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EVALUATION OF AN ELECTRIC, SELF-CLEANING CHAR BROILER

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Army Natick Laboratories
Natick, Massachusetts

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13. ABSTRACT

The char-broiler evaluated in this report is considered acceptable for use in DoD Food Service Facilities. The broiler will cook hamburgers, frankfurters, sausages, and steaks to a high degree of acceptability. Hamburger cooking time is reduced by one-half over conventional grilling, and frankfurters, sausages, and steaks require less time than cooking by conventional methods.

The grid self-cleaning feature operates satisfactorily and does a good cleaning job. The unit is safe to use and with a few design changes can be constructed so cleaning is easily accomplished.

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FOREWORD

The char-broiler was evaluated to determine its acceptability for possible use in DoD Food Service Facilities and to compare food preparation results with results obtained on other designs of broilers.

Acknowledgment is given to personnel of the Engineering Evaluation Office and the Food Service Equipment and Evaluation Team, Food Systems Equipment Division, General Equipment & Packaging Laboratory for testing of the broiler.

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EVALUATION OF AN ELECTRIC, SELF-CLEANING CHAR BROILER

1. Introduction

An electric, self-cleaning char-broiler* was evaluated to determine its acceptability for use in DoD Food Service Facilities and to provide a comparison with present grilling methods and with other broilers previously evaluated. The evaluation encompassed design, quality and quantity of food production, sanitation, safety, and versatility.

2. Description of Broiler

The broiler is an electrically heated, two-section grid, self-cleaning, free-standing counter unit (Figure 1) measuring approximately 95.25 centimeters (cm) (37 1/2 in.) wide by 60.96 cm (24 in.) front to back by 33.97 cm (13 3/8 in.) high to broiling surface. Each grid section has a cooking area of 1652 square cm (256 square in.) and is individually controlled. Grids are designed so grease cannot drip onto the calrod heating elements. Each section has an ON-OFF switch, a grease drawer, a temperature control switch, and a pilot light. The broiler has one 0 to 20-minute timer and a selector switch position for pyrolytic cleaning of the heating grids. The unit is rated at 24 kw and requires a 208-volt, 60-Hertz, 1-phase, alternating current supply. The unit must be located under a ventilating canopy with an air removal capacity of at least 0.377 cu m/sec (800 cu ft/min) and must not be located closer than 30.48 cm (12 in.) to a wall at the sides and not closer than 12.70 cm (5 in.) at the back.

3. Design Tests

a. Preheat Time. The test was conducted to verify the manufacturer's stated grid preheat time and was done in three steps. Initially, the temperature attained after 11 minutes was determined for the righthand grid only. Next, the temperature was determined for the lefthand grid only and finally for the two grids simultaneously. The switch was pressed to the "BROIL" position and the control dial was set at the "HI" marking for the righthand grid. A Barnes Engineering Co., Model IT-4, Thermal Master Infrared Radiometer was focused to obtain the temperature at the approximate centerpoint of the grid. A stopwatch was used to determine the time

*Product of General Electric Co., Chicago Heights, Illinois - Model CB51.

