Bay Area Air Quality Management District

939 Ellis Street
San Francisco, CA 94109

Staff Report

Regulation 6, Rule 2:
Commercial Cooking Equipment

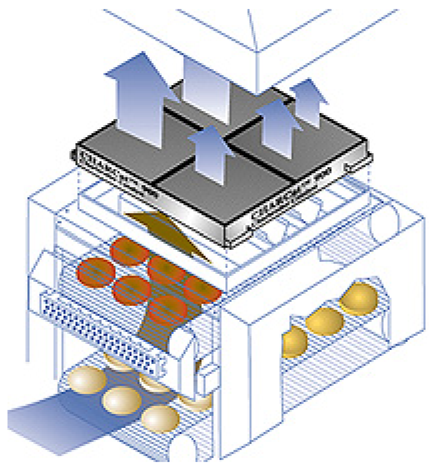

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Table of Contents

I. EXECUTIVE SUMMARY 1

II. BACKGROUND 3

- A. Introduction 3
- B. Source Description 4
- C. Emissions Inventory 5
- D. Regulatory Framework 8

III. AVAILABLE CONTROL TECHNOLOGY 9

IV. REGULATORY PROPOSAL 13

- A. Proposed Standard for Chain-Driven Charbroilers 13
- B. Proposed Standard for New Under-Fired Charbroiler Installations 14
- C. Proposed Standard for Existing Under-Fired Charbroilers 14
- D. Administrative Requirements 15

V. EMISSION REDUCTIONS 17

VI. ECONOMIC IMPACTS 18

- A. Cost Analysis for Charbroilers 18
- C. Incremental Cost Effectiveness 26
- D. District Staff Impacts 27
- E. Socioeconomic Impacts 28

VII. ENVIRONMENTAL IMPACTS 29

VIII. REGULATORY IMPACTS 29

IX. RULE DEVELOPMENT PROCESS 29

X. FUTURE RESEARCH 32

XI. CONCLUSION 33

XII. REFERENCES 34

APPENDICES

Appendix A Emission Calculations

Appendix B South Coast Air Quality Management District's Protocol's "Determination of Particulate and Volatile Organic Compound Emissions from Restaurant Operations", November 14, 1997

Appendix C Responses to Comments

Appendix D Socioeconomic Analysis

Appendix E CEQA Analysis and Negative Declaration

I. EXECUTIVE SUMMARY

Every day in the Bay Area, commercial charbroiling operations collectively emit an estimated 6.9 tons of particulate matter (PM) and 1.1 tons of volatile organic compounds (VOC). The Bay Area and neighboring regions are not yet in attainment with the State one-hour and eight-hour ozone standards and particulate matter standards and so further reductions of VOC and PM are needed.

Currently, no Bay Area Air Quality Management District (District) rule directly regulates emissions from restaurants. The District proposes adoption of Regulation 6, Rule 2 in accordance with its Senate Bill (SB) 656 Particulate Matter Implementation Schedule, and in connection with Further Study Measure (FS) 3 in the District's 2005 Ozone Strategy, which proposes evaluation of a rule to control emissions from commercial charbroilers.

The District focused its efforts on reducing emissions from two types of charbroilers: chain-driven charbroilers and under-fired charbroilers. Charbroilers are a central appliance for most restaurant kitchens and produce over 80% of commercial cooking emissions.

The District investigated a variety of control options for addressing emissions from charbroilers. To determine a list of available control technologies, the District reviewed reports and studies conducted either by universities, other air districts, and city health departments. Regulation 6, Rule 2 will require any restaurant with a chain-driven charbroiler to install a catalytic oxidizer to limit emissions of both PM and VOC if the restaurant purchases at least 500 pounds of beef per week and cooks at least 400 lbs of beef per week on the charbroiler. Owners of restaurants that have one or more under-fired charbroilers with a total grill surface area of at least 10 square feet that purchase at least 1,000 pounds of beef per week and that cook at least 800 pounds of beef per week on the charbroiler will be required to install a control device certified to reduce PM emissions. The proposed rule will become effective one year after the rule is adopted for chain-driven charbroilers and two or five years for under-fired charbroilers, depending on whether the charbroilers were new or existing, respectively. The District anticipates these proposed standards will result in an 85% reduction in PM emitted by all affected charbroilers and an 80% reduction in VOC emitted by chain-driven charbroilers.

A socioeconomic analysis of the proposed regulation concludes that the new regulation would not have significant adverse economic effects. An initial study of the proposed regulation concludes that the rule would not cause significant adverse environmental impacts, and a CEQA negative declaration is proposed for adoption.

Because this regulation addresses a new source category, the District undertook a comprehensive public outreach program to involve in the development of the proposed rule all stakeholders, including individual restaurant owners, hood manufacturers, restaurant trade organizations and industry representatives, county health departments, and vendors and installers of commercial kitchen appliances. The District held four public workshops on November 14 and 15, 2006, and based on public input, revised the draft proposal for presentation at a fifth workshop held on March 6, 2007. The draft proposal was presented before the Board of Directors at the May 16, 2007 public hearing. The Board directed District staff to conduct additional research. District staff surveyed over 400 Bay Area restaurants to determine charbroiler grill sizes and types and amounts of meats grilled. Based on analysis of the survey results, staff revised the proposed regulation. In addition, District staff refined its cost analysis based on further discussions with restaurant owners, control device manufacturers, and building maintenance personnel. The revised draft proposal was presented at a sixth public workshop on October 23, 2007, and comments received at that meeting and during the comment period have been incorporated into the final proposal and into this staff report, as appropriate.

In addition to proposed Regulation 6, Rule 2, the District proposes amendments to *Regulation 3, Schedule R: Equipment Registration Fees* and *Regulation 6: Particulate Matter and Visible Emissions*. The amendments to Schedule R propose a reduction in fees for restaurants and the amendments to Regulation 6 renumber and rename the rule. The amendments to *Regulation 6: Particulate Matter and Visible Emissions* do not have any substantive effect.

II. BACKGROUND

A. Introduction

Restaurants vent substantial amounts of particulate matter (PM) and volatile organic compounds (VOC) into the atmosphere. Every day in the Bay Area, commercial charbroiling operations collectively emit an estimated 6.9 tons of PM and 1.1 tons of VOC.

Several California air districts have adopted rules limiting emissions from commercial cooking operations. The South Coast Air Quality Management District (SCAQMD) funded a detailed study that determined chain-driven charbroilers, under-fired charbroilers, and griddles generate most of the VOC and PM emissions from commercial cooking operations. At present, SCAQMD, the San Joaquin Valley Unified Air Pollution Control District, and the Ventura County Air Pollution Control District have each adopted a rule that limits emissions from restaurant charbroilers. Each of these rules requires chain-driven charbroilers to operate with a control device to limit the emissions of VOC and PM.

Currently, no District rule directly regulates emissions from restaurants. The District proposes adoption of Regulation 6, Rule 2 to fulfill a commitment in its Senate Bill (SB) 656 Particulate Matter Implementation Schedule, and in connection with Further Study Measure (FS) 3 in the District's 2005 Ozone Strategy, which proposes evaluation of a rule to control emissions from commercial charbroilers.

The initial proposal was presented before the Board of Directors at the May 16, 2007 public hearing. At the conclusion of the meeting, the Board directed District staff to conduct additional research. The most significant changes that have been incorporated into the proposed rule include:

- A provision that defines which restaurants are subject to the proposed rule based on the amount of beef purchased;
- An exemption for restaurants that do not cook on the charbroiler most (80%) of the beef purchased; and
- The removal of the requirement to install listed ventilation hoods.

The Board of Directors directed District staff to conduct additional research on certain questions that were raised during the public hearing. District staff conducted a survey of Bay Area restaurants to determine charbroiler grill sizes and types and amounts of meats cooked. Staff also further analyzed the costs to operate and maintain control technologies. This staff report incorporates the findings from these studies as well as revisions to the proposed rule.

B. Source Description

Commercial cooking equipment generates grease, smoke, heat, water vapor, and combustion products. A typical kitchen ventilation system includes an exhaust hood, ductwork, and fan system that extracts heat and pollutants and captures grease using filters, extraction baffles, or water mist systems. The cooking plume rises from the cooking appliance through the filters aided by the suction of the exhaust fan, located in most cases on the roof of the restaurant. Large particulates are generally captured in the filters while additional particulates condense in the duct work or in the exhaust fan.

Broilers are the central appliance for most restaurant kitchens and are used to cook steak, hamburgers, fish, chicken, and seafood, as well as to brown food and reheat plated food. All broilers are comprised of a grated grill and a heat source, where food resting on the grated grill cooks as the food receives heat either directly from the heat source, or indirectly by way of a radiant surface.

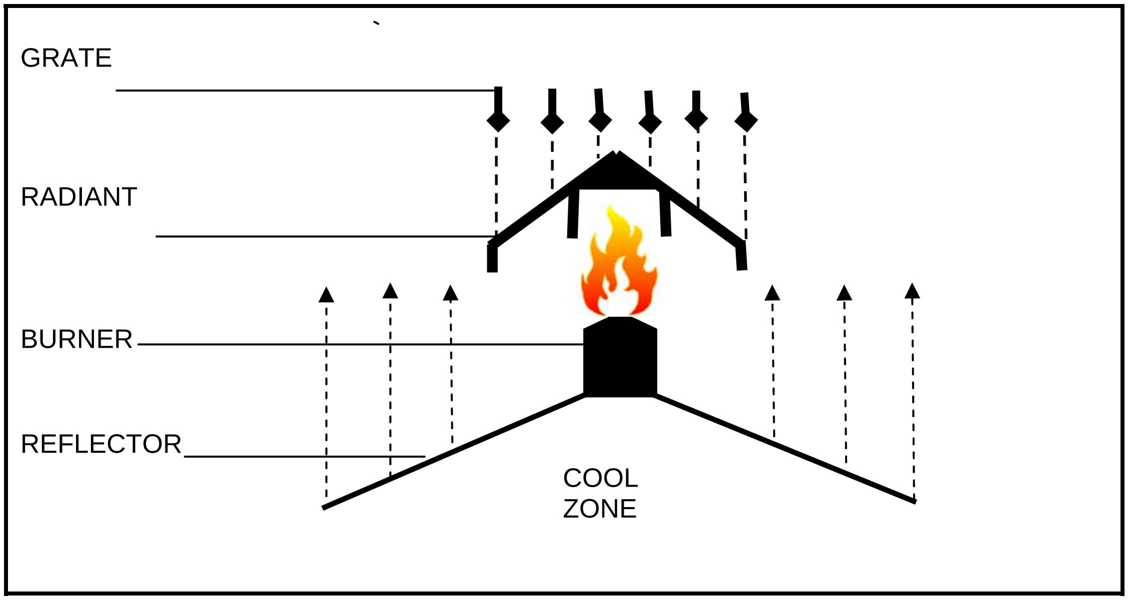
Proposed Regulation 6, Rule 2 would regulate two types of charbroilers: chain-driven and under-fired. Figure 1 presents examples of a chain-driven charbroiler and an under-fired charbroiler. A chain-driven (conveyorized) charbroiler is a semi-enclosed broiler designed to move food mechanically on a grated grill through the device as the food cooks. Food cooks quickly, because chain-driven charbroilers have burners located both above and below the grill. Chain-driven charbroilers are most common in fast food restaurants.

Figure 1. Examples of Chain-Driven Broiler (left) and Under-Fired Broiler (right)

Sources: Nieco and Magikitch'n

In an under-fired charbroiler, the heat source is positioned at or below the level of the grated grill. Designs of under-fired charbroilers vary widely. Some under-fired broilers use charcoal or wood for fuel, but usually, the broilers are fueled by gas or electricity. In gas under-fired charbroilers, a radiant surface, such as a bed of ceramic briquettes or a metal shield, placed above the burners diffuses heat from the burners. (See Figure 2.) The heating elements of electric charbroilers are often interwoven with, or sheathed inside, the grill. Under-fired charbroilers are common in fine dining and casual restaurants.

