# INDOOR AIR QUALITY: RESIDENTIAL COOKING EXPOSURES

## FINAL REPORT

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## ABSTRACT

A study was performed in a Test House in California to collect data that will provide a better understanding of the impact of residential cooking activities on exposure to particles and gaseous Toxic Air Contaminants. Particulate matter (PM), carbon monoxide (CO), nitric oxide (NO), nitrogen dioxide ($NO_2$), polycyclic aromatic hydrocarbons (PAHs), elements, and aldehydes were measured. Thirty-two tests were performed to measure the impact of cooking during typical cooking activities with gas and electric ranges and to evaluate variables that might impact emissions. The study also included tests of worst-case cooking conditions and of potential exposure reduction methods. The study demonstrated that cooking can produce high concentrations of particles and gases. $PM_{2.5}$ concentrations were over 1000 $\mu g/m^3$ during stovetop stir-frying, frying of tortillas in oil on the range top burner, and baking lasagna in the gas oven. $PM_{10}$ concentrations measured in the kitchen, living room, and bedroom ranged from below the detection limit to 3660 $\mu g/m^3$ in the 32 tests. Combustion pollutants were elevated in the house primarily during use of the gas range. CO concentrations during cooking periods were generally less than 4 ppm, but exceeded 9 ppm during preparation of a full meal and during oven cleaning. $NO_2$ concentrations were greater than 50 ppb during some tests with the gas range and averaged 400 ppb during the 5-hr oven cleaning test, exceeding the ARB Indoor Air Quality (IAQ) Guideline of 250 ppb over one hour, and representing a significant source of exposure. Formaldehyde concentrations exceeded the ARB action level of 0.1 ppm (124 $\mu g/m^3$) during oven cleaning and broiling of fish. Several PAH compounds were found in the fresh cooking oils used in the study, but the concentrations were low in the house during cooking. The data, however, suggest that additional study is warranted to fully evaluate the impact of cooking on PAH exposure. The results of the study demonstrated the significance of cooking as a source of exposure to particles and Toxic Air Contaminants. Because of the high variability of the emissions during cooking, it was difficult, however, to quantitatively determine the impact of variables such as food type, cooking method, pan material, or the impact of simple exposure reduction methods.

# EXECUTIVE SUMMARY

## Background

Cooking has been identified as a potentially significant source of indoor air pollution and personal exposure to Toxic Air Contaminants. Results of a number studies suggest that cooking may be a major source of exposure to particulate matter (PM), combustion pollutants, polycyclic aromatic hydrocarbons (PAHs), and other organic compounds. Epidemiological studies have found significant associations between increased respiratory symptoms and the presence of, or cooking with, a gas range. Despite the recognition that cooking may be an important source of air contaminants in residential dwellings, emissions from cooking and the resultant exposures have not been well characterized.

The current study was performed for the California Air Resources Board (ARB) to gain a better understanding of the impact of cooking on indoor air concentrations and personal exposures to air contaminants generated by cooking in residences. This study represents the first large-scale study of cooking emissions and the resultant exposures in a residential setting under semi-controlled conditions. The study included thirty-two cooking tests with a variety of cooking methods and foods. It addressed various factors that may impact emissions from cooking and evaluated simple exposure reduction methods.

## Methods

To meet the study objectives, a test house was rented in Rohnert Park, California. The house was a small single-story ranch style home constructed in the 1970s. The small size of the house (less than 1000 $ft^2$) and the layout of the rooms, consisting of a kitchen, adjacent living room, and three bedrooms, resulted in good air mixing in the house even though the house air handler was not operated during testing. The house had an attached garage where a laboratory was set up. The test house was instrumented for the following measurements:

- CO, NO, and $NO_2$ with continuous pollutant monitors,
- Real-time PM concentrations and size distributions (12 size fractions from 0.04 to 8.4 μm, aerodynamic mean diameter) with an electrical low pressure impactor (ELPI) that recorded data continuously,
- $PM_{2.5}$ and $PM_{10}$ mass, collected on Teflon® filters with size selective inlets,
- Air exchange rates,
- Temperature and relative humidity (RH) indoors and outdoors,
- Range top burner and oven temperatures,
- Gas or electric use during cooking, and
- PAHs, elements, and aldehydes, in a subset of tests.

Following a pre-test and refinement of the study design and test protocols, a main study was performed that consisted of 32 cooking tests at the test house. The tests involved cooking with an electric range, gas range, and microwave oven. The electric range was used for seven cooking tests. These same seven cooking activities were performed with the gas range for comparison.

The microwave was used in three tests to compare emissions with the gas and electric ranges. All other tests were performed with the gas range.

Realistic cooking activities were performed during the study. They involved cooking activities such as stovetop stir-frying on the range top burner, frying tortillas in oil, broiling fish in the oven, and baking a pre-packaged frozen lasagna in the oven. The amount of food cooked was larger than would be typical in a residential setting, and the duration of cooking was generally longer than typical in order to obtain sufficient pollutant mass for analysis.

## Results

Average $PM_{2.5}$ mass concentrations in the kitchen, living room, and bedroom ranged from 2.9 to 3,880 $\mu g/m^3$ during 32 cooking tests. $PM_{10}$ concentrations ranged from 0.4 to 3660 $\mu g/m^3$. Indoor concentrations during cooking were substantially higher than the outdoor concentrations, which ranged from 0.6 to 13.6 $\mu g/m^3$ during the study. The highest concentrations occurred during operation of the self-cleaning feature of an intentionally dirtied gas oven. During routine cooking, the concentrations of $PM_{2.5}$ were over 1000 $\mu g/m^3$ during stovetop stir-frying, frying of tortillas in oil on the range top burner, and baking lasagna in the gas oven. Continuous, real-time PM measurements with an electrical low-pressure impactor (ELPI) showed that the particles emitted during cooking were primarily in the size fractions of less than 1 $\mu m$.

The median and average $PM_{2.5}$ concentrations during the six standard (typical) cooking tests, which ranged from approximately 1.5 to 5 hours in duration, exceeded the pending Federal National Ambient Air Quality Standard (NAAQS) of 65 $\mu g/m^3$ (24 hour average). The median and average $PM_{10}$ concentrations exceeded the ARB IAQ Guideline of 50 $\mu g/m^3$ over 24 hours. The data indicated that cooking can be a significant source of exposure to PM.

Element concentrations measured in indoor air $PM_{10}$ samples during the cooking tests exceeded outdoor concentrations for most elements. Of potential importance were elevated concentrations of chromium, titanium, nickel, and zinc during the oven self-cleaning tests. Due to the short test periods and low mass levels in the samples, element measurements were below the method detection limit in many samples.

As expected, combustion pollutants were elevated in the house primarily during use of the gas range. Average CO concentrations during cooking periods were generally less than 4 ppm, although concentrations higher than 9 ppm were measured during preparation of a full meal and during oven cleaning. $NO_2$ concentrations were greater than 50 ppb during four of six standard cooking tests with the gas range and averaged over 400 ppb in all three rooms during the 5-hr oven cleaning test, exceeding the ARB IAQ Guideline of 250 ppb (1 hour).

A number of PAHs, which ARB has identified as Toxic Air Contaminants under the grouping of Polycyclic Organic Matter, were identified by gas chromatography/mass spectrometry analyses of bulk samples of cooking oils used in the study. During cooking tests with these oils, PAHs were measured in air samples collected in the kitchen. However, there was not a clear relationship between the presence of PAHs in the oils and the concentrations of the PAHs in the air samples. The concentrations of PAHs in the air samples collected in the kitchen during the

cooking tests were within the range of concentrations measured in other indoor air studies. The indoor concentrations were generally higher than concurrent outdoor concentrations indicating that cooking was a source of PAHs. The data suggest that additional testing and analyses are warranted to more fully evaluate the impact of cooking on exposure to PAHs.

Formaldehyde and acetaldehyde, Toxic Air Contaminants identified by the ARB, were present in air samples collected during oven cleaning, broiling fish, and oven pork roast tests. During the 5-hr oven cleaning tests, the formaldehyde concentrations of 417 and 224 $\mu g/m^3$ with the gas and electric ranges, respectively, substantially exceeded the Acute Reference Exposure Level (REL) of 94 $\mu g/m^3$ (1 hour) (OEHHA, 1999) and the Action Level of 0.10 ppm (124 $\mu g/m^3$) from the ARB IAQ Guideline (CARB, 1991). During the broiling fish test, the formaldehyde concentration of 129 $\mu g/m^3$ also exceeded the action level. Acetaldehyde concentrations of 434 and 92 $\mu g/m^3$ were measured during oven cleaning and fish broiling tests with the gas range. Although the aldehyde measurements were limited in scope, they indicated that cooking might have a significant impact on aldehyde exposures.

Oven cleaning resulted in the highest concentrations of the measured air contaminants in the house during the study. Of the six standard cooking tests performed with both the gas and electric range, the highest emissions of PM occurred during frying of tortillas in oil on the electric range and baking a frozen lasagna in the gas oven. Broiling fish also produced high PM emissions.

In worst-case tests that involved realistic activities such as heating cooking oils too hot or slightly burning food, indoor air concentrations and emission rates were generally higher than in the standard tests. With the exception of the oven-cleaning tests, the highest PM concentrations were measured during the worst-case stovetop stir-frying test.

The impact of variables such as type of cooking method, type of food, or pan material could not be determined quantitatively in this study. The concentrations of the air contaminants measured in the rooms and the emission rates calculated with the mass balance model were too variable to determine the significance of differences between different cooking activities. Adjusting the emission rates for the food mass lost or the energy used during cooking did not change the observed trends.

Tests with the microwave demonstrated that emissions of PM and combustion pollutants were lowest with this cooking method. It was the most effective exposure reduction method evaluated in the study. Tests with the range hood exhaust and range hood side shields resulted in lower concentrations of some of the air contaminants, but there was not a dramatic reduction in indoor air pollutant concentrations.

## Conclusions

The data collected in the study successfully addressed the project objectives. The results provide a better understanding of the impact of cooking on indoor air pollutant concentrations and exposure. The data indicated that cooking is a significant, although highly variable, source of PM indoors. Exposure to PM due to cooking may be substantial for many individuals, depending on the amount of cooking that is done and the duration of time spent in the home following cooking. With a gas range, exposure to CO and $NO_2$ is increased substantially.

Oven cleaning was identified as the most significant source of emissions of PM, CO, NO, $NO_2$, formaldehyde, and acetaldehyde. Data from the oven cleaning tests suggest that guidance should be developed to help reduce exposure to air contaminants during operation of the self-cleaning feature of gas and electric ovens.

The results of the study cannot be used to quantitatively assess the impact of different types of cooking methods, different foods, or other parameters related to cooking methods and utensils due to the high variability in the emissions. To evaluate the impact of these parameters, a much larger number of tests would need to be performed. These tests could be performed under highly controlled conditions in environment test chambers or in field studies under realistic cooking conditions.

The results of the study suggest that additional research is warranted to more fully characterize the impact of cooking on exposure to Toxic Air Contaminants, such as PAHs and aldehydes and to evaluate exposure reduction techniques under realistic conditions in residences.

# 1.0 INTRODUCTION

## 1.1 Background

The California Air Resources Board (ARB) Indoor Air Quality and Personal Exposure Assessment Program is working to identify and reduce Californian's indoor and personal exposure to air pollutants. To meet this goal, the ARB requires data on emissions from various air pollutant sources and the resultant personal exposure and indoor air concentrations in selected microenvironments. Data collected by the ARB can be used to improve estimates of human exposure to selected Toxic Air Contaminants in a variety of microenvironments and to develop guidance for Californians to help them reduce their exposure to air contaminants.

Various studies have identified cooking as a potentially significant source of indoor air pollution and personal exposures. Cooking has been reported to be a major source of particulate matter (PM), polycyclic aromatic hydrocarbons (PAHs), and other organic compounds in ambient air due to emissions from commercial cooking operations (Rogge et al., 1991; Schauer et al., 1998; and Schauer et al., 1996). Cooking has also been identified as a significant source of PM in residential dwellings (Brauer et al., 2000; Brauer et al., 1996; Ozkaynak et al., 1996; Ross et al., 1999; Wallace, 1998, 1996a, and 1996b). PAHs have been reported in fumes from cooking oils (Chiang et al., 1997; Shields et al., 1995; Shuguang et al., 1994; and Wu et al., 1998). Measurements in residences have shown increases in levels of PAHs associated with cooking (Chuang et al., 1991; Dubowsky et al., 1999; and Sheldon et al., 1993). Air contaminants may be emitted from the cooking appliance (Rogge et al., 1993; Rogge et al., 1997) and the cooking process (Annis and Annis, 1989; Rogge et al., 1991; Gerstler et al., 1998). Epidemiological studies have found significant associations between increased respiratory symptoms and the presence of, or cooking with, a gas range (Pope et al., 1995; Zhong et al., 1999).

Despite the recognition that cooking may be an important source of air contaminants in residential dwellings, emissions from cooking and the resultant exposures have not been well characterized. To meet its goals, the ARB required data to gain a better understanding of the impact of cooking on indoor air concentrations and personal exposures to air contaminants generated by cooking in residences. The current study was initiated to address those data needs. The ARB developed a design for a study to collect data on pollutant emissions and exposures from a wide range of cooking activities. The study objectives and design are described below. The current study represents the first large-scale study of various cooking emissions and exposures in a residential setting under semi-controlled conditions. Results from the study will provide a better understanding of the impact of cooking and will be useful for developing further research in this area of exposure.

## 1.2 Study Objectives

The goal of the project was to characterize the pollutant emissions and the potential human exposure impact from a range of residential cooking activities. The specific objectives of the project were the following:

- Characterize emission rates and resultant indoor air concentrations and personal exposures for particulate matter (PM), carbon monoxide (CO), nitric oxide (NO), and nitrogen dioxide ($NO_2$) produced by residential cooking under typical and realistic worst-case conditions
- Characterize emission rates and resultant indoor air concentrations for other cooking pollutants such as PAHs, elements, and other potential marker compounds
- Measure the effectiveness of selected exposure reduction practices

## 1.3 Study Design and Project Overview

The project objectives were addressed in an original study design submitted to the ARB in the ARCADIS Geraghty & Miller (ARCADIS) Technical Proposal. The plan was subsequently refined in consultation with ARB staff and members of a Technical Review Group (TRG, listed in Appendix B) that was formed to provide technical input to the study. The study design is outlined in the *Revised Study Design and Test Plan for Indoor Air Quality: Residential Cooking Exposures*, dated November 12, 1998. The project consisted of the following ten tasks:

- Task 1 – Review the literature and study design
- Task 2 – Meet and consult with the Technical Review Group and the ARB to finalize the study design
- Task 3 – Obtain a Test House in California where the tests will be performed
- Task 4 – Prepare the Test House for the study and perform a pre-test
- Task 5 – Conduct testing of cooking activities
- Task 6 – Test exposure reduction methods
- Task 7 – Perform data processing and analysis
- Task 8 – Prepare draft final report
- Task 9 – Prepare final report
- Task 10 – Present project seminar

A literature review was performed at the start of the project in an attempt to identify additional information that could be used to refine the study design, test protocols, or measurement methods. The ARB had already performed a literature review and identified the major peer-reviewed literature on the subject in their request for proposal. The literature review was performed using both computerized and manual search methods. At the time of the review (Fall, 1998), there was little information identified by ARCADIS beyond that already identified by the ARB. The bibliography for the literature review is included as Appendix A of the report.

The literature review did not result in any significant changes to the study design. Minor modifications were made to the study design based on discussions with the TRG and ARB staff. These modifications were incorporated in the study design referenced above. The following is a brief overview of the project. More detailed information is presented in the following sections of the report.

A test house was rented in Rohnert Park, California for the study. The house was a small single-story ranch style home constructed in the 1970s. It met a large number of the criteria for selection of the test house, as described in Section 2.0. The small size of the house (less than 1000 $ft^2$) and the layout of the rooms resulted in good air mixing in the house even though the house air handler was not operated during testing. The house had an attached garage where a laboratory was located. The test house was specially instrumented for the study. Temperature and relative humidity (RH) sensors were placed in selected rooms and outdoors. Temperature sensors, a power transducer, and a dry gas meter were installed on the ranges to collect data during cooking tests. Teflon® sampling lines were routed to the kitchen (K), living room (LR), master bedroom (MBR), and outdoors (OA) for collection of air contaminants. A second set of sampling lines was routed to the same rooms for collection of $SF_6$, the tracer gas measured to calculate air exchange rates. A laboratory was set up in the garage with pollutant monitoring instrumentation, a data acquisition system, and support hardware for instrument calibrations.

A pre-test was performed in May 1999 to test the instrumentation, sampling methods, and test protocols. The pre-test involved initial measurements of CO, NO, and $NO_2$ to characterize the performance of the gas range before and after tuning. The methods and results for the tuning are included in Appendix D.

Four cooking tests were then performed. Duplicate tests were performed that involved frying loose ground beef in a pan on the range top burner. A second set of duplicate tests was performed that involved preparation of a pork roast in the oven of the gas range. Results of the pre-test are summarized below and included in an electronic database accompanying the report.

The main cooking study was performed in February 2000, when the temperatures were moderate, to avoid the need for operation of an air conditioner during the cooking tests. The main study involved 32 cooking tests at the house in Rohnert Park. The tests involved cooking with an electric range, gas range, and microwave oven. The microwave was used in three of the tests and measurements were performed only with real-time monitoring methods (continuous monitors for CO, NO, $NO_2$ and PM). The electric range was used for seven cooking tests. These same seven cooking activities were performed with the gas range for comparison. All other tests were performed with the gas range. Parameters measured during all tests, except with the microwave, included the following:

- CO, NO, and $NO_2$ with continuous pollutant monitors
- PM concentrations and size distributions (12 size fractions from 0.04 to 8.4 μm, aerodynamic mean diameter) with an electrical low pressure impactor (ELPI) that recorded data continuously
- $PM_{2.5}$ and $PM_{10}$ mass, collected on Teflon® filters with size selective inlets,
- Air exchange rates
- Temperature and RH indoors and outdoors
- Range top burner and oven temperatures
- Gas or electric use during cooking

During selected tests, additional samples were collected for other air contaminants. These included samples for PAHs, elements, and aldehydes. Although fatty acids were originally proposed for measurement during the project, they were dropped from the main study. Samples were collected for aldehyde measurements instead because results from other studies (Theibaud et al., 1994, Schauer et al., 1998 and Kelly, 2000) suggested that cooking with the oven and broiler resulted in substantial emissions of carbonyl compounds.

The 32 tests were designed to collect information on the following factors:

- Appliance type (gas, electric, and microwave)
- Cooking method (frying, baking, broiling, range-top burner, oven)
- Food type (variety of foods cooked)
- Cooking vessel (pan material, lids)
- Exposure reduction methods (exhaust fan, hood shields)

## 1.4 Pre-Test Summary

The pre-test involved a set of four tests during which all measurements were performed and samples were collected for all target parameters. The tests, which involved relatively short duration cooking events, were designed to determine the performance of the sampling and analytical methods. The tests were performed in duplicate to assess the variability and method precision. The results of the pre-test are presented in the electronic database accompanying the report. Results of the pre-test and issues identified in the pre-test included the following:

- $PM_{2.5}$ mass concentrations ranged from below the minimum detection limit (MDL) in one outdoor sample to 1040 $\mu g/m^3$ in the kitchen during one of the tests with pan frying of loose ground beef
- $PM_{10}$ mass concentrations ranged from 9.9 to 11.8 $\mu g/m^3$ outdoors and 25 to 144 $\mu g/m^3$ indoors during the four cooking tests
- Results of the pre-tests indicated that the cooking protocol should be changed to increase the amount of PM mass that could be collected by the integrated sampling methods. The average mass of PM on the filters for all samples collected during the pre-test was only 100 $\mu g$. Mass on the filter samples collected outdoors was near the limit of detection due to the short sampling periods. This was because the cooking period for pan-frying of ground beef lasted only 20 minutes, and the total exposure duration during which the samples were collected was only 2 hours long. Although the sampling period was longer for the pork roast in the oven (4.3 hours), the total mass collected was still low because of the lower emissions during this cooking activity.
- Real-time measurements of particle concentrations in the 12 size fractions with the ELPI indicated that the particles were predominantly in the smaller size fractions (less than 0.5 $\mu m$). This observation suggested that additional measurement methods, such as a scanning mobility particle sizer (SMPS), would be required to characterize the particle size distribution. An SMPS was not available for the study, and the ELPI represented the best single piece of instrumentation for measurements over a wide range of particle sizes.

- PAH concentrations were low and below the limit of detection in many of the samples. Few compounds were detected in samples collected during the short beef pan-frying tests. PAH levels were generally higher indoors than outdoors. PAH concentrations in the living room were not substantially different from those in the kitchen, suggesting that sampling should be limited to the kitchen. Precision was poor for duplicate samples. The poor precision and large number of samples with non-detectable PAHs suggested that the cooking periods and sampling durations should be longer.
- The elements measured by X-ray fluorescence (XRF) in $PM_{10}$ samples were typical of ambient air particles, predominantly comprised of silicon, aluminum, sulfur, calcium, and iron. Chlorine was also detected frequently at this location, which was near the ocean. Although copper and zinc were detected in over two-thirds of the samples, there was no clear trend of higher indoor concentrations. Due to low mass levels on the filters, there was poor precision for the duplicates. As for the other parameters measured by collection of integrated samples, the data suggested that the data quality would be improved if cooking protocols were modified to facilitate collection of higher levels of PM mass.
- CO, NO, and $NO_2$ emissions were consistent with published results for gas ranges
- Indoor temperatures in the house ranged from 17.0 to 26.8 °C. Indoor relative humidity during the pretest ranged from 32.4 to 61.7%. Air exchange rates ranged from 0.31 to 1.07 air changes per hour

Results from the pre-test were used to refine the study design. The primary change was to develop cooking protocols that incorporated either cooking of multiple batches of food during a single cooking event or performing two sequential cooking events during which a single set of integrated air samples were collected.

## 2.0 MATERIALS AND METHODS

### 2.1 Overview

The test house was procured for use in April 1999 and configured for use in the study. Teflon® sampling lines were routed from the attached garage laboratory to the house for collection of gaseous pollutants (CO, NO, and $NO_2$). A second set of polypropylene sampling lines was installed for collection of the $SF_6$ that was measured to calculate air exchange rates. The sampling lines were approximately 15 m long. Signal lines were routed from the laboratory to the house for collection of data from the room temperature sensors, RH probes, thermocouples, and the power transducer. Lines were also routed for collection of outdoor temperature and RH. Pollutant monitors, the data acquisition system (DAS), and support hardware were set up in the garage laboratory.

Following set up and calibration of the instrumentation, testing began in the house. A used gas range was procured for the study, and a gas line was installed for the range. An electric range was also procured because the one in the house when rented did not have a self-cleaning feature. Preliminary measurements were performed to validate performance of the monitoring instrumentation. Air exchange rates were measured over a few days to validate performance of the method. The pollutant monitors were operated to measure background CO, NO, and $NO_2$ concentrations indoors and outdoors. Tests were then performed to measure baseline CO, NO, and $NO_2$ concentrations during operation of the gas range top burner and the oven without food cooking. Following the initial measurements, adjustments were made to the gas range burners, and additional measurements were performed.

The pre-test was performed in May 1999. It involved measurements of all parameters during two types of cooking activities – frying of loose ground beef in an un-covered pan on the gas range top burner and baking a pork roast in the gas oven. Both types of cooking were performed in duplicate in order to evaluate the variability between tests. Duplicate samples were collected during the tests to determine method precision. Results of the tests were used to refine the study design.

The main study was performed in February 2000. Thirty-two cooking tests were performed. Additional tests were performed to measure baseline concentrations of pollutants generated by the gas range top burner and the oven. The following sub-sections describe the main study.

### 2.2 Description of the Test House and Appliances

A test house was rented in Rohnert Park, California for use in the project. Rohnert Park, located approximately 60 miles north of San Francisco and 20 miles from the Pacific Ocean has a relatively moderate climate. During February and March 2000, while the tests in the main study were being performed, the average high temperatures were 61.6 °F (16.4 °C) and 64.4 °F (18 °C), respectively. Average lows were 40.2 and 41.4 °F (4.6 and 5.3 °C), respectively for February and March 2000. The average heating degree-days for February is 15 (base 65 °F) for the years 1931 to 2000.

The house, built in 1983, was a single story ranch style home on a crawl space. The floor plan of the house is depicted in Figure 2-1, which also depicts the sampling locations in the kitchen, living room, and master bedroom. The front elevation of the house is depicted in Figure 2-2. There were a number of criteria defined for selection of the house including the following:

- Single family residence of typical California construction
- Built after 1988
- Two to three bedrooms
- Single story
- Floor area of 1300 to 2000 $ft^2$
- Double glazed windows and adequate insulation to have air exchange rates representative of California residences
- Central heating and air conditioning system
- Located in moderate climate (to minimize the need for operating the heating or air conditioning system during testing
- Located in a residential area away from major industrial sources of PM and SVOC contaminants
- No fugitive dust sources nearby (gravel driveways or roadways)
- Located at least one mile away from establishments that emit cooking fumes,
- Range top exhaust that vents to outdoors
- Attached garage (to facilitate set up of the laboratory)

Figure 2-1. Floor Plan of the Test House (Not to Scale)

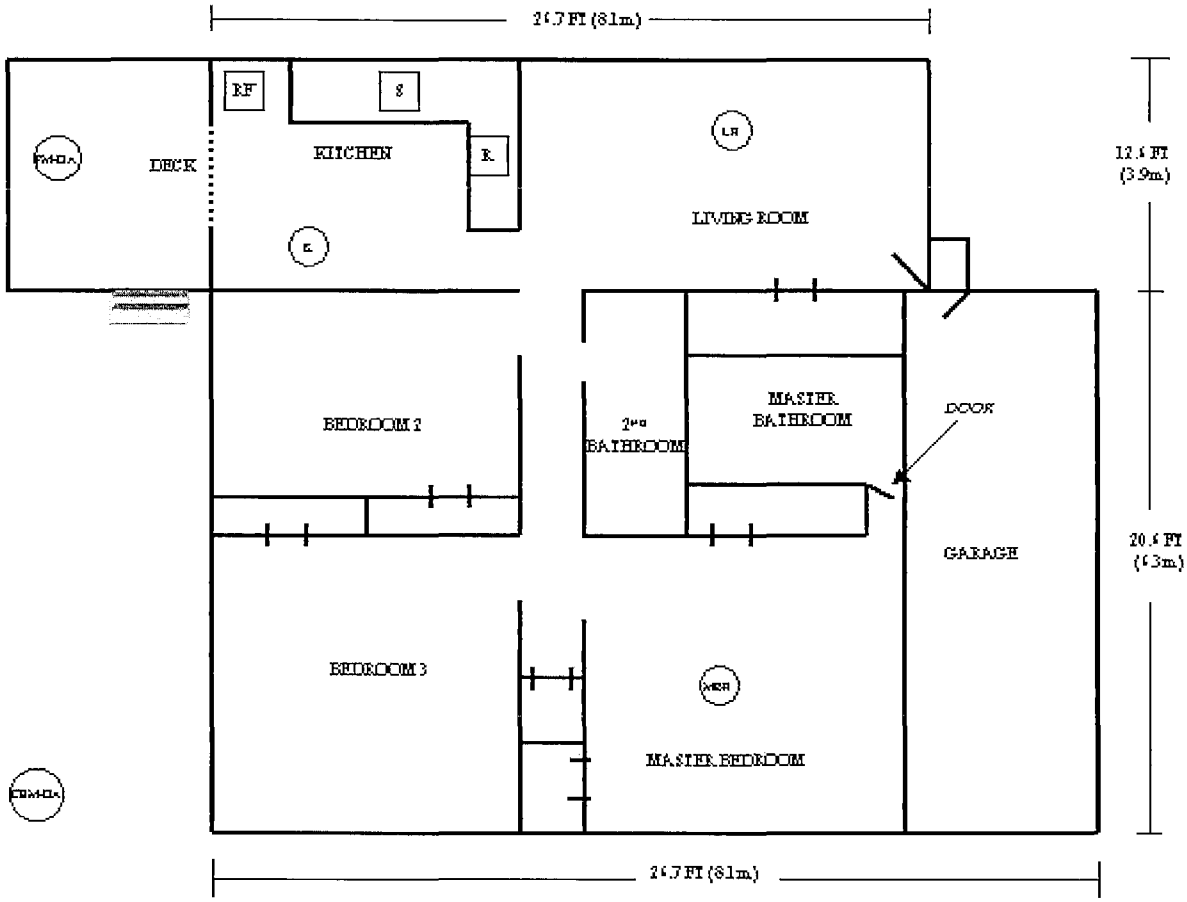


Figure 2-2. Front Elevation of the Test House

Many of the criteria were met. However, some criteria were not met due to difficulty finding a rental home at the time that the study was performed. At the time of the study, there was an extremely limited rental home market in the area selected for the study. It was necessary to locate the test house in an area with a relatively moderate climate because the intention was not to operate a ducted heating and cooling system while tests were being performed. Operation of an air handler would likely result in substantial particle loss in the ductwork. There was difficulty finding homes that could meet the selection criteria. There was also reluctance by landlords to rent a house for a one-year period for use as a test house. As a result of these complications, the search for an appropriate house that would meet the criteria lasted over five months.

The house that was rented was a single story home typical of California housing stock, but it was somewhat older and smaller than desired. The best available information is that it was built in 1983. The house had a floor area of 824 $ft^2$ (76.56 $m^2$) and a volume of 187 $m^3$. The size of the house was smaller than the original selection criterion. The rental company advised us that the house had a floor area of approximately 1100 $ft^2$, which turned out to be incorrect. However, as the data indicate, the small size and the layout of the house apparently resulted in good air mixing and relatively uniform air contaminant concentrations in the different rooms, most likely improving the accuracy of the source emission rate calculations. The house had three bedrooms, a living room, and kitchen separated by walls from the other rooms in the house (Figure 2-1). It had central heating, but no air conditioning. The furnace was fitted with a standard disposable high performance filter that was replaced at the start of the tests. The air exchange rate measurements showed that the house was relatively well insulated and sealed. Air exchange rates measured in

February 2000 ranged from 0.18 to 1.08 $hr^{-1}$ and were typically 0.22 to 0.30 $hr^{-1}$ (Table 3-25, Section 3). The range hood exhaust was vented to the outdoors. There were no major sources of particles from cooking activities located near the house. There was some wood burning in the residential neighborhood during the period of the main study.

The house was minimally furnished. There was a refrigerator in the kitchen, which was operating during the study. The furnishings in the adjacent living room consisted of an upholstered couch, upholstered loveseat, plastic chairs, and a coffee table. There were beds, but no dressers in two of the three bedrooms. There were plastic vertical blinds on all windows, but no curtains. The entire house, except for the bathrooms and kitchen, was carpeted. Therefore, although minimally furnished, there was a fairly substantial amount of surface area that could serve as reversible or non-reversible "sinks" for deposition of gaseous and particulate air contaminants. Plastic runners were placed over carpets in the main walkways of the living room and hallway in order to minimize particle resuspension by the technicians.

The house was equipped with an electric range when rented, but the oven did not include a self-cleaning feature. Therefore, a used electric range was obtained from a local appliance dealer. Gas piping was installed to the kitchen, and a gas range was purchased for the study. A microwave was also rented. All appliances were used and were at least five years old. The appliances were typical of those that would be found in a rental home of this size and age. All cooking appliances were cleaned prior to the start of testing. The only available information on the appliances was the following:

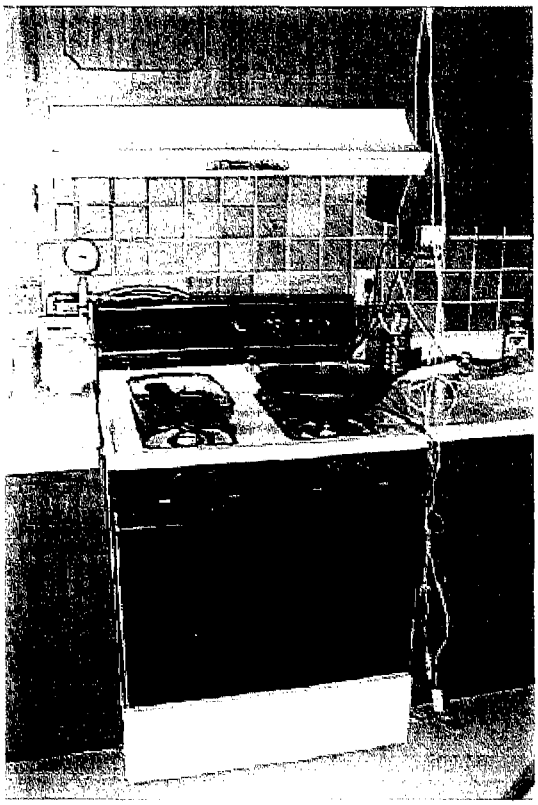
- Magic Chef Gas Range with self-cleaning oven, broiler in oven, and 4 equal-size, stovetop burners, Model # 34428RA (Figure 2-3). The right front burner was used for all range top burner tests. All of the burners were used in the full meal-cooking test.
- Whirlpool Electric Range with self-cleaning oven, 2 large burners, 2 small burners, Model No. RF385PXPW, Serial No. F62602406. The right front burner was used for all tests.
- Quasar Microwave Oven, Model No. MQ5540WW, Serial No. NM33409260, manufacture date of Dec. 1993, Output Frequency = 2450 MHz, Input = 110 volts, 13 amps.

During the main study, the main gas valve on the gas range failed after the first four tests. The valve was replaced. No other adjustments or changes were made to the gas range. The change of the valve did not impact the performance of the gas range top burners or oven.

A limited number of cooking utensils were purchased from local retail outlets in Rohnert Park, CA. They consisted of the following:

- Frying pan – Ecko Endura. 12-inch diameter, non-stick stainless steel skillet
- Baking dish – Pyrex, 9-in X 12-in
- Baking pan – Disposable aluminum baking pan, 8-in X 11-in
- Deep fat frying – Cast iron pan with aluminum frying basket (for French fries)
- Stir-frying–wok, carbon steel, 12 in. diameter
- Vegetable steaming and water boiling – 4 quart stainless steel steamers

Figure 2-3. Test House Gas Range and Cooking Utensils



## 2.3 Description of the Tests and Cooking Protocols

The main study consisted of the 32 cooking tests listed in Table 2-1. The tests involved cooking with a gas range, electric range, and microwave oven. Tests were performed to measure emissions for a variety of types of cooking, including frying of foods on the range top burners, broiling foods in the oven, and cooking meat in the oven. The tests addressed emissions from cooking of a variety of foods.

During the development of the study design, an attempt was made to obtain data on the predominant food types and cooking methods used in California. Population-based surveys of cooking method frequencies in California or the U.S. were not publicly available. Data on the dietary intake of the U.S. population is available from The U.S. Department of Agriculture (USDA) Continuing Survey of Food Intake of Individuals (CSFII) studies (USDA, 2000). But data on the dietary intake of Californians would be difficult to obtain from the CSFII database cost-effectively and within the time frame of this study. The CSFII studies show that beef, pork, and chicken are the most commonly consumed meats, and that vegetable and seed oils are a significant portion of the dietary fat intake in the U.S. Other information that was available suggested that, after baking or roasting meat, frying was the most common cooking method for meat (Mitchell, 1998). There was a high frequency of frying in fat and oils. Results reported by Rogge (1997) and Gerstler et al. (1998) showed that frying of food and broiling meat and fish resulted in high emissions.

Table 2-1. List of Cooking Tests

| Test No. | Type | Range | Conditions | Notes/Comments[a] |
|---|---|---|---|---|
| 1 | Oven Cleaning | Gas | Standard | Oven problem; data not reported |
| 1R | Oven Cleaning | Gas | Standard | Repeated test 1 |
| 2 | Stovetop Stir Fry | Gas | Standard | Two batches cooked in one event |
| 3A | Bacon | Gas | Standard | Two event cooking test |
| 3B | Bacon | | | Second event |
| 4 | Tortillas | Gas | Standard | |
| 5 | French Fries | Gas | Standard | Two batches cooked in one event |
| 6A | Broil Fish | Gas | Standard | Two event cooking test |
| 6B | Broil Fish | | | Second event |
| 7 | Bake Lasagna | Gas | Standard | |
| 8 | Oven Cleaning | Electric | Standard | Tests 1–7 and 8–14 = same cooking protocols |
| 9 | Stovetop Stir Fry | Electric | Standard | Two batches cooked in one event |
| 10A | Bacon | Electric | Standard | Two event cooking test |
| 10B | Bacon | | | Second event |
| 11 | Tortillas | Electric | Standard | |
| 12 | French Fries | Electric | Standard | Two batches cooked in one event |
| 13A | Broil Fish | Electric | Standard | Two event cooking test |
| 13B | Broil Fish | | | Second event |
| 14 | Bake Lasagna | Electric | Standard | |
| 15 | Bacon | Microwave | Standard | Two event cooking test |
| 15A | Bacon | | | Second event |
| 16 | Bake Lasagna | Microwave | Standard | |
| 17A | Stovetop Stir Fry | Gas | Worst Case | Oil hotter; food cooked longer |
| 17B | Stovetop Stir Fry | | | Second event in the test |
| 18A | Bacon | Gas | Worst Case | Extra crisp bacon |
| 18B | Bacon | | | Second event in the test |
| 19A | Broil Fish | Gas | Worst Case | Burned |
| 19B | Broil Fish | | | Second event in the test |
| 20 | Full Meal | Gas | Standard | Large meal with multiple foods; oven and range top burner used |
| 21A | Stovetop Stir Fry | Gas | Test 2 Replicate | Not true replicate – changed to two event test |
| 21B | Stovetop Stir Fry | | | Second event in the test |
| 22 | French Fries | Gas | Test 5 Replicate | |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | |
| 24 | Fry Beef | Gas | Cast Iron Pan | Data logger failed |
| 24RA | Fry Beef | Gas | Cast Iron Pan | Repeated Test 24 to evaluate pan type |
| 24RB | | | | Second event in the test |
| 25 | Pork Roast | Gas | Aluminum Pan | Compare pan types |

Table 2-1. List of Cooking Tests Cont.

| Test No. | Type | Range | Conditions | Notes/Comments[a] |
|---|---|---|---|---|
| 26 | Fry Beef | Gas | Range Hood | Operated on high |
| 27 | Pork Roast | Gas | Range Hood | Operated on high |
| 28 | Fry Beef | Gas | Range Side Shields | Exhaust on high with side shields |
| 29 | Pork Roast | Gas | Range Side Shields | Exhaust on high with side shields |
| 30A | Stovetop Stir Fry | Gas | Vegetable Oil | Compare oils |
| 30B | | | | Second event in the test |
| 31A | Fry Beef | Gas | Pan Lid | Impact of pan lid |
| 31B | | | | Second event in the test |
| 32A | Popcorn | Microwave | Standard | Two event test |
| 32B | | | | Second event in the test |
| 33 | Burner Baseline | Gas | | Range top burner with pot of water only |
| 34 | Oven Baseline | Gas | | No food in oven |
| 35 | Instrument Comparison | Gas | | No food in oven |
| 36 | Instrument Comparison | Gas | | No food in oven |
| 37 | Instrument Comparison | Gas | | No food in oven |
| 38 | Oven Dirtying | Gas | | Bake off food and oil used to dirty oven |
| 38R | Oven Dirtying | Gas | | Bake off food and oil used to dirty oven |
| 39 | Oven Dirtying | Electric | | Bake off food and oil used to dirty oven |

[a] See text for definition of "test," "event," and "batches."

Based on the limited available information, discussions with the ARB, and teleconferences with members of the TRG, the matrix of tests presented in Table 2-1 was developed. The types of cooking included frying of foods on the range top because of the continued widespread use of frying for food preparation and the expected high emissions. Stir-frying of chicken and vegetables and frying of tortillas were expected to be common in the ethnically diverse cuisine and population of California. One type of cooking involved frying of loose ground beef in a pan on the range top burner because this food item can be used in a wide variety of food dishes. Broiling of fish in the oven was selected because it is a relatively simple food preparation method and likely to be common in California. A fish with high oil content, Salmon, was selected for the broiling tests. The primary oven baking method involved cooking a large (2.5 lb) pre-packaged lasagna, representing another easy type of cooking. Selection of the pre-packaged lasagna also allowed comparison of the emissions from gas and electric ovens with those from the microwave. Similarly, bacon was selected for the tests because it is a popular food item, and a comparison could be made between the microwave cooking method and standard frying on the range top. In a limited number of tests, a pork roast was cooked in the gas oven, allowing comparison of emissions from the meat with emissions from the lasagna. French fries were prepared by frying in oil because of the popularity of the food item and anticipation of high emissions from the heated oil. Two different cooking oils, vegetable and peanut oil, were used in the tests for comparison of

emissions, particularly the PAH emissions. The oils were analyzed for PAH content prior to the main study.

The first 14 tests consisted of seven tests with the gas range for comparison to an identical set of seven tests with the electric range. Identical cooking protocols were used for the comparisons. Three tests were performed with the microwave. Two of the tests compared cooking of the same foods (bacon and lasagna) that were prepared with the gas and electric ranges. The other test was with a popular microwave food – popcorn. Three tests (Nos. 21, 22, and 23) were performed with the gas range as replicates of test numbers 2, 5, and 7, respectively.

The other tests were designed to evaluate factors that might impact emissions and indoor air concentrations during cooking. Tests 24 and 25 compared cooking with different pan materials. Test 24 was repeated as 24R because of a problem with the DAS during the first test. Tests 26 through 31 evaluated simple exposure reduction methods.

All tests involved preparation of a single food item, except test 20, which involved preparation of a full meal. All tests, except Test 20, were performed using either a range top burner or the oven, but not both at the same time. Each test, except Test 20, was performed for only a single type of cooking activity (e.g., broiling fish, stovetop stir-frying, baking a lasagna). In Test 20, preparation of the full meal involved cooking a number of different foods, using both the range top burners and the oven.

Also shown in the table are eight other tests that were performed. The gas range top burner was operated for one hour to obtain the baseline concentrations of combustion pollutants in Test 33. The oven was operated for two hours in Test 34 to obtain baseline concentrations. Tests 35, 36, and 37 were performed to evaluate sampling instrumentation in the kitchen. The last three tests listed (38, 38R, and 39) were not actually tests. For oven cleaning tests, the oven was first "dirtied" by applying a mixture of tomato puree and cherry pie filling to the bottom of the oven and cooking oil on the walls of the oven. After dirtying the oven, the oven was operated for a one-hour period at 350 °F to bake the material onto the surfaces in preparation for the test with the self-cleaning oven.

Tests 1 and 8 were performed to measure emissions during the self-cleaning cycles of the gas and electric ovens, respectively. Although oven cleaning is not performed frequently, the self-cleaning feature of both gas and electric ovens involves baking the surfaces at high temperatures (~450 °F). Therefore, this feature may result in high emissions from very dirty ovens. The Underwriters Laboratory (Underwriters Laboratory, 1993) has a method for dirtying an oven for measuring emissions of CO that involves application of 5-ounce of a beef gravy and vegetable oil shortening mixture. In January 2000, the Consumers Union reported a method for dirtying ovens during their performance tests of self-cleaning ovens (Consumers Reports, 2000). It involved a mixture of cherry pie filling, egg yolks, cheese, lard, tapioca, and tomato puree, but the quantities and test protocol could not be obtained in time for the tests. A modified protocol using five oz. of tomato puree, oil, and cherry pie filling was used in the first test, but the amount of material was too high, resulting in excessively high emissions. The amount was reduced to 3 oz. for tests 1R and 8. The protocol for dirtying the oven used a mixture of 28 g of tomato puree, 28 g of cherry pie filling, and 28 g of vegetable oil. The tomato puree and pie filling were wiped on the floor of the oven to

represent spills. The oil was wiped on the walls of the oven with a brush. After application, the oven was operated at 350 °F for one hour to bake the material onto the surface. The self-cleaning test was performed on the following day.

To the extent possible, cooking was performed following published recipes and routine cooking practices that would be performed in a residence. When available, as for the pre-packaged lasagna, the instructions on the package were followed. The cook, an ARCADIS chemist, was an experienced cook, but not a professional. He did much of the cooking in his own home and was considered to be representative of an "average" cook. By design, a professional cook was not used for the tests. During tests with the same food and cooking method, protocols were followed to insure that the food preparation methods, cooking methods, and cooking times were as consistent as possible to facilitate comparisons between tests.

As shown in Table 2-1, there were four types of cooking protocols implemented during the study:

1. Single event cooking tests with one batch of food - The simplest type of cooking protocol was a single event with a single batch of food cooked, as in Test Nos. 7 and 14 in which a single, large, pre-packaged frozen lasagna was baked in the oven. The cooking period was approximately two hours, and the post-exposure period was one hour, for a total exposure period of three hours.
2. Single event cooking tests during which two batches of food were prepared - In the second type of cooking protocol, there was a single event during which two batches of food were cooked sequentially. After all of the food was cooked, there was a one-hour post-cooking exposure period. This protocol was used in Test Nos. 5 and 12 during which a basket of French fries was cooked in oil, removed, and then a second batch was placed in the same oil to cook. It took approximately one hour to complete the cooking event, including the initial heating of the oil. After both batches of French fries were cooked, there was a one-hour post-cooking period, resulting in a total exposure period of approximately two hours.
3. Two event cooking tests - The third type of cooking protocol involved two cooking events separated by one hour. The protocol was used, for example, in Test Nos. 6 and 13. The test started by turning on the oven, then broiling a large salmon steak. At the end of the cooking period, the fish was removed and the oven was turned off. This cooking event, denoted as 6A in Table 2-1, was followed by a one-hour post-cooking period to simulate eating and clean-up. Then the oven was turned on again; a second salmon steak was broiled, and the oven was turned off. This cooking event was followed by another one-hour post-cooking period. The total duration of the test was 3.25 hours. The $PM_{2.5}$ and $PM_{10}$ samples for gravimetric analysis were collected throughout the entire two-event cooking test. Continuous monitoring with the ELPI and other pollutant monitors provided concentration data over the entire test.
4. Exposure reduction tests consisted of replicate cooking experiments conducted with the addition of pan lid, range hood fan and side shields.

The need to perform these different protocols was demonstrated in the pre-test. During the pre-test, a single batch of loose ground beef was fried in a pan on the range-top burner. Due to the small amount of food cooked and the short duration of the test, there was insufficient $PM_{2.5}$ and $PM_{10}$ mass on the filters for accurate gravimetric analysis. To increase the amount of mass collected, these protocols were implemented.

The durations of the cooking events are presented in Table 2-2. The table lists the start time for background measurements, the cooking times, and the duration of the cooking time and the total exposure period. The total exposure period represents the total duration of the test. The test durations ranged from 1 hour and 30 minutes (Test 2) to 5 hours and 8 minutes for oven cleaning (Test 1R). The cooking period started when the range top burner or the oven was turned on. The cooking period ended when the burner or oven was turned off. Therefore, cooking periods included the time required to pre-heat the oven, pan, or cooking oil. The total exposure period was the total period in which the cook or occupants would be exposed to emissions from the cooking. The total exposure period included the cooking period plus a one-hour post-cooking period during which the meal would be eaten and cleanup would be performed. The assumption was that the cook and occupants would be in the residence for at least one hour after cooking. For the first two types of cooking protocols, the total exposure period included one hour of post-cooking exposure. In two event tests, the third type of protocol, there were two hour-long post-cooking exposure periods. A single $PM_{2.5}$ and $PM_{10}$ mass measurement was made for each test regardless of the number of batches of food cooked or the number of cooking events within the test. During two event tests, data collected with the continuous monitors (CO, NO, $NO_2$, and PM with the ELPI) are reported as Test XA and XB in the results tables. The two event tests facilitated additional replication of cooking events, as recommended by the TRG, for measurements of CO, NO, $NO_2$, and PM with the ELPI.

Multiple cooking tests were performed on many days during the main study. Because of the amount of time necessary for zero and span checks of the continuous monitors, ELPI, and gas chromatograph used for $SF_6$ measurements, as well as set up of the instrumentation, performance of multiple tests on a day improved efficiency.

In order to obtain sufficient sample mass for PM, PAHs, and elements, a single set of outdoor air samples was collected on each day of testing. If only a single test was performed, for example with a total exposure period duration of 4 hours, the outdoor sample was collected during the same 4-hr period. If three tests were performed over a 9-hr period during the day, the outdoor air sample was integrated over the entire nine hours. This protocol was used because the mass of PM collected during short cooking tests would be inadequate for accurate gravimetric analysis.

On days with multiple tests, the house was flushed with outdoor air between tests to exhaust the air pollutants generated during the test and to re-establish the indoor background pollutant concentrations to reasonable levels prior to the start of the next test. The flush out was accomplished with the central air handler fan operating in conjunction with window fans and open doors. Because of this protocol, data was collected during most tests for only one hour after the source was turned off.

Cooking protocols were developed that involved reasonable and representative cooking scenarios. The detailed cooking protocols are included in Appendix C of the report. Table 2-3 presents a brief description of the cooking protocols. To the extent possible, cooking was performed to be representative of typical residential cooking. All foods were purchased from local grocery stores in Rohnert Park. The foods to be used in multiple tests were purchased in large quantities and stored in the freezer to insure comparability between the tests. All pans, foods, and oils were weighed prior to, and following cooking, in order to determine the weight loss during the cooking event. Food weights are reported in Section 3.0. All cooking tests, except Test No. 20, involved cooking a single meal item. The stovetop stir-fry cooking protocol, for example, involved cooking both the vegetables and chicken for the dish, but involved use of only a single stovetop pan and burner. Most other cooking protocols involved a single food.

