SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

- PROTOCOL -

DETERMINATION OF PARTICULATE AND VOLATILE ORGANIC COMPOUND EMISSIONS FROM RESTAURANT OPERATIONS

November 14, 1997

SOURCE TESTING AND ENGINEERING BRANCH

APPLIED SCIENCE AND TECHNOLOGY

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

- PROTOCOL -

DETERMINATION OF PARTICULATE AND VOLATILE ORGANIC COMPOUND EMISSIONS FROM RESTAURANT OPERATIONS

November 14, 1997

SOURCE TESTING AND ENGINEERING BRANCH

APPLIED SCIENCE AND TECHNOLOGY

RESTAURANT TESTING PROTOCOL

TABLE OF CONTENTS

RESTAURANT TESTING PROTOCOL

1.0 OVERVIEW AND APPLICABILITY

The South Coast Air Quality Management District (SCAQMD) has jurisdiction over the emissions of pollutants into the air from a variety of sources in Los Angeles County, Orange County, Riverside County and the non-desert portion of San Bernardino County. This area exceeds the national and state standards for PM10 and ozone. To address those and other pollutants, the SCAQMD developed a twenty-year Air Quality Management Plan (AQMP) to improve the air quality in the basin. Measure #PRC-03 of the 1997 AQMP proposes to reduce the emissions of particulate matter (PM) from restaurant operations. The control measure proposed to control emission from restaurant sources such as charbroilers (under-fired and chain-driven), deep-fat fryers, and indirect-fired grills (griddles). In addition, the June 1988 amendment to District Rule 219 requires that charbroiling equipment be permitted.

Charbroilers generate particulate matter emissions when the food being charbroiled secretes fluids which come into contact with the heating source. The fluids also vaporize or partially oxidize into volatile organic compounds that are emitted into the atmosphere. These emissions contribute to the production of suspended particulate matter and photochemical smog, both of which have demonstrated adverse health effects. Similar emissions are produced by a wide variety of cooking equipment.

This protocol has been developed to ensure standardization of compliance testing procedures. It is applicable to all restaurant appliances, with or without control devices, venting their emissions through any stack. Both "field" and "laboratory" type tests may be performed using this protocol. The section regarding product cooking rate (process weight) however, is oriented towards field testing, since the cooking rate at actual restaurants during high traffic periods often cannot be precisely controlled. In addition, cooking rate for laboratory testing at standardized test kitchens are generally specified in separate cooking protocols.

This document is best used by referring to the specific section needed for a specific task. For example, the main sampling protocol gives general guidance for test procedures (section 4), calculations (section 5), reporting (section 6), and quality assurance/quality control (section 7). The test method for particulate matter is identified as SCAQMD Method 5.1 (see section 3 for complete reference) and the VOC test method is attached in Appendix D. These test methods have been applied to the following restaurant operations:

1) hamburger cooked on under-fired charbroiler
2) whole chicken cooked on under-fired charbroiler
3) Atlantic salmon fillet cooked on under-fired charbroiler
4) hamburger cooked on chain-driven charbroiler, with and without catalytic control device
5) breaded cod fillets cooked on flat griddle
6) hamburger cooked on griddle with shell down
7) hamburger cooked on griddle with shell up
8) chicken cooked on griddle with shell up
9) shoestring fries cooked in a deep-fat fryer
10) breaded chicken patties cooked in deep-fat fryer
11) breaded cod fillets cooked in deep-fat fryer
12) steak on an underfired charbroiler

The cooking pre-test and test procedures presented in this protocol only apply to hamburger cooked on a chain-driven charbroiler, with or without a catalytic oxidizer as a control device. For pre-test and testing procedures applicable to restaurant equipment and cooking configurations listed above, the reader is referred to the document "Further Development of Emission Test Methods and Development of Emission Factors for Various Commercial Cooking

Operations" Final Report for Applied Science and Technology Division, Contract No. 96027, July 24, 1997. It is SCAQMD staff's intent to include the cooking pre-test and test procedures for the above listed restaurant cooking configurations not currently included in this document later. Additionally, any other restaurant operations that will be regulated in future rules will be included. The test methods for both particulate matter and VOCs are those referenced and included in this document.

2.0 DEFINITIONS

For the purposes of this test protocol, the following definitions apply:

HOURS OF OPERATION are those hours beginning from the time an appliance is started (gas/heat source turned on) until the appliance is secured (gas/heat source turned off).

PARTICULATE MATTER (PM) means any material, except uncombined water, which exists in a finely divided form as a liquid or solid at standard conditions.

PROCESS WEIGHT is the pre-cooking weight of all products cooked during the test period. If actual weight is not possible, it is acceptable to average seven units of each product type, given that each piece is of similar size, composition and weight. Process weight is listed in terms of each product in the product mix.

PRODUCT MIX is the listing of all product types cooked during the testing period.

RESTAURANT means any stationary commercial cooking establishment which prepares food for human consumption.

SOLID PARTICULATE MATTER means particulate matter which exists as a solid at standard conditions.

VOLATILE ORGANIC COMPOUNDS (VOC) is any volatile compound of carbon, excluding methane, carbon monoxide, carbon dioxide, carbonic acid, metallic carbides or carbonates, ammonium carbonate and exempt compounds. EXEMPT COMPOUNDS are listed in District Rule 102.

3.0 SAMPLING AND ANALYTICAL METHODS

3.1 Particulate Matter

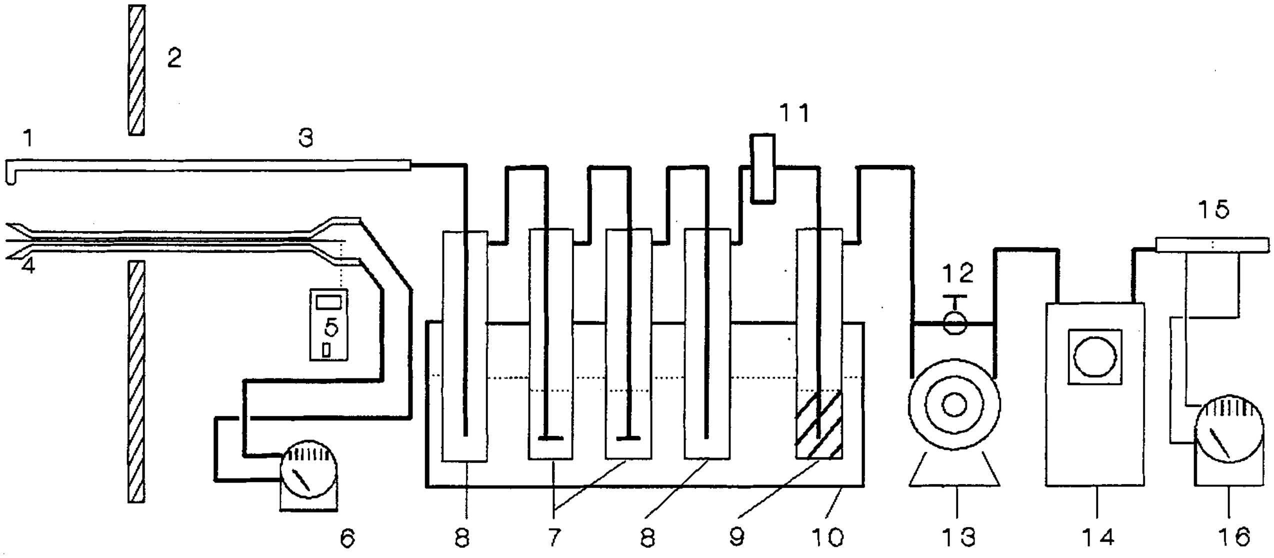
Sample the exhaust isokinetically following District Method 5.1 (refer to *South Coast Air Quality Management District Source Test Manual*, Method 5.1, "Determination of Particulate Matter Emissions from Stationary Sources Using a Wet Impingement Train"). The minimum testing time of 72 minutes is recommended. Longer testing times may be required for cooking processes with very low emissions in order to obtain samples above the lower detection limits. Use a stainless steel or glass probe and nozzle and a District Method 5.1 train. An additional straight tube impinger (empty bubbler) shall be placed in the front of the train [See Figure 1]. Perform organic extraction and particulate matter analysis on the probe and nozzle, the filter and the impingers using a modified District Method 5.1. The change in analysis methods involves using methylene chloride as a wash in addition to water and is detailed in Appendix C. All stopcock grease must be completely removed from joints following proper Laboratory Procedure before recovering the samples with methylene chloride. (WARNING: methylene chloride produces dangerous fumes and appropriate safety measures should be taken during its use.) IMPORTANT: If the sample is not analyzed within 48 hours, it should be recovered and stored at $4^{O}C$ until analysis can be completed. Analysis should be completed within two weeks.

3.2 Volatile Organic Compounds

The VOC test method is presented in Appendix D.

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Particulate Sampling Apparatus - Wet Impingement Method



1. Nozzle
2. Stack Wall
3. Stainless Steel Probe
4. "S" Type Pitot Tube
   and Type "K" Thermocouple
5. Digital Potentiometer
6. Pitot Tube Differential Pressure Guage
7. Impingers with 100 ml De-ionized Water
8. Empty Bubbler
9. Bubbler with Tared Silica Gel
10. Ice Bath
11. Back-up Filter
12. By-pass Valve
13. Sealed Pump
14. Temperature Compensated Dry Gas Meter
15. Orifice
16. Orifice Differential Pressure Guage

Figure 1

Modified Method 5.1

3.3 Flow Rate & Process Weight

3.3.1 Stack Flow Rate Measurements

Measure the flow rate during the isokinetic, traversed particulate sampling as specified in Section 2.7 of District Method 5.1, dated March 1989 (refer to *South Coast Air Quality Management District Source Test Manual*). For calculating the stack velocity, use the average of the flow rates measured at each point sampled during the test.