Figure 2. Diagram of Under-Fired Charbroiler



Source: Vulcan-Hart Company

C. Emissions Inventory

Charbroilers produce air pollutants through combustion. The air pollutants are primarily generated from incomplete combustion of grease and meat additives, such as tenderizers and marinade. The air contaminants are released when grease and meat additives fall onto the heat source, radiant surface, or hot plate, or when grease flares in the drip tray or bubbles at the surface.

The smoke and vapors generated from the process contain VOC and PM that consist of aldehydes, organic acids, alcohol, nitrogen and sulfur compounds, and polycyclic aromatic hydrocarbons (PAHs). VOC reacts with other compounds in the atmosphere to form ground-level ozone, commonly called smog. PM consists of airborne particles. PM can be emitted directly and also can be formed in the atmosphere through chemical reactions between other pollutants, including VOC. Cooking emissions include fine particles that are equal to or less than 10 microns in diameter, commonly referred to as PM_{10}. PM_{10} generated by cooking appliances passes through the ventilation system and is exhausted into the atmosphere. Particulate matter greater than 10 microns in diameter is typically captured in the grease filter in the ventilation hood, and is not exhausted to the atmosphere.

Both VOC and PM_{10} present public health risks. Ozone produced from chemical reactions involving VOC may damage lung tissues and the respiratory tract. Once inhaled, PM_{10} may become lodged in the respiratory tract and lead to wheezing, nose and throat irritation, bronchitis, aggravated asthma, and lung damage.

The SCAQMD and the California Air Resources Board (CARB) sponsored several studies in order to determine the percentage of restaurants that use charbroilers, the amount and type of meat cooked on charbroilers, and the amount of PM_{10} and VOC produced from meat cooked on charbroilers. The District relied on these research studies, and on information provided by the health department of each of the nine Bay Area counties, to estimate the amount of PM_{10} and VOC emitted from restaurant charbroilers in the Bay Area. A more detailed description of the methodology is presented in Appendix A.

District staff estimated the number of restaurants in operation in the Bay Area with assistance from the health department of each county in the District. Each county health department provided the District with the number of restaurants permitted within the county. District staff refined the number of restaurants by eliminating the establishments that are not open to the public (e.g., private clubs, dormitories, and company cafeterias) because charbroiler usage would likely be much less than a commercial restaurant. Restaurants that have gone out of business, as well as those that are less likely to cook, such as, ice cream parlors and delicatessens were also eliminated. The District estimates that there are approximately 14,838 restaurants in the Bay Area.

To estimate the number of charbroilers used in Bay Area restaurants, the District consulted the 1997 SCAQMD report, "Staff Recommendations Regarding Controlling Emissions from Restaurant Operations." The SCAQMD report surveyed the type of equipment that was used in restaurant cooking operations in Southern California. The report found that approximately 33% of restaurants operate under-fired charbroilers and 3.7% operate chain-driven broilers. The District verified these percentages by conducting an independent survey of Bay Area restaurants. District staff interviewed a random sample of approximately 400 restaurants that included fast food chains and franchises and found that the SCAQMD percentages are representative of the Bay Area. Based on these percentages, the District estimates that approximately 4,897 Bay Area restaurants operate under-fired charbroilers and 554 operate chain-driven charbroilers.

The District used several studies to estimate the amount of meat cooked on restaurant charbroilers and the associated emissions. The District relied on data developed for CARB by the Public Research Institute pertaining to the average amount of meat cooked on each type of appliance. Table 1 presents the estimated average pounds of meat cooked per year on an individual charbroiler in the Bay Area.

Emission factors developed by the University of California Riverside (UCR) and the University of Minnesota were used to quantify average emissions from each type of meat cooked on under-fired charbroilers including hamburger, steaks, chicken with or without skin, pork, and seafood. For chain-driven charbroilers, emission factors for poultry, pork, and seafood were estimated from the factors developed for under-fired charbroilers. The estimated emissions of PM_{10} and VOC by chain-driven and under-fired broilers are presented in Table 2.

Table 1. Estimated Average Yearly
Pounds of Meat Cooked per Charbroiler in the Bay Area

Type of Food	Conveyorized Broiler (lbs/year)	Under-Fired Broiler (lbs/year)
Hamburger	41,486	14,049
Beef Steaks	12,281	9,363
Poultry with Skin	7,651	7,485
Poultry without Skin	13,842	9,311
Pork	2,997	7,699
Seafood	6,179	7,416
TOTAL	**84,436**	**55,323**

Source: PRI

Table 2. Emissions from Charbroilers in the Bay Area

Type of Food	Chain-driven Broiler		Under-Fired Broiler	
	PM10 (tons/day)	VOC (tons/day)	PM10 (tons/day)	VOC (tons/day)
Hamburger	0.23	0.072	0.90	0.37
Beef Steaks	0.069	0.021	0.60	0.25
Poultry with Skin	0.0091	0.0061	0.10	0.092
Poultry without Skin	0.016	0.011	0.12	0.11
Pork	0.0036	0.0024	0.10	0.094
Seafood	0.012	0.010	0.16	0.019
Total Emissions (tons/day)	0.34	0.11	2.0	0.94
Total Emissions (tons/year)	126	41	724	342

As noted in Table 2, a significant portion of the PM_{10} and VOC emissions from charbroilers are produced from beef products such as hamburgers and beef steaks. Beef products account for approximately 62% of PM_{10} and VOC emissions from chain-driven charbroilers and approximately 75% of PM_{10} and

66% of VOC emissions from under-fired charbroilers. The Bay Area restaurant survey also verified that beef is the meat most commonly cooked on a charbroiler. The proposed rule would regulate those restaurants that purchase and grill a significant amount of beef because these restaurants are responsible for the largest share of emissions. Emission reductions were estimated assuming that restaurants subject to this proposed rule cook a variety of meats, but predominately beef.

In addition to VOC and PM emissions, cooking operations also produce carbon dioxide (CO_2), a gas contributing to climate change. In 2005, the District adopted a Climate Protection Program aimed at reducing greenhouse gas emissions. A University of Minnesota study found that gas charbroilers generated most of the CO_2 emitted by cooking operations. Charbroilers generate CO_2 through the combustion of natural gas and when grease drippings combust on hot radiant surfaces. The District estimates that the average CO_2 emissions for cooking activities per restaurant are approximately 25,000 pounds of CO_2 annually based on operation of the cooking appliances and energy usage for the associated ventilation system[1].

D. Regulatory Framework

The District is proposing Regulation 6, Rule 2, in accordance with the District's SB 656 Particulate Matter Implementation Schedule and in connection with FS 3 in the District's 2005 Ozone Strategy, as a means to reduce restaurant emissions of PM and VOC in the Bay Area. VOCs are ozone precursors, and also contribute to indirect or secondary PM. The Bay Area is not yet in attainment of the State ozone and particulate matter standards, and so, further reductions of VOC and PM are needed.

SB 656 requires that all air districts in California adopt an implementation schedule that prioritizes appropriate measures for reducing PM emissions. The District's Particulate Matter Implementation Schedule, adopted in November 2005 proposed to adopt Regulation 6, Rule 2 as a measure to reduce direct and indirect PM emissions in the Bay Area.

Under FS 3, the District proposed to examine the feasibility of reducing ozone precursor emissions from restaurants. FS 3 is part of the District's 2005 Ozone Strategy, directed towards attainment of the State one-hour ozone standard.

Currently, no District rule directly regulates the emissions of air pollutants from restaurants. Restaurants, cafeterias, and other food establishments are not required to obtain a permit to operate under the District's Regulation 2, Rule 1. Nevertheless, restaurants must comply with the District's regulations of general

[1] Energy usage only accounts for the energy required to operate the cooking appliances and associated ventilation system. It does not include the energy required to power the air conditioning and heating systems, refrigeration units, make-up air, lights, and other types of equipment.

applicability, such as *Regulation 6: Particular Matter and Visible Emissions*, and *Regulation 7: Odorous Substances*[2]. Regulation 6 sets limitations on the emissions of particulate matter. Regulation 7 restricts the discharge of odorous substances.

Bay Area restaurants are issued permits to operate by county health departments and in some cases, city health departments. The health departments require restaurants to adhere to California building codes, fire protection codes, and retail food laws. These codes require restaurants to install an exhaust ventilation hood with a fire suppression system above commercial cooking equipment that generates grease, smoke, steam, and vapor. The health departments also monitor the handling of food and ensure that all of the grease traps and hood filters are routinely cleaned.

At present, the SCAQMD, San Joaquin Valley Unified Air Pollution Control District, and Ventura County Air Pollution Control District have each adopted a rule that limits emissions from restaurant charbroilers. These rules each require that chain-driven charbroilers be operated with a control device to limit emissions of VOC and PM.

In addition, the City of Aspen Environmental Health Department has an ordinance regulating restaurant charbroiler emissions under Municipal Code Section 13.08.100: Restaurant Grills. The ordinance requires all restaurants that operate any charbroiler to install a control device that is certified by the manufacturer to reduce PM_{10} emissions by 90%.

III. AVAILABLE CONTROL TECHNOLOGY

The District considered a variety of technologies to control emissions from charbroilers. District staff reviewed reports and studies conducted by the UCR, College of Engineering, Center for Environmental Research and Technology (CE-CERT), on available control technologies in support of the SCAQMD Regulation 1138 to control emissions from chain-driven charbroilers. In addition, District staff contacted the City of Aspen Environmental Health Department regarding their ordinance regulating restaurant charbroiler emissions under Municipal Code Section 13.08.100: Restaurant Grills. District staff also consulted hood manufacturers and industry representatives.

Available control technologies that are effective at removing either or both PM and VOC from charbroilers include catalytic oxidizers and thermal incinerators. Each of these is a reliable, proven, and commonly-used control technology. The District also considered wet scrubbers, electrostatic precipitators (ESPs), fiber-bed filters, and high-efficiency particulate arresting (HEPA) filters as effective control devices for removing PM only. Other control technologies such as

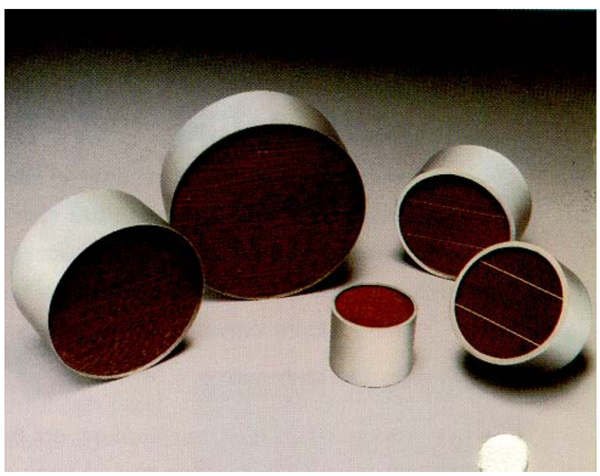
[2] On adoption of proposed Regulation 6, Rule 2, current Regulation 6 will be re-numbered as Regulation 6, Rule 1.

ultraviolet (UV) lamps and high-efficiency filters are available. The effectiveness of UV lamps at removing PM and VOC has not been investigated in an independent research study. High-efficiency filters have a significantly lower PM removal efficiency in comparison to the proven control technologies discussed below.

