SAN JOAQUIN VALLEY UNIFIED AIR POLLUTION CONTROL DISTRICT

Final Draft Staff Report

Rule 4692 (Commercial Charbroiling)

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I. REASONS FOR RULE DEVELOPMENT AND IMPLEMENTATION

The San Joaquin Valley Air Basin (SJVAB) has been classified as a nonattainment area for the state and federal health based ambient ozone standards by the California Air Resources Board (ARB) and the U.S. Environmental Protection Agency (USEPA). The SJVAB, currently classified as severe nonattainment for the National Ambient Air Quality Standards (NAAQS) and is therefore required by the Federal Clean Air Act to attain the one-hour NAAQS for ozone by November 15, 2005.

As part of its ozone attainment strategy, the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD, the District) is required to reduce ozone-forming emissions of volatile organic compounds (VOCs) and oxides of nitrogen (NOx). The 1994 SJVUAPCD Ozone Attainment Demonstration Plan (OADP) commits the District to develop new rules or amend existing rules each year to achieve these emission reductions. Additionally, the California Clean Air Act (CCAA) requires the District to adopt all feasible control measures.

In addition to the ozone standard, the San Joaquin Valley Air Basin (SJVAB) has also been classified as a serious nonattainment area for the federal health based standard for particulate matter ten microns in size and smaller (PM-10). Controls that reduce VOC emissions from chain-driven charbroilers will also reduce PM-10 emissions.

The District committed in the 1994 OADP to control emissions from commercial charbroiling. For this source category, South Coast Air Quality Management District's (SCAQMD) Rule 1138 (Control of Emissions from Restaurants) adopted in 1997 and implemented in November 1999, is the most effective regulatory standard in effect. In keeping with the District's commitments to reduce emissions from this source category, District staff will use the SCAQMD rule as guidance in developing Rule 4692.

The 1994 OADP indicated that the emissions reductions that might be achieved from regulating all commercial charbroiling is approximately 0.39 tons of VOCs per day. The District has not identified available cost effective controls for charbroling techniques other than chain-driven charbroilers. District staff has estimated the PM-10 and VOC emission reductions for this project and estimates 0.11 ton per day of PM-10 and 0.033 ton per day of VOC from controlling chain-driven charbroilers. The District will continue to evaluate and assess the feasibility of emission reductions and cost-effective control devices and/or other methods available for the control of emissions from under-fired charbroilers and other commercial restaurant cooking equipment. Please refer to Appendix A of this staff report for further details on the emissions reduction analysis.

II. RULE DEVELOPMENT PROCESS

A scoping meeting was held May 2000 to present the goals of the rulemaking project, to achieve VOC and PM-10 reductions and implement California and federal clean air acts. During the scoping meeting, District staff introduced the feasible control measure for commercial charbroiling and operators of affected sources, consultants, vendors, and trade associations were asked to provide technical feasibility and compliance cost information which would be useful in developing the draft rule. Comments and information received was then used to develop the current draft rule, emission reductions, and cost effectiveness analyses. The resources that District staff used in developing the draft of Rule 4692 (Commercial Charbroiling) are: information received at the scoping meeting, technical documents, analysis conducted for other regulatory agencies, vendor cost data, and South Coast Air Quality Management District (SCAQMD) Rule 1138 (Control of Emissions from Restaurants) adopted November 14, 1997.

On October 9, 2001, the District signed a consent decree with Earthjustice Legal Defense Fund representing the Medical Alliance for Healthy Air, Latino Issues Forum, Center on Race, Poverty and the Environment, and the Sierra Club. The consent decree establishes project schedules for several District rulemaking projects, including this one. Consequently, the project schedule for Rule 4692 is now under court oversight, and calls for the rule to be presented to the District Governing Board in March 2002. This schedule allows time for only one series of public workshops, which will occur in November 2001.

Permitting emission control equipment ensures compliance with the rule requirements and the use and installation of appropriate control equipment. Rule 2020 (Exemptions) would be amended so that appropriate requirements for these units can be established. See Section 6.4.1 of Rule 2020 (Exemptions) for the complete text.

On June 21, 2001, the District revised Rule 2020 in anticipation that the rule and State law would have to be changed in order to obtain USEPA's full approval of the District's Title V operating permit program. Specifically, the District revised Rule 2020 to remove the agricultural source permit exemption required by the California Health and Safety Code (CH&SC) Section 42310(e). However, USEPA (FR 63503, December 7, 2001) has recently fully approved the District's Title V program even though the state-wide agricultural exemption remains in effect. Moreover, USEPA has deferred California permit-exempt agricultural sources from Title V requirements for up to three years. That deferral allows the continuation of studies related to agricultural emissions and federal Clean Air Act applicability, and the determination of the extent to which such sources may be major sources subject to Title V.

