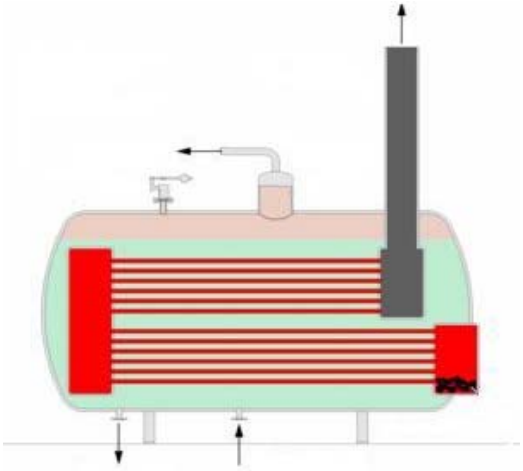
Bay Area Air Quality Management District
939 Ellis Street
San Francisco, CA 94109

Staff Report

Proposed Amendments to BAAQMD Regulation 9, Rule 7:

NITROGEN OXIDES AND CARBON MONOXIDE FROM INDUSTRIAL, INSTITUTIONAL, AND COMMERCIAL BOILERS, STEAM GENERATORS, AND PROCESS HEATERS



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I Executive Summary

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") will implement Control Measure SS 12 in the Bay Area 2005 Ozone Strategy. This control measure 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 and particulate matter. The Air District has non-attainment status for both the state 1-hr and 8-hr ozone standards and the federal 8-hour ozone standard. Therefore, state law requires that the Air District implement all feasible measures to reduce emissions of ozone precursors, including NOx. NOx reductions also reduce the formation of secondary particulate matter in the atmosphere.

Regulation 9-7 is a non-industry specific rule that applies to most combustion devices that are 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, schools, 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 currently does not apply to space heating, except where hot water or steam is used for heating; to devices that burn only natural gas or liquefied petroleum gas (LPG) fuel and that have an input heat rating less than 10 million BTU/hr (10 MM BTU/hr); to devices that burn non-gaseous fuel and that have an input heat rating less than 1 MM BTU/hr; or to devices classified as ovens, kilns, furnaces or dryers. Similarly, no Air District Permit to Operate is required for natural gas or LPG-fueled devices rated less than 10 MM BTU/hr.

The proposed amendments will:

- Expand the rule applicability for natural gas/LPG devices from an input heat rating of 10 MM BTU/hr or more to a rating of greater than 2 MM BTU/hr and establish NOx and CO emission limits for this size category;
- Reduce the NOx emission limit for devices already subject to this rule – gas-fired devices with an input heat rating of 10 MM BTU/hr or more;
- Establish a manufacturer certification requirement for new devices with a heat rating greater than 2 but less than 10 MM BTU/hr and operator registration requirements for new and existing devices in this size range; and
- Establish insulation requirements, stack gas temperature limits and tune-up requirements to ensure reasonable energy efficiency which will reduce fuel use and the associated NOx and greenhouse gas emissions.

On November 7, 2007, the Air District adopted amendments to Regulation 9, Rule 6: *NOx Emissions from Natural Gas-Fired Boilers and Water Heaters* that extended the applicability of Regulation 9, Rule 6 from a maximum heat rating of 75,000 BTU/hr up to 2 MM BTU/hr.

The proposed amendments to Regulation 9-7 will reduce NOx emissions by at least 3.8 tons per day - a 61% reduction for this source category. Secondary particulate matter will be reduced by

approximately 0.5 tons per day. The proposed amendments have been found to be cost-effective and a socio-economic analysis has determined that these amendments can be implemented without significant economic dislocation or loss of jobs.

A California Environmental Quality Act (CEQA) Initial Study has determined that there are no significant adverse impacts associated with this project.

In conjunction with the proposed amendments to Regulation 9-7, amendments to *Regulation 3: Fees, Schedule R: Equipment Registration Fees* are proposed for devices required to be registered under Regulation 9-7. A one-time fee of $425 is proposed for the first heater at any affected facility, with a $50 fee for each additional device at the facility. This fee will cover the Air District's costs of inspecting boilers and reviewing certifications.