Catalytic Oxidizers (flameless)

A catalytic oxidizer is a flameless incineration device that is fitted to the top of a chain-driven charbroiler. Cooking exhaust is initially processed in the catalytic oxidizer through the heat exchanger where air is introduced. The air mixture then enters a flameless combustion chamber where it is evenly distributed onto the catalyst bed to ensure complete mixing of PM and VOC with oxygen. The PM and VOC oxidize into carbon dioxide and water vapor once the mixture reaches the combustion temperature. The released combustion energy is absorbed by the catalyst bed and is transferred to the heat recovery system. The control device is activated by the heat of the charbroiler and does not require any additional fuel to operate. The catalyst, which is a metal alloy, covers a substrate, typically either a honeycombed ceramic or a bed of ceramic beads housed in a canister. (See Figure 3.)

Figure 3. Catalytic Oxidizers Canisters



Source: W.R. Grace and Company

The catalyst is cleaned by immersion in water for one hour per month. Testing has shown catalytic oxidizers are capable of an overall PM and VOC removal efficiency of approximately 85% (83% for PM and 86% for VOC). Catalytic oxidizers are highly effective and virtually maintenance-free control devices for chain-driven charbroilers. However, this technology is not used to control emissions from under-fired charbroilers because the temperature at which the catalyst operates would require significant energy usage. Control equipment for under-fired charbroilers is mounted in the exhaust system, not on the broiler.

Thermal Incineration

Thermal incineration oxidizes PM and VOC from an air stream at high temperatures, converting them into carbon dioxide and water. Thermal incinerators are not commonly used in commercial cooking applications. There are two types of thermal incinerators, recuperative and regenerative. Thermal recuperative incinerators consist of a gas preheating section (heat exchanger), a combustion chamber typically equipped with gas burner(s), and a heat recovery section. The heat exchanger is used to preheat the exhaust stream prior to combustion and may be used to recover heat to generate steam.

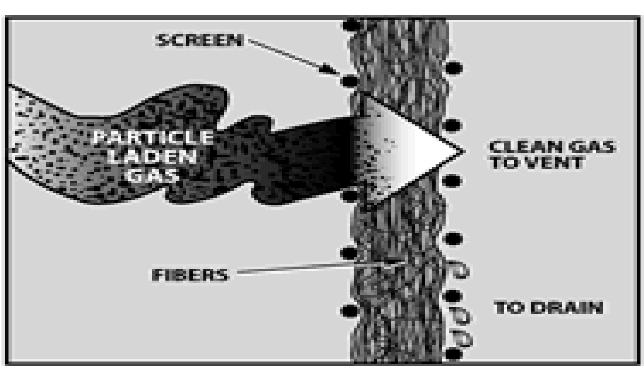
Regenerative incinerators use direct contact with a high-density medium such as a ceramic-packed bed or catalyst bed for heat recovery and to preheat the exhaust stream. Preheated PM and VOC enters the combustion chamber where they are converted to carbon dioxide and water. Cleaned gases are then diverted to reheat the packed beds. PM and VOC removal efficiency is dependent upon temperature, residence time, and mixing inside the incinerator.

PM and VOC conversion efficiencies typically range from 97% to 99.9% for recuperative incineration and 95% to 99% for regenerative incinerators. Thermal incinerators may be used as a control device for both chain-driven and under-fired charbroilers.

Fiber-Bed Filters

Fiber-bed filters may be used as stand-alone control devices or in conjunction with another control device such as a wet scrubber. Fiber-bed filters use a combination of impaction, interception and Brownian diffusion to remove particulate matter from an air stream. Particulates become trapped in the fibers of the filter and eventually drain into a capture area below the filter as illustrated in Figure 4. The filter bed may be made of fiberglass, polyester, polypropylene, or ceramic, depending on the PM concentration, exhaust flow, and temperature of the air stream.

Figure 4. Operation of Typical Fiber-Bed Filters



Source: Kimre, Inc.

Periodically the filters must be replaced or washed to remove grease and other materials before returning to service. Fiber-bed filters have an overall PM removal efficiency of 90%. Filter-bed technology has been successfully used on chain-driven charbroilers in Southern California; however, they are not used in restaurants that operate under-fired charbroilers and thus, the costs for installing and maintaining the control device are not included for under-fired charbroilers.

Electrostatic Precipitators

Electrostatic precipitators (ESPs) have a proven track record of removing PM from the gas streams of many industries. An ESP functions by screening out large PM with a pre-filter, and then imparting an electrostatic charge in the remaining exhaust particles with a high voltage direct current. The charged particles then attach to an oppositely charged plate, from which they are later removed. An after filter is occasionally used after the plates to restore a positive back-pressure and ensure good gas distribution.

The PM removal efficiencies of ESPs range from 90% to 99%. The removal efficiencies depend largely on whether the ESPs are frequently and properly cleaned. ESPs are effective control devices for either chain-driven charbroilers or under-fired charbroilers.

Wet Scrubbers

Wet scrubbers use a finely atomized stream of water to remove PM from an air stream. An exhaust stream flows upward through a series of grated impingement plates. Water is introduced from the top of the wet scrubber and flows down to each successive plate, counter to the exhaust flow. The cooking exhaust rises through the grated grills and cools once it contacts the water. The particles adhere to the water droplets which are then collected as liquid waste. The liquid waste collected at the bottom of the scrubbers requires either treatment for reuse or disposal. Liquid particles entrained in the exhaust gas leaving the scrubber are removed using an after filter. PM removal efficiencies of 90% to 99% have been achieved depending on particle size, load, flows, and pressure drop. Wet scrubbers may be used as a control device for either the chain-driven or under-fired charbroiler.

HEPA Filters

HEPA filters are comprised of a series of three (3) filters designed to capture successively finer particles sizes. The first filter is called a pre-filter, which is a fully disposable pleated filter that must be replaced every four (4) weeks. The second filter is a medium filter that is a fully disposable bag filter that is replaced every eight (8) weeks. The final filter is a fully disposable 12 inch HEPA filter that is replaced every six (6) months. The PM removal efficiencies of HEPA filters varies from 95% to 99%. HEPA filters have been exclusively used at restaurants that operate under-fired charbroilers. Because there are more inexpensive control options available, restaurants with chain-driven charbroilers have not installed this control device.

IV. REGULATORY PROPOSAL

Under proposed Regulation 6, Rule 2: Commercial Cooking Equipment, the District is seeking to achieve further reductions of VOC and PM by requiring controls for under-fired and chain-driven charbroiler emissions. This chapter describes the proposed standards in Regulation 6, Rule 2.

A. Proposed Standard for Chain-Driven Charbroilers

Based on studies conducted by the UCR CE-CERT (1997), chain-driven charbroilers account for 4% of restaurant PM emissions and 13% of VOC emissions. Proposed Regulation 6, Rule 2 requires that, within one year of adoption of the rule, those owners of restaurants that have chain-driven charbroilers and that purchase 500 pounds (lbs.) or more of beef per week would be required to install and operate a District-approved catalytic oxidizer or other certified control. Restaurants that demonstrate, through meat purchase invoices or other documentation, that they cook less than 400 lbs. of beef per week on their charbroilers would be exempt from this proposed rule.

Currently, three California air districts regulate chain-driven charbroiler emissions: SCAQMD, San Joaquin Valley Unified Air Pollution Control District, and Ventura County Air Pollution Control District. Each of these air districts requires chain-driven charbroilers to be equipped and operated with a catalytic oxidizer or equivalent control. As a result, the catalytic oxidizer has an established track record and has been proven capable of reliably reducing chain-driven charbroiler emissions of PM_{10} by 83% and VOC by 86%. The South Coast AQMD has already approved catalytic oxidizers from a variety of manufacturers to meet the same emissions standard as included in proposed Regulation 6, Rule 2; the devices SCAQMD has already approved at the time of this writing will be approved for use in the Bay Area. A manufacturer of a new catalytic oxidizer will be required to test and certify the equipment according to the protocol SCAQMD established, attached to this staff report as Appendix B.

The proposed rule allows a restaurant operator the flexibility to install an alternative control device, provided the device has been certified by the manufacturer to reduce emissions to no more than 0.74 lbs. of PM_{10} per 1,000 lbs. of beef cooked. Alternative controls, such as electrostatic precipitators, are capable of achieving a higher PM_{10} removal efficiency, but at greater cost, than a catalytic oxidizer. In some cases, other controls have already been installed on District restaurants. The manufacturer is required to have an independent laboratory perform the certification test, in accordance with specific procedures prescribed in the rule, to determine the ability of the control to meet the emission standards the rule requires.

B. Proposed Standard for New Under-Fired Charbroiler Installations

Under-fired charbroilers account for 82% of PM emissions generated by restaurants, according to the 1997 University of California, Riverside study. The focus of the proposed rule for newly-installed under-fired charbroilers is to reduce emissions from high-production restaurants that cook large quantities of beef on under-fired charbroilers and, consequently, are responsible for a large portion of the emissions. Effective January 1, 2010, the proposal calls for any owner or operator of any restaurant that contains one or more new under-fired charbroilers that have a total of at least 10 square feet of grill surface area and that purchases 1,000 lbs. of beef or more per week, to exhaust the restaurant's charbroiler emissions through a certified control device. The control device must be certified by the manufacturer to limit emissions to no more than 1.0 lbs. of PM_{10} per 1,000 lbs. of beef cooked, as measured by the test method set out in section 603 of the proposed rule. Any restaurant that demonstrates that it grills less than 800 lbs. of beef per week on its charbroiler(s) would be exempt.

The rule recognizes that effective control equipment that meets these emission standards requires planning to install. Newly constructed restaurants can integrate the installation of the controls into their ventilation system to effectively reduce emissions. Owners of an existing restaurant who choose to install new under-fired charbroiler(s) in the restaurant and thereby become subject to the rule will have to install an approved control device. Alternatively, the restaurant owner may elect to install cooking equipment other than an under-fired charbroiler, such as a clamshell griddle or over-fired charbroiler, that emits much less PM than an under-fired charbroiler, and consequently, is not subject to the regulation. Cooking appliances such as clamshell griddles and over-fired charbroilers have the added benefit of using less energy than under-fired charbroilers.

C. Proposed Standard for Existing Under-Fired Charbroilers

Approximately 82% of Bay Area PM emissions from commercial cooking are attributable to the approximately 5,000 under-fired charbroilers in use in the Bay Area. PM emissions from already-existing under-fired charbroilers can be reduced by 14% (up to 0.28 tpd) by regulating the highest emitting restaurants (approximately the top 4%) that operate under-fired charbroilers.

Five years after rule adoption, January 1, 2013, the proposed rule will require all restaurants that have one or more under-fired charbroilers with an aggregate grill surface area of 10 square feet or more and that purchase 1,000 lbs of beef or more per week to install control technology certified to emit no more than 1.0 lbs. of PM_{10} per 1,000 lbs. of beef cooked, as measured by the test method set out in section 603 of the proposed rule. This will reduce PM_{10} emissions from these restaurants by 90%. Any restaurant that demonstrates that it grills less than 800 lbs. of beef per week would be exempt.

Current control technologies are available that can be retrofitted into existing restaurants. However, some restaurants may require remodeling, additional plumbing, or additional structural support in order to install and operate currently available control devices. As a result, an extended implementation date for existing under-fired charbroilers is proposed to allow adequate time for restaurant owners to plan, obtain the necessary building permits, purchase, and install the control.

D. Administrative Requirements

Chain-Driven Charbroilers

All operators of chain-driven charbroilers that are subject to this proposed rule will be required to register the charbroiler and control device with the District. The District will implement a web-based registration system to simplify the registration process. Controls that have been certified for use in the South Coast will be approved and listed on the District web site as well as new, District-certified catalytic oxidizers. Restaurant owners will be assessed an initial registration fee and recurring annual fee to recover the District's costs of administering and enforcing the proposed rule. The proposed initial registration fee is $360 and the proposed annual fee is $100. The fees are to be adopted as part of the proposed amendments to Regulation 3: Fees.