Table 2-2. Cooking Times and Test Durations

| Test No. | Date | Test Type | Range Type | Cooking Event | Background Start Time | Cooking Start Time | Cooking End Time | Exposure End Time | Cooking Duration (Hr:Min) | Exposure Duration (Hr:Min) |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 2/3/00 | Oven Cleaning | Gas | Total | 12:44 | 12:54 | 16:54 | 18:24 | 4:00 | 5:30 |
| 1R | 2/24/00 | Oven Cleaning | Gas | Total | 12:08 | 12:18 | 16:18 | 17:26 | 4:00 | 5:08 |
| 2 | 2/5/00 | Stovetop Stir Fry | Gas | Total | 13:59 | 14:09 | 14:30 | 15:39 | 0:21 | 1:30 |
| 3 | 2/5/00 | Bacon | Gas | Total | 9:08 | 10:08 | 11:57 | 13:06 | 0:42 | 2:58 |
| 3A | 02/05/00 | Bacon | Gas | 1st event | 9:08 | 10:08 | 10:30 | 11:36 | 0:22 | 1:28 |
| 3B | 02/05/00 | Bacon | Gas | 2nd event | 11:27 | 11:37 | 11:57 | 13:06 | 0:20 | 1:29 |
| 4 | 2/4/00 | Tortillas | Gas | Total | 10:31 | 10:41 | 11:26 | 12:38 | 0:45 | 1:57 |
| 5 | 2/4/00 | French Fries | Gas | Total | 13:31 | 13:41 | 14:49 | 16:13 | 1:08 | 2:32 |
| 6 | 2/6/00 | Broil Fish | Gas | Total | 10:54 | 11:04 | 12:55 | 14:05 | 0:44 | 3:01 |
| 6A | 02/06/00 | Broil Fish | Gas | 1st event | 10:54 | 11:04 | 11:28 | 12:34 | 0:24 | 1:30 |
| 6B | 02/06/00 | Broil Fish | Gas | 2nd event | 12:25 | 12:35 | 12:55 | 14:05 | 0:20 | 1:30 |
| 7 | 2/9/00 | Bake Lasagna | Gas | Total | 9:52 | 10:02 | 12:08 | 13:11 | 2:06 | 3:09 |
| 8 | 2/10/00 | Oven Cleaning | Electric | Total | 10:06 | 10:16 | 14:16 | 15:23 | 4:00 | 5:07 |
| 9 | 2/14/00 | Stovetop Stir Fry | Electric | Total | 14:02 | 14:12 | 14:33 | 15:44 | 0:21 | 1:32 |
| 10 | 2/11/00 | Bacon | Electric | Total | 15:06 | 15:23 | 17:14 | 18:25 | 0:51 | 3:02 |
| 10A | 02/11/00 | Bacon | Electric | 1st event | 15:06 | 15:23 | 15:46 | 16:45 | 0:23 | 1:22 |
| 10B | 02/11/00 | Bacon | Electric | 2nd event | 16:36 | 16:46 | 17:14 | 18:25 | 0:28 | 1:39 |
| 11 | 2/11/00 | Tortillas | Electric | Total | 9:52 | 10:02 | 10:45 | 11:54 | 0:43 | 1:52 |
| 12 | 2/11/00 | French Fries | Electric | Total | 12:47 | 12:57 | 13:22 | 14:35 | 0:25 | 1:38 |

Table 2-2. Cooking Times and Test Durations Cont.

| Test No. | Date | Test Type | Range Type | Cooking Event | Background Start Time | Cooking Start Time | Cooking End Time | Exposure End Time | Cooking Duration (Hr:Min) | Exposure Duration (Hr:Min) |
|---|---|---|---|---|---|---|---|---|---|---|
| 13 | 2/14/00 | Broil Fish | Electric | Total | 9:43 | 9:53 | 11:51 | 13:08 | 0:36 | 3:15 |
| 13A | 02/14/00 | Broil Fish | Electric | 1st event | 9:43 | 9:53 | 10:11 | 11:32 | 0:18 | 1:39 |
| 13B | 02/14/00 | Broil Fish | Electric | 2nd event | 11:23 | 11:33 | 11:51 | 13:08 | 0:18 | 1:35 |
| 14 | 2/13/00 | Bake Lasagna | Electric | Total | 15:26 | 15:36 | 17:37 | 18:58 | 2:01 | 3:22 |
| 15 | 2/8/00 | Bacon | Microwave | Total | 17:34 | 17:44 | 20:16 | 21:23 | 0:81 | 3:39 |
| 15A | 02/08/00 | Bacon | Microwave | 1st event | 17:34 | 17:44 | 18:28 | 19:38 | 0:44 | 1:54 |
| 15B | 02/08/00 | Bacon | Microwave | 2nd event | 19:29 | 19:39 | 20:16 | 21:23 | 0:37 | 1:44 |
| 16 | 2/8/00 | Bake Lasagna | Microwave | Total | 14:22 | 14:32 | 15:07 | 16:08 | 0:35 | 1:36 |
| 17 | 2/29/00 | Stovetop Stir Fry | Gas | Total | 14:50 | 15:00 | 16:56 | 18:38 | 0:51 | 3:38 |
| 17A | 02/29/00 | Stovetop Stir Fry | Gas | 1st event | 14:50 | 15:00 | 15:26 | 16:30 | 0:26 | 1:30 |
| 17B | 02/29/00 | Stovetop Stir Fry | Gas | 2nd event | 16:21 | 16:31 | 16:56 | 18:38 | 0:25 | 2:07 |
| 18 | 2/27/00 | Bacon | Gas | Total | 10:53 | 11:03 | 13:04 | 14:10 | 0:57 | 3:07 |
| 18A | 02/27/00 | Bacon | Gas | 1st event | 10:53 | 11:03 | 11:29 | 12:32 | 0:26 | 1:29 |
| 18B | 02/27/00 | Bacon | Gas | 2nd event | 12:23 | 12:33 | 13:04 | 14:10 | 0:31 | 1:37 |
| 19 | 2/27/00 | Broil Fish | Gas | Total | 18:45 | 18:55 | 20:49 | 21:57 | 0:50 | 3:02 |
| 19A | 02/27/00 | Broil Fish | Gas | 1st event | 18:45 | 18:55 | 19:20 | 20:23 | 0:25 | 1:28 |
| 19B | 02/27/00 | Broil Fish | Gas | 2nd event | 20:14 | 20:24 | 20:49 | 21:57 | 0:25 | 1:33 |
| 20 | 2/28/00 | Full Meal | Gas | Total | 8:38 | 8:48 | 11:08 | 15:53 | 2:20 | 7:05 |

Table 2-2. Cooking Times and Test Durations Cont.

| Test No. | Date | Test Type | Range Type | Cooking Event | Background Start Time | Cooking Start Time | Cooking End Time | Exposure End Time | Cooking Duration (Hr:Min) | Exposure Duration (Hr:Min) |
|---|---|---|---|---|---|---|---|---|---|---|
| 21 | 2/27/00 | Stovetop Stir Fry | Gas | Total | 15:02 | 15:12 | 16:51 | 18:00 | 0:39 | 2:48 |
| 21A | 02/27/00 | Stovetop Stir Fry | Gas | 1st event | 15:02 | 15:12 | 15:31 | 16:30 | 0:19 | 1:18 |
| 21B | 02/27/00 | Stovetop Stir Fry | Gas | 2nd event | 16:21 | 16:31 | 16:51 | 18:00 | 0:20 | 1:29 |
| 22 | 2/26/00 | French Fries | Gas | Total | 12:27 | 12:37 | 14:05 | 15:32 | 1:28 | 2:55 |
| 23 | 2/23/00 | Bake Lasagna | Gas | Total | 16:11 | 16:21 | 18:22 | 19:30 | 2:01 | 3:09 |
| 24 | 2/17/00 | Fry Beef | Gas | Total | 9:59 | 10:09 | 10:30 | 11:47 | 0:21 | 1:38 |
| 24R | 2/25/00 | Fry Beef | Gas | Total | 10:20 | 10:30 | 12:13 | 13:25 | 0:42 | 2:55 |
| 24RA | 2/25/00 | Fry Beef | Gas | 1st event | 10:20 | 10:30 | 10:51 | 11:51 | 0:21 | 1:21 |
| 24RB | 2/25/00 | Fry Beef | Gas | 2nd event | 11:42 | 11:52 | 12:13 | 13:25 | 0:21 | 1:33 |
| 25 | 2/17/00 | Pork Roast | Gas | Total | 12:52 | 13:02 | 16:02 | 17:16 | 3:00 | 4:14 |
| 26 | 2/15/00 | Fry Beef | Gas | Total | 11:55 | 12:05 | 12:26 | 13:33 | 0:21 | 1:28 |
| 27 | 2/15/00 | Pork Roast | Gas | Total | 14:47 | 14:57 | 17:58 | 19:09 | 3:01 | 4:12 |
| 28 | 2/16/00 | Fry Beef | Gas | Total | 12:13 | 12:23 | 12:44 | 13:50 | 0:21 | 1:27 |
| 29 | 2/16/00 | Pork Roast | Gas | Total | 14:28 | 14:38 | 17:38 | 18:45 | 3:00 | 4:07 |
| 30 | 2/29/00 | Stovetop Stir Fry | Gas | Total | 10:32 | 10:42 | 12:17 | 13:29 | 0:35 | 2:47 |
| 30A | 02/29/00 | Stovetop Stir Fry | Gas | 1st event | 10:32 | 10:42 | 11:00 | 11:59 | 0:18 | 1:17 |
| 30B | 02/29/00 | Stovetop Stir Fry | Gas | 2nd event | 11:50 | 12:00 | 12:17 | 13:29 | 0:17 | 1:29 |
| 31 | 2/23/00 | Fry Beef | Gas | Total | 11:56 | 12:06 | 13:50 | 14:58 | 0:39 | 2:52 |
| 31A | 02/23/00 | Fry Beef | Gas | 1st event | 11:56 | 12:06 | 12:27 | 13:31 | 0:21 | 1:25 |

Table 2-2. Cooking Times and Test Durations Cont.

| Test No. | Date | Test Type | Range Type | Cooking Event | Background Start Time | Cooking Start Time | Cooking End Time | Exposure End Time | Cooking Duration (Hr:Min) | Exposure Duration (Hr:Min) |
|---|---|---|---|---|---|---|---|---|---|---|
| 31B | 02/23/00 | Fry Beef | Gas | 2nd event | 13:22 | 13:32 | 13:50 | 14:58 | 0:18 | 1:26 |
| 32 | 2/15/00 | Popcorn | Microwave | Standard | 20:05 | 20:15 | 21:18 | 22:19 | 0:08 | 2:04 |
| 32A | 2/15/00 | Popcorn | Microwave | 1st batch | 20:05 | 20:15 | 20:19 | 21:13 | 0:04 | 0:58 |
| 32B | 2/15/00 | Popcorn | Microwave | 2nd batch | 21:03 | 21:13 | 21:17 | 22:19 | 0:04 | 1:06 |
| 33 | 2/24/00 | Range Baseline | Gas | Total | 8:51 | 9:01 | 10:01 | 11:05 | 1:00 | 2:04 |
| 34 | 2/24/00 | Oven Baseline | Gas | Total | 18:15 | 18:25 | 20:25 | 21:33 | 2:00 | 3:08 |
| 35 | 2/28/00 | Instrument Comparison | Gas | Total | 17:25 | 17:35 | 18:05 | 18:49 | 0:30 | 1:14 |
| 36 | 2/28/00 | Instrument Comparison | Gas | Total | 19:20 | 19:30 | 20:01 | 20:58 | 0:31 | 1:28 |
| 37 | 2/29/00 | Instrument Comparison | Gas | Total | -- | 18:38 | 19:41 | -- | 1:03 | 1:03 |
| 38 | 2/2/00 | Oven Dirtying | Gas | Total | 20:23 | 20:33 | 22:03 | 23:04 | 1:30 | 2:31 |
| 38R | 2/23/00 | Oven Dirtying | Gas | Total | 20:06 | 20:16 | 21:16 | 22:18 | 1:00 | 2:02 |
| 39 | 2/9/00 | Oven Dirtying | Electric | Total | 14:14 | 14:31 | 15:31 | 16:35 | 1:00 | 2:04 |

Table 2-3. Summary of the Cooking Protocols

| Test Number | Summary Description of Cooking Protocols |
|---|---|
| 1R | Oven Cleaning – Test was performed by running test 38R prior to this test. Oven lock was engaged and the oven was set to the clean setting. The oven was operated for 4 hours. |
| 2, 9, 17, 21 | Stovetop Stir Fry – Using a stovetop, 16 g of peanut oil was added and heated for one minute on high. Two batches of pre-packaged frozen vegetables were fried in peanut oil sequentially in two batches and removed. Boneless skinless chicken breasts cut into 2-inch pieces were fried in peanut oil sequentially in two batches, removed, and weighed. In total, 65 g of peanut oil was used. |
| 3, 10, 18, | Bacon – Using the skillet, 6 to 8 pieces of sliced bacon were placed into the pan and cooked turning once. Cooked bacon was removed, and 6 to 8 pieces of bacon was added to pan and cooked in drippings from first batch. Cooking continued until the pound of bacon was cooked. Bacon was removed and served. |
| 4, 11 | Tortillas – Using the skillet, 1075 g of vegetable oil was added to the pan and heated for 10 minutes on medium high. Individual white corn flour tortillas were cooked in oil for 1 to 2 minutes each, until golden brown. A total of 24 tortillas were cooked. |
| 5, 12, 22 | French Fries – Using cast iron kettle with fryer basket, 3045 g of vegetable oil was added and heated on high until oil temperature reached 190 °C. The contents of one 2-lb bag of steak cut French fires were put into the basket and cooked for 9 minutes. After the first batch of French fries was cooked, a second bag of French fries was cooked. |
| 6, 13, 19 | Broil Fish – Using the Pyrex baking dish, one Atlantic salmon steak was placed in the center and brushed with 15 g of extra virgin olive oil. The broiler was heated for 5 minutes, and the steak was placed under the broiler. The steak was cooked for 5 minutes, then removed, turned over, and brushed with 15 g of oil. The steak was cooked for an additional 5 minutes, removed, and served. |
| 7, 14 | Bake Lasagna – Using the pan provided by the packaging, one frozen pre-packaged lasagna was removed from the freezer. The oven was turned on to 375 °F and pre-heated for 30 minutes. The lasagna was placed in the center of the oven and cooked for 1.5 hours, removed, and served. |
| 15 | Microwave Bacon – Using the Pyrex baking dish and paper towels, 6 strips of sliced bacon was placed on two paper towels in the dish and covered with 2 paper towels. The dish was placed in the microwave and cooked on the highest setting for 15 minutes. The bacon and towels were removed and the test repeated with 6 more strips of bacon. |
| 16 | Microwave Lasagna – Using the pan provided by the packaging, one frozen pre-packaged lasagna was removed from the freezer. The lasagna was placed in the center of the microwave and cooked on the highest setting for 30 minutes, turning 90 degrees every 10 minutes. |
| 20 | Full Meal – Consisted of baked potatoes, fried chicken, boiled vegetables, boiled broccoli, brown gravy, and rolls. Oven was pre-heated to 400 °F for 30 minutes. Potatoes were poked with knife and placed in Pyrex baking dish. The potatoes were cooked for 1 hour 50 minutes. Yellow squash was prepared by slicing the squash into ½ inch slices and adding one diced yellow onion to the 4-quart pot. Water was added to cover the vegetables. The squash and onions were covered and simmered for 50 minutes. Broccoli was prepared by cutting the florets from the stem, placing them in a 4-quart pot and covering with water. The broccoli was covered and simmered for 50 minutes. The fried chicken was prepared by covering the chicken pieces with a fryer breading mix and cooking in 3390 g of vegetable oil in the cast iron kettle with fryer basket. One half of the chicken was cooked at a time for 20 minutes. The gravy was prepared from a pre-packaged dehydrated brown gravy mix. One cup of water was added to a 4-quart pan and heated for one minute. The gravy mix was added and cooked while stirring for 1 minute. The biscuits were prepared by heating a package of frozen rolls for 23 minutes in the oven during the end of the potatoes cooking time. Food cooking was timed to have all of the food cooking end times within a few minutes of each other. |
| 24, 26, 28, 31 | Fry Beef – Using the skillet, ground beef was browned. The skillet was pre-heated for 1 minute; the ground beef was added to the pan and stirred for 1 minute. The ground beef was cooked for 20 minutes, stirring every 5 minutes. |
| 25,27,29 | Pork Roast – Using the Pyrex baking dish, the center cut pork roast was placed fat side up in the dish. The oven was pre-heated to 275 °F for 30 minutes, and the roast was placed in the center of the oven. The roast was cooked for 2.5 hours |
| 30 | Stovetop Stir Fry – Same as test 2 except used vegetable oil rather than peanut oil. |
| 32 | Microwave Popcorn – This test was performed by taking one bag of microwave popcorn and placing it in the center of the microwave oven. The oven was operated on maximum power for 4 minutes |
| 33 | Burner Background – Performed by boiling water for 1 hour in a 4-quart pot. |
| 34 | Oven Background – Performed by setting oven to bake at 375 deg F for 2 hours. |
| 38R, 39 | Oven Dirtying – These tests were performed by spreading a tomato puree and cherry pie filling mixture on the bottom of the oven and cooking oil was spread on the walls, top and bottom of the oven. A total of 90 grams of material was used to dirty the oven prior to oven cleaning. The oven was set to 350 °F for 1 hour to allow the material to bake on. |

Note: No spices were used in these preparations.

## 2.4 Measurement Methods and Performance

### 2.4.1 Test House and Appliance Measurement Parameters

A laboratory was set up in the garage of the test house. Signal lines were routed from the DAS to temperature and relative humidity probes located in the rooms of the house and outdoors. Signal lines were also routed from the appliances (e.g. for thermocouples in the oven) to the DAS. Tubing for collection of air samples was routed from the garage laboratory to the rooms. Sampling and monitoring inlets were at a standing breathing height of approximately 1.5 m (60 inches). An enclosure was set up in the back yard for temperature and RH sensors.

The Test House was set up for continuous measurements of temperature and RH indoor and outdoors, continuous CO and $NO_2$ monitoring indoors and outdoors (described in a following section), and automated measurements of air exchange rates by the $SF_6$ tracer gas decay method. Automated sampling systems were used for collection of air samples from multiple locations. A DAS was used for recording data from the monitors.

The test house and appliance measurement parameters and instrumentation are summarized in Tables 2-4 and 2-5.

Temperature and RH were measured continuously in the kitchen, living room, and master bedroom. Probes consisting of resistance temperature detectors (RTDs) were used for temperature measurements. Thin-film capacitance sensors were used for RH. Temperature and RH were also measured outdoors at the location indicated on Figure 2-1. The outdoor probe was appropriately shielded.

Air exchange rates were measured using an automated $SF_6$ tracer gas decay method. The method was based on ASTM method E-741 (ASTM, 1999). The tracer gas was introduced into the house manually by releasing 50 mL of pure $SF_6$ throughout the house, with the volume introduced into each room weighed for the room volume. Dosing was performed approximately 30 minutes before the start of each test. Air was sampled sequentially from the kitchen, living room, master bedroom, and outdoors with an automated system to obtain an average air exchange rate for the house. Analysis was performed with a Hewlett Packard gas chromatograph (GC) with an electron capture detector (ECD). The GC was calibrated with $SF_6$ standards over a range of 0.5 to 100 ppb. Zero and span checks were performed prior to the start of each day of testing.

Temperatures were measured with thermocouples interfaced to the DAS. Temperatures measured during the tests included the temperature of the flame of the stovetop burner, oven flame temperature and oven compartment temperature, and temperature of cooking oils and/or temperature of foods (e.g., roasts). Placement of the probes in the foods and the flame was difficult to reproduce, making it difficult to compare temperatures between the tests. The volume of gas used in each cooking test was measured with a dry gas meter. The local natural gas supplier reported the BTU content of the gas as $1000 \pm 20$ Btu/ft$^3$. During tests with the electric stove, a similar set of temperatures was measured. Electric power was measured with a power transducer (lights and clocks were disabled). Temperature was not measured in the microwave.

Table 2-4. Test House Environmental Measurement Parameters and Instrumentation

| Parameter | Instrument | Measurement Principle/Method | Measurement Range | Locations[a] |
|---|---|---|---|---|
| Temperature | HyCal HT-2W-C-D9-TT-B | Resistance Temperature Detector | -17 to 37.7 °C | K, LR, MBR, OA |
| Relative Humidity | HyCal HT-2W-C-D9-TT-B | Thin Film Capacitance | 0-100 % | K, LR, MBR, OA |
| Air Exchange | Hewlett-Packard 5890 | Tracer Gas ($SF_6$) Decay w/ GC/ECD | 0-100 ppbv | K, LR, MBR, OA |
| Air Flow Rates | Shortridge ADM 860 | Pitot tube | 25-10,000 fpm | Air handler |
| Exhaust Air Flow Rates | Solomat MPM 500 | Anemometer (hot wire or vane) | 30 - 2500 fpm | Range hood |
| Data Acquisition | | | | |
| LabTech Notebook for Win '95 | DAS computer | 12 bit A/D | Hardware dependent | Inputs from all locations |
| 8-channel A/D board | CyberResearch CYDAS 8 | 8 channel, 12 bit A/D, 20 kHz | ±5 V, 0-10 V | DAS |
| 32-channel multiplexing panel | CyberResearch CYEXP 32 | Voltage, current, or thermocouple | switchable gains | DAS |
| Dosing & Sample Acquisition | | | | |
| $SF_6$ Dosing | | Manual release of pure $SF_6$ | Not applicable | All rooms with weighted release volumes |
| $SF_6$ Sampling System | ARCADIS-configured - poly-line, valves/manifold | Sequential sampling | Not applicable | K, LR, MBR, OA |
| $NO_2$/CO Sampling System | ARCADIS-configured - Teflon® line, valves/manifold | Sequential sampling | Not applicable | K, LR, MBR, OA |

[a] Locations: Kitchen (K), Living Room (LR), Master Bedroom (MBR), Outdoor Air (OA)

Table 2-5. Appliance Measurement Parameters and Instrumentation

| Parameter | Instrument | Measurement Principle/Method | Measurement Range | Locations |
|---|---|---|---|---|
| Cooking Oil or Food Temperature | K type thermocouple | emf, Seebeck Effect | -200 to 1250 °C | Range top |
| Flame Temperature | K type thermocouple | emf, Seebeck Effect | -200 to 1250 °C | Range-top burner |
| Food Temperature | K type thermocouple | EMF, Seebeck Effect | -200 to 1250 °C | Oven |
| Oven Temperature | K type thermocouple | EMF, Seebeck Effect | -200 to 1250 °C | Oven |
| Natural Gas Volume | Dry Gas Meter | Positive displacement | | Gas range |
| Electrical Power | Power Transducer | Hall Effect | | Electric range |

### 2.4.2 Pollutant Measurement Parameters and Instrumentation

The pollutant sampling and analysis methods are summarized in Table 2-6 and described below. The performance of the measurement methods and instrumentation is summarized in Section 3.10 and highlighted below.

#### 2.4.2.1 Carbon Monoxide (CO) Monitoring

CO was monitored with a Thermo Environmental Instruments Model 48 non-dispersive infrared (NDIR) monitor located in the garage laboratory. The monitor is a bench top sized instrument that is an approved Federal Reference Method (FRM) monitor for National Ambient Air Quality Standards (NAAQS) ambient air monitoring. The monitor was set up to sample from an automated sampling valve and manifold system to sequentially measure CO in air samples from the outdoors (OA), kitchen (K), living room (LR), and master bedroom (MBR). Teflon® sample collection tubes were plumbed from the garage laboratory to each sampling location in the house. To allow for sufficient instrument rise time, the sampling time for each location was 3.75 minutes, which resulted in four measurements at each location per hour. Data from the monitor were recorded with the DAS. Data were processed with a routine that averaged the monitor readings only for the last minute of the measurement cycle. The average during the minute period was saved to the DAS.

Certified gas standards in gas cylinders were used with a dilution system to perform weekly multi-point calibrations over a range from 0 to 20 ppm. Zero and span checks were performed at the start of each day of testing.

The CO monitor, being an FRM, was appropriate for measurements during this study. The detection limit of 0.1 ppm was adequate for the study. The performance of the instruments was excellent based on daily zero and span checks. The bias was less than 2.1 % for all 18 span checks. The relative standard deviation for the span checks performed with a 19.4 ppm standard was 1.0 %.

#### 2.4.2.2 Nitric Oxide (NO) and Nitrogen Dioxide ($NO_2$) Monitoring

NO and $NO_2$ were measured with a Thermo Environmental Instruments Model 42 chemiluminescent monitor located in the garage. The instrument is also a FRM. The monitor was set up in the same manner as the CO monitor, with samples supplied to one instrument with the sampling system that alternated between locations. Teflon® sampling lines were used for transferring the sample to the instrument. The instrument was calibrated over a range of 0 to 1000 ppb with certified gas standards in gas cylinders and a dilution system. Zero and span checks were performed at the start of each day of testing. Measurements for NO may be truncated to 1000 ppb due to scale limitations during monitoring.

Table 2-6. Pollutant Measurement Parameters and Instrumentation

| Parameter | Instrument | Measurement Principle/Method | Measurement Range | Minimum Detection Limits | Locations[a] |
|---|---|---|---|---|---|
| Gases - Continuous | | | | | |
| Carbon Monoxide - Area Monitor | Thermo-Environmental Instruments, Inc. Model 48 | Non-dispersive Infra-red (NDIR) | 1-20 ppm | 0.1 ppm | K, LR, MBR, OA (Sequential) |
| Nitric Oxide ($NO_x$) - Area Monitor | Thermo-Environmental Instruments, Inc. Model 42 | Chemiluminescence Detector | 0-1,000 ppb | 0.50 ppb | K, LR, MBR, OA (Sequential) |
| PM (Continuous) - Range from 0.03 μm to 10 μm) | Dekati Electrical Low Pressure Impactor | Multi-stage impactors with multi-channel electrometers | Size range dependent | 0.56/$cm^3$ (6.5 μm)<br>381/$cm^3$ (0.047μm) | Kitchen |
| $PM_{2.5}$ (Integrated) - Personal | Personal Environmental Monitor (PEM) | Impactor/ Gravimetric | Not applicable | 17 μg/$m^3$ | Kitchen |
| $PM_{2.5}$ (Integrated) - Indoor rooms, outdoors | MS&T Sampler | Impactor/ Gravimetric | Not applicable | 3 μg/$m^3$ | LR, MBR, OA |
| $PM_{10}$ (Integrated) - Personal | Personal Environmental Monitor (PEM) | Impactor/ Gravimetric | Not applicable | 17 μg/$m^3$ | Kitchen |
| $PM_{10}$ (Integrated) - Indoor rooms, outdoors | MS&T Area Sampler | Impactor/ Gravimetric | | 3 μg/$m^3$ | LR, MBR, OA |
| Polyaromatic Hydrocarbons (PAHs) | Low Flow SKC Pump | Quartz filter/GC/MS[b] | Not applicable | 0.4 ng/$m^3$ | K, OA |
| Elements ($PM_{10}$) | Same as Particles, Integrated | Filter/XRF[c] | Not applicable | Element dependent | K, OA |
| Aldehydes | Low Flow SKC Pump | DNPH-Silica gel/HPLC[d] | Not applicable | 0.5 μg/$m^3$ | K, OA |

[a] Locations: Kitchen (K), Living Room (LR), Master Bedroom (MBR), Outdoor Air (OA)
[b] Gas chromatography/mass spectrometry
[c] X-ray fluorescence
[d] High performance liquid chromatography

The chemiluminescent monitor, being a FRM, was appropriate for measurements during this study. The instrument was operated on the 0 – 1000 ppb range. The detection limit of 0.5 ppb was adequate for the study. The performance of the instrument used to measure the concentrations from the four locations was excellent based on daily zero and span checks. The bias measured with the 1000 ppb standard was less than 3% for NO and 8% for $NO_2$ for all span checks. The relative standard deviation for the span checks was 1.6 % for NO and 4.3% for $NO_2$.

### 2.4.2.3 Real-Time Particle Monitoring

Real-time measurements of particle concentrations were performed during the cooking tests using a Dekati Electrical Low Pressure Impactor (ELPI) that is distributed by TSI Particle Instrument Division (St. Paul, MN). The instrument was well suited for the project because it enables real time particle size distribution (particle counts) and concentration measurement ($\mu g/m^3$) in the size range from 30 nm up 10 μm. The instrument has been used in recent studies of PM emissions from commercial kitchen cooking appliances (Gerstler et al., 1998) and indoor sources such as candles and incense (Guo et al., 2000). The ELPI is based on combining electrical detection principle with low-pressure impactor size classification. The electric current carried by charged particles into each of the 12 impactor stages is measured in real-time by a multichannel electrometer. The mid-points of the size fractions measured are 0.04, 0.08, 0.13, 0.21, 0.32, 0.51, 0.81, 1.3, 2.0, 3.2, 5.2, and 8.4 μm.

The ELPI is a bench top size instrument that requires a large vacuum pump for operation. The exhaust of the ELPI vacuum pump was filtered through a high efficiency particulate air (HEPA) filter. The instrument and pump were placed on a cart so that the ELPI could be moved between the kitchen and outdoors. However, the instrument is not very portable. The ELPI was generally located in the kitchen at a location immediately adjacent to the inlets of the integrated PM samplers. The inlet was at the approximate cook breathing height at 3 feet from the front of the stove. To avoid additional air mixing in the kitchen, the ELPI exhaust was ducted in a plastic tube through a gap in the rear sliding door to the outdoors; the gap was filled with a foam strip. The instrument was moved onto the back deck of the house prior to each day's tests and at the end of the tests to perform short term outdoor air measurements. The only location measured indoors was in the kitchen. The instrument was calibrated by the manufacturer. No additional calibrations or performance checks could be performed with the instrument in the field. The instrument was zeroed at the start of each day of testing. The impactor stages were cleaned according to manufacturers instructions.

Data were collected as one-minute averages. Data were collected for at least ten minutes prior to the start of each test to measure the background in the kitchen.

Although there were few operational problems with the instrument, there were short periods during some tests when the electrometers did not appear to operate properly, despite routine cleaning and zeroing of the instrument. Most of the apparent electrometer problems occurred for the larger impactor stages. These problems may have been related to the nature of the aerosol (grease droplets) or due to the elevated moisture levels in the kitchen during cooking of some foods. There were few particles in the three largest size fractions, further reducing the accuracy of the measurements.

The ELPI manufacturer provides an internal algorithm for estimating the mass concentrations for each measurement channel. The mass was estimated using a density of 1.0 $g/cm^3$. Mass estimates were reasonable for smaller particles based on comparisons to the $PM_{2.5}$ gravimetric data. But the mass estimates for the three channels measuring the larger particles were generally in poor agreement with the $PM_{10}$ gravimetric mass data and were frequently unrealistically high. This may have been due to the low number of large particles and poor counting statistics for these size fractions with a one-minute averaging time.

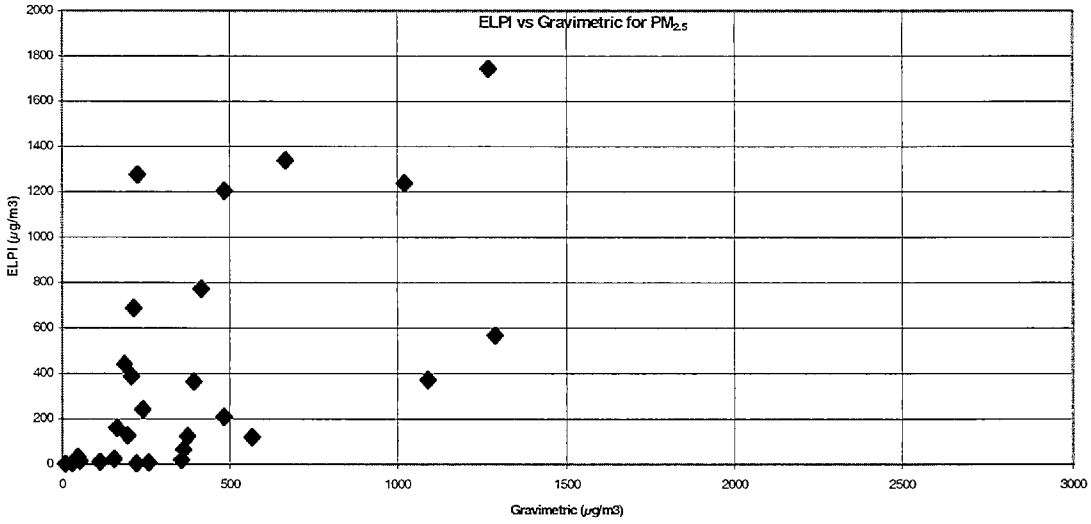
Guo et al. (2000) reported that mass estimated by the ELPI for the size fractions representing $PM_{2.5}$ could be related to $PM_{2.5}$ gravimetric mass measurements for tests measuring emissions from candles in the EPA Indoor Air Research House. They reported that the correlation could be determined empirically as:

$$\ln C_{grav} = 0.829 \ln C_{ELPI} - 0.475,$$

where $C_{grav}$ is the gravimetric measurement and $C_{ELPI}$ is the estimated $PM_{2.5}$ mass from the ELPI measurement. They reported an $R^2$ of 0.967 for N = 14.

An attempt was made to determine a relationship between ELPI and gravimetric measurements during the cooking tests in this study, but there was no correlation between the methods. During some tests, the ELPI concentrations were higher than gravimetric. But in other tests, the gravimetric concentrations were higher. The relationship between the gravimetric measurements and the ELPI mass estimates for particles in the $PM_{2.5}$ size fraction are depicted in Figure 2-4.

Figure 2-4. Relationship Between $PM_{2.5}$ Gravimetric Measurements and ELPI Measurements



### 2.4.2.4 Integrated Sampling for $PM_{2.5}$ and $PM_{10}$

Particle mass in the $PM_{2.5}$ and $PM_{10}$ size fractions was collected with the personal environmental monitors (PEMs) previously used in PTEAM (Thomas et al, 1993) and the MS&T size selective impactor that has been used in the EPA Large Building Studies (EPA, 1994), the EPA Duct Cleaning Study (Fortmann et al, 1997) and other indoor air studies. Both sampling inlets have been described in the literature (Ozkaynak et al., 1996; Turner et al., 2000). The PEM is a small personal sampler that operates at either 4 or 10 L/min. The inlets of the 4 L/min version used in this study have 10 holes that direct the flow toward an oil-coated, sintered metal impactor ring. After impaction, the remaining particles are drawn to the membrane filter in the inlet base. The MS&T Area Sampler draws the air sample through an inlet and nozzle. After the air passes through the nozzle, sized for either $PM_{2.5}$ or $PM_{10}$ cutpoints, the air impacts on an oiled sintered metal impactor plate. For both inlets, the samples were collected on tared Teflo® membrane filters.

$PM_{2.5}$ and $PM_{10}$ were collected with the PEMs in the kitchen. The MS&T samplers were used in the LR, MBR, and outdoors where the concentrations were expected to be lower. The MS&T samplers operated at 20 L/min. Following sampling, filters were stored in a freezer at –10 °C. To minimize volatilization of PM, samples were transported to the lab in coolers using ice packs.

Particle mass was determined gravimetrically. Weighing was performed in a controlled environment weighing facility using a microbalance with a 1 μg resolution. Filters were conditioned in the facility for 48 hours prior to weighing, which was performed according to the protocol developed for the EPA Large Building Study (U.S. EPA, 1993). The method detection limit (MDL) for the ARCADIS weighing protocol with the microbalance in a controlled environment facility is 8 μg mass on the filter, which results in a MDL of 3 $\mu g/m^3$ for a 2-hour sample collected at 20 L/min.

### 2.4.2.5 PAH Sampling and Analysis Method

PAHs were collected in a subset of tests. Samples were collected outdoors and in the kitchen. The pre-test results indicated that the concentrations in the living room were not substantially different than the kitchen concentrations. The sample collection method involved collection with the $PM_{10}$ size selective inlet containing a quartz filter for collection of particulate matter, followed by an in-line sampler (between the filter and pump) containing XAD-4/PUF. Samplers were operated at the required flow rate for the size cutpoint (4 L/min for the PEM in the kitchen and 20 L/min for the MS&T sampler outdoors). Following sampling, filters and sampling media were stored in a freezer at –10 °C. To minimize volatilization of material, samples were shipped to the lab in ice-packed coolers.

PAH analyses were performed by the Desert Research Institute (DRI) using a Gas Chromatography/Mass Spectrometry (GC/MS) method (Zielinska et al., 1998). Prior to extraction, the following deuterated internal standards were added to each filter-sorbent pair: naphthalene-$d_8$, acenaphthylene-$d_8$, phenanthrene-$d_{10}$, anthracene-$d_{10}$, chrysene-$d_{12}$, pyrene-$d_{10}$, benz[a]anthracene-$d_{12}$, benzo[a]pyrene-$d_{12}$, benzo[e]pyrene-$d_{12}$, benzo[k]fluoranthene-d-$_{12}$,

benzo[g,h,i]perylene-$d_{12}$, coronene - $d_{12}$, and 1-nitropyrene-$d_{11}$. The filter-XAD pairs were microwave extracted with dichloromethane. The extracts were then concentrated by rotary evaporation at 20 °C under gentle vacuum to ~1 ml and filtered through 0.45 mm Acrodiscs (Gelman Scientific), rinsing the sample flask twice with 1 ml $CH_2Cl_2$ each time. Approximately 100 µl of acetonitrile was added to the sample, and $CH_2Cl_2$ was evaporated under a gentle stream of nitrogen. The final volume was adjusted to 100 $\mu$l.

The samples were analyzed by the EI (electron impact) GC/MS technique. A Varian Star 3400CX GC equipped with an 8200CX Automatic Sampler and interfaced to a Varian Saturn 2000 Ion Trap was used for these analyses. Injections (1 $\mu$L) were made in the splitless mode onto a 30 m 5% phenylmethylsilicone fused-silica capillary column (DB-5ms, J&W Scientific). Quantification of the individual compounds was obtained by selective ion storage (SIS) technique, monitoring the molecular ion of each compound of interest and the corresponding deuterated internal standard, added prior to extraction.

Calibration curves for the GC/MS quantification were made for the most abundant and characteristic ion peaks of the PAH compounds using the deuterated species most closely matched in volatility and retention characteristics as internal standards. Authentic PAH standards (purchased from Aldrich, Inc.) plus National Institute of Standards and Technology (NIST) Standard Reference Material (SRM) 1647 (certified PAH) with the addition of deuterated internal standards were used to make calibration solutions.

A three-level calibration was performed for each compound of interest, and the calibration check (using median calibration standards) was run every ten samples to check for accuracy of analyses. If the relative accuracy of measurement (defined as a percentage difference from the standard value) was less than 20%, the instrument was recalibrated.

MDLs for the PAHs were estimated to range from 3 ng/$m^3$ for naphthalene to 6 ng/$m^3$ for coronene assuming a 1 L sample volume. Sample volumes in this study ranged from 0.75 to 1.9 $m^3$. The DRI laboratory does not include the MDL for each PAH in each sample, but calculates an uncertainty level for each compound in the sample. The uncertainty is calculated as follows:

1. Determine the replicate precision by comparing the same compound result (ng/sample) in replicate injections. The replicate precision is calculated as a fraction (difference/mean of the two values) and averaged over all replicates.
2. Then compute the root-mean-square of (A) the replicate precision from step 1 multiplied by the value for which the uncertainty is being determined, and (B) the analytical detection limit.

The effect of this calculation is that the uncertainty is equal to the MDL if the measured value is zero, and the uncertainty becomes increasingly small as the sample concentration gets very high. In this report, all concentrations are reported, but the values below the uncertainty level calculated by DRI are italicized.

### 2.4.2.6 Elemental Analyses

Elemental analyses were performed for particles collected in the $PM_{10}$ fraction during a subset of tests. Samples were analyzed by Desert Research Institute with XRF using a Kevex Corporation Model 700/8000 energy dispersive x-ray fluorescence (EDXRF) analyzer. Analyses were performed following the DRI Standard Procedure No. 2-205.2. The method is the same as used in the previous ARB study of air pollutants inside California vehicles (Rodes et al., 1998). The estimated detection limits for a 2.4 $m^3$ volume sample (20 L/min for 120 minutes) are listed in Table 2-7. The MDL for samples collected with the PEMs would be five times higher. As was the case for PAHs, DRI no longer reports the MDL, but they report the uncertainty associated with each measurement instead. Therefore, all element concentrations are presented in this report, with concentrations below the uncertainty level presented in italics.

### 2.4.2.7 Aldehydes

Samples were collected during a limited number of tests for determination of selected aldehydes. Air samples were collected on silica gel cartridges coated with acidified 2,4-dinitrophenylhydrazine (DNPH). The method is described in the *EPA Compendium of Methods for the Determination of Air Pollutants in Indoor Air* (U.S. EPA, 1999). The commercially available cartridges (Waters Sep-Pak DNPH Silica Gel Cartridge, Waters Associates, Milford, PA) contain 2.9 grams of a 55 to 105 μm chromatographic-grade silica gel. Samples of 40 to 140 L volume were collected with a vacuum pump and mass flow controller at nominal sampling rates of 0.2 to 0.3L/min. The sampling volumes were well below the maximum volumes recommended in the EPA Compendium Method TO-11A (U.S. EPA, 1999). The sampling flow rates were measured at the start and end of each collection period.

Samples collected on DNPH-coated silica gel cartridge were extracted with 5 mL of acetonitrile (UV grade). Twenty-five μL of the extract was then analyzed with a HP 1090 HPLC equipped with a diode array detector. Chromatography was performed with a C-18 reverse phase column (Zorbax ODS, 4.6 x 250 mm) using a gradient program [0 - 10 min at 60 % acetonitrile (ACN) and 40% water, 10 - 20 min at 70% ACN and 30% water, 20-25 min at 100% ACN, and 25-41 min at 60 % ACN and 40% water].

Table 2-7. Minimum Detection Limits for Elements Analyzed by XRF

| Element | ng/m$^{3a}$ | Element | ng/m$^{3a}$ |
|---|---|---|---|
| Al | 44.8 | Br | 4.5 |
| Si | 28.2 | Rb | 4.5 |
| P | 25.1 | Sr | 4.9 |
| S | 22.4 | Y | 5.8 |
| Cl | 44.8 | Zr | 7.6 |
| K | 27.3 | Mo | 12.1 |
| Ca | 20.2 | Pd | 49.3 |
| Ti | 13.0 | Ag | 53.8 |
| V | 11.2 | Cd | 53.8 |
| Cr | 8.5 | In | 58.2 |
| Mn | 7.2 | Sn | 76.1 |
| Fe | 6.7 | Sb | 80.6 |
| Co | 3.9 | Ba | 232.9 |
| Ni | 4.0 | La | 277.7 |
| Cu | 4.9 | Au | 13.9 |
| Zn | 4.9 | Hg | 11.6 |
| Ga | 8.5 | Tl | 11.2 |
| As | 7.2 | Pb | 13.4 |
| Se | 5.4 | U | 10.3 |

[a] Based on a 2.4 m$^3$ sample volume on a 37 mm filter

The HPLC was calibrated for seven carbonyl compounds: formaldehyde, acetaldehyde, propanal, butanal, benzaldehyde, pentanal, and hexanal. The target compounds were identified by comparison of their chromatographic retention times with those of the derivatized standards. Quantification was performed using an external standard method with a five-point calibration based on peak area of derivatized standards. Standards were prepared at five concentration levels (between 0.04 and 1.50 ng/μL), and a calibration curve was generated by linear regression treatment of the concentration and chromatographic response data. Performance of the instrument was verified on each day of analysis by analysis of a calibration check sample prior to analysis of samples. The practical quantitation limit, which was based on the lowest calibration standard was 3.9 μg/m$^3$ for a nominal 45 L sample volume. The MDL was 0.5 μg/m$^3$ for a 40 L sample. None of the target compounds were detected in the field blanks.

## 2.5 Data Analysis and Emission Rate Calculation

### 2.5.1 Analysis Objectives and Analysis Plan

The major analysis objectives for the study are summarized in Table 2-8. Although there were 32 cooking tests performed in the main study, there was a minimal amount of replicate testing. The design of the study was such that it addressed many different variables to characterize the range of the resultant emission rates and exposures. Due to the limited number of replicates, the significance of differences between the tests is difficult to determine. It should be recognized

that the analysis of the data consists almost exclusively of preparation of the summary statistics and comparison of summary data from different tests or groups of tests. The data set was too small to perform more complicated analyses. Much of the discussion in Section 4.0 is descriptive.

### 2.5.2 Summary Statistics

The summary statistics presented in this report are the basic statistical techniques and include the calculation of averages, standard deviations, medians, minimums, and maximums.

For real-time data on CO and $NO_2$, the data were analyzed to obtain peak and average concentrations during the cooking period and the total exposure period (duration of cooking plus time period after termination of cooking, as specified in the cooking protocol).

Table 2-8. Data Analysis Objectives and Plan

| Program Objective | Analysis Plan |
|---|---|
| Measure personal exposures and indoor concentrations for $PM_{2.5}$ and $PM_{10}$ during cooking | Calculate average and variance of concentrations during cooking exposure period at all locations in the house |
| Measure personal exposures and indoor concentrations for CO and $NO_2$ during cooking | Compute peak, average, and standard deviation of concentrations of pollutants at all locations |
| Measure personal exposures and indoor concentrations for PM in size fractions from 0.1 to 10 μm | |
| Measure personal exposure and indoor concentrations of PAHs, elements, and aldehydes during cooking | Compute peak, average, standard deviation, and median concentrations during cooking and exposure periods |
| Compare personal exposures and indoor concentrations under typical and worst-case conditions during cooking | Determine differences between indoor concentrations and emission rates |
| Determine emission rates of PM, CO, and $NO_2$ produced by cooking under typical conditions | Calculate emission rates using mass balance model |
| Determine emission rates of PM, CO, and $NO_2$ produced by cooking under worst-case conditions | Calculate emission rates using mass balance model |
| Evaluate impact of appliance type (gas range, electric range, microwave) on pollutant emission rates | Determine differences in indoor concentrations and emission rates |
| Evaluate impact of the type of cooking method on pollutant emission rates | Determine differences in indoor concentrations and emission rates |
| Evaluate impact of food type on pollutant emission rates | Determine differences in indoor concentrations and emission rates |
| Evaluate impact of cooking utensil material (iron or aluminum) on pollutant emission rates | Determine differences in indoor concentrations and emission rates |
| Evaluate impact of exposure reduction methods on cook exposure and indoor concentrations | Determine differences in indoor concentrations and emission rates |

### 2.5.3 Emission Rates

Although the primary objective of the study was to measure exposures to air contaminants due to cooking in the test house, the technical approach was developed such that emission rates and source strengths could be calculated using a dynamic mass balance model. Emission rates were calculated for $PM_{2.5}$ and $PM_{10}$, measured by the gravimetric method, CO, NO, and $NO_2$, and for selected size fractions measured with the ELPI. A dynamic mass balance model was used, as follows:

$$ER = \frac{V(a+k)T_e\left(C_i - \frac{fa}{a+k}C_o\right)}{T_c - \frac{1}{(k+a)}\left[\left(e^{(-(k+a)(T_e-T_c))}\right) - \left(e^{(-(k+a)T_e)}\right)\right]}$$

Where:

ER = emission rate ($\mu$g/hr)
V = house volume ($m^3$)
a = air exchange rate ($hr^{-1}$)
k = pollutant deposition or decay rate ($hr^{-1}$)
$C_i$ = indoor kitchen concentration ($\mu g/m^3$)
f = penetration factor (unitless)
$C_0$ = outdoor concentration ($\mu g/m^3$)
$T_e$ = total exposure time (hr)
$T_c$ = total cooking time (hr)

Parameters in the model that were measured included $C_i$, $C_0$, air exchange rate, and house volume. The value f was set to one, assuming complete mixing in the house. The penetration factor was set to 1 for all parameters. The deposition rates were set equal to 0.0 $hr^{-1}$ for CO and NO. A deposition rate of 0.8 $hr^{-1}$ was used for $NO_2$, based on data collected previously for ARB model development (Koontz et al., 1998) and published data compiled by Traynor (1999) for the California Department of Health Services Indoor Air Quality Section.

The deposition velocity for $PM_{2.5}$ was set to 0.31 $hr^{-1}$. This rate was determined based on the differences in the decay rates of $PM_{2.5}$ mass concentrations measured with the ELPI data and $SF_6$ decay rates measured to calculate air exchange rates in 14 representative tests that covered a range of cooking activities. The rate was in reasonable agreement with the rate of 0.39 $hr^{-1}$ reported by Wallace (1996) from PTEAM. The rate of 1.01 $hr^{-1}$ reported by Wallace from PTEAM was used for the $PM_{10}$ and elemental deposition rate because the ELPI data for the larger size fractions were inadequate to estimate the deposition rate during the cooking tests in this study. A deposition velocity of 1.01 $hr^{-1}$ was also used for the elements analyzed in samples of $PM_{10}$.

Data on deposition velocity for PAHs, aldehydes, and elements were not available. A deposition velocity of 0.0 was used for calculating the emission rates of PAHs, consistent with that used by Sheldon et al. (1992) in a previous ARB project. Due to the lack of data, a deposition velocity of 0.0 was also used for aldehydes.

Source strengths were calculated as $\mu$g of pollutant emitted per g of food cooked and per unit of energy ($\mu$g/BTU). Emission rates were also calculated as $\mu$g of pollutant emitted per g of food per hour ($\mu$g/g/h).

Some mass balance model calculations resulted in negative values because the outdoor concentration was higher than in the kitchen. The primary cause of this was environmental effects. For example - outdoor samples were integrated over a full day's operation while indoor samples were taken only during each cooking test. The outdoor sample tended to be more accurate because the longer sampling period provided a larger sample, while the shorter period indoor samples yielded smaller catches or values closer to the method detection or quantification limits. In addition, for some constituents, there was no measurable difference between outdoor and indoor samples because the indoor cooking emissions were balanced by the effects of multiple traffic rush hours, woodstove heating cycles, surrounding residential cooking, etc. on the day-long, average ambient pollutant levels. A related experimental error occurred when very low measured concentrations were reduced to zero or negative values when corrected for media blank data. Because it is a possibility that outdoor concentrations would exceed indoor concentrations of these pollutants, all resulting negative values are entered into the data tables as flagged zeros.

Peak concentrations for the gaseous emissions were computed using the peak kitchen concentrations and peak outdoor concentrations. This may have resulted in an underestimation of the peak concentrations due to a peak outdoor concentrations possibly not occurring at the same time as the indoor peak concentration. This is seen in only a few cases for CO and NO.

## 3.0 RESULTS

Data are presented in this section that summarize the results of the project. Summary data, including averages, standard deviations, medians, maximum, and minimum concentrations are reported for all parameters. The averages and medians are provided as reference values and are useful for comparing the emissions and resultant exposures for the different tests. However, it should be noted that the 32 tests do not represent a statistical sample of different types of cooking. The 32 tests include replicates and tests performed with the same foods or cooking methods but with different pans or oils. The 32 tests also include tests of simple exposure reduction methods. The averages, standard deviations, and medians should not be interpreted as representative for cooking in this test house or any other house.

Results from the pre-test were reported previously and are included in a complete database, which will be submitted to the ARB in electronic format.

This section contains limited discussion of the data. The results are further summarized and discussed in Section 4.0.

### 3.1 Test Descriptions

A total of 32 cooking tests were performed during the study. The tests are summarized in Table 3-1. In addition to the 32 cooking tests, eight other tests were performed. These eight additional tests included baseline measurements of CO, NO, and $NO_2$ concentrations during operation of the gas range burner (Test 33) and oven (Test 34) and evaluation of the impact of the URG sampling pumps in the kitchen on pollutant measurements (Tests 35, 36, and 37). Results are also presented for three test periods when the oven was operated at 350 °F following application of the oven-dirtying foods (Tests 38, 38R, and 39). The results from tests 33 through 39 were not included in the calculation of the summary statistics because these were not cooking tests.

As discussed in Section 2.0 and shown in Table 3-1, both the types of cooking and the foods varied. Some foods were cooked in pans on the range top burner, including bacon, tortillas, and stovetop stir frying. French fries were prepared in oil in a pan on the range top. The oven was used to broil fish and bake lasagna. Most of the cooking involved some type of frying or use of cooking oil. None of the foods in this study was prepared by boiling in water or by steaming, except during Test 20 when a full meal was prepared. The mass of food at the start of the cooking event is listed in the table. The mass includes the cooking oil if required for the food preparation. The final column presents the mass lost during the cooking event. This will include both particulate matter and vapor-phase emissions, including water from the foods. The mass lost during the cooking events ranged from 10 g during preparation of popcorn in the microwave to 1830 g during preparation of the full meal.

Cooking oils were used during preparation of a number of the foods. The type of cooking oil used is also listed in Table 3-1. Peanut oil, vegetable oil, and olive oil were used in the cooking activities. Prior to the tests, the oils were extracted and analyzed to determine the PAH concentrations. Results of the analyses of the bulk oils are presented in Table 3-2. PAHs were

detected in all five oils tested. The PAH concentrations were generally higher in the olive and peanut oils than in the canola, corn, or vegetable oils. Twenty-one of the 22 PAHs targeted for quantitation were measured in the olive oil. But, the peanut oil had higher concentrations of most of the PAHs. The peanut oil was used for stovetop stir-frying. The PAH emissions during the stir-fry cooking with peanut oil were compared to stir-fry cooking using vegetable oil in Test 30.

Table 3-1. Summary of the Cooking Tests

| Test No. | Range Type | Test | Food Description/Notes | Starting Food Mass (g) | Mass Loss (g) |
|---|---|---|---|---|---|
| 1 | Gas | Oven Cleaning | Test aborted due to oven problem | -- | -- |
| 1R | Gas | Oven Cleaning | Self-cleaning feature | 90 | 90 |
| 2 | Gas | Stovetop Stir Fry | Chicken, frozen vegetables, peanut oil | 1015 | 135 |
| 3 | Gas | Bacon | Extra lean bacon – Total | 975 | 290 |
| 3A | Gas | Bacon | Extra lean bacon – First event | 495 | 145 |
| 3B | Gas | Bacon | Extra lean bacon – Second event | 480 | 145 |
| 4 | Gas | Tortillas | White corn tortillas fried in vegetable oil | 1840 | 295 |
| 5 | Gas | French Fries | Steak cut French fries in 1 gal of vegetable oil | 4870 | 695 |
| 6 | Gas | Broil Fish | Atlantic salmon steaks with olive oil – Total | 1040 | 155 |
| 6A | Gas | Broil Fish | Atlantic salmon steaks with olive oil – 1st event | 525 | 70 |
| 6B | Gas | Broil Fish | Atlantic salmon steaks with olive oil – 2nd event | 515 | 85 |
| 7 | Gas | Bake Lasagna | Frozen lasagna with meat sauce | 1165 | 45 |
| 8 | Electric | Oven Cleaning | Self-cleaning feature | 90 | 90 |
| 9 | Electric | Stovetop Stir Fry | Chicken, frozen vegetables, peanut oil | 1060 | 195 |
| 10 | Electric | Bacon | Extra lean bacon – Total | 890 | 385 |
| 10A | Electric | Bacon | Extra lean bacon – First event | 435 | 170 |
| 10B | Electric | Bacon | Extra lean bacon – Second event | 455 | 215 |
| 11 | Electric | Tortillas | White corn tortillas fried in vegetable oil | 1905 | 380 |
| 12 | Electric | French Fries | Steak cut French fries in 1 gal of vegetable oil | 4875 | 1120 |
| 13 | Electric | Broil Fish | Atlantic salmon steaks with olive oil – Total | 835 | 90 |
| 13A | Electric | Broil Fish | Atlantic salmon steaks with olive oil – 1st event | 420 | 45 |
| 13B | Electric | Broil Fish | Atlantic salmon steaks with olive oil – 2nd event | 445 | 45 |
| 14 | Electric | Lasagna | Frozen lasagna with meat sauce | 1170 | 145 |
| 15 | Microwave | Bacon | Extra lean bacon – Total | 940 | 470 |
| 15A | Microwave | Bacon | Extra lean bacon – First event | 535 | 265 |
| 15B | Microwave | Bacon | Extra lean bacon – Second event | 405 | 205 |
| 16 | Microwave | Lasagna | Frozen lasagna with meat sauce | 1160 | 165 |
| 17 | Gas | Stovetop Stir Fry | Chicken, frozen vegetables, peanut oil – Total | 1805 | 555 |
| 17A | Gas | Stovetop Stir Fry | Chicken, frozen vegetables, peanut oil – 1st event | 905 | 290 |

Table 3-1. Summary of the Cooking Tests Cont.

| Test No. | Range Type | Test | Food Description/Notes | Starting Food Mass (g) | Mass Loss (g) |
|---|---|---|---|---|---|
| 17B | Gas | Stovetop Stir Fry | Chicken, frozen vegetables, peanut oil – 2nd event | 900 | 265 |
| 18 | Gas | Bacon | Extra lean bacon – Total | 910 | 390 |
| 18A | Gas | Bacon | Extra lean bacon – First event | 445 | 190 |
| 18B | Gas | Bacon | Extra lean bacon – Second event | 465 | 200 |
| 19 | Gas | Broil Fish | Atlantic salmon steaks with olive oil – Total | 810 | 180 |
| 19A | Gas | Broil Fish | Atlantic salmon steaks with olive oil – 1st event | 390 | 70 |
| 19B | Gas | Broil Fish | Atlantic salmon steaks with olive oil – 2nd event | 420 | 110 |
| 20 | Gas | Full Meal | Fried chicken, yellow squash, broccoli, gravy | 13145 | 1830 |
| 21 | Gas | Stovetop Stir Fry | Chicken, frozen vegetables, peanut oil – Total | 1800 | 370 |
| 21A | Gas | Stovetop Stir Fry | Chicken, frozen vegetables, peanut oil – 1st event | 885 | 175 |
| 21B | Gas | Stovetop Stir Fry | Chicken, frozen vegetables, peanut oil – 2nd event | 915 | 195 |
| 22 | Gas | French Fries | Steak cut French fries in 1 gal of vegetable oil | 5215 | 795 |
| 23 | Gas | Bake Lasagna | Frozen lasagna with meat sauce | 1170 | 200 |
| 24 | Gas | Fry Beef | Less than 30% fat ground beef, browned | 915 | 175 |
| 24R | Gas | Fry Beef | Less than 30% fat ground beef, browned | 910 | 190 |
| 25 | Gas | Pork Roast | Roasted center cut pork loin rib roast | 1920 | 195 |
| 26 | Gas | Fry Beef | Less than 30% fat ground beef, browned | 905 | 225 |
| 27 | Gas | Pork Roast | Roasted center cut pork loin rib roast | 1960 | 305 |
| 28 | Gas | Fry Beef | Less than 30% fat ground beef, browned | 915 | 140 |
| 29 | Gas | Pork Roast | Roasted center cut pork loin rib roast | 2405 | 140 |
| 30 | Gas | Stovetop Stir Fry | Chicken, frozen vegetables, peanut oil – Total | 1795 | 310 |
| 30A | Gas | Stovetop Stir Fry | Chicken, frozen vegetables, peanut oil – 1st event | 885 | 150 |
| 30B | Gas | Stovetop Stir Fry | Chicken, frozen vegetables, peanut oil – 2nd event | 910 | 160 |
| 31 | Gas | Fry Beef | Less than 30% fat ground beef, browned – Total | 1820 | 210 |
| 31A | Gas | Fry Beef | Less than 30% fat ground beef, browned – 1st event | 910 | 120 |
| 31B | Gas | Fry Beef | Less than 30% fat ground beef, browned – 2nd event | 910 | 90 |
| 32 | Microwave | Popcorn | Movie theatre butter flavor popcorn – Total | 220 | 20 |
| 32A | Microwave | Popcorn | Movie theatre butter flavor popcorn – 1st event | 110 | 10 |
| 32B | Microwave | Popcorn | Movie theatre butter flavor popcorn – 2nd event | 110 | 10 |
| 33 | Gas | Range Baseline (with pan of water) | | 0 | |
| 34 | Gas | Oven Baseline | | 0 | |

Table 3-2. Concentrations (ηg/g) of PAHs in Cooking Oils[a]

| Compound | Olive | Peanut | Canola | Corn | Vegetable |
|---|---|---|---|---|---|
| Acenaphtylene | ND[b] | ND[b] | ND[b] | ND[b] | ND[b] |
| Acenaphthene | 19.88 | ND[b] | ND[b] | ND[b] | ND[b] |
| Phenanthrene [c,m] | 10.67 | ND[b] | ND[b] | 0.72 | ND[b] |
| Anthracene [c,m] | 1.12 | 2.60 | 1.12 | 1.54 | 0.56 |
| Fluoranthene [m,t] | 4.07 | 1.28 | 0.71 | 0.65 | 1.64 |
| Pyrene [c,m] | 7.10 | 10.23 | 1.79 | ND[b] | ND[b] |
| Benz(a)anthracene [c,m] | 4.49 | 13.57 | 6.51 | ND[b] | 2.22 |
| Chrysene [c] | 3.29 | 14.73 | ND[b] | ND[b] | 2.22 |
| Benzo(b+j+k)fluoranthene | 77.33 | 72.82 | ND[b] | 4.68 | 5.28 |
| Benzo(e)pyrene [c,m] | 0.26 | 19.44 | ND[b] | 2.70 | 3.66 |
| Benzo(a)pyrene) [c,m] | 8.32 | 24.48 | ND[b] | 10.96 | 4.22 |
| Indeno[1,2,3-cd]pyrene [c] | 16.25 | 30.34 | 2.67 | 2.03 | 9.84 |
| Benzo(g,h,i)perylene | 5.31 | 26.58 | 18.72 | 3.20 | 8.40 |
| Fluorene | 1.73 | ND[b] | 0.21 | 0.28 | 0.30 |
| 1-methylphenanthrene | 4.25 | 0.74 | 3.56 | 3.59 | 4.38 |
| Perylene | 1.50 | 15.53 | ND[b] | 1.90 | 3.06 |
| Dibenzo(ah+ac)anthracene | 9.26 | 27.10 | ND[b] | 0.59 | 9.20 |
| Naphthalene | 31.70 | 13.93 | 15.53 | 13.29 | 17.58 |
| 1-methylnaphthalene | 10.11 | ND[b] | ND[b] | ND[b] | 0.66 |
| Biphenyl | 2.99 | 0.12 | 0.72 | 0.26 | ND[b] |
| 2,6+2,7-dimethylnaphthalene | 8.63 | ND[b] | ND[b] | ND[b] | ND[b] |
| 2,3,5+1-trimethylnaphthalene | 4.63 | 0.16 | 0.63 | ND[b] | 0.32 |

[a] Data are corrected for the analytical blank
[b] ND: Not detected at a concentration higher than the analytical blank
[c] Designated as a carcinogen or probable carcinogen
[m] Designated as a mutagen
[t] Designated as a teratogen

*Designations from: U.S. Environmental Protection Agency (USEPA), 1989a. Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Volume I, Part A. Interim Final. Office of Emergency and Remedial Response, Washington, DC. EPA/540/1-89/002. December.*

PAH concentrations in bulk cooking oils have not been reported previously. Benzo(a)pyrene and dibenzo(a,h)anthracene have been reported previously in fumes from refined vegetable, soybean, and vegetable oil (Shuguang et al., 1994), but the concentrations in the oil were not reported. Wu et al. (1998) also reported PAHs in fumes from cooking oils, but did not determine the concentration of the PAHs in the oils.