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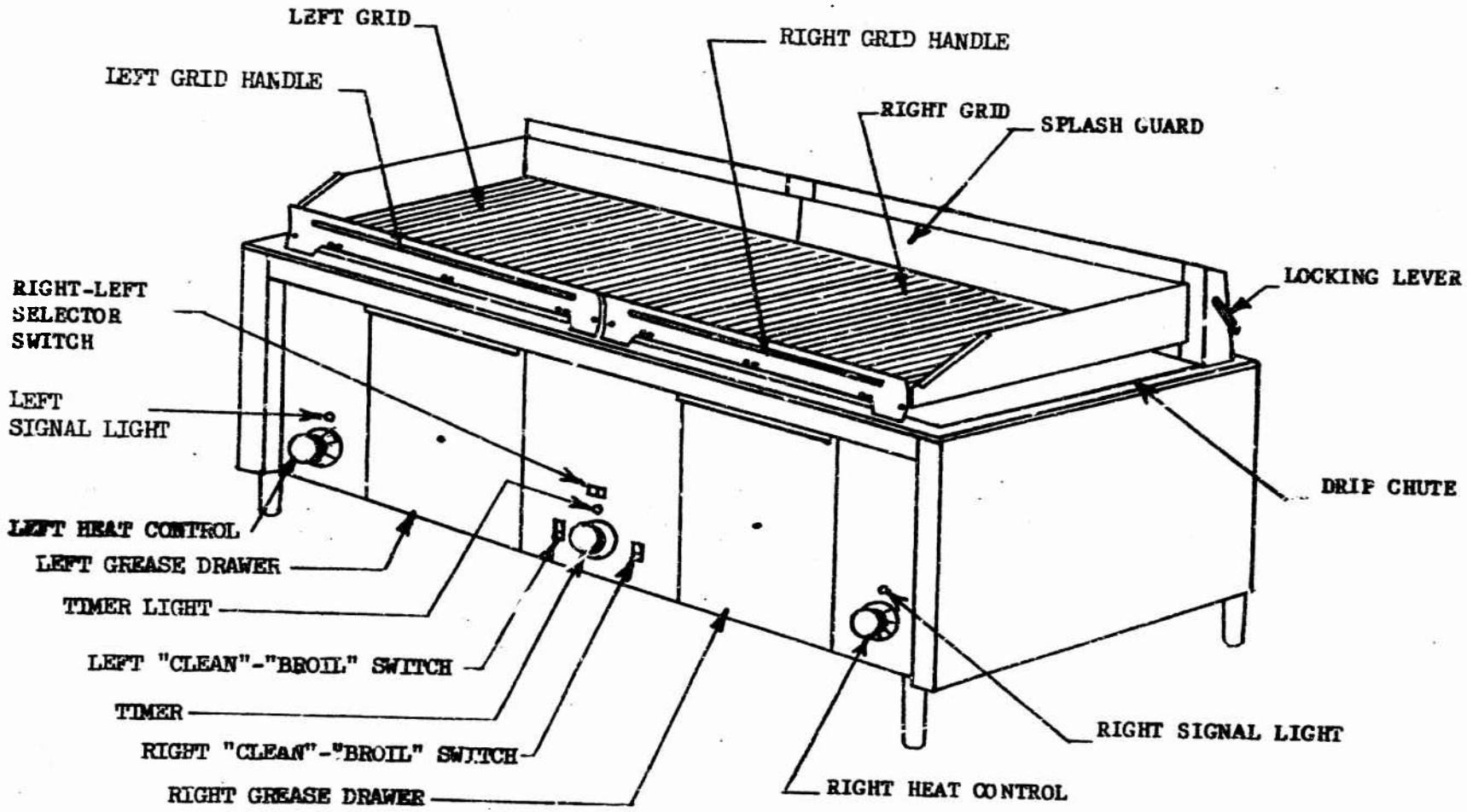

FIGURE 1. GENERAL VIEW OF BROILER

between when the grid was energized and when the 11 minutes had elapsed. The switch was then pressed to the "OFF" position and the grid allowed to cool for thirty minutes. The procedure was repeated for the lefthand grid and again for the two grids operating simultaneously.

b. Grid Temperatures at Various Settings. The test to determine the grid temperatures at selected control settings was done in three steps. First, the temperatures of the righthand grid were determined with only that grid operating. Second, the temperatures of the lefthand grid were determined with only that grid in operation. Finally, the temperatures were determined for both grids with both grids in operation. The switch was pressed to the "BROIL" position and the right broiling control dial was set at the "HI" position for preheating and allowed to remain at that setting for 15 minutes. The control was then set at "LO" and temperatures were immediately taken at the left front, right front, center, left rear, and right rear of the grid. The broiler was allowed to cool and the procedure was then repeated for the left grid and again while both grids were operated simultaneously. Broiler was allowed to cool and procedure was repeated with the control dial set at "HI" for the right grid and after cooling, for the left grid. The procedure was repeated with the control dial set midway between the "HI" and "LO" settings. After cooling, readings were taken with both grids operating simultaneously at "HI" and then at the midway position. Temperatures were taken with the radiometer specified above, the minimum and maximum temperatures were recorded, and the average temperatures were computed. Results are shown in Table I.