The proposed rule also has a recordkeeping provision that requires owners and operators to record the date of installation of, and any maintenance and repairs performed on, the control device. The repair logs will contain the date, time, and description of the work that was performed. The owner or operator must keep the records for at least five years. The purpose of this recordkeeping requirement is to ensure that the control is operated in accordance with the manufacturer's specifications.

Under-Fired Charbroilers

An operator of a restaurant with one or more under-fired charbroiler(s) that is subject to this proposed rule will be required to register the under-fired charbroiler(s) and the control device. Restaurant owners will be assessed an initial registration fee, followed by a recurring annual fee to recover the District's costs of administering and enforcing the proposed rule. The proposed registration fee is $360 and the proposed annual fee is $100, consistent with the fees for chain-driven charbroilers. The fees are to be adopted as part of the proposed amendments to Regulation 3: Fees.

The proposed rule requires that owners and/or operators of restaurants subject to the rule must keep records for not less than five years. The records must include date of installation of any control device operated to comply with the rule and records of any maintenance or repairs performed on the control device. The maintenance and repair records must contain the date, time, and description of the work that was performed. The purpose of this recordkeeping requirement is to ensure that the control is operated in accordance with the manufacturer's specifications.

Certification of Control Equipment

The manufacturer of an emission control device must contract an independent laboratory to perform a test, in accordance with specific procedures prescribed in the rule, to certify the ability of the control to meet the relevant emission standards in the rule. The manufacturer is required to submit to the District an application containing a complete source test report along with information describing the control and to certify that the device meets the emissions requirements.

The proposed rule requires the certification tests for all devices controlling emissions from under-fired charbroilers and for controls other than catalytic oxidizers for chain-driven charbroilers to performed according to the protocol set out in proposed section 6-2-603 and -602, respectively. The test protocol are intended to measure PM_{10}, excluding condensable vapors.

The proposed sections 6-2-602 and -603 protocols employ EPA Method 5, which measures total particulate, and not PM_{10} as such; however, the protocol are designed so that the vast majority of PM in the effluent stream that reaches the EPA Method 5 sampling train will be PM_{10}.

According to the CE-CERT study, "Further Development of Emission Test Methods and Development of Emission Factors for Various Commercial Cooking Operations" (1997), particulate matter greater than 10 microns in size is generally not emitted into the atmosphere, because the standard baffle filters installed in restaurant kitchen ventilation systems capture particles greater than 10 microns in size, termed coarse particulate. The CE-CERT study showed that the particulate matter that passed through the baffle filter was all PM_{10}. Likewise, the effluent stream that will reach the EPA Method 5 sampling train under the proposed sections 6-2-602 and -603 protocol will consist of particulates less than 10 microns in diameter because the test protocol requires that the test effluent stream pass through a baffle filter.

In addition, the testing protocol set out in sections 602 and 603 of the proposed rule are intended to exclude condensable vapors from measurement. Emissions from charbroiling include particulate matter and compounds that condense into particulate matter as they cool. These latter compounds are termed condensable vapors, and are included in the definition of total PM_{10}. As condensable vapors leave the very hot surface of a charbroiler, they cool and condense into PM. Some condensable vapors condense prior to being exhausted into the atmosphere; much does not. A control device that does not oxidize emissions, such as an electrostatic precipitator or a HEPA filter, will remove only the vapors that condense prior to reaching the control device. The test method set out in sections 602 and 603 of the proposed rule, which provide the standards for certification testing of control devices other than catalytic oxidizers for use with charbroilers, measures only particles captured by, and condensable vapors that condense onto, the particulate filters used in the front half of the EPA Method 5 test. As a result, the test methods set out in sections 602 and 603 of the proposed rule are designed to measure the particulate matter, including condensable particulate, that the control device could be expected to collect.

V. EMISSION REDUCTIONS

Charbroilers produce PM and VOC through incomplete combustion of tenderizers, marinade, and fats in the meat cooked. The District estimates that chain-driven charbroilers in the Bay Area emit a total of 0.34 tons per day (tpd) of PM and 0.11 tpd of VOC. Under-fired charbroilers, which produce significantly more emissions and outnumber chain-driven charbroilers by roughly a ten to one ratio, collectively emit approximately 2.0 tpd of PM and 0.94 tpd of VOC in the Bay Area. Cooking beef produces approximately 62% of the particulate emissions from chain-driven charbroilers and 75% of the particulate emissions from under-fired charbroilers because it represents the bulk of the meat cooked on these appliances and has about three times the emission rate of chicken, pork, or seafood. A more detailed discussion of the emissions estimates is presented in Appendix A.

Chain-Driven Charbroilers

The proposed standards for chain-driven charbroilers will become effective on January 1, 2009. Based on Bay Area restaurant survey, it is estimated that approximately 80% of all chain-driven charbroilers will be subject to this proposed rule; the remaining 20% of restaurants with chain-driven charbroilers either do not purchase over 500 lbs of beef per week or cook less than 400 lbs of beef per week on the charbroiler. The restaurants subject to this proposed rule emit 93% of the PM and VOC emissions from chain-driven charbroilers. The installation of control equipment is anticipated to reduce emissions of PM from these chain-driven charbroilers by 83% (0.27 tpd) and of VOC by 86% (0.091 tpd). Laboratory testing (UCR, 2002) conducted on catalytic oxidizers has verified that the control devices are capable of achieving these emission reductions.

New Under-Fired Charbroilers

The proposed standards for new installations of large under-fired charbroilers will become effective on January 1, 2010. Based on data provided by the county health departments, about 25 restaurants per year (about 0.5% of all permitted restaurants with under-fired charbroilers) will become subject to the requirements of this rule due to remodeling or new construction. Each year, these new installations will add an additional 0.010 tons of PM production per day that will be subject to the requirements of the rule. The proposed rule would reduce PM emissions from these new installations by 90% (0.009 tpd).

Existing Under-Fired Charbroilers

The District estimates that there are currently 489 restaurants in the District operating one or more under-fired charbroilers with a total grill surface area of at least 10 square feet. The District estimates that approximately 40% of these restaurants (about 200 restaurants) purchase at least 1,000 lbs of beef per week, and grill at least 800 lbs of beef per week. These restaurants emit 16% of the total PM emissions from under-fired charbroilers, or 0.32 tpd. Effective January 1, 2013, the rule is anticipated to reduce total PM emissions from under-fired charbroilers by 14% (0.28 tpd) (90% from affected under-fired charbroilers). The remaining emissions, approximately 1.7 tpd of PM, are produced from the 4,700 restaurants that currently operate under-fired charbroilers, but are not subject to this proposed rule.

Table 3 presents emissions and emission reductions for charbroilers subject to the proposed rule.

Table 3. Emission Reductions from Charbroilers Subject to Proposed Rule

Type of Charbroiler	Uncontrolled PM_{10} Emissions (tpd)	PM_{10} Emission Reduction (tpd)	Uncontrolled VOC Emissions (tpd)	VOC Emission Reduction (tpd)
Chain-Driven Charbroilers	0.32	0.27	0.10	0.091
Existing Under-Fired Charbroilers	0.32	0.28	0.15	---
TOTAL	**0.64**	**0.55**	**0.25**	**0.091**
New Under-Fired Charbroilers*	0.010	0.009	0.005	---

* Note: New under-fired charbroilers estimated to increase at a rate of 10% per year.

VI. ECONOMIC IMPACTS

This section discusses the estimated costs associated with the proposed rule.

A. Cost Analysis for Charbroilers

The District investigated the technical feasibility, potential emission reductions, and costs of installing and operating the control strategies identified in Section III. The total annual costs for a control technology are calculated based on a ten year period and are comprised of the annualized capital costs and the annual recurring operation and maintenance (O&M) costs.

The District estimated capital costs using the capital recovery method, which accounts for depreciation and interest (i.e., inflation) costs over the useful life of the control. The District annualized the capital costs using the following equation:

Total Annualized Cost = (*Capital Recovery Factor*)×(*Capital Expenditure) + Annual O & M Costs*

Where:

> *Capital Expenditure* is the equipment and installation costs
> *Capital Recovery Factor* is 14.2% (7% per year over 10 years)
> *Annual O&M Costs* are expenditures for utilities and equipment maintenance

The annual recurring O&M cost includes expenditures for cleaning the equipment and the duct work.

District staff also estimated a control technology's cost effectiveness by summing the total annual costs for the control technology installed at restaurants and dividing that sum by the total annual PM and VOC emissions reductions to be achieved.

Chain-driven Charbroilers

Costs associated with control devices for chain-driven charbroilers were derived from the SCAQMD Staff Report for Proposed Rule 1138 (1997) and San Joaquin Valley Unified Air Pollution Control District Draft Staff Report for Commercial Charbroiling (2001). The District verified and adjusted costs to 2007 dollars. Table 4 presents a summary of the total annual cost for installing and maintaining the equipment and Table 5 presents the cost-effectiveness. Because catalytic oxidizers have been designed to work with chain-driven charbroilers and are certified for use in other districts, and because of their low costs relative to other controls, is the District expects that restaurants with chain-driven charbroilers will install catalytic oxidizers.

Catalytic Oxidizers

Capital Costs: Manufacturers sell a catalytic oxidizer at a cost ranging from $1,500 to $4,700. For this analysis, the capital cost was assumed to be $9,000 for a new chain-driven charbroiler equipped with a catalytic oxidizer that includes costs for installing the control, initial catalyst, and replacement catalyst after 5 years ($4,000). The cost would essentially be the same if an existing broiler was retrofitted with a catalytic oxidizer. Installation of the equipment was assumed to be $1,000, although typical installation costs ranges from $500 to $1,000.

Operating Costs: Annual O&M costs of cleaning the catalyst are expected to be

$750, which includes monthly cleaning of the catalyst and the cost of cleaning the exhaust stack once a year. Cost savings associated with less frequent cleaning of the grease traps were not included in this cost estimate. The anticipated lifetime of the catalytic oxidizer is seven to eleven years with proper maintenance.

The total annualized cost of installing a catalytic oxidizer, including O&M, is $2,028 (see Table 5). Based on the estimates of 0.34 tpd of PM emissions and 0.11 tpd of VOC emissions (Table 3) from chain-driven charbroilers, it is expected that 0.27 tpd of PM and 0.091 tpd of VOC (132 tons per year) emission reductions can be achieved by installing a catalytic oxidizer, assuming an 83% removal efficiency for PM and 86% removal efficiency for VOC. The cost-effectiveness to reduce emissions from all chain-driven charbroilers in the Bay Area is $6,837 per ton of PM and VOC reduced.

Wet Scrubbers

<u>Capital Costs:</u> A wet scrubber unit has a capital cost of $27,025 that includes an estimated installation cost of $2,000. The unit contains all the components and accessories to operate at 2,000 cfm, including surfactant feeder, controller, remote start/stop control, re-circulation pump, valves, and exhaust blower.

<u>Operating Costs:</u> Annual O & M costs are anticipated to not exceed $2,000. O&M includes the energy cost for operating the controller and exhaust blower as well as the monthly expense of purchasing non-foaming surfactants detergent.

The total annualized cost of installing this control, including O&M, is $5,838. PM removal efficiencies of 90% or higher have been achieved at restaurants in which wet scrubbers were installed as the control device. Based on the estimates of 0.34 tpd of PM emissions, it is expected that 0.29 tpd of PM emission reductions can be achieved. The cost-effectiveness to reduce emissions from a chain-driven charbroiler by installing a wet scrubber is $24,558 per ton of PM reduced.