During each test, cooking temperatures were recorded on a continuous basis. Depending on the type of cooking activity, temperatures measured included the temperature of the food, the oven temperature, and the flame temperature (oven or range top burner). The average

temperatures during each cooking event are listed in Table 3-3 for the oven and burner. The maximum temperature is listed for the food. There was difficulty placing the thermocouple into the burner flame at exactly the same location, making it difficult to compare flame temperatures between tests. It was also difficult to place the thermocouple into the meat and fish at the start of the test. The thermocouple could not be inserted into the Salmon steaks used for the broiling tests. The temperature data should be used to evaluate relative differences between tests, rather than absolute differences.

Although it was difficult to accurately measure the temperatures in the food or the range-top burner flame temperature due to the difficultly of achieving a consistent probe placement relative to the flame, the oven temperature measurements were more repeatable. During the two replicate tests (Nos. 7 and 23) that involved baking of lasagna in the gas oven, the average oven temperatures were 190 and 198 °C and the oven burner flame temperatures averaged 225 and 243°C during the 2-hr cooking events. During two tests (Nos. 27 and 29) in which a pork roast was cooked in the oven, the average oven temperatures were 153 and 146 °C and oven burner flame temperatures were 180 and 176 °C. For both types of cooking, the variation between cooking temperatures was small. As shown in Table 3-3, similar repeatability could not be obtained for the range-top burner flame temperatures during replicate tests.

The gas or electric use during the cooking test was recorded with either a dry gas meter or a wattmeter. Results of these measurements are also included in Table 3-3. Values for gas use are based on heating content of 1000 btu/$ft^3$ of gas. The local gas company reported that the gas supplied to the test house was 1000 ± 20 btu/$ft^3$.

Table 3-3. Cooking Temperatures and Energy Use during Cooking Tests

| Test No. | Type | Range | Conditions | Temperature (°C)[a] | | | | Cooking | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Food | Oven | Oven Flame | Burner Flame | Total Event Energy Use | Energy Rate | |
| | | | | | | | | BTU | BTU/h | kJ/h |
| 1R | Oven Cleaning | Gas | Standard | NA[e] | 434 | 481 | -- | 55667 | 13917 | 14683 |
| 2 | Stovetop Stir Fry | Gas | Standard | 79.6 | -- | -- | 85[b] | 5594 | 7991 | 8431 |
| 3A | Bacon | Gas | Standard | 148 | -- | -- | 108[b] | 2133 | 5817 | 6138 |
| 3B | Bacon | Gas | Standard | 156 | -- | -- | 105[b] | 1949 | 5848 | 6170 |
| 4 | Tortillas | Gas | Standard | 172[d] | -- | -- | 97[b] | 4704 | 6272 | 6617 |
| 5 | French Fries | Gas | Standard | 182[d] | -- | -- | 729 | 8740 | 7712 | 8137 |
| 6A | Broil Fish | Gas | Standard | NM[e] | 112 | 18 | -- | 3673 | 9182 | 9687 |
| 6B | Broil Fish | Gas | Standard | NM[e] | 112 | 25 | -- | 3553 | 10658 | 11245 |
| 7 | Bake Lasagna | Gas | Standard | 47.4 | 190 | 225 | -- | 10181 | 4848 | 5115 |
| 8 | Oven Cleaning | Electric | Standard | NA | 450 | 466 | -- | 28756 | 7189 | 7585 |
| 9 | Stovetop Stir Fry | Electric | Standard | 105 | -- | -- | 289 | 2956 | 8445 | 8910 |
| 10A | Bacon | Electric | Standard | 73.7 | -- | -- | 272 | 684 | 1784 | 1883 |
| 10B | Bacon | Electric | Standard | 72.8 | -- | -- | 298 | 700 | 1501 | 1584 |
| 11 | Tortillas | Electric | Standard | 232.9[d] | -- | -- | No data[f] | 5489 | 7659 | 8081 |
| 12 | French Fries | Electric | Standard | 171.4[d] | -- | -- | 446 | 4392 | 10540 | 11120 |
| 13A | Broil Fish | Electric | Standard | NM[e] | 189 | 83 | -- | 3662 | 12206 | 12878 |
| 13B | Broil Fish | Electric | Standard | NM[e] | 187 | 110 | -- | 1889 | 6295 | 6642 |
| 14 | Lasagna | Electric | Standard | 107.9 | 178 | 182 | -- | 6629 | 3287 | 3468 |
| 15A | Bacon | Microwave | Standard | NA | -- | -- | -- | 3753 | 5118 | 5400 |
| 15B | Bacon | Microwave | Standard | NA | -- | -- | -- | 3156 | 5118 | 5400 |
| 16 | Lasagna | Microwave | Standard | NA | -- | -- | -- | 2986 | 5118 | 5400 |
| 17A | Stovetop Stir Fry | Gas | Worst Case | 124 | -- | -- | 398 | 3489 | 8052 | 2360 |
| 17B | Stovetop Stir Fry | Gas | Worst Case | 119 | -- | -- | 284 | 3394 | 8145 | 2387 |
| 18A | Bacon | Gas | Worst Case | 184.1 | -- | -- | 268 | 2642 | 6096 | 1787 |
| 18B | Bacon | Gas | Worst Case | 143.6 | -- | -- | 337 | 2613 | 5058 | 1482 |
| 19A | Broil Fish | Gas | Worst Case | NM[e] | 168 | 24 | -- | 4393 | 10544 | 3090 |
| 19B | Broil Fish | Gas | Worst Case | NM[e] | 188 | 34 | -- | 4365 | 10476 | 3070 |
| 20 | Full Meal | Gas | Standard | 192[d] | 207 | 258 | 351 | 33309 | 14275 | 4184 |
| 21A | Stovetop Stir Fry | Gas | Test 2 Replicate | 88.3 | -- | -- | 418 | 2490 | 7862 | 2304 |
| 21B | Stovetop Stir Fry | Gas | Test 2 Replicate | 100 | -- | -- | 439 | 2808 | 8423 | 2468 |
| 22 | French Fries | Gas | Test 5 Replicate | 186.9[d] | -- | -- | 277 | 11181 | 7623 | 2234 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 112.3 | 198 | 243 | -- | 10796 | 5353 | 1569 |
| 24 | Fry Beef | Gas | Cast Iron Pan | 95.3 | -- | -- | No data[f] | 1561 | 4460 | 1307 |
| 24RA | Fry Beef | Gas | Cast Iron Pan | 93.7 | -- | -- | 270 | 1727 | 4934 | 1446 |

| Test No. | Type | Range | Conditions | Temperature (°C)[a] | | | | Cooking | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Food | Oven | Oven Flame | Burner Flame | Total Event Energy Use | Energy Rate | |
| | | | | | | | | BTU | BTU/h | kJ/h |
| 24RB | Fry Beef | Gas | Cast Iron Pan | 93.0 | -- | -- | 304 | 1293 | 3693 | 1082 |
| 25 | Pork Roast | Gas | Aluminum Pan | 77.3 | -- | -- | No data[f] | 10199 | 3400 | 996 |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 94.7 | -- | -- | 264 | 1935 | 5529 | 1620 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 81.8 | 153 | 180 | -- | 11001 | 3647 | 1069 |
| 28 | Fry Beef | Gas | Range Hood Shields | 81.7 | -- | -- | 237 | 1420 | 4056 | 1189 |
| 29 | Pork Roast | Gas | Range Hood Shields | 74.0 | 146 | 176 | -- | 11039 | 3680 | 1078 |
| 30A | Stovetop Stir Fry | Gas | Vegetable Oil | 104 | -- | -- | 513 | 2363 | 7875 | 2308 |
| 30B | Stovetop Stir Fry | Gas | Vegetable Oil | 95.3 | -- | -- | 295 | 2207 | 7790 | 2283 |
| 31A | Fry Beef | Gas | Pan Lid | NM[g] | -- | -- | 300 | 1289 | 3683 | 1079 |
| 31B | Fry Beef | Gas | Pan Lid | NM[g] | -- | -- | 253 | 1165 | 3885 | 1138 |
| 32A | Popcorn | Microwave | Standard | NM[e] | -- | -- | -- | 341 | 5118 | 5400 |
| 32B | Popcorn | Microwave | Standard | NM[e] | -- | -- | -- | 341 | 5118 | 5400 |
| 33 | Burner Baseline | Gas | | NA | -- | -- | 260 | 7787 | 7787 | 2282 |
| 34 | Oven Baseline | Gas | | NA | 187 | 210 | -- | 9567 | 4783 | 1402 |
| N for Tests 1 through 32 | | | | 37 | 14 | 14 | 26 | 46 | 46 | 46 |
| Minimum | | | | 17 | 112 | 18 | 0 | 341 | 1501 | 996 |
| Maximum | | | | 178 | 450 | 481 | 729 | 55667 | 14275 | 14683 |

[a] Peak temperature of the food during the test; average temperature for burner or oven during the test
[b] Thermocouple probe location for this test was inconsistent with later tests yielding variable flame temperatures, but other parameters indicate similar cooking temperatures
[c] Not applicable
[d] Temperature of cooking oil
[e] Not measured due to difficulty of inserting thermocouple into the uncooked food at the start of the test
[f] No data due to problem with the data acquisition system
[g] Not measured because of pan lid

## 3.2 $PM_{2.5}$ and $PM_{10}$ Integrated Mass Measurements

$PM_{2.5}$ and $PM_{10}$ mass was collected on Teflon® filters using size selective impactors to achieve the desired size cut-point. Mass was determined gravimetrically. Samples were collected in the kitchen, living room, master bedroom, and outdoors. Indoor samples were collected during the duration of the total exposure period of the test, as described in Section 2.0. Outdoor air samples were collected during the duration of testing on each day. If more than one test was conducted on a day, the integrated samples were collected over the total duration of all tests on that day. This protocol was followed to increase the amount of mass on the filters to improve the accuracy and precision of the gravimetric analysis. Results of the mass measurements are presented in Tables 3-4 and 3-5. Concentrations of $PM_{2.5}$ ranged from approximately 1 to 14 $\mu g/m^3$ outdoors. Indoor concentrations during the 31 tests with PM mass measurements ranged from 9 to 2660 $\mu g/m^3$ in the kitchen, 4.5 to 3880 $\mu g/m^3$ in the LR, and 2.9 to 2820 $\mu g/m^3$ in the MBR. The highest concentrations were during oven cleaning. $PM_{10}$ concentrations outdoors ranged from none detectable to 19.3 $\mu g/m^3$. The indoor concentrations ranged from below the detection limit (3 $\mu g/m^3$) to 3660 $\mu g/m^3$ in the three rooms where samples were collected. The results of the PM mass measurements are discussed in Section 4.0.

## 3.3 Particle Concentrations and Size Distributions Measured with the ELPI

Measurements were performed continuously with the ELPI during cooking tests. One-minute averages were recorded for the data in 12 channels with size cutpoints of 0.04 to 8.38 μm geometric particle diameter. The average concentrations were calculated for the cooking period only and during the total exposure period. The results plus summary statistics for the 32 cooking tests are presented for the particle concentrations (Tables 3-6 and 3-7), dN/dlog(Dp) mode (Tables 3-8 and 3-9), and the estimated mass concentrations using the ELPI algorithm and a particle specific gravity of 1.0 g/ml (Tables 3-10 and 3-11). Results of background measurements before and after the tests are presented in Table 3-12. The background measurements were recorded for a minimum of ten minutes prior to the start of each test to measure the background PM levels in the kitchen. At the end of each day of testing, measurements were also made outdoors with the ELPI.

A strong correlation was not found between the PM mass concentrations measured with the ELPI and the mass measurements should only be used for comparison with gravimetric measurements. By comparing gravimetric outdoor data from Table 3-4 and ELPI background data from Table 3-12, it was found that concentration data was similar but not directly correlated. Therefore, the ELPI measurements should only be used as a comparison with gravimetric methods. $PM_{10}$ measurements with the ELPI are reported in Table 3-12, but it can be seen that the measurements are not useful for documenting background concentrations. Due to the low particle counts in the channels for the three largest size fractions of particles, results for the large size fraction do not appear to be reasonable in most cases when compared to the results for the gravimetric samples.

Table 3-4. $PM_{2.5}$ Mass Concentrations ($\mu g/m^3$) during Cooking Tests

| Test No. | Type | Range | Condition | K | LR | MBR | OUT |
|---|---|---|---|---|---|---|---|
| 1R | Oven Cleaning | Gas | Standard | 2032 | 3879 | 2818 | 3.8 |
| 2 | Stovetop Stir Fry | Gas | Standard | 241 | 191 | 185 | 7.0 |
| 3 | Bacon | Gas | Standard | 482 | 142 | 286 | 7.0 |
| 4 | Tortillas | Gas | Standard | 566 | 260 | 77.4 | 4.2 |
| 5 | French Fries | Gas | Standard | 195 | 71.9 | 83.3 | 4.2 |
| 6 | Broil Fish | Gas | Standard | 698 | NA | 673 | 7.0 |
| 7 | Bake Lasagna | Gas | Standard | 1090 | 139 | 48.7 | 4.9 |
| 8 | Oven Cleaning | Electric | Standard | 1020 | 577 | 106 | 13.6 |
| 9 | Stovetop Stir Fry | Electric | Standard | 214 | 1124 | 364 | 5.6 |
| 10 | Bacon | Electric | Standard | 207 | 276 | 235 | 5.7 |
| 11 | Tortillas | Electric | Standard | 1269 | 1175 | 1173 | 5.7 |
| 12 | French Fries | Electric | Standard | 374 | 94.7 | 90.2 | 5.7 |
| 13 | Broil Fish | Electric | Standard | 415 | 505 | 504 | 5.6 |
| 14 | Lasagna | Electric | Standard | 112 | 23.8 | 13.1 | 5.6 |
| 15 | Bacon | Microwave | Standard | ELPI Only | | -- | -- |
| 16 | Lasagna | Microwave | Standard | ELPI Only | | -- | -- |
| 17 | Stovetop Stir Fry | Gas | Worst Case | 1289 | 850 | 798 | 8.1 |
| 18 | Bacon | Gas | Worst Case | 484 | 711 | 771 | 8.8 |
| 19 | Broil Fish | Gas | Worst Case | 225 | 734 | 727 | 8.8 |
| 20 | Full Meal | Gas | Standard | 666 | 739 | 772 | 5.2 |
| 21 | Stovetop Stir Fry | Gas | Test 2 Replicate | 185 | 323 | 301 | 8.8 |
| 22 | French Fries | Gas | Test 5 Replicate | 162 | 91.9 | 70.5 | 4.1 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 362 | 44.6 | 45.9 | 4.0 |
| 24 | Fry Beef | Gas | Cast Iron Pan | 51.9 | 8.6 | 8.8 | 3.6 |
| 24R | Fry Beef | Gas | Cast Iron Pan | 153 | 7.73 | 8.64 | 1.5[a] |
| 25 | Pork Roast | Gas | Aluminum Pan | 46.4 | 11.4 | 11.6 | 3.6 |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 258 | 9.8 | 7.7 | 6.3 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 8.96 | 54.3 | 8.24 | 6.3 |
| 28 | Fry Beef | Gas | Range Hood Shields | 29.9 | 5.7 | 3.8 | 3.0 |
| 29 | Pork Roast | Gas | Range Hood Shields | 222 | 4.5 | 1.5[a] | 3.0 |
| 30 | Stovetop Stir Fry | Gas | Vegetable Oil | 392 | 294 | 303 | 8.1 |
| 31 | Fry Beef | Gas | Pan Lid | 355 | 5.8 | 6.4 | 4.0 |
| 32 | Popcorn | Microwave | Standard | ELPI Only | | -- | -- |
| | | | N | 30 | 29 | 29 | 29 |
| | | | Minimum | 9.0 | 4.5 | 1.5 | 1.5 |
| | | | Maximum | 2032 | 3879 | 2818 | 13.6 |

[a] – Below detectable limits. Value taken at ½ MDL.

Table 3-5. $PM_{10}$ Mass Concentrations ($\mu g/m^3$) during Cooking Tests

| Test No. | Type | Range | Conditions | K | LR | MBR | OUT |
|---|---|---|---|---|---|---|---|
| 1R | Oven Cleaning | Gas | Standard | 3661 | 2667 | 2159 | 10.4 |
| 2 | Stovetop Stir Fry | Gas | Standard | 269 | 469 | 385 | 9.7 |
| 3 | Bacon | Gas | Standard | 261 | 180 | 162 | 9.7 |
| 4 | Tortillas | Gas | Standard | 242 | 130 | 112 | 13.5 |
| 5 | French Fries | Gas | Standard | 342 | 147 | 114 | 13.5 |
| 6 | Broil Fish | Gas | Standard | 451 | 711 | 816 | NA |
| 7 | Bake Lasagna | Gas | Standard | 185 | 253 | 413 | 6.7 |
| 8 | Oven Cleaning | Electric | Standard | 395 | 634 | 957 | 9.30 |
| 9 | Stovetop Stir Fry | Electric | Standard | 1171 | 580 | 962 | 17.7 |
| 10 | Bacon | Electric | Standard | 289 | 304 | 294 | 8.0 |
| 11 | Tortillas | Electric | Standard | 1315 | 1213 | 1182 | 8.0 |
| 12 | French Fries | Electric | Standard | 207 | 131 | 118 | 8.0 |
| 13 | Broil Fish | Electric | Standard | 723 | 509 | 509 | 17.7 |
| 14 | Lasagna | Electric | Standard | 352 | 19.9 | 13.9 | 10.5 |
| 15 | Bacon | Microwave | Standard | ELPI Only | | -- | -- |
| 16 | Lasagna | Microwave | Standard | ELPI Only | | -- | -- |
| 17 | Stovetop Stir Fry | Gas | Worst Case | 1436 | 1361 | 1356 | 7.6 |
| 18 | Bacon | Gas | Worst Case | 753 | 792 | 834 | 14.4 |
| 19 | Broil Fish | Gas | Worst Case | 729 | 743 | 778 | 14.4 |
| 20 | Full Meal | Gas | Standard | 817 | 20.3 | 799 | 13.2 |
| 21 | Stovetop Stir Fry | Gas | Test 2 Replicate | 774 | 642 | 554 | 14.4 |
| 22 | French Fries | Gas | Test 5 Replicate | 183 | 114 | 103 | 5.9 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 99.1 | 54.6 | 52.5 | 6.5 |
| 24 | Fry Beef | Gas | Cast Iron Pan | 98.2 | 23.6 | 18.9 | 6.2 |
| 24R | Fry Beef | Gas | Cast Iron Pan | 189 | 24.2 | 22.7 | 1.5[a] |
| 25 | Pork Roast | Gas | Aluminum Pan | 60.5 | 20.3 | 17.7 | 6.2 |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 277 | 17.7 | 45.5 | 19.3 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 69.5 | 20.5 | 14.3 | 19.3 |
| 28 | Fry Beef | Gas | Range Hood Shields | 136 | 20.4 | 14.6 | 7.3 |
| 29 | Pork Roast | Gas | Range Hood Shields | 38.7 | 1.5[a] | 6.4 | 7.3 |
| 30 | Stovetop Stir Fry | Gas | Vegetable Oil | 913 | 587 | 606 | 7.6 |
| 31 | Fry Beef | Gas | Pan Lid | 135 | 22.7 | 17.1 | 6.50 |
| 32 | Popcorn | Microwave | Standard | ELPI Only | | -- | -- |
| | | | N | 30 | 30 | 30 | 28 |
| | | | Minimum | 38.7 | 0.4 | 6.4 | 1.5 |
| | | | Maximum | 3661 | 2667 | 2159 | 19.3 |

[a] – Below detectable limits. Value taken at ½ MDL.

Table 3-6. ELPI Average Particle Concentrations in 12 Size Fractions during the Cooking Period

| | | | Concentration (Particles/cm$^3$) in Size Fraction | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Range** | **Food** | **0.04** | **0.08** | **0.13** | **0.21** | **0.32** | **0.51** | **0.81** | **1.29** | **2.02** | **3.18** | **5.24** | **8.38** | **$PM_{2.5}$** | **$PM_{10}$** |
| 1 | Gas | Oven Cleaning | 227,014 | 90,766 | 45,390 | 33,091 | 35,469 | 19,045 | 7,900 | 2,100 | 157 | 73 | 47 | 45 | 460,933 | 461,098 |
| 1R | Gas | Oven Cleaning | 280,903 | 171,750 | 116,159 | 94,022 | 73,510 | 44,320 | 1,921 | 124 | 40 | 25 | 21 | 26 | 782,750 | 782,822 |
| 2 | Gas | Stovetop Stir Fry | 83,240 | 36,312 | 15,621 | 6,697 | 1,044 | 202 | 54 | 25 | 12 | 7 | 5 | 5 | 143,205 | 143,222 |
| 3 | Gas | Bacon | 61,361 | 37,401 | 24,554 | 14,065 | 1,591 | 190 | 29 | 10 | 4 | 1 | 1 | 2 | 139,205 | 139,209 |
| 3A | Gas | Bacon | 57,365 | 25,669 | 14,008 | 6,186 | 561 | 97 | 19 | 8 | 4 | 2 | 1 | 2 | 103,917 | 103,922 |
| 3B | Gas | Bacon | 57,478 | 42,031 | 29,058 | 17,334 | 2,104 | 247 | 38 | 12 | 4 | 1 | 1 | 2 | 148,308 | 148,313 |
| 4 | Gas | Tortillas | 143,682 | 47,460 | 10,278 | 1,848 | 195 | 72 | 19 | 12 | 8 | 3 | 2 | 2 | 203,574 | 203,581 |
| 5 | Gas | French Fries | 125,329 | 38,240 | 12,358 | 3,548 | 273 | 83 | 23 | 12 | 9 | 3 | 2 | 2 | 179,875 | 179,882 |
| 6 | Gas | Broil Fish | 87,260 | 56,137 | 39,931 | 32,348 | 19,494 | 7,359 | 754 | 66 | 14 | 6 | 4 | 6 | 243,364 | 243,381 |
| 6A | Gas | Broil Fish | 82,172 | 49,462 | 19,305 | 5,561 | 865 | 129 | 16 | 8 | 4 | 3 | 2 | 3 | 157,523 | 157,531 |
| 6B | Gas | Broil Fish | 90,114 | 57,559 | 39,358 | 33,643 | 23,157 | 9,936 | 1,338 | 124 | 27 | 13 | 10 | 12 | 255,257 | 255,293 |
| 7 | Gas | Bake Lasagna | 219,036 | 89,693 | 40,291 | 24,344 | 4,128 | 818 | 127 | 27 | 7 | 3 | 2 | 3 | 378,472 | 378,480 |
| 8 | Electric | Oven Cleaning | 151,442 | 73,683 | 45,749 | 44,183 | 16,940 | 6,125 | 800 | 105 | 10 | 2 | 10 | 1 | 339,036 | 339,049 |
| 9 | Electric | Stovetop Stir Fry | 81,015 | 45,301 | 17,063 | 8,156 | 2,088 | 932 | 274 | 103 | 37 | 17 | 8 | 5 | 154,971 | 155,000 |
| 10 | Electric | Bacon | 20,562 | 13,792 | 11,641 | 12,147 | 3,168 | 451 | 30 | 8 | 0 | 3 | 0 | 1 | 61,799 | 61,804 |
| 10A | Electric | Bacon | 11,925 | 5,865 | 3,929 | 3,210 | 596 | 71 | 11 | 3 | 0 | 2 | 0 | 1 | 25,610 | 25,614 |
| 10B | Electric | Bacon | 26,368 | 18,892 | 14,799 | 14,660 | 3,604 | 519 | 40 | 11 | 1 | 4 | 1 | 1 | 78,894 | 78,899 |
| 11 | Electric | Tortillas | 136,828 | 125,806 | 90,918 | 48,176 | 13,700 | 3,716 | 566 | 119 | 26 | 12 | 6 | 7 | 419,854 | 419,879 |
| 12 | Electric | French Fries | 66,141 | 30,406 | 7,305 | 2,153 | 306 | 76 | 18 | 8 | 2 | 3 | 1 | 2 | 106,416 | 106,422 |
| 13 | Electric | Broil Fish | 70,217 | 39,672 | 27,294 | 25,406 | 7,238 | 1,988 | 169 | 19 | 4 | 1 | 1 | 1 | 172,007 | 172,010 |
| 13A | Electric | Broil Fish | 23,185 | 10,800 | 5,246 | 3,397 | 806 | 233 | 27 | 5 | 2 | 1 | 1 | 1 | 43,702 | 43,704 |
| 13B | Electric | Broil Fish | 66,827 | 36,244 | 23,784 | 23,234 | 6,785 | 1,810 | 145 | 16 | 4 | 1 | 1 | 1 | 158,848 | 158,851 |
| 14 | Electric | Lasagna | 7,715 | 3,556 | 1,585 | 692 | 101 | 9 | 0 | 0 | 1 | 0 | 1 | 1 | 13,659 | 13,661 |
| 15 | Microwave | Lasagna | 2,561 | 850 | 762 | 465 | 170 | 60 | 5 | 2 | 1 | 0 | 0 | 0 | 4,876 | 4,876 |
| 16 | Microwave | Bacon | 2,299 | 1,123 | 797 | 640 | 263 | 121 | 27 | 10 | 3 | 1 | 1 | 0 | 5,283 | 5,285 |
| 16A | Microwave | Bacon | 2,235 | 989 | 753 | 598 | 251 | 109 | 22 | 7 | 2 | 2 | 1 | 0 | 4,967 | 4,969 |
| 16B | Microwave | Bacon | 2,115 | 1,173 | 831 | 696 | 288 | 141 | 34 | 13 | 4 | 2 | 1 | 0 | 5,296 | 5,298 |
| 17 | Gas | Stovetop Stir Fry | 126,334 | 44,158 | 29,020 | 24,276 | 8,102 | 2,796 | 0 | 0 | 0 | 0 | 0 | 0 | 234,686 | 234,686 |
| 17A | Gas | Stovetop Stir Fry | 100,731 | 32,731 | 17,825 | 11,049 | 3,585 | 1,397 | 0 | 0 | 0 | 0 | 0 | 0 | 167,319 | 167,319 |
| 17B | Gas | Stovetop Stir Fry | 134,944 | 48,289 | 31,148 | 30,030 | 10,092 | 3,408 | 0 | 0 | 0 | 0 | 0 | 0 | 257,911 | 257,911 |
| 18 | Gas | Bacon | 75,732 | 59,894 | 47,714 | 52,855 | 16,203 | 4,089 | 296 | 61 | 13 | 4 | 2 | 3 | 256,855 | 256,864 |
| 18A | Gas | Bacon | 101,005 | 63,976 | 38,823 | 26,955 | 5,552 | 975 | 99 | 33 | 11 | 5 | 4 | 4 | 237,429 | 237,443 |
| 18B | Gas | Bacon | 91,291 | 58,998 | 44,217 | 53,728 | 17,796 | 4,565 | 319 | 67 | 14 | 5 | 3 | 4 | 270,995 | 271,007 |
| 19 | Gas | Broil Fish | 205,502 | 155,142 | 114,378 | 77,253 | 7,803 | 1,013 | 99 | 41 | 0 | 0 | 0 | 0 | 561,232 | 561,232 |

| Concentration (Particles/cm$^3$) in Size Fraction | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Range** | **Food** | **0.04** | **0.08** | **0.13** | **0.21** | **0.32** | **0.51** | **0.81** | **1.29** | **2.02** | **3.18** | **5.24** | **8.38** | **$PM_{2.5}$** | **$PM_{10}$** |
| 19A | Gas | Broil Fish | 317,050 | 217,412 | 109,773 | 37,096 | 2,815 | 497 | 122 | 67 | 0 | 0 | 0 | 0 | 684,833 | 684,833 |
| 19B | Gas | Broil Fish | 248,370 | 250,981 | 184,203 | 101,825 | 10,370 | 1,364 | 125 | 59 | 0 | 0 | 0 | 0 | 797,297 | 797,297 |
| 20 | Gas | Full Meal | 460,280 | 168,719 | 84,717 | 65,281 | 21,608 | 4,240 | 517 | 110 | 27 | 14 | 10 | 14 | 805,499 | 805,536 |
| 21 | Gas | Stovetop Stir Fry | 96,357 | 35,925 | 19,854 | 14,191 | 2,381 | 434 | 96 | 48 | 20 | 9 | 5 | 4 | 169,307 | 169,324 |
| 21A | Gas | Stovetop Stir Fry | 103,859 | 34,203 | 14,591 | 9,222 | 1,546 | 305 | 68 | 36 | 17 | 9 | 6 | 5 | 163,847 | 163,867 |
| 21B | Gas | Stovetop Stir Fry | 146,088 | 52,646 | 29,306 | 21,930 | 4,286 | 800 | 168 | 79 | 32 | 16 | 9 | 7 | 255,334 | 255,366 |
| 22 | Gas | French Fries | 124,804 | 66,432 | 25,839 | 7,280 | 531 | 131 | 26 | 14 | 7 | 3 | 2 | 2 | 225,065 | 225,073 |
| 22A | Gas | French Fries | 99,122 | 46,337 | 11,000 | 2,371 | 283 | 80 | 16 | 10 | 5 | 2 | 2 | 2 | 159,225 | 159,232 |
| 22B | Gas | French Fries | 162,854 | 88,602 | 49,758 | 17,435 | 1,009 | 226 | 43 | 23 | 10 | 4 | 2 | 3 | 319,960 | 319,969 |
| 23 | Gas | Bake Lasagna | 108,482 | 49,030 | 14,956 | 3,062 | 153 | 38 | 9 | 6 | 0 | 0 | 0 | 0 | 175,735 | 175,735 |
| 24 | Gas | Fry Beef | 9,377 | 2,009 | 659 | 226 | 59 | 22 | 4 | 2 | 2 | 0 | 0 | 0 | 12,359 | 12,361 |
| 24R | Gas | Fry Beef | 24,998 | 10,623 | 2,388 | 577 | 99 | 26 | 7 | 3 | 2 | 1 | 1 | 1 | 38,723 | 38,725 |
| 24RA | Gas | Fry Beef | 41,458 | 12,285 | 2,406 | 531 | 93 | 26 | 8 | 4 | 2 | 1 | 1 | 1 | 56,814 | 56,817 |
| 24RB | Gas | Fry Beef | 10,975 | 7,363 | 1,703 | 446 | 84 | 22 | 6 | 2 | 2 | 1 | 0 | 0 | 20,603 | 20,604 |
| 25 | Gas | Pork Roast | 20,757 | 12,883 | 5,237 | 2,399 | 318 | 31 | 2 | 1 | 2 | 0 | 0 | 0 | 41,628 | 41,628 |
| 26 | Gas | Fry Beef | 6,912 | 970 | 359 | 164 | 61 | 17 | 5 | 2 | 0 | 0 | 0 | 0 | 8,490 | 8,490 |
| 27 | Gas | Pork Roast | 6,552 | 2,534 | 891 | 375 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10,352 | 10,352 |
| 28 | Gas | Fry Beef | 0 | 746 | 348 | 142 | 64 | 16 | 2 | 1 | 0 | 0 | 0 | 2 | 1,319 | 1,321 |
| 29 | Gas | Pork Roast | 1,739 | 271 | 97 | 60 | 24 | 5 | 1 | 0 | 1 | 0 | 0 | 0 | 2,198 | 2,199 |
| 30 | Gas | Stovetop Stir Fry | 94,119 | 32,867 | 20,025 | 10,291 | 2,937 | 1,046 | 255 | 59 | 20 | 9 | 5 | 3 | 161,618 | 161,635 |
| 30A | Gas | Stovetop Stir Fry | 55,191 | 16,141 | 7,058 | 2,849 | 813 | 341 | 100 | 27 | 12 | 6 | 5 | 3 | 82,533 | 82,547 |
| 30B | Gas | Stovetop Stir Fry | 91,171 | 29,215 | 18,962 | 10,849 | 3,091 | 1,063 | 240 | 56 | 19 | 7 | 5 | 3 | 154,666 | 154,680 |
| 31 | Gas | Fry Beef | 0 | 536 | 155 | 89 | 32 | 6 | 11 | 0 | 3 | 0 | 1 | 6 | 832 | 839 |
| 31A | Gas | Fry Beef | 0 | 508 | 176 | 92 | 30 | 6 | 9 | 0 | 2 | 0 | 0 | 3 | 822 | 825 |
| 31B | Gas | Fry Beef | 0 | 575 | 147 | 92 | 34 | 6 | 12 | 0 | 4 | 0 | 1 | 8 | 870 | 879 |
| 32 | Microwave | Popcorn | 7,366 | 2,582 | 1,300 | 811 | 191 | 50 | 7 | 2 | 1 | 0 | 0 | 0 | 12,310 | 12,311 |
| 33 | Gas | Range Baseline | 27,883 | 12,847 | 2,422 | 651 | 153 | 47 | 12 | 5 | 2 | 2 | 1 | 1 | 44,022 | 44,026 |
| 34 | Gas | Oven Baseline | 47,611 | 24,904 | 7,174 | 2,306 | 464 | 80 | 5 | 0 | 0 | 0 | 0 | 0 | 82,544 | 82,544 |
| N | | | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 |
| Minimum | | | 0 | 271 | 97 | 60 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 822 | 825 |
| Maximum | | | 460,280 | 250,981 | 184,203 | 101,825 | 73,510 | 44,320 | 1,921 | 124 | 40 | 25 | 21 | 26 | 805,499 | 805,536 |

Table 3-7. Average Particle Concentrations in 12 Size Fractions during the Total Exposure Period of Cooking Events

| | | | Concentration (Particles/cm$^3$) in Size Fraction | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Range** | **Food** | **0.04** | **0.08** | **0.13** | **0.21** | **0.32** | **0.51** | **0.81** | **1.29** | **2.02** | **3.18** | **5.24** | **8.38** | **$PM_{2.5}$** | **$PM_{10}$** |
| 1 | Gas | Oven Cleaning | 169,009 | 68,156 | 34,313 | 25,266 | 31,146 | 18,675 | 6,519 | 1,783 | 126 | 56 | 35 | 34 | 354,993 | 355,119 |
| 1R | Gas | Oven Cleaning | 229,191 | 141,593 | 98,010 | 80,803 | 62,748 | 38,967 | 1,872 | 97 | 31 | 19 | 16 | 20 | 653,311 | 653,367 |
| 2 | Gas | Stovetop Stir Fry | 69,580 | 34,140 | 19,792 | 9,807 | 1,504 | 278 | 71 | 31 | 13 | 6 | 3 | 4 | 135,217 | 135,230 |
| 3 | Gas | Bacon | 54,250 | 36,875 | 25,754 | 16,178 | 2,039 | 230 | 34 | 10 | 4 | 1 | 1 | 2 | 135,373 | 135,376 |
| 3A | Gas | Bacon | 62,448 | 36,422 | 23,563 | 13,331 | 1,474 | 177 | 27 | 9 | 4 | 1 | 1 | 2 | 137,456 | 137,460 |
| 3B | Gas | Bacon | 46,289 | 37,413 | 27,978 | 19,027 | 2,601 | 282 | 41 | 11 | 4 | 1 | 0 | 2 | 133,648 | 133,651 |
| 4 | Gas | Tortillas | 109,938 | 53,960 | 19,598 | 4,588 | 237 | 85 | 18 | 11 | 7 | 2 | 1 | 1 | 188,442 | 188,446 |
| 5 | Gas | French Fries | 101,538 | 33,164 | 14,413 | 5,544 | 366 | 105 | 26 | 13 | 8 | 2 | 2 | 1 | 155,178 | 155,182 |
| 6 | Gas | Broil Fish | 91,059 | 55,516 | 48,509 | 47,698 | 28,707 | 11,840 | 1,365 | 105 | 21 | 9 | 6 | 9 | 284,818 | 284,843 |
| 6A | Gas | Broil Fish | 86,951 | 56,052 | 40,183 | 32,094 | 18,662 | 6,766 | 620 | 53 | 11 | 5 | 3 | 5 | 241,391 | 241,404 |
| 6B | Gas | Broil Fish | 95,525 | 55,213 | 57,004 | 63,426 | 38,799 | 16,928 | 2,111 | 157 | 31 | 14 | 10 | 13 | 329,195 | 329,232 |
| 7 | Gas | Bake Lasagna | 169,667 | 72,118 | 35,355 | 22,670 | 3,802 | 727 | 107 | 21 | 6 | 2 | 1 | 2 | 304,472 | 304,478 |
| 8 | Electric | Oven Cleaning | 124,142 | 62,247 | 39,152 | 39,288 | 15,705 | 5,479 | 689 | 87 | 8 | 1 | 10 | 0 | 286,796 | 286,808 |
| 9 | Electric | Stovetop Stir Fry | 66,622 | 32,037 | 16,338 | 10,016 | 2,976 | 1,340 | 397 | 144 | 44 | 17 | 6 | 3 | 129,914 | 129,939 |
| 10 | Electric | Bacon | 21,681 | 19,129 | 17,320 | 21,733 | 7,058 | 1,316 | 76 | 13 | 1 | 4 | 0 | 1 | 88,328 | 88,333 |
| 10A | Electric | Bacon | 18,607 | 12,061 | 10,571 | 11,294 | 3,020 | 428 | 27 | 7 | 0 | 3 | 0 | 1 | 56,014 | 56,018 |
| 10B | Electric | Bacon | 24,277 | 25,043 | 22,961 | 30,449 | 10,427 | 2,057 | 118 | 19 | 2 | 4 | 0 | 1 | 115,354 | 115,359 |
| 11 | Electric | Tortillas | 70,689 | 85,950 | 86,298 | 66,471 | 28,195 | 5,346 | 682 | 124 | 23 | 9 | 5 | 5 | 343,778 | 343,798 |
| 12 | Electric | French Fries | 79,847 | 41,988 | 18,266 | 6,071 | 612 | 157 | 36 | 15 | 2 | 5 | 1 | 1 | 146,994 | 147,001 |
| 13 | Electric | Broil Fish | 79,560 | 46,734 | 33,489 | 32,121 | 9,333 | 2,832 | 429 | 49 | 6 | 2 | 1 | 1 | 204,554 | 204,558 |
| 13A | Electric | Broil Fish | 70,989 | 40,394 | 27,990 | 25,830 | 7,325 | 2,022 | 174 | 19 | 4 | 2 | 1 | 1 | 174,748 | 174,752 |
| 13B | Electric | Broil Fish | 88,688 | 53,463 | 39,295 | 38,733 | 11,440 | 3,682 | 696 | 81 | 8 | 2 | 0 | 1 | 236,086 | 236,090 |
| 14 | Electric | Lasagna | 8,772 | 4,212 | 1,911 | 863 | 126 | 6 | 0 | 0 | 0 | 0 | 1 | 1 | 15,890 | 15,892 |
| 15 | Microwave | Lasagna | 2,232 | 791 | 678 | 420 | 156 | 58 | 5 | 2 | 1 | 0 | 0 | 0 | 4,342 | 4,342 |
| 16 | Microwave | Bacon | 2,378 | 1,229 | 847 | 663 | 268 | 127 | 30 | 11 | 3 | 1 | 0 | 0 | 5,556 | 5,558 |
| 16A | Microwave | Bacon | 2,360 | 1,107 | 787 | 622 | 255 | 115 | 25 | 9 | 2 | 1 | 1 | 0 | 5,281 | 5,284 |
| 16B | Microwave | Bacon | 2,399 | 1,364 | 913 | 708 | 282 | 141 | 35 | 13 | 4 | 1 | 0 | 0 | 5,861 | 5,863 |
| 17 | Gas | Stovetop Stir Fry | 116,545 | 42,779 | 28,851 | 27,286 | 9,578 | 3,121 | 0 | 0 | 0 | 0 | 0 | 0 | 228,160 | 228,160 |
| 17A | Gas | Stovetop Stir Fry | 124,218 | 43,097 | 28,476 | 22,681 | 7,548 | 2,627 | 0 | 0 | 0 | 0 | 0 | 0 | 228,646 | 228,646 |
| 17B | Gas | Stovetop Stir Fry | 111,280 | 42,620 | 29,156 | 30,585 | 11,029 | 3,475 | 0 | 0 | 0 | 0 | 0 | 0 | 228,146 | 228,146 |
| 18 | Gas | Bacon | 65,626 | 52,039 | 43,777 | 54,568 | 18,717 | 4,618 | 322 | 67 | 14 | 4 | 2 | 3 | 239,747 | 239,756 |
| 18A | Gas | Bacon | 70,509 | 60,410 | 49,063 | 52,605 | 15,644 | 3,920 | 287 | 59 | 13 | 4 | 2 | 3 | 252,510 | 252,519 |
| 18B | Gas | Bacon | 61,324 | 44,498 | 39,014 | 56,431 | 21,553 | 5,260 | 353 | 75 | 15 | 4 | 2 | 2 | 228,523 | 228,532 |
| 19 | Gas | Broil Fish | 166,267 | 124,286 | 104,311 | 111,548 | 18,776 | 2,032 | 157 | 50 | 0 | 0 | 0 | 0 | 527,427 | 527,427 |

| Concentration (Particles/cm$^3$) in Size Fraction | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Range** | **Food** | **0.04** | **0.08** | **0.13** | **0.21** | **0.32** | **0.51** | **0.81** | **1.29** | **2.02** | **3.18** | **5.24** | **8.38** | **$PM_{2.5}$** | **$PM_{10}$** |
| 19A | Gas | Broil Fish | 194,131 | 128,309 | 94,801 | 70,441 | 7,085 | 916 | 92 | 36 | 0 | 0 | 0 | 0 | 495,812 | 495,812 |
| 19B | Gas | Broil Fish | 140,611 | 121,052 | 113,773 | 150,893 | 29,921 | 3,097 | 219 | 64 | 0 | 0 | 0 | 0 | 559,630 | 559,630 |
| 20 | Gas | Full Meal | 184,066 | 70,895 | 40,228 | 37,416 | 15,266 | 5,702 | 927 | 105 | 10 | 5 | 4 | 5 | 354,615 | 354,629 |
| 21 | Gas | Stovetop Stir Fry | 97,480 | 37,167 | 23,549 | 18,655 | 3,647 | 638 | 130 | 59 | 22 | 10 | 5 | 3 | 181,346 | 181,363 |
| 21A | Gas | Stovetop Stir Fry | 83,702 | 31,678 | 17,435 | 12,200 | 1,888 | 340 | 78 | 40 | 17 | 8 | 4 | 3 | 147,377 | 147,392 |
| 21B | Gas | Stovetop Stir Fry | 109,861 | 42,092 | 28,976 | 24,368 | 5,201 | 902 | 175 | 76 | 27 | 11 | 5 | 3 | 211,678 | 211,698 |
| 22 | Gas | French Fries | 99,049 | 50,020 | 24,758 | 9,333 | 615 | 142 | 26 | 13 | 6 | 2 | 1 | 1 | 183,963 | 183,967 |
| 22A | Gas | French Fries | 115,484 | 61,063 | 20,155 | 4,885 | 418 | 109 | 22 | 12 | 6 | 3 | 2 | 2 | 202,154 | 202,161 |
| 22B | Gas | French Fries | 87,198 | 42,137 | 27,820 | 12,380 | 749 | 164 | 30 | 14 | 6 | 1 | 1 | 1 | 170,498 | 170,500 |
| 23 | Gas | Bake Lasagna | 96,610 | 42,043 | 15,604 | 3,991 | 169 | 36 | 7 | 4 | 0 | 0 | 0 | 0 | 158,463 | 158,463 |
| 24 | Gas | Fry Beef | 10,862 | 2,171 | 563 | 197 | 59 | 22 | 4 | 2 | 2 | 0 | 0 | 0 | 13,881 | 13,882 |
| 24R | Gas | Fry Beef | 19,269 | 8,956 | 2,044 | 498 | 88 | 23 | 6 | 3 | 2 | 1 | 0 | 0 | 30,890 | 30,891 |
| 24RA | Gas | Fry Beef | 28,778 | 11,504 | 2,573 | 612 | 103 | 27 | 8 | 4 | 2 | 1 | 1 | 1 | 43,612 | 43,614 |
| 24RB | Gas | Fry Beef | 11,021 | 6,745 | 1,586 | 399 | 74 | 20 | 5 | 2 | 2 | 0 | 0 | 0 | 19,853 | 19,854 |
| 25 | Gas | Pork Roast | 16,186 | 10,437 | 4,305 | 1,954 | 257 | 25 | 1 | 1 | 2 | 0 | 0 | 0 | 33,166 | 33,167 |
| 26 | Gas | Fry Beef | 11,324 | 1,439 | 393 | 165 | 65 | 19 | 6 | 2 | 0 | 0 | 0 | 0 | 13,413 | 13,413 |
| 27 | Gas | Pork Roast | 5,157 | 1,981 | 728 | 329 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8,195 | 8,195 |
| 28 | Gas | Fry Beef | 4 | 632 | 285 | 118 | 60 | 14 | 2 | 0 | 1 | 0 | 0 | 2 | 1,116 | 1,118 |
| 29 | Gas | Pork Roast | 1,499 | 285 | 115 | 69 | 26 | 5 | 1 | 0 | 1 | 0 | 0 | 0 | 2,002 | 2,003 |
| 30 | Gas | Stovetop Stir Fry | 96,241 | 32,529 | 20,883 | 11,768 | 3,448 | 1,178 | 146 | 33 | 12 | 5 | 3 | 2 | 166,237 | 166,246 |
| 30A | Gas | Stovetop Stir Fry | 94,992 | 33,763 | 20,291 | 10,171 | 2,904 | 1,043 | 259 | 59 | 21 | 9 | 5 | 3 | 163,502 | 163,520 |
| 30B | Gas | Stovetop Stir Fry | 97,514 | 31,521 | 21,422 | 13,164 | 3,924 | 1,296 | 47 | 11 | 4 | 1 | 1 | 1 | 168,902 | 168,905 |
| 31 | Gas | Fry Beef | 0 | 528 | 147 | 86 | 32 | 6 | 12 | 0 | 4 | 0 | 1 | 7 | 814 | 822 |
| 31A | Gas | Fry Beef | 0 | 528 | 157 | 89 | 31 | 6 | 11 | 0 | 3 | 0 | 1 | 5 | 825 | 831 |
| 31B | Gas | Fry Beef | 0 | 529 | 137 | 83 | 33 | 5 | 12 | 0 | 5 | 0 | 1 | 9 | 804 | 814 |
| 32 | Microwave | Popcorn | 7,926 | 2,648 | 1,308 | 808 | 197 | 54 | 8 | 2 | 1 | 0 | 0 | 0 | 12,952 | 12,953 |
| 33 | Gas | Range Baseline | 23,512 | 21,234 | 4,661 | 876 | 156 | 46 | 10 | 4 | 2 | 2 | 1 | 1 | 50,501 | 50,505 |
| 34 | Gas | Oven Baseline | 34,831 | 19,366 | 6,054 | 2,038 | 430 | 70 | 4 | 0 | 0 | 0 | 0 | 0 | 62,793 | 62,793 |
| N | | | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 |
| Minimum | | | 0 | 285 | 115 | 69 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 804 | 814 |
| Maximum | | | 229,191 | 141,593 | 113,773 | 150,893 | 62,748 | 38,967 | 2,111 | 157 | 44 | 19 | 16 | 20 | 653,311 | 653,367 |

Table 3-8. Average Particle Concentrations [dN/dlog (Dp)] in 12 Size Fractions during the Cooking Period

| Particle Concentrations [dN/dlog (Dp)] in Size Fractions | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Range** | **Food** | **0.04** | **0.08** | **0.13** | **0.21** | **0.32** | **0.51** | **0.81** | **1.29** | **2.02** | **3.18** | **5.24** | **8.38** |
| 1 | Gas | Oven Cleaning | 754,123 | 373,466 | 219,596 | 176,874 | 189,588 | 90,609 | 41,132 | 9,977 | 858 | 349 | 208 | 249 |
| 1R | Gas | Oven Cleaning | 933,140 | 706,681 | 561,976 | 502,560 | 392,921 | 210,860 | 10,002 | 590 | 221 | 119 | 92 | 145 |
| 2 | Gas | Stovetop Stir Fry | 276,517 | 149,407 | 75,572 | 35,795 | 5,579 | 960 | 280 | 118 | 67 | 34 | 20 | 27 |
| 3 | Gas | Bacon | 203,837 | 153,890 | 118,792 | 75,180 | 8,504 | 905 | 151 | 47 | 20 | 6 | 4 | 10 |
| 3A | Gas | Bacon | 190,562 | 105,616 | 67,772 | 33,066 | 2,999 | 461 | 99 | 39 | 21 | 9 | 6 | 10 |
| 3B | Gas | Bacon | 190,939 | 172,942 | 140,585 | 92,655 | 11,249 | 1,173 | 196 | 57 | 25 | 6 | 5 | 13 |
| 4 | Gas | Tortillas | 477,302 | 195,279 | 49,723 | 9,878 | 1,044 | 341 | 98 | 56 | 44 | 16 | 10 | 9 |
| 5 | Gas | French Fries | 416,334 | 157,340 | 59,788 | 18,964 | 1,461 | 397 | 117 | 59 | 47 | 15 | 11 | 9 |
| 6 | Gas | Broil Fish | 289,871 | 230,981 | 193,187 | 172,901 | 104,200 | 35,014 | 3,926 | 316 | 77 | 30 | 19 | 34 |
| 6A | Gas | Broil Fish | 272,969 | 203,515 | 93,396 | 29,726 | 4,624 | 614 | 84 | 40 | 24 | 14 | 11 | 17 |
| 6B | Gas | Broil Fish | 299,354 | 236,829 | 190,414 | 179,828 | 123,777 | 47,273 | 6,968 | 590 | 148 | 64 | 44 | 69 |
| 7 | Gas | Bake Lasagna | 727,623 | 369,051 | 194,929 | 130,123 | 22,067 | 3,890 | 660 | 128 | 39 | 15 | 8 | 16 |
| 8 | Electric | Oven Cleaning | 503,080 | 303,173 | 221,332 | 236,164 | 90,546 | 29,141 | 4,167 | 497 | 54 | 9 | 46 | 3 |
| 9 | Electric | Stovetop Stir Fry | 269,126 | 186,396 | 82,553 | 43,595 | 11,161 | 4,436 | 1,428 | 491 | 200 | 81 | 35 | 25 |
| 10 | Electric | Bacon | 68,304 | 56,749 | 56,320 | 64,925 | 16,933 | 2,147 | 157 | 37 | 2 | 16 | 2 | 5 |
| 10A | Electric | Bacon | 39,615 | 24,131 | 19,007 | 17,159 | 3,185 | 337 | 56 | 16 | 1 | 12 | 2 | 4 |
| 10B | Electric | Bacon | 87,591 | 77,735 | 71,595 | 78,359 | 19,264 | 2,468 | 207 | 52 | 8 | 17 | 3 | 7 |
| 11 | Electric | Tortillas | 454,534 | 517,640 | 439,858 | 257,506 | 73,231 | 17,677 | 2,944 | 564 | 140 | 57 | 28 | 36 |
| 12 | Electric | French Fries | 219,714 | 125,109 | 35,339 | 11,507 | 1,635 | 363 | 96 | 40 | 13 | 14 | 6 | 9 |
| 13 | Electric | Broil Fish | 233,255 | 163,235 | 132,048 | 135,796 | 38,687 | 9,459 | 880 | 89 | 23 | 7 | 3 | 6 |
| 13A | Electric | Broil Fish | 77,018 | 44,437 | 25,379 | 18,157 | 4,311 | 1,111 | 140 | 25 | 12 | 4 | 3 | 5 |
| 13B | Electric | Broil Fish | 149,129 | 115,068 | 124,190 | 36,265 | 8,610 | 753 | 74 | 22 | 5 | 3 | 6 | 0 |
| 14 | Electric | Lasagna | 25,628 | 14,631 | 7,667 | 3,700 | 540 | 44 | 0 | 0 | 3 | 0 | 5 | 7 |
| 15 | Microwave | Lasagna | 8,509 | 3,496 | 3,688 | 2,485 | 909 | 284 | 28 | 8 | 5 | 2 | 1 | 1 |
| 16 | Microwave | Bacon | 7,636 | 4,621 | 3,858 | 3,419 | 1,407 | 578 | 140 | 46 | 15 | 7 | 2 | 1 |
| 16A | Microwave | Bacon | 7,426 | 4,068 | 3,645 | 3,196 | 1,342 | 517 | 115 | 35 | 11 | 8 | 3 | 1 |
| 16B | Microwave | Bacon | 7,026 | 4,828 | 4,021 | 3,721 | 1,540 | 671 | 177 | 61 | 22 | 8 | 3 | 1 |
| 17 | Gas | Stovetop Stir Fry | 419,674 | 181,692 | 140,397 | 129,758 | 43,307 | 13,304 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17A | Gas | Stovetop Stir Fry | 334,622 | 134,674 | 86,239 | 59,060 | 19,164 | 6,644 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17B | Gas | Stovetop Stir Fry | 448,274 | 198,688 | 150,692 | 160,515 | 53,944 | 16,213 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | Gas | Bacon | 251,575 | 246,438 | 230,838 | 282,514 | 86,606 | 19,453 | 1,539 | 289 | 72 | 21 | 10 | 16 |
| 18A | Gas | Bacon | 335,530 | 263,235 | 187,825 | 144,080 | 29,677 | 4,639 | 516 | 157 | 60 | 26 | 17 | 23 |
| 18B | Gas | Bacon | 303,264 | 242,751 | 213,922 | 287,183 | 95,121 | 21,717 | 1,659 | 318 | 79 | 25 | 13 | 20 |
| 19 | Gas | Broil Fish | 682,661 | 638,345 | 553,358 | 412,927 | 41,710 | 4,822 | 517 | 195 | 0 | 0 | 0 | 0 |

| Particle Concentrations [dN/dlog (Dp)] in Size Fractions | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Range** | **Food** | **0.04** | **0.08** | **0.13** | **0.21** | **0.32** | **0.51** | **0.81** | **1.29** | **2.02** | **3.18** | **5.24** | **8.38** |
| 19A | Gas | Broil Fish | 1,053,219 | 894,559 | 531,080 | 198,282 | 15,046 | 2,366 | 635 | 321 | 0 | 0 | 0 | 0 |
| 19B | Gas | Broil Fish | 825,066 | 1,032,681 | 891,172 | 544,265 | 55,429 | 6,490 | 651 | 281 | 0 | 0 | 0 | 0 |
| 20 | Gas | Full Meal | 1,529,018 | 694,207 | 409,861 | 348,935 | 115,499 | 20,171 | 2,690 | 522 | 147 | 65 | 46 | 75 |
| 21 | Gas | Stovetop Stir Fry | 320,091 | 147,818 | 96,054 | 75,853 | 12,724 | 2,066 | 502 | 228 | 107 | 45 | 22 | 19 |
| 21A | Gas | Stovetop Stir Fry | 345,012 | 140,732 | 70,592 | 49,290 | 8,265 | 1,450 | 355 | 172 | 91 | 45 | 27 | 25 |
| 21B | Gas | Stovetop Stir Fry | 485,294 | 216,618 | 141,780 | 117,219 | 22,908 | 3,807 | 873 | 375 | 173 | 76 | 41 | 38 |
| 22 | Gas | French Fries | 414,592 | 273,342 | 125,009 | 38,912 | 2,838 | 625 | 134 | 69 | 38 | 14 | 8 | 13 |
| 22A | Gas | French Fries | 329,277 | 190,657 | 53,217 | 12,675 | 1,515 | 381 | 85 | 45 | 30 | 12 | 8 | 11 |
| 22B | Gas | French Fries | 540,990 | 364,562 | 240,730 | 93,191 | 5,391 | 1,075 | 224 | 111 | 52 | 18 | 9 | 15 |
| 23 | Gas | Bake Lasagna | 360,371 | 201,736 | 72,357 | 16,367 | 816 | 180 | 46 | 26 | 0 | 0 | 0 | 0 |
| 24 | Gas | Fry Beef | 31,151 | 8,264 | 3,189 | 1,210 | 315 | 102 | 22 | 9 | 9 | 2 | 1 | 2 |
| 24R | Gas | Fry Beef | 83,040 | 43,708 | 11,552 | 3,083 | 531 | 125 | 38 | 16 | 12 | 4 | 3 | 3 |
| 24RA | Gas | Fry Beef | 137,719 | 50,549 | 11,641 | 2,837 | 497 | 126 | 43 | 21 | 13 | 6 | 4 | 5 |
| 24RB | Gas | Fry Beef | 36,457 | 30,294 | 8,240 | 2,384 | 451 | 104 | 31 | 11 | 10 | 3 | 2 | 2 |
| 25 | Gas | Pork Roast | 68,954 | 53,006 | 25,334 | 12,822 | 1,697 | 146 | 10 | 5 | 9 | 1 | 0 | 1 |
| 26 | Gas | Fry Beef | 22,963 | 3,992 | 1,738 | 879 | 324 | 79 | 27 | 8 | 0 | 0 | 0 | 0 |
| 27 | Gas | Pork Roast | 21,765 | 10,428 | 4,310 | 2,004 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28 | Gas | Fry Beef | 0 | 3,070 | 1,685 | 759 | 340 | 74 | 11 | 3 | 3 | 0 | 1 | 8 |
| 29 | Gas | Pork Roast | 5,777 | 1,115 | 471 | 322 | 127 | 22 | 7 | 1 | 4 | 0 | 0 | 2 |
| 30 | Gas | Stovetop Stir Fry | 312,655 | 135,232 | 96,881 | 55,005 | 15,698 | 4,978 | 1,329 | 278 | 111 | 41 | 23 | 15 |
| 30A | Gas | Stovetop Stir Fry | 183,342 | 66,415 | 34,146 | 15,229 | 4,344 | 1,623 | 520 | 131 | 65 | 31 | 21 | 17 |
| 30B | Gas | Stovetop Stir Fry | 302,865 | 120,207 | 91,738 | 57,987 | 16,520 | 5,060 | 1,252 | 264 | 103 | 34 | 21 | 15 |
| 31 | Gas | Fry Beef | 0 | 2,204 | 751 | 477 | 170 | 29 | 58 | 0 | 17 | 0 | 3 | 32 |
| 31A | Gas | Fry Beef | 0 | 2,090 | 850 | 489 | 160 | 27 | 46 | 0 | 10 | 0 | 1 | 17 |
| 31B | Gas | Fry Beef | 0 | 2,366 | 709 | 494 | 180 | 28 | 65 | 0 | 22 | 0 | 4 | 45 |
| 32 | Microwave | Popcorn | 16,618 | 7,964 | 5,476 | 4,102 | 907 | 190 | 28 | 7 | 5 | 1 | 1 | 0 |
| 33 | Gas | Range Baseline | 92,627 | 52,861 | 11,718 | 3,479 | 816 | 225 | 62 | 22 | 11 | 9 | 6 | 6 |
| 34 | Gas | Oven Baseline | 158,159 | 102,471 | 34,706 | 12,326 | 2,480 | 380 | 26 | 0 | 0 | 0 | 0 | 0 |
| N | | | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 |
| Minimum | | | 0 | 1,115 | 471 | 322 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum | | | 1,529,018 | 1,032,681 | 891,172 | 544,265 | 392,921 | 210,860 | 10,002 | 590 | 221 | 119 | 92 | 145 |

