Results Reporting Sheets

Section 11.6 Idle Energy Rate

Test Voltage	208 V
Gas Heating Value	1026.6 Btu/ft^3
Idle Energy Rate	64,500 Btu/h

Section 11.7 Pilot Energy Rate

Gas Heating Value	N/A
Pilot Energy Rate	N/A

Section 11.8 Cooking Energy Efficiency and Cooking Energy Rate

Cook Time Determination:

Cook Time	3.6 min
Conveyor Speed	3.0 min

Light Load:

Test Voltage	208 V
Gas Heating Value	1026.1 Btu/ft^3
Cooking Energy Efficiency	12.8 ± 0.5 %
Gas Cooking Energy Rate	72,300 Btu/h
Electric Cooking Energy Rate	0.55 kW

Heavy Load:

Test Voltage	208 V
Gas Heating Value	1026.2 Btu/ft^3
Cooking Energy Efficiency	45.0 ± 0.6 %
Gas Cooking Energy Rate	111,400Btu/h
Electric Cooking Energy Rate	0.55 kW
Production Capacity	282.4 Pizzas/h

D Cooking Energy Efficiency Data

Table D-1. Physical Properties.

Specific Heat (Btu/lb °F)	
Pizza	0.593
Latent Heat (Btu/lb)	
Vaporization, Water	970

Table D-2. Light Load Pizza Efficiency Test Data.

Measured Values	Repetition #1	Repetition #2	Repetition #3
Number of Pizzas	6	6	6
Conveyor Speed (min)	3.0	3.0	3.0
Initial Pizza Temperature (°F)	40	40	40
Final Average Pizza Temperature (°F)	194.6	193.4	196.7
Total Initial Pizza Weight (lb)	8.622	8.630	8.588
Total Final Pizza Weight (lb)	8.253	8.245	8.224
Test Time (min.)	7.3	7.3	7.3
Gas Volume (ft^3)	9.1	9.0	9.1
Electric Energy (Wh)	70	60	70
Calculated Values			
Energy Consumed by Pizzas (Btu)	1200	1200	1200
Gas Energy Consumed by Oven (Btu)	8800	8700	8800
Electric Energy Consumed by Oven (Btu)	240	200	240
Total Energy Consumed by Oven(Btu)	9,040	8,900	9,040
Cooking Energy Efficiency (%)	**12.7**	**13.0**	**12.7**
Gas Cooking Energy Rate (Btu/h)	**72,700**	**71,600**	**72,600**
Electric Cooking Energy Rate (kW)	**0.58**	**0.49**	**0.58**

Cooking Energy Efficiency Data

Table D-3. Heavy Load Pizza Efficiency Test Data.

Measured Values	Repetition #1	Repetition #2	Repetition #3
Number of Pizzas	24	24	24
Conveyor Speed (min)	3.0	3.0	3.0
Initial Pizza Temperature (°F)	40	40	40
Final Average Pizza Temperature (°F)	193.5	192.1	195.5
Total Initial Pizza Weight (lb)	34.344	34.437	34.373
Total Final Pizza Weight (lb)	33.145	33.229	33.119
Test Time (min.)	5.1	5.1	5.1
Gas Volume (ft^3)	9.8	9.7	10.0
Electric Energy (Wh)	40	50	50
Calculated Values			
Energy Consumed by Pizzas (Btu)	4300	4300	4400
Gas Energy Consumed by Oven (Btu)	9500	9300	9600
Electric Energy Consumed by Oven (Btu)	140	170	170
Total Energy Consumed by Oven(Btu)	9640	9470	9770
Cooking Energy Efficiency (%)	**44.8**	**45.2**	**45.0**
Gas Cooking Energy Rate (Btu/h)	**111,600**	**109,700**	**113,100**
Electric Cooking Energy Rate (kW)	**0.47**	**0.59**	**0.59**
Production Capacity (Pizzas/h)	**282.4**	**282.4**	**282.4**