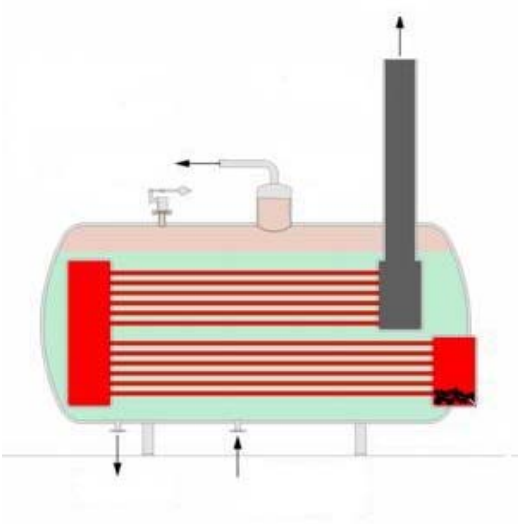
Bay Area Air Quality Management District

939 Ellis Street
San Francisco, CA 94109

Bay Area Ozone Strategy
Control Measure SS 12

BAAQMD Regulation 9, Rule 7:
NITROGEN OXIDES AND CARBON MONOXIDE FROM INDUSTRIAL, INSTITUTIONAL, AND COMMERCIAL BOILERS, STEAM GENERATORS, AND PROCESS HEATERS



Workshop Report
May 2007

Prepared by:

J. Julian Elliot
Senior Air Quality Engineer
Planning, Rules and Research Division

TABLE OF CONTENTS

I Introduction

The proposed amendments to Bay Area Air Quality Management District ("BAAQMD" or the "Air District") Regulation 9, Rule 7: *Nitrogen Oxides and Carbon Monoxide from Industrial, Institutional, and Commercial Boilers, Steam Generators, and Process Heaters* ("Regulation 9-7") are intended to implement Control Measure SS 12 in the Bay Area 2005 Ozone Strategy. Control Measure SS 12 proposes to reduce emissions of nitrogen oxides (NOx) by lowering the current NOx emission limits and also by extending applicability of the regulation to smaller devices. NOx compounds are precursors in the formation of ground level ozone. The Air District has non-attainment status for both the state 1-hr ozone standard and the federal 8-hour ozone standard. Therefore, state law requires that it implement all feasible measures to reduce emissions of ozone precursors, including NOx.

Regulation 9-7 is a non-industry specific rule that applies to almost any combustion device that is not subject to a more specific combustion rule, including new and existing:

- Small boilers used to provide hot water or steam to office buildings, commercial establishments, hospitals, hotels and industrial facilities;
- Larger boilers used to provide hot water or steam for industrial uses; and
- Process heaters used to heat material streams at industrial facilities.

Regulation 9-7 does not apply to the following categories of sources, because these are subject to other Air District rules:

- Residential central furnaces (Regulation 9, Rule 4);
- Residential water heaters (Regulation 9, Rule 6);
- Combustion devices used in petroleum refineries (Regulation 9, Rule 10); and
- Electric utility steam boilers (Regulation 9, Rule 11).

Also, Regulation 9-7 does not apply to space heating; to devices that burn only natural gas or liquefied petroleum gas (LPG) fuel and that have a heat rating less than 10 million BTU/hr (10 MM BTU/hr); to devices that burn non-gaseous fuel and that have a heat rating less than 1 MM BTU/hr; or to devices classified as ovens, kilns, furnaces or dryers.

The proposed amendments will:

- Lower the applicability criterion for natural gas/LPG devices from a heat rating of 10 to 2 MM BTU/hr (liquid-fueled devices rated down to 1 MM BTU/hr will remain regulated) and establish NOx and CO emission limits for this size category,
- Reduce the NOx emission limit for devices already subject to this rule,
- Establish a certification requirement for new devices with a heat rating between 2 MM BTU/hr (1 MM BTU/hr if liquid-fueled) and 10 MM BTU/hr and a registration program for new and existing devices in this size range,
- Establish periodic monitoring requirements for devices with a heat rating of 10 MM BTU/hr or more.

These amendments are being proposed in conjunction with amendments to Regulation 9-6: *NOx Emissions from Natural Gas-Fired Water Heaters* that will extend the applicability criterion of Regulation 9-6 from a maximum heat rating of 75,000 BTU/hr up to 2 MM BTU/hr, reduce existing emission limits, and extend the regulation to boilers as well as water heaters.

II Background

Source Description and Number of Sources

Regulation 9-7 applies to boilers, steam generators, and process heaters that are used in industrial, institutional or commercial applications. As defined in this rule, the terms boiler, steam generator and process heater collectively refer to any closed vessel that uses heat derived from the combustion of a gas, liquid or solid fuel in order to heat water, steam or any process stream, or to boil water into steam. The term "heater" will be used in this report to collectively refer to boilers, steam generators, and process heaters subject to Regulation 9-7.