c. Self-Cleaning

(1) Ambient Temperature During Cleaning Cycle. The ambient temperature was recorded at a distance of 15.24 cm (6 in.) above the grids during the self-cleaning operation. The temperature was first taken for the righthand grid, then the lefthand grid, for a total of five 20-minute cycles each. The timer on the machine was used for the test. A thermocouple was located above the centerpoint of the grid and connected to a strip chart recorder. The recorder was operated during the entire 20-minute cleaning cycle, and a record was made of the ambient temperatures. The maximum ambient temperature was recorded and results are shown on Table II.

TABLE I. Grid Temperatures

Dial Setting	Right Grid						Left Grid					
	Max Temp		Min Temp		Avg Temp		Max Temp		Min Temp		Avg Temp	
	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F	°C	°F
	Operating Separately											
LO	143.3	290	115.6	240	129.5	265	104.4	220	93.3	200	98.8	210
Intermediate	235	455	193.3	380	215.6	420	221.2	430	146.2	295	180.5	357
HI	340.5	645	298.8	570	322.3	612	335	635	248.8	480	306.2	583
	Operating Simultaneously											
LO	121.1	250	104.4	220	112.8	235	104.4	220	87.7	190	96.1	205
Intermediate	210	410	193.3	380	205.6	402	204.4	400	162.9	325	191.2	376
HI	329.5	625	282.2	540	302.7	577	323.9	615	229.5	445	286.7	548

TABLE II. Maximum Temperatures Attained During Cleaning Cycle

	Handle		Grease		Ambient	
	°C	°F	°C	°F	°C	°F
Right Grid	31.2	88	39.5	103	165.5	330
Left Grid	29.5	85	39.5	103	158.9	318

(2) Grid Handle Temperature During Cleaning Cycle. It is not possible to clean the two grids simultaneously so the handle temperature must be determined individually for each grid. The grids were both coated with grease prior to the start of the test. The righthand grid was raised until it locked in the upright position and the selector switch was pressed to the "CLEAN" position. The timer was set at 20 minutes. After approximately 15 minutes, three temperature readings were obtained at three random points on the handle using the infrared radiometer. When the timer signal light went out, the grid was allowed to cool for 30 minutes. The procedure was repeated for the lefthand grid. The maximum grid handle temperatures were recorded and are shown in Table II.

(3) Temperature of Grease in Grease Drawer During Cleaning Cycle. The temperature of the grease in the grease drawer during the cleaning cycle was taken at the same time as the handle temperatures. Prior to the start of the test, a thermocouple was positioned in each of the two grease drawers in such a way that they were not contacted by the hot grease from the end of the drip chute. The thermocouples were attached to a strip recorder. Liquid shortening was poured into each drawer to a depth of 3.81 cm (1 1/2 in.) which was approximately 16.51 cm (6 1/2 in.) below the underside of the grid heating elements. A record of the maximum temperature of the grease in the grease drawer was made and a visual examination was made to determine if grease splattered or burned.

d. Temperature of Grease in Grease Drawer During Use. The temperature of the grease in the two grease drawers was taken with the control dial set at "HI" and the broiler in operation. Thermocouple locations and instrumentation stated for the grease temperature (para. 3c(3) above) during the cleaning cycle were used. The broiler was operated for four hours. A record of the maximum temperature of the grease was made, and a visual examination was performed to determine if grease splattered or burned.