3.3.2 Process Weight Measurements

The process weight is the weight of products that are cooked during the sampling time. Any food item cooked on any equipment vented to the outside through the exhaust stack must be counted and reported. Separate the product into food types, i.e. number of hamburgers, number of skinned chicken pieces, number of unskinned chicken pieces, etc. Specify the tally, grouping items if necessary, after testing is completed. Fat content from the supplier should also be noted when available. Also note other information that would demonstrate and identify the product being cooked, such as supplier, grade, etc. Measure an exact weight of each food type cooked, prior to cooking. It is acceptable to evaluate an average unit weight (average of at least 7 typical units), as long as every piece is of similar size, composition and weight. The standard deviation of the meat product weight should not exceed 6% of the average unit weight. To determine the process weight of each food type, multiply the number of units cooked by the average pre-determined weight per unit. The total process weight is the sum of all individual process weights.

If applicable, obtain and report a daily meat production rate in order to calculate a pounds of emissions per day value.

3.3.3 CO, CO_2, and O_2 Determination

These gases may be quantified using either District Method 10.1 or Method 100.1. For processes with high dilution, the oxygen content may be considered to be 20.9%.

4.0 TESTING PROCEDURES

4.1 Set-Up

Follow stack and port set-up in District Method 1.1 (refer to *SCAQMD Source Test Manual*). Perform a cyclonic flow check, and document that cyclonic flow complies with District Method 1.1. Refer to Chapter X of the Source Test Manual for alternative procedures if cyclonic flow is present.

If either the ducting, cooking equipment or control device are new, condition the entire set-up before testing. To condition, allow normal cooking to occur for one week while all the equipment (including the control device) is in normal operation. Normal cleaning may occur during this conditioning time.

4.2 Pre-Test

Leak check the PM train according to District Method 5.1. Weigh the product to be cooked or determine the average weights per each food type in the product mix. If not already in use, allow the cooking device to warm-up according to the manufacturer's instructions.

4.3 Test

Conduct the particulate testing over a minimum period of 72 minutes and under the specified loading condition of the cooking equipment. In a restaurant setting, the normal lunch period (11 am to 2 pm) and the normal dinner period (6 pm to 9 pm) will be considered maximum loading conditions, unless a specific restaurant has special operating times or unusual peak hours.

Normal cleaning may occur during testing, but should be carefully noted and reported.

During the test, record the specific items that are being cooked, the quantity and the cooking devices involved. These records are to be kept for any cooking device in operation that is vented to the stack being tested.

Field data sheets to be used for the particulate and the VOC tests are included in Appendix A.

4.4 Post-Test

After the test, leak check the sampling train as done in the pre-test check. Tally the weight of all the food cooked during the sampling time using the methods described in Section 3.3 of this report. During field tests, obtain from restaurant manager the quantities and types of food cooked during the entire day.

5.0 CALCULATIONS

Carry out all calculations to at least one digit beyond that of acquired data, then round off after the final calculations to two significant digits. Round off all numbers according to ASTM E380-82 procedures. Use the calculation sheets in Appendix B.

5.1 Process Weight Calculations

Using the data acquired during testing, determine the process weights for individual product types. Include the weight of each item cooked, or show the weights of the units used to determine an average unit weight. Indicate the pounds per unit type cooked during the sampling period. Calculate the total pounds of product cooked per hour. Report the individual and total pounds cooked during the sample period, individual and total pounds cooked per hour and individual and total pounds cooked during the entire day.

5.2 Particulate Matter Calculations

Use the calculation sheets in Appendix B to determine pounds per hour emission rate of solid particulate matter (EE) and the particulate matter concentration in grains per dry standard cubic foot (BB). Isokinetic sampling rates must also be between 90% and 110% in order for the test to be valid.

Report the volume flow rate (dscfm), the total PM solid emission rates (lbs/hr) and the PM sample concentrations (gr/dscf).

5.3 Pounds per Day Calculations

Calculate the pounds per day value for both the particulate matter and the VOC using the following equation:

$$\text{Total Daily Emissions} = \frac{\text{Hourly Emissions}}{\text{Total Hourly Process Wt}} \times \text{Total Daily Process Weight}$$

$$= \frac{\text{PM (lb/hr)}}{\text{Product (lb/hr)}} \times \text{Product (lb/day)}$$

Report PM emission rates in lbs/day.

5.4 Efficiency of the Control Device

Calculate the destruction efficiency for PM and VOCs using the following equation:

$$\text{Destruction Efficiency} = \frac{\text{Inlet Mass Emission Rate - Outlet Mass Emission Rate}}{\text{Inlet Mass Emission Rate}} \times 100\%$$

Generally simultaneous samples at the inlet and outlet of the control device are collected. For test conditions in which simultaneous inlet and outlet sampling is not possible, alternative sampling methods shall be submitted for AQMD approval.

6.0 REPORTING

A formal report shall be submitted in the format outlined in Chapter II of the *SCAQMD Source Test Manual*. If deviations occur between the manual and this protocol, follow this protocol.

All compliance certification reports shall include the following:

1. QA/QC procedures followed for all measuring equipment, including calibration test data.
2. QA/QC procedures followed for all sampling and analysis equipment, including calibration test data.
3. Chain of custody for samples.
4. Field notes and data sheets.
5. Calculations/averaging sheets/printouts.

7.0 QUALITY ASSURANCE/QUALITY CONTROL REQUIREMENTS

Follow the Quality Assurance/Quality Control guidelines outlined in the *SCAQMD Source Test Manual,* unless otherwise specified in this protocol. The following are examples of QA/QC requirements in the guidelines that pertain to restaurant operations:

1. Chain-of-Custody and calibration documents must be submitted for all restaurant testing.
2. Trip blanks of the Method 5.1 PM train should accompany the sampling apparatus and the Chain-of-Custody. These trains shall also be analyzed for quality assurance purposes.
3. The cooking equipment should be maintained according to manufacturer's instructions.

APPENDIX A FIELD DATA SHEETS

Use the following sheets (attached) when collecting field data.

Tests No.__________ **SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT** Date:______________

Sampling Location____

Field Calculations Reference Sheet

Table 1-2
Location of Traverse Points in Circular Stacks

(Percent of stack diameter from inside wall to traverse point)

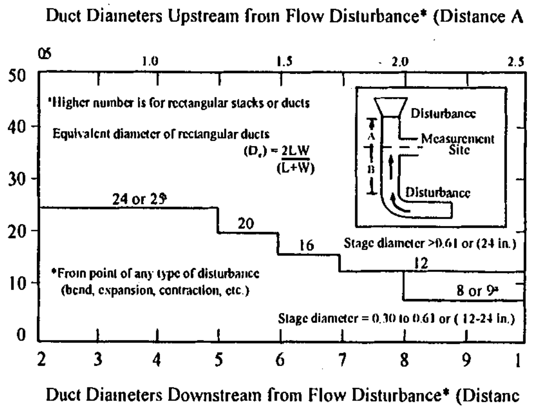
Traverse point number on a diameter	Number of traverse points on a diameter												Diameter
	2	4	6	8	10	12	14	16	18	20	22	24	
1	14.6	6.7	4.4	3.2	2.6	2.1	1.8	1.6	1.4	1.3	1.1	1.1	
2	85.4	25.0	14.6	10.5	8.2	6.7	5.7	4.9	4.4	3.9	3.5	3.2	
3		75.0	29.6	19.4	14.6	11.8	9.9	8.5	7.5	6.7	6.0	5.5	
4		93.3	70.4	32.3	22.6	17.7	14.6	12.5	1.4	1.3	1.1	1.1	
5			85.4	61.7	34.2	25.0	20.1	16.9	14.6	12.9	11.6	10.5	
6			95.6	80.6	65.8	35.6	26.9	22.0	18.8	16.5	14.6	13.2	
7				89.5	77.4	64.4	36.6	28.3	23.6	20.4	18.0	16.1	
8				96.8	85.4	75.0	63.4	37.5	29.6	25.0	21.8	19.4	
9					91.8	82.3	73.1	62.5	38.2	30.6	26.2	23.0	
10					97.4	88.2	79.9	71.7	61.8	38.8	31.5	27.2	
11						93.3	85.4	78.0	70.4	61.2	39.3	32.3	
12						97.9	90.1	83.1	76.4	69.4	60.7	39.8	
13							94.3	87.5	81.2	75.0	68.5	60.2	
14							98.4	91.5	85.4	79.6	73.8	67.7	
15								95.1	89.1	83.5	78.2	72.8	
16								98.4	92.5	87.1	82.0	77.0	
17									95.6	90.3	85.4	80.6	
18									98.6	93.3	88.4	83.9	
19										96.1	91.3	86.8	
20										98.7	94.0	89.5	
21											96.5	92.1	
22											98.9	94.5	
23												96.8	
24												98.9	

Note:

First and last sample points cannot be closer than <u>one inch</u> from the edge of the stack.