Amendments to the Manual of Procedure, Volume 1, Chapter 5: *Boiler, Steam Generator and Process Heater Tuning Procedure* are proposed. These amendments will add insulation and stack gas temperature monitoring for boilers and steam generators to ensure that these devices operate at reasonable efficiency levels.

II Background

Heaters Subject to Regulation 9, Rule 7

Regulation 9, Rule 7 ("Regulation 9-7") applies to boilers, steam generators, and process heaters that are used in industrial, institutional or commercial applications. As defined in the rule, "boilers" and "steam generators" are devices used to produce steam or to heat water through combustion. "Process heaters" are devices used to heat process streams other than water through combustion, with the exception of kilns, furnaces and ovens used for drying, baking, heat treating, cooking, calcining or vitrifying. Space heaters (which are intended to heat ambient air) are not subject to this rule unless they heat water or create steam. Boilers, steam generators and process heaters used in petroleum refineries are subject to a separate rule – Regulation 9, Rule 10. 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 and a few other facilities. Many hospitals and a few large manufacturers primarily use natural gas fuel in their heaters, but maintain the ability to use #2 distillate fuel (diesel) in case natural gas supplies are interrupted, and occasionally burn diesel for reliability testing. 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 #2 distillate fuel), with the rest provided almost entirely by natural gas.

NOx and CO Emissions and the Formation of Ozone

The purpose of Regulation 9-7 is to achieve emission reductions of nitrogen oxides (NOx) and carbon monoxide (CO) from heaters. NOx and CO react with other atmospheric pollutants to form ground-level ozone, which is the primary component of smog. Because the Air District has non-attainment status for the state 1-hour and 8-hour ozone standards and the federal 8-hour ozone standard, the Air District is required to implement all feasible measures to reduce emissions of ozone precursors, including NOx.

Ozone causes eye irritation and affects the respiratory system by irritating the mucous membranes in the nose and throat and lung tissue. Ozone also impairs normal lung function, thereby reducing the ability to perform physical exercise. These effects are more severe on people with chronic lung disease such as asthma and emphysema and on the very young and the elderly. The ARB has determined that ozone and its precursors are sometimes transported from the Bay Area Air Basin into neighboring air basins.

It is important to reduce the public's exposure to heater emissions to minimize their adverse health effects and to comply with legal requirements to make progress in reducing ambient ozone levels. The proposed amendments to Regulation 9-7 will implement the commitment that the Air District has made in Control Measure SS 12 of the 2005 Ozone Strategy to reduce ozone exposure by reducing emissions of NOx from heaters subject to Regulation 9-7.

CO is produced by the incomplete oxidation of carbon in a fossil fuel to CO rather than to CO_2. This is caused either by a low combustion temperature or insufficient combustion oxygen, or both. The most common NOx-reduction strategies (low-NOx burners, flue gas recirculation, low excess air) create conditions that tend to promote the formation of CO while they reduce the formation of NOx,

and attempts to reduce emissions of both NOx and CO to low levels may be counter-productive. Reduction of NOx emissions is clearly the priority, since the Air District is in attainment status with all state and federal ambient air quality standards for CO, and because CO has less than one-tenth of the ozone-forming potential of NOx. Therefore, the proposed amendments to Regulation 9-7 emphasize NOx emission reductions and limit the concentration of CO in the exhaust stream of heaters to a reasonable level (400 ppmv), rather than attempting to achieve further CO emission reductions.

NOx Emissions and the Formation of Airborne Particulate Matter

NOx reacts with other pollutants to form airborne particles smaller than 2.5 microns in diameter ($PM_{2.5}$). Inhalation of $PM_{2.5}$ deep into the lungs reduces lung function. The Bay Area is currently in attainment of the federal standard for particulate matter smaller than 10 microns in diameter (PM_{10}), but has non-attainment status for the State PM_{10} and $PM_{2.5}$ standards.