Table 3-9. Average Particle Concentrations [dN/dlog (Dp)] in 12 Size Fractions during the Total Exposure Period of Cooking Events

| Particle Concentrations [dN/dlog (Dp)] in Size Fractions | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Range** | **Food** | **0.04** | **0.08** | **0.13** | **0.21** | **0.32** | **0.51** | **0.81** | **1.29** | **2.02** | **3.18** | **5.24** | **8.38** |
| 1 | Gas | Oven Cleaning | 561,437 | 280,431 | 166,007 | 135,051 | 166,477 | 88,849 | 33,940 | 8,472 | 690 | 270 | 157 | 186 |
| 1R | Gas | Oven Cleaning | 761,355 | 582,595 | 474,172 | 431,901 | 335,394 | 185,393 | 9,745 | 460 | 172 | 93 | 72 | 113 |
| 2 | Gas | Stovetop Stir Fry | 231,140 | 140,471 | 95,755 | 52,419 | 8,040 | 1,322 | 369 | 148 | 74 | 29 | 15 | 21 |
| 3 | Gas | Bacon | 180,214 | 151,727 | 124,595 | 86,471 | 10,897 | 1,095 | 178 | 49 | 20 | 4 | 3 | 10 |
| 3A | Gas | Bacon | 207,448 | 149,862 | 113,999 | 71,257 | 7,878 | 844 | 141 | 44 | 19 | 5 | 3 | 9 |
| 3B | Gas | Bacon | 153,770 | 153,940 | 135,357 | 101,701 | 13,905 | 1,344 | 214 | 54 | 21 | 3 | 2 | 10 |
| 4 | Gas | Tortillas | 365,207 | 222,023 | 94,813 | 24,525 | 1,267 | 405 | 94 | 51 | 37 | 9 | 5 | 6 |
| 5 | Gas | French Fries | 337,301 | 136,457 | 69,728 | 29,636 | 1,959 | 501 | 136 | 62 | 44 | 10 | 7 | 5 |
| 6 | Gas | Broil Fish | 302,490 | 228,424 | 234,685 | 254,950 | 153,440 | 56,330 | 7,105 | 499 | 116 | 45 | 29 | 49 |
| 6A | Gas | Broil Fish | 288,844 | 230,629 | 194,405 | 171,545 | 99,751 | 32,191 | 3,226 | 253 | 61 | 22 | 14 | 27 |
| 6B | Gas | Broil Fish | 317,327 | 227,178 | 275,784 | 339,021 | 207,387 | 80,541 | 10,990 | 745 | 171 | 69 | 44 | 71 |
| 7 | Gas | Bake Lasagna | 563,621 | 296,735 | 171,047 | 121,174 | 20,320 | 3,460 | 557 | 101 | 30 | 11 | 5 | 11 |
| 8 | Electric | Oven Cleaning | 412,390 | 256,120 | 189,415 | 209,999 | 83,945 | 26,065 | 3,588 | 412 | 45 | 7 | 46 | 2 |
| 9 | Electric | Stovetop Stir Fry | 221,312 | 131,820 | 79,045 | 53,538 | 15,906 | 6,375 | 2,065 | 684 | 241 | 79 | 25 | 15 |
| 10 | Electric | Bacon | 72,022 | 78,710 | 83,794 | 116,164 | 37,724 | 6,262 | 398 | 64 | 6 | 17 | 2 | 6 |
| 10A | Electric | Bacon | 61,810 | 49,624 | 51,142 | 60,369 | 16,141 | 2,037 | 140 | 31 | 0 | 16 | 1 | 4 |
| 10B | Electric | Bacon | 80,648 | 103,040 | 111,086 | 162,755 | 55,735 | 9,786 | 613 | 91 | 10 | 18 | 2 | 7 |
| 11 | Electric | Tortillas | 234,823 | 353,648 | 417,509 | 355,297 | 150,707 | 25,435 | 3,550 | 588 | 125 | 45 | 24 | 30 |
| 12 | Electric | French Fries | 265,244 | 172,762 | 88,370 | 32,449 | 3,273 | 748 | 188 | 72 | 11 | 22 | 4 | 8 |
| 13 | Electric | Broil Fish | 264,294 | 192,289 | 162,017 | 171,692 | 49,888 | 13,475 | 2,233 | 235 | 34 | 8 | 3 | 7 |
| 13A | Electric | Broil Fish | 235,821 | 166,206 | 135,417 | 138,063 | 39,152 | 9,621 | 904 | 92 | 24 | 7 | 3 | 7 |
| 13B | Electric | Broil Fish | 219,980 | 190,109 | 207,032 | 61,148 | 17,516 | 3,625 | 385 | 44 | 8 | 2 | 8 | 0 |
| 14 | Electric | Lasagna | 29,141 | 17,331 | 9,245 | 4,611 | 675 | 27 | 0 | 0 | 2 | 0 | 3 | 4 |
| 15 | Microwave | Lasagna | 7,414 | 3,253 | 3,281 | 2,244 | 831 | 274 | 28 | 8 | 5 | 1 | 0 | 0 |
| 16 | Microwave | Bacon | 7,899 | 5,058 | 4,097 | 3,542 | 1,433 | 606 | 154 | 51 | 17 | 7 | 2 | 1 |
| 16A | Microwave | Bacon | 7,839 | 4,555 | 3,807 | 3,323 | 1,364 | 548 | 128 | 42 | 13 | 7 | 2 | 1 |
| 16B | Microwave | Bacon | 7,969 | 5,614 | 4,419 | 3,785 | 1,510 | 670 | 183 | 62 | 22 | 7 | 2 | 1 |
| 17 | Gas | Stovetop Stir Fry | 387,155 | 176,017 | 139,580 | 145,847 | 51,196 | 14,848 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17A | Gas | Stovetop Stir Fry | 412,642 | 177,326 | 137,765 | 121,235 | 40,343 | 12,497 | 0 | 0 | 0 | 0 | 0 | 0 |
| 17B | Gas | Stovetop Stir Fry | 369,666 | 175,365 | 141,056 | 163,482 | 58,954 | 16,533 | 0 | 0 | 0 | 0 | 0 | 0 |
| 18 | Gas | Bacon | 218,003 | 214,117 | 211,793 | 291,672 | 100,046 | 21,971 | 1,675 | 319 | 75 | 20 | 8 | 14 |
| 18A | Gas | Bacon | 234,226 | 248,561 | 237,368 | 281,179 | 83,620 | 18,650 | 1,496 | 279 | 69 | 20 | 9 | 15 |
| 18B | Gas | Bacon | 203,714 | 183,091 | 188,748 | 301,633 | 115,204 | 25,026 | 1,840 | 355 | 81 | 20 | 8 | 13 |
| 19 | Gas | Broil Fish | 552,326 | 511,384 | 504,658 | 596,236 | 100,360 | 9,666 | 819 | 239 | 0 | 0 | 0 | 0 |
| 19A | Gas | Broil Fish | 644,890 | 527,938 | 458,648 | 376,517 | 37,873 | 4,358 | 480 | 171 | 0 | 0 | 0 | 0 |
| 19B | Gas | Broil Fish | 467,100 | 498,078 | 550,432 | 806,541 | 159,930 | 14,733 | 1,143 | 306 | 0 | 0 | 0 | 0 |
| 20 | Gas | Full Meal | 611,453 | 291,705 | 194,623 | 199,994 | 81,597 | 27,129 | 4,824 | 499 | 56 | 23 | 16 | 27 |

| Particle Concentrations [dN/dlog (Dp)] in Size Fractions | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Range** | **Food** | **0.04** | **0.08** | **0.13** | **0.21** | **0.32** | **0.51** | **0.81** | **1.29** | **2.02** | **3.18** | **5.24** | **8.38** |
| 21 | Gas | Stovetop Stir Fry | 323,821 | 152,925 | 113,932 | 99,714 | 19,491 | 3,035 | 674 | 281 | 122 | 46 | 20 | 17 |
| 21A | Gas | Stovetop Stir Fry | 278,053 | 130,342 | 84,350 | 65,210 | 10,092 | 1,616 | 406 | 190 | 90 | 37 | 17 | 15 |
| 21B | Gas | Stovetop Stir Fry | 364,952 | 173,190 | 140,186 | 130,249 | 27,797 | 4,289 | 912 | 362 | 150 | 54 | 22 | 19 |
| 22 | Gas | French Fries | 329,034 | 205,811 | 119,780 | 49,886 | 3,286 | 675 | 137 | 64 | 32 | 9 | 5 | 8 |
| 22A | Gas | French Fries | 383,630 | 251,249 | 97,509 | 26,113 | 2,233 | 519 | 112 | 58 | 35 | 13 | 8 | 13 |
| 22B | Gas | French Fries | 289,666 | 173,376 | 134,591 | 66,174 | 4,005 | 781 | 154 | 67 | 30 | 6 | 2 | 5 |
| 23 | Gas | Bake Lasagna | 320,930 | 172,990 | 75,494 | 21,332 | 901 | 169 | 36 | 20 | 0 | 0 | 0 | 0 |
| 24 | Gas | Fry Beef | 36,081 | 8,933 | 2,722 | 1,053 | 317 | 104 | 21 | 9 | 10 | 2 | 1 | 1 |
| 24R | Gas | Fry Beef | 64,010 | 36,851 | 9,891 | 2,662 | 469 | 111 | 34 | 13 | 11 | 3 | 2 | 2 |
| 24RA | Gas | Fry Beef | 95,599 | 47,334 | 12,450 | 3,272 | 553 | 130 | 40 | 18 | 12 | 4 | 3 | 4 |
| 24RB | Gas | Fry Beef | 36,609 | 27,753 | 7,672 | 2,132 | 396 | 94 | 28 | 10 | 10 | 2 | 1 | 1 |
| 25 | Gas | Pork Roast | 53,767 | 42,944 | 20,825 | 10,442 | 1,373 | 119 | 7 | 3 | 10 | 0 | 0 | 1 |
| 26 | Gas | Fry Beef | 37,618 | 5,921 | 1,902 | 884 | 349 | 89 | 30 | 9 | 0 | 0 | 0 | 0 |
| 27 | Gas | Pork Roast | 17,130 | 8,149 | 3,524 | 1,758 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 28 | Gas | Fry Beef | 14 | 2,599 | 1,381 | 631 | 319 | 68 | 9 | 1 | 4 | 0 | 1 | 11 |
| 29 | Gas | Pork Roast | 4,981 | 1,172 | 556 | 371 | 141 | 23 | 7 | 1 | 5 | 0 | 0 | 2 |
| 30 | Gas | Stovetop Stir Fry | 319,705 | 133,843 | 101,029 | 62,901 | 18,430 | 5,604 | 758 | 159 | 63 | 24 | 13 | 8 |
| 30A | Gas | Stovetop Stir Fry | 315,556 | 138,920 | 98,169 | 54,364 | 15,521 | 4,964 | 1,348 | 282 | 113 | 43 | 24 | 15 |
| 30B | Gas | Stovetop Stir Fry | 323,935 | 129,695 | 103,639 | 70,365 | 20,972 | 6,164 | 245 | 52 | 20 | 7 | 4 | 3 |
| 31 | Gas | Fry Beef | 0 | 2,172 | 711 | 459 | 172 | 27 | 60 | 0 | 20 | 0 | 4 | 39 |
| 31A | Gas | Fry Beef | 0 | 2,171 | 761 | 473 | 168 | 30 | 56 | 0 | 15 | 0 | 3 | 30 |
| 31B | Gas | Fry Beef | 0 | 2,175 | 663 | 445 | 176 | 24 | 64 | 0 | 25 | 0 | 4 | 49 |
| 32 | Microwave | Popcorn | 26,330 | 10,894 | 6,330 | 4,318 | 1,053 | 255 | 42 | 10 | 6 | 1 | 1 | 0 |
| 33 | Gas | Range Baseline | 78,106 | 87,369 | 22,547 | 4,684 | 835 | 218 | 54 | 19 | 9 | 8 | 5 | 5 |
| 34 | Gas | Oven Baseline | 115,706 | 79,682 | 29,289 | 10,893 | 2,298 | 333 | 22 | 0 | 0 | 0 | 0 | 0 |
| 39 | Electric | Oven Dirtying | 180,287 | 90,063 | 75,054 | 66,874 | 17,357 | 3,921 | 387 | 89 | 24 | 6 | 0 | 2 |
| N | | | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 |
| Minimum | | | 0 | 1,172 | 556 | 371 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Maximum | | | 761,355 | 582,595 | 550,432 | 806,541 | 335,394 | 185,393 | 10,990 | 745 | 241 | 93 | 72 | 113 |

Table 3-10. Average Estimated Particle Mass Concentrations in 12 Size Fractions during the Cooking Period

| | | | μg/m³ | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Range** | **Food** | **0.04** | **0.08** | **0.13** | **0.21** | **0.32** | **0.51** | **0.81** | **1.29** | **2.02** | **3.18** | **5.24** | **8.38** | **$PM_{2.5}$** | **$PM_{10}$** |
| **1** | **Gas** | **Oven Cleaning** | **9** | **24** | **56** | **160** | **623** | **1,319** | **2,195** | **2,345** | **683** | **1,223** | **3,547** | **13,862** | **7,413** | **26,046** |
| 1R | Gas | Oven Cleaning | 11 | 45 | 144 | 453 | 1,291 | 3,069 | 534 | 139 | 176 | 417 | 1,568 | 8,061 | 5,862 | 15,907 |
| 2 | Gas | Stovetop Stir Fry | 3 | 10 | 19 | 32 | 18 | 14 | 15 | 28 | 53 | 118 | 349 | 1,482 | 193 | 2,142 |
| 3 | Gas | Bacon | 2 | 10 | 30 | 68 | 28 | 13 | 8 | 11 | 16 | 20 | 62 | 548 | 187 | 816 |
| 3A | Gas | Bacon | 2 | 7 | 17 | 30 | 10 | 7 | 5 | 9 | 17 | 32 | 111 | 536 | 104 | 783 |
| 3B | Gas | Bacon | 2 | 11 | 36 | 84 | 37 | 17 | 10 | 13 | 20 | 23 | 83 | 746 | 230 | 1,082 |
| 4 | Gas | Tortillas | 6 | 12 | 13 | 9 | 3 | 5 | 5 | 13 | 35 | 57 | 172 | 490 | 102 | 821 |
| 5 | Gas | French Fries | 5 | 10 | 15 | 17 | 5 | 6 | 6 | 14 | 37 | 54 | 183 | 498 | 116 | 850 |
| 6 | Gas | Broil Fish | 3 | 15 | 49 | 156 | 342 | 510 | 210 | 74 | 61 | 105 | 328 | 1,921 | 1,421 | 3,775 |
| 6A | Gas | Broil Fish | 3 | 13 | 24 | 27 | 15 | 9 | 5 | 9 | 19 | 48 | 183 | 933 | 124 | 1,288 |
| 6B | Gas | Broil Fish | 4 | 15 | 49 | 162 | 407 | 688 | 372 | 139 | 118 | 223 | 752 | 3,842 | 1,953 | 6,771 |
| 7 | Gas | Bake Lasagna | 9 | 23 | 50 | 117 | 73 | 57 | 35 | 30 | 31 | 54 | 137 | 902 | 425 | 1,517 |
| 8 | Electric | Oven Cleaning | 6 | 19 | 57 | 213 | 297 | 424 | 222 | 117 | 43 | 30 | 778 | 163 | 1,399 | 2,370 |
| 9 | Electric | Stovetop Stir Fry | 3 | 12 | 21 | 39 | 37 | 65 | 76 | 115 | 159 | 283 | 599 | 1,417 | 528 | 2,826 |
| 10 | Electric | Bacon | 1 | 4 | 14 | 59 | 56 | 31 | 8 | 9 | 2 | 57 | 26 | 254 | 183 | 521 |
| 10A | Electric | Bacon | 0 | 2 | 5 | 15 | 10 | 5 | 3 | 4 | 1 | 41 | 28 | 216 | 45 | 330 |
| 10B | Electric | Bacon | 1 | 5 | 18 | 71 | 63 | 36 | 11 | 12 | 6 | 60 | 56 | 365 | 224 | 706 |
| 11 | Electric | Tortillas | 5 | 33 | 113 | 232 | 241 | 257 | 157 | 133 | 112 | 201 | 483 | 2,029 | 1,282 | 3,996 |
| 12 | Electric | French Fries | 3 | 8 | 9 | 10 | 5 | 5 | 5 | 9 | 11 | 49 | 102 | 508 | 66 | 724 |
| 13 | Electric | Broil Fish | 3 | 10 | 34 | 123 | 127 | 138 | 47 | 21 | 19 | 24 | 53 | 362 | 521 | 959 |
| 13A | Electric | Broil Fish | 1 | 3 | 6 | 16 | 14 | 16 | 7 | 6 | 10 | 14 | 53 | 265 | 80 | 412 |
| 13B | Electric | Broil Fish | 3 | 9 | 29 | 112 | 119 | 125 | 40 | 17 | 17 | 17 | 43 | 311 | 473 | 844 |
| 14 | Electric | Lasagna | 0 | 1 | 2 | 3 | 2 | 1 | 0 | 0 | 2 | 0 | 85 | 369 | 11 | 465 |
| 15 | Microwave | Lasagna | 0 | 0 | 1 | 2 | 3 | 4 | 1 | 2 | 4 | 6 | 9 | 29 | 18 | 61 |
| 16 | Microwave | Bacon | 0 | 0 | 1 | 3 | 5 | 8 | 7 | 11 | 12 | 25 | 41 | 42 | 48 | 156 |
| 16A | Microwave | Bacon | 0 | 0 | 1 | 3 | 4 | 8 | 6 | 8 | 9 | 27 | 52 | 68 | 39 | 186 |
| 16B | Microwave | Bacon | 0 | 0 | 1 | 3 | 5 | 10 | 9 | 14 | 18 | 29 | 44 | 44 | 61 | 178 |
| 17 | Gas | Stovetop Stir Fry | 5 | 12 | 36 | 117 | 142 | 194 | 0 | 0 | 0 | 0 | 0 | 0 | 506 | 506 |
| 17A | Gas | Stovetop Stir Fry | 4 | 9 | 22 | 53 | 63 | 97 | 0 | 0 | 0 | 0 | 0 | 0 | 248 | 248 |
| 17B | Gas | Stovetop Stir Fry | 5 | 13 | 39 | 145 | 177 | 236 | 0 | 0 | 0 | 0 | 0 | 0 | 615 | 615 |
| 18 | Gas | Bacon | 3 | 16 | 59 | 255 | 285 | 283 | 82 | 68 | 57 | 75 | 174 | 918 | 1,107 | 2,275 |
| 18A | Gas | Bacon | 4 | 17 | 48 | 130 | 98 | 68 | 28 | 37 | 48 | 91 | 292 | 1,309 | 476 | 2,168 |
| 18B | Gas | Bacon | 4 | 15 | 55 | 259 | 313 | 316 | 89 | 75 | 63 | 86 | 224 | 1,100 | 1,188 | 2,598 |
| 19 | Gas | Broil Fish | 8 | 41 | 142 | 373 | 137 | 70 | 28 | 46 | 0 | 0 | 0 | 0 | 844 | 844 |
| 19A | Gas | Broil Fish | 13 | 57 | 136 | 179 | 49 | 34 | 34 | 75 | 0 | 0 | 0 | 0 | 577 | 577 |

| | | | μg/m³ | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Range** | **Food** | **0.04** | **0.08** | **0.13** | **0.21** | **0.32** | **0.51** | **0.81** | **1.29** | **2.02** | **3.18** | **5.24** | **8.38** | **$PM_{2.5}$** | **$PM_{10}$** |
| 19B | Gas | Broil Fish | 10 | 66 | 228 | 491 | 182 | 94 | 35 | 66 | 0 | 0 | 0 | 0 | 1,172 | 1,172 |
| 20 | Gas | Full Meal | 18 | 44 | 105 | 315 | 379 | 294 | 144 | 123 | 117 | 228 | 776 | 4,208 | 1,539 | 6,751 |
| 21 | Gas | Stovetop Stir Fry | 4 | 9 | 25 | 68 | 42 | 30 | 27 | 54 | 85 | 158 | 376 | 1,086 | 344 | 1,963 |
| 21A | Gas | Stovetop Stir Fry | 4 | 9 | 18 | 44 | 27 | 21 | 19 | 41 | 73 | 157 | 455 | 1,391 | 256 | 2,259 |
| 21B | Gas | Stovetop Stir Fry | 6 | 14 | 36 | 106 | 75 | 55 | 47 | 88 | 138 | 265 | 695 | 2,129 | 565 | 3,654 |
| 22 | Gas | French Fries | 5 | 17 | 32 | 35 | 9 | 9 | 7 | 16 | 30 | 50 | 144 | 734 | 161 | 1,090 |
| 22A | Gas | French Fries | 4 | 12 | 14 | 11 | 5 | 6 | 5 | 11 | 24 | 41 | 132 | 640 | 90 | 904 |
| 22B | Gas | French Fries | 7 | 23 | 62 | 84 | 18 | 16 | 12 | 26 | 42 | 62 | 152 | 829 | 288 | 1,332 |
| 23 | Gas | Bake Lasagna | 4 | 13 | 19 | 15 | 3 | 3 | 2 | 6 | 0 | 0 | 0 | 9 | 64 | 74 |
| 24 | Gas | Fry Beef | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 7 | 8 | 22 | 84 | 16 | 130 |
| 24R | Gas | Fry Beef | 1 | 3 | 3 | 3 | 2 | 2 | 2 | 4 | 9 | 14 | 43 | 195 | 28 | 280 |
| 24RA | Gas | Fry Beef | 2 | 3 | 3 | 3 | 2 | 2 | 2 | 5 | 10 | 20 | 62 | 272 | 31 | 385 |
| 24RB | Gas | Fry Beef | 0 | 2 | 2 | 2 | 1 | 2 | 2 | 3 | 8 | 9 | 29 | 124 | 22 | 184 |
| 25 | Gas | Pork Roast | 1 | 3 | 6 | 12 | 6 | 2 | 1 | 1 | 7 | 2 | 5 | 41 | 39 | 87 |
| 26 | Gas | Fry Beef | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 7 | 7 |
| 27 | Gas | Pork Roast | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 |
| 28 | Gas | Fry Beef | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 2 | 0 | 16 | 473 | 7 | 496 |
| 29 | Gas | Pork Roast | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 4 | 116 | 5 | 126 |
| 30 | Gas | Stovetop Stir Fry | 4 | 9 | 25 | 50 | 52 | 72 | 71 | 65 | 88 | 145 | 396 | 826 | 435 | 1,802 |
| 30A | Gas | Stovetop Stir Fry | 2 | 4 | 9 | 14 | 14 | 24 | 28 | 31 | 51 | 109 | 356 | 930 | 177 | 1,572 |
| 30B | Gas | Stovetop Stir Fry | 4 | 8 | 23 | 52 | 54 | 74 | 67 | 62 | 82 | 119 | 357 | 824 | 426 | 1,727 |
| 31 | Gas | Fry Beef | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 13 | 0 | 49 | 1,805 | 18 | 1,872 |
| 31A | Gas | Fry Beef | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 8 | 0 | 24 | 924 | 12 | 960 |
| 31B | Gas | Fry Beef | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 18 | 0 | 71 | 2,515 | 23 | 2,608 |
| 32 | Microwave | Popcorn | 0 | 1 | 2 | 4 | 3 | 3 | 2 | 2 | 5 | 5 | 12 | 17 | 23 | 58 |
| 33 | Gas | Range Baseline | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 5 | 9 | 31 | 99 | 321 | 34 | 485 |
| 34 | Gas | Oven Baseline | 2 | 7 | 9 | 11 | 8 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 43 | 43 |
| N | | | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 |
| Minimum | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 4 |
| Maximum | | | 18 | 66 | 228 | 491 | 1,291 | 3,069 | 534 | 139 | 176 | 417 | 1,568 | 8,061 | 5,862 | 15,907 |

Table 3-11. Average Estimated Particle Mass Concentrations in 12 Size Fractions during the Total Exposure Period

| | | | $\mu g/m^3$ | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Range** | **Food** | **0.04** | **0.08** | **0.13** | **0.21** | **0.32** | **0.51** | **0.81** | **1.29** | **2.02** | **3.18** | **5.24** | **8.38** | **$PM_{2.5}$** | **$PM_{10}$** |
| 1 | Gas | Oven Cleaning | 7 | 18 | 42 | 122 | 547 | 1,293 | 1,811 | 1,991 | 549 | 947 | 2,670 | 10,387 | 6,381 | 20,384 |
| 1R | Gas | Oven Cleaning | 9 | 37 | 121 | 390 | 1,102 | 2,699 | 520 | 108 | 137 | 325 | 1,223 | 6,287 | 5,123 | 12,958 |
| 2 | Gas | Stovetop Stir Fry | 3 | 9 | 24 | 47 | 26 | 19 | 20 | 35 | 59 | 102 | 253 | 1,183 | 242 | 1,781 |
| 3 | Gas | Bacon | 2 | 10 | 32 | 78 | 36 | 16 | 9 | 12 | 16 | 14 | 45 | 537 | 210 | 807 |
| 3A | Gas | Bacon | 2 | 10 | 29 | 64 | 26 | 12 | 8 | 10 | 15 | 19 | 58 | 503 | 177 | 757 |
| 3B | Gas | Bacon | 2 | 10 | 35 | 92 | 46 | 20 | 11 | 13 | 17 | 10 | 33 | 573 | 244 | 860 |
| 4 | Gas | Tortillas | 4 | 14 | 24 | 22 | 4 | 6 | 5 | 12 | 30 | 32 | 90 | 320 | 122 | 563 |
| 5 | Gas | French Fries | 4 | 9 | 18 | 27 | 6 | 7 | 7 | 14 | 35 | 35 | 115 | 257 | 128 | 534 |
| 6 | Gas | Broil Fish | 4 | 15 | 60 | 230 | 504 | 820 | 379 | 117 | 92 | 159 | 487 | 2,722 | 2,221 | 5,588 |
| 6A | Gas | Broil Fish | 3 | 15 | 50 | 155 | 328 | 469 | 172 | 59 | 48 | 79 | 233 | 1,491 | 1,299 | 3,102 |
| 6B | Gas | Broil Fish | 4 | 14 | 71 | 306 | 681 | 1,172 | 587 | 175 | 136 | 240 | 742 | 3,962 | 3,146 | 8,090 |
| 7 | Gas | Bake Lasagna | 7 | 19 | 44 | 109 | 67 | 50 | 30 | 24 | 24 | 38 | 92 | 617 | 373 | 1,120 |
| 8 | Electric | Oven Cleaning | 5 | 16 | 48 | 189 | 276 | 379 | 192 | 97 | 36 | 24 | 791 | 128 | 1,239 | 2,181 |
| 9 | Electric | Stovetop Stir Fry | 3 | 8 | 20 | 48 | 52 | 93 | 110 | 161 | 192 | 278 | 429 | 830 | 687 | 2,225 |
| 10 | Electric | Bacon | 1 | 5 | 21 | 105 | 124 | 91 | 21 | 15 | 5 | 60 | 26 | 310 | 388 | 785 |
| 10A | Electric | Bacon | 1 | 3 | 13 | 54 | 53 | 30 | 7 | 7 | 0 | 57 | 16 | 217 | 169 | 459 |
| 10B | Electric | Bacon | 1 | 7 | 28 | 147 | 183 | 142 | 33 | 21 | 8 | 64 | 35 | 389 | 571 | 1,058 |
| 11 | Electric | Tortillas | 3 | 23 | 107 | 321 | 495 | 370 | 189 | 138 | 100 | 159 | 405 | 1,679 | 1,745 | 3,989 |
| 12 | Electric | French Fries | 3 | 11 | 23 | 29 | 11 | 11 | 10 | 17 | 9 | 76 | 75 | 440 | 123 | 715 |
| 13 | Electric | Broil Fish | 3 | 12 | 41 | 155 | 164 | 196 | 119 | 55 | 27 | 27 | 45 | 403 | 773 | 1,248 |
| 13A | Electric | Broil Fish | 3 | 11 | 35 | 125 | 129 | 140 | 48 | 22 | 19 | 26 | 55 | 373 | 530 | 983 |
| 13B | Electric | Broil Fish | 4 | 14 | 49 | 187 | 201 | 255 | 193 | 90 | 35 | 28 | 36 | 436 | 1,028 | 1,529 |
| 14 | Electric | Lasagna | 0 | 1 | 2 | 4 | 2 | 0 | 0 | 0 | 1 | 0 | 51 | 221 | 12 | 284 |
| 15 | Microwave | Lasagna | 0 | 0 | 1 | 2 | 3 | 4 | 2 | 2 | 4 | 5 | 7 | 21 | 17 | 50 |
| 16 | Microwave | Bacon | 0 | 0 | 1 | 3 | 5 | 9 | 8 | 12 | 14 | 24 | 36 | 38 | 52 | 150 |
| 16A | Microwave | Bacon | 0 | 0 | 1 | 3 | 4 | 8 | 7 | 10 | 10 | 24 | 40 | 42 | 44 | 149 |
| 16B | Microwave | Bacon | 0 | 0 | 1 | 3 | 5 | 10 | 10 | 15 | 17 | 25 | 32 | 34 | 61 | 152 |
| 17 | Gas | Stovetop Stir Fry | 5 | 11 | 36 | 132 | 168 | 216 | 0 | 0 | 0 | 0 | 0 | 0 | 568 | 568 |
| 17A | Gas | Stovetop Stir Fry | 5 | 11 | 35 | 109 | 133 | 182 | 0 | 0 | 0 | 0 | 0 | 0 | 475 | 475 |
| 17B | Gas | Stovetop Stir Fry | 4 | 11 | 36 | 148 | 194 | 241 | 0 | 0 | 0 | 0 | 0 | 0 | 634 | 634 |
| 18 | Gas | Bacon | 3 | 14 | 54 | 263 | 329 | 320 | 89 | 75 | 60 | 71 | 143 | 785 | 1,206 | 2,206 |
| 18A | Gas | Bacon | 3 | 16 | 61 | 254 | 275 | 271 | 80 | 66 | 55 | 71 | 158 | 857 | 1,080 | 2,166 |

| | | | μg/m³ | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Test** | **Range** | **Food** | **0.04** | **0.08** | **0.13** | **0.21** | **0.32** | **0.51** | **0.81** | **1.29** | **2.02** | **3.18** | **5.24** | **8.38** | **$PM_{2.5}$** | **$PM_{10}$** |
| 18B | Gas | Bacon | 2 | 12 | 48 | 272 | 378 | 364 | 98 | 83 | 65 | 71 | 130 | 722 | 1,324 | 2,247 |
| 19 | Gas | Broil Fish | 7 | 33 | 129 | 538 | 330 | 141 | 44 | 56 | 0 | 0 | 0 | 0 | 1,277 | 1,277 |
| 19A | Gas | Broil Fish | 8 | 34 | 117 | 340 | 124 | 63 | 26 | 40 | 0 | 0 | 0 | 0 | 752 | 752 |
| 19B | Gas | Broil Fish | 6 | 32 | 141 | 728 | 525 | 214 | 61 | 72 | 0 | 0 | 0 | 0 | 1,779 | 1,779 |
| 20 | Gas | Full Meal | 7 | 19 | 50 | 180 | 268 | 395 | 257 | 117 | 45 | 79 | 265 | 1,505 | 1,339 | 3,188 |
| 21 | Gas | Stovetop Stir Fry | 4 | 10 | 29 | 90 | 64 | 44 | 36 | 66 | 97 | 161 | 341 | 943 | 440 | 1,885 |
| 21A | Gas | Stovetop Stir Fry | 3 | 8 | 22 | 59 | 33 | 24 | 22 | 45 | 72 | 130 | 295 | 819 | 287 | 1,531 |
| 21B | Gas | Stovetop Stir Fry | 4 | 11 | 36 | 118 | 91 | 62 | 49 | 85 | 119 | 189 | 383 | 1,055 | 576 | 2,203 |
| 22 | Gas | French Fries | 4 | 13 | 31 | 45 | 11 | 10 | 7 | 15 | 26 | 32 | 81 | 459 | 161 | 734 |
| 22A | Gas | French Fries | 5 | 16 | 25 | 24 | 7 | 8 | 6 | 14 | 28 | 47 | 141 | 710 | 131 | 1,030 |
| 22B | Gas | French Fries | 3 | 11 | 34 | 60 | 13 | 11 | 8 | 16 | 24 | 22 | 39 | 282 | 181 | 525 |
| 23 | Gas | Bake Lasagna | 4 | 11 | 19 | 19 | 3 | 2 | 2 | 5 | 0 | 0 | 0 | 6 | 65 | 72 |
| 24 | Gas | Fry Beef | 0 | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 8 | 7 | 15 | 59 | 17 | 98 |
| 24R | Gas | Fry Beef | 1 | 2 | 3 | 2 | 2 | 2 | 2 | 3 | 9 | 11 | 28 | 128 | 25 | 193 |
| 24RA | Gas | Fry Beef | 1 | 3 | 3 | 3 | 2 | 2 | 2 | 4 | 10 | 16 | 47 | 214 | 30 | 306 |
| 24RB | Gas | Fry Beef | 0 | 2 | 2 | 2 | 1 | 1 | 1 | 2 | 8 | 8 | 12 | 54 | 21 | 94 |
| 25 | Gas | Pork Roast | 1 | 3 | 5 | 9 | 5 | 2 | 0 | 1 | 8 | 1 | 4 | 29 | 34 | 67 |
| 26 | Gas | Fry Beef | 0 | 0 | 0 | 1 | 1 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 8 | 8 |
| 27 | Gas | Pork Roast | 0 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| 28 | Gas | Fry Beef | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 3 | 0 | 14 | 635 | 7 | 656 |
| 29 | Gas | Pork Roast | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 1 | 3 | 114 | 6 | 123 |
| 30 | Gas | Stovetop Stir Fry | 4 | 9 | 26 | 57 | 61 | 82 | 40 | 37 | 50 | 82 | 226 | 471 | 365 | 1,144 |
| 30A | Gas | Stovetop Stir Fry | 4 | 9 | 25 | 49 | 51 | 72 | 72 | 66 | 90 | 151 | 407 | 830 | 438 | 1,826 |
| 30B | Gas | Stovetop Stir Fry | 4 | 8 | 27 | 63 | 69 | 90 | 13 | 12 | 16 | 23 | 70 | 161 | 302 | 556 |
| 31 | Gas | Fry Beef | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 16 | 0 | 60 | 2,198 | 21 | 2,279 |
| 31A | Gas | Fry Beef | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 12 | 0 | 44 | 1,648 | 17 | 1,709 |
| 31B | Gas | Fry Beef | 0 | 0 | 0 | 0 | 1 | 0 | 3 | 0 | 20 | 0 | 75 | 2,741 | 25 | 2,841 |
| 32 | Microwave | Popcorn | 0 | 1 | 2 | 4 | 3 | 4 | 2 | 2 | 5 | 4 | 9 | 13 | 23 | 50 |
| 33 | Gas | Range Baseline | 1 | 6 | 6 | 4 | 3 | 3 | 3 | 5 | 7 | 26 | 83 | 282 | 37 | 429 |
| 34 | Gas | Oven Baseline | 1 | 5 | 7 | 10 | 8 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 37 | 37 |
| N | | | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 | 48 |
| Minimum | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 3 |
| Maximum | | | 9 | 37 | 141 | 728 | 1,102 | 2,699 | 587 | 175 | 192 | 325 | 1,223 | 6,287 | 5,123 | 12,958 |

Table 3-12. ELPI Estimated PM Mass Concentrations in Background Samples Prior to Cooking Tests and Outdoors at the End of the Tests

| Test No. | Type | Range | Conditions | Kitchen Pre-test | | | | Outdoor Post Test | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Particles/cm$^3$ | | Mass (μg/m$^3$) | | Particles/cm$^3$ | | Mass (μg/m$^3$) | |
| | | | | $PM_{2.5}$ | $PM_{10}$ | $PM_{2.5}$ | $PM_{10}$ | $PM_{2.5}$ | $PM_{10}$ | $PM_{2.5}$ | $PM_{10}$ |
| 1R | Oven Cleaning | Gas | Standard | 4001 | 4003 | 10 | 153 | 9201 | 9201 | 37 | 37 |
| 2 | Stovetop Stir Fry | Gas | Standard | 2683 | 2684 | 7 | 439 | 6509 | 6510 | 16 | 400 |
| 3 | Bacon | Gas | Standard | 2376 | 2376 | 5 | 111 | 2644 | 2645 | 8 | 459 |
| 4 | Tortillas | Gas | Standard | 2202 | 2202 | 13 | 22 | 3797 | 3797 | 19 | 19 |
| 5 | French Fries | Gas | Standard | 3423 | 3424 | 16 | 24 | 2876 | 2876 | 17 | 17 |
| 6 | Broil Fish | Gas | Standard | 2028 | 2028 | 6 | 13 | 2638 | 2638 | 26 | 26 |
| 7 | Bake Lasagna | Gas | Standard | 876 | 876 | 7 | 54 | 7400 | 7400 | 21 | 24 |
| 8 | Oven Cleaning | Electric | Standard | 1641 | 1642 | 4 | 108 | 1232 | 1244 | 12 | 890 |
| 9 | Stovetop Stir Fry | Electric | Standard | 1405 | 1406 | 13 | 30 | 982 | 982 | 15 | 19 |
| 10 | Bacon | Electric | Standard | 1215 | 1216 | 2 | 89 | 15992 | 15992 | 29 | 50 |
| 11 | Tortillas | Electric | Standard | 3994 | 3999 | 147 | 618 | 15992 | 15992 | 29 | 50 |
| 12 | French Fries | Electric | Standard | 4844 | 4845 | 7 | 118 | 15992 | 15992 | 29 | 50 |
| 13 | Broil Fish | Electric | Standard | 954 | 954 | 10 | 12 | 590 | 591 | 13 | 15 |
| 14 | Lasagna | Electric | Standard | 3965 | 3967 | 6 | 379 | 4923 | 4923 | 5 | 5 |
| 15 | Bacon | Microwave | Standard | 4563 | 4565 | 16 | 113 | 3757 | 3757 | 20 | 30 |
| 16 | Lasagna | Microwave | Standard | 5064 | 5064 | 15 | 60 | 3076 | 3076 | 22 | 28 |
| 17 | Stovetop Stir Fry | Gas | Worst Case | 1039 | 1039 | 3 | 3 | 7786 | 7786 | 8 | 8 |
| 18 | Bacon | Gas | Worst Case | 1394 | 1394 | 8 | 8 | 319 | 319 | 9 | 9 |
| 19 | Broil Fish | Gas | Worst Case | 4616 | 4616 | 9 | 9 | 8377 | 8377 | 21 | 21 |
| 20 | Full Meal | Gas | Standard | 3756 | 3756 | 7 | 18 | 356 | 356 | 4 | 4 |
| 21 | Stovetop Stir Fry | Gas | Test 2 Replicate | 1645 | 1645 | 9 | 13 | 2755 | 2755 | 15 | 16 |
| 22 | French Fries | Gas | Test 5 Replicate | 462 | 462 | 6 | 6 | 1849 | 1849 | 9 | 9 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 575 | 576 | 3 | 151 | 11698 | 11698 | 12 | 12 |
| 24 | Fry Beef | Gas | Cast Iron Pan | 1615 | 1615 | 7 | 7 | 2374 | 2374 | 15 | 15 |
| 24R | Fry Beef | Gas | Cast Iron Pan | 2479 | 2480 | 7 | 33 | 1879 | 1879 | 12 | 12 |
| 25 | Pork Roast | Gas | Aluminum Pan | 2290 | 2290 | 10 | 14 | 1668 | 1668 | 11 | 11 |
| 26 | Fry Beef | Gas | Exhaust Hood On | 1588 | 1588 | 4 | 4 | 1137 | 1137 | 3 | 3 |

| Test No. | Type | Range | Conditions | Kitchen Pre-test | | | | Outdoor Post Test | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Particles/cm$^3$ | | Mass (μg/m$^3$) | | Particles/cm$^3$ | | Mass (μg/m$^3$) | |
| | | | | $PM_{2.5}$ | $PM_{10}$ | $PM_{2.5}$ | $PM_{10}$ | $PM_{2.5}$ | $PM_{10}$ | $PM_{2.5}$ | $PM_{10}$ |
| 27 | Pork Roast | Gas | Exhaust Hood On | 1449 | 1449 | 1 | 1 | 9406 | 9406 | 6 | 6 |
| 28 | Fry Beef | Gas | Range Shields | 1480 | 1481 | 7 | 352 | 16629 | 16629 | 26 | 26 |
| 29 | Pork Roast | Gas | Range Shields | 808 | 808 | 3 | 54 | 16629 | 16629 | 26 | 26 |
| 30 | Stovetop Stir Fry | Gas | Vegetable Oil | 857 | 858 | 7 | 28 | 325 | 325 | 1 | 1 |
| 31 | Fry Beef | Gas | Pan Lid | 481 | 483 | 7 | 499 | 90 | 101 | 25 | 3068 |
| 32 | Popcorn | Microwave | Standard | 8512 | 8512 | 17 | 36 | 9435 | 9435 | 11 | 11 |
| 33 | Burner Baseline | Gas | | 5909 | 5910 | 12 | 83 | 5324 | 5325 | 15 | 51 |
| 34 | Oven Baseline | Gas | | 3855 | 3855 | 13 | 13 | 14802 | 14802 | 22 | 22 |
| N | | | | 35 | 35 | 35 | 35 | 35 | 35 | 35 | 35 |
| Minimum | | | | 461.9 | 461.9 | 0.8 | 0.8 | 89.7 | 100.5 | 1.1 | 1.1 |
| Maximum | | | | 8512 | 8512 | 147 | 618 | 16629 | 16629 | 37 | 3068 |

## 3.4 Particle Element Concentrations

A subset of the filters used to collect $PM_{10}$ mass was selected for elemental analysis by XRF. Samples were analyzed from the oven cleaning tests with the gas and electric ranges, the full meal cooking test, and in tests during which ground beef or a pork roast were cooked using different pan materials. The results are summarized in Table 3-13. Summary statistics are presented in Table 3-14 for samples collected indoors and 3-15 for samples collected outdoors. The number and percent measurable represent samples with concentrations above the method uncertainty level, which was a function of the MDL and analytical uncertainty, as described in Section 2. Because of the small number of samples, and large number of samples with non-detectable concentrations, the summary statistics were calculated for all samples with detectable concentrations and with the non-detectable samples excluded. As shown in Table 3-14, only silicon and calcium were measurable in all nine indoor samples. A number of the heavy metals were detected in the indoor samples, but at concentrations below the MDL. Chromium was detected in 4 of the 9 indoor samples. In the outdoor samples, the number of elements that were measurable was higher. These samples were generally collected for longer time periods. The results are discussed in Section 4.0.

Table 3-13. Concentrations ($\eta g/m^3$) of Selected Elements Measured in $PM_{10}$ Samples[a]

| **Test No.** | **1** | **1** | **1R** | **1R** | **8** | **8** | **25** |
|---|---|---|---|---|---|---|---|
| Cooking Type | Oven Cleaning | Oven Cleaning | Oven Cleaning | Oven Cleaning | Oven Cleaning | Oven Cleaning | Pork Roast |
| Pan Material | NA[b] | NA | NA | NA | NA | NA | Aluminum |
| Range Type | Gas | Gas | Gas | Gas | Electric | Electric | Gas |
| Location | K | OUT | K | OUT | K | OUT | K |
| Sodium | 569.0 | 218.9 | *225.2* | 156.1 | 365.5 | 471.7 | *250.1* |
| Magnesium | 0.0[c] | 40.9 | *121.5* | *18.0* | 0.0[c] | 82.8 | 0.0[c] |
| Aluminum | 392.9 | 38.2 | 0.0[c] | 34.8 | 97.6 | *4.2* | 124.2 |
| Silicon | 845.5 | 131.0 | 8532.3 | 137.4 | 644.0 | 31.0 | 465.2 |
| Phosphorous | 177.7 | *2.3* | 7937.3 | 7.0 | 43.5 | *6.0* | *18.0* |
| Sulfur | 1613.8 | 187.6 | 2198.8 | 162.4 | 266.5 | 116.8 | 231.9 |
| Chlorine | 1715.4 | 267.6 | 6458.1 | 178.3 | 790.3 | 1096.0 | *49.3* |
| Potassium | 1086.6 | 60.4 | 3832.5 | 70.1 | 409.9 | 59.3 | *4.3* |
| Calcium | 216.6 | 58.6 | 345.4 | 37.3 | 94.7 | 45.8 | 221.5 |
| Titanium | *19.7* | *3.4* | 0.0[c] | *5.5* | *29.0* | *6.8* | 0.0[c] |
| Vanadium | 0.0[c] | *3.5* | 0.0[c] | *2.4* | 0.0[c] | *2.3* | 0.0[c] |
| Chromium | 80.8 | *1.3* | 1222.8 | *1.7* | 134.2 | *1.0* | *15.5* |
| Manganese | 0.0[c] | *0.6* | 0.0[c] | *2.1* | 0.0[c] | 0.0[c] | 0.0[c] |
| Iron | 221.1 | 67.6 | 109.9 | 98.4 | 62.3 | 28.0 | 102.3 |
| Cobalt | 0.0[c] | 0.0[c] | 0.0[c] | *0.3* | 0.0[c] | *0.7* | *4.1* |
| Nickel | *0.1* | *0.8* | 37.7 | *0.6* | 27.7 | *0.2* | *5.1* |
| Copper | 100.1 | *2.5* | 273.7 | 4.8 | 42.9 | 4.6 | 92.3 |
| Zinc | 59.2 | 6.6 | 60.2 | 7.5 | 43.6 | 7.5 | 36.3 |

| Test No. | 1 | 1 | 1R | 1R | 8 | 8 | 25 |
|---|---|---|---|---|---|---|---|
| Cooking Type | Oven Cleaning | Oven Cleaning | Oven Cleaning | Oven Cleaning | Oven Cleaning | Oven Cleaning | Pork Roast |
| Pan Material | NA[b] | NA | NA | NA | NA | NA | Aluminum |
| Range Type | Gas | Gas | Gas | Gas | Electric | Electric | Gas |
| Location | K | OUT | K | OUT | K | OUT | K |
| Gallium | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] |
| Arsenic | *5.3* | *1.6* | 0.0[c] | *0.2* | 0.0[c] | *0.2* | *2.2* |
| Selenium | 0.0[c] | *0.8* | 0.0[c] | *1.0* | 0.0[c] | *0.5* | *4.6* |
| Bromine | 62.4 | 2.8 | 3433.6 | *1.1* | *7.3* | 2.5 | *2.8* |
| Rubidium | 0.0[c] | *0.3* | 0.0[c] | 0.0[c] | *3.6* | 0.0[c] | 0.0[c] |
| Strontium | 0.0[c] | *0.7* | 0.0[c] | *0.2* | *1.2* | *1.1* | *4.6* |
| Yttrium | 0.0[c] | *0.2* | 0.0[c] | *0.5* | *6.7* | *0.6* | *9.8* |
| Zirconium | *3.3* | *0.7* | 0.0[c] | *1.4* | *8.3* | *1.1* | *8.6* |
| Molybdenum | 0.0[c] | *1.2* | 0.0[c] | *2.2* | *12.2* | *2.6* | *17.4* |
| Palladium | 0.0[c] | *8.1* | 0.0[c] | *3.3* | 0.0[c] | 0.0[c] | 0.0[c] |
| Silver | 0.0[c] | *7.4* | *89.9* | *1.9* | 0.0[c] | 0.0[c] | *17.3* |
| Cadmium | 0.0[c] | *2.1* | 0.0[c] | *3.2* | *52.8* | *6.5* | *38.1* |
| Indium | 0.0[c] | 0.0[c] | 0.0[c] | *1.2* | 0.0[c] | 0.0[c] | 0.0[c] |
| Tin | 0.0[c] | 0.0[c] | *10.0* | *3.6* | 0.0[c] | 0.0[c] | 0.0[c] |
| Antimony | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | *4.5* | 0.0[c] |
| Barium | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | *113.4* | *9.2* | *251.3* |
| Lanthanum | 0.0[c] | 0.0[c] | *127.4* | 0.0[c] | *278.4* | 0.0[c] | *540.3* |
| Gold | 0.0[c] | *1.1* | 0.0[c] | 0.0[c] | 42.0 | 0.0[c] | *26.1* |
| Mercury | 0.0[c] | *0.5* | 0.0[c] | *1.6* | 25.6 | *1.6* | *18.6* |
| Thallium | *3.2* | *0.9* | 0.0[c] | *0.4* | 0.0[c] | *1.4* | *6.2* |
| Lead | 0.0[c] | *1.4* | 0.0[c] | 4.2 | *22.7* | *3.6* | *2.8* |
| Uranium | 0.0[c] | *0.2* | 0.0[c] | *1.4* | *3.7* | *1.6* | *14.2* |

[a] Concentrations in italics are below the uncertainty level, as defined in Section 2.0
[b] Not applicable; no pan used
[c] Correction for background data resulted in zero or negative values.