% of H_2O at Saturation

Temp. °F	% H_2O	Temp. °F	% H_2O	Temp. °F	% H_2O
50	1.2	**130**	15.1	**180**	51.1
60	1.7	**140**	19.7	**185**	57.0
70	2.5	**150**	25.3	**190**	63.6
80	3.5	**155**	28.7	**195**	70.8
90	4.8	**160**	32.3	**200**	78.6
100	6.5	**165**	36.4	**205**	87.0
110	8.7	**170**	40.8	**210**	96.2
120	11.5	**175**	45.7	**212**	100.0



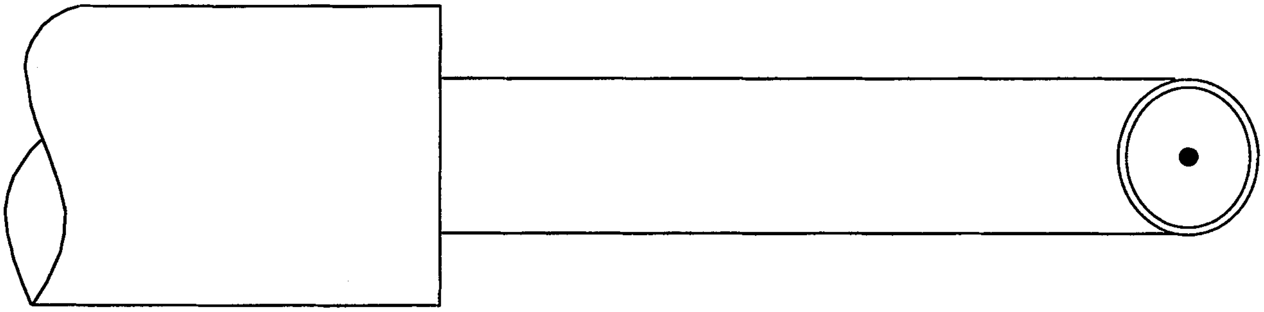
Nozzle Calibration

Date:________________ Calibrated by: ______________

Nozzle Identification Number	D_1 mm (in.)	D_2 mm (in.)	D_3 mm (in.)	ΔD mm (in.)	D_{avg}

Where:

$D_{1,2,3}$ = nozzle diameter measured on a different diameter mm (in.). Tolerance - measure within 0.25 mm (0.001 in.)
Δ = maximum difference in any two measurements mm (in.). Tolerance = 0.1 mm (0.004 in.).
D_{avg} = average of D_1 D_2 D_3



SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No.________

METER/PUMP SAMPLING SYSTEM CHECK

Pretest: Date: _________ Time: _______

Meter #______
Pump #______
Orifice #______

A-Orifice ΔH (in H_2O)	B - Metered Volume (ft^3)	C-Time (seconds)	K*
0.40			
0.75			
1.6			

Average________

Performed by_________________________
Senior_______________________________

Post Test: Date ________________ Time _________

A-Orifice ΔH (in H_2O)	B - Metered Volume (ft^3)	C-Time (seconds)	K*
0.40			
0.75			
1.6			

Average________

Performed by_________________________
Senior_______________________________

$$*K = \frac{60 \times B}{C \times \sqrt{A}}$$

*Maximum allowable difference in any two measurements of K is 0.02.

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

Test No.________ Date:__________
Sampling Location:____________________ Sample Train:_________

TRAVERSE SOURCES TEST DATA

Pre-Test Leak Check:
Filter ______cfm @ ______"Hg vac
Probe ______cfm @ ______"Hg vac
(Pitot Tube Leak Check __________)

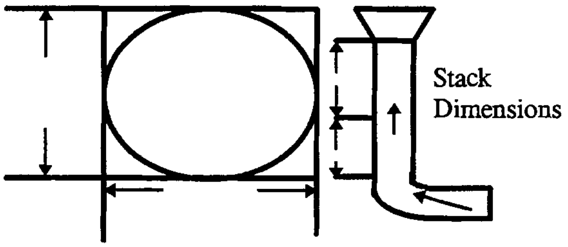
Post-Test Leak Check:
Filter ______cfm @ ______"Hg vac
Probe ______cfm @ ______"Hg vac
(Pitot Tube Leak Check __________)

Time		Sample Point	Gas Meter Reading (dcf)	Stack		Calculated			Probe temp ^{0}F	Filter temp ^{0}F	Meter Temp ^{0}F		Vacumm "Hg
On	Off			Velocity Head ("H_2O)	Temp ^{0}F	Velocity (fps)	Sampling Rate (cfm)	Orifice Δp ("H_2O)			in	out	
(Net Vol. Uncorr.)				Avg									

Nozzle #
Nozzle Diameter________mm (_______")
Barometric Pressure ______________ "Hg
Static Pressure in Stack................________________ "HgA (+/-_______"H_2O)

Recorded by ________________________________
Pitot Factor .__________________________

Calibration Data
Inclined Manometer________(Cal: N/A)
Magnehelic No.___________(Cal:___________)
Pitot Tube No.___________(Cal:___________)
Potentiometer No._________(Cal:___________)
Thermocouple No._________(Cal:___________)
Gas Meter No.____________(Cal:___________)
Meter Corr. Factor:



Type Sampling Probe____________________

APPENDIX B CALCULATION SHEETS

Use the following sheets (attached) in performing calculations.

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT TECHNICAL SERVICES DIVISION SOURCE TESTING AND MONITORING BRANCH	PAGES	PAGE
	TEST NO.	DATE
CALCULATION SHEET	PROCESSED BY	CHECKED BY

METHOD 5.1

LAB ANALYSIS

A. Probe Catch...______________mg
B. (1) Probe Acid...______________mg
(2) Probe Total Sulfate...______mg
C. Impinger Catch...______________mg
D. (1) Impinger Acid...______________mg
(2) Impinger Total Sulfate...______mg
E. Organic Extract...______________mg
F. Filter Catch...______________mg
G. (1) Filter Acid...______________mg
(2) Filter Total Sulfate...______________mg
H. $H_2SO_4 \cdot 2H_2O$ from SO_x Train Thimble.......................................______________mg
I. Particulate Train Corrected Gas Volume Metered.........................______________dscf
J. SO_x Train Corrected Gas Volume Metered.................................______________dscf

K. Prorated $H_2SO_4 \cdot 2H_2O$ Mass $\left(\frac{HxI}{J}\right)$.................................. ______________mg

L. Total Particulate (A-B* + C-D* +E+F-G* +K).................. ______________mg
M. Solid Particulate (L-E-K).. ______________mg

* USE LOWER OF (1) AND (2)

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT
SOURCE TEST CALCULATIONS

Test No. __________ Sampling Train: ______________ Date: _______
Calculated by: ______________ Checked by: ______________

Summary

A. Average Traverse Velocity..___________fps
B. Gas Meter Temperature (use 60^0F, for Temp. Comp. Meters)..................___________^{0}F
C. Gas Meter Correction Factor..___________
D. Average Stack Temp........__________^{0}F
E. Stack Cross-Sect. Area.....__________ft^2
F. Barometric Pressure.........__________"HgA
G. Gas Meter Pressure.........__________"HgA
H. Total Stack Pressure.........__________"HgA
I. Pitot Correction Factor.....__________
J. Sampling Time......................________min.
K. Nozzle Cross-Sect. Area.........________ft^2
L. Net Sample Collection...........________mg
M. Net Solid Collection...............________mg
N. Water Vapor Condensed.........________ml
O. Total Volume Sampled...........________dcf

P. Corrected Gas Volume Metered [(O x G/29.92) x $\frac{520}{(460+B)}$ x C].................______dscf

Percent Moisture/Gas Density

Q. Percent Water Vapor in Gas Sample [$\frac{4.64 \text{ x } N}{(0.0464 \text{ x } N)+P}$]..................................______%

R. Average Molecular Weight (Wet):

(Component)	(Volume %/100)	x (1 -Q/100)	x (Molec.Wt. =	(Wt./Mole))
Water		1.00	18.0	
Carbon Dioxide	Dry Basis		44.0	
Carbon Monoxide	Dry Basis		28.0	
Oxygen	Dry Basis		32.0	
Nitrogen/Inerts	Dry Basis		28.2	

Sum_______

Flow Rate

S. Gas Density Correction Factor ($\sqrt{28.95/R}$)..____________
T. Velocity Pressure Correction Factor ($\sqrt{29.92/H}$)......................................____________
U. Corrected Velocity (A x I x S x T)...____________fps
V. Flow Rate (U x E x 60)...____________cfm
W. Flow Rate [V x $\frac{H}{29.92}$ x $\frac{520}{(460+D)}$]..____________scfm
AA. Flow Rate [W x (1- Q/100)]..____________dscfm