Electrostatic Precipitators

<u>Capital Costs:</u> Manufacturers provided a range of costs for a double pass electrostatic precipitator (ESP) with ducting, exhaust fan, and one set of replacement plates: $20,000 for a ventilation rate of 2,000 cfm to $40,000 for a ventilation rate of 5,000 cfm. The District assumed a cost of $20,000 for an ESP that operates at a ventilation rate of 2,000 cfm, which is sufficient ventilation for single chain-driven charbroiler unit. The District also included additional costs for installing optional equipment designed to enhance the performance and operation of the electrostatic precipitator and reduce the overall maintenance costs:

- First pass autowash module, including timer, to automatically wash the plates - $4,000

- Outdoor weather package to insulate and weatherproof the unit if it is installed on the roof of the restaurant - $4,000
- Advanced hood filters in the hood system that capture 55% to 60% of the large particles and consequently reduces the cleaning frequency of the plates - $1,500.

A hot water line, drain, and wiring to the timer would be installed to support the automatic wash system at a cost of $7,500. The total capital cost for installing the ESP with automatic wash is estimated at $37,000. This cost is relatively high based on the additional options that were included in the cost estimate. Restaurants may purchase a single pass electrostatic precipitator without any additional enhancements for about $20,000.

<u>Operating Costs:</u> Annual O&M costs are anticipated not to exceed $1,480. The ESP unit itself uses minimal energy, equivalent to that used by a 60 watt light bulb. However, industry representatives have stated that O & M costs will vary depending on the options that are installed in the unit at the time of purchase.

A self-cleaning ESP with automatic water wash requires some additional cleaning of the plates and inside housing to ensure optimal performance. The automatic washing unit requires approximately one (1) gallon of detergent for each plate per week at a cost ranging from $9 to $18 per gallon. If the automatic wash cycle is not installed, then one to two gallons of detergent is sufficient to soak and clean the plates per month.

A restaurant owner can either contract with a cleaning service or perform the maintenance and cleaning of the ESP themselves. A cleaning service will remove the first pass of plates; insert clean plates; soak, clean, and store the used plates; and power-wash the housing of the ESP using manufacturer's approved detergent, at a cost ranging from $303 to $920 per month.

Restaurants that choose to clean the ESP themselves, may soak the plates overnight and install a second set of plates while the first set is being washed for a cost of $123 per month, which includes the cost of the detergent for the autowash unit. If the restaurant opts to install more efficient hood filters, then the cleaning frequency and, thus, the cost of cleaning, can be reduced by half.

Restaurant owners may also purchase optional odor control units that will increase the cost of the unit by at least $1,000 and the operating cost by at least $10,000 per year. For this assessment, staff estimated costs for operating a double pass electrostatic precipitator without an odor control unit where the plates are cleaned in-house and advanced hood filters have been installed.

The total annualized cost of installing this control, including O&M, is $6,734. An ESP has a 90% collection efficiency for PM. It is expected that 0.29 tpd of PM (total of 105 tons per year) emission reductions can be achieved. The cost-effectiveness to reduce emissions by installing an ESP for a chain-driven charbroiler is $28,329 per ton of PM reduced.

Fiber-Bed Filters

Capital Costs: Fiber bed filter systems have a capital cost of $25,000 with an estimated installation cost of $2,500.

Operating Costs: Annual O&M costs of replacing the filter ($3.18 per cubic feet per minute flow) and utility costs for operating the equipment are $7,500.

The total annualized cost of installing this control, including O&M, is $11,405. The filters are capable of removing 90% of PM emissions. Based on the estimates of 0.34 tpd of PM emissions, it is expected that 0.29 tpd of PM (total of 105 tons per year) emission reductions can be achieved. The cost-effectiveness to reduce emissions by installing fiber-bed filters for a chain-driven charbroiler is $47,980 per ton of PM reduced.

Thermal or Direct-fired Incineration

Capital Costs: Manufacturers estimated a cost of $25,000 for the incineration unit plus an additional $6,350 for the installation.

Operating Costs: The unit requires 26 therms of natural gas per hour to operate. Using a rate of $0.63 cents per therm and assuming 16 hours of operation for 365 days per year, the annual O & M cost is $95,659.

The total annualized cost of installing this control including O & M is $100,111. PM and VOC removal efficiencies range from 95% to 99.9% depending upon the temperature, residence time, and mixing inside the incinerator. Assuming a removal efficiency of 95%, a total PM and VOC emission reduction of 0.40 tpd (148 tons per year) is expected. The cost-effectiveness is approximately $303,761 per ton of PM and VOC reduced from a chain-driven charbroiler.

Table 4. Annual Cost for Controls on Chain-driven Charbroilers

Control for Chain-driven Charbroiler	Capital Cost for Equipment and Installation (Dollars)	Annualized Capital Cost (Dollars per year)	Annual Recurring O&M Costs (Dollars per year)	Total Annual Cost (Dollars per year over 10 years)
Catalytic Oxidizer	$9,000	$1,278	$750	$2,028
Wet Scrubber	$27,025	$3,838	$2,000	$5,838
Electrostatic Precipitators	$37,000	$5,254	$1,480	$6,734
Fiber Bed Filters	$27,500	$3,905	$7,500	$11,405
Thermal Incinerator	$31,350	$4,452	$95,659	$100,111

Table 5. Cost Effectiveness of Potential Controls on Chain-driven Charbroilers

Control for Chain-driven Charbroiler	Total Annual Cost (Dollars per year over 10 years)	Total PM and VOC Emission Reduction (Tons per year)	Number of Chain-Driven Charbroilers	Cost-Effectiveness (Dollars per ton of VOC and PM removed)
Catalytic Oxidizer	$2,028	132	443	$6,837
Wet Scrubber	$5,838	105	443	$24,558
Electrostatic Precipitators	$6,734	105	443	$28,329
Fiber Bed Filters	$11,405	105	443	$47,980
Thermal Incinerator	$100,111	148	443	$303,761

Under-fired Charbroilers

As described in Section III, the District evaluated the technical feasibility, potential emission reductions, and costs of installing an ESP, thermal incinerator, wet scrubber, or HEPA filter to control particulate matter emissions from under-fired charbroilers. Table 6 presents a summary of the total annual cost for installing and maintaining the equipment, and Table 7 presents the cost-effectiveness. Catalytic oxidizers, designed to fit directly on top of a chain-driven charbroiler, have not been developed for under-fired charbroilers. The currently available control options for an under-fired charbroiler are more expensive although under-fired charbroilers produce more emissions. For this reason, the proposal to control under-fired charbroilers is focused on restaurants with large grills (equal to or greater than 10 square feet) that purchase 1000 lbs. of beef per week rather than 500 and grills 800 lbs. of beef per week.

HEPA Filters

Capital Costs: HEPA filters have a capital cost of $35,000 for a 3,000 cfm unit and an estimated installation cost of $2,000.

Operating Costs: The annual O&M costs are anticipated to not exceed $3,000. HEPA filter units use a filter module that consists of three filters placed in series. The first filter is called a pre-filter that is fully disposable pleated filter that cost $6 per filter and must be replaced every four (4) weeks. The second filter is a medium filter that is a fully disposable bag filter that cost approximately $10 per filter and is replaced every eight (8) weeks. The final filter is a fully disposable 12 inch HEPA filter that costs $200 per filter and is replaced every six (6) months.

The total annualized cost of installing this control, including O&M, is $8,254. It is expected that 95% of PM may be captured using this control device. Based on estimate of 0.31 tpd of PM emissions from restaurants affected by the proposal, the PM emission reduction is anticipated to be 0.29 tpd (total of 107 tons per year). The cost-effectiveness to reduce emissions by installing HEPA filters to control an under-fired charbroiler is $17,306 per ton of PM reduced.

Electrostatic Precipitators

Capital Costs: Manufacturers provided a range of costs for a double pass electrostatic precipitator (ESP) with ducting and exhaust fan of $20,000 for a ventilation rate of 2,000 cfm to $40,152 for a ventilation rate of 5,000 cfm. For this assessment of the costs to control an under-fired charbroiler, a maximum ventilation rate of 4,000 cfm was used. This ventilation rate is typical required for a large under-fired charbroiler. The cost of an ESP that operates at this ventilation rate is $27,500. Installation costs are site-specific and will vary depending on given local building codes. The District calculated costs for a 4,000 cfm ESP that includes an automatic wash system, outdoor weather package, more efficient hood filters, plumbing for a hot water line and drain, and electrical wiring for the autowash system. The total capital cost is estimated to be $44,500. However, the cost of the electrostatic precipitator may be as low as $20,000, if fewer options were installed, or may be higher if the ESP must accommodate a higher ventilation rate.

Operating Costs: The annual O&M cost is anticipated not to exceed $2,480. The ESP is assumed to be serviced in-house including cleaning and the plates and power-washing the housing. Detergent costs are estimated at $2,000 per year. For more information regarding O&M costs for an ESP, see the discussion of electrostatic precipitator operating costs under the heading “Chain-Driven Charbroilers,” above.

The total annualized cost of installing this control, including O&M, is $8,799.

ESPs will remove 90% of PM. Based on the estimates of 0.31 tpd of PM emissions from restaurants subject to this rule, it is expected that 0.28 tpd of PM (total of 102 tons per year) emission reductions can be achieved. The cost-effectiveness to reduce emissions by installing an ESP on an under-fired charbroiler is $19,468 per ton of PM reduced. If a restaurant chooses to contract with a service company for monthly cleaning of the plates and housing, the cost-effectiveness can be as high as $37,847 per ton of PM removed. ESPs that are installed without the autowash system and are cleaned nightly by restaurant personnel have a cost–effectiveness of $11,899 per ton of PM.

Wet Scrubbers

Capital Costs: A wet scrubber unit has a capital cost of $30,452 for a system that operates at 3,000 cfm, and an estimated installation cost of $6,266. The costs include all components and accessories necessary for the complete operation of the unit.

Operating Costs: The annual O&M cost is anticipated to not exceed $6,582. This O & M cost estimate includes the energy cost for operating the controller and exhaust blower, as well as the monthly expense of purchasing non-foaming surfactants detergent.

The total annualized cost of installing this control including O&M is $11,796. Although wet scrubbers have achieved PM removal efficiencies of 90% at restaurants in the South Coast Air Quality Management District, wet scrubbers are not commonly used in restaurants located in the Bay Area. Based on the estimates of 0.31 tpd of PM emissions from mixed meats, it is expected that 0.28 tpd of PM (total of 102 tons per year) emission reductions can be achieved. The cost-effectiveness to reduce emissions by installing a wet scrubber on an under-fired charbroiler is $26,098 per ton of PM reduced.

Thermal or Direct-fired Incineration

Capital Costs: Manufacturers estimated a cost of $25,000 for the incineration unit plus an additional $6,350 for the installation.

Operating Costs: The unit requires 26 therms of natural gas per hour to operate. Using a rate of $0.63 cents per therm and assuming 16 hours of operation for 365 days per year, the annual O&M cost is $95,659.

The total annualized cost of installing this control, including O&M, is $100,111. PM and VOC removal efficiencies range from 95% to 99.9% depending upon the temperature, residence time, and mixing inside the incinerator. Assuming a removal efficiency of 95%, a total PM and VOC emission reduction of 0.43 tpd (158 tons per year) is expected from restaurants subject to this proposal. The cost-effectiveness is approximately $142,588 per ton of PM and VOC reduced.

Table 6. Annual Cost for Controls on Under-Fired Charbroilers

Control for Chain-driven Charbroiler	Capital Cost for Equipment and Installation (Dollars)	Annualized Capital Cost (Dollars per year)	Annual Recurring O&M Costs (Dollars per year)	Total Annual Cost (Dollars per year over 10 years)
HEPA Filters	$37,000	$5,254	$3,000	$8,254
Electrostatic Precipitators	$44,500	$6,319	$2,480	$8,799
Wet Scrubber	$36,718	$5,214	$6,582	$11,796
Thermal Incinerator	$31,350	$4,452	$95,659	$100,111

Table 7. Cost Effectiveness of Proposed Controls on Under-Fired Charbroilers

Control for Chain-driven Charbroiler	Total Annual Cost (Dollars per year over 10 years)	Total PM Emission Reduction (Tons per year)	Number of Under-Fired Charbroilers*	Cost-Effectiveness (Dollars per ton of VOC and PM removed)
HEPA Filters	$8,254	107	225	$17,306
Electrostatic Precipitator	$8,799	102	225	$19,468
Wet Scrubber	$11,796	102	225	$26,098
Thermal Incinerator	$100,111	158	225	$142,588

*Includes 25 additional under-fired charbroilers from new construction in the first year.