Heaters in the Bay Area typically use natural gas fuel exclusively and the amount of natural gas used in heaters subject to Regulation 9-7 is far higher than that of all other fuels combined. The second most commonly used gaseous fuel is digester gas, sometimes called biogas, which is a by-product of sewage treatment, and which is used as a fuel at sewage treatment plants. Most hospitals and a few large manufacturers primarily use natural gas fuel in their heaters, but maintain the ability to use diesel fuel in case natural gas supplies are interrupted. U.S. EPA has estimated that between 2000 and 2003, less than 4% of the fuel input to commercial boilers in the western U.S. was provided by fuel oil (including diesel), with the rest provided almost entirely by natural gas.

The Air District has fuel usage data for all heaters currently subject to Regulation 9-7, since all heaters currently subject to this rule are also required to obtain an Air District permit to operate. These are devices that use natural gas or liquefied petroleum gas (LPG) and that have a heat rating of 10 million BTU/hr (10 MM BTU/hr) or more, plus devices that use non-gaseous fuel and that have a heat rating of 1 MM BTU/hr or more. Table 1 shows these heaters, divided into various size categories.

Table 1 – Permitted Heaters Currently Subject to Regulation 9-7

Rated Heat Input (MM BTU/hr)	Number of Heaters	Number with Add-On NOx Controls (*note 1*)
Greater than 200	3	2
100 to 200	20	3
50 to 100	19	0
10 to 50	280	0
Less than 10 (non-natural gas, non-LPG fuel only)	442	0
Totals	**764**	**5**

Notes:

1. In each case, the add-on control system is a selective catalytic reduction (SCR) system. 4 of the 5 heaters with SCR are at a single facility.

The proposed amendments would extend the applicability of Regulation 9-7 to natural gas and LPG-fired heaters with heat ratings between 2 and 10 MM BTU/hr. Heaters rated as low as 1 MM BTU/hr that use non-gaseous fuel would continue to be subject to this regulation. Because gas-fueled heaters rated less than 10 MM BTU/hr do not require an Air District permit to operate, the exact number of these devices in the Air District is unknown. Control Measure SS 12 estimated that 420 heaters between 5 and 10 MM BTU/hr operate in the Bay Area based on an extrapolation of boiler population data compiled by the city of San Francisco. As Table 1 shows, smaller heaters are more numerous than larger heaters. Therefore, the number of heaters between 2 and 5 MM BTU/hr is expected to be at least similar to that of heaters between 5 and 10 MM BTU/hr. Thus, the total number of heaters between 2 and 10 MM BTU/hr that would become subject to Regulation 9-7 under the proposed amendments is expected to approach 1,000 and could be significantly higher.

NOx Emissions Subject to Control by Regulation 9-7

The NOx emissions from sources already subject to Regulation 9-7 is available as an element of the Air District emission inventory: **3.49 ton/day for currently-regulated heaters**.

The NOx emissions from all heaters that would be subject to this rule under the proposed amendments may be estimated using natural gas consumption data from Pacific Gas & Electric Company (PG&E), and distribution factors for natural gas consumption derived from government statistics: **6.22 ton/day for all heaters proposed to be regulated**.

The difference between these amounts represents the estimated NOx emissions from heaters between 2 and 10 MM BTU/hr that will be newly regulated under the proposed amendments: **2.73 ton/day for heaters that will become regulated**.

Detailed calculations of these emission estimates is shown are included in Attachment 1.

NOx Control Regulations – Typical Provisions

Every California air district has adopted one or more NOx control regulations that apply to boilers, steam generators and process heaters. These regulations tend to be similar in structure, with the following provisions:

- The rules exclude heaters at power plants and petroleum refineries which are often subject to separate rules.
- Most rules apply to both existing and newly-installed heaters.
- All rules limit the concentration of NOx (and CO in most cases) in the exhaust of the heater, but do not specify the means by which the standard is to be achieved.
- All rules include a provision for verification testing to ensure that the heater satisfies the NOx and CO exhaust concentration standards.
- All rules include an exception from compliance with NOx and CO standards for heaters that use less than a specified amount of fuel each year.

In general, compliance with NOx control regulations has been achieved with integral controls (most commonly "low-NOx" burners and flue gas recirculation) that reduce the formation of NOx, rather than through the use of add-on controls that treat NOx in the combustion exhaust after it has been formed. As previously shown in Table 1, the use of add-on controls is limited to the largest heaters, with heat ratings of 100 MM BTU/hr or more.

NOx Control Regulations - BAAQMD

The Air District has adopted NOx rules for eight different combustion categories, as shown in Table 2.

Table 2 – BAAQMD NOx Regulations

Regulation	Adopted / Amended	Source Category
9-4	1983	Residential Central Furnaces
9-6	1992	Residential Water Heaters
9-7	1992 (amended 1993)	Industrial, Institutional & Commercial Boilers, Steam Generators & Process Heaters
9-8	1993 (amended 2001)	Stationary Internal Combustion Engines
9-9	1993 (amended 2006)	Stationary Gas Turbines
9-10	1994 (amended 2002)	Refinery Boilers, Steam Generators & Process Heaters
9-11	1994 (amended 2000)	Power Plant Steam Boilers
9-12	1994	Glass Melting Furnaces

Of these rules, Regulation 9-7 is the broadest in scope, addressing every type of heater (new and existing), except for internal combustion engines and space heating, in industrial, institutional and commercial applications. Regulation 9-7 currently includes the provisions shown in Table 3:

Table 3 –Current Provisions of Regulation 9-7	
Provision	**Standard**
1. NOx exhaust concentration limit	gaseous fuel: **30 ppm** @ 3% oxygen non-gaseous fuel: **40 ppm** @ 3% oxygen
2. CO exhaust concentration limit	all fuels: **400** ppm @ 3% oxygen
3. Options for heaters burning less than 90,000 therm/yr of fuel OR heaters rated between 1 and 10 MM BTU/hr heat rating and using non-natural gas, non-LPG fuel	a. comply with provisions 1 and 2, **or** b. operate with no more than 3% oxygen in exhaust, **or** c. tune the heater every year
4. Monitoring	initial source test

These amendments are being proposed in conjunction with amendments to Regulation 9-6: *NOx Emissions from Natural Gas-Fired Water Heaters* that will extend the applicability criterion of Regulation 9-6 from a maximum heat rating of 75,000 BTU/hr up to 2 MM BTU/hr, reduce existing emission limits, and extend the regulation to boilers as well as water heaters. If adopted as proposed, Regulations 9-6 and 9-7 would regulate NOx emissions from all natural gas-fired water heaters, including residential heaters, all natural gas-fired steam boilers with heat ratings greater than 75,000 BTU/hr; and all boilers using non-gaseous fuel with heat ratings of 1 MM BTU/hr or more.

III Technical Review

Emission Mechanisms and Controls

The primary products of any combustion process are water vapor (H_2O) and the greenhouse gas carbon dioxide (CO_2). Because CO_2 is a necessary product of combustion, the only way to reduce CO_2 emissions from a combustion process without reducing the output of useful energy is to increase the thermal efficiency of the process, thereby reducing the fuel consumption rate.

In addition, all combustion processes produce all of the specific pollutants regulated by the Air District: carbon monoxide (CO), nitrogen oxides (NOx), sulfur oxides (SOx), volatile organic compounds (VOCs) and particulate matter. CO and NOx emissions are the focus of Regulation 9-7 and Control Measure SS 12. Emissions of SOx, VOCs and particulate matter are negligible compared to those of NOx, CO and CO_2 when natural gas fuel is used.

NOx Emissions

In addition to fuel, combustion requires oxygen, so that carbon in the fuel can be oxidized to CO_2 and hydrogen in the fuel to H_2O. Because ambient air is used as an oxygen source, and because ambient air contains almost four times as much nitrogen gas (N_2) as oxygen gas (O_2), N_2 gas is exposed to the high temperatures of the combustion process. Some of this N_2 gas is oxidized into NO and NO_2 (collectively known as NOx) and emitted in the combustion

exhaust stream. This emitted NOx is known as "thermal NOx" because its formation depends on exposure to combustion temperatures – higher combustion temperatures and longer exposure result in a greater NOx formation rate and higher concentrations of NOx in the exhaust stream.

In addition, all common fuels contain elemental nitrogen (N) or N_2 that is also oxidized in the combustion process. Natural gas contains very little nitrogen, while refined fuel oils, such as diesel, can contain significant concentrations of elemental nitrogen which can account for as much as half of the overall NOx emissions when standard fuel oils are burned. The emitted NOx that results from nitrogen in the fuel is known as "fuel NOx".

NOx Controls

Because "thermal NOx" and "fuel NOx" are created through independent mechanisms, NOx emission controls may be designed to reduce thermal NOx formation, to reduce fuel NOx formation, or to reduce the concentration of previously-formed fuel and thermal NOx after it reaches the exhaust stream (post-combustion control).

The nitrogen content of pipeline natural gas is limited by federal Department of Energy standards (4% by volume). The nitrogen content of diesel fuel, which is the only non-gaseous fuel in significant use in the Bay Area, is not explicitly limited by either state or federal standards. However, virtually all diesel fuel marketed in California since 2006 complies with "ultra low-sulfur diesel" (ULSD) standards that limit sulfur content to 15 ppm by weight and the processes used to remove sulfur from diesel also remove nitrogen. This nitrogen removal is so effective that the amount of fuel NOx created in diesel fuel combustion may also be considered to be negligible compared to amount of thermal NOx. Therefore, only thermal NOx controls are considered in the proposed rule amendments.

Thermal NOx emissions can be reduced by lowering the average combustion temperature and by eliminating combustion "hot spots". "Low-NOx burners" achieve a lower average combustion temperature by creating a larger flame which dilutes the flame energy over a larger volume, or by performing combustion in more than one stage. In staged combustion, only partial combustion occurs in the first stage because either the oxygen or fuel concentration is restricted. The exhaust gases from the first stage proceed to subsequent stages where combustion is allowed to proceed by increasing the concentration of the restricted component (oxygen or fuel). The combustion temperature of the second and subsequent stages is reduced because some of the exhaust gases from the first stage are inert and will not burn. Low-NOx burners may also limit the amount of "excess air" used. Heaters normally operate with some degree of "excess air" beyond that which is theoretically required for complete fuel combustion in order to ensure that fuel is not wasted and to prevent uncontrolled detonation of unburned fuel outside of the combustion zone. However, the greater the amount of excess air, the more nitrogen and oxygen is available to form NOx. Limiting the level of excess air reduces the potential amount of NOx that can form, while improving combustion efficiency. Hot spots in the combustion zone may be minimized by thoroughly mixing fuel and combustion air upstream of the burner. Low-NOx burners, by themselves, will reduce NOx emissions by at least 10% and as much as 50% compared to basic burners, and typically will not reduce overall combustion efficiency. However, low-NOx burners usually create a longer flame, so some existing heaters may not have sufficient