Table 3-13 (continued). Concentrations (ηg/m$^3$) of Selected Elements Measured in $PM_{10}$ Samples[a]

| Test No. | 24 | 24 | 24R | 24R | 31 | 31 | 20 | 20 | 20 |
|---|---|---|---|---|---|---|---|---|---|
| Cooking Type | Fry Beef | Fry Beef | Fry Beef | Fry Beef | Fry Beef | Fry Beef | Full Meal | Full Meal | Full Meal |
| Pan Material | Cast Iron | Cast Iron | Cast Iron | Cast Iron | Teflon® w/lid | Teflon® w/lid | Multiple types | Multiple types | Multiple types |
| Range Type | Gas | Gas | Gas | Gas | Gas | Gas | Gas | Gas | Gas |
| Location | K | OUT | K | OUT | K | OUT | K | K | OUT |
| Sodium | *631.2* | 252.9 | *310.8* | *47.3* | 582.8 | 353.8 | *309.1* | *154.6* | 1077.3 |
| Magnesium | *453.1* | 28.7 | *104.7* | 0.0[b] | 0.0[b] | 63.1 | *94.8* | *19.7* | 141.8 |
| Aluminum | 539.5 | 25.6 | *127.3* | 37.3 | 255.3 | 17.3 | 216.0 | *77.8* | 37.5 |
| Silicon | 855.4 | 102.6 | 1125.8 | 106.0 | 460.8 | 72.6 | 3901.6 | 3458.4 | 180.1 |
| Phosphorous | 166.2 | *4.1* | 152.6 | 16.4 | 65.1 | *3.8* | 263.6 | 239.9 | *7.8* |
| Sulfur | *77.6* | 167.5 | 322.2 | 140.9 | 117.3 | 100.9 | 1521.8 | 1286.3 | 234.6 |
| Chlorine | *188.7* | 386.3 | *58.6* | *1.4* | 208.8 | 707.8 | 804.0 | 720.5 | 2667.6 |
| Potassium | 0.0[b] | 35.8 | 158.6 | 29.4 | 134.1 | 58.0 | 130.1 | 146.7 | 111.7 |
| Calcium | 339.8 | 42.5 | 595.3 | 37.7 | 409.1 | 46.4 | 446.7 | 398.9 | 133.6 |
| Titanium | *11.3* | *7.6* | *55.5* | *3.3* | *13.8* | *6.9* | 0.0[b] | *4.2* | *4.8* |
| Vanadium | 0.0[b] | *5.3* | *30.0* | *3.4* | *22.6* | *3.9* | 0.0[b] | *20.4* | *1.6* |
| Chromium | *20.3* | *1.3* | *6.1* | 0.0[b] | 0.0[b] | 0.0[b] | 39.4 | *21.9* | *0.1* |
| Manganese | 0.0[b] | *0.6* | 0.0[b] | 0.0[b] | 0.0[b] | *0.2* | 0.0[b] | 0.0[b] | 0.0[b] |
| Iron | *60.5* | 65.7 | 128.6 | 52.2 | 60.2 | 61.7 | 105.1 | 83.6 | 92.9 |
| Cobalt | *7.4* | *2.1* | 0.0[b] | 0.0[b] | *0.6* | *0.6* | *2.9* | 0.0[b] | 0.0[b] |
| Nickel | 0.0[b] | 0.0[b] | *0.5* | 0.0[b] | 0.0[b] | *0.5* | *1.5* | 0.0[b] | 0.0[b] |
| Copper | *65.1* | 3.7 | 99.5 | 8.9 | 108.2 | 4.0 | 91.5 | 64.8 | *2.1* |
| Zinc | *66.3* | 5.1 | 69.8 | 15.7 | 58.0 | 6.6 | 30.4 | *21.5* | 6.8 |
| Gallium | *7.4* | *1.4* | *19.3* | *3.9* | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | *1.3* |
| Arsenic | *4.2* | *1.0* | 0.0[b] | *0.2* | 0.0[b] | *0.2* | 0.0[b] | 0.0[b] | *2.0* |
| Selenium | 0.0[b] | *0.1* | 0.0[b] | *0.6* | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| Bromine | *17.7* | 1.5 | *13.2* | *0.9* | *5.5* | 1.9 | 183.2 | 157.6 | 4.8 |
| Rubidium | 0.0[b] | *0.0* | 0.0[b] | 0.0[b] | 0.0[b] | *0.1* | 0.0[b] | 0.0[b] | 0.0[b] |
| Strontium | *6.8* | *0.6* | *6.7* | *0.8* | *0.1* | *0.1* | *0.9* | 0.0[b] | *1.6* |
| Yttrium | *1.9* | *0.4* | *3.4* | 0.0[b] | 0.0[b] | *0.1* | 0.0[b] | *0.1* | *1.5* |
| Zirconium | *22.5* | *0.2* | *24.7* | *1.8* | *20.0* | *0.8* | 26.3 | *11.3* | 0.0[b] |
| Molybdenum | *5.2* | *1.6* | *38.5* | *3.8* | *27.3* | *1.8* | *7.5* | *15.5* | *3.4* |
| Palladium | 0.0[b] | *7.5* | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | *12.7* | 0.0[b] | 0.0[b] |
| Silver | 0.0[b] | *1.1* | 0.0[b] | 0.0[b] | 0.0[b] | *2.7* | 0.0[b] | 0.0[b] | 0.0[b] |
| Cadmium | *77.6* | *6.6* | *44.1* | 0.0[b] | *120.5* | *8.7* | 0.0[b] | *43.3* | 0.0[b] |
| Indium | *139.5* | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | *9.4* | 0.0[b] |
| Tin | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| Antimony | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |

| Test No. | 24 | 24 | 24R | 24R | 31 | 31 | 20 | 20 | 20 |
|---|---|---|---|---|---|---|---|---|---|
| Cooking Type | Fry Beef | Fry Beef | Fry Beef | Fry Beef | Fry Beef | Fry Beef | Full Meal | Full Meal | Full Meal |
| Pan Material | Cast Iron | Cast Iron | Cast Iron | Cast Iron | Teflon® w/lid | Teflon® w/lid | Multiple types | Multiple types | Multiple types |
| Range Type | Gas | Gas | Gas | Gas | Gas | Gas | Gas | Gas | Gas |
| Location | K | OUT | K | OUT | K | OUT | K | K | OUT |
| Barium | *610.3* | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | *262.5* | 0.0[b] | 0.0[b] |
| Lanthanum | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | *28.8* | 0.0[b] | *86.9* | *27.7* |
| Gold | 0.0[b] | 0.0[b] | *13.5* | *0.6* | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| Mercury | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| Thallium | *33.2* | 0.0[b] | 0.0[b] | 0.0[b] | *4.1* | 0.0[b] | 0.0[b] | *8.0* | *1.0* |
| Lead | 0.0[b] | *0.1* | *36.9* | *1.2* | *7.4* | *1.0* | 0.0[b] | 0.0[b] | *0.8* |
| Uranium | *32.9* | 0.0[b] | *16.1* | 0.0[b] | 0.0[b] | *1.0* | 0.0[b] | *9.0* | *2.1* |

[a] Concentrations in italics are below the uncertainty level, as defined in Section 2.0
[b] Correction for background data resulted in zero or negative values.

Table 3-14. Summary Statistics for Element Measurements Indoors[a]

| Element | Number Measurable | Percent Measurable | Minimum | Maximum | Average | Std. Dev. | Median |
|---|---|---|---|---|---|---|---|
| | | | ηg/m$^3$ | ηg/m$^3$ | ηg/m$^3$ | ηg/m$^3$ | ηg/m$^3$ |
| Sodium | 3 | 33 | 154.6 | 631.2 | 377.6 | 173.8 | 310.8 |
| Magnesium | 0 | 0 | 19.7 | 453.1 | 158.8 | 169.1 | 104.7 |
| Aluminum | 6 | 67 | 77.8 | 539.5 | 228.8 | 162.8 | 171.6 |
| Silicon | 9 | 100 | 460.8 | 8532 | 2254 | 2688 | 855.4 |
| Phosphorous | 8 | 89 | 18.0 | 7937 | 1007 | 2600 | 166.2 |
| Sulfur | 8 | 89 | 77.6 | 2198 | 848.5 | 804.6 | 322.2 |
| Chlorine | 6 | 67 | 49.3 | 6458 | 1221 | 2034 | 720.5 |
| Potassium | 7 | 78 | 4.3 | 3832 | 737.9 | 1296 | 152.7 |
| Calcium | 9 | 100 | 94.7 | 595.3 | 340.9 | 147.6 | 345.4 |
| Titanium | 0 | 0 | 4.2 | 55.5 | 22.3 | 18.3 | 16.7 |
| Vanadium | 0 | 0 | 20.4 | 30.0 | 24.3 | 5.1 | 22.6 |
| Chromium | 4 | 44 | 6.1 | 1222 | 192.6 | 418.4 | 30.6 |
| Manganese | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Iron | 8 | 89 | 60.2 | 221.1 | 103.7 | 50.4 | 102.3 |
| Cobalt | 0 | 0 | 0.6 | 7.4 | 3.7 | 2.9 | 3.5 |
| Nickel | 2 | 22 | 0.1 | 37.7 | 12.1 | 16.3 | 3.3 |
| Copper | 8 | 89 | 42.9 | 273.7 | 104.2 | 67.0 | 92.3 |
| Zinc | 7 | 78 | 21.5 | 69.8 | 49.5 | 17.1 | 58.0 |
| Gallium | 0 | 0 | 7.4 | 19.3 | 13.3 | 8.4 | 13.3 |
| Arsenic | 0 | 0 | 2.2 | 5.3 | 3.9 | 1.6 | 4.2 |
| Selenium | 0 | 0 | 4.6 | 4.6 | 4.6 | 0.0 | 4.6 |
| Bromine | 4 | 44 | 2.8 | 3433 | 431 | 1127 | 17.7 |
| Rubidium | 0 | 0 | 3.6 | 3.6 | 3.6 | 0.0 | 3.6 |
| Strontium | 0 | 0 | 0.1 | 6.8 | 3.4 | 3.0 | 2.9 |
| Yttrium | 0 | 0 | 0.1 | 9.8 | 4.4 | 3.9 | 3.4 |
| Zirconium | 1 | 11 | 3.3 | 26.3 | 15.6 | 8.8 | 15.7 |
| Molybdenum | 0 | 0 | 5.2 | 38.5 | 17.7 | 11.7 | 15.5 |
| Palladium | 0 | 0 | 12.7 | 12.7 | 12.7 | 0.0 | 12.7 |
| Silver | 0 | 0 | 17.3 | 89.9 | 53.6 | 51.3 | 53.6 |
| Cadmium | 0 | 0 | 38.1 | 120.5 | 62.7 | 31.6 | 48.5 |
| Indium | 0 | 0 | 9.4 | 139.5 | 74.4 | 92.0 | 74.4 |
| Tin | 0 | 0 | 10.0 | 10.0 | 10.0 | 0.0 | 10.0 |
| Antimony | 0 | 0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Barium | 0 | 0 | 113.4 | 610.3 | 309.4 | 211.8 | 256.9 |
| Lanthanum | 0 | 0 | 86.9 | 540.3 | 258.2 | 205.3 | 202.9 |
| Gold | 1 | 11 | 13.5 | 42.0 | 27.2 | 14.3 | 26.1 |
| Mercury | 1 | 11 | 18.6 | 25.6 | 22.1 | 4.9 | 22.1 |
| Thallium | 0 | 0 | 3.2 | 33.2 | 10.9 | 12.6 | 6.2 |
| Lead | 0 | 0 | 2.8 | 36.9 | 17.5 | 15.5 | 15.0 |
| Uranium | 0 | 0 | 3.7 | 32.9 | 15.2 | 11.0 | 14.2 |

[a] Number and percent measurable: samples with concentrations above the level of uncertainty, as defined in Section 2.0; summary statistics calculated for all detectable concentrations and non-detectable samples excluded

Table 3-15. Summary Statistics for Element Measurements Outdoors[a]

| Element | Number Measurable | Percent Measurable | Minimum | Maximum | Average | Std. Dev. | Median |
|---|---|---|---|---|---|---|---|
| | | | ηg/m$^3$ | ηg/m$^3$ | ηg/m$^3$ | ηg/m$^3$ | ηg/m$^3$ |
| Sodium | 7 | 78 | 47.3 | 1077 | 368.3 | 340.9 | 252.9 |
| Magnesium | 7 | 78 | 18.0 | 141.8 | 62.6 | 45.4 | 52.0 |
| Aluminum | 6 | 67 | 4.2 | 38.2 | 27.8 | 13.0 | 34.8 |
| Silicon | 7 | 78 | 31.0 | 180.1 | 108.7 | 48.0 | 106.0 |
| Phosphorous | 5 | 56 | 2.3 | 16.4 | 6.8 | 4.7 | 6.0 |
| Sulfur | 7 | 78 | 100.9 | 234.6 | 158.7 | 44.9 | 162.4 |
| Chlorine | 7 | 78 | 1.4 | 2667 | 757.9 | 917.4 | 386.3 |
| Potassium | 7 | 78 | 29.4 | 111.7 | 60.7 | 26.8 | 59.3 |
| Calcium | 7 | 78 | 37.3 | 133.6 | 57.4 | 34.3 | 45.8 |
| Titanium | 2 | 22 | 3.3 | 7.6 | 5.5 | 1.7 | 5.5 |
| Vanadium | 2 | 22 | 1.6 | 5.3 | 3.2 | 1.2 | 3.4 |
| Chromium | 2 | 22 | 0.1 | 1.7 | 1.1 | 0.6 | 1.3 |
| Manganese | 2 | 22 | 0.2 | 2.1 | 0.9 | 0.8 | 0.6 |
| Iron | 7 | 78 | 28.0 | 98.4 | 66.6 | 23.9 | 65.7 |
| Cobalt | 2 | 22 | 0.3 | 2.1 | 0.9 | 0.8 | 0.7 |
| Nickel | 2 | 22 | 0.2 | 0.8 | 0.5 | 0.2 | 0.6 |
| Copper | 6 | 67 | 2.1 | 8.9 | 4.4 | 2.2 | 4.0 |
| Zinc | 7 | 78 | 5.1 | 15.7 | 8.0 | 3.5 | 6.8 |
| Gallium | 2 | 22 | 1.3 | 3.9 | 2.2 | 1.5 | 1.4 |
| Arsenic | 2 | 22 | 0.2 | 2.0 | 0.8 | 0.8 | 0.2 |
| Selenium | 2 | 22 | 0.1 | 1.0 | 0.6 | 0.3 | 0.6 |
| Bromine | 6 | 67 | 0.9 | 4.8 | 2.2 | 1.3 | 1.9 |
| Rubidium | 2 | 22 | 0.0 | 0.3 | 0.1 | 0.1 | 0.1 |
| Strontium | 3 | 33 | 0.1 | 1.6 | 0.7 | 0.5 | 0.7 |
| Yttrium | 2 | 22 | 0.1 | 1.5 | 0.6 | 0.5 | 0.5 |
| Zirconium | 2 | 22 | 0.2 | 1.8 | 1.0 | 0.6 | 0.9 |
| Molybdenum | 2 | 22 | 1.2 | 3.8 | 2.4 | 1.0 | 2.2 |
| Palladium | 2 | 22 | 3.3 | 8.1 | 6.3 | 2.6 | 7.5 |
| Silver | 2 | 22 | 1.1 | 7.4 | 3.3 | 2.9 | 2.3 |
| Cadmium | 2 | 22 | 2.1 | 8.7 | 5.4 | 2.7 | 6.5 |
| Indium | 2 | 22 | 1.2 | 1.2 | 1.2 | 0 | 1.2 |
| Tin | 2 | 22 | 3.6 | 3.6 | 3.6 | 0 | 3.6 |
| Antimony | 2 | 22 | 4.5 | 4.5 | 4.5 | 0 | 4.5 |
| Barium | 2 | 22 | 9.2 | 9.2 | 9.2 | 0 | 9.2 |
| Lanthanum | 2 | 22 | 27.7 | 28.8 | 28.2 | 0.8 | 28.2 |
| Gold | 2 | 22 | 0.6 | 1.1 | 0.9 | 0.4 | 0.9 |
| Mercury | 2 | 22 | 0.5 | 1.6 | 1.2 | 0.6 | 1.6 |
| Thallium | 2 | 22 | 0.4 | 1.4 | 0.9 | 0.4 | 1.0 |
| Lead | 2 | 22 | 0.1 | 4.2 | 1.8 | 1.5 | 1.2 |
| Uranium | 2 | 22 | 0.2 | 2.1 | 1.3 | 0.7 | 1.4 |

[a] Number and percent measurable: samples with concentrations above the level of uncertainty, as defined in Section 2.0; summary statistics calculated for all detectable concentrations and non-detectable samples excluded

## 3.5 PAH Measurement Results

Samples were collected during selected tests for measurements of total PAHs (combined gas-phase and $PM_{10}$ particulate phase). PAH samples were collected in Test No. 30 (stir-fry with vegetable oil) for comparison to emissions during stir-fry cooking with peanut oil, which had higher PAH concentrations in the bulk formulation (Table 3-2). Samples were also collected during the full meal cooking test and a limited number of other tests, as shown in Table 3-16. The table includes results for PAHs that were targeted for analysis in the study and a number of other semi-volatile compounds that were analyzed targeted for quantitation by DRI at the time of the main study. As shown in the table, the concentrations of the PAHs and other SVOCs were generally low. The summary statistics for the 13 samples collected in the main study are presented in Table 3-17. The results are discussed in Section 4.

## 3.6 Aldehyde Measurement Results

Although aldehydes were not originally targeted for measurement in the Study Design, a limited number of samples were collected to determine the magnitude of emissions during selected cooking events. The results of the measurements are presented in Table 3-18 and discussed in Section 4.

## 3.7 CO, NO, and $NO_2$ Concentrations During Cooking Tests

CO, NO, and $NO_2$ were measured continuously during the cooking tests with a system that collected samples sequentially from the kitchen, living room, master bedroom, and outdoors. The data were processed to obtain average concentrations during the cooking period and for the total exposure period. For each pollutant, two tables of summary data are presented. The first table presents the average and maximum concentrations during the cooking period, that is, from the time the oven or burner was turned on until it was turned off. The second table for each pollutant presents the average and maximum concentrations for the total exposure period, which included both the cooking period plus the one-hour post-cooking exposure period. For tests that had multiple cooking events, for example for broiling fish, the data are summarized for the separate cooking events. Results of the measurements and summary statistics for all 32 cooking tests are presented in Tables 3-19 through 3-24. The results are discussed in Section 4.

Table 3-16. PAH Concentrations (ηg/m$^3$) Measured during Cooking Tests[a]

| Test No. | 21 | 18,19,21 | 17 | 17- Dup | 30 | 17,30 |
|---|---|---|---|---|---|---|
| Cooking Method | Stir Fry | | Stir Fry | Stir Fry | Stir Fry | |
| Range | Gas | | Gas | Gas | Gas | |
| Test Type | Standard | | Worst Case | | Standard | |
| Cooking Oil | Peanut Oil | | Peanut Oil | Peanut Oil | Veg. Oil | |
| Sampling Location | K | OUT | K | K | K | OUT |
| Acenaphthylene | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| Acenaphthene | 0.0[b] | 0.0[b] | 0.0[b] | 9.0 | 0.0[b] | 0.0[b] |
| Phenanthrene [c,m] | 53.3 | 6.2 | 21.6 | 0.0[b] | 33.6 | 0.0[b] |
| Anthracene [c,m] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |

| Test No. | 21 | 18,19,21 | 17 | 17- Dup | 30 | 17,30 |
|---|---|---|---|---|---|---|
| Cooking Method | Stir Fry | | Stir Fry | Stir Fry | Stir Fry | |
| Range | Gas | | Gas | Gas | Gas | |
| Test Type | Standard | | Worst Case | | Standard | |
| Cooking Oil | Peanut Oil | | Peanut Oil | Peanut Oil | Veg. Oil | |
| Sampling Location | K | OUT | K | K | K | OUT |
| Fluoranthene [m,r] | 19.8 | 0.0[b] | 0.0[b] | 0.0[b] | *0.7*[a] | 0.0[b] |
| Pyrene [c,m] | 16.3 | 0.0[b] | 19.1 | 9.0 | 17.4 | 0.0[b] |
| Benz(a)anthracene [c,m] | 0.0[b] | *0.7* | 0.0[b] | 0.0[b] | *17.6* | 0.0[b] |
| Chrysene [c] | 0.0[b] | *0.2* | 0.0[b] | *5.7* | 0.0[b] | 0.0[b] |
| Benzo(b+j+k)phenanthrene | *6.6* | *2.5* | 0.0[b] | *7.4* | 0.0[b] | 4.8 |
| BeP [c,m] | *3.5* | *0.2* | *9.6* | *0.8* | *4.3* | 3.5 |
| BaP [c,m] | *2.6* | *0.4* | *3.7* | 0.0[b] | *2.7* | 2.1 |
| Indeno[1,2,3-cd]pyrene [c] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| Benzo(g,h,i)perylene | 0.0[b] | *0.1* | 0.0[b] | 0.0[b] | *0.5* | 0.0[b] |
| Coronene | 0.0[b] | *0.7* | *6.2* | *1.2* | 0.0[b] | 0.0[b] |
| Naphthalene | 600.6 | 0.0[b] | 631.4 | 0.0[b] | 646.1 | 0.0[b] |
| Fluorene | 40.5 | *8.1* | *23.3* | *21.8* | 33.4 | 5.1 |
| 2-Methylnaphthalene | 33.0 | 8.5 | 27.4 | 22.2 | 43.9 | 0.0[b] |
| 1-Methylnaphthalene | 41.0 | 7.8 | 53.6 | 20.9 | 50.7 | 0.0[b] |
| Biphenyl | 36.6 | 3.1 | 28.3 | 37.8 | 34.0 | 0.0[b] |
| 1+2-Ethylnaphthalene | 0.0[b] | 10.3 | 28.7 | 23.4 | 0.0[b] | 6.9 |
| 2,6+2,7-Dimethylnaphthalene | *22.5* | *5.0* | *18.7* | *27.1* | *49.4* | 0.0[b] |
| 1,3+1,6+1,7-Dimethylnaphthalene | *57.3* | *6.9* | *56.5* | *68.2* | *55.9* | 0.0[b] |
| 1,4+1,5+2,3-Dimethylnaphthalene | *17.2* | *3.2* | *20.0* | *14.8* | *23.0* | 0.0[b] |
| 1,2-Dimethylnaphthalene | 0.0[b] | *1.3* | *0.8* | 0.0[b] | 0.0[b] | 0.0[b] |
| 2-Methylbiphenyl | 736.7 | 0.0[b] | 602.7 | 0.0[b] | 588.6 | 0.0[b] |
| 3-Methylbiphenyl | 103.5 | 0.0[b] | 298.5 | 220.9 | 0.0[b] | 0.0[b] |
| 4-Methylbiphenyl | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| a-Trimethylnaphthalene | 10.1 | 75.6 | 19.5 | 63.6 | 0.0[b] | 9.9 |
| c-Trimethylnaphthalene | 15.9 | 3.9 | 10.0 | 17.2 | 23.0 | 2.7 |
| 2-Ethyl-1-methylnaphthalene | *2.6* | 0.0[b] | 0.0[b] | 0.0[b] | *0.7* | 0.0[b] |
| e-Trimethylnaphthalene | 22.0 | 4.5 | 9.6 | 18.1 | 27.9 | 3.5 |
| f-Trimethylnaphthalene | 11.9 | 1.8 | 5.0 | 8.6 | 17.6 | 0.0[b] |
| 2,3,5+I-Trimethylnaphtalene | 14.1 | 8.1 | 13.3 | 25.5 | 16.5 | 0.4 |
| 2,4,5-Trimethylnaphthalene | 0.0[b] | *0.8* | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| j-Trimethylnaphthalene | 5.3 | 1.8 | 22.4 | 28.3 | 9.5 | 1.1 |
| 1,4,5-Trimethylnaphthalene | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| 1,2,8-Trimethylnaphthalene | *4.4* | *1.5* | *16.6* | *9.0* | 0.0[b] | 1.2 |
| a-Methylfluorene | 28.6 | 0.6 | 27.0 | 5.7 | 24.6 | 0.9 |

| **Test No.** | **21** | **18,19,21** | **17** | **17- Dup** | **30** | **17,30** |
|---|---|---|---|---|---|---|
| Cooking Method | Stir Fry | | Stir Fry | Stir Fry | Stir Fry | |
| Range | Gas | | Gas | Gas | Gas | |
| Test Type | Standard | | Worst Case | | Standard | |
| Cooking Oil | Peanut Oil | | Peanut Oil | Peanut Oil | Veg. Oil | |
| Sampling Location | K | OUT | K | K | K | OUT |
| 1-Methylfluorene | 0.0[b] | 0.0[b] | 3.3 | 14.4 | 0.0[b] | 0.0[b] |
| b-Methylfluorene | *4.0* | *0.4* | *6.2* | *2.5* | *3.4* | 1.6 |
| 9-Fluorenone | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| Xanthone | 0.0[b] | 6.0 | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| Acenaphthenequinone | 0.0[b] | 0.0[b] | 0.0[b] | 9.9 | 0.0[b] | 0.0[b] |
| Perinaphthenone | *8.4* | *0.8* | *4.2* | 0.0[b] | 21.4 | 14.0 |
| a-Methylphenanthrene | 6.2 | 0.9 | 5.8 | 0.0[b] | 7.0 | 0.0[b] |
| 2-Methylphenanthrene | 15.4 | 0.0[b] | 0.0[b] | 0.0[b] | 6.3 | 0.0[b] |
| b-Methylphenanthrene | *2.2* | 0.0[b] | 0.0[b] | 0.0[b] | *2.9* | 0.0[b] |
| c-Methylphenanthrene | 22.9 | 0.0[b] | 2.9 | 0.0[b] | 5.2 | 0.0[b] |
| 1-Methylphenanthrene | 65.2 | 0.0[b] | 4.2 | 0.0[b] | 0.0[b] | 0.0[b] |
| Anthraquinone | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| 3,6-Dimethylphenanthre | 15.0 | 1.2 | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| a-Dimethylphenanthrene | 11.9 | 2.5 | 5.0 | 0.0[b] | 0.0[b] | 0.0[b] |
| b-Dimethylphenanthrene | 14.1 | 0.0[b] | 0.8 | 0.0[b] | 0.0[b] | 0.0[b] |
| c-Dimethylphenanthrene | 31.7 | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| 1,7-Dimethylphenanthre | 13.7 | 0.0[b] | 0.4 | 0.0[b] | 0.0[b] | 0.0[b] |
| d-Dimethylphenanthrene | 4.0 | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| e-Dimethylphenanthrene | 11.0 | 0.0[b] | 0.0[b] | 0.0[b] | 6.5 | 0.0[b] |
| 9-Methylanthracene | 0.0[b] | *11.4* | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| 9-Anthraldehyde | *20.7* | 0.0[b] | *4.6* | 0.0[b] | 0.0[b] | 0.0[b] |
| Retene | 13.7 | 1.9 | 30.3 | 0.0[b] | 3.8 | 0.0[b] |
| Benzonaphthothiophene | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| 1-MeFl+C-MePy/Fl | 56.4 | 0.0[b] | 4.6 | 0.0[b] | 0.0[b] | 0.0[b] |
| a-MePy/MeFl | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| b-MePy/MeFl | *7.5* | 0.0[b] | *10.8* | 0.0[b] | *11.7* | 0.0[b] |
| c-MePy/MeFl | *4.8* | 0.0[b] | 0.0[b] | *5.7* | *0.9* | 1.4 |
| d-MePy/MeFl | 8.8 | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| 4-Methylpyrene | *1.3* | 0.0[b] | 0.0[b] | *11.1* | *0.7* | 0.5 |
| 1-Methylpyrene | *4.0* | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| Benzo(c)phenanthrene | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| 7-Methylbenz(a)anthracene | *1.3* | 0.0[b] | *2.5* | *1.2* | 39.2 | 0.0[b] |
| Benz(a)anthracene-7,12-dione | *4.4* | 10.8 | *0.4* | 0.0[b] | 4.5 | 2.8 |
| 5+6-Methylchrysene | 0.0[b] | *1.8* | 0.0[b] | 0.0[b] | *3.4* | 0.0[b] |

| Test No. | 21 | 18,19,21 | 17 | 17- Dup | 30 | 17,30 |
|---|---|---|---|---|---|---|
| Cooking Method | Stir Fry | | Stir Fry | Stir Fry | Stir Fry | |
| Range | Gas | | Gas | Gas | Gas | |
| Test Type | Standard | | Worst Case | | Standard | |
| Cooking Oil | Peanut Oil | | Peanut Oil | Peanut Oil | Veg. Oil | |
| Sampling Location | K | OUT | K | K | K | OUT |
| 7-Methylbenzo(a)pyrene | 0.0[b] | *35.1* | 0.0[b] | 0.0[b] | *1187.4* | 0.0[b] |
| Perylene | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| Dibenz(ah+ac)anthracene | *5.7* | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |
| Benzo(b)chrysene | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] | 0.0[b] |

[a] Concentrations in italics are below the uncertainty level, as defined in Section 2.0
[b] Correction with background data resulted in zero or negative value.
[c] Designated as a carcinogen or probable carcinogen
[m] Designated as a mutagen
[t] Designated as a teratogen

*Designations from: U.S. Environmental Protection Agency (USEPA), 1989a. Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Volume I, Part A. Interim Final. Office of Emergency and Remedial Response, Washington, DC. EPA/540/1-89/002. December.*

Table 3-16 (continued) PAH Concentrations (ηg/m$^3$) Measured during Cooking Tests[a]

| Test No. | 18 | 19 | 20 | 20-Dup | 20 | 22 | 22 |
|---|---|---|---|---|---|---|---|
| Cooking Method | Bacon | Fish | Full Meal | Full Meal | | Fr. Fries | |
| Range | Gas | Gas | Gas | Gas | | Gas | |
| Test Type | Worst Case | Worst Case | Standard | Standard | | Standard | |
| Cooking Oil | | Olive | | | | Veg. | |
| Sampling Location | K | K | K | K | OUT | K | OUT |
| Acenaphthylene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| Acenaphthene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | *3.1* |
| Phenanthrene [c,m] | 16.1 | 18.5 | 12.9 | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| Anthracene [c,m] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| Fluoranthene [m,t] | 0.0[a] | 0.0[a] | *1.7* | 0.0[a] | 0.0[a] | 0.0[a] | *2.7* |
| Pyrene [c,m] | 7.7 | 16.7 | 15.4 | 0.4 | 4.9 | 6.0 | *2.4* |
| Benz(a)anthracene [c,m] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| Chrysene [c] | *10.5* | *0.8* | 11.5 | 0.0[a] | 0.0[a] | 0.0[a] | *0.9* |
| Benzo(b+j+k)phenanthrene | *7.3* | *0.6* | *2.5* | 0.0[a] | *1.8* | 0.0[a] | *1.3* |
| BeP [c,m] | 0.0[a] | *8.3* | *8.1* | *2.9* | *2.4* | 0.0[a] | 0.0[a] |
| BaP [c,m] | 0.0[a] | *20.6* | 0.0[a] | *1.1* | *3.7* | 0.0[a] | 0.0[a] |
| Indeno[1,2,3-cd]pyrene [c] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| Benzo(g,h,i)perylene | 0.0[a] | *9.2* | 0.0[a] | *1.4* | 0.0[a] | 0.0[a] | 0.0[a] |
| Coronene | 0.0[a] | 0.0[a] | *2.5* | 0.0[a] | *2.8* | 0.0[a] | *0.7* |
| Naphthalene | 365.5 | 553.6 | 284.9 | 0.0[a] | 0.0[a] | 44.9 | 154.6 |
| Fluorene | *28.6* | *28.3* | 34.2 | *12.6* | *7.0* | *13.4* | *0.2* |
| 2-Methylnaphthalene | 89.5 | 53.1 | 167.6 | 18.3 | 10.1 | 40.2 | 0.0[a] |
| 1-Methylnaphthalene | 94.3 | 58.7 | 174.3 | 33.4 | 15.6 | 55.5 | 0.0[a] |
| Biphenyl | 35.9 | 51.4 | 69.6 | 15.8 | 0.0[a] | 27.3 | 0.0[a] |
| 1+2-Ethylnaphthalene | 0.0[a] | 38.1 | 40.4 | 0.0[a] | 14.7 | 44.4 | *9.3* |
| 2,6+2,7-Dimethylnaphthalene | *23.0* | *19.4* | *49.7* | *24.8* | *2.8* | *27.7* | 0.0[a] |
| 1,3+1,6+1,7-Dimethylnaphthalene | *58.4* | *41.0* | 92.1 | *47.8* | *15.0* | *68.4* | 0.0[a] |
| 1,4+1,5+2,3-Dimethylnaphthalene | *15.7* | *15.0* | *37.9* | *15.1* | *4.6* | *16.6* | 0.0[a] |
| 1,2-Dimethylnaphthalene | *4.4* | *3.3* | *15.7* | *24.4* | *0.6* | 0.0[a] | *4.9* |
| 2-Methylbiphenyl | 42.7 | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 258.0 |
| 3-Methylbiphenyl | 0.0[a] | 46.6 | 0.0[a] | 0.0[a] | 0.0[a] | 24.0 | 103.2 |
| 4-Methylbiphenyl | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| a-Trimethylnaphthalene | 121.7 | 50.2 | 11.5 | 78.3 | *1.5* | 48.1 | 1.6 |
| c-Trimethylnaphthalene | 14.5 | 15.0 | 30.3 | 21.5 | 11.9 | 15.3 | 0.0[a] |
| 2-Ethyl-1-methylnaphthalene | 0.0[a] | *1.2* | *4.2* | 0.0[a] | *0.9* | 0.0[a] | 0.0[a] |
| e-Trimethylnaphthalene | 22.6 | 17.7 | 25.0 | 14.7 | 8.9 | *14.8* | *2.2* |
| f-Trimethylnaphthalene | 13.3 | 8.1 | 16.0 | 5.4 | 5.5 | 5.5 | 0.0[a] |

| Test No. | 18 | 19 | 20 | 20-Dup | 20 | 22 | 22 |
|---|---|---|---|---|---|---|---|
| Cooking Method | Bacon | Fish | Full Meal | Full Meal | | Fr. Fries | |
| Range | Gas | Gas | Gas | Gas | | Gas | |
| Test Type | Worst Case | Worst Case | Standard | Standard | | Standard | |
| Cooking Oil | | Olive | | | | Veg. | |
| Sampling Location | K | K | K | K | OUT | K | OUT |
| 2,3,5+I-Trimethylnaphtalene | 20.1 | 13.9 | 30.9 | 13.6 | 6.1 | 24.5 | 11.6 |
| 2,4,5-Trimethylnaphthalene | 0.0[a] | 0.0[a] | *0.3* | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| j-Trimethylnaphthalene | 2.4 | 13.1 | 32.0 | 0.0[a] | 11.0 | *2.8* | 0.0[a] |
| 1,4,5-Trimethylnaphthalene | 21.4 | 0.0[a] | *1.4* | 0.0[a] | 0.0[a] | *0.9* | *4.9* |
| 1,2,8-Trimethylnaphthalene | *18.5* | *11.7* | *4.5* | *0.4* | 0.0[a] | *24.0* | 0.0[a] |
| a-Methylfluorene | 17.7 | 19.6 | 27.5 | 10.4 | 1.5 | 21.7 | 0.0[a] |
| 1-Methylfluorene | 0.0[a] | 10.2 | 0.0[a] | 0.0[a] | 0.0[a] | 12.0 | 0.0[a] |
| b-Methylfluorene | *6.0* | 0.0[a] | *3.4* | *2.2* | 0.0[a] | 0.0[a] | *2.0* |
| 9-Fluorenone | 0.0[a] | 32.9 | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| Xanthone | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| Acenaphthenequinone | 0.0[a] | 2.5 | 0.0[a] | 0.0[a] | 0.0[a] | 22.2 | 0.0[a] |
| Perinaphthenone | *4.0* | *1.7* | 0.0[a] | 19.8 | *3.1* | *0.5* | *6.5* |
| a-Methylphenanthrene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 2.2 |
| 2-Methylphenanthrene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.9 |
| b-Methylphenanthrene | *0.8* | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | *0.9* | 0.0[a] |
| c-Methylphenanthrene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 17.1 |
| 1-Methylphenanthrene | 4.0 | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| Anthraquinone | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| 3,6-Dimethylphenanthre | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| a-Dimethylphenanthrene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 3.3 |
| b-Dimethylphenanthrene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 2.9 |
| c-Dimethylphenanthrene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 10.0 |
| 1,7-Dimethylphenanthre | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 13.1 |
| d-Dimethylphenanthrene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 3.3 |
| e-Dimethylphenanthrene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 10.5 |
| 9-Methylanthracene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | *118.1* |
| 9-Anthraldehyde | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| Retene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 12.5 |
| Benzonaphthothiophene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| 1-MeFl+C-MePy/Fl | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 4.9 |
| a-MePy/MeFl | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| b-MePy/MeFl | 0.0[a] | *4.6* | *2.2* | *8.3* | *2.4* | *9.2* | *0.2* |
| c-MePy/MeFl | 0.0[a] | *0.8* | *0.6* | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| d-MePy/MeFl | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| 4-Methylpyrene | 0.0[a] | *7.5* | *4.2* | *1.1* | *3.7* | *6.9* | *3.3* |
| 1-Methylpyrene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | *0.9* | 0.0[a] | 0.0[a] |
| Benzo(c)phenanthrene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | *49.2* |

| Test No. | 18 | 19 | 20 | 20-Dup | 20 | 22 | 22 |
|---|---|---|---|---|---|---|---|
| Cooking Method | Bacon | Fish | Full Meal | Full Meal | | Fr. Fries | |
| Range | Gas | Gas | Gas | Gas | | Gas | |
| Test Type | Worst Case | Worst Case | Standard | Standard | | Standard | |
| Cooking Oil | | Olive | | | | Veg. | |
| Sampling Location | K | K | K | K | OUT | K | OUT |
| 7-Methylbenz(a)anthracene | *1.2* | *1.2* | 114.5 | 20.5 | *0.9* | *25.0* | *5.3* |
| Benz(a)anthracene-7,12-dione | *11.3* | *0.4* | *1.1* | *5.7* | *4.9* | *3.2* | *6.5* |
| 5+6-Methylchrysene | 0.0[a] | *3.1* | 49.7 | *20.5* | 0.0[a] | *15.3* | *0.7* |
| 7-Methylbenzo(a)pyrene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| Perylene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | *0.2* |
| Dibenz(ah+ac)anthracene | 0.0[a] | 0.0[a] | 0.0[a] | *0.4* | *3.1* | 0.0[a] | 0.0[a] |
| Benzo(b)chrysene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |

[a] Correction with background data resulted in zero or negative value.
[c] Designated as a carcinogen or probable carcinogen
[m] Designated as a mutagen
[t] Designated as a teratogen

*Designations from: U.S. Environmental Protection Agency (USEPA), 1989a. Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Volume I, Part A. Interim Final. Office of Emergency and Remedial Response, Washington, DC. EPA/540/1-89/002. December.*

Table 3-17 Summary Statistics for Indoor and Outdoor PAH Measurements

| Compound | N | Measurable | Minimum | Maximum |
|---|---|---|---|---|
| | | % | ηg/m$^3$ | ηg/m$^3$ |
| Acenaphthylene | 0 | 0% | -- | -- |
| Acenaphthene | 2 | 15% | 0 | 9.0 |
| Phenanthrene [c,m] | 7 | 54% | 0 | 53.3 |
| Anthracene [c,m] | 0 | 0% | -- | -- |
| Fluoranthene [m,t] | 4 | 31% | 0 | 19.8 |
| Pyrene [c,m] | 11 | 85% | 0 | 19.1 |
| Benz(a)anthracene [c,m] | 2 | 15% | 0 | 17.6 |
| Chrysene [c] | 6 | 46% | 0 | 11.5 |
| Benzo(b+j+k)phenanthrene | 9 | 69% | 0 | 7.4 |
| BeP [c,m] | 10 | 77% | 0 | 9.6 |
| BaP [c,m] | 8 | 62% | 0 | 20.6 |
| Indeno[123-cd]pyrene [c] | 0 | 0% | -- | -- |
| Benzo(ghi)perylene | 4 | 31% | 0 | 9.2 |
| Coronene | 6 | 46% | 0 | 6.2 |
| Naphthalene | 8 | 62% | 0 | 646.1 |
| Fluorene | 13 | 100% | 0 | 40.5 |
| 2-Methylnaphthalene | 11 | 85% | 0 | 167.6 |
| 1-Methylnaphthalene | 11 | 85% | 0 | 174.3 |
| Biphenyl | 10 | 77% | 0 | 69.6 |
| 1+2-Ethylnaphthalene | 9 | 69% | 0 | 44.4 |
| 2,6+2,7-Dimethylnaphthalene | 11 | 85% | 0 | 49.7 |
| 1,3+1,6+1,7-Dimethylnaphthalene | 11 | 85% | 0 | 92.1 |
| 1,4+1,5+2,3-Dimethylnaphthalene | 11 | 85% | 0 | 37.9 |
| 1,2-Dimethylnaphthalene | 8 | 62% | 0 | 24.4 |
| 2-Methylbiphenyl | 5 | 38% | 0 | 736.7 |
| 3-Methylbiphenyl | 6 | 46% | 0 | 298.5 |
| 4-Methylbiphenyl | 0 | 0% | -- | -- |
| a-Trimethylnaphthalene | 12 | 92% | 0 | 121.7 |
| c-Trimethylnaphthalene | 12 | 92% | 0 | 30.3 |
| 2-Ethyl-1-methylnaphthalene | 5 | 38% | 0 | 4.2 |
| e-Trimethylnaphthalene | 13 | 100% | 0 | 27.9 |
| f-Trimethylnaphthalene | 11 | 85% | 0 | 17.6 |
| 2,3,5+I-Trimethylnaphtalene | 13 | 100% | 0 | 30.9 |
| 2,4,5-Trimethylnaphthalene | 2 | 15% | 0 | 0.8 |
| j-Trimethylnaphthalene | 11 | 85% | 0 | 32.0 |
| 1,4,5-Trimethylnaphthalene | 4 | 31% | 0 | 21.4 |
| 1,2,8-Trimethylnaphthalene | 10 | 77% | 0 | 24.0 |

| Compound | N | Measurable | Minimum | Maximum |
|---|---|---|---|---|
| | | % | ηg/m$^3$ | ηg/m$^3$ |
| a-Methylfluorene | 12 | 92% | 0 | 28.6 |
| 1-Methylfluorene | 4 | 31% | 0 | 14.4 |
| b-Methylfluorene | 10 | 77% | 0 | 6.2 |
| 9-Fluorenone | 1 | 8% | -- | -- |
| Xanthone | 1 | 8% | -- | -- |
| Acenaphthenequinone | 3 | 23% | 0 | 22.2 |
| Perinaphthenone | 11 | 85% | 0 | 21.4 |
| a-Methylphenanthrene | 5 | 38% | 0 | 7.0 |
| 2-Methylphenanthrene | 3 | 23% | 0 | 15.4 |
| b-Methylphenanthrene | 4 | 31% | 0 | 2.9 |
| c-Methylphenanthrene | 4 | 31% | 0 | 22.9 |
| 1-Methylphenanthrene | 3 | 23% | 0 | 65.2 |
| Anthraquinone | 0 | 0% | -- | -- |
| 3,6-Dimethylphenanthre | 2 | 15% | 0 | 15.0 |
| a-Dimethylphenanthrene | 4 | 31% | 0 | 11.9 |
| b-Dimethylphenanthrene | 3 | 23% | 0 | 14.1 |
| c-Dimethylphenanthrene | 2 | 15% | 0 | 31.7 |
| 1,7-Dimethylphenanthre | 3 | 23% | 0 | 13.7 |
| d-Dimethylphenanthrene | 2 | 15% | 0 | 4.0 |
| e-Dimethylphenanthrene | 3 | 23% | 0 | 11.0 |
| 9-Methylanthracene | 2 | 15% | 0 | 118.1 |
| 9-Anthraldehyde | 2 | 15% | 0 | 20.7 |
| Retene | 5 | 38% | 0 | 30.3 |
| Benzonaphthothiophene | 0 | 0% | -- | -- |
| 1-MeFl+C-MePy/Fl | 3 | 23% | 0 | 56.4 |
| a-MePy/MeFl | 0 | 0% | -- | -- |
| b-MePy/MeFl | 9 | 69% | 0 | 11.7 |
| c-MePy/MeFl | 6 | 46% | 0 | 5.7 |
| d-MePy/MeFl | 1 | 8% | 0 | 8.8 |
| 4-Methylpyrene | 10 | 77% | 0 | 11.1 |
| 1-Methylpyrene | 2 | 15% | 0 | 4.0 |
| Benzo(c)phenanthrene | 1 | 8% | 0 | 49.2 |
| 7-Methylbenz(a)anthracene | 11 | 85% | 0 | 114.5 |
| Benz(a)anthracene-7,12-dione | 12 | 92% | 0 | 11.3 |
| 5+6-Methylchrysene | 7 | 54% | 0 | 49.7 |
| 7-Methylbenzo(a)pyrene | 2 | 15% | 0 | 1187.4 |
| Perylene | 1 | 8% | 0 | 0.2 |
| Dibenz(ah+ac)anthracene | 3 | 23% | 0 | 5.7 |

| Compound | N | Measurable | Minimum | Maximum |
|---|---|---|---|---|
| | | % | ηg/m$^3$ | ηg/m$^3$ |
| Benzo(b)chrysene | 0 | 0% | -- | -- |

[c] Designated as a carcinogen or probable carcinogen
[m] Designated as a mutagen
[t] Designated as a teratogen

*Designations from: U.S. Environmental Protection Agency (USEPA), 1989a. Risk Assessment Guidance for Superfund, Human Health Evaluation Manual, Volume I, Part A. Interim Final. Office of Emergency and Remedial Response, Washington, DC. EPA/540/1-89/002. December.*

Table 3-18. Aldehyde Measurement Results

| Test No. | Type | Range | Conditions | | µg/m³ | |
|---|---|---|---|---|---|---|
| | | | | | K | OUT |
| 1 | Oven Cleaning | Gas | Standard | Formaldehyde | 417.3 | 2.7 |
| | | | | Acetaldehyde | 433.7 | 0.25[a] |
| | | | | Propanal | 144.3 | 0.25[a] |
| | | | | Butanal | 72.4 | 0.25[a] |
| | | | | Benzaldehyde | 16.1 | 0.25[a] |
| | | | | Pentanal | 145.7 | 0.25[a] |
| | | | | Hexanal | 131.3 | 0.25[a] |
| 6 | Broil Fish | Gas | Standard | Formaldehyde | 129.3 | 1.5 |
| | | | | Acetaldehyde | 92.3 | 0.25[a] |
| | | | | Propanal | 28.5 | 0.25[a] |
| | | | | Butanal | 11.1 | 0.25[a] |
| | | | | Benzaldehyde | 8.6 | 0.25[a] |
| | | | | Pentanal | 20.2 | 0.25[a] |
| | | | | Hexanal | 26.5 | 0.25[a] |
| 8 | Oven Cleaning | Electric | Standard | Formaldehyde | 224.5 | 0.8 |
| | | | | Acetaldehyde | 330.8 | 0.25[a] |
| | | | | Propanal | 86.6 | 0.25[a] |
| | | | | Butanal | 40.2 | 0.25[a] |
| | | | | Benzaldehyde | 13.0 | 0.25[a] |
| | | | | Pentanal | 81.7 | 0.25[a] |
| | | | | Hexanal | 76.9 | 0.25[a] |
| 13 | Broil Fish | Electric | Standard | Formaldehyde | 129.4 | 0.4 |
| | | | | Acetaldehyde | 109.2 | 0.7 |
| | | | | Propanal | 34.3 | 0.25[a] |
| | | | | Butanal | 14.6 | 0.25[a] |
| | | | | Benzaldehyde | 3.8 | 0.25[a] |
| | | | | Pentanal | 24.5 | 0.25[a] |
| | | | | Hexanal | 34.4 | 0.25[a] |
| 25 | Pork Roast | Gas | Aluminum Pan | Formaldehyde | 49.1 | 1.0 |
| | | | | Acetaldehyde | 13.2 | 16.6 |
| | | | | Propanal | 3.0 | 0.25[a] |
| | | | | Butanal | 1.6 | 0.25[a] |
| | | | | Benzaldehyde | 0.0 | 0.25[a] |
| | | | | Pentanal | 4.3 | 0.25[a] |
| | | | | Hexanal | 13.7 | 0.25[a] |

| Test No. | Type | Range | Conditions | | µg/m³ | |
|---|---|---|---|---|---|---|
| | | | | | K | OUT |
| 27 | Pork Roast | Gas | Exhaust Ventilation | Formaldehyde | 36.5 | 1.1 |
| | | | | Acetaldehyde | 14.2 | 1.0 |
| | | | | Propanal | 1.9 | 0.25[a] |
| | | | | Butanal | 1.1 | 0.25[a] |
| | | | | Benzaldehyde | 0.0 | 0.25[a] |
| | | | | Pentanal | 3.0 | 0.25[a] |
| | | | | Hexanal | 10.2 | 0.25[a] |

| Summary Statistics | | Indoor | Indoor | Indoor |
|---|---|---|---|---|
| | | N | Minimum | Maximum |
| | Formaldehyde | 6 | 36.5 | 417.3 |
| | Acetaldehyde | 6 | 13.2 | 433.7 |
| | Propanal | 6 | 1.9 | 144.3 |
| | Butanal | 6 | 1.1 | 72.4 |
| | Benzaldehyde | 4 | 0.0 | 16.1 |
| | Pentanal | 6 | 3.0 | 145.7 |
| | Hexanal | 6 | 10.2 | 131.3 |
| | | Outdoor | Outdoor | Outdoor |
| | | N | Minimum | Maximum |
| | Formaldehyde | 6 | 0.4 | 2.7 |
| | Acetaldehyde | 6 | 0.25[a] | 16.6 |
| | Propanal | 6 | 0.25[a] | 0.25[a] |
| | Butanal | 6 | 0.25[a] | 0.25[a] |
| | Benzaldehyde | 6 | 0.25[a] | 0.25[a] |
| | Pentanal | 6 | 0.25[a] | 0.25[a] |
| | Hexanal | 6 | 0.25[a] | 0.25[a] |

[a] – Below detection limits. Value taken at ½ MDL.