C. Incremental Cost Effectiveness

Section 40920.6 of the California Health and Safety Code requires an air district to perform an incremental cost analysis for any proposed Best Available Retrofit Control Technology rule or feasible measure. The air district must: (1) identify one or more control options achieving the emission reduction objectives for the proposed rule, (2) determine the cost effectiveness for each option, and (3) calculate the incremental cost effectiveness for each option. To determine incremental costs, the air district must "calculate the difference in the dollar costs divided by the difference in the emission reduction potentials between each progressively more stringent potential control option as compared to the next less expensive control option."

To determine incremental costs, the District compared the cost-effectiveness of each control device presented in Table 5 for chain-driven charbroilers and Table 7 for under-fired charbroilers. Table 8 presents a summary of the incremental cost-effectiveness associated with the proposed regulation.

As shown in Table 8, the catalytic oxidizer is the most cost-effective control device for chain-driven charbroiler. The cost-effectiveness of the other control technologies ranges from $24,558 to $303,761 per ton of PM removed. In addition, the catalytic oxidizer operates without an external energy supply since it uses the heat generated from the cooking process to activate the catalyst. The catalyst also radiates heat back to the charbroiler, and as a result, less energy is required to operate the charbroiler. Although the proposed standard essentially allows the use of any of the control technologies listed in Table 8, the proposed standard is based on the use of a catalytic oxidizer.

For under-fired charbroilers, ESPs and HEPA filters are the most cost-effective control devices for controlling PM emissions. The wet scrubber is also a viable control option to restaurant owners given its proven control efficiencies in other industries. The thermal incinerator has substantially higher costs to operate.

Table 8. Incremental Cost Effectiveness of Proposed Controls on Under-Fired Charbroiler

Type of Charbroiler	Control	Cost-Effectiveness (Dollars per ton of VOC and PM removed)	Incremental Cost Effectiveness (PM only)
Chain-Driven Charbroiler	Catalytic Oxidizer	$6,837	$0.0
	Wet Scrubber	$24,558	$17,721
	Electrostatic Precipitator	$28,329	$21,492
	Fiber Bed Filters	$47,980	$41,143
	Thermal Incinerator	$303,761	$296,924
Under-Fired Charbroiler	HEPA Filters	$17,306	$0.0
	Electrostatic Precipitator	$19,468	$2,162
	Wet Scrubber	$26,098	$10,049
	Thermal Incinerator	$142,588	$126,539

D. District Staff Impacts

Currently, the District does not regulate emissions from restaurants except on a nuisance or smoke basis. Implementing this rule will require District resources from several divisions including Compliance and Enforcement, Engineering, and Administration. The actual personnel involved will likely involve air quality inspectors; an air quality technician to coordinate development of the web-based registration system, review registrations, and answers questions from the public; engineers to review the manufacturer's certification and testing procedures; a program analyst to design the web-based registration and maintain the registration database; and an accountant to process registration and fees.

In the first year after adoption, the proposal calls for all owners and operators of restaurants that have chain-driven charbroilers and that purchase at least 500 pounds of beef and cook at least 400 pounds of beef on the charbroiler to install a catalytic oxidizer or alternative control device certified for use under the rule. There are approximately 443 chain-driven charbroilers currently operating in the Bay Area that would be subject to this proposed rule. The District anticipates that an inspection should require no more than 100 minutes for each restaurant including drive time and paperwork. Given the number of restaurants, inspection time would be about 739 hours in the first year which is equivalent to 0.36 full-time employees (FTE), at a cost of $77,040 for an air quality inspector.

This proposal would be the first District rule to require web-based registration. In order to develop this system, a program analyst and an air quality engineer will be required to develop the registration form, maintain the registration database, review registrations, and respond to public inquiries. This is estimated to cost approximately $45,800 (0.21 FTE). Because many catalytic oxidizers have already been approved by the South Coast air district for control of chain-driven charbroilers, no more than $5,260 (0.02 FTE for a Principal Engineer) would be required to review manufacturers' certifications.

Starting two years after the rule is adopted, owners and operators of restaurants that have newly-installed under-fired charbroilers with a total of at least ten square feet of grill surface area would have to install and operate a control device if the restaurant purchases at least 1,000 lbs. of beef and cooks at least 800 lbs. of beef on the charbroiler. In five years, all restaurants with under-fired charbroilers totaling at least ten square feet of grill surface area that are subject to the proposed rule would be required to install a control device. There are currently 489 restaurants in the Bay Area that have under-fired charbroilers totaling at least 10 square feet of grill surface area. The rule would apply to approximately 200 of these restaurants. Inspections are anticipated to cost $23,219 based on 217 hours per year (0.11 FTE, Air Quality Inspector). Maintenance of the web-based registration system will cost $11,235 (0.05 FTE, Air Quality Engineer). Review of the certifications provided by control device manufacturers expected to cost $15,770 (120 hours or 0.06 FTE, Principal Air Quality Engineer).

In total, the District is anticipated to incur a cost of approximately 0.81 FTE per year in the first five years to implement this proposed rule based on the estimates above. To recover costs, a registration fee of $360 and annual recurring fee of $100 is proposed. The fee schedule for restaurants in Regulation 3, Schedule R is proposed to be revised to reflect the current proposed Regulation 6, Rule 2.

E. Socioeconomic Impacts

Section 40728.5 of the Health and Safety Code requires an air district to assess the socioeconomic impacts of the adoption, amendment, or repeal of a rule if the rule is one that "will significantly affect air quality or emissions limitations."

Applied Economic Development, Berkeley, California, has prepared a socioeconomic analysis. The analysis concludes that the affected restaurants should be able to absorb the costs of compliance with the proposed rule without significant economic dislocation or loss of jobs. The socioeconomic analysis is attached as Appendix D.

VII. ENVIRONMENTAL IMPACTS

Pursuant to the California Environmental Quality Act, the District has had an initial study for the proposed amendments prepared by Environmental Audit, Inc. The initial study concludes that there are no potential significant adverse environmental impacts associated with the proposed amendments. A negative declaration is proposed for adoption by the District Board of Directors. The initial study and negative declaration will be circulated for public comment.

VIII. REGULATORY IMPACTS

Section 40727.2 of the Health and Safety Code requires an air district, in adopting, amending, or repealing an air district regulation, to identify existing federal and district air pollution control requirements for the equipment or source type affected by the proposed change in district rules. The district must then note any differences between these existing requirements and the requirements imposed by the proposed change.

Adoption of this rule would not conflict with any existing federal or District requirement. Under the federal air pollution requirements, there is no rule that limits emissions from restaurants. The District also does not have any rules that are applicable to restaurants except those of general applicability such as Regulation 1, Section 301: Public Nuisance and Regulation 6: Particulate Matter.

IX. RULE DEVELOPMENT PROCESS

District staff has undertaken a comprehensive public outreach program to involve all stakeholders in developing this proposal, including individual restaurant owners, hood manufacturers, restaurant trade organizations and industry representatives, county health departments, and vendors and installers of commercial kitchen appliances.

The District started the rule development process in January 2005. At that time, the District contacted the SCAQMD to receive copies of all research documents and staff reports that were produced in support of SCAQMD Regulation 1138. The District then contacted the health departments of all the counties in the District in March 2005 and December 2005, to request an inventory of currently permitted restaurants and to apprise the counties of the District’s intent to consider restaurant controls. The District held two meetings with county health officials, one on January 19, 2006, and another on July 28, 2006. The purpose of the meetings was to discuss the current emission inventory, solicit suggestions for ways to control emissions, and development of a cooperative enforcement strategy between the District and the various counties.

The District also initiated contacted with the Golden Gate Restaurant Association in February 2006 to invite their participation in the rule development process. The District met with representatives of the Golden Gate Restaurant Association on February 24, 2006, and had follow-on telephone discussions as the rule evolved.

District staff contacted the PG&E Food Service Technology Center in San Ramon, California in May 2006 regarding emission factors for specific types of commercial cooking equipment. After conducting a site walk of their facility, District staff has been in continuous discussions with representatives from the Food Service Technology Center in developing this proposal. The Center represents the interests of the restaurant industry and kitchen ventilation hood manufacturers. The Center is also a clearing house for commercial kitchen equipment performance and has expertise in commercial kitchen ventilation and building energy efficiency.

District staff also verified the emission inventory by conducting source tests on four restaurants in the Bay Area. District staff tested two restaurants that operated either a chain-driven charbroiler or under-fired charbroiler that exhausted their emissions through a control device. For comparison purposes, the District also collected particulate matter samples from two restaurants that operated either a chain-driven charbroiler or under-fired charbroiler without any control device. The emission estimates were used to determine emission standards in the proposed rule.

In October 2006, in advance of public workshops held in November 2006, District staff published the draft regulation and provided a workshop report explaining the proposed regulation. The first draft of Regulation 6, Rule 2, and the workshop report were posted on the District web site and e-mailed to stakeholders on October 16, 2006. Simultaneous to the posting on the District web site, the District sent out approximately 17,000 postcards to individual restaurant owners, hood vendors, and installers informing them of the rule and the then-upcoming public workshop. The District also developed a rule summary fact sheet that was translated to Chinese and Spanish and made available on the District web site.

Once the regulation was posted, the District received and responded to more than 20 telephone inquiries and e-mails regarding specific topics and issues about the draft rule and workshop report.

The District held four (4) public workshops on November 14 and 15, 2006, in San Francisco, San Jose, Oakland, and Vallejo to solicit comments from public, members of county health departments, industry organizations, and other interested parties on the proposed rule. A total of approximately 20 people attended these workshops, with most of the interested parties being hood manufacturers, a restaurant organization, and independent local restaurants. The District received written comments from hood manufacturers that were identical to comments provided by the restaurant organization.

Overall, the public comments supported the standard for chain-driven charbroilers. Input from the first workshop raised concerns about the technical feasibility and costs of installing high efficiency filters, a modest control, in all restaurants that operate a Type I hood. There was disagreement within the industry regarding the effectiveness of high efficiency filters. The trade organization did not support the installation of controls on restaurants that utilize low emission cooking equipment. Another comment suggested that the rule would result in more energy consumption and additional greenhouse gas emissions.

After the November public workshops, the District continued discussions with hood manufacturers and trade organizations regarding ways to revise the proposal. These interactions lead directly to developing a second draft of Regulation 6, Rule 2 to address emissions from only charbroilers. A supplement to the workshop report was generated to summarize the differences from the original proposal. The District presented the revised proposal before the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) Technical Committee 5.10 Kitchen Ventilation on January 27, 2007. The second workshop notice and revised rule were posted on the District website and e-mailed to all interested parties. The second workshop was held on March 6, 2007.

Input from the second workshop was focused primarily on removing certain requirements intended to promote energy efficiency and on the cost-effectiveness of control technologies. One set of comments requested that the District lower the effective grill size from 10 square feet to six (6) square feet and include a provision to regulate emissions from griddles. Staff used input received from the second workshop to develop the final draft of the proposed regulation that is published as a companion to this Staff Report for comments on April 2, 2007.