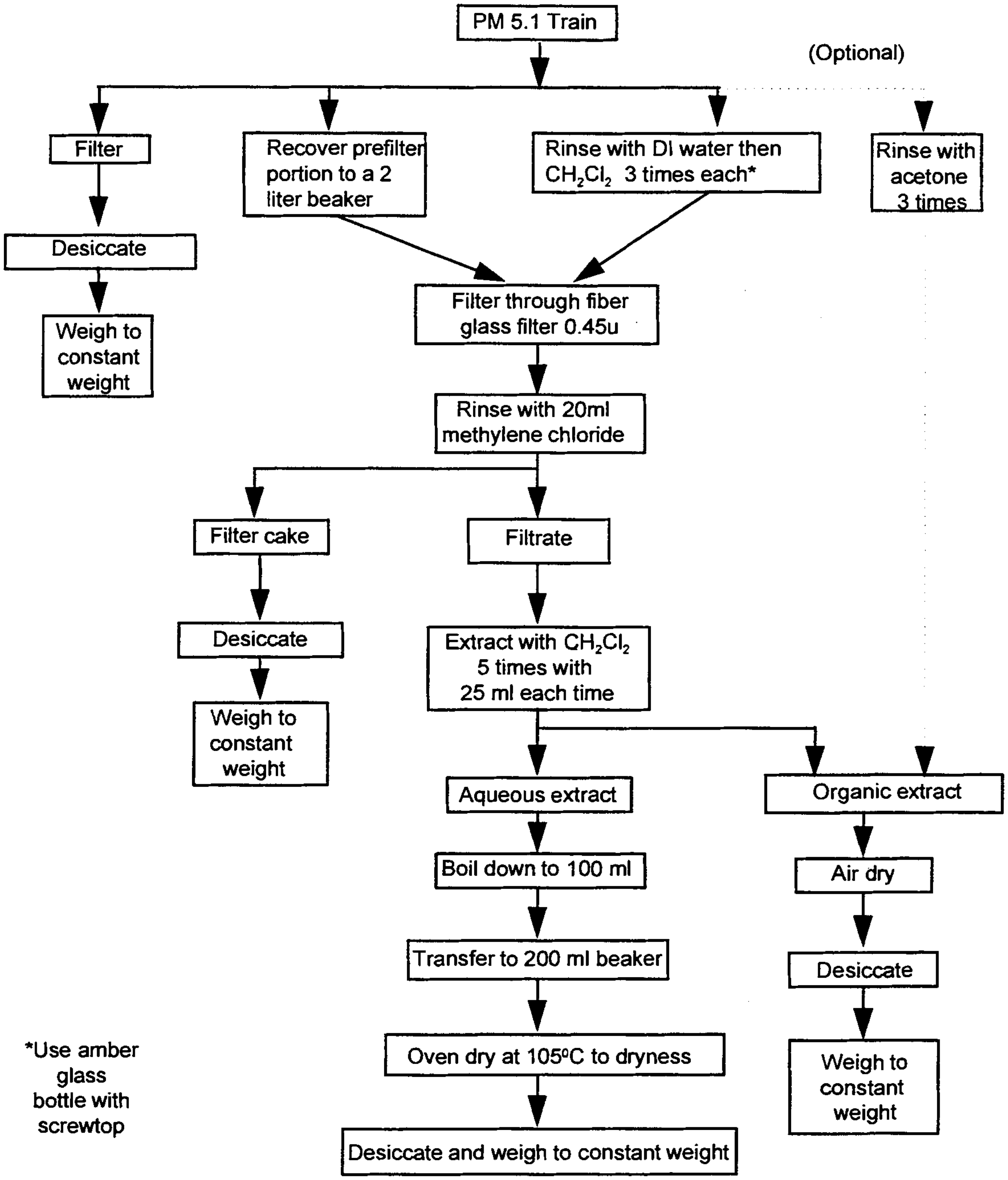
Sample Concentration/Emission Rate

BB. Sample Concentration (0.01543 x L/P)...____________gr/dscf
CC. Sample Concentration (54,143 x BB/___ Molec. Wt.).....................................____________ppm(dry)
DD. Sample Emission Rate (0.00857 x AA x BB)..____________lb/hr
EE. Solid Emission Rate ($\frac{0.0001322 \text{ x } M \text{ x } AA}{P}$)..____________lb/hr
FF. Percent Isokinetic ($\frac{E \text{ x } P \text{ x } 100}{J \text{ x } K \text{ x } AA}$)..____________

APPENDIX C MODIFIED METHOD 5.1 ANALYTICAL PROCEDURE

Attached is a flowchart detailing the recovery and analytical procedure for the analysis of the modified method 5.1 train used for charbroiler emissions sampling.

Charbroiler Recovery and Analytical Procedure Flowchart



*Use amber glass bottle with screwtop

APPENDIX D VOC METHOD

INSTRUMENTAL ANALYZER PROCEDURES FOR VOLATILE ORGANIC COMPOUND (VOC) EMISSION SAMPLING FROM COOKING EMISSIONS

1.0 Overview

1.1 Principle

A representative sample of an exhaust gas stream is continuously extracted, conditioned, and conveyed to instrumental analyzers for the determination of VOC emissions from cooking processes. A sample conditioner removes liquid condensate from the sample stream, so that particulate matter may be condensed, and "double counting" of particulates with VOC may be avoided. A Flame Ionization Detector (FID) is used to continuously determine the VOC concentration in the sample gas stream. Simultaneous samples are also collected to determine the quantity of methane, aldehydes, and ketones. The final averaged VOC concentration is then corrected to subtract methane, and remove any response factor bias attributed to aldehydes and ketones.

Other systems may be used to measure VOC if they meet the specifications of this method and have been subjected to a relative accuracy test to determine equivalence.

Performance specifications and test procedures are provided to ensure reliable data. Typical analyzer specifications are shown in Table 1.

1.2 Applicability

This method measures emissions of VOC from cooking processes flowing in ducts. Repeatability of the method has been demonstrated for Standardized Test Kitchens[1]. The method has yet to be field validated at commercial kitchens.

---

[1] 12 % coefficient of variation for a chain-driven charbroiler cooking hamburger patties. See "Further Development of Emission Test Methods and Development of Emission Factors for Various Commercial Cooking Operations," July 24, 1997.

2.0 Definitions

2.1 Measurement System

Equipment required to determine sample gas concentration consists of three major sub-systems:

Sample Interface - The portion of the system used for sample acquisition, sample transport, sample conditioning, and protection of the analyzers from the effects of the stack effluent.

Gas Analyzer - The portion of the system that identifies the gas component and generates an output proportional to its concentration.

Data Acquisition - An analog computer and printer for recording measurement data from the analyzer output.

2.2 Analyzer Calibration Error

The difference between the known concentration of the calibration gas and the gas concentration exhibited by the gas analyzer when the calibration gas is introduced directly to the analyzer.

2.3 Sampling System Bias

The difference between the gas concentrations exhibited by the measurement system when calibration gas is introduced at the sampling probe tip and when the same calibration gas is introduced directly to the analyzer.

2.4 Zero Drift

The difference in the measurement system responses at a zero concentration level during the initial calibration, and final calibration check after a test. During this test there should be no unscheduled maintenance, repair, or adjustment of the measurement system.

2.5 Calibration Drift

The difference in the measurement system responses at a mid-range or high-range concentration level during the initial calibration, and final calibration check after a test. During this test there should be no unscheduled maintenance, repair, or adjustment of the measurement system.

2.6 Response Time

The time required for the system to display 95 percent of a step change in gas concentration on the data recorder.

2.7 Interference Response

The output response of the measurement system to a component in the sample gas, other than the gas component being measured.

2.8 Calibration Curve

A graph or other systematic method of establishing the relationship between the analyzer response and the actual calibration gas concentration introduced to the analyzer.

2.9 Linearity

Maximum deviation as a percent of range, between a mid-range calibration reading and the reading predicted by a straight line drawn between high-range and zero gas calibration points.

3.0 FID Analyzer Requirements

3.1 Measurement System Performance Specifications

VOC shall be measured and reported in units of parts per million (ppm) as CH_2.

3.1.1 Analyzer Calibration Error

Less than ± 3 percent of the high span gas concentration for the zero, mid-range, and high range calibration gases.

3.1.2 Sampling System Bias

Less than ± 5 percent of the span range for the zero, and the mid-range or high-range calibration gases.

3.1.3 Zero Drift

Less than ± 3 percent of the span range over the period of each run.

3.1.4 Calibration Drift

Less than ± 3 percent of the span range over the period of each run.

3.1.6 Linearity

Less than ± 3 percent of the span range.

3.2 Apparatus and Measurement System

A schematic of an acceptable measurement system is shown in Figure 1. The essential components of the measurement system are described below.

3.2.1 Probe

Use quartz, borosilicate glass, or stainless steel tubing of approximately 1/4 inch diameter or larger. Use a heated probe if condensation occurs.

3.2.2 Sample Line

Use Teflon or stainless steel tubing to transport the sample gas to the moisture removal system. The sampling line should be heated to prevent condensation. It is not necessary to heat the sample transport line downstream of the moisture removal trap. A sample line made from another material may be used if the material does not absorb, adsorb, evolve, or alter the pollutants being monitored.

3.2.3 Sample Conditioning

a. The sample conditioner shall reduce the sample temperature to 60°F and remove liquid condensate from the sample stream.
b. All parts exposed to the sample should be glass, stainless steel, or Teflon.

3.2.4 Sample Transport Lines

Use Teflon or stainless steel lines to transport the sample from the moisture removal system to the sample pump, sample flow rate control, and sample gas manifold.

3.2.5 Impingers

The impingers shall be prepared and assembled similarly to the Rule 1138 protocol particulate train except for the final impinger. The silica gel containing impinger shall be excluded from the conditioning train.

3.2.6 Particulate Filter

A 0.45 micron glass fiber filter, without organic binder, shall be used. The filters shall comply with the requirements in Paragraph 2.2 of District Method 5.1 for a 0.45 micron filter. The filter should be fabricated of materials that are nonreactive to the gas being sampled.

3.2.7 Sample Pump

Use a leak-free pump to pull the sample gas through the system at a flow rate sufficient to minimize the response time of the measurement system. The pump may be constructed of any material that is nonreactive to the gas being sampled.

3.2.8 Sample Flow Rate Control

Use a control valve and rotameter to maintain a sampling rate constant within 10 percent.

The tester may elect to install a back pressure regulator to maintain the sample gas manifold at a constant pressure in order to protect the analyzers from over pressurization or the need for flow rate adjustments.

3.2.9 Sample Gas Manifold

Use a sample gas manifold to divert a portion of the sample gas stream to the analyzer, and the remainder to the aldehyde and ketone (DNPH) sampling. The manifold may be constructed of any material that is nonreactive to the gas being sampled.

3.2.10 Data Recorder

Use an analog computer or digital recorder for recording measurement data. The data recorder resolution, or readability should be 0.5 percent of range. Sampling measurements should be obtained at a minimum of 5 second intervals.

3.2.11 Vacuum Gauge

Use a 30 in. Hg gauge for leak checking the sampling system.

3.2.12 FID Analyzer

An FID analyzer shall be used to measure uncorrected VOC emissions. A summary of typical specifications is shown in Table I (see Appendix).

3.3 Calibration Gases

Calibration gases shall be certified according to EPA Traceability Protocol Number 1. The calibration gas for VOC shall be methane. The balance gas shall be air, unless methane levels approach explosive limits.

3.3.1 High-Range Gas

The choice of the high range gas is dependent on the selection of the analytical range (see Paragraph 3.4.1) The high range gas concentration shall be between 80 to 100 ppm for VOC emissions less than 100 ppm, or shall be selected such that the VOC emission concentrations will be greater than 20% and less than 95% of the high span calibration gas value.

3.3.2 Mid-Range Gas

The concentration should be equivalent to 40 to 60 percent of the appropriate high range gas value.