Table 3-19. Average CO Concentrations (ppm) Measured at Four Locations during the Cooking Period

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 1R | Oven Cleaning | Gas | Standard | 14.8 | 19.9 | 14.9 | 19.9 | 14.8 | 20.0 | 0.6 | 0.9 |
| 2 | Stovetop Stir Fry | Gas | Standard | 1.2 | 1.5 | 1.4 | 2.2 | 0.9 | 1.4 | 0.4 | 0.5 |
| 3A | Bacon | Gas | Standard | 0.4 | 0.5 | 0.4 | 0.5 | 0.5 | 0.8 | 0.4 | 0.4 |
| 3B | Bacon | Gas | Standard | 1.0 | 1.0 | 1.0 | 1.0 | 0.9 | 1.2 | 0.3 | 0.3 |
| 4 | Tortillas | Gas | Standard | 0.8 | 1.2 | 0.9 | 1.1 | 0.8 | 1.1 | 0.3 | 0.3 |
| 5 | French Fries | Gas | Standard | 2.5 | 4.6 | 2.5 | 4.7 | 2.4 | 4.4 | 0.3 | 0.4 |
| 6A | Broil Fish | Gas | Standard | 3.2 | 4.0 | 4.0 | 4.4 | 2.6 | 4.0 | 0.3 | 0.4 |
| 6B | Broil Fish | Gas | Standard | 10.1 | 11.4 | 8.9 | 9.6 | 8.6 | 9.4 | 0.3 | 0.4 |
| 7 | Bake Lasagne | Gas | Standard | 2.5 | 3.6 | 2.6 | 3.3 | 2.4 | 3.4 | 0.3 | 0.6 |
| 8 | Oven Cleaning | Electric | Standard | 7.8 | 12.0 | 7.9 | 12.1 | 7.5 | 11.5 | 0.6 | 1.1 |
| 9 | Stovetop Stir Fry | Electric | Standard | 0.7 | 0.7 | 0.9 | 0.9 | 0.7 | 0.8 | 0.5 | 0.6 |
| 10A | Bacon | Electric | Standard | 0.5 | 0.7 | 0.4 | 0.5 | 0.4 | 0.5 | 0.4 | 0.4 |
| 10B | Bacon | Electric | Standard | 0.5 | 0.5 | 0.5 | 0.6 | 0.5 | 0.6 | 0.4 | 0.5 |
| 11 | Tortillas | Electric | Standard | 1.1 | 1.4 | 1.2 | 1.4 | 1.1 | 1.5 | 0.5 | 0.8 |
| 12 | French Fries | Electric | Standard | 1.0 | 1.2 | 1.1 | 1.2 | 0.8 | 0.9 | 0.6 | 0.7 |
| 13A | Broil Fish | Electric | Standard | 0.6 | 0.7 | 0.8 | 0.8 | 0.8 | 0.9 | 0.7 | 0.8 |
| 13B | Broil Fish | Electric | Standard | 2.6 | 2.6 | 2.9 | 3.6 | 2.6 | 3.2 | 0.6 | 0.6 |
| 14 | Lasagne | Electric | Standard | 0.6 | 1.1 | 0.6 | 1.3 | 0.7 | 1.2 | 0.4 | 1.1 |
| 15A | Bacon | Microwave | Standard | 0.6 | 0.7 | 0.6 | 0.7 | 0.7 | 0.8 | 0.8 | 1.1 |
| 15B | Bacon | Microwave | Standard | 0.9 | 0.9 | 0.9 | 0.9 | 0.8 | 1.0 | 0.8 | 0.9 |
| 16 | Lasagne | Microwave | Standard | 0.7 | 0.8 | 0.7 | 0.8 | 0.7 | 0.7 | 0.5 | 0.5 |
| 17A | Stovetop Stir Fry | Gas | Worst Case | 1.1 | 1.8 | 0.8 | 1.6 | 0.7 | 1.4 | 0.2 | 0.3 |
| 17B | Stovetop Stir Fry | Gas | Worst Case | 2.5 | 3.0 | 2.7 | 3.5 | 2.4 | 3.0 | 0.1 | 0.1 |
| 18A | Bacon | Gas | Worst Case | 1.0 | 1.3 | 1.3 | 1.6 | 0.9 | 1.4 | 0.5 | 0.6 |
| 18B | Bacon | Gas | Worst Case | 1.7 | 2.1 | 1.8 | 2.2 | 1.8 | 2.3 | 0.4 | 0.4 |
| 19A | Broil Fish | Gas | Worst Case | 3.3 | 4.8 | 3.8 | 5.4 | 2.4 | 3.6 | 0.5 | 0.6 |
| 19B | Broil Fish | Gas | Worst Case | 3.7 | 4.7 | 4.6 | 6.8 | 3.5 | 4.3 | 0.8 | 0.9 |
| 20 | Full Meal | Gas | Standard | 4.6 | 8.8 | 4.6 | 9.5 | 4.4 | 9.1 | 0.4 | 0.6 |

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 21A | Stovetop Stir Fry | Gas | Test 2 Replicate | 1.1 | 1.8 | 1.1 | 1.6 | 0.6 | 0.9 | 0.4 | 0.5 |
| 21B | Stovetop Stir Fry | Gas | Test 2 Replicate | 2.6 | 3.3 | 2.8 | 3.2 | 2.2 | 2.4 | 0.4 | 0.4 |
| 22 | French Fries | Gas | Test 5 Replicate | 4.3 | 7.5 | 4.1 | 7.0 | 3.1 | 5.9 | 0.4 | 0.5 |
| 23 | Bake Lasagne | Gas | Test 7 Replicate | 2.0 | 2.9 | 1.8 | 2.9 | 1.7 | 2.7 | 0.3 | 0.6 |
| 24 | Fry Beef | Gas | Cast Iron Pan | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] |
| 24RA | Fry Beef | Gas | Cast Iron Pan | 0.9 | 1.0 | 0.9 | 1.0 | 1.0 | 1.0 | 0.5 | 0.6 |
| 24RB | Fry Beef | Gas | Cast Iron Pan | 1.0 | 1.1 | 1.1 | 1.1 | 1.0 | 1.1 | 0.5 | 0.5 |
| 25 | Pork Roast | Gas | Aluminum Pan | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] |
| 26 | Fry Beef | Gas | Exhaust Ventillation | 0.9 | 0.9 | 0.8 | 0.8 | 0.8 | 0.9 | 0.5 | 0.6 |
| 27 | Pork Roast | Gas | Exhaust Ventillation | 1.2 | 1.8 | 1.2 | 1.7 | 1.1 | 1.5 | 0.5 | 0.7 |
| 28 | Fry Beef | Gas | Range Hood Shields | 0.4 | 0.4 | 0.4 | 0.5 | 0.4 | 0.5 | 0.3 | 0.3 |
| 29 | Pork Roast | Gas | Range Hood Shields | 1.0 | 2.0 | 0.9 | 1.4 | 0.9 | 1.5 | 0.3 | 0.4 |
| 30A | Stovetop Stir Fry | Gas | Vegetable Oil | 0.9 | 1.5 | 0.9 | 1.3 | 0.6 | 0.7 | 0.1 | 0.1 |
| 30B | Stovetop Stir Fry | Gas | Vegetable Oil | 1.7 | 1.9 | 2.2 | 2.5 | 1.8 | 2.0 | 0.2 | 0.2 |
| 31A | Fry Beef | Gas | Pan Lid | 0.5 | 0.5 | 0.4 | 0.4 | 0.4 | 0.5 | 0.4 | 0.4 |
| 31B | Fry Beef | Gas | Pan Lid | 0.4 | 0.4 | 0.6 | 0.7 | 0.5 | 0.6 | 0.3 | 0.3 |
| 32A | Popcorn | Microwave | Standard | 0.8 | 0.9 | 0.9 | 0.9 | 0.8 | 0.8 | 1.1 | 1.1 |
| 32B | Popcorn | Microwave | Standard | 0.9 | 0.9 | 1.0 | 1.0 | 0.9 | 0.9 | 0.8 | 0.8 |
| 33 | Burner Baseline | Gas | | 3.2 | 5.1 | 3.5 | 5.3 | 2.8 | 4.6 | 1.2 | 1.4 |
| 34 | Oven Baseline | Gas | | 2.0 | 3.0 | 2.0 | 3.3 | 2.1 | 3.2 | 0.5 | 0.6 |
| N | | | | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| Minimum | | | | 0.4 | 0.4 | 0.4 | 0.4 | 0.4 | 0.5 | 0.1 | 0.1 |
| Maximum | | | | 14.8 | 19.9 | 14.9 | 19.9 | 14.8 | 20.0 | 1.1 | 1.1 |

[a] No sample – data acquisition system failed on this day of testing

Table 3-20. Average CO Concentrations (ppm) Measured at Four Locations during the Total Exposure Period

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 1R | Oven Cleaning | Gas | Standard | 13.7 | 19.9 | 13.8 | 19.9 | 13.9 | 20.0 | 0.6 | 0.9 |
| 2 | Stovetop Stir Fry | Gas | Standard | 2.0 | 2.3 | 1.9 | 2.4 | 1.8 | 2.3 | 0.5 | 0.6 |
| 3A | Bacon | Gas | Standard | 0.6 | 1.0 | 0.7 | 1.2 | 0.7 | 0.9 | 0.5 | 0.6 |
| 3B | Bacon | Gas | Standard | 1.1 | 1.2 | 1.0 | 1.1 | 1.0 | 1.2 | 0.5 | 0.6 |
| 4 | Tortillas | Gas | Standard | 1.0 | 1.3 | 1.0 | 1.2 | 1.0 | 1.2 | 0.3 | 0.4 |
| 5 | French Fries | Gas | Standard | 3.5 | 5.1 | 3.4 | 4.9 | 3.6 | 5.0 | 0.3 | 0.4 |
| 6A | Broil Fish | Gas | Standard | 6.9 | 9.3 | 7.0 | 8.9 | 6.9 | 9.4 | 0.3 | 0.4 |
| 6B | Broil Fish | Gas | Standard | 11.7 | 13.2 | 11.5 | 13.3 | 11.6 | 13.5 | 0.3 | 0.4 |
| 7 | Bake Lasagna | Gas | Standard | 2.7 | 3.7 | 2.8 | 3.7 | 2.6 | 3.6 | 0.3 | 0.6 |
| 8 | Oven Cleaning | Electric | Standard | 7.2 | 12.0 | 7.2 | 12.1 | 6.9 | 11.5 | 0.5 | 1.1 |
| 9 | Stovetop Stir Fry | Electric | Standard | 0.6 | 0.7 | 0.6 | 0.9 | 0.5 | 0.8 | 0.4 | 0.6 |
| 10A | Bacon | Electric | Standard | 0.4 | 0.7 | 0.4 | 0.5 | 0.4 | 0.5 | 0.3 | 0.4 |
| 10B | Bacon | Electric | Standard | 0.5 | 0.5 | 0.5 | 0.7 | 0.4 | 0.6 | 0.4 | 0.7 |
| 11 | Tortillas | Electric | Standard | 1.1 | 1.4 | 1.1 | 1.4 | 1.1 | 1.5 | 0.3 | 0.8 |
| 12 | French Fries | Electric | Standard | 0.8 | 1.2 | 0.8 | 1.2 | 0.8 | 1.1 | 0.4 | 0.7 |
| 13A | Broil Fish | Electric | Standard | 2.0 | 2.8 | 2.1 | 3.0 | 1.9 | 2.7 | 0.4 | 0.8 |
| 13B | Broil Fish | Electric | Standard | 3.4 | 3.9 | 3.4 | 4.0 | 3.4 | 4.0 | 0.3 | 0.6 |
| 14 | Lasagna | Electric | Standard | 0.6 | 1.1 | 0.7 | 1.3 | 0.7 | 1.2 | 0.4 | 1.1 |
| 15A | Bacon | Microwave | Standard | 0.6 | 0.7 | 0.6 | 0.7 | 0.7 | 0.8 | 0.8 | 1.1 |
| 15B | Bacon | Microwave | Standard | 0.9 | 1.1 | 0.9 | 1.0 | 0.9 | 1.0 | 0.7 | 0.9 |
| 16 | Lasagna | Microwave | Standard | 0.7 | 0.8 | 0.7 | 0.8 | 0.7 | 0.8 | 0.5 | 0.7 |
| 17A | Stovetop Stir Fry | Gas | Worst Case | 1.8 | 2.3 | 1.7 | 2.3 | 1.6 | 2.1 | 0.2 | 0.3 |
| 17B | Stovetop Stir Fry | Gas | Worst Case | 3.0 | 3.7 | 3.0 | 3.8 | 3.0 | 3.7 | 0.2 | 0.5 |
| 18A | Bacon | Gas | Worst Case | 1.5 | 1.9 | 1.6 | 1.8 | 1.4 | 1.7 | 0.5 | 0.6 |
| 18B | Bacon | Gas | Worst Case | 1.9 | 2.3 | 1.9 | 2.2 | 1.9 | 2.3 | 0.4 | 0.5 |
| 19A | Broil Fish | Gas | Worst Case | 4.0 | 8.0 | 3.8 | 7.1 | 3.9 | 6.4 | 0.6 | 0.7 |

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 19B | Broil Fish | Gas | Worst Case | 5.7 | 9.4 | 5.7 | 10.6 | 5.7 | 9.0 | 0.8 | 1.0 |
| 20 | Full Meal | Gas | Standard | 4.7 | 9.4 | 4.7 | 9.5 | 4.8 | 9.1 | 0.3 | 0.6 |
| 21A | Stovetop Stir Fry | Gas | Test 2 Replicate | 1.8 | 2.2 | 1.9 | 2.3 | 1.6 | 2.1 | 0.4 | 0.5 |
| 21B | Stovetop Stir Fry | Gas | Test 2 Replicate | 2.9 | 3.4 | 3.2 | 3.7 | 3.0 | 3.4 | 0.4 | 0.6 |
| 22 | French Fries | Gas | Test 5 Replicate | 5.2 | 7.5 | 5.0 | 7.0 | 4.7 | 7.1 | 0.4 | 0.7 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 2.2 | 2.9 | 2.1 | 3.0 | 1.9 | 2.9 | 0.4 | 0.8 |
| 24 | Fry Beef | Gas | Cast Iron Pan | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] |
| 24RA | Fry Beef | Gas | Cast Iron Pan | 1.0 | 1.1 | 1.0 | 1.1 | 1.0 | 1.1 | 0.5 | 0.6 |
| 24RB | Fry Beef | Gas | Cast Iron Pan | 0.9 | 1.1 | 1.0 | 1.1 | 1.0 | 1.1 | 0.5 | 0.6 |
| 25 | Pork Roast | Gas | Aluminum Pan | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 0.8 | 0.9 | 0.8 | 0.9 | 0.8 | 0.9 | 0.5 | 0.6 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 1.1 | 1.8 | 1.1 | 1.7 | 1.1 | 1.5 | 0.6 | 0.9 |
| 28 | Fry Beef | Gas | Range Hood Shields | 0.4 | 0.5 | 0.4 | 0.5 | 0.4 | 0.6 | 0.3 | 0.5 |
| 29 | Pork Roast | Gas | Range Hood Shields | 0.9 | 2.0 | 0.8 | 1.4 | 0.8 | 1.5 | 0.3 | 0.7 |
| 30A | Stovetop Stir Fry | Gas | Vegetable Oil | 1.4 | 1.8 | 1.5 | 2.0 | 1.4 | 1.9 | 0.2 | 0.3 |
| 30B | Stovetop Stir Fry | Gas | Vegetable Oil | 2.1 | 2.5 | 2.2 | 2.6 | 2.2 | 2.7 | 0.2 | 0.3 |
| 31A | Fry Beef | Gas | Pan Lid | 0.5 | 0.6 | 0.5 | 0.6 | 0.5 | 0.6 | 0.3 | 0.4 |
| 31B | Fry Beef | Gas | Pan Lid | 0.6 | 0.7 | 0.6 | 0.7 | 0.6 | 0.7 | 0.3 | 0.4 |
| 32A | Popcorn | Microwave | Standard | 0.9 | 0.9 | 0.9 | 0.9 | 0.9 | 1.0 | 0.9 | 1.1 |
| 32B | Popcorn | Microwave | Standard | 0.9 | 1.1 | 0.9 | 1.0 | 0.9 | 1.0 | 0.7 | 1.0 |
| 33 | Range Baseline | Gas | | 4.2 | 5.8 | 4.5 | 5.9 | 4.0 | 5.9 | 1.1 | 1.4 |
| 34 | Oven Baseline | Gas | | 2.2 | 3.4 | 2.4 | 3.4 | 2.2 | 3.3 | 0.6 | 0.9 |
| N | | | | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| Minimum | | | | 0.4 | 0.5 | 0.4 | 0.5 | 0.4 | 0.5 | 0.2 | 0.3 |
| Maximum | | | | 13.7 | 19.9 | 13.8 | 19.9 | 13.9 | 20.0 | 0.9 | 1.1 |

No sample – data acquisition system failed on this day of testing

Table 3-21. Average NO Concentrations (ppb) Measured at Four Locations during the Cooking Period

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 1R | Oven Cleaning | Gas | Standard | 692.1 | 999.4 | 716.4 | 999.4 | 699.2 | 999.4 | 24.9 | 33.0 |
| 2 | Stovetop Stir Fry | Gas | Standard | 45.9 | 82.2 | 76.1 | 138.4 | 32.2 | 78.1 | 7.8 | 11.9 |
| 3A | Bacon | Gas | Standard | 9.6 | 12.9 | 12.0 | 22.8 | 8.3 | 14.5 | 2.2 | 3.6 |
| 3B | Bacon | Gas | Standard | 111.3 | 128.6 | 119.8 | 156.0 | 89.3 | 127.7 | 4.5 | 8.3 |
| 4 | Tortillas | Gas | Standard | 109.4 | 206.2 | 136.6 | 238.3 | 108.2 | 219.9 | 12.4 | 20.7 |
| 5 | French Fries | Gas | Standard | 282.0 | 514.0 | 282.6 | 548.2 | 282.1 | 519.2 | 17.7 | 28.0 |
| 6A | Broil Fish | Gas | Standard | 4.9 | 11.2 | 14.3 | 18.8 | 0.9 | 2.3 | 0.0 | 0.0 |
| 6B | Broil Fish | Gas | Standard | 29.6 | 40.9 | 24.5 | 38.2 | 27.3 | 37.2 | 8.1 | 13.5 |
| 7 | Bake Lasagna | Gas | Standard | 190.8 | 314.1 | 199.4 | 327.2 | 176.5 | 294.5 | 9.6 | 18.2 |
| 8 | Oven Cleaning | Electric | Standard | 148.9 | 184.2 | 149.3 | 184.8 | 143.1 | 181.9 | 14.8 | 29.9 |
| 9 | Stovetop Stir Fry | Electric | Standard | 14.0 | 19.9 | 15.6 | 19.1 | 14.0 | 19.3 | 12.1 | 14.6 |
| 10A | Bacon | Electric | Standard | 11.0 | 14.2 | 6.1 | 8.3 | 10.2 | 11.6 | 12.2 | 20.1 |
| 10B | Bacon | Electric | Standard | 5.8 | 13.5 | 20.2 | 29.4 | 7.2 | 14.5 | 10.7 | 18.8 |
| 11 | Tortillas | Electric | Standard | 8.1 | 15.1 | 9.6 | 18.8 | 6.3 | 11.2 | 3.9 | 14.9 |
| 12 | French Fries | Electric | Standard | 5.0 | 14.9 | 1.7 | 5.0 | 2.1 | 4.0 | 3.5 | 8.3 |
| 13A | Broil Fish | Electric | Standard | 8.1 | 12.9 | 12.7 | 23.4 | 3.1 | 6.3 | 0.0 | 0.0 |
| 13B | Broil Fish | Electric | Standard | 0.0 | 0.0 | 5.0 | 9.9 | 2.3 | 4.6 | 8.8 | 8.8 |
| 14 | Lasagna | Electric | Standard | NA | NA | NA | NA | NA | NA | NA | NA |
| 15A | Bacon | Microwave | Standard | 17.8 | 31.0 | 25.6 | 39.3 | 21.5 | 36.6 | 17.4 | 33.5 |
| 15B | Bacon | Microwave | Standard | 58.4 | 76.9 | 49.1 | 68.4 | 47.0 | 65.8 | 13.8 | 17.8 |
| 16 | Lasagna | Microwave | Standard | 21.8 | 31.3 | 25.6 | 33.8 | 21.5 | 24.3 | 18.0 | 21.5 |
| 17A | Stovetop Stir Fry | Gas | Worst Case | 120.1 | 191.4 | 97.7 | 170.0 | 87.0 | 173.9 | 33.9 | 42.1 |
| 17B | Stovetop Stir Fry | Gas | Worst Case | 255.0 | 312.8 | 265.9 | 326.5 | 251.7 | 298.2 | 34.4 | 37.1 |
| 18A | Bacon | Gas | Worst Case | 75.8 | 128.2 | 107.2 | 164.9 | 62.3 | 116.3 | 19.4 | 25.4 |
| 18B | Bacon | Gas | Worst Case | 182.4 | 242.3 | 183.3 | 221.0 | 171.4 | 227.5 | 15.9 | 19.0 |
| 19A | Broil Fish | Gas | Worst Case | 33.5 | 40.0 | 29.1 | 41.0 | 31.0 | 40.1 | 18.6 | 20.2 |

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 19B | Broil Fish | Gas | Worst Case | 34.3 | 41.4 | 44.4 | 51.8 | 33.6 | 40.7 | 17.6 | 22.2 |
| 20 | Full Meal | Gas | Standard | 530.4 | 999.4 | 523.3 | 999.4 | 502.0 | 999.4 | 27.3 | 34.4 |
| 21A | Stovetop Stir Fry | Gas | Test 2 Replicate | 88.8 | 155.1 | 86.9 | 123.2 | 35.9 | 50.2 | 20.4 | 25.0 |
| 21B | Stovetop Stir Fry | Gas | Test 2 Replicate | 222.0 | 274.2 | 216.9 | 259.6 | 163.9 | 190.7 | 22.1 | 26.3 |
| 22 | French Fries | Gas | Test 5 Replicate | 354.6 | 629.3 | 332.7 | 621.3 | 273.5 | 541.4 | 10.1 | 18.8 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 301.1 | 430.4 | 290.8 | 447.1 | 270.6 | 427.3 | 24.2 | 29.6 |
| 24 | Fry Beef | Gas | Cast Iron Pan | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] |
| 24RA | Fry Beef | Gas | Cast Iron Pan | 90.5 | 121.9 | 81.4 | 99.8 | 54.1 | 68.9 | 20.9 | 22.3 |
| 24RB | Fry Beef | Gas | Cast Iron Pan | 126.2 | 154.1 | 120.7 | 131.5 | 115.3 | 137.9 | 18.0 | 21.5 |
| 25 | Pork Roast | Gas | Aluminum Pan | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 49.3 | 84.0 | 46.4 | 72.3 | 36.1 | 61.6 | 11.9 | 13.0 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 80.1 | 137.0 | 79.6 | 113.9 | 75.7 | 116.1 | 28.7 | 41.4 |
| 28 | Fry Beef | Gas | Range Hood Shields | 19.8 | 22.7 | 18.4 | 24.0 | 14.4 | 14.7 | 17.3 | 30.0 |
| 29 | Pork Roast | Gas | Range Hood Shields | 68.6 | 115.3 | 66.4 | 157.3 | 62.5 | 107.6 | 19.3 | 28.6 |
| 30A | Stovetop Stir Fry | Gas | Vegetable Oil | 72.7 | 129.7 | 83.2 | 116.6 | 44.7 | 52.5 | 28.8 | 35.0 |
| 30B | Stovetop Stir Fry | Gas | Vegetable Oil | 157.3 | 176.2 | 184.5 | 216.3 | 160.7 | 183.6 | 18.4 | 22.2 |
| 31A | Fry Beef | Gas | Pan Lid | 57.4 | 73.5 | 27.2 | 45.6 | 29.1 | 45.1 | 13.5 | 18.0 |
| 31B | Fry Beef | Gas | Pan Lid | 93.4 | 97.8 | 73.8 | 80.6 | 78.6 | 92.0 | 27.9 | 33.1 |
| 32A | Popcorn | Microwave | Standard | 26.0 | 32.3 | 26.4 | 26.4 | 20.9 | 20.9 | 35.5 | 38.8 |
| 32B | Popcorn | Microwave | Standard | 27.2 | 28.9 | 29.9 | 29.9 | 35.2 | 36.9 | 16.3 | 16.3 |
| 33 | Range Baseline | Gas | | 268.5 | 451.8 | 293.2 | 462.1 | 218.5 | 396.3 | 55.9 | 69.3 |
| 34 | Oven Baseline | Gas | | 276.3 | 385.9 | 272.2 | 378.6 | 279.8 | 381.9 | 23.8 | 36.8 |
| N | | | | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| Minimum | | | | 0.0 | 0.0 | 1.7 | 5.0 | 0.9 | 2.3 | 0.0 | 0.0 |
| Maximum | | | | 692.1 | 999.4 | 716.4 | 999.4 | 699.2 | 999.4 | 35.5 | 42.1 |

No sample – data acquisition system failed on this day of testing

Measurements for NO may be truncated to 1000 ppb due to scale limitations during monitoring.

Table 3-22. Average NO Concentrations (ppb) Measured at Four Locations during the Total Exposure Period

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 1R | Oven Cleaning | Gas | Standard | 763.0 | 999.4 | 776.0 | 999.4 | 762.4 | 999.4 | 25.6 | 37.5 |
| 2 | Stovetop Stir Fry | Gas | Standard | 105.6 | 126.5 | 105.5 | 138.4 | 98.3 | 137.7 | 12.5 | 36.6 |
| 3A | Bacon | Gas | Standard | 40.5 | 84.8 | 39.5 | 81.2 | 40.1 | 85.7 | 3.8 | 20.8 |
| 3B | Bacon | Gas | Standard | 128.3 | 160.0 | 119.4 | 158.8 | 123.5 | 158.5 | 4.2 | 12.9 |
| 4 | Tortillas | Gas | Standard | 180.0 | 256.6 | 189.4 | 257.9 | 180.7 | 247.8 | 11.5 | 20.7 |
| 5 | French Fries | Gas | Standard | 411.0 | 580.7 | 393.0 | 581.1 | 413.9 | 579.4 | 19.6 | 28.0 |
| 6A | Broil Fish | Gas | Standard | 11.7 | 29.7 | 12.7 | 27.4 | 7.1 | 15.3 | 0.0 | 0.0 |
| 6B | Broil Fish | Gas | Standard | 39.4 | 50.4 | 38.6 | 48.7 | 40.6 | 53.0 | 8.9 | 14.0 |
| 7 | Bake Lasagna | Gas | Standard | 222.5 | 316.8 | 223.6 | 327.2 | 210.7 | 295.1 | 9.8 | 18.2 |
| 8 | Oven Cleaning | Electric | Standard | 148.6 | 184.2 | 148.9 | 184.8 | 144.3 | 181.9 | 16.4 | 29.9 |
| 9 | Stovetop Stir Fry | Electric | Standard | 16.8 | 28.7 | 15.6 | 19.7 | 18.0 | 28.4 | 14.2 | 20.8 |
| 10A | Bacon | Electric | Standard | 5.7 | 14.2 | 3.9 | 8.9 | 4.5 | 11.6 | 7.1 | 20.1 |
| 10B | Bacon | Electric | Standard | 14.4 | 28.2 | 18.9 | 29.4 | 14.0 | 24.4 | 12.8 | 22.8 |
| 11 | Tortillas | Electric | Standard | 6.4 | 15.1 | 8.5 | 19.0 | 6.5 | 14.5 | 2.4 | 14.9 |
| 12 | French Fries | Electric | Standard | 4.6 | 14.9 | 3.2 | 14.5 | 6.2 | 16.2 | 3.3 | 8.9 |
| 13A | Broil Fish | Electric | Standard | 16.3 | 27.3 | 16.4 | 24.5 | 12.9 | 25.7 | 11.0 | 24.4 |
| 13B | Broil Fish | Electric | Standard | 1.7 | 10.2 | 4.7 | 17.1 | 6.3 | 22.8 | 2.5 | 9.9 |
| 14 | Lasagna | Electric | Standard | NA | NA | NA | NA | NA | NA | NA | NA |
| 15A | Bacon | Microwave | Standard | 17.8 | 31.0 | 25.6 | 39.3 | 21.5 | 36.6 | 17.4 | 33.5 |
| 15B | Bacon | Microwave | Standard | 62.8 | 76.9 | 61.7 | 78.2 | 61.0 | 77.1 | 13.4 | 22.2 |
| 16 | Lasagna | Microwave | Standard | 19.1 | 31.3 | 22.0 | 33.8 | 21.0 | 24.3 | 14.9 | 21.5 |
| 17A | Stovetop Stir Fry | Gas | Worst Case | 188.9 | 239.2 | 184.0 | 237.8 | 168.7 | 220.7 | 30.4 | 42.1 |
| 17B | Stovetop Stir Fry | Gas | Worst Case | 284.7 | 342.2 | 285.9 | 349.9 | 289.7 | 349.1 | 32.7 | 44.4 |
| 18A | Bacon | Gas | Worst Case | 134.0 | 183.5 | 141.0 | 169.1 | 130.4 | 176.6 | 16.4 | 25.4 |
| 18B | Bacon | Gas | Worst Case | 219.2 | 267.4 | 216.7 | 252.7 | 214.5 | 258.8 | 17.6 | 25.3 |
| 19A | Broil Fish | Gas | Worst Case | 28.5 | 40.0 | 28.3 | 41.0 | 27.6 | 40.1 | 18.5 | 22.4 |

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 19B | Broil Fish | Gas | Worst Case | 31.5 | 41.4 | 35.6 | 51.8 | 33.1 | 40.7 | 19.1 | 28.4 |
| 20 | Full Meal | Gas | Standard | 639.5 | 999.4 | 627.6 | 999.4 | 642.7 | 999.4 | 32.9 | 43.7 |
| 21A | Stovetop Stir Fry | Gas | Test 2 Replicate | 138.6 | 173.9 | 145.6 | 186.6 | 124.0 | 157.1 | 20.8 | 25.0 |
| 21B | Stovetop Stir Fry | Gas | Test 2 Replicate | 256.0 | 306.6 | 258.1 | 295.4 | 246.0 | 295.8 | 22.4 | 30.4 |
| 22 | French Fries | Gas | Test 5 Replicate | 429.4 | 629.3 | 414.2 | 622.1 | 397.5 | 601.0 | 10.7 | 22.6 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 324.6 | 430.4 | 319.1 | 447.1 | 301.8 | 427.3 | 26.4 | 42.5 |
| 24 | Fry Beef | Gas | Cast Iron Pan | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] |
| 24RA | Fry Beef | Gas | Cast Iron Pan | 107.7 | 132.2 | 108.9 | 129.9 | 97.9 | 123.0 | 20.3 | 23.2 |
| 24RB | Fry Beef | Gas | Cast Iron Pan | 130.2 | 156.1 | 131.4 | 152.7 | 132.6 | 154.4 | 25.3 | 37.6 |
| 25 | Pork Roast | Gas | Aluminum Pan | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 69.6 | 94.5 | 66.6 | 81.7 | 65.2 | 81.7 | 16.9 | 25.5 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 75.7 | 137.0 | 74.1 | 113.9 | 71.3 | 116.1 | 28.3 | 41.9 |
| 28 | Fry Beef | Gas | Range Hood Shields | 24.4 | 30.5 | 23.7 | 34.4 | 23.7 | 31.0 | 18.1 | 30.0 |
| 29 | Pork Roast | Gas | Range Hood Shields | 61.6 | 115.3 | 61.0 | 157.3 | 57.9 | 107.6 | 20.0 | 29.0 |
| 30A | Stovetop Stir Fry | Gas | Vegetable Oil | 118.8 | 156.1 | 130.9 | 172.0 | 120.9 | 171.1 | 25.6 | 35.2 |
| 30B | Stovetop Stir Fry | Gas | Vegetable Oil | 183.3 | 222.7 | 184.0 | 216.3 | 182.5 | 228.1 | 22.0 | 27.8 |
| 31A | Fry Beef | Gas | Pan Lid | 68.4 | 79.7 | 58.5 | 78.3 | 61.0 | 74.2 | 17.1 | 26.1 |
| 31B | Fry Beef | Gas | Pan Lid | 92.7 | 100.5 | 89.2 | 102.0 | 89.3 | 104.3 | 20.4 | 33.1 |
| 32A | Popcorn | Microwave | Standard | 27.2 | 32.8 | 26.1 | 32.0 | 29.4 | 34.0 | 26.8 | 38.8 |
| 32B | Popcorn | Microwave | Standard | 31.4 | 37.0 | 29.8 | 33.7 | 33.2 | 39.6 | 22.8 | 30.1 |
| 33 | Range Baseline | Gas | | 355.2 | 504.0 | 374.7 | 516.5 | 330.2 | 509.9 | 44.6 | 69.3 |
| 34 | Oven Baseline | Gas | | 300.6 | 391.4 | 297.2 | 388.9 | 306.3 | 397.8 | 23.8 | 36.8 |
| | | | N | 43 | 43 | 43 | 43 | 43 | 43 | 43 | 43 |
| | | | Minimum | 1.7 | 10.2 | 3.2 | 8.9 | 4.5 | 11.6 | 0.0 | 0.0 |
| | | | Maximum | 763.0 | 999.4 | 776.0 | 999.4 | 762.4 | 999.4 | 32.9 | 44.4 |

No sample – data acquisition system failed on this day of testing
Measurements for NO may be truncated to 1000 ppb due to scale limitations during monitoring.

Table 3-23. Average $NO_2$ Concentrations (ppb) Measured at Four Locations during the Cooking Period

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 1R | Oven Cleaning | Gas | Standard | 402.7 | 564.6 | 427.3 | 617.6 | 446.6 | 673.7 | 25.8 | 46.7 |
| 2 | Stovetop Stir Fry | Gas | Standard | 40.0 | 41.1 | 55.8 | 72.2 | 30.9 | 47.0 | 19.2 | 22.6 |
| 3A | Bacon | Gas | Standard | 13.2 | 17.0 | 15.1 | 21.6 | 15.2 | 20.9 | 21.8 | 29.7 |
| 3B | Bacon | Gas | Standard | 53.4 | 61.2 | 55.8 | 63.4 | 50.2 | 60.0 | 17.2 | 17.6 |
| 4 | Tortillas | Gas | Standard | 30.8 | 54.3 | 39.7 | 58.0 | 28.3 | 54.8 | 4.7 | 9.4 |
| 5 | French Fries | Gas | Standard | 70.4 | 113.0 | 68.6 | 123.4 | 66.0 | 119.5 | 10.3 | 16.0 |
| 6A | Broil Fish | Gas | Standard | 94.1 | 124.6 | 121.1 | 145.4 | 78.4 | 119.3 | 32.0 | 39.1 |
| 6B | Broil Fish | Gas | Standard | 114.9 | 158.0 | 107.2 | 138.5 | 75.0 | 85.6 | 26.8 | 32.9 |
| 7 | Bake Lasagna | Gas | Standard | 91.2 | 113.1 | 94.4 | 131.3 | 84.6 | 102.9 | 23.8 | 32.3 |
| 8 | Oven Cleaning | Electric | Standard | 34.5 | 65.5 | 41.4 | 70.2 | 36.3 | 69.3 | 22.8 | 47.8 |
| 9 | Stovetop Stir Fry | Electric | Standard | 15.4 | 16.9 | 22.5 | 31.1 | 18.0 | 24.1 | 23.3 | 31.2 |
| 10A | Bacon | Electric | Standard | 25.7 | 30.6 | 21.7 | 24.6 | 19.8 | 24.9 | 20.7 | 23.6 |
| 10B | Bacon | Electric | Standard | 24.4 | 27.1 | 30.0 | 37.0 | 23.7 | 35.8 | 25.9 | 29.7 |
| 11 | Tortillas | Electric | Standard | 34.8 | 43.5 | 40.7 | 47.0 | 32.0 | 49.0 | 32.5 | 46.3 |
| 12 | French Fries | Electric | Standard | 33.7 | 35.7 | 28.2 | 30.5 | 30.5 | 38.5 | 30.6 | 36.6 |
| 13A | Broil Fish | Electric | Standard | 25.4 | 27.8 | 32.1 | 33.8 | 20.2 | 32.1 | 19.1 | 23.9 |
| 13B | Broil Fish | Electric | Standard | 27.2 | 27.2 | 37.6 | 50.2 | 31.8 | 42.6 | 19.1 | 19.1 |
| 14 | Lasagna | Electric | Standard | 27.6 | 37.5 | 34.1 | 44.0 | 32.9 | 39.6 | 36.0 | 48.1 |
| 15A | Bacon | Microwave | Standard | 10.5 | 15.4 | 14.3 | 20.0 | 8.2 | 12.7 | 13.8 | 18.3 |
| 15B | Bacon | Microwave | Standard | 21.4 | 27.6 | 17.8 | 26.7 | 19.9 | 21.7 | 22.2 | 25.9 |
| 16 | Lasagna | Microwave | Standard | 12.8 | 21.3 | 17.2 | 31.5 | 17.7 | 30.0 | 11.6 | 16.9 |
| 17A | Stovetop Stir Fry | Gas | Worst Case | 47.0 | 70.3 | 36.8 | 60.1 | 31.3 | 52.4 | 7.7 | 10.6 |
| 17B | Stovetop Stir Fry | Gas | Worst Case | 55.7 | 68.4 | 57.6 | 92.7 | 62.8 | 76.7 | 16.6 | 24.5 |
| 18A | Bacon | Gas | Worst Case | 40.4 | 50.6 | 35.2 | 45.5 | 24.2 | 31.7 | 11.9 | 19.3 |
| 18B | Bacon | Gas | Worst Case | 40.4 | 61.1 | 35.9 | 54.6 | 34.2 | 49.8 | 10.9 | 16.8 |
| 19A | Broil Fish | Gas | Worst Case | 92.7 | 150.5 | 96.5 | 167.3 | 46.0 | 84.2 | 17.3 | 27.1 |

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 19B | Broil Fish | Gas | Worst Case | 81.4 | 131.4 | 109.4 | 170.3 | 47.1 | 70.2 | 11.4 | 16.6 |
| 20 | Full Meal | Gas | Standard | 190.9 | 374.9 | 195.6 | 402.5 | 184.1 | 421.4 | 7.4 | 19.1 |
| 21A | Stovetop Stir Fry | Gas | Test 2 Replicate | 41.6 | 75.6 | 37.8 | 51.9 | 25.9 | 35.6 | 11.8 | 17.9 |
| 21B | Stovetop Stir Fry | Gas | Test 2 Replicate | 57.8 | 80.0 | 67.3 | 79.1 | 34.6 | 39.0 | 11.5 | 17.4 |
| 22 | French Fries | Gas | Test 5 Replicate | 120.4 | 167.6 | 112.6 | 158.3 | 84.3 | 131.3 | 19.4 | 32.1 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 85.4 | 95.7 | 84.9 | 108.9 | 73.0 | 106.0 | 18.8 | 34.2 |
| 24 | Fry Beef | Gas | Cast Iron Pan | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] |
| 24RA | Fry Beef | Gas | Cast Iron Pan | 17.9 | 28.7 | 24.5 | 28.8 | 16.6 | 22.7 | 12.5 | 27.9 |
| 24RB | Fry Beef | Gas | Cast Iron Pan | 23.7 | 34.3 | 20.2 | 22.0 | 27.2 | 28.7 | 3.5 | 6.9 |
| 25 | Pork Roast | Gas | Aluminum Pan | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 27.2 | 43.4 | 24.3 | 35.0 | 23.7 | 30.0 | 22.3 | 23.6 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 17.5 | 40.3 | 15.7 | 33.2 | 15.2 | 30.2 | 11.9 | 43.4 |
| 28 | Fry Beef | Gas | Range Hood Shields | 1.6 | 2.7 | 10.2 | 14.8 | 2.2 | 4.5 | 0.9 | 2.7 |
| 29 | Pork Roast | Gas | Range Hood Shields | 18.3 | 61.2 | 14.5 | 45.0 | 15.5 | 31.9 | 9.7 | 29.1 |
| 30A | Stovetop Stir Fry | Gas | Vegetable Oil | 25.0 | 33.0 | 54.0 | 68.9 | 29.4 | 41.2 | 9.9 | 13.6 |
| 30B | Stovetop Stir Fry | Gas | Vegetable Oil | 28.1 | 38.9 | 43.2 | 50.1 | 36.8 | 41.1 | 22.1 | 32.4 |
| 31A | Fry Beef | Gas | Pan Lid | 24.4 | 31.6 | 13.1 | 15.7 | 13.6 | 14.8 | 6.8 | 16.0 |
| 31B | Fry Beef | Gas | Pan Lid | 29.0 | 40.3 | 24.4 | 26.4 | 27.6 | 30.2 | 8.7 | 12.4 |
| 32A | Popcorn | Microwave | Standard | 19.3 | 20.3 | 7.4 | 7.4 | 5.1 | 5.1 | 25.8 | 39.1 |
| 32B | Popcorn | Microwave | Standard | 12.4 | 14.2 | 0.0 | 0.0 | 12.7 | 25.1 | 0.0 | 0.0 |
| 33 | Range Baseline | Gas | | 67.0 | 108.2 | 73.7 | 108.2 | 53.2 | 97.5 | 18.8 | 23.7 |
| 34 | Oven Baseline | Gas | | 90.3 | 129.2 | 78.8 | 114.9 | 93.7 | 121.0 | 17.3 | 22.6 |
| 35 | $NO_X$ Background | Gas | | 62.4 | 68.1 | 48.5 | 71.4 | 67.2 | 86.9 | 24.7 | 35.5 |
| 36 | $NO_X$ Background | Gas | | 72.0 | 86.4 | 83.1 | 116.8 | 61.8 | 87.5 | 20.9 | 27.7 |
| 37 | $NO_X$ Verification | Gas | | 16.9 | 21.1 | 18.4 | 26.4 | 19.6 | 26.5 | 19.7 | 27.7 |
| 38 | Oven Dirtying | Gas | | 113.3 | 190.7 | 122.2 | 177.5 | 94.9 | 178.2 | 22.6 | 33.1 |
| 38R | Oven Dirtying | Gas | | 108.2 | 146.2 | 113.1 | 161.7 | 64.4 | 94.6 | 23.3 | 30.1 |

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 39 | Oven Dirtying | Electric | | 26.4 | 41.9 | 25.7 | 37.3 | 29.0 | 40.1 | 22.0 | 30.2 |
| | | | N | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| | | | Minimum | 1.6 | 2.7 | 0.0 | 0.0 | 2.2 | 4.5 | 0.0 | 0.0 |
| | | | Maximum | 402.7 | 564.6 | 427.3 | 617.6 | 446.6 | 673.7 | 36.0 | 48.1 |

[a] No sample – data acquisition system failed on this day of testing

Table 3-24. Average $NO_2$ Concentrations (ppb) Measured at Four Locations during the Total Exposure Period

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 1R | Oven Cleaning | Gas | Standard | 377.8 | 564.6 | 400.0 | 617.6 | 425.1 | 673.7 | 24.0 | 46.7 |
| 2 | Stovetop Stir Fry | Gas | Standard | 45.1 | 77.6 | 46.8 | 72.2 | 42.1 | 67.9 | 15.9 | 28.9 |
| 3A | Bacon | Gas | Standard | 32.2 | 58.3 | 30.9 | 57.6 | 30.8 | 56.8 | 25.2 | 39.4 |
| 3B | Bacon | Gas | Standard | 49.7 | 64.7 | 50.8 | 63.4 | 47.9 | 72.2 | 21.2 | 30.9 |
| 4 | Tortillas | Gas | Standard | 33.2 | 54.3 | 37.8 | 60.2 | 29.8 | 56.7 | 4.7 | 15.4 |
| 5 | French Fries | Gas | Standard | 74.3 | 136.2 | 70.5 | 123.4 | 67.6 | 119.5 | 10.7 | 17.9 |
| 6A | Broil Fish | Gas | Standard | 108.3 | 160.2 | 115.5 | 164.0 | 105.0 | 169.7 | 33.9 | 41.6 |
| 6B | Broil Fish | Gas | Standard | 118.0 | 178.6 | 120.4 | 194.4 | 116.6 | 187.5 | 20.3 | 32.9 |
| 7 | Bake Lasagna | Gas | Standard | 82.9 | 113.1 | 86.0 | 131.3 | 78.4 | 102.9 | 23.4 | 32.3 |
| 8 | Oven Cleaning | Electric | Standard | 31.1 | 65.5 | 37.9 | 70.2 | 33.6 | 69.3 | 20.6 | 47.8 |
| 9 | Stovetop Stir Fry | Electric | Standard | 15.0 | 27.7 | 21.2 | 33.4 | 14.8 | 24.5 | 18.3 | 31.2 |
| 10A | Bacon | Electric | Standard | 27.5 | 35.8 | 26.3 | 40.8 | 26.0 | 35.8 | 27.0 | 43.5 |
| 10B | Bacon | Electric | Standard | 19.7 | 31.3 | 21.6 | 37.0 | 18.1 | 35.8 | 19.8 | 29.7 |
| 11 | Tortillas | Electric | Standard | 34.4 | 47.0 | 39.0 | 47.0 | 36.5 | 49.0 | 32.5 | 46.3 |
| 12 | French Fries | Electric | Standard | 28.1 | 43.5 | 27.6 | 39.0 | 30.5 | 38.5 | 28.7 | 37.3 |
| 13A | Broil Fish | Electric | Standard | 23.0 | 37.4 | 22.7 | 33.8 | 19.4 | 37.7 | 18.8 | 35.7 |

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 13B | Broil Fish | Electric | Standard | 33.3 | 42.6 | 37.0 | 57.6 | 35.6 | 50.0 | 28.8 | 45.8 |
| 14 | Lasagna | Electric | Standard | 34.4 | 52.3 | 36.4 | 50.6 | 35.8 | 53.4 | 35.5 | 48.1 |
| 15A | Bacon | Microwave | Standard | 10.5 | 15.4 | 14.3 | 20.0 | 8.2 | 12.7 | 13.8 | 18.3 |
| 15B | Bacon | Microwave | Standard | 18.9 | 27.6 | 15.1 | 26.7 | 18.7 | 27.4 | 21.3 | 29.3 |
| 16 | Lasagna | Microwave | Standard | 11.0 | 25.8 | 12.7 | 31.5 | 13.9 | 30.0 | 14.1 | 27.6 |
| 17A | Stovetop Stir Fry | Gas | Worst Case | 50.1 | 74.5 | 49.9 | 76.3 | 45.4 | 63.3 | 10.6 | 22.7 |
| 17B | Stovetop Stir Fry | Gas | Worst Case | 53.2 | 93.0 | 49.2 | 92.7 | 50.0 | 90.2 | 15.3 | 26.8 |
| 18A | Bacon | Gas | Worst Case | 32.4 | 52.2 | 31.5 | 45.5 | 29.6 | 47.0 | 7.3 | 19.3 |
| 18B | Bacon | Gas | Worst Case | 40.5 | 61.1 | 41.0 | 64.8 | 37.8 | 60.4 | 10.5 | 20.0 |
| 19A | Broil Fish | Gas | Worst Case | 98.3 | 250.3 | 87.4 | 201.3 | 74.1 | 145.9 | 12.7 | 27.1 |
| 19B | Broil Fish | Gas | Worst Case | 97.9 | 234.0 | 103.1 | 237.2 | 85.1 | 171.2 | 13.4 | 19.5 |
| 20 | Full Meal | Gas | Standard | 114.1 | 374.9 | 117.1 | 402.5 | 125.5 | 421.4 | 15.2 | 43.9 |
| 21A | Stovetop Stir Fry | Gas | Test 2 Replicate | 38.3 | 75.6 | 41.7 | 66.0 | 37.3 | 57.4 | 11.3 | 17.9 |
| 21B | Stovetop Stir Fry | Gas | Test 2 Replicate | 52.1 | 83.1 | 51.1 | 79.1 | 41.2 | 56.5 | 13.7 | 30.6 |
| 22 | French Fries | Gas | Test 5 Replicate | 100.0 | 167.6 | 97.1 | 158.3 | 84.7 | 146.8 | 17.4 | 32.1 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 74.1 | 95.7 | 72.4 | 108.9 | 68.6 | 106.0 | 22.3 | 36.4 |
| 24 | Fry Beef | Gas | Cast Iron Pan | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] |
| 24RA | Fry Beef | Gas | Cast Iron Pan | 20.6 | 32.8 | 27.4 | 42.0 | 23.4 | 34.0 | 12.3 | 44.0 |
| 24RB | Fry Beef | Gas | Cast Iron Pan | 23.8 | 41.1 | 40.3 | 73.3 | 38.3 | 71.6 | 9.3 | 30.0 |
| 25 | Pork Roast | Gas | Aluminum Pan | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 21.9 | 43.4 | 22.3 | 41.7 | 23.2 | 40.4 | 14.8 | 24.3 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 17.1 | 40.3 | 13.8 | 33.2 | 14.9 | 30.2 | 11.9 | 43.4 |
| 28 | Fry Beef | Gas | Range Hood Shields | 7.0 | 19.1 | 12.4 | 26.1 | 12.2 | 28.5 | 3.0 | 13.4 |
| 29 | Pork Roast | Gas | Range Hood Shields | 15.7 | 61.2 | 12.4 | 45.0 | 14.2 | 31.9 | 9.6 | 29.1 |
| 30A | Stovetop Stir Fry | Gas | Vegetable Oil | 32.2 | 49.4 | 43.6 | 71.4 | 37.6 | 64.0 | 9.8 | 34.3 |
| 30B | Stovetop Stir Fry | Gas | Vegetable Oil | 35.6 | 59.3 | 39.4 | 52.1 | 40.0 | 67.0 | 10.3 | 32.4 |
| 31A | Fry Beef | Gas | Pan Lid | 22.2 | 31.6 | 18.1 | 29.2 | 17.4 | 25.9 | 11.3 | 21.8 |

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 31B | Fry Beef | Gas | Pan Lid | 23.2 | 40.3 | 17.6 | 27.0 | 24.6 | 33.0 | 14.2 | 32.4 |
| 32A | Popcorn | Microwave | Standard | 12.2 | 24.8 | 9.8 | 25.8 | 8.3 | 31.2 | 14.4 | 28.8 |
| 32B | Popcorn | Microwave | Standard | 7.3 | 12.4 | 12.4 | 31.2 | 15.7 | 25.8 | 8.2 | 16.6 |
| 33 | Range Baseline | Gas | | 72.2 | 112.0 | 75.6 | 117.6 | 67.7 | 128.5 | 21.1 | 33.8 |
| 34 | Oven Baseline | Gas | | 84.5 | 129.2 | 78.5 | 116.0 | 91.9 | 121.0 | 17.7 | 29.4 |
| N | | | | 44 | 44 | 44 | 44 | 44 | 44 | 44 | 44 |
| Minimum | | | | 7.0 | 12.4 | 9.8 | 20.0 | 8.2 | 12.7 | 3.0 | 13.4 |
| Maximum | | | | 377.8 | 564.6 | 400.0 | 617.6 | 425.1 | 673.7 | 35.5 | 48.1 |

[a] No sample – data acquisition system failed on this day of testing

## 3.8 Air Exchange Rates and Environmental Monitoring Data

Air exchange rates were measured by the tracer gas decay method using $SF_6$. $SF_6$ was measured in the kitchen, living room, and master bedroom, and air exchange rates were calculated for each room. A whole house air exchange rate was calculated as the average of the measurements in the three rooms. The results are presented in Table 3-25. The whole house air exchange rate averaged $0.32 \pm 0.19$ air changes per hour (ACH) for all 42 measurement periods. The median was 0.27 ACH. The 42 measurement periods included four tests with the range hood on and one test during which a bedroom window was inadvertently left open. If these five periods are excluded, the average air exchange rate was 0.26 $hr^{-1}$. As shown in the Table, the air exchange rates in the three rooms were generally very similar even though there were no mixing fans operating during the tests.

Temperature and relative humidity were measured indoors and outdoors during the test period. Average temperature and relative humidity during each test are presented in Table 3-26. Humidity measurements sometimes reached 100% with the thin film capacitance sensors on rainy days.

## 3.9 Estimated Emission Rates

Emission rates were calculated for each test using a dynamic mass balance model, as described in Section 2.0. In addition to the rates, the source strengths were calculated normalized to the food weight and the power use for cooking. The results are summarized in Tables 3-27 through 3-37 and are discussed in Section 4.0.

Emission rates were calculated for $PM_{2.5}$ and $PM_{10}$ using the gravimetric mass data. Emission rates were also calculated for $PM_{0.1}$, $PM_{0.5}$, $PM_{1.0}$, $PM_{2.5}$, and $PM_{10}$ mass and particle concentrations using the data from the ELPI for the total exposure period. The data are calculated for the total particle or mass emissions for particles of less than the indicated size. The usefulness of this data is primarily for comparison of the relative differences between the size fractions. It cannot be compared to the emission rates calculated from the gravimetric data because the relationship between ELPI mass measurements and gravimetric could not be established.

Emission rates were also calculated for CO, NO, and $NO_2$. The data are presented for the average emissions over the duration of the test and for the peak emissions.

Emission rates were also estimated for the PAHs and elements even though the concentrations were low and there were only a limited number of samples. These values should be considered only as crude estimates because many of the values are based on concentrations that were below the method uncertainty level, and because they are based on only a single sample collected in the kitchen. The estimated emission rate was made using the kitchen concentration and volume. Because so many of the concentrations of the elements were below the uncertainty level, only the emission rates are presented; the emission rates have not been normalized to the amount of food cooked or energy used.

Table 3-25. Air Exchange Rates ($hr^{-1}$) during the Cooking Tests

| Test No. | Type | Range | Conditions | LR | Kitchen | MBR | House |
|---|---|---|---|---|---|---|---|
| 1 | Oven Cleaning | Gas | Standard | 0.24 | 0.28 | 0.30 | 0.27 |
| 1R | Oven Cleaning | Gas | Standard | 0.29 | 0.29 | 0.29 | 0.29 |
| 2 | Stovetop Stir Fry | Gas | Standard | 0.28 | 0.27 | 0.28 | 0.28 |
| 3 | Bacon | Gas | Standard | 0.27 | 0.26 | 0.37 | 0.30 |
| 4 | Tortillas | Gas | Standard | 0.23 | 0.22 | 0.23 | 0.22 |
| 5 | French Fries | Gas | Standard | 0.25 | 0.24 | 0.25 | 0.25 |
| 6 | Broil Fish | Gas | Standard | 0.20 | 0.22 | 0.23 | 0.22 |
| 7 | Bake Lasagna | Gas | Standard | 0.24 | 0.24 | 0.25 | 0.24 |
| 8 | Oven Cleaning | Electric | Standard | 0.25 | 0.27 | 0.25 | 0.26 |
| 9 | Stovetop Stir Fry | Electric | Standard | 0.21 | 0.22 | 0.23 | 0.22 |
| 10 | Bacon | Electric | Standard | 0.23 | 0.27 | 0.29 | 0.26 |
| 11 | Tortillas | Electric | Standard | 0.29 | 0.30 | 0.30 | 0.29 |
| 12 | French Fries | Electric | Standard | 0.18 | 0.20 | 0.21 | 0.20 |
| 13 | Broil Fish | Electric | Standard | 0.32 | 0.29 | 0.29 | 0.30 |
| 14 | Lasagna | Electric | Standard | 0.22 | 0.22 | 0.24 | 0.23 |
| 15 | Lasagna | Microwave | Standard | 0.26 | 0.26 | 0.23 | 0.25 |
| 16 | Bacon | Microwave | Standard | 0.22 | 0.24 | 0.19 | 0.22 |
| 17 | Stovetop Stir Fry | Gas | Worst Case | 0.27 | 0.27 | 0.26 | 0.27 |
| 18 | Bacon | Gas | Worst Case | 0.24 | 0.24 | 0.23 | 0.24 |
| 19 | Broil Fish | Gas | Worst Case & Open Window | 0.99 | 0.94 | 1.02 | 0.98 |
| 20 | Full Meal | Gas | Standard | 0.26 | 0.26 | 0.25 | 0.26 |
| 21 | Stovetop Stir Fry | Gas | Test 2 Replicate | 0.24 | 0.25 | 0.22 | 0.24 |
| 22 | French Fries | Gas | Test 5 Replicate | 0.25 | 0.25 | 0.23 | 0.24 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 0.28 | 0.29 | 0.28 | 0.28 |
| 24 | Fry Beef | Gas | Cast Iron Pan | 0.31 | 0.31 | 0.27 | 0.30 |
| 24R | Fry Beef | Gas | Cast Iron Pan | 0.31 | 0.27 | 0.27 | 0.28 |
| 25 | Pork Roast | Gas | Aluminum Pan | 0.28 | 0.28 | 0.28 | 0.28 |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 0.52 | 0.62 | 0.59 | 0.58 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 1.06 | 1.07 | 1.08 | 1.07 |
| 28 | Fry Beef | Gas | Range Hood Shields | 0.55 | 0.50 | 0.54 | 0.53 |
| 29 | Pork Roast | Gas | Range Hood Shields | 0.78 | 0.78 | 0.78 | 0.78 |
| 30 | Stovetop Stir Fry | Gas | Vegetable Oil | 0.30 | 0.30 | 0.29 | 0.30 |
| 31 | Fry Beef | Gas | Pan Lid | 0.24 | 0.24 | 0.24 | 0.24 |
| 32 | Popcorn | Microwave | Standard | 0.29 | 0.24 | 0.32 | 0.29 |
| 33 | Range Baseline | Gas | | 0.27 | 0.26 | 0.32 | 0.28 |
| 34 | Oven Baseline | Gas | | 0.23 | 0.26 | 0.28 | 0.26 |

| Test No. | Type | Range | Conditions | LR | Kitchen | MBR | House |
|---|---|---|---|---|---|---|---|
| 35 | Instrument Evaluation | Gas | | 0.29 | 0.28 | 0.27 | 0.28 |
| 36 | Instrument Evaluation | Gas | | 0.21 | 0.22 | 0.21 | 0.21 |
| 37 | Instrument Evaluation | Gas | | 0.27 | 0.26 | 0.23 | 0.25 |
| 38 | Oven Dirtying | Gas | | 0.27 | 0.27 | 0.26 | 0.26 |
| 38R | Oven Dirtying | Gas | | 0.31 | 0.32 | 0.32 | 0.32 |
| 39 | Oven Dirtying | Electric | | 0.24 | 0.24 | 0.20 | 0.23 |
| | Summary - all tests | | N | 42 | 42 | 42 | 42 |
| | | | Minimum | 0.18 | 0.20 | 0.19 | 0.20 |
| | | | Maximum | 1.06 | 1.07 | 1.08 | 1.07 |

Table 3-26. Average Temperature (°C) during Cooking Tests

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 1R | Oven Cleaning | Gas | Standard | 24.7 | 27.3 | 22.7 | 25.5 | 21.8 | 23.7 | 7.1 | 9.2 |
| 2 | Stovetop Stir Fry | Gas | Standard | 20.9 | 22.7 | 19.8 | 21.5 | 20.3 | 21.6 | 13.2 | 14.7 |
| 3A | Bacon | Gas | Standard | 19.6 | 21.1 | 18.9 | 20.1 | 19.0 | 19.5 | 10.9 | 11.7 |
| 3B | Bacon | Gas | Standard | 20.5 | 21.5 | 20.3 | 20.9 | 19.5 | 19.8 | 11.0 | 12.6 |
| 4 | Tortillas | Gas | Standard | 21.9 | 23.2 | 19.7 | 21.3 | 19.5 | 20.2 | 13.7 | 15.3 |
| 5 | French Fries | Gas | Standard | 23.4 | 24.5 | 21.3 | 22.5 | 19.9 | 20.8 | 13.1 | 15.7 |
| 6A | Broil Fish | Gas | Standard | 21.2 | 23.0 | 20.5 | 21.6 | 18.2 | 18.8 | 15.1 | 17.0 |
| 6B | Broil Fish | Gas | Standard | 23.0 | 23.5 | 22.5 | 23.2 | 19.9 | 21.1 | 18.0 | 18.8 |
| 7 | Bake Lasagna | Gas | Standard | 21.8 | 24.6 | 21.7 | 23.1 | 20.8 | 21.4 | 12.7 | 14.6 |
| 8 | Oven Cleaning | Electric | Standard | 22.5 | 25.4 | 21.9 | 24.7 | 21.8 | 24.4 | 10.9 | 13.2 |
| 9 | Stovetop Stir Fry | Electric | Standard | 22.9 | 23.3 | 23.2 | 23.5 | 22.8 | 23.1 | 12.1 | 13.4 |
| 10A | Bacon | Electric | Standard | 20.5 | 21.1 | 20.5 | 20.9 | 20.5 | 20.8 | 9.2 | 10.7 |
| 10B | Bacon | Electric | Standard | 21.4 | 22.5 | 21.3 | 21.6 | 20.8 | 21.1 | 8.4 | 10.3 |
| 11 | Tortillas | Electric | Standard | 21.3 | 22.9 | 21.1 | 21.7 | 20.3 | 20.5 | 9.7 | 11.5 |
| 12 | French Fries | Electric | Standard | 20.6 | 21.4 | 20.6 | 21.3 | 20.2 | 20.5 | 9.4 | 10.6 |
| 13A | Broil Fish | Electric | Standard | 22.2 | 23.6 | 22.3 | 22.7 | 22.1 | 22.5 | 11.1 | 12.2 |
| 13B | Broil Fish | Electric | Standard | 23.4 | 24.0 | 23.1 | 23.7 | 22.1 | 22.5 | 12.6 | 14.5 |
| 14 | Lasagna | Electric | Standard | 22.2 | 23.5 | 22.0 | 23.2 | 21.0 | 21.5 | 12.2 | 14.2 |
| 15A | Bacon | Microwave | Standard | 19.2 | 19.9 | 19.9 | 20.6 | 19.1 | 19.5 | 11.1 | 11.9 |
| 15B | Bacon | Microwave | Standard | 20.3 | 20.9 | 21.0 | 21.2 | 19.5 | 19.7 | 9.7 | 10.3 |
| 16 | Lasagna | Microwave | Standard | 21.5 | 22.0 | 22.0 | 22.3 | 20.6 | 21.1 | 13.8 | 14.9 |
| 17A | Stovetop Stir Fry | Gas | Worst Case | 26.1 | 27.0 | 24.7 | 25.2 | 23.1 | 23.9 | 15.1 | 15.5 |
| 17B | Stovetop Stir Fry | Gas | Worst Case | 27.2 | 28.3 | 25.4 | 25.7 | 23.8 | 24.2 | 12.8 | 15.0 |
| 18A | Bacon | Gas | Worst Case | 21.9 | 23.0 | 21.6 | 22.6 | 20.7 | 21.0 | 11.5 | 14.2 |
| 18B | Bacon | Gas | Worst Case | 23.4 | 24.3 | 23.0 | 23.4 | 21.4 | 21.9 | 12.5 | 14.7 |
| 19A | Broil Fish | Gas | Worst Case | 22.1 | 22.6 | 20.8 | 21.2 | 19.9 | 20.2 | 6.5 | 7.3 |
| 19B | Broil Fish | Gas | Worst Case | 22.3 | 23.0 | 20.8 | 21.3 | 19.8 | 20.2 | 5.6 | 6.0 |