Removal of the reference to agricultural operations in our exemption rule did not change permitting requirements since the District is still prohibited from permitting such operations by the CH&SC. The removal of that section, however, has created some confusion about our intent and possible conflicts with state law. Therefore, we are proposing to add language explicitly stating that such sources are exempt from permitting to the extent allowed by state law. This amendment is a clarification of current requirements and is neither a relaxation nor strengthening of the rule.

III. BACKGROUND

The purpose of Rule 4692 is to control both VOC and PM-10 emissions from commercial charbroiling. The SCAQMD passed a similar regulation in November 1997, which became effective November 1999 requiring controls on emissions from charbroiling in restaurants.

SCAQMD Rule 1138 (Control of Emissions from Restaurant Operations), applies only to chain driven charbroilers used to cook meat. Only two major fast food chains, Carl's Jr. and Burger King, are known to currently employ chain driven charbroilers. All other commercial restaurant equipment including, but not limited to, under-fired charbroilers, may be subject to future rule provisions pending development of cost-effective control technologies. The application of updated emissions factors from actual testing indicated that under-fired charbroilers contributed a majority of the emissions from restaurants. However, chain-driven charbroilers are currently the best candidates for emissions reductions. The flameless catalytic oxidizer is the most cost effective available method for controlling VOC and PM-10 emissions from new and existing chain-driven charbroilers.

The commercial charbroiling source category includes the operations of direct meat firing grills (charbroilers) at restaurants and fast food facilities. Emissions from this source category include organic gases (mainly aldehydes) and particulate matter (fat, grease, and carbon) which result from the melting and incomplete combustion of fat during charbroiling of meats. Findings from studies completed by the University of California Riverside, College of Engineering, Center for Environmental Research and Technology (CE-CERT) indicate that the type of food cooked and the type of appliance used greatly influence the emissions. A brief description of restaurant cooking appliances follows:

Chain-driven (conveyorized) charbroiler
This type of broiler has conveyor belts to carry the meat through the flame area. It also may have a belt to carry buns through the appliance. Flames broil the meat on the top and bottom simultaneously. Most chain-driven charbroilers burn natural gas. This appliance normally produces lower PM-10 and VOC emissions than under-fired charbroilers.

Under-fired charbroiler
These appliances consist of three main components: a heating source, a high temperature radiant surface, and a slotted grill. The grill holds the meat or other food while exposing it to the radiant heat. When grease from the meat falls onto the high temperature radiant surface, PM-10 and VOC emissions occur. Most under-fired charbroilers burn natural gas; however, solid fuels, such as charcoal or wood with and without the addition of ceramic stones are sometimes used. This category includes broilers, grill charbroilers, flamebroilers, and direct-fired barbecues.

Deep fat fryers
Fryers use an exposed hot metal surface to heat cooking oil, which is then used to cook the food. Typically, the food is totally immersed in hot melted shortening at about 350^{o}F. The fryers may be either gas-fired or electric with fuel type not affecting emissions. Most of the raw food products have a water content in the range of 10% to 75% by weight prior to deep fat frying. Most of the water at the surface of the product vaporizes during the cooking process causing a carry-over of oil mist and oil distillation, resulting in VOC and PM-10 emissions. Practically all fast-food establishments use deep fat fryers to prepare food in batches.

Griddles
These appliances consist of an exposed metal plate used to cook food. The temperatures on the hot surface are typically lower than those encountered in broiling. Unlike deep fat frying, the food is not immersed in shortening, rather the process is similar to sautéing, and the emissions include light oil particulates and odors. Some griddles are grooved in order to give a “broiled” appearance to the food. Most griddles are gas-fired, although electric griddles are also used. Fuel type does not affect emissions.

A newer griddle type, called a “clam-Shell” employs a two-sided cooking configuration, lowering an upper hot plate on top of the food product to cook the side while a lower plate cooks the bottom of the product. This reduces cooking time and decreases emissions.

IV. CURRENTLY AVAILABLE CONTROL TECHNOLOGIES

The following discussions include proven technologies, and technologies proven in other industries that may be transferable. Reduction of both VOCs and PM-10 is accomplished with catalytic oxidizers, self-cleaning ceramic filters, fiber-bed filters, and incineration (catalytic and thermal). Those technologies reducing only PM-10 emissions include electrostatic precipitators (ESPs) and wet scrubbers. Activated carbon adsorbers solely reduce VOC emissions.