In response to the enactment of California Senate Bill 656 (SB 656) in 2003, the Air District has committed to implement a number of particulate matter (PM) control measures to directly and indirectly reduce PM exposure, including an amendment of Regulation 9-7 to reduce emissions of NOx.

NOx Emissions and Global Warming

Emitted NOx is an indirect contributor to global warming because ozone is considered a greenhouse gas (GHG). Ozone is not included in tables that list the global warming potentials (GWP) of GHGs because it is short-lived, and the GWP is usually estimated over a 100 year time span. Nevertheless, a reduction in NOx emissions will reduce GHG emissions.

Heaters also emit GHG - primarily carbon dioxide (CO_2) - that contribute directly to global climate change. A net reduction in fuel and electrical consumption at the heaters subject to Regulation 9-7 will reduce global warming.

Heater Emission Mechanisms

The combustion process in heaters involves the oxidation of carbon and hydrogen in a hydrocarbon-based fuel to produce heat. For example, when methane (CH_4), the primary constituent of natural gas, is burned, the reaction proceeds as follows:

$$CH_4 + 2(O_2) \rightarrow \text{heat} + CO_2 + 2(H_2O) + \text{other pollutants} \qquad (\textit{Equation 1})$$

Thus, the products of any combustion process are CO_2 and water vapor (H_2O), as well as much smaller amounts of other pollutants including NOx, CO, sulfur oxides (SOx), volatile organic compounds (VOCs) and particulate matter (PM). Emissions of SOx, VOCs and PM are negligible compared to those of NOx and CO when natural gas fuel is used.

The true combustion reaction is more complex than shown in Equation 1 because heaters are provided with ambient air as an oxygen source, rather than pure oxygen. Because ambient air contains almost four times as much nitrogen gas (N_2) as oxygen gas (O_2), N_2 gas is also 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 is caused by exposure to combustion temperatures – with higher temperatures and longer exposure resulting in a higher NOx formation rate and higher concentrations of NOx in the exhaust stream.

In addition, all common fuels contain elemental nitrogen (N) or nitrogen gas 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 fuel oils are burned. The NOx emissions that result from nitrogen in the fuel are known as "fuel NOx".

The third NOx emission mechanism results in "prompt NOx", which is NOx formed as a result of reactions between N_2 gas and radical molecules derived from hydrocarbon fuels, and which is independent of combustion temperature. The amount of prompt NOx formed is generally small compared to that of thermal NOx, except at very low NOx emission rates (less than 10 ppmv).

NOx Emission Controls

NOx emission controls may be designed to reduce NOx formation ("thermal", "prompt or "fuel NOx"), or to reduce the concentration of previously-formed 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 the amounts of thermal and prompt NOx. Therefore, only thermal and prompt NOx controls and post-combustion controls are considered in this report.

Boilers, steam generators and process heaters that are not designed to achieve any particular NOx emission level ("uncontrolled heaters") will have a NOx emission concentration ranging from 75 ppmv up to as much as 200 ppmv, depending on the burner design and on the fuel/air ratio used in the burner. The first level of NOx control, which can comply with an emission concentration limit of 30 ppmv (requiring that the heater operate at an emission concentration somewhat lower than 30 ppmv at all times), is most typically achieved with "low-NOx burners" (LNBs) that reduce the formation of thermal NOx by reducing the average combustion temperature and by eliminating combustion "hot spots" through a variety of fuel/air mixing techniques. A similar level of NOx control can be achieved with "flue gas recirculation" (FGR), where a portion of the exhaust gas is vented back to the burner and mixed with the combustion air. Although the exhaust gas is hot, it is much cooler than the combustion temperature, so the addition of any amount of FGR to the combustion zone will reduce the combustion temperature, with larger amounts of FGR resulting in lower NOx emissions. FGR however, is typically not used to comply with a 30 ppmv NOx limit because FGR requires the installation of ductwork for the recirculated flue gas, as well as a high-temperature gas blower. Currently, Regulation 9-7 requires this level of NOx control (30 ppmv) for heaters with input heat ratings of 10 MM BTU/hr or more. A slightly higher NOx limit (40 ppmv) is allowed for combustion of liquid fuel because LNBs and FGR are somewhat less effective for liquid-fired heaters.