3.3.3 Zero Air

The impurity concentration should be less than 0.25% of the full-scale range. Purified ambient air may be used for the zero gas by passing compressed air through a heatless dryer, a catalytic oxidizer, and a carbon dioxide scrubber.

3.4 FID Performance Test Procedures

Perform the following procedures before measurement of emissions.

3.4.1 Analytical Range

The analytical range is selected as follows for range settings of 100 ppm, 1000 ppm, and 10,000 ppm:

a) For VOC concentrations less than, or equal to 100 ppm, the sample gas concentrations shall be measured using the 100 ppm range. Concentrations shall be between 20 and 100 percent of the range (or equivalently, between 20 ppm and 100 ppm), for 95 percent of the test period. The run is considered invalid if the measured gas concentration exceeds the range during the test period. Data obtained below 20 percent of the range can be used only for qualitative purpose;

b) For VOC concentrations greater than 100 ppm, the sample concentrations shall be measured using the next highest analytical range. A high span calibration gas shall be selected such that the emission concentrations will be greater than 20% and less than 95% of the high span calibration gas value. The run is considered invalid if the measured gas concentration exceeds the range during the test period. Data obtained below 20 percent of the range can be used only for qualitative purpose.

3.4.2 Sampling System Preparation

Allow the analyzer to warm up according to manufacturer's instructions. A leak check of the sampling system is a good practice. However, it is optional.

Assemble the sample train as shown in Figure 1. Leak check the vacuum side of the assembly to a minimum of 20 inches of Hg (gauge). The sampling system should hold 20 inches of Hg vacuum for 5 minutes with less than 1 in. Hg loss. Correct any leaks found and repeat the leak check until a satisfactory result is obtained. Check the pressure side of the system with liquid soap solution and correct any leaks. Alternative leak check methods are acceptable if equivalent or better than the specified method.

Introduce zero and high range calibration gases directly to the instrument and make all necessary adjustments to calibrate the analyzer and the data recording system. Adjust system components to achieve the analyzer sampling rate recommended by the instrument manufacturer.

3.4.3 Analyzer Calibration Error

Conduct the analyzer calibration error check at the beginning and end of each test run by introducing calibration gases to the measurement system at any point upstream of the gas analyzer as follows:

> After the measurement system has been prepared for use, introduce the zero, mid-range, and high-range gases to the analyzer. During this check, make no adjustments to the system except those necessary to achieve the correct calibration gas flow rate at the analyzer. Record the analyzer responses to each calibration gas on a form similar to Figure 100.1-4 of District Method 100.1.

The calibration error check should be considered invalid if the gas concentration displayed by the analyzer exceeds ± 3 percent of the high span gas. If an invalid calibration is exhibited, take corrective action and repeat the analyzer calibration error check until acceptable performance is achieved.

3.4.5 Instrument Response Time

Establish instrument response time daily.

3.4.6 Sampling System Bias Check

A bias check of the sampling system is mandatory.

A zero gas and either the mid-range or high-range gas, whichever most closely approximates the effluent concentrations, should be used for this check as follows:

a. Introduce the upscale calibration gas and record the gas concentration displayed by the analyzer on a form similar to Figure

100.1-5 of District Method 100.1. Introduce the zero gas and record the gas concentration displayed by the analyzer. During the sampling system bias check operate the system at the normal sampling rate and make no adjustments to the measurement system other than those necessary to achieve manufacturer recommended calibration gas flow rates at the analyzer.

b. The sampling system bias check shall be considered invalid if the difference between the gas concentrations exhibited by the measurement system when a known concentration gas is introduced at the sampling probe tip and when the same gas is introduced directly to the analyzer, exceeds ± 5 percent of the analyzer range. If an invalid calibration is exhibited, take corrective action and repeat the sampling system bias check until acceptable performance is achieved.

If adjustment to the analyzer is required, first repeat the analyzer calibration error check, then repeat the sampling system bias check.

4.0 Aldehyde/ Ketone and Methane Sampling Requirements

4.1 Aldehyde/ Ketone Sampling Train

The DNPH Cartridge shall prepared in accordance with the EPA Compendium Method T0-11 (Determination of Formaldehyde in Ambient Air Using Adsorbant Cartridge Followed by High Performance Liquid Chromatography, dated June 1988). The gas meter shall be calibrated per Chapter III of the District Source Test Manual. Connecting tubing shall comprise of materials unreactive to the sampling gases.

4.2 Methane Sampling System

Methane sampling may be performed using one of the following methods:

a. methane shall be collected into an evacuated 9 liter nominal stainless steel canister (as specified in District Method 25.1). The gaseous sample shall be drawn into the canister at a constant rate. The condensate trap may be eliminated.

b. The methane sample shall be pumped into a 10 liter (minimum) Tedlar Bag. All seams shall be heat-sealed.

c. A second FID analyzer with an activated carbon filter may be used to continuously monitor methane.

5.0 Test Procedure

5.1 Set-up

The duct should be traversed to determine if there is stratification (see Chapter X of the District Source Test Manual). Determine moisture content and velocity pressures in the stack gas according to SCAQMD Methods 1.1, 2.1 and 4.1 if required for mass flow rate calculations. As an alternate method, the mass flow rate may be obtained by stoichiometric and gas composition relations. For processes with high dilution, the oxygen content may be considered to be 20.9%.

Assemble Aldehyde/ Ketone sampling train as shown in Figure 1 by placing the DNPH Cartridges in series. The tester shall determine the number of DNPH cartridges required to prevent break-through by performing a trial run. To date, experience has shown that three cartridges in series was adequate to prevent break-though.

A separate system shall be assembled for methane sampling.

The inlet probes shall be placed at the center of the duct.

5.2 Data Acquisition

Turn on the data acquisition system and label as to source, range, calibration cylinder ID number, certified expiration date, zero and upper range calibration settings, sample measurement rate, date, time, person operating instruments, and other pertinent data.

5.3 Sampling Time

A minimum sample time of 60 minutes is required. It is recommended however, that VOC sampling period be extended throughout the entire sampling period for particulate matter.

5.4 Zero and Calibration Drift Tests

Immediately preceding and following each run, or if adjustments are necessary for the measurement system during the run, repeat the sampling system bias check procedure. (Make no adjustments to the measurement system until after the drift checks are completed.) Record the analyzer's responses on a form similar to Figure 100.1-5 of District Method 100.1.

If either the zero or upscale calibration value exceeds the sampling system bias specification, then the run is considered invalid. Repeat both the analyzer calibration error check procedure and the sampling system bias check procedure before repeating the run.

Confirm that both the zero and upscale calibration values are within the sampling system bias specification. If the zero or upscale calibration drift value exceeds the drift limits, based on the difference between the sampling system bias check responses immediately before and after the run, repeat both the analyzer calibration error check procedure and the sampling system bias check procedure before conducting additional runs.

5.5 Sampling Rate

VOC sampling shall be at a rate to support the requirements of both the FID analyzer and the Aldehyde/ Ketone sampling systems. The Aldehyde/ Ketone sampling shall proceed at 1 cfm. The initial and final volumes of the Aldehyde/ Ketone gas meter shall be recorded. In addition, the gas meter temperature shall be recorded if the meter is not temperature compensated.

If methane is collected into a container, sampling shall be adjusted according to the volume of the stainless steel canister or Tedlar bag. If methane is measured continuously using an FID, the sampling rate shall be per manufacturer's instructions.

6.0 Aldehyde/ Ketone Determination

6.1 DNPH Analysis

The procedures in Compendium Method T0-11 (Determination of Formaldehyde in Ambient Air Using Adsorbant Cartridge Followed by High Performance Liquid Chromatography, dated May 1988) shall be followed to quantify aldehydes and ketones. Note that Section 14 of the Compendium Method discusses the detection of carbonyl containing compounds other than formaldehyde.

7.0 Calculations and Reporting

7.1 Emission Calculation

Determine the average VOC effluent concentration from the average gas concentration displayed by the gas analyzer. The average gas concentration displayed by the analyzer may be determined by averaging all of the effluent measurements. Sampling measurements should be obtained at a minimum of 5 second intervals. Calculate the effluent gas concentration by subtracting the methane concentration from the average VOC concentration, and adjusting for the aldehyde and ketone bias.

The unbiased aldehyde concentration is calculated by determining the biased parts per million concentration of aldehydes as CH_2, and dividing that number by 0.7425. Add the unbiased result to the VOC average, and subtract the biased aldehyde concentration.

The unbiased ketone concentration is calculated similarly. Use a correction factor of 0.49 for acetone, and 0.61 for 2-butanone.