- **Catalytic Oxidizers (flameless) (PM-10 and VOC control)**
  In this process, the exhaust stream containing PM-10 and VOCs is mixed with air before entering the flameless reactor vessel. The air mixture is evenly distributed into a bed of inert ceramic material coated with a metal catalyst. This bed provides complete mixing of the PM-10 and VOC with oxygen. The PM-10 and VOC will oxidize into carbon dioxide and water vapor once the mixture reaches the combustion temperature. The released combustion energy is absorbed by the ceramic bed and is transferred to the exhaust stream leaving the catalytic oxidizer. The temperature control of the system is very important in effective oxidation of VOCs and PM-10. This process is a flameless incineration, as opposed to catalytic incineration, which uses an external fuel source. The catalytic oxidizer uses the heat of the exhaust, the exhaust gas entering the reactor needs to be at least 600^{o}F for proper operation. Testing has shown an overall PM-10 and VOC removal efficiency approaching 85% can be achieved, (83% of PM-10 and 86% of VOCs). The gas outlet temperature of the catalytic reactor may be as high as 1,100^{o}F, depending on the PM-10 and VOC in the gases at the inlet.

  Protech Incorporated and Engelhard Corporation have developed and produced catalytic reactors that have been permitted and are operating successfully for PM-10 and VOC removal from the exhaust of chain-driven NIECO charbroilers at several locations in the South Coast Air Basin. Catalytic oxidizers in use at existing restaurants have decreased gas usage (fuel costs) and maintenance (hood and duct cleaning) costs. The exhaust stream from the typical chain-driven charbroiler ranges from 600^{o}F to 700^{o}F and this temperature range is suitable for high emission reduction efficiency. According to catalyst vendors, poisoning of catalyst is not expected at restaurants, and their guaranteed life is about five years with proper cleaning. Some catalysts installed over four years ago in the SCAQMD are still performing satisfactorily in reducing both PM-10 and VOC emissions and are expected to last five years or more.

  The catalyst is cleaned by immersion in water for one hour once a month. Catalytic oxidizers for restaurant applications are typically 24 inches in diameter, by 3.5 inches high.

- **Self-cleaning Ceramic Filters (PM-10 and VOC control)**
  Self-cleaning ceramic filters may be used alone or in conjunction with catalytic oxidizers, as an integral component of the oxidizers. In certain applications contaminates, such as grease, can coat or mask a monolithic precious metal catalyst. For these types of operations, filters can serve to keep the catalyst clean by preventing blockage or coating of the catalyst, and thereby extending catalyst life and performance. The typical configuration consists of a self-cleaning ceramic filter located downstream of the charbroiler hood and integral impingement grease traps and located ahead of the catalytic oxidizer. Partially cleaned gas from the ceramic filter may be exhausted directly into the atmosphere or may enter a catalytic

oxidizer, where the VOCs and remaining PM-10 are oxidized to carbon dioxide and water vapor.

The ceramic filter may be operated in two different modes. In the first, the ceramic matrix is periodically heated by a natural gas burner to volatilize organics collected on the matrix. In the second, this heating is conducted continually, and may be used when grease loadings are high. Inorganic material is converted to ash and drops into a chamber located below the filter.

- **Fiber-bed Filters (PM-10 and VOC control)**
  Fiber-bed filters use a combination of impaction, interception and Brownian diffusion to remove particulate materials from an air stream. The air flows through the filter bed in a horizontal direction to enhance dropout of collected material to the drain area below the filter. The flow may be routed from the outside of the filter face to the inside or from the opposite direction. The bed is enclosed in a rigid cage-type container.

  The dominant mechanism for PM-10 collection may be Brownian motion, a behavior primarily associated with particles less than 0.5 microns in size, which approaches the mean free path of the fluid. When the face velocity is reduced to adequately allow Brownian motion to occur, the particles collide in a random manner with the collecting surface of the fiber bed. Overall, particulate collection is enhanced by the impaction and interception mechanisms occurring at the same time.

  For charbroiler emissions, the air stream from the hood with an integral grease trap would pass through the fiber bed container. The filter material is usually selected based on the PM-10 and VOC concentrations and exhaust flow and temperature. Materials available include fiberglass, polyester, polypropylene and even ceramic. The filter is periodically shut down and replaced or washed to remove grease and other materials before returning the equipment to service. At present, there are several fiber media filters located downstream of permitted wet scrubbers at restaurants operating in the South Coast AQMD.