4. Design Findings

a. Preheat Time. Manufacturer's literature states the broiler will attain a preheat temperature of 343.3°C (650°F) within 11 minutes. The test conducted herein does not verify the literature as being correct. Grid temperatures after 11 minutes were 310°C (590°F) for the righthand grid and 315.5°C (600°F) for the lefthand grid. Temperatures of 315.5°C (600°F) on the righthand grid and 310°C (590°F) on the lefthand grid were attained in approximately 11 minutes with both grids operating simultaneously.

b. Grid Temperatures. The minimum, maximum, and average grid temperatures computed from the readings taken are shown in Table I.

c. Self Cleaning. The maximum handle temperature, ambient temperature taken 15.24 cm (6 in.) above the grid, and grease temperature in the grease drawers during the cleaning cycle are shown in Table II. There was no evidence of splattering or burning of the grease in the drawers and drip chutes, and there were no unsafe temperatures in the grease drawers. Handle temperatures were suprisingly low compared to the grid temperature of 537.7°C (1000°F) during the cleaning cycle; however, the proximity of the handle to the grid would not allow an operator to grasp the handle during, or shortly after, the cleaning cycle. Extreme caution should be taken during the cleaning cycle because of the high temperatures.

d. Grease Temperature During Use. The maximum temperature of the grease in the grease drawer during four hours of operation at the "HI" setting was approximately the same as the grease temperature taken during the cleaning cycle. There was no splattering or burning of the grease in the grease drawers and drip chutes.

5. Food Production

a. Procedures

(1) Hamburger Patties. Hamburger patties used for this evaluation were 85.05-gm (3-oz.), .635-cm (1/4-in.) thick ground beef with a maximum fat content of 22% conforming to Military Specification MIL-B-3854. Some patties had a 1.67°C (35°F) to 4.44°C (40°F) temperature prior to starting the test and some were partially frozen in the center.

(a) Cooking Time. A series of three evaluations were conducted broiling 8 hamburgers (4 each grid section) for each evaluation to determine if the manufacturer's specified cooking time of 1 1/2 minutes per side of patty was correct.

(b) Production Output. Maximum output runs were conducted by a non-skilled cook. Two sustained runs of 28 patties per run were made and the time recorded from the placing of the first patty on the broiler grids to the time the last patty on the second run was removed from the grids.

(c) Yield. Five loads of 10 patties each were run and the yield rates were calculated.

(d) Grease Drippings. Sixteen and one half (16.5) kg (3o 1/2 lbs) of patties were broiled and the grease drippings in the grease drawers were weighed.

(2) Pork Sausage Links. Pork sausage links used for this evaluation were a non-issue type packaged by the USAF Commissary, Hanscom AFB. Links weighed 70.85 gm (2 1/2 oz.) and measured 10.16 cm (4 in.) long by 3.18 cm (1 1/4 in.) diameter. Internal starting temperature varied from 3.33°C (38°F) to 8.89°C (48°F).

(a) Cooking Time and Yield. Three tests using four sausages each (two on each grid section) were conducted to determine the best thermostat setting and cooking time. Eleven pounds of sausage links were broiled with the thermostat dial set midway between the "HI" and "LO" settings and the sausage cooking time, cooked yield, and fat drippage were noted.

(3) Frankfurters. Frankfurters used for this evaluation were Nepco brand, all-beef, skinless, 10-count per pound. Product starting temperature was between 6.67°C (44°F) and 8.89°C (48°F). Six rows of frankfurters, (14 per row) weighing 3.8 kg (8.4 lbs) were broiled to determine cooking time.

(4) Chicken. Chicken used for this evaluation was Country Cousin brand, frozen fryers, weighing approximately 1.45 Kg (3.2 lbs) each. Melted butter and Armed Forces Recipe No. L61-barbecue sauce were spread over the product to develop a large residue of burned particles on the broiler unit to test the self-cleaning cycle. Six and eighty-five hundredths (6.85) kg (15 lbs) of product were cooked, and cooking time and product appearance were noted.

(5) Steaks. Steaks used for this evaluation were military issue, 6-way beef, type 4 loin strip, weighing between 170.10 gm (6 oz.) and 198.45 gm (7 oz.). Product starting temperature was between 4.44°C (40°F) and 8.89°C (48°F). Several steaks were prepared to determine the best thermostat setting and cooking time, then four rows of six steaks each were char-broiled at one time. The right grid control was set at "HI" preparing medium rare steaks, and the left grid control was set approximately 1/3 of the distance between "LO" and "HI" for medium steaks.