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 20 | Full Meal | Gas | Standard | 27.1 | 29.7 | 24.8 | 26.6 | 23.3 | 24.6 | 13.6 | 15.9 |
| 21A | Stovetop Stir Fry | Gas | Test 2 Replicate | 23.4 | 24.5 | 22.1 | 22.6 | 21.9 | 22.4 | 12.2 | 13.2 |
| 21B | Stovetop Stir Fry | Gas | Test 2 Replicate | 24.7 | 25.2 | 22.7 | 23.0 | 21.7 | 22.0 | 9.9 | 11.0 |
| 22 | French Fries | Gas | Test 5 Replicate | 22.2 | 23.0 | 22.5 | 23.2 | 22.1 | 22.7 | 10.4 | 10.8 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 24.3 | 25.2 | 21.8 | 22.7 | 20.7 | 21.0 | 7.2 | 11.0 |
| 24 | Fry Beef | Gas | Cast Iron Pan | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] |
| 24RA | Fry Beef | Gas | Cast Iron Pan | 22.9 | 23.6 | 21.7 | 23.0 | 22.3 | 22.5 | 11.9 | 12.9 |
| 24RB | Fry Beef | Gas | Cast Iron Pan | 24.2 | 24.7 | 22.0 | 23.4 | 22.5 | 22.7 | 14.0 | 15.7 |
| 25 | Pork Roast | Gas | Aluminum Pan | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 22.3 | 23.8 | 21.0 | 22.3 | 21.4 | 21.9 | 15.6 | 16.5 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 24.0 | 25.0 | 21.9 | 22.9 | 21.9 | 22.5 | 12.3 | 15.8 |
| 28 | Fry Beef | Gas | Range Hood Shields | 21.3 | 22.0 | 21.1 | 21.5 | 20.8 | 21.1 | 8.9 | 9.2 |
| 29 | Pork Roast | Gas | Range Hood Shields | 21.4 | 22.6 | 20.9 | 21.9 | 20.6 | 21.0 | 9.0 | 11.8 |
| 30A | Stovetop Stir Fry | Gas | Vegetable Oil | 23.5 | 24.6 | 23.9 | 24.7 | 22.3 | 22.6 | 13.1 | 14.6 |
| 30B | Stovetop Stir Fry | Gas | Vegetable Oil | 24.8 | 27.2 | 25.0 | 25.4 | 22.4 | 23.3 | 14.3 | 16.2 |
| 31A | Fry Beef | Gas | Pan Lid | 20.0 | 21.4 | 19.3 | 20.1 | 18.7 | 19.0 | 12.0 | 15.0 |
| 31B | Fry Beef | Gas | Pan Lid | 21.4 | 22.1 | 19.5 | 21.3 | 19.3 | 19.8 | 11.7 | 13.3 |
| 32A | Popcorn | Microwave | Standard | 21.2 | 21.8 | 19.5 | 19.7 | 21.3 | 21.4 | 10.4 | 10.9 |
| 32B | Popcorn | Microwave | Standard | 21.5 | 21.9 | 19.6 | 20.0 | 21.1 | 21.4 | 10.0 | 10.4 |
| 33 | Range Baseline | Gas | | 20.3 | 20.7 | 19.7 | 20.1 | 18.9 | 19.4 | 4.2 | 6.7 |
| 34 | Oven Baseline | Gas | | 23.3 | 23.9 | 22.6 | 23.3 | 21.3 | 22.0 | 5.3 | 6.5 |
| N | | | | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| Minimum | | | | 19.2 | 19.9 | 18.9 | 19.7 | 18.2 | 18.8 | 5.6 | 6.0 |
| Maximum | | | | 27.2 | 29.7 | 25.4 | 26.6 | 23.8 | 24.6 | 18.0 | 18.8 |

[a] No sample due to problem with the data acquisition system on this day of testing

Table 3-27. Average Relative Humidity (%) during the Cooking Tests

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 1 | Oven Cleaning | Gas | Standard | 58.1 | 62.8 | 67.2 | 71.5 | 75.6 | 78.7 | 99.9 | 100.0 |
| 1R | Oven Cleaning | Gas | Standard | 47.9 | 49.8 | 57.3 | 58.7 | 65.9 | 69.2 | 42.0 | 58.2 |
| 2 | Stovetop Stir Fry | Gas | Standard | 60.2 | 63.3 | 69.2 | 74.2 | 72.4 | 76.9 | 100.0 | 100.0 |
| 3 | Bacon | Gas | Standard | 59.7 | 60.9 | 67.0 | 69.9 | 71.5 | 72.6 | 100.0 | 100.0 |
| 3B | Bacon | Gas | Standard | 59.1 | 60.3 | 67.3 | 69.6 | 73.7 | 75.1 | 100.0 | 100.0 |
| 4 | Tortillas | Gas | Standard | 56.4 | 57.3 | 65.6 | 67.5 | 72.1 | 74.3 | 83.3 | 86.0 |
| 5 | French Fries | Gas | Standard | 57.0 | 61.2 | 66.6 | 71.8 | 73.6 | 78.2 | 76.7 | 81.2 |
| 6 | Broil Fish | Gas | Standard | 54.8 | 57.9 | 62.0 | 63.8 | 67.9 | 68.7 | 89.6 | 100.0 |
| 6B | Broil Fish | Gas | Standard | 52.6 | 54.2 | 61.1 | 63.0 | 69.2 | 71.3 | 75.0 | 82.9 |
| 7 | Bake Lasagna | Gas | Standard | 54.6 | 60.0 | 63.1 | 65.0 | 68.9 | 69.9 | 78.3 | 100.0 |
| 8 | Oven Cleaning | Electric | Standard | 51.4 | 56.6 | 55.3 | 60.1 | 64.9 | 66.6 | 70.4 | 90.4 |
| 9 | Stovetop Stir Fry | Electric | Standard | 52.1 | 53.1 | 62.2 | 63.2 | 65.3 | 66.3 | 51.5 | 60.8 |
| 10 | Bacon | Electric | Standard | 54.9 | 56.5 | 62.8 | 64.6 | 65.1 | 67.2 | 87.4 | 88.5 |
| 10B | Bacon | Electric | Standard | 55.3 | 57.5 | 63.9 | 65.5 | 66.7 | 68.2 | 86.3 | 90.3 |
| 11 | Tortillas | Electric | Standard | 53.3 | 55.0 | 58.3 | 60.5 | 66.2 | 68.2 | 87.6 | 90.9 |
| 12 | French Fries | Electric | Standard | 57.5 | 62.4 | 67.0 | 74.2 | 69.2 | 73.7 | 88.0 | 89.7 |
| 13 | Broil Fish | Electric | Standard | 54.3 | 56.2 | 63.7 | 65.0 | 69.0 | 70.3 | 56.8 | 69.3 |
| 13B | Broil Fish | Electric | Standard | 53.8 | 58.6 | 63.9 | 64.8 | 70.5 | 71.8 | 62.6 | 79.5 |
| 14 | Lasagna | Electric | Standard | 58.7 | 63.0 | 64.8 | 67.4 | 71.7 | 73.2 | 95.5 | 97.8 |
| 15 | Bacon | Microwave | Standard | 60.7 | 63.4 | 61.8 | 63.0 | 69.7 | 71.1 | 100.0 | 100.0 |
| 15B | Bacon | Microwave | Standard | 61.6 | 62.8 | 66.3 | 67.3 | 74.2 | 75.3 | 100.0 | 100.0 |
| 16 | Lasagna | Microwave | Standard | 57.0 | 57.8 | 59.5 | 61.6 | 69.2 | 70.4 | 92.5 | 95.4 |
| 17 | Stovetop Stir Fry | Gas | Worst Case | 46.4 | 51.4 | 57.4 | 59.4 | 60.8 | 63.0 | 15.4 | 16.2 |
| 17B | Stovetop Stir Fry | Gas | Worst Case | 48.2 | 52.6 | 60.7 | 65.2 | 66.3 | 68.2 | 15.7 | 16.4 |
| 18 | Bacon | Gas | Worst Case | 54.1 | 55.8 | 65.4 | 67.6 | 71.4 | 73.3 | 36.1 | 46.0 |
| 18B | Bacon | Gas | Worst Case | 51.9 | 53.4 | 64.6 | 66.2 | 72.0 | 73.6 | 23.9 | 32.0 |
| 19 | Broil Fish | Gas | Worst Case | 48.1 | 50.1 | 56.3 | 59.5 | 62.9 | 64.5 | 49.3 | 57.4 |

| Test No. | Type | Range | Conditions | K | | LR | | MBR | | OUT | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Avg. | Max | Avg. | Max | Avg. | Max | Avg. | Max |
| 19B | Broil Fish | Gas | Worst Case | 48.1 | 49.7 | 56.8 | 58.3 | 63.5 | 64.8 | 65.5 | 70.2 |
| 20 | Full Meal | Gas | Standard | 50.3 | 55.5 | 63.9 | 74.9 | 72.2 | 89.2 | 16.7 | 50.5 |
| 21 | Stovetop Stir Fry | Gas | Test 2 Replicate | 48.3 | 49.4 | 60.6 | 62.1 | 62.4 | 66.0 | 17.6 | 22.7 |
| 21B | Stovetop Stir Fry | Gas | Test 2 Replicate | 51.9 | 54.9 | 64.8 | 66.5 | 69.2 | 71.4 | 18.9 | 35.4 |
| 22 | French Fries | Gas | Test 5 Replicate | 56.2 | 61.4 | 66.4 | 71.8 | 69.7 | 73.2 | 64.9 | 74.2 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 49.0 | 55.0 | 59.5 | 61.8 | 64.8 | 66.8 | 19.8 | 42.0 |
| 24 | Fry Beef | Gas | Cast Iron Pan | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] |
| 24R | Fry Beef | Gas | Cast Iron Pan | 51.4 | 53.9 | 61.0 | 63.5 | 65.6 | 67.3 | 39.4 | 51.3 |
| 24RB | Fry Beef | Gas | Cast Iron Pan | 48.2 | 50.6 | 60.5 | 63.0 | 65.3 | 66.1 | 17.9 | 28.1 |
| 25 | Pork Roast | Gas | Aluminum Pan | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] | NS[a] |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 53.2 | 56.4 | 64.5 | 65.9 | 70.1 | 72.0 | 33.4 | 41.2 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 48.1 | 51.0 | 60.1 | 62.0 | 65.2 | 67.6 | 22.6 | 46.1 |
| 28 | Fry Beef | Gas | Range Hood Shields | 51.0 | 52.5 | 60.1 | 61.2 | 61.7 | 63.5 | 62.4 | 69.4 |
| 29 | Pork Roast | Gas | Range Hood Shields | 50.4 | 54.1 | 59.3 | 62.1 | 64.6 | 67.6 | 63.8 | 80.0 |
| 30 | Stovetop Stir Fry | Gas | Vegetable Oil | 48.0 | 51.3 | 59.7 | 62.3 | 65.3 | 67.1 | 18.5 | 29.9 |
| 30B | Stovetop Stir Fry | Gas | Vegetable Oil | 46.4 | 49.4 | 58.4 | 61.0 | 65.6 | 67.4 | 16.1 | 19.8 |
| 31 | Fry Beef | Gas | Pan Lid | 51.3 | 54.7 | 60.9 | 62.9 | 65.3 | 66.1 | 15.7 | 16.4 |
| 31B | Fry Beef | Gas | Pan Lid | 50.5 | 52.2 | 61.0 | 61.9 | 65.6 | 66.5 | 17.5 | 29.2 |
| 32 | Popcorn | Microwave | Standard | 52.6 | 58.0 | 59.9 | 60.8 | 62.1 | 64.3 | 59.5 | 64.6 |
| 32B | Popcorn | Microwave | Standard | 53.2 | 53.7 | 61.2 | 61.9 | 64.8 | 65.7 | 58.4 | 62.3 |
| 33 | Range Baseline | Gas | | 56.3 | 60.6 | 63.9 | 69.4 | 68.0 | 74.7 | 58.2 | 68.5 |
| 34 | Oven Baseline | Gas | | 50.6 | 53.1 | 56.3 | 59.1 | 61.8 | 65.2 | 56.7 | 61.7 |
| N | | | | 45 | 45 | 45 | 45 | 45 | 45 | 45 | 45 |
| Minimum | | | | 46.4 | 49.4 | 55.3 | 58.3 | 60.8 | 63.0 | 15.4 | 16.2 |
| Maximum | | | | 61.6 | 63.4 | 69.2 | 74.9 | 75.6 | 89.2 | 100.0 | 100.0 |

[a] No sample due to problem with the data acquisition system on this day of testing

Table 3-28. CO Emission Rates during the Cooking Tests

| Test No. | Type | Range | Conditions | Emission Rate | | Source Strength (per gram of food) | | Food-specific Emission Factor | | Power-specific Emission Factor | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Average | Peak[a] | Average | Peak | Average | Peak | Average | Peak |
| | | | | mg/hr | mg/hr | µg/g | µg/g | µg/g/hr | µg/g/hr | µg/BTU | µg/BTU |
| 1R | Oven Cleaning | Gas | Standard | 1991.9 | 2900.9 | No food | No food | No food | No food | 143.1 | 208.5 |
| 2 | Stovetop Stir Fry | Gas | Standard | 1344.1 | 1557.5 | 463.5 | 537.1 | 1324.2 | 1534.5 | 168.2 | 194.9 |
| 3A | Bacon | Gas | Standard | 160.2 | 323.7 | 118.6 | 239.8 | 323.6 | 653.9 | 27.5 | 55.6 |
| 3B | Bacon | Gas | Standard | 543.6 | 529.3 | 377.5 | 367.6 | 1132.4 | 1102.8 | 92.9 | 90.5 |
| 4 | Tortillas | Gas | Standard | 328.5 | 400.4 | 133.9 | 163.2 | 178.5 | 217.6 | 52.4 | 63.8 |
| 5 | French Fries | Gas | Standard | 1103.7 | 1584.6 | 256.8 | 368.8 | 226.6 | 325.4 | 143.1 | 205.5 |
| 6A | Broil Fish | Gas | Standard | 5093.2 | 6900.9 | 3880.6 | 5257.8 | 9701.4 | 13144.6 | 554.7 | 751.6 |
| 6B | Broil Fish | Gas | Standard | 10405.4 | 11688.5 | 6734.9 | 7565.4 | 20204.6 | 22696.2 | 976.3 | 1096.7 |
| 7 | Bake Lasagna | Gas | Standard | 535.6 | 674.3 | 965.5 | 1215.4 | 459.7 | 578.8 | 110.5 | 139.1 |
| 8 | Oven Cleaning | Electric | Standard | 990.8 | 1619.9 | No food | No food | No food | No food | 137.8 | 225.3 |
| 9 | Stovetop Stir Fry | Electric | Standard | 122.5 | 91.7 | 40.4 | 30.3 | 115.6 | 86.5 | 14.5 | 10.9 |
| 10A | Bacon | Electric | Standard | 69.3 | 183.1 | 61.0 | 161.3 | 159.2 | 420.8 | 38.8 | 102.6 |
| 10B | Bacon | Electric | Standard | 25.7 | 0.0[c] | 26.4 | 0.0[c] | 56.5 | 0.0[c] | 17.1 | 0.0[c] |
| 11 | Tortillas | Electric | Standard | 395.9 | 326.9 | 149.0 | 123.0 | 207.8 | 171.6 | 51.7 | 42.7 |
| 12 | French Fries | Electric | Standard | 309.2 | 368.3 | 26.4 | 31.5 | 63.4 | 75.5 | 29.3 | 34.9 |
| 13A | Broil Fish | Electric | Standard | 1702.9 | 2129.1 | 1216.3 | 1520.8 | 4054.5 | 5069.2 | 139.5 | 174.4 |
| 13B | Broil Fish | Electric | Standard | 3196.7 | 3459.7 | 2155.1 | 2332.4 | 7183.6 | 7774.7 | 507.8 | 549.6 |
| 14 | Lasagna | Electric | Standard | 43.7 | 0.0[c] | 75.3 | 0.0[c] | 37.3 | 0.0[c] | 13.3 | 0.0[c] |
| 15A | Bacon | Microwave | Standard | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] |
| 15B | Bacon | Microwave | Standard | 145.4 | 96.1 | 221.3 | 146.4 | 358.9 | 237.3 | 28.4 | 18.8 |
| 16 | Lasagna | Microwave | Standard | 40.0 | 11.3 | 87.4 | 24.6 | 34.5 | 9.7 | 7.8 | 2.2 |
| 17A | Stovetop Stir Fry | Gas | Worst Case | 1227.7 | 1554.3 | 587.9 | 744.2 | 1356.6 | 1717.4 | 152.5 | 193.0 |
| 17B | Stovetop Stir Fry | Gas | Worst Case | 2145.0 | 2519.7 | 993.1 | 1166.5 | 2383.4 | 2799.6 | 263.4 | 309.4 |
| 18A | Bacon | Gas | Worst Case | 742.8 | 935.8 | 723.3 | 911.3 | 1669.1 | 2102.9 | 121.8 | 153.5 |
| 18B | Bacon | Gas | Worst Case | 930.8 | 1124.9 | 1034.3 | 1249.9 | 2001.8 | 2419.2 | 184.0 | 222.4 |
| 19A | Broil Fish | Gas | Worst Case | 3837.5 | 8000.4 | 4099.8 | 8547.4 | 9839.6 | 20513.7 | 364.0 | 758.8 |

| Test No. | Type | Range | Conditions | Emission Rate | | Source Strength (per gram of food) | | Food-specific Emission Factor | | Power-specific Emission Factor | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Average | Peak[a] | Average | Peak | Average | Peak | Average | Peak |
| | | | | mg/hr | mg/hr | µg/g | µg/g | µg/g/hr | µg/g/hr | µg/BTU | µg/BTU |
| 19B | Broil Fish | Gas | Worst Case | 5471.4 | 9282.4 | 5428.0 | 9208.7 | 13027.1 | 22101.0 | 522.3 | 886.1 |
| 20 | Full Meal | Gas | Standard | 906.2 | 1815.3 | 160.9 | 322.2 | 68.9 | 138.1 | 63.5 | 127.2 |
| 21A | Stovetop Stir Fry | Gas | Test 2 Replicate | 1359.8 | 1665.8 | 486.6 | 596.1 | 1536.5 | 1882.3 | 173.0 | 211.9 |
| 21B | Stovetop Stir Fry | Gas | Test 2 Replicate | 2313.5 | 2639.5 | 842.8 | 961.6 | 2528.4 | 2884.7 | 274.7 | 313.4 |
| 22 | French Fries | Gas | Test 5 Replicate | 1367.0 | 1924.6 | 384.4 | 541.3 | 262.1 | 369.1 | 179.3 | 252.5 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 414.3 | 488.5 | 714.2 | 842.1 | 354.1 | 417.6 | 77.4 | 91.3 |
| 24RA | Fry Beef | Gas | Cast Iron Pan | 425.3 | 415.7 | 163.6 | 159.9 | 467.4 | 456.8 | 86.2 | 84.3 |
| 24RB | Fry Beef | Gas | Cast Iron Pan | 406.3 | 475.3 | 156.3 | 182.8 | 446.5 | 522.4 | 110.0 | 128.7 |
| 25 | Pork Roast | Gas | Aluminum Pan | NS[b] | NS[b] | NS[b] | NS[b] | NS[b] | NS[b] | NS[b] | NS[b] |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 355.9 | 353.1 | 137.6 | 136.6 | 393.3 | 390.2 | 64.4 | 63.9 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 216.3 | 332.1 | 333.0 | 511.2 | 110.4 | 169.5 | 59.3 | 91.1 |
| 28 | Fry Beef | Gas | Range Hood Shields | 139.1 | 83.0 | 53.2 | 31.8 | 152.0 | 90.7 | 34.3 | 20.5 |
| 29 | Pork Roast | Gas | Range Hood Shields | 161.1 | 374.5 | 201.0 | 467.1 | 67.0 | 155.7 | 43.8 | 101.8 |
| 30A | Stovetop Stir Fry | Gas | Vegetable Oil | 1308.5 | 1577.5 | 443.6 | 534.7 | 1478.6 | 1782.5 | 166.2 | 200.3 |
| 30B | Stovetop Stir Fry | Gas | Vegetable Oil | 2148.8 | 2453.6 | 669.1 | 764.0 | 2361.4 | 2696.3 | 275.8 | 315.0 |
| 31A | Fry Beef | Gas | Pan Lid | 182.2 | 153.0 | 70.1 | 58.8 | 200.2 | 168.1 | 49.5 | 41.5 |
| 31B | Fry Beef | Gas | Pan Lid | 281.1 | 278.9 | 92.7 | 91.9 | 308.9 | 306.4 | 72.4 | 71.8 |
| 32A | Popcorn | Microwave | Standard | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] |
| 32B | Popcorn | Microwave | Standard | 817.4 | 412.6 | 495.4 | 250.1 | 7430.5 | 3751.2 | 159.7 | 80.6 |
| 33 | Burner Baseline | Gas | | 1194.0 | 1644.2 | N/A | N/A | N/A | N/A | 153.3 | 211.1 |
| 34 | Oven Baseline | Gas | | 374.6 | 567.0 | N/A | N/A | N/A | N/A | 78.3 | 118.5 |
| N (All gas range tests except oven cleaning) | | | | 42 | 40 | 40 | 38 | 40 | 38 | 42 | 40 |
| Minimum | | | | 25.7 | 11.3 | 26.4 | 24.6 | 34.5 | 9.7 | 7.8 | 2.2 |
| Maximum | | | | 10405.4 | 11688.5 | 6734.9 | 9208.7 | 20204.6 | 22696.2 | 976.3 | 1096.7 |

[a] Emission rate calculated using the maximum concentration measured during the cooking test
[b] No sample due to problem with the data acquisition system on this day of testing
[c] Correction with background data resulted in zero or negative value.
*Note: Peak emission rates may be lower than the average emission rates due to the peak outdoor concentration being higher than peak indoor concentrations. This may have resulted in an underestimation of the peak emission rates.*

Table 3-29. NO Emission Rates during Cooking Tests

| Test No. | Type | Range | Conditions | Emission Rate[a] | | Source Strength (per gram of food) | | Food-specific Emission Factor | | Power-specific Emission Factor | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Average | Peak | Average | Peak | Average | Peak | Average | Peak |
| | | | | mg/hr | mg/hr | µg/g | µg/g | µg/g/hr | µg/g/hr | µg/BTU | µg/BTU |
| 1R | Oven Cleaning | Gas | Standard | 120.4 | 146.3 | No food | No food | No food | No food | 8.7 | 10.5 |
| 2 | Stovetop Stir Fry | Gas | Standard | 90.3 | 80.7 | 31.2 | 27.8 | 89.0 | 79.5 | 11.3 | 10.1 |
| 3A | Bacon | Gas | Standard | 34.0 | 55.0 | 25.2 | 40.7 | 68.6 | 111.1 | 5.8 | 9.5 |
| 3B | Bacon | Gas | Standard | 124.3 | 137.3 | 86.3 | 95.3 | 258.9 | 286.0 | 21.3 | 23.5 |
| 4 | Tortillas | Gas | Standard | 83.5 | 108.6 | 34.0 | 44.3 | 45.4 | 59.0 | 13.3 | 17.3 |
| 5 | French Fries | Gas | Standard | 143.2 | 188.1 | 33.3 | 43.8 | 29.4 | 38.6 | 18.6 | 24.4 |
| 6A | Broil Fish | Gas | Standard | 9.7 | 23.1 | 7.4 | 17.6 | 18.5 | 44.0 | 1.1 | 2.5 |
| 6B | Broil Fish | Gas | Standard | 30.3 | 33.1 | 19.6 | 21.4 | 58.8 | 64.2 | 2.8 | 3.1 |
| 7 | Bake Lasagna | Gas | Standard | 49.6 | 64.8 | 89.4 | 116.8 | 42.6 | 55.6 | 10.2 | 13.4 |
| 8 | Oven Cleaning | Electric | Standard | 21.2 | 22.9 | No food | No food | No food | No food | 3.0 | 3.2 |
| 9 | Stovetop Stir Fry | Electric | Standard | 3.3 | 6.9 | 1.1 | 2.3 | 3.1 | 6.5 | 0.4 | 0.8 |
| 10A | Bacon | Electric | Standard | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] |
| 10B | Bacon | Electric | Standard | 1.8 | 3.8 | 1.9 | 3.9 | 4.0 | 8.3 | 1.2 | 2.5 |
| 11 | Tortillas | Electric | Standard | 2.3 | 0.1 | 0.9 | 0.1 | 1.2 | 0.1 | 0.3 | 0.0 |
| 12 | French Fries | Electric | Standard | 1.3 | 4.4 | 0.1 | 0.4 | 0.3 | 0.9 | 0.1 | 0.4 |
| 13A | Broil Fish | Electric | Standard | 6.7 | 3.0 | 4.8 | 2.1 | 16.0 | 7.1 | 0.6 | 0.2 |
| 13B | Broil Fish | Electric | Standard | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] |
| 14 | Lasagna | Electric | Standard | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] | 0.0[c] |
| 15A | Bacon | Microwave | Standard | 0.8 | 0.0[c] | 1.1 | 0.0[c] | 1.5 | 0.0[c] | 0.2 | 0.0[c] |
| 15B | Bacon | Microwave | Standard | 29.5 | 29.9 | 44.9 | 45.5 | 72.8 | 73.8 | 5.8 | 5.8 |
| 16 | Lasagna | Microwave | Standard | 1.1 | 1.9 | 2.4 | 4.2 | 0.9 | 1.7 | 0.2 | 0.4 |
| 17A | Stovetop Stir Fry | Gas | Worst Case | 128.9 | 147.8 | 61.7 | 70.8 | 142.4 | 163.3 | 16.0 | 18.4 |
| 17B | Stovetop Stir Fry | Gas | Worst Case | 211.1 | 230.8 | 97.7 | 106.8 | 234.5 | 256.4 | 25.9 | 28.3 |
| 18A | Bacon | Gas | Worst Case | 93.4 | 116.1 | 90.9 | 113.0 | 209.8 | 260.8 | 15.3 | 19.0 |
| 18B | Bacon | Gas | Worst Case | 137.6 | 153.4 | 152.9 | 170.4 | 295.9 | 329.8 | 27.2 | 30.3 |
| 19A | Broil Fish | Gas | Worst Case | 13.2 | 19.4 | 14.1 | 20.8 | 33.8 | 49.8 | 1.3 | 1.8 |
| 19B | Broil Fish | Gas | Worst Case | 16.1 | 14.3 | 16.0 | 14.1 | 38.4 | 34.0 | 1.5 | 1.4 |
| 20 | Full Meal | Gas | Standard | 134.4 | 197.1 | 23.9 | 35.0 | 10.2 | 15.0 | 9.4 | 13.8 |
| 21A | Stovetop Stir Fry | Gas | Test 2 Replicate | 123.4 | 143.9 | 44.2 | 51.5 | 139.4 | 162.6 | 15.7 | 18.3 |

| Test No. | Type | Range | Conditions | Emission Rate[a] | | Source Strength (per gram of food) | | Food-specific Emission Factor | | Power-specific Emission Factor | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Average | Peak | Average | Peak | Average | Peak | Average | Peak |
| | | | | mg/hr | mg/hr | µg/g | µg/g | µg/g/hr | µg/g/hr | µg/BTU | µg/BTU |
| 21B | Stovetop Stir Fry | Gas | Test 2 Replicate | 232.6 | 255.3 | 84.8 | 93.0 | 254.3 | 279.0 | 27.6 | 30.3 |
| 22 | French Fries | Gas | Test 5 Replicate | 127.1 | 171.6 | 35.7 | 48.3 | 24.4 | 32.9 | 16.7 | 22.5 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 75.6 | 91.3 | 130.3 | 157.3 | 64.6 | 78.0 | 14.1 | 17.0 |
| 24RA | Fry Beef | Gas | Cast Iron Pan | 85.5 | 97.9 | 32.9 | 37.7 | 93.9 | 107.6 | 17.3 | 19.9 |
| 24RB | Fry Beef | Gas | Cast Iron Pan | 102.6 | 106.5 | 39.5 | 41.0 | 112.7 | 117.0 | 27.8 | 28.8 |
| 25 | Pork Roast | Gas | Aluminum Pan | NS[b] | NS[b] | NS[b] | NS[b] | NS[b] | NS[b] | NS[b] | NS[b] |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 62.5 | 74.8 | 24.2 | 28.9 | 69.1 | 82.6 | 11.3 | 13.5 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 19.5 | 35.2 | 30.1 | 54.2 | 10.0 | 18.0 | 5.4 | 9.7 |
| 28 | Fry Beef | Gas | Range Hood Shields | 8.2 | 0.4 | 3.1 | 0.2 | 8.9 | 0.5 | 2.0 | 0.1 |
| 29 | Pork Roast | Gas | Range Hood Shields | 13.6 | 25.6 | 17.0 | 31.9 | 5.7 | 10.6 | 3.7 | 6.9 |
| 30A | Stovetop Stir Fry | Gas | Vegetable Oil | 106.3 | 126.3 | 36.0 | 42.8 | 120.1 | 142.7 | 13.5 | 16.0 |
| 30B | Stovetop Stir Fry | Gas | Vegetable Oil | 191.5 | 214.2 | 59.6 | 66.7 | 210.4 | 235.4 | 24.6 | 27.5 |
| 31A | Fry Beef | Gas | Pan Lid | 49.6 | 47.3 | 19.1 | 18.2 | 54.5 | 52.0 | 13.5 | 12.9 |
| 31B | Fry Beef | Gas | Pan Lid | 79.6 | 68.1 | 26.2 | 22.4 | 87.5 | 74.8 | 20.5 | 17.5 |
| 32A | Popcorn | Microwave | Standard | 9.4 | 0.0[c] | 5.7 | 0.0[c] | 85.6 | 0.0[c] | 1.8 | 0.0[c] |
| 32B | Popcorn | Microwave | Standard | 44.3 | 28.2 | 26.8 | 17.1 | 402.4 | 256.5 | 8.6 | 5.5 |
| 33 | Burner Baseline | Gas | | 126.9 | 164.2 | N/A | N/A | N/A | N/A | 16.3 | 21.1 |
| 34 | Oven Baseline | Gas | | 68.1 | 81.0 | N/A | N/A | N/A | N/A | 14.2 | 16.9 |
| N (All gas range tests except oven cleaning) | | | | 41 | 39 | 39 | 37 | 39 | 37 | 41 | 39 |
| Minimum | | | | 0.8 | 0.1 | 0.1 | 0.1 | 0.3 | 0.1 | 0.1 | 0.0 |
| Maximum | | | | 232.6 | 255.3 | 152.9 | 170.4 | 402.4 | 329.8 | 27.8 | 30.3 |

[a] Emission rate calculated using the maximum concentration measured during the cooking test
[b] No sample due to problem with the data acquisition system on this day of testing
[c] Correction with background data resulted in zero or negative value.

*Note: Peak emission rates may be lower than the average emission rates due to the peak outdoor concentration being higher than peak indoor concentrations. This may have resulted in an underestimation of the peak emission rates.*

Table 3-30. $NO_2$ Emission Rates during Cooking Tests

| Test No. | Type | Range | Conditions | Emission Rate | | Source Strength (per gram of food) | | Food-specific Emission Factor | | Power-specific Emission Factor | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Average | Peak[a] | Average | Peak | Average | Peak | Average | Peak |
| | | | | mg/hr | mg/hr | µg/g | µg/g | µg/g/hr | µg/g/hr | µg/BTU | µg/BTU |
| 1R | Oven Cleaning | Gas | Standard | 137.4 | 190.5 | No food | No food | No food | No food | 9.9 | 13.7 |
| 2 | Stovetop Stir Fry | Gas | Standard | 60.0 | 95.1 | 20.7 | 32.8 | 59.1 | 93.7 | 7.5 | 11.9 |
| 3A | Bacon | Gas | Standard | 36.7 | 63.1 | 27.2 | 46.8 | 74.2 | 127.5 | 6.3 | 10.9 |
| 3B | Bacon | Gas | Standard | 67.3 | 80.1 | 46.7 | 55.6 | 140.2 | 166.9 | 11.5 | 13.7 |
| 4 | Tortillas | Gas | Standard | 25.7 | 37.9 | 10.5 | 15.5 | 13.9 | 20.6 | 4.1 | 6.0 |
| 5 | French Fries | Gas | Standard | 44.6 | 76.5 | 10.4 | 17.8 | 9.2 | 15.7 | 5.8 | 9.9 |
| 6A | Broil Fish | Gas | Standard | 129.0 | 179.5 | 98.3 | 136.7 | 245.8 | 341.8 | 14.1 | 19.5 |
| 6B | Broil Fish | Gas | Standard | 167.8 | 235.8 | 108.6 | 152.6 | 325.8 | 457.9 | 15.7 | 22.1 |
| 7 | Bake Lasagna | Gas | Standard | 35.0 | 44.3 | 63.1 | 79.9 | 30.1 | 38.1 | 7.2 | 9.1 |
| 8 | Oven Cleaning | Electric | Standard | 9.6 | 18.2 | No food | No food | No food | No food | 1.3 | 2.5 |
| 9 | Stovetop Stir Fry | Electric | Standard | 16.0 | 27.7 | 5.3 | 9.1 | 15.1 | 26.1 | 1.9 | 3.3 |
| 10A | Bacon | Electric | Standard | 28.5 | 31.3 | 25.1 | 27.5 | 65.5 | 71.9 | 16.0 | 17.5 |
| 10B | Bacon | Electric | Standard | 17.4 | 25.7 | 17.8 | 26.3 | 38.2 | 56.5 | 11.6 | 17.1 |
| 11 | Tortillas | Electric | Standard | 22.4 | 27.6 | 8.4 | 10.4 | 11.8 | 14.5 | 2.9 | 3.6 |
| 12 | French Fries | Electric | Standard | 27.8 | 41.1 | 2.4 | 3.5 | 5.7 | 8.4 | 2.6 | 3.9 |
| 13A | Broil Fish | Electric | Standard | 30.5 | 43.4 | 21.8 | 31.0 | 72.6 | 103.4 | 2.5 | 3.6 |
| 13B | Broil Fish | Electric | Standard | 43.4 | 47.2 | 29.2 | 31.8 | 97.5 | 106.1 | 6.9 | 7.5 |
| 14 | Lasagna | Electric | Standard | 12.3 | 17.7 | 21.2 | 30.4 | 10.5 | 15.1 | 3.7 | 5.4 |
| 15A | Bacon | Microwave | Standard | 6.2 | 8.6 | 8.5 | 11.8 | 11.6 | 16.0 | 1.2 | 1.7 |
| 15B | Bacon | Microwave | Standard | 13.3 | 18.0 | 20.2 | 27.4 | 32.7 | 44.4 | 2.6 | 3.5 |
| 16 | Lasagna | Microwave | Standard | 3.3 | 7.5 | 7.1 | 16.3 | 2.8 | 6.4 | 0.6 | 1.5 |
| 17A | Stovetop Stir Fry | Gas | Worst Case | 58.3 | 78.7 | 27.9 | 37.7 | 64.4 | 86.9 | 7.2 | 9.8 |
| 17B | Stovetop Stir Fry | Gas | Worst Case | 62.6 | 101.6 | 29.0 | 47.1 | 69.5 | 112.9 | 7.7 | 12.5 |
| 18A | Bacon | Gas | Worst Case | 37.2 | 53.7 | 36.2 | 52.3 | 83.6 | 120.7 | 6.1 | 8.8 |
| 18B | Bacon | Gas | Worst Case | 40.2 | 55.5 | 44.7 | 61.7 | 86.6 | 119.4 | 8.0 | 11.0 |
| 19A | Broil Fish | Gas | Worst Case | 155.6 | 372.7 | 166.3 | 398.2 | 399.1 | 955.6 | 14.8 | 35.3 |
| 19B | Broil Fish | Gas | Worst Case | 154.5 | 353.4 | 153.2 | 350.6 | 367.8 | 841.5 | 14.7 | 33.7 |

| Test No. | Type | Range | Conditions | Emission Rate | | Source Strength (per gram of food) | | Food-specific Emission Factor | | Power-specific Emission Factor | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Average | Peak[a] | Average | Peak | Average | Peak | Average | Peak |
| | | | | mg/hr | mg/hr | µg/g | µg/g | µg/g/hr | µg/g/hr | µg/BTU | µg/BTU |
| 20 | Full Meal | Gas | Standard | 48.2 | 148.1 | 8.6 | 26.3 | 3.7 | 11.3 | 3.4 | 10.4 |
| 21A | Stovetop Stir Fry | Gas | Test 2 Replicate | 55.8 | 103.6 | 20.0 | 37.1 | 63.0 | 117.1 | 7.1 | 13.2 |
| 21B | Stovetop Stir Fry | Gas | Test 2 Replicate | 73.3 | 105.6 | 26.7 | 38.5 | 80.1 | 115.4 | 8.7 | 12.5 |
| 22 | French Fries | Gas | Test 5 Replicate | 51.8 | 80.5 | 14.6 | 22.6 | 9.9 | 15.4 | 6.8 | 10.6 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 32.5 | 38.1 | 56.0 | 65.6 | 27.8 | 32.5 | 6.1 | 7.1 |
| 24RA | Fry Beef | Gas | Cast Iron Pan | 25.6 | 29.4 | 9.9 | 11.3 | 28.2 | 32.3 | 5.2 | 6.0 |
| 24RB | Fry Beef | Gas | Cast Iron Pan | 31.3 | 45.4 | 12.1 | 17.5 | 34.4 | 49.9 | 8.5 | 12.3 |
| 25 | Pork Roast | Gas | Aluminum Pan | NS[b] | NS[b] | NS[b] | NS[b] | NS[b] | NS[b] | NS[b] | NS[b] |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 26.9 | 51.9 | 10.4 | 20.1 | 29.7 | 57.3 | 4.9 | 9.4 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 6.9 | 9.3 | 10.6 | 14.3 | 3.5 | 4.7 | 1.9 | 2.6 |
| 28 | Fry Beef | Gas | Range Hood Shields | 9.6 | 20.9 | 3.7 | 8.0 | 10.5 | 22.9 | 2.4 | 5.2 |
| 29 | Pork Roast | Gas | Range Hood Shields | 6.2 | 24.1 | 7.8 | 30.1 | 2.6 | 10.0 | 1.7 | 6.6 |
| 30A | Stovetop Stir Fry | Gas | Vegetable Oil | 49.5 | 62.4 | 16.8 | 21.2 | 55.9 | 70.5 | 6.3 | 7.9 |
| 30B | Stovetop Stir Fry | Gas | Vegetable Oil | 57.6 | 82.4 | 17.9 | 25.6 | 63.3 | 90.5 | 7.4 | 10.6 |
| 31A | Fry Beef | Gas | Pan Lid | 28.3 | 35.5 | 10.9 | 13.6 | 31.1 | 39.0 | 7.7 | 9.6 |
| 31B | Fry Beef | Gas | Pan Lid | 32.8 | 49.8 | 10.8 | 16.4 | 36.0 | 54.7 | 8.4 | 12.8 |
| 32A | Popcorn | Microwave | Standard | 57.4 | 107.4 | 34.8 | 65.1 | 521.4 | 976.4 | 11.2 | 21.0 |
| 32B | Popcorn | Microwave | Standard | 34.8 | 50.4 | 21.1 | 30.6 | 316.6 | 458.3 | 6.8 | 9.9 |
| 33 | Burner Baseline | Gas | | 45.5 | 65.3 | N/A | N/A | N/A | N/A | 5.8 | 8.4 |
| 34 | Oven Baseline | Gas | | 37.4 | 53.0 | N/A | N/A | N/A | N/A | 7.8 | 11.1 |
| N (All gas range tests except oven cleaning) | | | | 44 | 44 | 42 | 42 | 42 | 42 | 44 | 44 |
| Minimum | | | | 3.3 | 7.5 | 2.4 | 3.5 | 2.6 | 4.7 | 0.6 | 1.5 |
| Maximum | | | | 167.8 | 372.7 | 166.3 | 398.2 | 521.4 | 976.4 | 16.0 | 35.3 |

[a] Emission rate calculated using the maximum concentration measured during the cooking test
[b] No sample due to problem with the data acquisition system on this day of testing

Table 3-31. $PM_{2.5}$ Mass Emission Rates during Cooking Tests

| Test No. | Type | Range | Conditions | Emission Rate | Source Strength (per gram of food) | Food-specific Emission Factor | Power-specific Emission Factor |
|---|---|---|---|---|---|---|---|
| | | | | mg/hr | µg/g | µg/g/hr | µg/BTU |
| 1R | Oven Cleaning | Gas | Standard | 359.5 | No Food | No Food | 25.8 |
| 2 | Stovetop Stir Fry | Gas | Standard | 201.5 | 69.5 | 198.6 | 25.2 |
| 3 | Bacon | Gas | Standard | 233.0 | 167.3 | 239.0 | 40.0 |
| 4 | Tortillas | Gas | Standard | 253.2 | 103.2 | 137.6 | 40.4 |
| 5 | French Fries | Gas | Standard | 65.9 | 15.3 | 13.5 | 8.5 |
| 6 | Broil Fish | Gas | Standard | 318.2 | 224.3 | 305.9 | 32.3 |
| 7 | Bake Lasagna | Gas | Standard | 251.2 | 452.8 | 215.6 | 51.8 |
| 8 | Oven Cleaning | Electric | Standard | 176.3 | No Food | No Food | 24.5 |
| 9 | Stovetop Stir Fry | Electric | Standard | 175.1 | 57.8 | 165.2 | 20.7 |
| 10 | Bacon | Electric | Standard | 86.7 | 82.8 | 97.4 | 53.2 |
| 11 | Tortillas | Electric | Standard | 617.8 | 232.4 | 324.3 | 80.7 |
| 12 | French Fries | Electric | Standard | 262.2 | 22.4 | 53.8 | 24.9 |
| 13 | Broil Fish | Electric | Standard | 228.5 | 164.2 | 273.7 | 24.7 |
| 14 | Lasagna | Electric | Standard | 25.5 | 44.0 | 21.8 | 7.8 |
| 15 | Bacon | Microwave | Standard | N/A | N/A | N/A | N/A |
| 16 | Lasagna | Microwave | Standard | N/A | N/A | N/A | N/A |
| 17 | Stovetop Stir Fry | Gas | Worst Case | 545.7 | 257.0 | 302.3 | 67.4 |
| 18 | Bacon | Gas | Worst Case | 184.1 | 192.2 | 202.3 | 33.3 |
| 19 | Broil Fish | Gas | Worst Case | 137.0 | 140.9 | 169.1 | 13.0 |
| 20 | Full Meal | Gas | Standard | 147.2 | 26.1 | 11.2 | 10.3 |
| 21 | Stovetop Stir Fry | Gas | Test 2 Replicate | 92.4 | 33.4 | 51.3 | 11.3 |
| 22 | French Fries | Gas | Test 5 Replicate | 46.2 | 13.0 | 8.9 | 6.1 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 89.0 | 153.5 | 76.1 | 16.6 |
| 24 | Fry Beef | Gas | Cast Iron Pan | 43.4 | 16.6 | 47.5 | 9.7 |
| 24R | Fry Beef | Gas | Cast Iron Pan | 74.9 | 28.8 | 41.2 | 17.4 |
| 25 | Pork Roast | Gas | Aluminum Pan | 8.9 | 13.9 | 4.6 | 2.6 |

| Test No. | Type | Range | Conditions | Emission Rate | Source Strength (per gram of food) | Food-specific Emission Factor | Power-specific Emission Factor |
|---|---|---|---|---|---|---|---|
| | | | | mg/hr | µg/g | µg/g/hr | µg/BTU |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 256.9 | 99.4 | 283.9 | 46.5 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 1.5 | 2.3 | 0.8 | 0.4 |
| 28 | Fry Beef | Gas | Range Hood Shields | 26.8 | 10.3 | 29.3 | 6.6 |
| 29 | Pork Roast | Gas | Range Hood Shields | 66.5 | 82.9 | 27.6 | 18.1 |
| 30 | Stovetop Stir Fry | Gas | Vegetable Oil | 221.8 | 72.1 | 123.6 | 28.3 |
| 31 | Fry Beef | Gas | Pan Lid | 179.4 | 64.1 | 98.6 | 47.5 |
| 32 | Popcorn | Microwave | Standard | N/A | N/A | N/A | N/A |
| N (without oven cleaning tests 1 and 8) | | | | 28 | 28 | 28 | 28 |
| Minimum | | | | 1.5 | 2.3 | 0.8 | 0.4 |
| Maximum | | | | 617.8 | 452.8 | 324.3 | 80.7 |

Table 3-32. $PM_{10}$ Mass Emission Rates during Cooking Tests

| Test No. | Type | Range | Conditions | Emission Rate | Source Strength (per gram of food) | Food-specific Emission Factor | Power-specific Emission Factor |
|---|---|---|---|---|---|---|---|
| | | | | mg/hr | µg/g | µg/g/hr | µg/BTU |
| 1R | Oven Cleaning | Gas | Standard | 1173.4 | No Food | No Food | 84.3 |
| 2 | Stovetop Stir Fry | Gas | Standard | 318.3 | 109.8 | 313.6 | 39.8 |
| 3 | Bacon | Gas | Standard | 183.9 | 132.0 | 188.6 | 31.5 |
| 4 | Tortillas | Gas | Standard | 158.9 | 64.8 | 86.4 | 25.3 |
| 5 | French Fries | Gas | Standard | 177.0 | 41.2 | 36.3 | 22.9 |
| 6 | Broil Fish | Gas | Standard | 302.3 | 213.2 | 290.7 | 30.7 |
| 7 | Bake Lasagna | Gas | Standard | 70.7 | 127.4 | 60.7 | 14.6 |
| 8 | Oven Cleaning | Electric | Standard | 124.5 | No Food | No Food | 17.3 |
| 9 | Stovetop Stir Fry | Electric | Standard | 1361.8 | 449.7 | 1284.7 | 161.3 |
| 10 | Bacon | Electric | Standard | 180.3 | 172.2 | 202.6 | 110.7 |
| 11 | Tortillas | Electric | Standard | 933.9 | 351.3 | 490.3 | 121.9 |
| 12 | French Fries | Electric | Standard | 206.5 | 17.6 | 42.4 | 19.6 |
| 13 | Broil Fish | Electric | Standard | 574.4 | 412.7 | 687.9 | 62.1 |
| 14 | Lasagna | Electric | Standard | 135.6 | 233.8 | 115.9 | 41.3 |
| 15 | Bacon | Microwave | Standard | N/A | N/A | N/A | N/A |
| 16 | Lasagna | Microwave | Standard | N/A | N/A | N/A | N/A |
| 17 | Stovetop Stir Fry | Gas | Worst Case | 902.9 | 425.2 | 500.2 | 111.5 |
| 18 | Bacon | Gas | Worst Case | 432.7 | 451.7 | 475.5 | 78.2 |
| 19 | Broil Fish | Gas | Worst Case | 623.5 | 641.4 | 769.7 | 59.3 |
| 20 | Full Meal | Gas | Standard | 303.9 | 53.9 | 23.1 | 21.3 |
| 21 | Stovetop Stir Fry | Gas | Test 2 Replicate | 571.7 | 206.4 | 317.6 | 70.1 |
| 22 | French Fries | Gas | Test 5 Replicate | 82.6 | 23.2 | 15.8 | 10.8 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 39.4 | 68.0 | 33.7 | 7.4 |
| 24 | Fry Beef | Gas | Cast Iron Pan | 117.4 | 44.9 | 128.4 | 26.3 |
| 24R | Fry Beef | Gas | Cast Iron Pan | 134.6 | 51.8 | 73.9 | 31.2 |
| 25 | Pork Roast | Gas | Aluminum Pan | 20.5 | 32.0 | 10.7 | 6.0 |

| Test No. | Type | Range | Conditions | Emission Rate | Source Strength (per gram of food) | Food-specific Emission Factor | Power-specific Emission Factor |
|---|---|---|---|---|---|---|---|
| | | | | mg/hr | µg/g | µg/g/hr | µg/BTU |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 372.9 | 144.2 | 412.0 | 67.4 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 31.4 | 48.4 | 16.0 | 8.6 |
| 28 | Fry Beef | Gas | Range Hood Shields | 175.8 | 67.3 | 192.2 | 43.3 |
| 29 | Pork Roast | Gas | Range Hood Shields | 16.4 | 20.5 | 6.8 | 4.5 |
| 30 | Stovetop Stir Fry | Gas | Vegetable Oil | 747.9 | 243.0 | 416.6 | 95.5 |
| 31 | Fry Beef | Gas | Pan Lid | 98.7 | 35.3 | 54.3 | 26.1 |
| 32 | Popcorn | Microwave | Standard | N/A | N/A | N/A | N/A |
| N (without oven cleaning tests 1 and 8) | | | | 28 | 28 | 28 | 28 |
| Minimum | | | | 16.4 | 17.6 | 6.8 | 4.5 |
| Maximum | | | | 1361.8 | 641.4 | 1284.7 | 161.3 |

Table 3-33. Particle Emission Rates Measured with the ELPI during Cooking Tests

| Test No. | Type | Range | Conditions | Particles X million/hr in size fraction of less than | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 0.1 μm | 0.5 μm | 1.0 μm | 2.5 μm | 10μm |
| 1R | Oven Cleaning | Gas | Standard | 108 | 152 | 158 | 158 | 158 |
| 2 | Stovetop Stir Fry | Gas | Standard | 116 | 144 | 144 | 144 | 144 |
| 3A | Bacon | Gas | Standard | 106 | 139 | 139 | 139 | 139 |
| 3B | Bacon | Gas | Standard | 97 | 143 | 143 | 143 | 143 |
| 4 | Tortillas | Gas | Standard | 101 | 113 | 113 | 113 | 113 |
| 5 | French Fries | Gas | Standard | 65 | 72 | 72 | 72 | 72 |
| 6A | Broil Fish | Gas | Standard | 140 | 209 | 214 | 214 | 214 |
| 6B | Broil Fish | Gas | Standard | 171 | 309 | 325 | 325 | 325 |
| 7 | Bake Lasagna | Gas | Standard | 85 | 101 | 101 | 101 | 101 |
| 8 | Oven Cleaning | Electric | Standard | 53 | 71 | 72 | 72 | 72 |
| 9 | Stovetop Stir Fry | Electric | Standard | 108 | 133 | 134 | 134 | 135 |
| 10A | Bacon | Electric | Standard | 32 | 52 | 52 | 52 | 52 |
| 10B | Bacon | Electric | Standard | 44 | 87 | 88 | 88 | 88 |
| 11 | Tortillas | Electric | Standard | 104 | 196 | 198 | 198 | 199 |
| 12 | French Fries | Electric | Standard | 114 | 134 | 134 | 134 | 134 |
| 13A | Broil Fish | Electric | Standard | 142 | 203 | 205 | 205 | 205 |
| 13B | Broil Fish | Electric | Standard | 181 | 271 | 275 | 275 | 275 |
| 14 | Lasagna | Electric | Standard | 5 | 5 | 5 | 5 | 5 |
| 15A | Bacon | Microwave | Standard | 2 | 3 | 3 | 3 | 3 |
| 15B | Bacon | Microwave | Standard | 3 | 3 | 4 | 4 | 4 |
| 16 | Lasagna | Microwave | Standard | 1 | 1 | 1 | 1 | 1 |
| 17A | Stovetop Stir Fry | Gas | Worst Case | 158 | 201 | 203 | 203 | 203 |
| 17B | Stovetop Stir Fry | Gas | Worst Case | 150 | 203 | 205 | 205 | 205 |
| 18A | Bacon | Gas | Worst Case | 122 | 206 | 209 | 209 | 209 |
| 18B | Bacon | Gas | Worst Case | 86 | 157 | 161 | 161 | 161 |
| 19A | Broil Fish | Gas | Worst Case | 419 | 604 | 605 | 605 | 605 |
| 19B | Broil Fish | Gas | Worst Case | 340 | 647 | 650 | 650 | 650 |
| 20 | Full Meal | Gas | Standard | 87 | 108 | 110 | 110 | 110 |
| 21A | Stovetop Stir Fry | Gas | Test 2 Replicate | 138 | 168 | 169 | 169 | 169 |
| 21B | Stovetop Stir Fry | Gas | Test 2 Replicate | 174 | 228 | 229 | 229 | 229 |
| 22 | French Fries | Gas | Test 5 Replicate | 62 | 74 | 74 | 74 | 74 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 51 | 57 | 57 | 57 | 57 |

| Test No. | Type | Range | Conditions | Particles X million/hr in size fraction of less than | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 0.1 μm | 0.5 μm | 1.0 μm | 2.5 μm | 10μm |
| 24 | Fry Beef | Gas | Cast Iron Pan | 14 | 15 | 15 | 15 | 15 |
| 24RA | Fry Beef | Gas | Cast Iron Pan | 45 | 48 | 48 | 48 | 48 |
| 24RB | Fry Beef | Gas | Cast Iron Pan | 20 | 21 | 21 | 21 | 21 |
| 25 | Pork Roast | Gas | Aluminum Pan | 8 | 10 | 10 | 10 | 10 |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 16 | 16 | 16 | 16 | 16 |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 3 | 4 | 4 | 4 | 4 |
| 28 | Fry Beef | Gas | Range Hood Shields | 0 | 1 | 1 | 1 | 1 |
| 29 | Pork Roast | Gas | Range Hood Shields | 1 | 1 | 1 | 1 | 1 |
| 30A | Stovetop Stir Fry | Gas | Vegetable Oil | 165 | 200 | 201 | 201 | 201 |
| 30B | Stovetop Stir Fry | Gas | Vegetable Oil | 174 | 215 | 217 | 217 | 217 |
| 31A | Fry Beef | Gas | Pan Lid | 0 | 0 | 0 | 0 | 0 |
| 31B | Fry Beef | Gas | Pan Lid | 0 | 0 | 0 | 0 | 0 |
| 32A | Popcorn | Microwave | Standard | 43 | 52 | 52 | 52 | 52 |
| 32B | Popcorn | Microwave | Standard | 56 | 65 | 65 | 65 | 65 |
| 33 | Burner Baseline | Gas | | 23 | 26 | 26 | 26 | 26 |
| 34 | Oven Baseline | Gas | | 20 | 22 | 22 | 22 | 22 |
| N | | | | 48 | 48 | 48 | 48 | 48 |
| Minimum | | | | 0.2 | 0.4 | 0.4 | 0.4 | 0.4 |
| Maximum | | | | 418.6 | 646.7 | 649.9 | 649.9 | 650.0 |

Table 3-34. Estimated Mass Emission Rates Measured with the ELPI during Cooking Tests

| Test No. | Type | Range | Conditions | µg/hr in size fraction of less than | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 0.1 µm | 0.5 µm | 1.0 µm | 2.5 µm | 10µm |
| 1R | Oven Cleaning | Gas | Standard | 13.5 | 258.4 | 757.7 | 805.3 | 4433.7 |
| 2 | Stovetop Stir Fry | Gas | Standard | 13.1 | 94.7 | 124.8 | 203.5 | 2592.4 |
| 3A | Bacon | Gas | Standard | 12.9 | 108.2 | 122.0 | 139.7 | 1002.7 |
| 3B | Bacon | Gas | Standard | 13.5 | 161.1 | 185.3 | 208.0 | 1191.9 |
| 4 | Tortillas | Gas | Standard | 11.4 | 34.9 | 38.8 | 56.1 | 450.3 |
| 5 | French Fries | Gas | Standard | 6.1 | 23.6 | 27.6 | 43.7 | 335.6 |
| 6A | Broil Fish | Gas | Standard | 17.8 | 385.3 | 831.4 | 913.8 | 3387.8 |
| 6B | Broil Fish | Gas | Standard | 20.8 | 867.9 | 2307.0 | 2591.4 | 10410.3 |
| 7 | Bake Lasagna | Gas | Standard | 9.0 | 57.6 | 74.3 | 85.4 | 489.2 |
| 8 | Oven Cleaning | Electric | Standard | 6.1 | 84.6 | 173.5 | 200.4 | 668.7 |
| 9 | Stovetop Stir Fry | Electric | Standard | 12.1 | 107.6 | 268.2 | 574.2 | 2920.8 |
| 10A | Bacon | Electric | Standard | 4.0 | 93.5 | 119.4 | 122.0 | 532.2 |
| 10B | Bacon | Electric | Standard | 6.7 | 231.3 | 340.1 | 358.4 | 959.2 |
| 11 | Tortillas | Electric | Standard | 16.8 | 439.2 | 696.3 | 820.0 | 2946.1 |
| 12 | French Fries | Electric | Standard | 13.3 | 57.7 | 70.7 | 87.4 | 861.9 |
| 13A | Broil Fish | Electric | Standard | 17.1 | 283.9 | 455.9 | 492.7 | 1289.2 |
| 13B | Broil Fish | Electric | Standard | 22.4 | 426.2 | 843.7 | 972.4 | 1849.0 |
| 14 | Lasagna | Electric | Standard | 0.5 | 2.3 | 2.0 | 1.2 | 151.3 |
| 15A | Bacon | Microwave | Standard | 0.2 | 3.5 | 9.2 | 17.0 | 113.3 |
| 15B | Bacon | Microwave | Standard | 0.3 | 4.6 | 13.5 | 28.8 | 121.0 |
| 16 | Lasagna | Microwave | Standard | 0.1 | 1.0 | 1.7 | 1.9 | 18.7 |
| 17A | Stovetop Stir Fry | Gas | Worst Case | 15.4 | 202.6 | 321.3 | 317.5 | 317.5 |
| 17B | Stovetop Stir Fry | Gas | Worst Case | 15.2 | 276.3 | 439.1 | 435.1 | 435.1 |
| 18A | Bacon | Gas | Worst Case | 17.4 | 406.4 | 636.6 | 724.0 | 2139.1 |
| 18B | Bacon | Gas | Worst Case | 11.5 | 406.5 | 668.9 | 763.1 | 1820.9 |
| 19A | Broil Fish | Gas | Worst Case | 53.8 | 637.3 | 721.2 | 757.7 | 757.7 |
| 19B | Broil Fish | Gas | Worst Case | 48.5 | 1413.5 | 1678.4 | 1751.2 | 1751.2 |
| 20 | Full Meal | Gas | Standard | 8.9 | 108.7 | 242.2 | 282.9 | 1259.8 |
| 21A | Stovetop Stir Fry | Gas | Test 2 Replicate | 14.0 | 114.2 | 152.1 | 259.2 | 2337.0 |
| 21B | Stovetop Stir Fry | Gas | Test 2 Replicate | 17.7 | 222.5 | 313.8 | 498.1 | 3105.1 |
| 22 | French Fries | Gas | Test 5 Replicate | 7.2 | 32.5 | 36.6 | 47.6 | 407.7 |
| 23 | Bake Lasagna | Gas | Test 7 Replicate | 5.5 | 16.2 | 16.7 | 16.7 | 20.1 |

| Test No. | Type | Range | Conditions | µg/hr in size fraction of less than | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | 0.1 µm | 0.5 µm | 1.0 µm | 2.5 µm | 10µm |
| 24 | Fry Beef | Gas | Cast Iron Pan | 1.1 | 2.6 | 3.0 | 7.1 | 135.2 |
| 24RA | Fry Beef | Gas | Cast Iron Pan | 4.6 | 10.8 | 12.4 | 20.0 | 449.8 |
| 24RB | Fry Beef | Gas | Cast Iron Pan | 2.4 | 6.2 | 6.8 | 11.5 | 125.4 |
| 25 | Pork Roast | Gas | Aluminum Pan | 1.1 | 4.7 | 4.7 | 5.3 | 21.9 |
| 26 | Fry Beef | Gas | Exhaust Ventilation | 1.0 | 2.3 | 2.3 | 0.0[a] | 0.0[a] |
| 27 | Pork Roast | Gas | Exhaust Ventilation | 0.3 | 0.8 | 0.0[a] | 0.0[a] | 0.0[a] |
| 28 | Fry Beef | Gas | Range Hood Shields | 0.2 | 1.0 | 0.0[a] | 0.0[a] | 1086.9 |
| 29 | Pork Roast | Gas | Range Hood Shields | 0.0 | 0.0 | 0.0[a] | 0.0[a] | 69.6 |
| 30A | Stovetop Stir Fry | Gas | Vegetable Oil | 16.2 | 134.9 | 269.4 | 425.7 | 2909.0 |
| 30B | Stovetop Stir Fry | Gas | Vegetable Oil | 16.4 | 173.6 | 271.2 | 296.1 | 772.4 |
| 31A | Fry Beef | Gas | Pan Lid | 0.1 | 0.4 | 1.7 | 7.7 | 2583.7 |
| 31B | Fry Beef | Gas | Pan Lid | 0.1 | 0.4 | 2.2 | 16.4 | 4859.7 |
| 32A | Popcorn | Microwave | Standard | 4.3 | 33.7 | 46.4 | 57.5 | 253.6 |
| 32B | Popcorn | Microwave | Standard | 4.3 | 33.7 | 46.4 | 57.5 | 253.6 |
| 33 | Burner Baseline | Gas | | 3.4 | 8.0 | 9.5 | 12.2 | 313.0 |
| 34 | Oven Baseline | Gas | | 2.3 | 8.1 | 9.0 | 7.7 | 7.7 |
| N | | | | 48 | 48 | 45 | 44 | 46 |
| Minimum | | | | 0.0 | 0.0 | 1.7 | 1.2 | 7.7 |
| Maximum | | | | 53.8 | 1413.5 | 2307.0 | 2591.4 | 10410.3 |

[a] Data correction for background data resulted in zero or negative value.