space to allow such a burner to be retro-fitted. If a retrofit is possible, the maximum firing capacity of the device may have to be reduced, possibly to an unacceptable level, to accommodate the longer flame. Burners that are capable of NOx concentrations of 15 ppm or less are referred to as "ultra low-NOx burners".

"Flue gas recirculation" (FGR) reduces flame temperature by diverting some of the combustion exhaust gas back to the burner inlet, where it is mixed with the fuel and combustion air. The exhaust gas, while hot, is cooler than the combustion temperature, so the use of FGR reduces the average flame temperature. Also, the diverted flue gas will have a depleted oxygen content compared to ambient air, so will also lower the level of excess oxygen available to form NOx. FGR, by itself, will reduce NOx emissions by as much as 80%, but is most commonly used in conjunction with low-NOx burners. It is less likely that a given burner can be successfully retrofitted with FGR than with a low-NOx burner because an FGR system must not only be compatible with the burner assembly, but may also have significant space requirements for ductwork and a blower.

A technique similar to FGR is the injection of water or steam into the combustion zone to lower combustion temperature. This technique can cause a significant loss of efficiency and is typically used only on the largest heaters, which are typically not subject to Regulation 9-7.

NOx emissions can also be reduced with add-on controls that convert previously-formed NOx to N_2 by reacting NOx with ammonia (NH_3), with or without the use of a catalyst. These post-combustion controls are known as "selective catalytic reduction" (SCR) and "selective non-catalytic reduction" (SNCR) systems. NOx catalysts operate well only in a narrow temperature band, so SCR systems are not used in "load-following" applications where a heater operates over a wide load range, which results in a wide temperature variation at the exhaust catalyst. SCR and SNCR systems can be costly to design, install and operate. As previously shown in Table 1, only five of these systems have been installed on heaters subject to Regulation 9-7, and in each case these devices were subject to the more stringent, best available control technology (BACT) requirements of Regulation 2.

In general, compliance with the current NOx standards in Regulation 9-7 has been achieved with low-NOx burners or FGR, or both.

CO Emissions and Controls

CO is produced by the incomplete oxidation of carbon in a fossil fuel to CO rather than to CO_2. Because the Air District is in attainment status with all state and federal ambient air quality standards for CO, Regulation 9-7 attempts to limit the concentration of CO in the exhaust stream of combustion processes to a reasonable level (400 ppmv), but does not attempt to achieve further CO emission reductions. All other California air districts that address CO emissions from combustion sources impose the same standard.

The most common NOx control strategies, which limit NOx formation by limiting combustion temperature, tend to also limit complete oxidation of carbon to CO_2, thereby increasing the CO formation rate. In order to maintain CO emission levels below 400 ppm, no control technology is required. Instead, the NOx control technology must be implemented in a way that does not result in an excessive CO formation rate.

Greenhouse Gas Emissions and Controls

Combustion of conventional hydrocarbon fuel results in the release of energy as bonds between carbon and hydrogen are broken and reformed with oxygen to create water vapor (H_2O) and the greenhouse gas carbon dioxide (CO_2). For example, when methane (CH_4), the primary constituent of natural gas, is burned, the reaction proceeds as follows:

$$CH_4 + 2(O_2) \rightarrow CO_2 + 2(H_2O)$$

Thus, CO_2 is not a pollutant that occurs in relatively low concentrations as a by-product of the combustion process; CO_2 is a necessary combustion product of any fuel containing carbon. Therefore, attempts to reduce emissions of greenhouse gases from combustion focus on increasing energy efficiency – consuming less fuel to provide the same useful energy output.

Boilers generally operate at no more than 85% overall efficiency. In other words, only up to 85% of the heat value of the fuel that is consumed is transferred to the material that is being heated and the other 15% is released to the atmosphere as waste heat. Waste heat is released in 3 ways:

• as heat in the combustion exhaust which is released from the boiler stack,

• as radiant heat from the outside of the boiler because the boiler is not perfectly insulated,

• as heat in the liquid "blowdown" stream that is constantly drained from the boiler to prevent solids from concentrating inside the boiler and ultimately fouling the heat exchange surfaces.

The most significant of these factors is heat loss through the boiler stack. Stack losses may be minimized by minimizing the amount of excess air and therefore the amount of oxygen and nitrogen that is heated and released from the stack. As previously discussed under "NOx Controls", above, reducing excess air to the minimum level necessary for complete fuel combustion, with a reasonable safety margin, is a very effective way to control NOx emissions.