6. Food Production Findings

a. Hamburger Patties

(1) Cooking Time. Hamburger cooking time was 1 1/2 minutes per side for thawed patties and verified the manufacturer's statement, however partially frozen patties required up to 30 seconds longer total time.

(2) Production Output. The total elapsed time from the placing of the first of the 28 patties on the grids to when the last patty was removed was 7 minutes and 45 seconds. Using this time as a basis, an hourly output of approximately 420 patties or 28 patties every 4 minutes could be attained. Time consumed for loading, turning, and removing patties was approximately 40 seconds.

(3) Yield. The yield rate for the 5 loads of 10 patties each ranged from 73.7% to 75.8%.

(4) Grease Drippings. Grease drippings from the 16.45 kg (36 1/2 lbs) of patties was extremely low measuring only 119.5 gm (4 1/2 oz.).

(5) Product Appearance and Taste. Appearance of the cooked hamburgers was excellent. Wide charred strips were evident on both sides while very few blood bubbles were noticeable. The product was juicy and tasty. General comments from personnel sampling the hamburgers were most favorable as compared to hamburgers prepared on conveyor broilers previously tested.

b. Pork Sausage Links. A setting of midway between "HI" and "LO" and a cooking time of 15 minutes, turning every 5 minutes was determined to be ideal. Fifteen minutes cooking time gave an internal temperature between 76.67°C (170°F) and 81.11°C (178°F). Cooked yield was 65% and very little fat was noticed in the grease drawers. Appearance of the cooked product was excellent and was juicy and flavorful. Some difficulty was encountered while turning this shaped product.

c. Frankfurters. A broiling time of 9 1/2 minutes was determined as the best cooking time and the product had an internal temperature between 71.11°C (160°F) and 76.67°C (170°F). Product appearance and taste were excellent.

d. Chicken. The product was tasty but appearance was poor and required approximately 40 minutes of constant monitoring. The preparation of such a product is not practical for quantity preparation in military feeding facilities. A large residue did accumulate on the grids but one cleaning cycle properly burned off this buildup. Although the drip pans were cleaned prior to start of the cleaning cycle, additional fat and residue dripped from the grids and burned into the drip pans requiring overnight soaking.

e. Steaks. The following thermostat settings and cooking times were found to be best for this product:

Rare - 2 1/2 to 3 minutes per side on "HI" setting.
Medium rare - 3 to 3 1/2 minutes per side on "HI" setting.
Medium - 5 to 6 minutes per side at 1/3 distance between "LO" and "HI" setting.
Well done - 6 to 8 minutes per side at midpoint between "LO" and "HI" setting.

The quality and appearance of the product were excellent.

7. Conclusions

The char-broiler is considered acceptable for use in DoD Food Service Facilities and cooks hamburgers, frankfurters, sausages, and steaks to a high degree of acceptability. Hamburger cooking time is reduced by one-half over conventional grilling, while the other products require less than average time to cook when compared to conventional grilling and other equipment previously evaluated.

The following specific conclusions/comments are offered with respect to design, sanitation, safety, and versatility: Specific temperature settings marked on the thermostat dials would increase ease of operation. There is insufficient space for cleaning between the back end of the grids and the rear connection and between the front end of the grids and the handles. The use of aluminum foil to cover the drip pans prior to "self-cleaning" the grids will increase ease of cleaning drip pans. The broiler has National Sanitation Foundation (NSF) approval. The addition of a removable grill top in either one or two sections would allow the broiler to be used in the preparation of eggs, hot cakes, and other grilled products thus increasing versatility. The use of a grill top could eliminate the need for a separate griddle, especially in small kitchens where space is a major consideration. The broiler reaches a preheat temperature of 343.3°C (650°F) in 15 minutes instead of the 11 minutes stated in the manufacturer's literature. Broiler design is considered safe and all controls and signal lights function as intended. The unit does bear the Underwriters' Laboratories (UL) Seal of Approval and no electrical problems were encountered during the evaluation.