- **Catalytic Incineration (Fuel Assisted) – (PM-10 and VOC control)**
  In catalytic incineration (typically, fuel assisted using natural gas), the VOCs and PM-10 in an emission stream are oxidized in the presence of a catalyst. The catalyst will accelerate the VOC oxidation rate while decreasing the oxidation temperature and consequently lowering the fuel usage. Catalytic incinerators are similar to thermal incinerators and consist of a pre-heater section, a combustion chamber housing the catalyst, and often a heat recovery system. Normally, the combustion chamber in a catalytic incinerator is smaller than that for a thermal incinerator. The catalyst commonly used in catalytic incineration is platinum deposited on a porous inert material (substrate). Typical VOC removal efficiencies of up to 98% are achievable, depending on the velocity of the catalyst bed and gas temperature. Metallic oxide catalysts are also used in VOC incineration. Equipment and fuel (natural gas) costs often make this method less favorable than the catalytic oxidizer (flameless incineration).

- **Thermal Incineration (PM-10 and VOC control)**
  The most commonly used air pollution control method for destruction of PM-10 and VOCs in an air stream is thermal incineration, wherein the PM-10 and VOCs are oxidized at high temperatures and converted to carbon dioxide and water. High VOC conversion rates (95%-99%) in a safe and clean process is the major advantage of thermal incineration. Thermal incinerators can be divided into two groups: 1) recuperative and 2) regenerative. The 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. Regenerative incinerators use a refractory to periodically store and transfer heat between the hot and cold gas streams. PM-10 and VOC conversion efficiencies range from 97% to 99.9% for the recuperative and 95% to 99% for regenerative incinerators. Energy recovery ranges from 45% to 76% for recuperative and 80% to 95% for regenerative incinerators. The PM-10 and VOC removal efficiency is dependent upon temperature, residence time, and mixing inside the incinerator. This option is also less favorable than catalytic oxidizers due to high fuel (natural gas) costs.

- **Activated Carbon Adsorber (VOC control)**
  Activated carbon systems rely on physical adsorption to remove VOCs from air streams. In contrast with chemisorption systems, which are the result of chemical interaction with the adsorbent, physical adsorption uses intermolecular (Van der Waals) forces of attraction to tie the adsorbed VOCs to the surface of the activated carbon. The adsorption process is exothermic, releasing heat while removing VOCs from the air stream.

  In a typical system, particulate is first removed from the VOC-laden air stream by pre-filtration and then the air stream flows through adsorber vessels containing the activated carbon. A large industrial system treating VOC emissions may consist of multiple adsorber vessels, some of which are in service while other vessels are being regenerated.

  Eventually, small amounts of the adsorbed VOCs will begin to “breakthrough” or be released to the air. Automatic controls tied to an on-line analyzer are used to sense breakthrough and remove the module with the longest adsorption time from service, bringing a freshly regenerated module on line.

  Typically, regeneration is accomplished by heating the spent carbon to 250^{o}F or higher with steam. The steam and desorbed VOCs then enter a condenser. The condensed vapors enter a separation (decanter) tank, where the insoluble solvent is separated from the water. The recovered VOCs are further treated by thermal oxidation or some other suitable method. In restaurant application, the regeneration would normally be performed off-site since the small amounts of carbon used cannot be economically regenerated on-site.

V. COST EFFECTIVENESS ANALYSIS

District staff has completed a cost effectiveness analysis pursuant to the Health and Safety Code, as part of the rule development process. Refer to Appendix B for details on the cost effectiveness analysis.

VI. SOCIOECONOMIC IMPACT ANALYSIS

Pursuant to state law, the District is required to analyze the socioeconomic impacts of any proposed rule amendment that affects air quality or strengthens an emission limitation. Proposed Rule 4692 is subject to the socioeconomic analysis mandate. The District's independent contractor, Jack Faucett Associates (JFA), has prepared an analysis of the impacts. The report is provided in Appendix C.

VII. RULE CONSISTENCY ANALYSIS

Pursuant to California Health and Safety Code Section 40727.2, a rule consistency analysis of the proposed Rule 4692 is as follows. No other District rule regulates this source category, and there are no current or proposed federal regulations or guidance on the source category.

VIII. ENVIRONMENTAL IMPACTS

Pursuant to the California Environmental Quality Act (CEQA), staff investigated the possible environmental impacts of the proposed rule. Based on the lack of evidence to the contrary, District staff has concluded that the proposed rule will not have any significant adverse effects on the environment. Staff recommends filing a Notice of Exemption under the provisions of Public Resource Code 15061 (b)(3).