Table 3-35. Aldehyde Emission Rates

| Test No. | Type | Range | Conditions | Emission Rate | Source Strength (per gram of food) | Food-specific Emission Factor | Power-specific Emission Factor |
|---|---|---|---|---|---|---|---|
| | | | | mg/hr | µg/g | µg/g/hr | µg/BTU |
| 1 | Oven Cleaning | Gas | Formaldehyde | 49.8 | N/A | N/A | 9.4 |
| | | | Acetaldehyde | 52.1 | N/A | N/A | 9.9 |
| | | | Propanal | 17.3 | N/A | N/A | 3.3 |
| | | | Butanal | 8.7 | N/A | N/A | 1.6 |
| | | | Benzaldehyde | 1.9 | N/A | N/A | 0.4 |
| | | | Pentanal | 17.5 | N/A | N/A | 3.3 |
| | | | Hexanal | 15.8 | N/A | N/A | 3.0 |
| 6 | Broil Fish | Gas | Formaldehyde | 48.0 | 33.9 | 46.2 | 4.9 |
| | | | Acetaldehyde | 34.7 | 24.5 | 33.4 | 3.5 |
| | | | Propanal | 10.7 | 7.5 | 10.3 | 1.1 |
| | | | Butanal | 4.2 | 2.9 | 4.0 | 0.4 |
| | | | Benzaldehyde | 3.2 | 2.3 | 3.1 | 0.3 |
| | | | Pentanal | 7.6 | 5.4 | 7.3 | 0.8 |
| | | | Hexanal | 10.0 | 7.0 | 9.6 | 1.0 |
| 8 | Oven Cleaning | Electric | Formaldehyde | 26.6 | N/A | N/A | 3.7 |
| | | | Acetaldehyde | 39.3 | N/A | N/A | 5.5 |
| | | | Propanal | 10.3 | N/A | N/A | 1.4 |
| | | | Butanal | 4.8 | N/A | N/A | 0.7 |
| | | | Benzaldehyde | 1.5 | N/A | N/A | 0.2 |
| | | | Pentanal | 9.7 | N/A | N/A | 1.4 |
| | | | Hexanal | 9.1 | N/A | N/A | 1.3 |
| 13 | Broil Fish | Electric | Formaldehyde | 59.5 | 42.7 | 71.2 | 6.4 |
| | | | Acetaldehyde | 50.0 | 35.9 | 59.9 | 5.4 |
| | | | Propanal | 15.8 | 11.4 | 18.9 | 1.7 |
| | | | Butanal | 6.7 | 4.8 | 8.1 | 0.7 |
| | | | Benzaldehyde | 1.8 | 1.3 | 2.1 | 0.2 |
| | | | Pentanal | 11.3 | 8.1 | 13.5 | 1.2 |
| | | | Hexanal | 15.9 | 11.4 | 19.0 | 1.7 |
| 25 | Pork Roast | Gas | Formaldehyde | 6.9 | 10.8 | 3.6 | 2.0 |
| | | | Acetaldehyde | 0.0[a] | N/A | N/A | N/A |
| | | | Propanal | 0.4 | 0.7 | 0.2 | 0.1 |
| | | | Butanal | 0.2 | 0.4 | 0.1 | 0.1 |
| | | | Benzaldehyde | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | Pentanal | 0.6 | 1.0 | 0.3 | 0.2 |

| Test No. | Type | Range | Conditions | Emission Rate | Source Strength (per gram of food) | Food-specific Emission Factor | Power-specific Emission Factor |
|---|---|---|---|---|---|---|---|
| | | | | mg/hr | µg/g | µg/g/hr | µg/BTU |
| | | | Hexanal | 2.0 | 3.1 | 1.0 | 0.6 |
| 27 | Pork Roast | Gas | Formaldehyde | 10.5 | 16.1 | 5.3 | 2.9 |
| | | | Acetaldehyde | 3.9 | 6.0 | 2.0 | 1.1 |
| | | | Propanal | 0.6 | 0.9 | 0.3 | 0.2 |
| | | | Butanal | 0.3 | 0.5 | 0.2 | 0.1 |
| | | | Benzaldehyde | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | Pentanal | 0.9 | 1.4 | 0.4 | 0.2 |
| | | | Hexanal | 3.0 | 4.7 | 1.5 | 0.8 |
| | | | N | 6 | 6 | 6 | 6 |
| | | | Minimum | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | Maximum | 59.5 | 42.7 | 71.2 | 9.9 |

[a] Data correction for outdoor data resulted in zero or negative value.

Table 3-36. PAH Emission Rates

| Test No. | Type | Range | Compound | Emission Rate | Source Strength (per gram of food) | Food-specific Emission Factor | Power-specific Emission Factor |
|---|---|---|---|---|---|---|---|
| | | | | µg/hr | ηg/g | ηg/g/hr | ηg/BTU |
| 21 | Stovetop Stir Fry | Gas | naphthalene | 253.1 | 91.4 | 140.6 | 31.1 |
| | | | acenaphthylene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | acenaphthene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | fluorene | 13.7 | 4.9 | 7.6 | 1.7 |
| | | | phenanthrene | 19.9 | 7.2 | 11.0 | 2.4 |
| | | | anthracene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | fluoranthene | 8.4 | 3.0 | 4.6 | 1.0 |
| | | | pyrene | 6.9 | 2.5 | 3.8 | 0.8 |
| | | | benz(a)anthracene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | chrysene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | benzo(b+j+k)phenanthrene | 1.7 | 0.6 | 1.0 | 0.2 |
| | | | BeP | 1.4 | 0.5 | 0.8 | 0.2 |
| | | | BaP | 1.0 | 0.3 | 0.5 | 0.1 |
| | | | indeno[123-cd]pyrene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | benzo(ghi)perylene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | coronene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| 17 | Stovetop Stir Fry | Gas | naphthalene | 109.6 | 51.6 | 60.7 | 13.5 |
| | | | acenaphthylene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | acenaphthene | 1.6 | 0.7 | 0.9 | 0.2 |
| | | | fluorene | 6.0 | 2.8 | 3.3 | 0.7 |
| | | | phenanthrene | 3.8 | 1.8 | 2.1 | 0.5 |
| | | | anthracene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | fluoranthene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | pyrene | 4.9 | 2.3 | 2.7 | 0.6 |
| | | | benz(a)anthracene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | chrysene | 1.0 | 0.5 | 0.6 | 0.1 |
| | | | benzo(b+j+k)phenanthrene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | BeP | 0.6 | 0.3 | 0.3 | 0.1 |
| | | | BaP | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | indeno[123-cd]pyrene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | benzo(ghi)perylene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | coronene | 1.3 | 0.6 | 0.7 | 0.2 |
| 30 | Stovetop Stir Fry | Gas | naphthalene | 307.7 | 100.0 | 171.4 | 39.3 |
| | | | acenaphthylene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | acenaphthene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | fluorene | 13.4 | 4.4 | 7.5 | 1.7 |
| | | | phenanthrene | 16.0 | 5.2 | 8.9 | 2.0 |
| | | | anthracene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | fluoranthene | 0.3 | 0.1 | 0.2 | 0.0 |
| | | | pyrene | 8.3 | 2.7 | 4.6 | 1.1 |
| | | | benz(a)anthracene | 8.4 | 2.7 | 4.7 | 1.1 |
| | | | chrysene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | benzo(b+j+k)phenanthrene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | BeP | 0.4 | 0.1 | 0.2 | 0.0 |
| | | | BaP | 0.3 | 0.1 | 0.2 | 0.0 |
| | | | indeno[123-cd]pyrene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | benzo(ghi)perylene | 0.2 | 0.1 | 0.1 | 0.0 |
| | | | coronene | 0.0 | 0.0 | 0.0 | 0.0 |
| 18 | Bacon | Gas | naphthalene | 113.6 | 118.6 | 124.8 | 20.5 |
| | | | acenaphthylene | 0.0 | 0.0 | 0.0 | 0.0 |

| Test No. | Type | Range | Compound | Emission Rate | Source Strength (per gram of food) | Food-specific Emission Factor | Power-specific Emission Factor |
|---|---|---|---|---|---|---|---|
| | | | | µg/hr | ηg/g | ηg/g/hr | ηg/BTU |
| | | | acenaphthene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | fluorene | 6.4 | 6.7 | 7.0 | 1.2 |
| | | | phenanthrene | 3.1 | 3.2 | 3.4 | 0.6 |
| | | | anthracene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | fluoranthene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | pyrene | 2.4 | 2.5 | 2.6 | 0.4 |
| | | | benz(a)anthracene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | chrysene | 3.2 | 3.3 | 3.5 | 0.6 |
| | | | benzo(b+j+k)phenanthrene | 1.5 | 1.5 | 1.6 | 0.3 |
| | | | BeP | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | BaP | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | indeno[123-cd]pyrene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | benzo(ghi)perylene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | coronene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| 19 | Broil Fish | Gas | naphthalene | 293.7 | 302.1 | 362.6 | 27.9 |
| | | | acenaphthylene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | acenaphthene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | fluorene | 10.7 | 11.1 | 13.3 | 1.0 |
| | | | phenanthrene | 6.6 | 6.7 | 8.1 | 0.6 |
| | | | anthracene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | fluoranthene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | pyrene | 8.8 | 9.1 | 10.9 | 0.8 |
| | | | benz(a)anthracene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | chrysene | 0.3 | 0.3 | 0.4 | 0.0 |
| | | | benzo(b+j+k)phenanthrene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | BeP | 4.3 | 4.4 | 5.3 | 0.4 |
| | | | BaP | 10.7 | 11.1 | 13.3 | 1.0 |
| | | | indeno[123-cd]pyrene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | benzo(ghi)perylene | 4.8 | 4.9 | 5.9 | 0.5 |
| | | | coronene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| 20 | Full Meal | Gas | naphthalene | 23.5 | 4.2 | 1.8 | 1.6 |
| | | | acenaphthylene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | acenaphthene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | fluorene | 2.7 | 0.5 | 0.2 | 0.2 |
| | | | phenanthrene | 1.1 | 0.2 | 0.1 | 0.1 |
| | | | anthracene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | fluoranthene | 0.1 | 0.0 | 0.0 | 0.0 |
| | | | pyrene | 0.5 | 0.1 | 0.0 | 0.0 |
| | | | benz(a)anthracene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | chrysene | 0.9 | 0.2 | 0.1 | 0.1 |
| | | | benzo(b+j+k)phenanthrene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | BeP | 0.5 | 0.1 | 0.0 | 0.0 |
| | | | BaP | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | indeno[123-cd]pyrene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | benzo(ghi)perylene | 0.1 | 0.0 | 0.0 | 0.0 |
| | | | coronene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| 22 | French Fries | Gas | naphthalene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | acenaphthylene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | acenaphthene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | fluorene | 3.0 | 0.8 | 0.6 | 0.4 |
| | | | phenanthrene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | anthracene | 0.0 | 0.0 | 0.0 | 0.0 |

| Test No. | Type | Range | Compound | Emission Rate | Source Strength (per gram of food) | Food-specific Emission Factor | Power-specific Emission Factor |
|---|---|---|---|---|---|---|---|
| | | | | µg/hr | ηg/g | ηg/g/hr | ηg/BTU |
| | | | fluoranthene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | pyrene | 0.8 | 0.2 | 0.2 | 0.1 |
| | | | benz(a)anthracene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | chrysene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | benzo(b+j+k)phenanthrene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | BeP | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | BaP | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | indeno[123-cd]pyrene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | benzo(ghi)perylene | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | coronene | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] |
| | | | N | 7 | 7 | 7 | 7 |
| | | | Minimum | 0.0 | 0.0 | 0.0 | 0.0 |
| | | | Maximum | 307.7 | 302.1 | 362.6 | 39.3 |

[a] Correction for outdoor data resulted in zero or negative value.

Table 3-37. Element Emission Rates (μg/hr)

| Test Type | Oven Cleaning | Oven Cleaning | Pork | Fry Beef | Fry Beef | Fry Beef | Full Meal |
|---|---|---|---|---|---|---|---|
| Conditions | Gas | Electric | Gas | Gas | Gas | Gas | Gas |
| Compound/Test No. | 1R | 8 | 25 | 24 | 24R | 31 | 20 |
| Sodium | 61.1 | 84.1 | 67.6 | 693.7 | 214.6 | 380.4 | 4.1 |
| Magnesium | 37.7 | 0.0[a] | 0.0[a] | 541.8 | 74.7 | 0.0[a] | 10.5 |
| Aluminum | 0.0[a] | 30.7 | 41.1 | 647.5 | 85.2 | 186.1 | 52.0 |
| Silicon | 2726.7 | 202.1 | 153.3 | 1008.9 | 787.2 | 330.0 | 1359.9 |
| Phosphorous | 2545.2 | 13.4 | 5.9 | 200.5 | 106.4 | 47.5 | 93.4 |
| Sulfur | 693.6 | 76.7 | 67.7 | 46.2 | 208.5 | 72.4 | 506.1 |
| Chlorine | 2058.5 | 176.8 | 0.0[a] | 118.3 | 41.6 | 54.3 | 80.4 |
| Potassium | 1224.2 | 126.0 | 0.0[a] | 0.0[a] | 108.7 | 90.8 | 43.1 |
| Calcium | 108.1 | 27.0 | 73.5 | 400.2 | 419.1 | 295.6 | 147.6 |
| Titanium | 0.0[a] | 8.7 | 0.0[a] | 11.5 | 39.1 | 9.2 | 0.4 |
| Vanadium | 0.0[a] | 0.0[a] | 0.0[a] | 0.0[a] | 20.9 | 16.1 | 3.7 |
| Chromium | 392.1 | 42.5 | 5.3 | 24.3 | 4.4 | 0.0 | 11.4 |
| Manganese | 0.0[a] | 0.0 | 0.0 | 0.0[a] | 0.0 | 0.0 | 0.0 |
| Iron | 28.2 | 17.9 | 30.5 | 54.7 | 83.8 | 35.8 | 28.1 |
| Cobalt | 0.0 | 0.0 | 1.3 | 8.4 | 0.0 | 0.3 | 0.5 |
| Nickel | 12.0 | 8.8 | 1.8 | 0.0 | 0.3 | 0.0[a] | 0.3 |
| Copper | 87.4 | 13.3 | 31.7 | 77.9 | 69.7 | 79.4 | 29.0 |
| Zinc | 18.8 | 13.3 | 12.2 | 79.1 | 47.4 | 41.9 | 9.2 |
| Gallium | 0.0 | 0.0 | 0.0[a] | 8.6 | 13.1 | 0.0 | 0.0[a] |
| Arsenic | 0.0 | 0.0 | 0.7 | 4.8 | 0.0 | 0.0 | 0.0[a] |
| Selenium | 0.0[a] | 0.0 | 1.6 | 0.0 | 0.0[a] | 0.0 | 0.0 |
| Bromine | 1101.1 | 2.2 | 0.9 | 21.1 | 9.2 | 3.8 | 63.3 |
| Rubidium | 0.0 | 1.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Strontium | 0.0 | 0.3 | 1.6 | 8.0 | 4.7 | 0.1 | 0.0 |
| Yttrium | 0.0 | 2.1 | 3.4 | 2.2 | 2.4 | 0.0 | 0.0[a] |
| Zirconium | 0.0[a] | 2.6 | 3.0 | 27.3 | 17.4 | 14.7 | 7.0 |
| Molybdenum | 0.0[a] | 3.7 | 5.9 | 5.8 | 26.9 | 19.9 | 4.0 |
| Palladium | 0.0[a] | 0.0 | 0.0[a] | 0.0[a] | 0.0 | 0.0 | 2.4 |
| Silver | 28.7 | 0.0 | 5.9 | 0.0[a] | 0.0 | 0.0[a] | 0.0 |
| Cadmium | 0.0[a] | 16.3 | 12.7 | 92.3 | 31.5 | 87.7 | 8.1 |
| Indium | 0.0[a] | 0.0 | 0.0 | 169.3 | 0.0 | 0.0 | 1.8 |
| Tin | 3.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Antimony | 0.0 | 0.0[a] | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Barium | 0.0 | 35.3 | 87.0 | 740.8 | 0.0 | 0.0 | 49.0 |
| Lanthanum | 40.9 | 88.3 | 187.0 | 0.0 | 0.0 | 0.0[a] | 14.1 |
| Gold | 0.0 | 13.3 | 9.0 | 0.0 | 9.5 | 0.0 | 0.0 |
| Mercury | 0.0[a] | 8.0 | 6.5 | 0.0 | 0.0 | 0.0 | 0.0 |
| Thallium | 0.0 | 0.0[a] | 2.2 | 40.3 | 0.0 | 3.0 | 1.4 |
| Lead | 0.0[a] | 7.0 | 1.0 | 0.0 | 26.2 | 5.3 | 0.0[a] |
| Uranium | 0.0[a] | 1.1 | 4.9 | 39.9 | 11.5 | 0.0[a] | 1.5 |

[a] Correction for outdoor data resulted in zero or negative value.

## 3.10 QA DATA SUMMARY

### 3.10.1 Data Quality Indicator Goals for Critical Measurements

Data Quality Indicator (DQI) goals in terms of accuracy, precision, and completeness were established for critical measurements in the study plan. Established goals are presented in Table 3-38. Accuracy, expressed as percent bias, was determined by obtaining measurements for standards of a known concentration. Precision is expressed as percent relative standard deviation (%RSD) and is calculated by taking the standard deviation of a set of replicate measurements and dividing by the mean. In cases where duplicate measurements were made, precision is expressed as a relative standard deviation (%RSD). Completeness was determined by comparing the number of measurements that fell within DQI goals to the total number of measurements taken for a particular parameter. The following sections summarize calculated DQI's for critical measurements and discuss data limitations if DQI goals were not met.

Accuracy is expressed as:

$$Percent\ Bias = \frac{R - C}{C} x\ 100 \qquad 1$$

Where:

R = instrument response or reading
C = calibration standard or audit sample value

Precision is expressed as:

$$RPD = \frac{100\ x\ |Q - B|}{(Q + B)/2} \qquad 2$$

Where:

Q = results from 1 duplicate run
B = results from second duplicate run
RPD = relative percent difference

#### 3.10.1.1 Air Exchange Rates

Air exchange rates in the test house were determined using the $SF_6$ trace gas decay method described in ASTM E-741. The GC used to measure $SF_6$ concentrations was calibrated by injecting a calibration standard in concentration from 0.5 to 100 ppb. Daily calibration checks were performed prior to each test using the 100 ppb standard. Full 6-point calibrations were performed on 2/3/00, 2/8/00, and 2/23/00 and resulted in the linear regressions data presented in Table 3-39. Using the equation y= mx + b, concentrations for daily calibration checks were calculated and the results are presented in Table 3-40. Acceptance criteria for accuracy and precision were established as ±10% and the completeness goal was 100%. Precision goals for replicate analysis were met, and accuracy goals were met for all but one daily calibration check. All planned air exchange measurements were performed during the main study.

Table 3-38 DQI Goals for Critical Measurements

| Measurement | Method | Accuracy (% Bias) | Precision (% RSD) | Completeness (%) |
|---|---|---|---|---|
| Air Exchange Rates | Tracer Gas Decay | ±10 | ±10 | 100 |
| Particulate (gravimetric) | Impactors/Filters | ±25 | ±25 | 95 |
| Particulate (continuous) | Electrical Low Pressure Impactor (ELPI) | NA[a] | NA[a] | 95 |
| Elemental Analysis | X-Ray Fluorescence | ±20 | ±15 | 95 |
| CO | Non-dispersive infrared | ±1% FS | ±1% FS | 95 |
| NO2 | Chemiluminescence | ±1% FS | ±1% FS | 95 |
| Temperature | Resistance Temperature Detector | ±0.3 °C | ±0.5 °C | 95 |
| Relative Humidity | Thin Film Capacitance Sensor | ±5 | ±5 | 95 |
| Aldehydes | DNPH/Silica Gel/HPLC | ±20 | ±15 | |
| PAH/Cooking Oils | GC/MS | ±25 | ±25 | 95 |
| PAH/Gas+Particulate | GC/MS | ±25 | ±25 | 95 |

[a] - Accuracy and precision data currently not available for this instrument.

Table 3-39. Linear Regressions for 6-Point $SF_6$ Calibrations

| Calibration Date | Correlation Coefficient | Slope (m) | Y-intercept (b) |
|---|---|---|---|
| 02/03/00 | 0.9993 | 1.82E-05 | -0.91 |
| 02/08/00 | 0.995 | 2.96E-06 | 4.25 |
| 02/23/00 | 0.995 | 2.82E-06 | 4.65 |

Table 3-40. $SF_6$ Daily Calibration Checks for 100 ppb Standard

| Date | Area Counts (x) | Concentration (ppb) | % Bias |
|---|---|---|---|
| 02/03/00 | 5603097 | 98.9 | 1.1 |
| 02/05/00 | 5657343 | 102.1 | 2.1 |
| 02/09/00 | 33543580 | 103.5 | 3.5. |
| 02/10/00 | 33020144 | 102 | 2.0 |
| 02/11/00 | 33232244 | 102.6 | 2.6 |
| 02/13/00 | 33191915 | 102.5 | 2.5 |
| 02/15/00 | 33811088 | 104.3 | 4.3 |
| 02/16/00 | 41862741 | 128.2 | 28.2 |
| 02/24/00 | 30420565 | 90.1 | 9.1 |
| 02/25/00 | 31227019 | 92.7 | 7.3 |
| 02/26/00 | 30800011 | 91.2 | 8.8 |
| 02/27/00 | 30566693 | 90.8 | 9.2 |
| 02/28/00 | 31447851 | 93.3 | 6.7 |
| **Average** | 100.2 | | |
| **Standard Deviation** | 10 | | |
| **% RSD** | 9.9 | | |
| **Completeness** | 13/14 passed = 93% | | |

### 3.10.1.2 Particulate Matter

The calibration of the microbalance used to weigh particulate filters was checked using a NIST-certified 10 μg standard weighed after every 10 filters.

Collocated samples were used to assess precision for $PM_{2.5}$ and $PM_{10}$ gravimetric measurements. Only PEMs, used for PM sampling in the kitchen, were available for collocated sampling to determine method precision. Precision of the MS&T samplers used in the LR, MBR, and outdoors could not be determined due to the limited number of samplers available. Collocated measurements were performed with PEMs and the MS&T samplers during a number of tests. But, because these were different sampling methods, the collocated measurements did not represent true method precision measurements, and the results are not reported.

Results for the collocated PEM samples collected in the kitchen are presented in Table 3-41. The $PM_{2.5}$ duplicate sample collected during Test No. 1 was lost due to high loading on the filter, which resulted in a pump failure. The RSD for the other $PM_{2.5}$ duplicate was 30%, which did not meet the precision goal of 25% RSD. Three duplicate samples for $PM_{10}$ collected with the PEMS had RSDs of 32, 12, and 96%. Only one of the three samples met the data quality goal of 25% RSD. The completeness goal of 90% was not met. During Test No. 23, for which the RSD was 96%, there was only 16 $\mu$g of PM mass on the filter.

Table 3-41. Precision Summary of Duplicate Particulate Filters

| Test No. – Location | Type | Primary ($\mu g/m^3$) | Duplicate ($\mu g/m^3$) | %RSD | Notes |
|---|---|---|---|---|---|
| 1 (oven cleaning)– K | $PM_{2.5}$ | 3651 | -- | -- | Invalid – Pump failed |
| 1R (oven cleaning) – K | $PM_{2.5}$ | 2459 | 1604 | 30 | -- |
| **Completeness (0/2 passed) = 0%** | | | | | |
| 2 (stovetop stir fry) – K | $PM_{10}$ | 329 | 209 | 32 | 66 μg on filter |
| 20 (full meal) – K | $PM_{10}$ | 888 | 745 | 12 | -- |
| 23 (bake lasagna) – K | $PM_{10}$ | 167 | 31.6 | 96 | 16 μg on PEM filter |
| **Completeness (1/3 passed) = 33%** | | | | | |

The poor precision may be related to problems with maintaining the target flow rate for the PEM samplers. Throughout the main study, there was poor stability of the flow rate for the pumps used on the PEMs. The flow rates for the MS&T and PEM samplers are listed in Tables 3-42 ($PM_{2.5}$) and 3-43 ($PM_{10}$). The values listed are the percent differences between the flow rate at the start of sampling and that measured at the end of the sampling period. As shown in the tables, the flows were relatively stable for the pumps used with the MS&T impactors, with the difference between the starting and ending flow rates generally lower than 5%. However, the difference was substantially higher for the pumps used on the PEMs. The starting and ending flows generally differed by greater than 20%. In some cases, such as in Test No. 1 (oven

cleaning), the flow decreased substantially during the test due to high particle loading on the filter. In other cases, the change in flow cannot be easily explained based simply on the amount of mass on the filters. The substantial decrease in the pump flow rates during sampling may be related to accumulation of grease droplets on the filters, but there is no data available to document that hypothesis. In general, the flow differences between the start and end of sampling were lower when samples were collected with the PEMs at locations other than in the kitchen. The problem persisted throughout the main study. Three different pumps were used for sample collection with the PEMs. Because the problem occurred with all three pumps, the field team leader elected to continue the testing despite the problem.

The poor performance of the pumps used for particle sampling with the PEMs in the kitchen is recognized to be a serious problem in this study. The problem adversely impacts the quality of the data from a quantitative standpoint because the accuracy of the data cannot be determined. For calculating the sample volumes, it was necessary to assume that the decrease in flow over time was linear. If this is not the case, the results could be substantially different. If the flow rate decreased in the early phase of a test, the sample volume would be over-estimated, resulting in calculated concentrations that are lower than actual. However, if the flow dropped off near the end of a test, due to particle or grease loading on the filter, the sample volume would be under-estimated, causing the concentrations to be over-estimated.

The precision problems with the PEM may also be related to the type of aerosol, which in the kitchen most likely consisted of large amounts of water and grease droplets. Data for collection efficiency for this type of aerosol with the PEM inlets has not been published.

Table 3-42. Variation in $PM_{2.5}$ Sampler Pump Flow Rates during The Cooking Tests

| Test No. | Location | % Diff.[a] | Test No. | Location | % Diff.[a] | Test No. | Location | % Diff.[a] |
|---|---|---|---|---|---|---|---|---|
| MS&T Samplers (20 L/min Flow Rate) | | | | | | | | |
| 1 | OUT | 4% | 11 | MBR | 2% | 23 | MBR | 1% |
| 1 | LR | 92% | 11 | OUT | 9% | 24 | OUT | 7% |
| 1 | MBR | 87% | 12 | LR | 1% | 24 | LR | 2% |
| 2 | LR | 1% | 12 | MBR | 2% | 24 | MBR | 2% |
| 2 | MBR | 0% | 13 | LR | 3% | 25 | LR | 0% |
| 3 | LR | 4% | 13 | MBR | 2% | 25 | MBR | 3% |
| 3 | MBR | 4% | 13 | OUT | 6% | 26 | LR | 2% |
| 3 | OUT | 12% | 14 | OUT | 0% | 26 | MBR | 0% |
| 4 | OUT | 8% | 14 | LR | 3% | 26 | OUT | 9% |
| 4 | LR | 0% | 14 | MBR | 2% | 27 | LR | 1% |
| 4 | MBR | 0% | 17 | LR | 3% | 27 | MBR | 1% |
| 5 | LR | 0% | 17 | MBR | 1% | 28 | MBR | 2% |
| 5 | MBR | 0% | 18 | LR | 3% | 28 | LR | 4% |
| 6 | LR | 75% | 18 | MBR | 2% | 28 | OUT | -1% |
| 6 | MBR | 77% | 18 | OUT | 0% | 29 | LR | 3% |

| Test No. | Location | % Diff.[a] | Test No. | Location | % Diff.[a] | Test No. | Location | % Diff.[a] |
|---|---|---|---|---|---|---|---|---|
| 7 | OUT | 4% | 19 | MBR | 2% | 29 | MBR | 1% |
| 7 | LR | 6% | 19 | LR | 0% | 30 | OUT | 10% |
| 7 | MBR | 3% | 20 | LR | 5% | 30 | LR | 3% |
| 8 | OUT | 8% | 20 | MBR | 4% | 30 | MBR | 2% |
| 8 | LR | 6% | 20 | OUT | 14% | 31 | MBR | 2% |
| 8 | MBR | 2% | 21 | LR | 0% | 31 | OUT | 3% |
| 9 | LR | 0% | 21 | MBR | 1% | 31 | LR | 4% |
| 9 | MBR | 2% | 22 | OUT | 5% | 1R | OUT | 8% |
| 10 | LR | 1% | 22 | LR | 4% | 1R | LR | 71% |
| 10 | MBR | 3% | 22 | MBR | 4% | 1R | MBR | 93% |
| 11 | LR | 1% | 23 | LR | -2% | 24R | LR | 2% |
| | | | | | | 24R | MBR | 2% |
| | | | | | | 24R | OUT | 12% |
| **PEM Samplers (4 L/min Flow Rate)** | | | | | | | | |
| 1 | K | 78% | 11 | K | 49% | 23 | K | 18% |
| 1 | K | 56% | 12 | K | 49% | 24 | K | 33% |
| 2 | K | 14% | 13 | K | 17% | 25 | K | 18% |
| 3 | K | 33% | 14 | K | 69% | 26 | K | 45% |
| 4 | K | 32% | 14 | LR | 19% | 27 | K | 26% |
| 4 | LR | 34% | 17 | K | 13% | 28 | K | 24% |
| 5 | K | 26% | 17 | K-Cook | 9% | 29 | K | 28% |
| 6 | K | 26% | 18 | K | 8% | 30 | K | 18% |
| 7 | K | 55% | 19 | K | 8% | 30 | OUT | 14% |
| 8 | K | 53% | 20 | K | 27% | 30 | K-Cook | 8% |
| 9 | K | 9% | 21 | K | 15% | 31 | K | 5% |
| 9 | MBR | 30% | 22 | MBR | 15% | 1R | K | 29% |
| 10 | K | 52% | 22 | K | 5% | 1R | K | 28% |
| | | | | | | 24R | K | 14% |

[a] [(Start flow rate minus end flow rate)/start flow rate] x 100

Table 3-43. Variation in $PM_{10}$ Sampler Pump Flow Rates during The Cooking Tests

| Test No. | Location | % Diff.[a] | Test No. | Location | % Diff.[a] | Test No. | Location | % Diff.[a] |
|---|---|---|---|---|---|---|---|---|
| **MS&T Samplers (20 L/min Flow Rate)** | | | | | | | | |
| 1 | LR | -4% | 11 | MBR | 1% | 24 | LR | 3% |
| 1 | MBR | 90% | 11 | OUT | 5% | 24 | MBR | 2% |
| 1 | OUT | 7% | 12 | LR | 1% | 24 | OUT | 6% |
| 2 | LR | 0% | 12 | MBR | 3% | 25 | LR | 4% |

| Test No. | Location | % Diff.[a] | Test No. | Location | % Diff.[a] | Test No. | Location | % Diff.[a] |
|---|---|---|---|---|---|---|---|---|
| 2 | MBR | 2% | 13 | LR | 2% | 25 | MBR | 3% |
| 3 | LR | 4% | 13 | MBR | 5% | 26 | LR | 4% |
| 3 | MBR | 9% | 13 | OUT | 4% | 26 | MBR | 7% |
| 3 | OUT | 16% | 14 | LR | 0% | 26 | OUT | 10% |
| 4 | LR | 0% | 14 | MBR | 4% | 27 | LR | 2% |
| 4 | MBR | 3% | 14 | OUT | 0% | 27 | MBR | 1% |
| 4 | OUT | 8% | 17 | LR | 4% | 28 | LR | 3% |
| 5 | LR | -2% | 17 | MBR | 1% | 28 | MBR | 3% |
| 5 | MBR | 6% | 18 | LR | 3% | 28 | OUT | 1% |
| 6 | LR | 82% | 18 | MBR | 8% | 29 | LR | -2% |
| 6 | MBR | 100% | 18 | OUT | 7% | 29 | MBR | 0% |
| 7 | MBR | 8% | 19 | LR | 0% | 30 | LR | 2% |
| 7 | LR | 6% | 19 | MBR | 1% | 30 | MBR | 3% |
| 7 | OUT | 0% | 20 | LR | 6% | 30 | OUT | 25% |
| 8 | LR | 19% | 20 | MBR | 5% | 31 | LR | 4% |
| 8 | MBR | 91% | 20 | OUT | 14% | 31 | MBR | 4% |
| 8 | OUT | 13% | 21 | LR | 2% | 31 | OUT | 7% |
| 9 | LR | 1% | 21 | MBR | -1% | 1R | LR | 14% |
| 9 | MBR | 2% | 22 | LR | 5% | 1R | MBR | 9% |
| 10 | LR | 0% | 22 | MBR | 8% | 1R | OUT | 12% |
| 10 | MBR | 2% | 22 | OUT | 7% | 24R | LR | 4% |
| 11 | LR | 1% | 23 | LR | 0% | 24R | MBR | 3% |
| | | | 23 | MBR | 0% | 24R | OUT | 14% |
| PEM Samplers (4 L/min Flow Rate) | | | | | | | | |
| 1 | K | 23% | 23 | K | 7% | 23 | K | 69% |
| 2 | K | 32% | 11 | K | 52% | 24 | K | 32% |
| 2 | K | 23% | 12 | K | 13% | 25 | K | 20% |
| 3 | K | 40% | 13 | K | 49% | 25 | MBR | 9% |
| 4 | K | -2% | 14 | K | 49% | 26 | K | 10% |
| 5 | K | 43% | 17 | K | 33% | 27 | K | 10% |
| 5 | LR | 21% | 17 | K-Cook | 27% | 28 | K | 27% |
| 6 | K | 33% | 17 | LR | 7% | 28 | OUT | 29% |
| 7 | K | 20% | 18 | K | 39% | 29 | K | 10% |
| 8 | K | 34% | 19 | K | 11% | 30 | K | 28% |
| 9 | K | -4% | 20 | K | 8% | 30 | K-Cook | 15% |
| 10 | K | 51% | 20 | K | 44% | 31 | K | 26% |
| 10 | MBR | 41% | 21 | K | 10% | 1R | K | 41% |
| | | | 22 | K | 29% | 24R | K | 25% |

[a] [(Start flow rate minus end flow rate)/start flow rate] x 100

Additional method performance evaluation and validation would be required for this type of aerosol if additional sampling work is performed on cooking emissions and exposure. In addition, measurements are being made in ambient sampling studies to determine the effects of positive and negative sampling artifacts with SVOCs (Cui et al., 1998) and negative artifacts from nitrate losses (Ashbaugh, et al., 1998). Although effects such as these likely influenced the results of this study, the basic differences between these studies make comparisons and overall losses difficult to estimate.

Another source of variability for the PM samples could be the loss of VOCs and SVOCs during sampling or handling. The samples were collected over periods of 1.5 to 5 hours, during which loss of SVOCs could occur. Losses may also have occurred during shipping and handling. Although the samples were stored in the freezer following sample collection and transported under refrigeration, SVOCs losses may have occurred during shipment on commercial aircraft.

Although the quality of the data for gravimetric PM samples collected with the PEMs does not meet the project criteria, the data are still useful for addressing the primary objective of the study, which was to gain a better understanding of the impact of cooking on indoor air concentrations and human exposure. As will be discussed in Section 4.0, the house was generally very well mixed during the tests. The concentrations of CO and NO, inert gases emitted during cooking, were very similar in the kitchen, LR, and MBR. The air exchange rates measured in the individual rooms were also very similar, suggesting good mixing in the house. Although the particles generated during cooking cannot be treated as inert gases, the PM concentrations in the kitchen may not be substantially higher than in the other rooms because the house appeared to be so well mixed. It can be expected that the concentrations would be somewhat higher in the kitchen because of losses due to deposition. Although the data cannot be used for quantitative estimates of human exposure in the kitchen, the data are still useful for assessing the potential impact of cooking on human exposure.

#### 3.10.1.3 Continuous Emissions Monitors (CO, $NO_X$)

Continuous emissions monitors were used to measure CO, NO, and $NO_2$ for each test. Daily QC checks were run for each monitor and recorded in the project notebook. Results from daily QC checks are summarized in Tables 3-44 and 3-45. DQI goals were met for all CEM measurements with the instrument that cycled through the four measurement locations.

#### 3.10.1.4 Elemental Analysis

Spiked performance evaluation samples were not planned for this measurement parameter. Internal quality control samples were performed by the laboratory, and all acceptance criteria were met. Precision was assessed by comparing results of duplicate samples. One set of duplicate samples was submitted for elemental analysis, and the results are presented in Table 3-46. The established goal for %RSD was 15%, and the completeness goal was 95%. As can be seen from the table, 7 of 9 elements met the precision goal for a completeness value of 78%.

### 3.10.1.5 PAH and Aldehydes

PAH performance evaluation samples were submitted to the laboratory to assess the accuracy of the analysis during the pre-test. There were two duplicate samples taken for PAH analysis to assess method precision, but the majority of compounds fell below the laboratory's calculated uncertainty. Compounds detected above the MDL are presented in Table 3-47.

Table 3-44. CO CEM Daily QC Checks

| Date | CO (ppm) | | % Bias |
|---|---|---|---|
| | Actual | Measured | |
| 02/03/00 | 19.4 | 19.5 | 0.5 |
| 02/04/00 | 19.4 | 19.4 | 0 |
| 02/05/00 | 19.4 | 19.8 | 2.1 |
| 02/06/00 | 19.4 | 19.0 | -2.1 |
| 02/08/00 | 19.4 | 19.4 | 0 |
| 02/09/00 | 19.4 | 19.4 | 0 |
| 02/10/00 | 19.4 | 19.5 | 0.5 |
| 02/11/00 | 19.4 | 19.4 | 0 |
| 02/13/00 | 19.4 | 19.6 | 1.0 |
| 02/15/00 | 19.4 | 19.6 | 1.0 |
| 02/16/00 | 19.4 | 19.1 | -1.6 |
| 02/17/00 | 19.4 | 19.6 | 1.0 |
| 02/24/00 | 19.4 | 19.4 | 0 |
| 02/25/00 | 19.4 | 19.4 | 0 |
| 02/26/00 | 19.4 | 19.4 | 0 |
| 02/27/00 | 19.4 | 19.4 | 0 |
| 02/28/00 | 19.4 | 19.1 | -1.6 |
| 02/29/00 | 19.4 | 19.6 | 1.0 |
| **Average** | | 19.4 | |
| **Standard Deviation** | | 0.2 | |
| **Precision (%RSD)** | | 1.0 | |
| **% Completeness** | | 100 | |

Table 3-45. $NO_X$ Monitor Daily QC Checks

| Date | Actual (ppb) | NO | | $NO_2$ | | $NO_X$ | |
|---|---|---|---|---|---|---|---|
| | | Measured (ppb) | % Bias | Measured (ppb) | % Bias | Measured (ppb) | % Bias |
| 02/03/00 | 1000 | 990 | -1.0 | 1053 | 5.3 | 991 | -0.9 |
| 02/04/00 | 1000 | 999 | -0.1 | 1023 | 2.3 | 996 | -0.4 |
| 02/05/00 | 1000 | 1006 | 0.6 | 1015 | 1.5 | 1007 | 0.7 |
| 02/06/00 | 1000 | 1001 | 0.1 | 1013 | 1.3 | 1006 | 0.6 |
| 02/08/00 | 1000 | 1023 | 2.3 | 1042 | 4.2 | 1028 | 2.8 |
| 02/09/00 | 1000 | 970 | -2.9 | 919 | -8.1 | 968 | -3.2 |
| 02/10/00 | 1000 | 969 | -3.1 | 930 | -7.0 | 969 | -3.1 |
| 02/11/00 | 1000 | 1018 | 1.8 | 993 | -0.7 | 1019 | 1.9 |
| 02/13/00 | 1000 | 995 | -0.5 | 990 | -1.0 | 992 | -0.8 |
| 02/15/00 | 1000 | 1007 | 0.7 | 974 | -2.6 | 1010 | 1.0 |
| 02/16/00 | 1000 | 1017 | 1.7 | 991 | -0.9 | -- | -- |
| 02/17/00 | 1000 | 1020 | 2.0 | 1082 | 8.2 | 1025 | 2.5 |
| 02/24/00 | 1000 | 1008 | 0.8 | 1054 | 5.4 | 1001 | 0.1 |
| 02/25/00 | 1000 | 1004 | 0.4 | 1048 | 4.8 | 998 | -0.2 |
| 02/26/00 | 1000 | 998 | -0.2 | 1042 | 4.2 | 990 | -1.0 |
| 02/27/00 | 1000 | 993 | -0.7 | 1021 | 2.1 | 997 | -0.3 |
| 02/28/00 | 1000 | 1022 | 2.2 | 1062 | 6.2 | 1012 | 1.2 |
| 02/29/00 | 1000 | 994 | -0.6 | 1034 | 3.4 | 989 | -1.1 |
| **AVG** | | 1002 | | 1016 | | 1000 | |
| **SD** | | 15.6 | | 43.7 | | 16.7 | |
| **Precision (%RSD)** | | 1.6 | | 4.3 | | 1.7 | |
| **% Completeness** | | 100 | | 100 | | 100 | |

Table 3-46. Calculated Precision for Elemental Analysis of Duplicate Sample

| Element | Test 20 ($ng/m^3$) | Test 20-Dup ($ng/m^3$) | %RSD |
|---|---|---|---|
| Silicon | 3902 | 3458 | 8.5 |
| Phosphorous | 263 | 240 | 6.7 |
| Sulfur | 1521 | 1286 | 11.9 |
| Chlorine | 804 | 721 | 7.7 |
| Potassium | 130 | 147 | 8.5 |
| Calcium | 447 | 399 | 8.0 |
| Iron | 105 | 84 | 16.2 |
| Copper | 92 | 65 | 24.2 |
| Bromine | 183 | 158 | 10.6 |

Table 3-47. Calculated Precision for PAH Analysis of Duplicate Samples

| XAD-ID | 11 | 7 | | | | 6 | 1 | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site | K | K | | | | K | K | | | |
| Test # | 17 | 17 | | | | 20 | 20 | | | |
| Primary/Duplicate Sample | Primary | Duplicate | | | | Primary | Duplicate | | | |
| Type | Stovetop Stir Fry | Stovetop Stir Fry | | | | Full Meal | Full Meal | | | |
| Range | Gas | Gas | | | | Gas | Gas | | | |
| Conditions | Worst Case | Worst Case | | | | Standard | Standard | | | |
| | Peanut Oil | Peanut Oil | | | | | | | | |
| Compound | ηg/m$^3$ | ηg/m$^3$ | avg | stdev | %RSD | ηg/m$^3$ | ηg/m$^3$ | avg | stdev | %RSD |
| **fluorene**[b] | 23.3 | 21.8 | 22.5 | 1.1 | 4.8 | 34.2 | 12.6 | 23.4 | 15.3 | 65.5 |
| **pyrene**[b] | 19.1 | 9.0 | 14.1 | 7.1 | 50.7 | 15.4 | 0.4 | 7.9 | 10.7 | 135.0 |
| **BeP**[b] | 9.6 | 0.8 | 5.2 | 6.2 | 119.0 | 8.1 | 2.9 | 5.5 | 3.7 | 67.6 |
| **coronene**[b] | 6.2 | 1.2 | 3.7 | 3.5 | 94.8 | 2.5 | 0.0[a] | 2.5 | NA | NA |
| 2-methylnaphthalene | 27.4 | 22.2 | 24.8 | 3.7 | 15.0 | 167.6 | 18.3 | 92.9 | 105.5 | 113.6 |
| 1-methylnaphthalene | 53.6 | 20.9 | 37.3 | 23.1 | 62.0 | 174.3 | 33.4 | 103.9 | 99.6 | 95.9 |
| biphenyl | 28.3 | 37.8 | 33.0 | 6.7 | 20.4 | 69.6 | 15.8 | 42.7 | 38.0 | 89.1 |
| 1+2-ethylnaphthalene | 28.7 | 23.4 | 26.0 | 3.7 | 14.3 | 40.4 | 0.0[a] | 40.4 | NA | NA |
| 2,6+2,7-dimethylnaphthalene | 18.7 | 27.1 | 22.9 | 5.9 | 25.9 | 49.7 | 24.8 | 37.2 | 17.6 | 47.3 |
| 1,3+1,6+1,7-dimethylnaphthalene | 56.5 | 68.2 | 62.3 | 8.2 | 13.2 | 92.1 | 47.8 | 69.9 | 31.3 | 44.8 |
| 1,4+1,5+2,3-dimethylnaphthalene | 20.0 | 14.8 | 17.4 | 3.7 | 21.1 | 37.9 | 15.1 | 26.5 | 16.1 | 60.9 |
| 1,2-dimethylnaphthalene | 0.8 | 0.0[a] | 0.8 | NA | NA | 15.7 | 24.4 | 20.1 | 6.2 | 30.7 |
| 3-methylbiphenyl | 298.5 | 220.9 | 259.7 | 54.8 | 21.1 | 0.0[a] | 0.0[a] | NA | NA | NA |
| A-trimethylnaphthalene | 19.5 | 63.6 | 41.6 | 31.2 | 75.0 | 11.5 | 78.3 | 44.9 | 47.2 | 105.2 |
| C-trimethylnaphthalene | 10.0 | 17.2 | 13.6 | 5.1 | 37.8 | 30.3 | 21.5 | 25.9 | 6.2 | 23.9 |
| E-trimethylnaphthalene | 9.6 | 18.1 | 13.8 | 6.0 | 43.5 | 25.0 | 14.7 | 19.9 | 7.3 | 36.5 |
| F-trimethylnaphthalene | 5.0 | 8.6 | 6.8 | 2.6 | 37.8 | 16.0 | 5.4 | 10.7 | 7.5 | 70.2 |
| 2,3,5+I-trimethylnaphtalene | 13.3 | 25.5 | 19.4 | 8.6 | 44.4 | 30.9 | 13.6 | 22.3 | 12.2 | 54.7 |
| J-trimethylnaphthalene | 22.4 | 28.3 | 25.4 | 4.2 | 16.4 | 32.0 | 0.0[a] | 32.0 | NA | NA |
| 1,2,8-trimethylnaphthalene | 16.6 | 9.0 | 12.8 | 5.4 | 41.9 | 4.5 | 0.4 | 2.4 | 2.9 | 120.5 |
| A-methylfluorene | 27.0 | 5.7 | 16.4 | 15.0 | 91.8 | 27.5 | 10.4 | 19.0 | 12.1 | 63.7 |
| 1-methylfluorene | 3.3 | 14.4 | 8.8 | 7.8 | 88.3 | 0.0[a] | 0.0[a] | NA | NA | NA |
| B-methylfluorene | 6.2 | 2.5 | 4.3 | 2.7 | 61.3 | 3.4 | 2.2 | 2.8 | 0.9 | 31.1 |
| B-MePy/MeFl | 10.8 | 0.0[a] | 10.8 | NA | NA | 2.2 | 8.3 | 5.3 | 4.3 | 81.0 |
| 4-methylpyrene | 0.0[a] | 11.1 | 11.1 | NA | NA | 4.2 | 1.1 | 2.6 | 2.2 | 83.8 |
| 7-methylbenz(a)anthracene | 2.5 | 1.2 | 1.9 | 0.9 | 47.9 | 114.5 | 20.5 | 67.5 | 66.5 | 98.5 |
| benz(a)anthracene-7,12-dione | 0.4 | 0.0[a] | 0.4 | NA | NA | 1.1 | 5.7 | 3.4 | 3.3 | 95.2 |
| 5+6-methylchrysene | 0.0[a] | 0.0[a] | NA | NA | NA | 49.7 | 20.5 | 35.1 | 20.7 | 58.9 |

[a] Correction with background data resulted in zero or negative value.
[b]Compounds in bold letters are PAHs.

No aldehyde performance evaluation samples were planned for the study because of the limited scope of sampling. Quality control samples prepared in the laboratory for other on-going tests were analyzed to assess the accuracy of the analysis. The laboratory performed internal quality control checks that resulted in recoveries that met method acceptance criteria. The data for the accuracy of the QC lab samples are presented in Table 3-48. The precision of the method could not be assessed at the field site because the sampling pump failed during collection of the one duplicate sample that was planned for collection.

Table 3-48. Calculated Accuracy for Aldehydes Analysis of QC Samples

| Date | %Recovery | | | Avg. | STD | %RSD |
|---|---|---|---|---|---|---|
| | 2/17/00 | 2/18/00 | 2/26/00 | | | |
| Formaldehyde | 102 | 101 | 102 | 102 | 0 | 0.3 |
| Acetaldehyde | 107 | 105 | 106 | 106 | 1 | 0.9 |
| Acrolein | 106 | 104 | 105 | 105 | 1 | 1.0 |
| Propanal | 107 | 105 | 105 | 106 | 1 | 1.3 |
| Butanal | 112 | 106 | 110 | 109 | 3 | 2.6 |
| Benzaldehyde | 116 | 106 | 110 | 111 | 5 | 4.6 |
| Pentanal | 109 | 106 | 109 | 108 | 1 | 1.3 |
| Hexanal | 105 | 104 | 106 | 105 | 1 | 1.1 |

### 3.10.2 Duplicate Cooking Tests

Three cooking tests were repeated to assess the variability of emissions during the tests. The following cooking tests were performed in duplicate:

- Stovetop Stir Fry/Gas (Test 2 and Test 21)
- French Fries/Gas (Test 5 and Test 22)
- Baked Lasagna/Gas (Test 7 and Test 23)

In addition to the planned tests, Test 24 was repeated because of a problem with the DAS. The CO, NO, and $NO_2$ data were lost for Test No. 24, but data were collected for PM by the gravimetric and ELPI methods and environmental data. Results for these tests are presented in the tables in this section and are discussed in Section 4.