In addition, boiler efficiency may be improved by limiting liquid blowdown to the lowest necessary level, by improving boiler shell insulation, and by maintaining clean boiler internals to maximize heat transfer to the medium being heated rather than to the atmosphere through the boiler stack.

Although the proposed amendments do not include an explicit efficiency requirement, the NOx emission limits are proposed to be expressed in terms of NOx concentration in the exhaust stack (parts per million by volume) as in the current regulation, and also in terms of mass of NOx produced per unit of fuel heat value (pounds of NOx per million BTU / hr), with the operator choosing which standard to meet. This approach has been endorsed by the California Air Resources Board (CARB) in its RACT/BARCT guidance for boilers, process heaters and steam generators and is used in many other California air district NOx regulations. This approach allows an operator to comply with the standard, at least in part, through energy efficiency.

IV Rule Amendments Under Consideration

Extend Regulation 9-7 to Heaters Rated Less Than 10 MM BTU/hr

Extending the applicability of Regulation 9-7 below 10 MM BTU/hr is one proposal in Control Measure SS 12. Several California air districts have adopted rules that apply a 30 ppm NOx concentration standard to heaters with heat ratings as low as 2 MM BTU/hr.

Compliance with a 30 ppm NOx standard is achievable for heaters burning natural gas or LPG fuel by retrofitting low-NOx burners. However, for some heaters a low-NOx burner retrofit may not be available or may not be practical to install and these devices would have to be replaced. If a retrofit is available, it may require that the maximum firing capacity of the heater be reduced or may result in an overall loss of efficiency that would require the device to be replaced.

The proposed amendments establish a 30 ppm exhaust concentration limit for heaters rated between 2 and 10 MM BTU/hr. A low-fuel usage exemption is proposed for heaters with annual fuel use less than 90,000 therms. This is the same exemption level currently provided in Regulation 9-7 for heaters with heat ratings of 10 MM BTU/hr or more.

Reduce Regulation 9-7 NOx Exhaust Concentration Limits

Control Measure SS 12 also proposes to reduce the existing NOx concentration limits in Regulation 9-7. Some California air districts have adopted rules that apply NOx concentration limits less than 30 ppm to heaters with heat ratings of 10 MM BTU/hr or more.

For heaters with heat ratings higher than 20 MM BTU/hr, compliance with a 9 ppm NOx limit has been achieved with natural gas or LPG fuel by retrofitting ultra low-NOx burners with or without flue gas recirculation (FGR) to control NOx formation, or by installing selective catalytic reduction (SCR) or selective non-catalytic reduction (SNCR) to reduce the NOx concentration in the heater exhaust. However, for some heaters an ultra low-NOx burner retrofit may not be available or may not be practical to install and these devices would have to be replaced. For some heaters FGR or SCR/SNCR may not be practical to install because of space limitations. For load-following heaters, SCR/SNCR may not achieve a 9 ppm concentration, so a limit of 15 ppm is proposed for these devices. For some heaters, installation of ultra low-NOx burners or FGR may require that the maximum firing capacity of the heater be reduced or may result in an overall loss of efficiency that would require the heater to be replaced.

For heaters with heat ratings between 10 and 20 MM BTU/hr, compliance with a 15 ppm NOx standard has been achieved with natural gas or LPG fuel by retrofitting ultra low-NOx burners with or without flue gas recirculation (FGR). However, as for larger heaters, an ultra low-NOx burner retrofit or FGR may not be available or may not be practical to install and these devices would have to be replaced or have their maximum firing capacity reduced.

Landfill gas and wastewater digester gas fuels have greater variability in heat value and other specifications than natural gas. This variability makes it more difficult to optimize a heater that uses these fuels for low NOx emissions. For this reason, and because combustion of these fuels is quite limited in the Bay Area, the proposed amendments establish a 30 ppm NOx limit for these fuels in every regulated size category.

Regulation 9-7 currently allows a 40 ppm NOx limit for combustion of non-gaseous fuels in heaters with heat ratings of 10 MM BTU/hr or more, compared to 30 ppm for gaseous fuels. Because non-gaseous fuels cannot be mixed with combustion air as completely as gaseous fuels, reduction of combustion hot-spots and associated NOx formation is more difficult for non-gaseous fuels. For this reason, and because combustion of non-gaseous fuel is quite limited in the Bay Area, the proposed amendments retain a 40 ppm NOx limit for non-gaseous fuel in heaters in every regulated size category.

Heaters with input heat ratings up to 100 MM BTU/hr would be exempt from the new standards if they use less than 200,000 therms of fuel per year. 200,000 therms per year represents a maximum utilization of 23% for heaters in this size range. Heaters rated higher than 100 MM BTU/hr would have a 300,000 therm/yr exemption. 300,000 therms per year represents a maximum utilization of 3% for heaters in this size range. Although these exemption levels are higher than the current level of 90,000 therms per year, the proposed exemption levels together with the proposed lower NOx emission limits, will maximize emission reductions while maintaining reasonable costs for the proposal.