Report the revised VOC concentrations in units of parts per million. The mass emission rate is calculated from the following relation:

$$\text{VOC Emission (lbs/hr)} = 1.583 \times 10^{-7} \text{ (Exhaust Flow dscfm)(VOC ppm)(14)}$$

An emission factor in units of pounds of VOC per 1000 pounds of cooked product may be calculated by:

$$\frac{\text{lbs ROG}}{\text{1000 lbs product}} = \frac{\text{ROG Emissions (lbs / hr)}}{\text{Product Cooking Rate (lbs / hr)}} \times 1000$$

Appendix

Tables and Figures

Table I
Typical Analyzer Specifications*

Analytical Method	Flame Ionization Detection
Measurement Ranges	0 - 100 ppm 0 - 1000 ppm 0 - 10,000 ppm
Sensitivity	1 ppm
Operating Temperatures	40 - 100 deg F.
Zero Drift	± 0.5% Full Scale
Fuel Consumption (H_2)	30 cc/min
Combustion Air	300 cc/min
Sample Flow Rate	7 liters/min

* Specifications based on the Ratfisch Instruments RS 55 oven heated analyzer

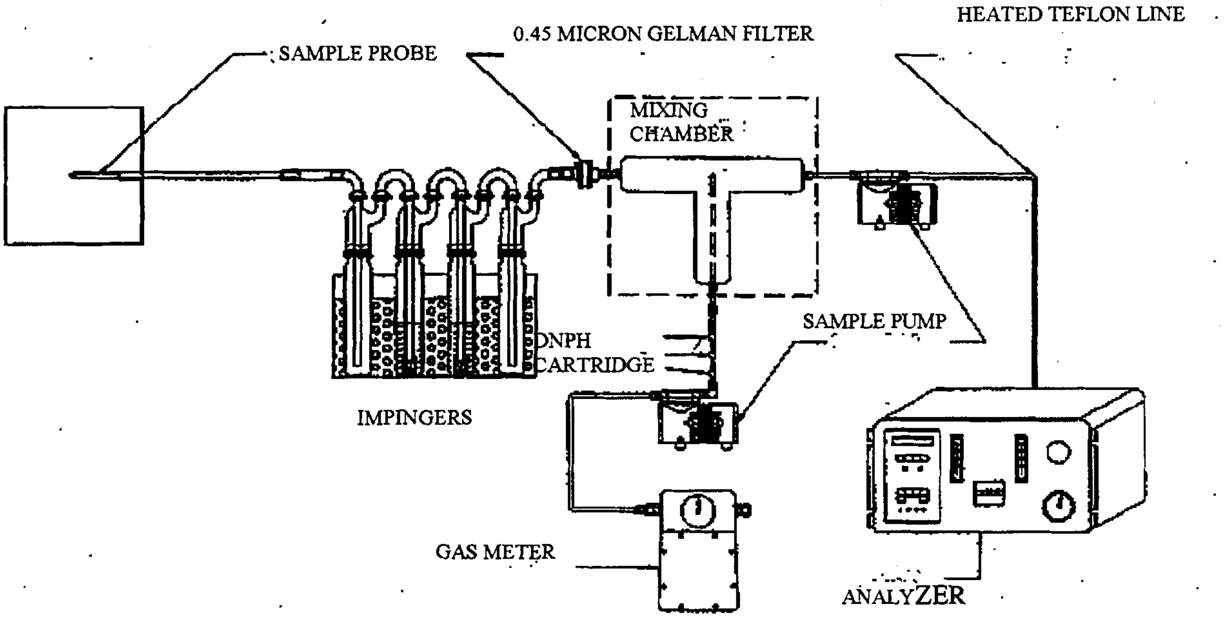


Figure 1

VOC Sampling System

APPENDIX E

SOUTH COAST AIR QUALITY MANAGEMENT DISTRICT

PROTOCOL

TEST PROTOCOL FOR DETERMINING PARTICULATE AND VOLATILE ORGANIC COMPOUND EMISSIONS FROM CHAIN-DRIVEN CHARBROILERS

NOVEMBER 14, 1997

SOURCE TESTING AND ENGINEERING BRANCH

APPLIED SCIENCE AND TECHNOLOGY

TABLE OF CONTENTS

TABLE OF CONTENTS - Continued

TABLE OF CONTENTS - Continued

FIGURES

ATTACHMENT

1.0 OVERVIEW AND APPLICABILITY

The South Coast Air Quality Management District (AQMD) proposed Rule 1138 to fulfill requirements of Control Measure PRC-03 (Control of Emissions from Restaurant Operations) of the 1997 Air Quality Management Plan. This rule seeks to limit particulate matter (PM) and volatile organic compounds (VOC) from chain-driven charbroilers. Restaurants which cook greater than 875 pounds of meat per week will be required to install a control device which has been found to be as or more effective than a catalytic oxidizer (83%) in reducing both PM and VOC emissions.

This protocol has been developed to support Rule 1138 and to ensure standardization of compliance certification test procedures including the use of: specified test conditions, required test methods, specifications for test equipment, data collection/reporting, and quality assurance requirements.

An independent testing laboratory, approved by the South Coast Air Quality Management District, shall conduct the testing and prepare a report of findings, including all raw data sheets/charts and laboratory analytical data. This report and a request for product certification must be submitted to the Executive Officer. The testing must demonstrate to the satisfaction of the Executive Officer that emission reductions from the installation of a control on a chain driven charbroiler meets the requirements of Rule 1138 before product compliance certification is granted. Any control device for a chain-driven charbroiler must achieve greater than or equal to 83 percent reduction in both PM and VOC emissions.

When the cooking parameters do not fall within the testing guidelines of this protocol, the protocol may be modified following an equivalency determination and written approval of the Executive Officer.

2.0 DEFINITIONS

For purposes of this test protocol, the following definitions shall apply:

2.1 CATALYTIC OXIDIZER

A control device which burns or oxidizes smoke and gases from the cooking process to carbon dioxide and water, using an infrastructure coated with a noble metal.

2.2 CHAIN-DRIVEN CHARBROILER

A semi-enclosed cooking device with a mechanical chain which automatically moves food through the device and consists of three main components: a grill, a high temperature radiant surface, and a heat source.

2.3 INDEPENDENT TESTING LABORATORY

A testing laboratory that meets the requirements of South Coast Air Quality Management District's Rule 304, Paragraph (K), and is approved by the SCAQMD to conduct testing under this protocol.

2.4 MEAT

For purposes of Rule 1138, meat includes beef, lamb, pork, poultry, fish, and seafood.

2.5 STANDARD CONDITIONS

A gas temperature of 60°F and a gas pressure of 760 mm Hg (14.7 pounds per square inch) absolute.

3.0 TEST KITCHEN AND INSTRUMENTATION

3.1 TEST KITCHEN DETAILS

3.1.1 General Chamber Features

A test chamber equipped with natural gas, electricity, ventilation and fire suppression utilities shall be used to conduct the testing program. The dimensions of the chamber are 25 feet x 25 feet x 10 feet. Exhaust ventilation is provided by a hood that is ducted to a centrifugal-type upblast blower located on the roof of the chamber. Make-up air is supplied by an evaporative cooler and blower through four penetrations and eight diffuser panels in the test chamber ceiling. Access to the sampling locations shall be provided by a stairway outside of the chamber. A schematic of the chamber is shown in Figure 1.

3.1.2 Natural Gas Supply

Natural gas shall be provided by piping inside the chamber, and shall have a higher heating value of 1020 ± 25 Btu per standard cubic foot.

3.1.3 Hood and Duct System

Emissions generated during the cooking process shall be captured by a 4 feet x 4 feet Captive-Aire (or equivalent) stainless steel wall canopy hood. The bottom face of the hood shall be positioned 6 feet, 6 inches above the floor. Emissions captured by the hood are drawn horizontally through a 12 inch x 12 inch duct across the roof of the test chamber to the upblast blower. The exhaust blower, equipped with a variable speed drive and controller, shall be adjustable for precise setting of the exhaust flow rate. Emissions samples are drawn from the horizontal section of the duct through access ports.

3.1.4 Sampling Ports

The access ports shall be located 8 feet ± 0.5 feet (8 duct diameters) downstream from a flow disturbance, and 2 feet ± 0.5 feet (2 duct diameters) upstream of the VOC sampling ports. The VOC ports shall be located a minimum of 2 feet (2 duct diameters) upstream from a flow disturbance. The ducting configuration is shown in Figure 2.

3.1.5 Data Acquisition/ Recording System

A computer or digital recorder may be used for recording measurement data. Sampling measurements shall be capable of recording at a minimum of 5 second intervals.

3.2 INSTRUMENTATION

3.2.1 Calibrations

All instrumentation within this section and pertaining to this protocol shall be calibrated as a minimum within the requirements set forth in SCAQMD Source Test Methods Chapter III, Calibrations.

3.2.2 Pressure Measurements

Pressure measurement instruments shall have an error no greater than the following values:

Measurement	Accuracy	Precision
Gas Pressure	± 0.1" of water column	± 0.05" of water column
Atmospheric Pressure	± 0.1" of Hg column	± 0.05" of Hg column

3.2.3 Temperature Measurements

Temperature measuring instruments shall have an error no greater than the following values:

Measurement	Accuracy	Precision
Ambient Temperature	± 0.5° F	± 0.25° F
Meat Temperature	± 0.2° F	± 0.1° F

3.2.4 Barometric Pressure

Use a mercury, aneroid, or other barometer capable of measuring atmospheric pressure to within 0.1 in. Hg.

3.2.5 Dry Gas Meter

The quantity of fuel used by the charbroiler shall be measured in cubic feet with dry gas meter and associated readout device that is accurate within ± 1% of the reading. The dry gas meter reading shall be corrected for gas pressure and temperature.

3.2.6 Mass Measurements

The weighing capacity of the scale shall be 6100 g, and be within a ± 0.3 g reproducibility. Mass measurements shall also be accurate to within ± 1% of measurement.

3.2.7 Time Measurements

The elapsed time measurement shall be measured with an instrument that is accurate within ± 0.5 seconds per hour.

3.2.8 Calorimeter

Heating value of the fuel must be measured. The repeatability of the measurement device shall be ± 1% of full scale, and the precision of the device shall be ± 2 Btu/dscf. Calibration shall be conducted weekly using the device manufacturer's directions.

Alternately, heating value may be calculated based on gas speciation of the fuel. Refer to ASTM Method D 1945, "Standard Method for Analysis of Natural Gas by Gas Chromatography" and D 3588, "Standard Practice for Calculating Heat Value, Compressibility Factor, and Relative Density of Gaseous Fuels."

4.0 ENVIRONMENTAL CRITERIA

4.1 Ambient Temperature

Testing shall be conducted indoors with the ambient air temperature of the test room maintained between 65°F and 85°F at all times during the test. The ambient temperature shall be monitored and recorded before and after the test.

4.2 Relative Humidity

The relative humidity shall be between 20% and 65% during the test. It shall be recorded before and after the test.

4.3 Barometric Pressure

The barometric pressure shall be monitored and recorded before and after each test.