IX. REFERENCES

South Coast Air Quality Management District. “Rule 1138 (Control of Emissions From Restaurant Operations) and Staff Report.” Adopted November 14, 1997.

San Joaquin Valley Unified Air Pollution Control District. "1994 Ozone Attainment Demonstration Plan". November 14, 1994.

Pacific Environmental Services, Inc. (PES), Final Report, “A Detailed Survey of Restaurant Operations in the South Coast Air Basin”, Dated February 5, 1999.

Final report by University of California Riverside, College of Engineering, Center for Environmental Research and Technology, Further Development of Emission Test Methods and Development of Emission Factors for Various Commercial Cooking Operations, Contract No. 96027, July 1997.

APPENDIX A

Emission Reduction Analysis for Rule 4692
(Commercial Charbroiling)

February 21, 2002

COMMERCIAL CHARBROILING

District staff estimated the VOC and PM-10 emissions from Commercial Charbroiling Operations by using information from studies done by Riverside College of Engineering - Center for Environmental Research and Technology (CE-CERT) and Pacific Environmental Services, Inc. (PES) for the SCAQMD.

Early in the development process, SCAQMD also contracted with the California Polytechnic University, Pomona, by the Center for Emission Research and Analysis (CERA), to develop PM-10 and VOC test methods and determine emission factors. Most of this testing was performed using hamburger meat patties. Additional testing, initiated in 1995 at CE-CERT, was sponsored by SCAQMD and the California Restaurant Association. The focus of these recent efforts was to develop a more suitable VOC test method and to determine emission factors for various combinations of appliances and food. Testing has encompassed a combination of four types of cooking equipment: under-fired charbroilers, chain-driven charbroilers (with and without a catalytic oxidizer), flat griddles, and deep fat fryers. Five types of food were tested: hamburger patties, steaks, chicken, fish, and potatoes.

The work done by CE-CERT significantly improved the reliability and acceptability of test methods and refined the understanding of emission characteristics and the relative contributions of the various restaurant-cooking operations. The final results on the PM-10 and VOC emission factors completed by UC Riverside CE-CERT for chain-driven charbroilers cooking hamburger meat patties are as follows:

Table #1
Chain-Driven Charbroiler
Emission Factors for Hamburger Patties

	PM-10 (lbs PM-10/1000 lbs Meat Cooked)	VOC (lbs VOC/1000 lbs Meat Cooked)
Uncontrolled Chain-driven Charbroilers	7.42 lbs PM-10	2.27 lbs VOC
Controlled Chain-driven Charbroilers	1.29 lbs PM-10	0.32 lb VOC
Pounds of Emissions Reduced	**6.13 lbs PM-10 reduced**	**1.95 lbs VOC reduced**
% Reductions from Uncontrolled Levels	**83%**	**86%**

The application of a catalyst to the chain-driven charbroiler significantly reduces both the PM-10 and VOC emissions.

To determine the number of restaurants within the District's eight county region, staff contacted the Health Departments of each county and were provided with lists of permitted restaurants. The list was further refined and it was determined that there are approximately 150 restaurants within the District that may operate a chain-driven charbroiler.

To estimate the baseline emissions inventory for chain-driven charbroilers the average amount of meat cooked by a restaurant is needed. Three sources were used and an average amount was determined. The following three sources reported these amounts as the average lbs of meat cooked either by day or week:

Table #2
Average Pounds of Meat Cooked Per Restaurant

Source	Average pound of Meat Cooked/Restaurant
SCAQMD Staff Report for Rule 1138 (Control of Emissions from Restaurant Operations) Dated October 10, 1997	233 lbs/day
EIIP Volume III - Area Source Category Method Abstract Dated December 2000	1,160 lbs/week
PES Detailed Study of Restaurant Operations, for SCAQMD Dated Feb 1999	2,093 lbs/week
Overall Average Pounds of Meat Cooked/Week (averaging all three sources)	**1,628 lbs/week**
Average Pounds Meat Cooked/Day	**233 lbs/day**

To estimate the baseline emissions inventory, staff applied the uncontrolled emission factors for chain-driven charbroilers to the 150 restaurants using the estimated average pounds of meat cooked per restaurant per day. Table #3 shows the results.

Table #3
Total PM-10 and VOC Emissions Reductions from Rule 4692

	PM -10 (ton/day)	VOC (ton/day)
Uncontrolled Chain-driven Charbroilers	0.13	0.039
Controlled Chain-driven Charbroilers	0.02	0.006
Emissions Reductions from all 150 Restaurants	**0.11**	**0.033**