Other Amendments Under Consideration

Certification and Registration for Heaters Rated less than 10 MM BTU/hr

Typically, heaters that are subject to a requirement in a prohibitory rule such as Regulation 9-7 are also required to obtain an Air District permit to operate. However, because the exact number of heaters rated less than 10 MM BTU/hr is unknown, but potentially very high, permits will not be required for these devices. Instead, heater manufacturers will be required to certify that they comply with the proposed NOx emission standards, only certified devices will be allowed to be installed, and both new and existing heaters subject to this rule will be required to be registered with the Air District, unless the heater has a permit to operate. A one-time registration fee of $500 per facility is proposed, with each heater after the first subject to an additional one-time $100 fee.

Periodic Monitoring

To ensure that heaters rated at 10 MM BTU/hr or more operate in compliance with Regulation 9-7, periodic monitoring of these devices will be required.

Potential Emission Reductions

The proposed amendments to Regulation 9-7 will reduce the NOx emission limit that is applicable to heaters rated over 20 MM BTU/hr from 30 ppm to 9 ppm. There are 152 of these heaters permitted in the Air District. Large sources are most likely to operate significantly below the concentration standard in the regulation because they are likely to trigger “best available control technology requirements” when they are permitted.

For heaters rated between 10 and 20 MM BTU/hr, the NOx emission limit will be reduced from 30 ppm to 15 ppm. There are 165 of these devices permitted in the Air District.

For heaters rated between 2 and 10 MM BTU/hr, an emission limit of 30 ppm will be established. There are 300 of these devices permitted in the Air District, but the total number is unknown since most are not subject to permit requirements. Although there is no existing standard for the smallest size category in Regulation 9-7, an emission concentration of 78

ppm would be typical for a heater of this size with no emission controls, based on U.S. EPA's AP-42 document.

Most heaters that will be subject to Regulation 9-7 (those rated between 2 and 20 MM BTU/hr) will have their existing emission concentration limit or existing average emission level reduced by about 50%, although some of the smallest heaters will probably be exempt from the proposed concentration limits because of low annual fuel use. The largest 152 heaters (rated over 20 MM BTU/hr) will have their existing emission concentration limit reduced by 70%, although the emission reductions may be less to the extent that these devices already operate at emission concentrations less than 30 ppm.

Therefore, as a preliminary estimate, it appears that the proposal will reduce emissions by about 50% from the new heaters that will become subject to Regulation 9-7, and also reduce emissions from already-controlled heaters by an additional 50%. The emissions from newly regulated heaters would be reduced by about 1.36 ton/day, and the emissions from currently controlled heaters by about 1.75 ton/day, for a total of approximately 3.1 ton/day of NOx reduced.

Cost of Controls

Cost to Operators

Operators of heaters that do not meet the proposed NOx emission standards will have to retrofit, replace or retire these devices. Retrofit and replacement costs increase as the size of the heater increases. The smallest boilers that are proposed to be subject to the amended rule typically cost around $50,000 to replace (including installation) and approximately half this amount to retrofit. A 100 MM BTU/hr boiler may cost $750,000 to replace (including installation) and approximately two-thirds this amount to retrofit.

CARB has found that retrofitting is less cost effective for smaller units and that the cost of control increases rapidly for units that operate at a utilization rates of less than 25%.

Operators of heaters rated between 2 and 10 MM BTU/hr will be charged a one-time registration fee of $500 per facility, with each heater after the first subject to an additional one-time $100 fee.

Operators of heaters rated at 10 MM BTU/hr or more will incur new, ongoing costs to perform periodic monitoring. Periodic monitoring would consist of a source test and typically would cost no more than $5,000 for each test. Depending on the size of the heater, a test would be required every one to two years.

Cost to Manufacturers

Manufacturers of heaters rated less than 10 MM BTU/hr will incur new costs to certify that these devices meet the proposed NOx emission standards. These administrative costs will include a certification test for each model to be offered for sale. This test is the same as a source test for NOx and CO and typically would cost no more than $5,000 for each model tested.

Cost to the Air District

In addition to the one-time cost of implementing the proposed amendments to Regulation 9-7, the Air District will incur new, ongoing costs to administer the certification of new heaters

rated between 2 and 10 MM BTU/hr, to administer the registration for new and existing heaters in this size range, and to enforce new standards for heaters in this size range. The proposed registration fee is expected to cover these costs. No new, ongoing enforcement costs will be incurred for heaters rated 10 MM BTU/hr or more, since these are already subject to NOx emission standards that are similar to those that are proposed.

Other Impacts – Greenhouse Gases

By expressing proposed NOx emission limits for some boilers in terms of NOx emitted per unit of fuel consumed, operators of these may achieve compliance not only by reducing the NOx emission rate, but also by improving the overall thermal efficiency of their boiler. Some operators may be able to meet the proposed, more stringent standards and also reduce CO_2 emissions through improved efficiency.

V Rule Development / Public Consultation Process

The Air District has developed proposed amendments and presents these amendments in this workshop report. These proposals are based on existing regulations in other air districts in California. Staff has consulted with equipment manufacturers and distributors and with other California air districts during the preparation of this document. The public workshop is the next step in the rule development process. Based on the input staff receives prior to and at the workshop, staff will determine whether changes to the proposal are necessary prior to a public hearing before the Air District Board of Directors.