On May 16, 2007 an initial public hearing was conducted by the Board of Directors on proposed Regulation 6, Rule 2. Comments and questions at the hearing addressed issues including: the number of restaurants with charbroilers larger than 10 square feet; emissions from meats other than beef; and potential impacts to small businesses. The District Board directed staff to do additional research and referred the rule to the Stationary Source Committee.

Staff conducted a survey of Bay Area restaurants, focusing on the grill size and amounts and types of meats cooked on under-fired and chain-driven charbroilers. District inspectors interviewed a representative sample of over 400 randomly selected restaurants from all nine Bay Area counties. The survey verified that the grill size specified in the rule focuses control requirements on large, high-production restaurants that represent approximately 4% of the restaurants that operate an under-fired charbroiler. In addition, staff has further investigated emissions from various types of meats and costs to operate and maintain control technologies. District staff also met with representatives from the Golden Gate Restaurant Association on June 14, 2007 and July 25, 2007, and with a representative from the California Restaurant Association on August 11, 2007.

Based on the findings from the survey and meetings with restaurant associations, the proposed rule was revised to focus control requirements on those restaurants that purchase and grill large quantities of beef. District staff revised the proposed Regulation 6, Rule 2 and held a workshop on the revised proposal on October 23, 2007.

The District sent approximately 13,300 postcards to Bay Area restaurants to notify them of the revised proposal and the public workshop. Comments at the workshop and in subsequent letters primarily focused on questions concerning the certification testing procedures to demonstrate compliance with the emission standard. One commenter noted the lack of a testing procedure in the proposed rule for new catalytic oxidizers and a question was asked about how a restaurant would demonstrate an exemption under the proposed rule. The proposed rule has been restructured based on these comments such that catalytic oxidizers certified by the SCAQMD are acceptable for installation in the Bay Area. The certification testing procedures have been revised for consistency with the definitions and the emission standards. Compliance advisories can provide guidance on how to demonstrate an exemption.

The District will continue to follow the development of cost effective control technologies for existing under-fired charbroilers and provide technical updates to the Board of Directors.

X. FUTURE RESEARCH

Emissions from restaurant operations currently make up over 6% of all PM_{10} emissions in the Bay Area. This rule is an important first step in achieving emission reductions from a source category that has not been regulated in the past. District staff is committed to working with industry representatives and to provide the Board of Directors with periodic updates on the development of control technology for under-fired charbroilers. This rule is an opportunity for hood manufacturers, abatement equipment manufacturers, and cooking equipment manufacturers and vendors to work together in developing new and adapting existing technologies.

Catalytic oxidizers, a highly cost-effective and virtually maintenance-free control device for chain-driven charbroilers were developed in response to the SCAQMD Regulation 1138, adopted in 1997. Because the SCAQMD rule did not regulate under-fired charbroilers, there has been limited research and development directed at control technologies for these cooking devices. A regulatory mandate will help to create a market for under-fired charbroiler abatement technology. For this reason, the compliance date for existing under-fired charbroilers is set five years in the future, to allow time for development of better, more cost-effective technologies.

The proposed rule is only the first step in an ongoing commitment to reduce emissions from commercial cooking appliances. As additional data becomes available, District staff will be evaluating possible controls on other types of cooking equipment, including griddles, woks, and wood-fired cooking appliances. There are over 7,000 griddles that operate in the Bay Area that, collectively, are responsible for about 14% of commercial cooking emissions. Studies conducted on wok cooking indicate woks emit a number of toxic compounds from volatilization and partial combustion of the cooking oils. Combustion of wood in wood-fired cooking appliances produces the same emissions as wood stoves and fireplaces and occurs much more frequently than residential wood burning. District investigation into possible controls on these and other types of cooking equipment will be part of efforts to reduce PM emissions in order to achieve state PM standards and (if necessary) the new federal 24-hour PM standard.

Staff is interested in further research in this field to support further development of data on emissions from griddles, woks, wood-fired cooking appliances, and other types of cooking appliances. The District will closely monitor research which could be used to refine the emission inventory, assess risk factors, and identify whether additional rule making should be conducted.

XI. CONCLUSION

Pursuant to Section 40727 of the California Health and Safety Code, the proposed rule must meet findings of necessity, authority, clarity, consistency, non-duplication, and reference. The proposed regulation is:

- Necessary to protect public health by reducing ozone precursors and particulate matter emissions to meet the requirements of Senate Bill 656 Particulate Matter Implementation Schedule and further study commitment of the Bay Area 2005 Ozone Strategy;
- Authorized by California Health and Safety Code Sections 40000, 40001, 40702, and 40725 through 40728;
- Clear, in that the new regulation specifically delineates the affected industry, compliance options, and administrative requirements for industry subject to this rule, so that its meaning can be easily understood by the

persons directly affected by it;
- Consistent with other District rules, and not in conflict with state or federal law;
- Non-duplicative of other statutes, rules, or regulations; and
- Implementing, interpreting and making specific the provisions of the California Health and Safety Code sections 40000 and 40702.

The proposed rule has met all legal noticing requirements, has been discussed with the regulated community and other interested parties, and reflects the input and comments of many affected and interested parties. In addition to Regulation 6, Rule 2, fees for registering charbroilers under Regulation 3 would be reduced, and Regulation 6: Particulate Matter and Visible Emissions would be renumbered and renamed for consistency. District staff recommends adoption of proposed Regulation 6, Rule 2: Commercial Cooking Equipment, adoption of proposed amendments to Regulation 3, Schedule R: Equipment Registration Fees, adoption of proposed amendments to Regulation 6: Particulate Matter and Visible Emissions, and adoption of the CEQA Negative Declaration.

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APPENDIX A
EMISSIONS CALCULATIONS

The following sections describe the method used to quantify PM and VOC emissions from broilers for the nine Bay Area counties.

A. Estimated Number of Restaurants with Charbroilers

To obtain an accurate estimate of the total number of commercial restaurants in the District, staff contacted the health and environmental departments from each of the nine Bay Area counties: Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Solano, and Sonoma. County health agencies maintain lists of restaurants and other facilities in order to inspect and regulate food handling practices within the county's jurisdiction. Table A-1 presents the results of the survey. Restaurants situated in the City of Berkeley are under the jurisdiction of the local health department and not regulated by the Alameda County health department. The number of restaurants in the City of Berkeley is included in Table A-1.

Table A-1. Commercial Restaurants by County

County/City	**Total Number of Restaurants**	**Adjusted Total for Commercial Restaurants**
Alameda County	3,700	2,651
Contra Costa County	1,989	1,425
City of Berkeley	468	336
Marin County	607	435
Napa County	345	248
San Francisco County	3,997	2,863
San Mateo County	2,018	1,446
Santa Clara County	4,933	3,534
Solano County*	1,146	821
Sonoma County*	1,504	1,078
TOTAL	**20,707**	**14,838**

Note: * - The number of restaurants for Solano and Sonoma counties was adjusted based on the percentage of the total population within the District jurisdiction (71.2% for Solano County and 87.7% for Sonoma County).

The initial estimate of 20,707 restaurants in the District includes establishments that do not cook (i.e., delicatessens, ice cream parlors, juice bars, etc), institutional eating facilities (i.e., school cafeterias, lodges, retirement homes), and restaurants that have gone out of business. Because the restaurant names and addresses were not requested as part of the survey, the exact number of facilities that would normally be excluded as "noncommercial" restaurants could not be determined. Pacific Environmental Services (PES) conducted a similar study for the South Coast Air Quality Management District (SCAQMD) in 1999 to determine the number of commercial restaurants under its jurisdiction and found that on average, approximately 77% of the facilities classified as restaurants were commercial facilities that served food to the general public. The study was based on a restaurant survey conducted in the City of Pasadena, the City of Vernon, and Riverside County where 19.4, 16.7 and 23.9 percent, respectively, of the facilities were not commercial restaurants. In addition, PES also determined that approximately 6.97% of the restaurants have gone out of business since the health department lists were compiled.

Using the results of the PES study, a factor of 0.7163 (0.77 for commercial restaurants multiplied by 0.9303 for open business) was then applied to the total number of restaurants in the District to exclude those facilities from the survey that did not serve food, were not open to the public, or have gone out of business. Rounding all estimates to the next whole number, the final number of commercial restaurants in the District was projected at 14,838.

The PES study further surveyed the type of equipment that was used in the cooking operations of the commercial restaurants. Based on the SCAQMD report, the majority of emissions (87% of PM and 82% of VOC) from cooking operations are generated from chain-driven and under-fired broilers.

Chain-driven broilers consist of conveyorized belts that carry meat to a flame area that broils the meat on the top and bottom simultaneously. Under-fired broilers have three components: a heating source, high temperature radiant surface, and slotted grill. The grill holds the meat while it is cooked from radiant heat. The study found that the fraction of facilities in the SCAQMD that operated chain-driven and under-fired broilers based on 95th percent confidence limits (in parenthesis) was:

Under-fired broilers:	0.330 (0.29 – 0.37), or 33%
Chain-driven broilers:	0.0373 (0.0212 – 0.0534), or 4%

A state-wide study conducted by Public Research Institute (PRI) in 2001 for the California Air Resources Board and the California Environmental Protection Agency found that approximately 8% of the restaurants had chain-driven broilers while 45% of the restaurants had under-fired broilers. The PRI study determined a higher average percentage of broilers per restaurant than the PES study mainly due to the fact that the PRI study focused on restaurants thought to conduct more broiling activities than other types of restaurants. Given this bias, District staff considered the PES study results more reflective of the likely representation of broilers in the Bay Area.

The District conducted an independent survey of Bay Area restaurants to verify the findings from the PES study. District inspectors surveyed over 400 randomly selected restaurants in the Bay Area and questioned them on the type of cooking equipment they used, the size of the equipment, and the amount and type of meat that is cooked per week. The Bay Area survey confirmed that the percentages of restaurants that operate a chain-driven charbroiler and/or under-fired charbroilers are consistent with the PES study findings.

Multiplying by the fraction of broilers determined in the PES study, the estimated number of broilers in the District is (rounding up to the nearest whole number):

Under-fired broilers: 4,897
Chain-driven broilers: 554

B. Amount and Type of Meat Cooked on Charbroilers

The PES study asked the restaurants to report their average weekly use of hamburger, steaks, poultry (with and without skin), pork and seafood, based on the type of cooking equipment used. The average food throughput for chain-driven broiler and under-fired broiler restaurants is presented in Table A-2.

Table A-2. Average Pounds of Meat Cooked Per Year Per Charbroiler (PES Study)

Type of Food	Chain-driven Broiler (lbs/year)	Under-Fired Broiler (lbs/year)
Hamburger	108,846	7,795
Steaks	9,443	6,474
Poultry with Skin	5,200	15,226
Poultry without Skin	18,413	6,027
Pork	6,932	1,404
Seafood	7,457	5,673
TOTAL	**156,291**	**42,599**

In a state-wide phone survey conducted by PRI, the average amount of meat cooked per year varied significantly from the results of the PES study. Table 3 presents the results of the PRI study.

Table A-3. Average Pounds of Meat Cooked Per Year Per Charbroiler (PRI Survey)

Type of Food	Chain-driven Broiler (lbs/year)	Under-Fired Broiler (lbs/year)
Hamburger	41,486	14,049
Steaks	12,281	9,363
Poultry with Skin	7,651	7,485
Poultry without Skin	13,842	9,311
Pork	2,997	7,699
Seafood	6,179	7,416
TOTAL	**84,436**	**55,323**

Although both studies had comparable number of responders (543 for PES and

655 for PRI), the major differences between the PES and PRI studies were: (1) the PRI study used computer-assisted telephone interviews instead of PES's use of a self-administered (mail-out) questionnaire; (2) PRI used a more detailed restaurant classification scheme and not all categories of restaurants were surveyed; (3) the PRI study focused on restaurants most likely to use broilers; and (4) PRI surveyed restaurants throughout California while PES investigated restaurants within SCAQMD. Overall, PES had a low response rate with only 12.9% of the restaurants responding to the survey while PRI had a response rate of 41%. Given that PES did not receive any responses from the 210 national chain restaurants in its study area, it is unknown if this would significantly impact their estimated amount of hamburger cooked on chain-driven broilers. (A majority of this type of equipment is utilized by fast food restaurants). It should be noted that PES did receive responses from local chain and fast food restaurants that were not considered "national" chains. PRI received responses from 157 fast food restaurants, which equated to 23.9% of the responders. Based on the broader geographic coverage of the responders and the inclusion of cooking practices from fast food restaurants, District staff considered the results of the PRI study (Table A-3) a more representative estimate of the amount of meat cooked on broilers per year. The Bay Area restaurant responses on the amount of meat purchased per week were not included due to the low response rate (less than 14% of the restaurants responded to the question).