4.4 Static Pressure

The static pressure in the test chamber shall be recorded before and after each test.

4.5 Background VOC Concentration

Background VOC readings in the test duct shall be recorded prior to and following each test. These readings are for quality assurance purposes however, and shall not be used to subtract from VOC measurements recorded during the test.

5.0 PRE-TEST PREPARATIONS

5.1 Test Kitchen

5.1.1 Grease Baffles

The grease baffles shall be cleaned with detergent and water prior to testing. The baffles need not be cleaned within a set of test runs, unless the cooking operations are impaired by grease build-up.

5.1.2 Ducting

For test kitchens which have never performed certification testing, a cyclonic flow and stratification check is required. The absence of cyclonic flow shall be verified by Paragraph 2.4 of District Method 1.1; gas stratification shall be checked using the procedure in Chapter X, Section 13, in the District Source Test Manual.

5.2 Charbroiler

5.2.1 Positioning

The chain-driven charbroiler shall be positioned under the hood such that the perimeter of the hood overlaps the outer edge of the charbroiler on the front and sides by at least 6 inches. In addition, both sides of the appliance shall be a minimum of 3 feet from any side wall, side partition, or other operating appliance. The vertical distance between the hood and the top of the charbroiler shall be per manufacturer specifications. It is recommended that preliminary testing be conducted to visually confirm that particulates emitted from the charbroiler are captured by the hood.

5.2.2 Firing Rate

The firing rate shall be set to operate within 5% of the manufacturer's specified input rate. Additionally, the burners shall be adjusted to within 2.5% of the specified operating pressure.

5.2.3 Broiler Controls

The broiler controls, including the conveyor speed and the thermostat, shall be set according to the manufacturer's specifications.

5.2.4 Fuel Consumption

Install one or more instruments to measure the quantity of natural gas consumed in accordance with Section 3.2.5 of this protocol.

5.2.5 Control Device

The control device shall be installed such that the hood positioning requirements of Section 5.2.1 are satisfied. The vertical distance between the hood and control device shall be per manufacturer's specifications.

5.2.6 Cleaning

Prior to conducting a test set, the charbroiler unit shall be cleaned according to manufacturer's instructions.

5.3 Meat

5.3.1 Meat Specifications

The nominal specifications of the hamburger meat shall be quarter-pound, finished grind, pure beef patties, 21% fat by weight, 58-62% moisture, 3/8 inch thick, and 5 inches in diameter. The fat and moisture content shall be analyzed in accordance with recognized laboratory procedures (AOAC Official Actions 960.39 and 950.46, respectively). One patty per test run shall be randomly selected for these analyses. A set of three test runs, for example, would require three patties be reserved for fat and moisture content analyses.

Depending on the test objectives, alternative meat specifications such as meat type, fat content, etc. may be tested following written approval of the Executive Officer.

5.3.2 Storage

Sheet pans shall be loaded with 24 patties (6 patties per level by 4 levels), separating each level by a double sheet of waxed freezer paper. Store the patties in a freezer maintained at approximately -5°F. The pans shall be stacked with approximately 1/4 inch spacers between each pan to allow air flow. The freezer temperature shall be continuously monitored with a thermocouple placed in the freezer to ensure the pre-cooked condition of the meat.

5.4 Internal Meat Temperature

5.4.1 Charbroiler Settings

The charbroiler chain speed shall be adjusted to a targeted internal meat temperature of 165°F for hamburger patties. Other internal meat temperatures may be acceptable based on food type or cooking procedure, following written approval of the Executive Officer.

5.4.2 Patty Temperature Measurement

The internal meat temperature shall be determined with a stack of six to eight hamburger patties placed in a temperature measurement system. The system consists of an insulated container with a thermocouple bundle attached to the lid (see Figure 3). One thermocouple is located in the center, and the remaining four are arranged in a square pattern at a radial distance of 1 inch from the center. The dimensions tabulated below apply to Figure 3:

Item	Dimension
Outer Casing Diameter	8"
Inner Casing Diameter	4.75"
Center Thermocouple Length (Below Top Plug)	2.25"
Radial Thermocouple Lengths (Below Top Plug)	1.25", 1.5", 1.75", 2.5"
Depth of Inner Casing	6.5" *
Top Insulation Plug	1"
Bottom Plug Thickness	Varies **

* Includes the thicknesses of the top and bottom plugs

** Varies depending on the thickness of the hamburger patties. For 3/8 inch thick patties, the plug thickness was 2.25 inches.

Patties shall be inserted into the temperature measurement system immediately after removal from the charbroiler.

5.4.3 Correlation Procedures

Research conducted by Pacific Gas & Electric Company (PG&E Standard Test Method for the Performance of Underfired Broilers, 1995) has determined that the final internal temperature of cooked hamburger patties may be measured by the percent weight loss incurred during cooking. For hamburger patties specified in Section 5.3.1 of this protocol, an internal meat temperature of 165°F corresponds to a weight loss of approximately 32%.

Weight loss measurements are determined as follows: measure the weight of a full pan (24 patties) prior to cooking. Subtract the weight of the pan to determine the initial weight of the patties. Once the patties have traversed the charbroiler, use tongs to spread the patties on a drip rack. After one minute, the patties are turned.

After the second minute, transfer the patties to a clean, tared pan for weighing. Weight loss shall be determined on a full pan (24 patties) basis.

For meats other than the hamburger patties specified in Section 5.3.1, a correlation shall be developed using a minimum of three temperatures. These temperatures shall bracket the targeted meat temperature.

5.4.4 Conveyor Speed

Operate the charbroiler as described in Section 6 of this protocol. Patties shall be loaded two at a time at 30 second intervals. The internal meat temperature shall be verified by the correlation method in Section 5.4.3. Adjust the conveyor speed to achieve a 32% weight loss.

6.0 TEST PROCEDURE

6.1 Test Runs

A minimum of three test runs shall comprise a test set. One test set shall be conducted without a control device, another test set shall be conducted with the control device installed. It is recommended that a test set be conducted within a span of one week.

Note that the minimum required runs are assumed for chain-driven charbroilers cooking meat with the specifications in Section 5.3.1, using a catalytic oxidizer as the control. Additional test runs may be necessary for other meats or control devices based on the variability of the cooking process.

6.2 Sampling Set-Up And Calibration

6.2.1 Air Flow Rate

The velocity in the duct shall be set at 1600 fpm (with the charbroiler on). This velocity corresponds to a hood flow rate of 400 cfm for each linear foot of hood length.

6.2.2 Particulate Matter

The particulate matter sampling train and connecting equipment shall be prepared, calibrated, and checked in accordance with the protocol: "Determination of Particulate and Volatile Organic Compound Emissions From Restaurant Operations" (Sampling Protocol). Refer to the Sampling Protocol for Quality Assurance/ Quality Control Requirements.

6.2.3 Gas Sampling

The sampling systems and connecting equipment for VOC, oxygen, carbon monoxide, carbon dioxide, and methane measurement shall be prepared, calibrated, and checked in accordance with the Sampling Protocol. Refer to the Sampling Protocol for Quality Assurance/ Quality Control Requirements.

6.3 Charbroiler Set-Up

6.3.1 Warm-Up Period

The charbroiler unit shall be operated for a minimum of one hour. VOC shall be monitored for background readings during the final 15 minutes of the warm-up period. As noted in Section 4.5, these readings are for quality assurance purposes, and shall not be used to subtract from VOC measurements recorded during the test.

6.3.2 Power Input

During the warm-up period, the flow meter shall be monitored to verify that the firing rate is within the requirements of Section 5.2.2 of this protocol.

6.4 Test Procedure

The conveyor speed shall be set to achieve the target weight loss, per Section 5.4.4 of this protocol. Prior to PM and VOC sampling, patties shall be loaded two at a time at 30 second intervals for at least 10 minutes.

Immediately following the 10 minute conditioning period, begin sampling for PM and VOC using the Sampling Protocol. The patties shall continue to be loaded two at a time at 30 second intervals. Sampling times shall be as follows:

Particulate Matter	72 minutes;
VOC	60 minutes; and,
CO, CO_2, O_2, methane	60 minutes.

The weight loss shall be verified every third tray using the procedures described in Section 5.4.3.

One cooked patty from each run shall be reserved for moisture analysis. If moisture analysis is not immediately conducted, place the cooked patties inside self-sealing plastic bags and store in a freezer maintained at -5°F.

6.5 Post-Test Calibration And Analysis

6.5.1 Particulate Matter And Gaseous Emissions

Post test calibration checks and leak checks shall be conducted in accordance with the Sampling Protocol. Follow procedures referenced in the Sampling Protocol to analyze for PM, the corrected concentration for VOC, carbon monoxide, carbon dioxide, oxygen, and methane.

6.5.2 Fat/Moisture Content In Patties

Fat and moisture content of the patties shall be analyzed according to procedures specified in Section 5.3.1 of this protocol. The fat content shall be determined for the uncooked patties only. Identify the cooked and uncooked samples so that moisture loss may be calculated.

6.5.3 Average Weight Loss

The average weight loss for the test run shall be 32% ± 5%. Repeat the test run if the average weight loss is outside this range.

7.0 CALCULATIONS/ REPORTING

PM and VOC calculations shall be in accordance with the Sampling Protocol, except the Pounds Per Day calculation, (Section 5.3 of the Sampling Protocol) shall be excluded.

Use weights of the uncooked meat for calculation and reporting purposes.

Report test results according to Section 6.0 of the Sampling Protocol. Destruction efficiency for the control device shall be calculated as follows:

$$\text{Destruction Efficiency} = \frac{\text{Without Control - With Control}}{\text{Without Control}} \times 100\%$$

where:

Without Control = Mass Emissions (lb/hr) from charbroiler without the control

With Control = Mass Emissions (lb/hr) from charbroiler with the control installed.