VI References

Bay Area Air Quality Management District: "*Bay Area 2005 Ozone Strategy*", Volume 1; January 2006

Bay Area Air Quality Management District: "*Bay Area 2005 Ozone Strategy*", Volume 2: Control Measure SS 12: "*Industrial, Institutional, and Commercial Boilers*"; January 2006

California Air Resources Board: "*Determination of Reasonably Available Control Technology and Best Available Retrofit Control Technology for Industrial, Institutional and Commercial Boilers, Steam Generators and Process Heaters*", July 1991

El Dorado County Air Quality Management District: Rule 229, "*Industrial, Institutional and Commercial Boilers, Steam Generators and Process Heaters*", January 2001

Mojave Desert Air Quality Management District: Rule 1157, "*Boilers and Process Heaters*", May 1997

Placer County Air Pollution Control District: Rule 231, "*Industrial, Institutional and Commercial Boilers, Steam Generators and Process Heaters*", October 1997

Sacramento Metropolitan Air Quality Management District: Rule 411, "*NOx from Boilers, Process Heaters and Steam Generators*", October 2005

San Diego County Air Pollution Control District: Rule 69.2, "*Industrial and Commercial Boilers, Steam Generators and Process Heaters*", September 1994

San Joaquin Valley Unified Air Pollution Control District: Rule 4306, "*Boilers, Steam Generators and Process Heaters – Phase 3*", March 2005

San Joaquin Valley Unified Air Pollution Control District: Rule 4307, "*Small Boilers, Steam Generators and Process Heaters – 2.0 MM BTU/hr to 5.0 MM BTU/hr*", April 2006

San Joaquin Valley Unified Air Pollution Control District: Rule 4308, "*Boilers, Steam Generators and Process Heaters – 0.075 MM BTU/hr to 2.0 MM BTU/hr*", October 2005

San Luis Obispo County Air Pollution Control District: Rule 430, "*Control of Oxides of Nitrogen from Industrial, Institutional and Commercial Boilers, Steam Generators and Process Heaters*", July 1995

Santa Barbara County Air Pollution Control District: Rule 342, "*Control of Oxides of Nitrogen (NOx) from Boilers, Steam Generators and Process Heaters"*, April 1997

Santa Barbara County Air Pollution Control District: Rule 360, "*Emissions of Oxides of Nitrogen from Large Water Heaters and Small Boilers"*, October 2002

South Coast Air Quality Management District: Rule 1146, "*Emissions of Oxides of Nitrogen from Industrial, Institutional and Commercial Boilers, Steam Generators and Process Heaters*", July 1995

South Coast Air Quality Management District: Rule 1146-1, "*Emissions of Oxides of Nitrogen from Small Industrial, Institutional and Commercial Boilers, Steam Generators and Process Heaters*", May 1994

South Coast Air Quality Management District: Rule 1146-2, "*Emissions of Oxides of Nitrogen from Large Water Heaters and Small Boilers and Process Heaters*", May 2006

U.S. Environmental Protection Agency: AP 42, 5th Edition, Volume I, Chapter 1: *"External Combustion Sources"*; Section 1.4: "*Natural Gas Combustion"*, Table 1.4-1

Ventura County Air Pollution Control District: Rule 74-15, "*Boilers, Steam Generators and Process Heaters*", November 1994

Ventura County Air Pollution Control District: Rule 74-15-1, "*Boilers, Steam Generators and Process Heaters*", June 2000

Yolo-Solano Air Quality Management District: Rule 2-27, "*Industrial, Institutional and Commercial Boilers, Steam Generators and Process Heaters*", August 1996

Attachment 1 – NOx Emissions Subject to Control

NOx Emissions from Heaters Already Subject to Regulation 9-7

NOx emissions from all permitted heaters ("point sources"), excluding those at petroleum refineries and power plants, are included in data element 307 of the Air District emission inventory. Based on 2005 fuel use data submitted by permit holders, this value is 3.49 ton/day. Some types of heaters, such as "kilns, ovens and furnaces used for drying, baking, heat treating, cooking, calcining, or vitrifying" have an exemption from the NOx emission limits in Regulation 9-7-110.6. The emissions from these miscellaneous heaters will not be affected by the proposed amendments.

NOx Emissions from All Heaters Proposed to Be Subject to Regulation 9-7

The NOx emissions from non-permitted sources ("area sources") are included in data element 1590 of the Air District emission inventory. The value in January 2007, based on non-residential natural gas consumption data for 2005 provided by Pacific Gas & Electric Company (PG&E), is 7.03 ton/day. These total emissions are produced by both commercial (non-manufacturing) and industrial (manufacturing) facilities. If emissions from space heating operations (which are not addressed by Regulation 9-7) and from heaters smaller than 2 MM BTU/hr (which will remain exempt from Regulation 9-7) are subtracted from this amount, then the remaining emissions may be attributed to all heaters that are proposed to be regulated by Regulation 9-7 (excluding exempt furnaces, dryers and ovens). The emissions from space heating operations and from heaters smaller than 2 MM BTU/hr may be estimated by determining the fraction of natural gas used by these operations and heaters, and using this fraction to estimate the corresponding fraction of emissions that may be attributed to these operations and heaters.