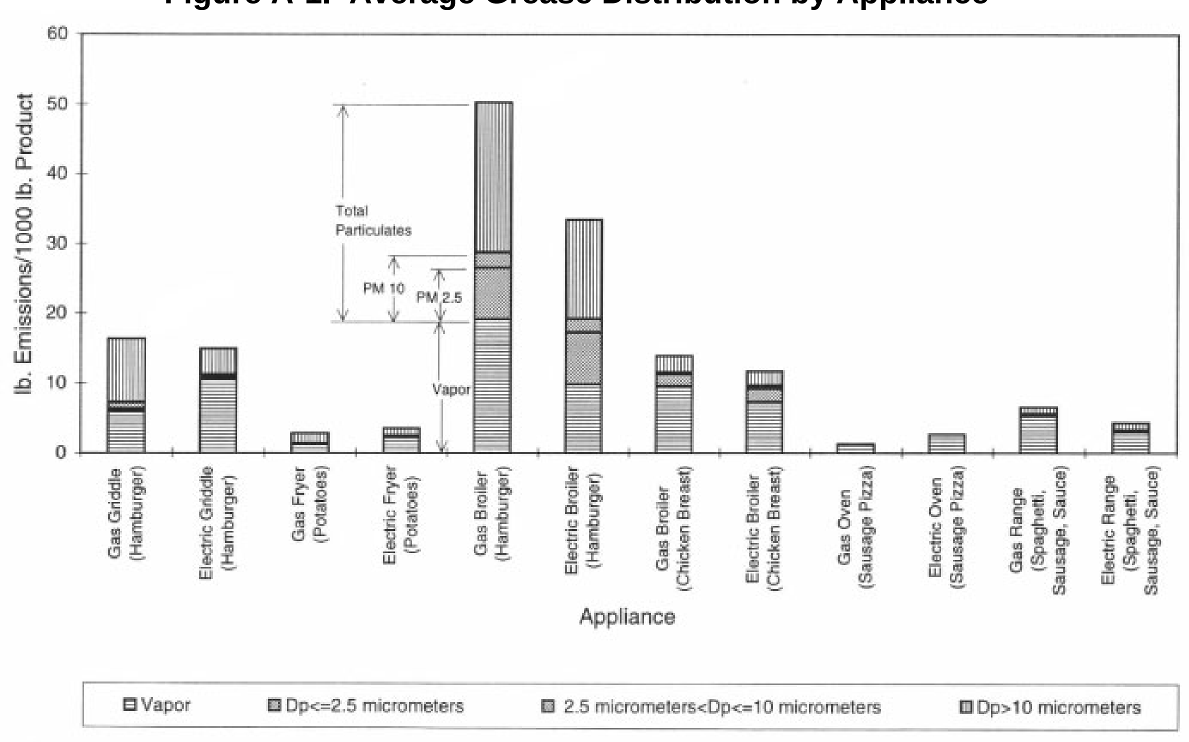
C. Emission Factors from Broilers

SCAQMD contracted the University of California Riverside, College of Engineering – Center for Environmental Research and Technology (CE-CERT) in 1997 to develop a test method that estimates emission factors for PM_{10} and VOC released from various restaurant cooking operations. The resulting study (the "CE-CERT study") included tests conducted for hamburger cooked on under-fired and chain-driven broilers. A subsequent study sponsored by ASHRAE, published in 1999 by Gerstler, et al., from the University of Minnesota, Department of Mechanical Engineering (the "Gerstler study") characterized the effluent emissions from various grease producing cooking processes. The study measured grease particulate and vapor emissions and real time particulate size distributions within the exhaust duct using a sample probe and following US EPA Method 5.

Figure A-1 shows the average grease distribution emitted from each appliance as determined by the Gerstler study. The actual composition of the emitted products is complex and it is difficult to determine the portion of the emissions that are particulates. That is because condensable vapors such as water and grease are present in vapor as well as liquid form. Generally, condensables are vapors in gaseous form at entry into the ventilation hood, but may condense into particulate form (i.e., liquid or solid state) in the duct works, on exiting the exhaust fan, or in the atmosphere. The CE-CERT study included the emissions from condensable vapors into its total particulate emission factor. Because these vapors behave as gases, they cannot be removed through mechanical filtration. Particulate matter greater than 10 microns in size are generally not emitted into the atmosphere, the CE-CERT study confirmed. Standard baffle filters capture particles coarse particulate, those greater than 10 microns in size. Previous testing conducted by CE-CERT for the SCAQMD showed that the particulate matter emitted was all PM_{10}. US EPA Method 5 measures total particulates, including particulates greater than 10 microns in diameter. Although the rule requires the use of US EPA Method 5 for determining compliance with the emission standard, the effluent stream that will be sampled will only consist of particulates less than 10 microns in diameter because the test protocol requires a baffle filter (as part of standard kitchen exhaust equipment). The heated probe situated at the front of the sampling train will not condense vapors and in turn, skew the test results.

Based on the emission factors from the Gerstler study, the District estimates that Type 1 hoods (hoods with fire suppression built into the exhaust system, required for all cooking appliances in restaurants) capture 1,573 tons per year (4.3 tons per day) of PM greater than 10 micron in size from the nine Bay Area counties. For this report, emissions were estimated for particulates less than PM_{10} and for VOC.

Figure A-1. Average Grease Distribution by Appliance



Source: Gerstler et al, 1999

A total of 50 lbs. of emissions is generated from a gas broiler for every 1000 lbs. of hamburger cooked. Based on the Gerstler study, approximately 39% (19 lbs.

for every 1000 lbs. of meat cooked) of the total grease emitted from cooking hamburgers on an under-fired broiler is in the form of condensable vapors. Of the remaining 61% (31 lbs) of grease emissions, 42% (21.5 lbs) of the particulates are greater than 10 microns and 15% (7.3 lbs) of the emissions are less than 2.5 microns in size. Significantly lower emissions are generated from cooking chicken on under-fired broilers due to the very low fat content. The Gerstler study measured only 14 lbs of total grease emissions for every 1000 lbs. of chicken breast cooked. Approximately 69% of the emissions from chicken are in the form of condensable vapors while the remaining 31% are particulates. Table A-4 presents a summary of the emissions factors produced from the Gerstler study.

Table A-4. PM Emission Factors for Under-Fired Broilers (lbs/1000 lbs of food cooked)

Type of Food	Under-Fired Broiler	
	PM >10 micron	PM < 10 micron
Hamburger	21.5	9.5
Chicken breast	2.5	2.0

Source: Gerstler et al, 1999

The emission factors for both types of meats from the Gerstler study compared well with previous emission factors determined by the CE-CERT study. It should be noted that the impinger methods used by both studies may create positive mass artifacts that result in higher emissions rates (Hildemann et al., 1999).

A study conducted in 2003 by MacDonald et al., from the Desert Research Institute (DRI) (the “DRI study”), used the same cooking equipment as at CE-CERT to estimate emissions of particulate matter less than 2.5 microns. The DRI study collected samples from a stainless steel dilution tube, rather than an impinger, because: (1) doing so allowed a broader range of sampling media and methods to be employed; and (2) the conditions experienced by the sample more closely match those experienced by the exhaust gas leaving the vent as they mix with the atmosphere (England et al., 2001). Hildemann et al., (1989) found that run-to-run variability is typically large using traditional impinger test methods due to the presence of random non-combustion generated particles that lead to artifact formation in the liquid impingers. Artifacts result in a large positive bias in the condensable particle measurement using traditional methods (England et al., 2001). Unfortunately, the DRI study only quantified emissions for particulates less than 2.5 micron and a portion of condensable vapors that solidified in the dilution tube. For this reason, the DRI emission factors are not directly comparable to either those of the CE-CERT study or the Gerstler study.

Thus, District staff used the emission factors from the Gerstler study to estimate emissions of PM_{10} from under-fired charbroilers. Because the Gerstler study did not test chain-driven charbroilers or determine emissions factors for VOC, District staff used emission factors developed in the CE-CERT study to estimate PM and VOC emissions from chain-driven charbroilers, and VOC emissions from under-fired charbroilers. For the chain-driven charbroiler, emission factors for poultry, pork, and seafood were estimated by applying the meat-specific ratios, determined by comparing the emission factors for each meat to hamburgers, for the under-fired charbroiler to the hamburger emission factor for chain-driven charbroiler, which is the only meat that was tested. Under-fired emission factors for chicken breast were used to estimate emissions from pork and chicken with and without skin cooked on under-fired broilers. District staff used emission factors for seafood developed in the CE-CERT study, because the Gerstler study did not develop any such emission factors. The final emission factors used in this study are presented in Table A-5.

Table A-5. Emission Factors (lbs/1000 lbs of food cooked)

Type of Food	Chain-driven Broiler		Under-Fired Broiler	
	PM10 (b)	VOC (b)	PM10 (a)	VOC (b)
Hamburger	7.42	2.27	9.5	3.94
Steaks	7.42 (c)	2.27 (c)	9.5 (c)	3.94 (c)
Poultry with Skin	1.56 (e)	1.05 (e)	2	1.82
Poultry without Skin	1.56 (e)	1.05 (e)	2 (d)	1.82 (d)
Pork	1.56 (e)	1.05 (e)	2 (d)	1.82 (d)
Seafood	2.58 (e)	0.22 (e)	3.3 (b)	0.38

Note:
a: Emission factors are taken from Gerstler et al study.
b: Emission factors are taken from CE-CERT study.
c: Emissions factors for hamburger were applied to beef steaks since these meats were not tested on this equipment.
d: Emission factors for chicken breast were applied to chicken with/without skin, and pork
e: Emission factors for chicken breast were applied to chicken with/without skin, and pork

D. Emission Inventory for Broilers

The emission inventory for chain-driven and under-fired broilers is estimated by multiplying the number of broilers by the average amount of meat cooked and the emission rates using the following relationship:

$$EM = \frac{EF \times Eall \times M}{2000 \text{ lbs/ton}}$$

Where:
EM = Emission inventory from broilers (tons/year);
EF = Emission factor (lbs of PM10 or VOC/1000 lbs of meat cooked);
Eall = Total number of broilers in District (unitless); and
M = Average pounds per year of meat cooked on one broiler.

Table A-6 presents the final estimated emissions of PM_{10} and VOC for broilers.

Table A-6. Emissions from Broilers

Type of Food	Chain-driven Broiler		Under-Fired Broiler	
	PM10 (tons/yr)	VOC (tons/yr)	PM10 (tons/yr)	VOC (tons/yr)
Hamburger	85.3	26.1	327	136
Steaks	25.2	7.72	218	90.3
Poultry with Skin	3.31	2.22	37	33.4
Poultry without Skin	5.99	4.02	45.6	41.5
Pork	1.30	0.87	37.7	34.3
Seafood	4.41	0.37	59.9	6.90
Total (tons/year)	126	41	724	342
Total (tons/day)	0.34	0.11	2.0	0.94