FIGURES

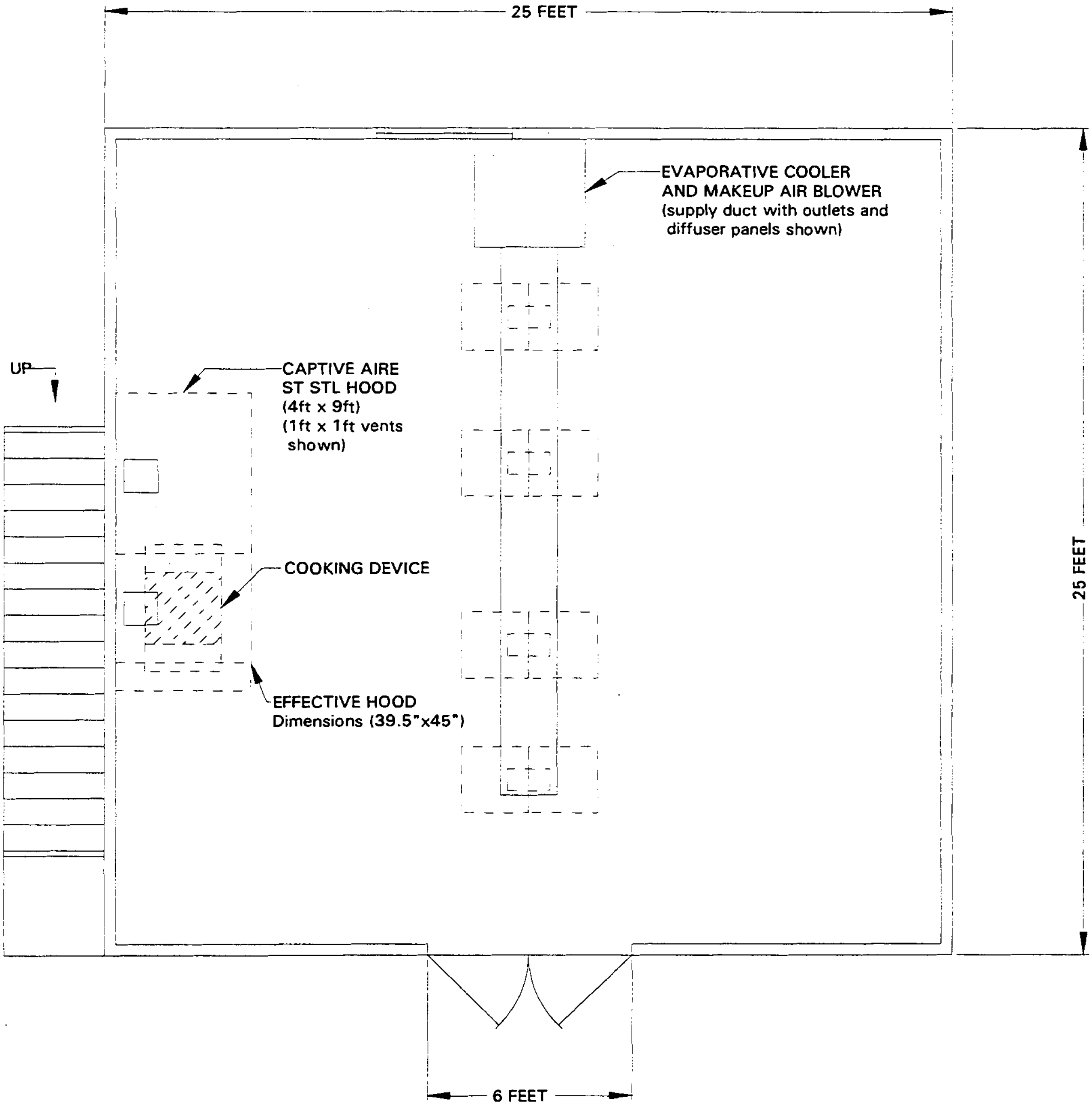


FIGURE 1
TEST KITCHEN DETAILS

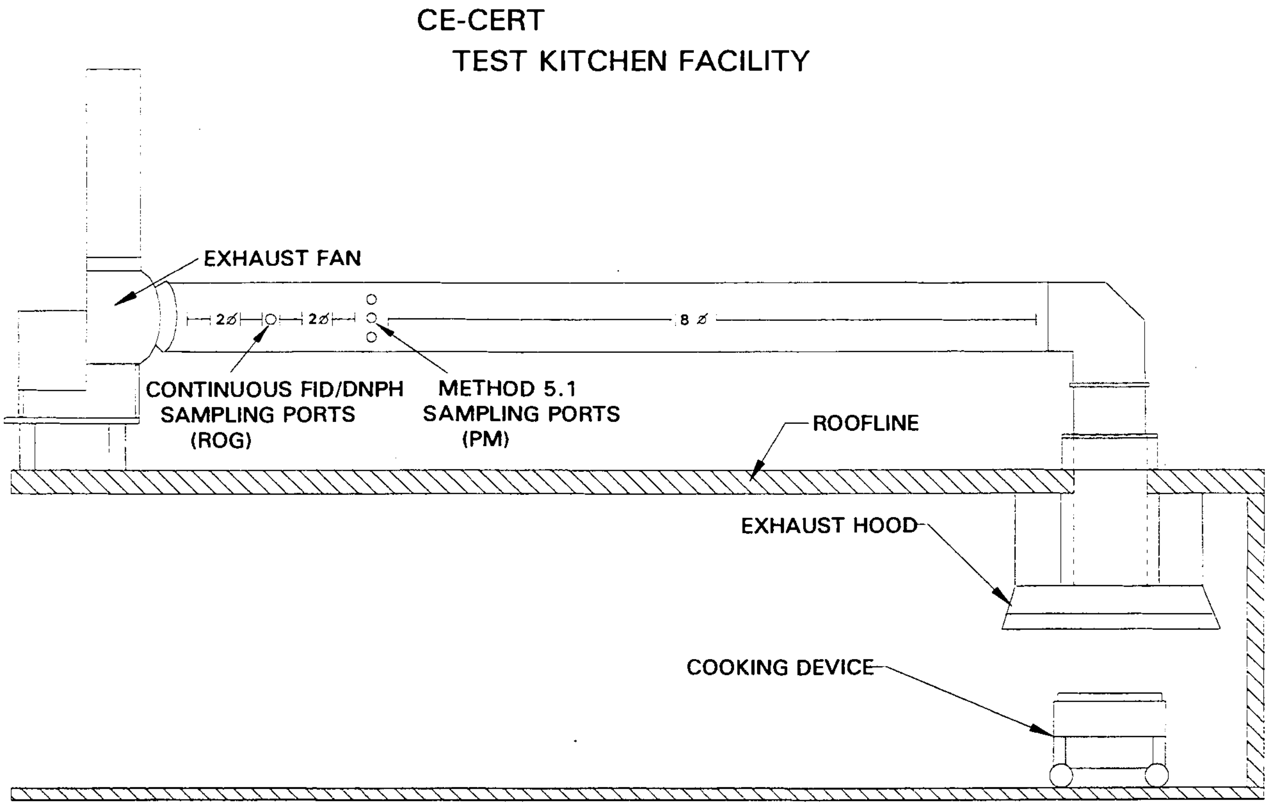


FIGURE 2
DUCT DETAILS

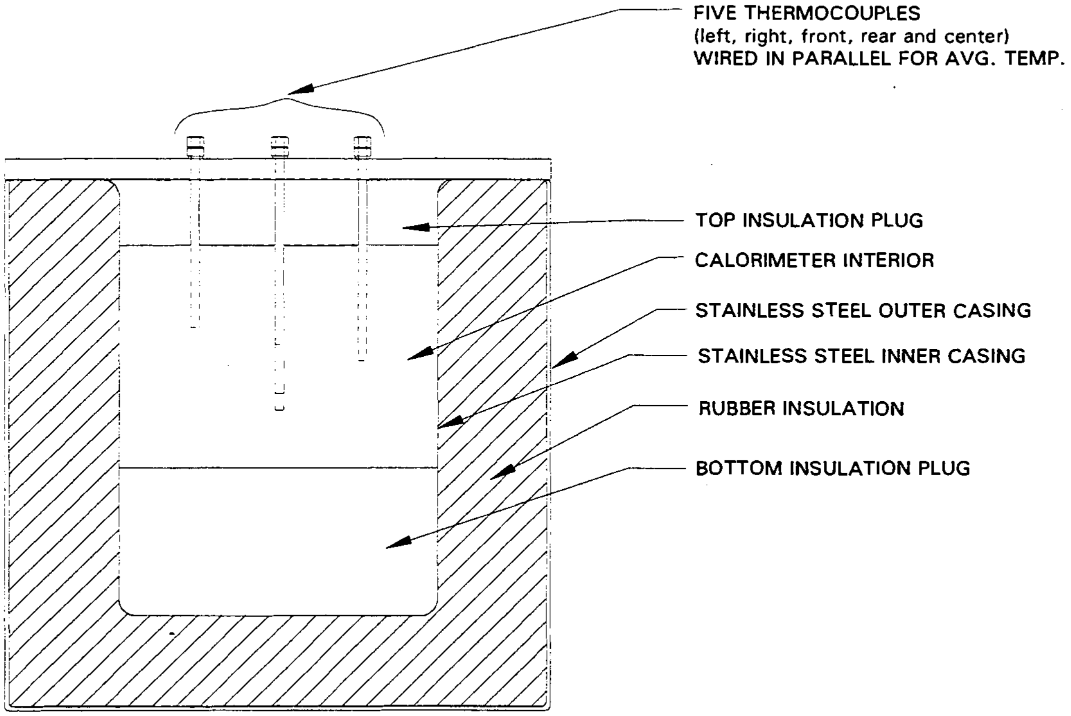


FIGURE 3
PATTY INTERNAL TEMPERATURE MEASUREMENT