Table 1-A shows monthly natural gas deliveries for commercial and industrial users in California from 2001 through 2005. This is the most recent data available from the U.S. Energy Information Administration (EIA). Commercial natural gas use has a strong seasonal variation that corresponds to the expected demand for space heating – fuel use is highest in January and lowest in July, while industrial use shows little seasonal variation, suggesting that only a small fraction of industrial fuel use is for space heating.

The following assumptions, suggested by this data, may be used to estimate the distribution of natural gas use between commercial and industrial users, and to estimate the amount of fuel used for space heating:

- Commercial use accounts for 24% of the total commercial and industrial fuel use; industrial use is 76% of the total: (236,280 / 996,869) = 0.24
- If commercial fuel use in July is assumed to include no space heating, then the average July fuel consumption (15,611 MMcf) may be used as a baseline for non-space heating fuel use. If average July fuel use is multiplied by 12 (187,332 MMcf), this represents annual commercial fuel use, less space heating. Then, non-space heating fuel use is 79% of total commercial fuel use: (187,332 / 236,280) = 0.79, and space heating fuel use is 21% of total fuel use.

• If every source is assumed to have the same NOx emission factor (NOx produced per unit of fuel burned), then NOx emissions may be assumed to be proportional to fuel use.

Table A-1 – Natural Gas Deliveries in California, million cubic feet (MMcf)						
	2001	**2002**	**2003**	**2004**	**2005**	**5-Year Monthly Avg**
Commercial						
Jan	27492	27340	31390	25447	26244	27583
Feb	25562	23711	26125	25795	24377	25114
Mar	22438	21883	21962	22236	20877	21879
April	26237	19797	19424	17684	18142	20257
May	16799	19836	18107	17561	18454	18151
June	15537	17245	15352	15914	16741	16158
July	15370	16694	14488	14895	16607	15611
Aug	17275	17287	14695	15212	16054	16105
Sept	16322	15819	14050	14792	17336	15664
Oct	18308	18131	15035	16771	17149	17079
Nov	19010	18290	18426	19780	17647	18631
Dec	25444	22275	23860	25510	23160	24050
Annual Total	245794	238308	232914	231597	232788	**236280**
Industrial						
Jan	53179	62945	59814	66480	72402	62964
Feb	49474	51558	60780	69591	71329	60546
Mar	46193	63581	65097	62162	65134	60433
April	50003	55898	59951	68688	67858	60480
May	51398	57251	61718	65201	66838	60481
June	51983	55782	63535	67632	62435	60273
July	54565	64753	63716	67551	65091	63135
August	65128	68124	68056	73433	62315	67411
Sept	63833	63667	71778	75362	64648	67858
Oct	61177	70242	69904	73862	63180	67673
Nov	57442	63406	68187	72814	61455	64661
Dec	62087	62987	66550	73046	58697	64673
Annual Total	666462	740194	779086	835822	781382	**760589**
Annual Grand Total						**996869**

Using these assumptions and conclusions, the emissions from space heating (compared to total emissions of 7.03 ton/day) may be estimated as:

Space heating emissions = (7.03 ton/day NOx)(0.24)(0.21) = 0.35 ton/day NOx

Emissions from heaters smaller than 2 MM BTU/hr may be estimated based on boiler population data compiled by the City of San Francisco's Department of Building Inspection (DBI). Data for 2003 shows that 33% of the boilers in San Francisco have heat ratings less than 2 MM BTU/hr. If this same size distribution is assumed to occur throughout the Bay Area for all heaters subject to Regulation 9-7, then 33% of the heaters that contribute to the total NOx emissions (7.03 ton/day) must be discounted. However, the fraction of emissions from these heaters would be expected to be lower than their population fraction. Because heaters smaller than 2 MM BTU/hr would be expected to be about 1 MM BTU/hr on average, while all heaters smaller than 10 MM BTU/hr would be expected to be about 5 MM BTU/hr

on average, emissions from heaters smaller than 2 MM BTU/hr will be estimated to be 20% of their population fraction: (1 MM BTU/hr)(5 MM BTU/hr) = 0.20

Heaters less than 2 MM BTU/hr: (7.03 ton/day)(0.33)(0.20) = 0.46 ton/day NOx

If the emissions attributed to space heating and to heaters rated less than 2 MM BTU/hr are subtracted from the total emissions from heaters with heat ratings less than 10 MM BTU/hr, the remaining emissions represent the total NOx emissions subject to control by the proposed amendment to Regulation 9-7:

(7.03 ton/day – 0.35 ton/day – 0.46 ton/day) = **6.22 ton/day NOx subject to control**

This estimate of total emissions subject to control is about 33% less than the amount estimated by Control Measure SS 12, but is believed to more accurately reflect current emission levels.

NOx Emissions from Small Heaters That Will Become Regulated

The difference between the NOx emission estimates from heaters currently subject to Regulation 9-7 and from heaters proposed to be subject to this rule represents the NOx emission estimate from heaters between 2 and 10 MM BTU/hr that will be newly regulated under the proposed amendments: **2.73 ton/day for heaters that will become regulated**.