Further reductions of thermal NOx can achieve compliance with the next level of NOx control – a 15 ppmv NOx limit (with operation somewhat lower than 15 ppmv at all times). Burners capable of this level of NOx control are called "ultra-low-NOx burners" (ULNBs). Compliance with a 15 ppmv limit requires not only the use of ULNBs, but also improved maintenance and operating practices. For example, ULNB burner tips are smaller than standard burner tips and may require more frequent

cleaning to prevent plugging. Heater leaks that allow air leakage into the combustion zone may allow compliance with a 30 ppmv NOx limit, but are less likely to allow compliance with a 15 ppmv or lower limit, so improved heater sealing may be necessary. Finally, upgraded combustion controls may be necessary to maintain proper fuel/air ratios necessary to comply with a 15 ppmv or lower limit. These improved maintenance and operating practices not only allow compliance with a 15 ppmv NOx limit, but also improve the overall efficiency of the heater.

Compliance with the next level of NOx control – a 9 ppmv limit – can be achieved in three ways. The least attractive options are the use of ULNBs with very large amounts of FGR (30% to 40% of the exhaust gas flow) and the use of add-on controls such as selective catalytic reduction (SCR). Very high FGR rates may reduce heater reliability by reducing flame stability, and will reduce net heater efficiency because of the significant amount of electrical power required to drive the gas recirculation blower. Also, at very high FGR rates, CO emissions may approach the 400 ppmv limit in Regulation 9-7. SCR requires a significant capital investment and introduces a completely new chemical process (storage and injection of ammonia into the exhaust stream to reduce NOx to nitrogen gas) to the boiler system. ULNBs with high levels of FGR only reduce thermal NOx, without reducing prompt NOx. SCR is a post-combustion control that does not reduce NOx formation in any way. The third option is the use of advanced ULNBs (AULNB) that reduce the formation of thermal NOx – using internal recirculation of combustion gas rather than FGR - and also reduce the formation of prompt NOx by performing combustion in stages that avoid conditions favorable to prompt NOx formation. Internal recirculation – sometimes called fuel-induced recirculation (FIR) - uses the energy of the incoming fuel to draw combustion gases back into the incoming fuel before they leave the heater. FIR is more effective than FGR because recirculating combustion gases into the incoming fuel rather than into the incoming combustion air (as FGR does) has proven more effective in reducing NOx formation. Although FIR burners have been demonstrated to comply with a 9 ppmv limit with no FGR, many FIR installations require the use of low to moderate levels of FGR to achieve this level of NOx reduction. However, the improved maintenance and operating practices required to meet a 15 ppmv limit would also be necessary for a 9 ppmv limit, such that no overall reduction in efficiency is considered necessary to comply with a 9 ppmv limit using a FIR burner.

The highest level of NOx control – a 5 or 6 ppmv limit – has been demonstrated in limited cases using AULNBs. However, compliance with a 5 ppmv limit will only be possible in most cases using SCR. SCR technology is well-developed and available for most heater applications, although the capital costs, operating costs and space requirements are typically greater than for any other NOx control technology. It should be noted that packaged SCR systems are available on a rental basis within the Air District. A rental system could be used to temporarily comply with any of the proposed NOx emission limits with minimal heater modification.

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), as previously shown in Equation 1. Thus, CO_2 is not a pollutant that occurs in relatively low concentrations as a by-product of the combustion process; it is a necessary combustion product of any fuel containing carbon. Therefore, attempts to reduce emissions of greenhouse gases from combustion typically focus on increasing energy efficiency – consuming less fuel to provide the same useful energy output.

Boilers and steam generators generally operate at no more than 85% overall efficiency. In other words, only 85% of the fuel heat value is transferred to the material that is being heated and the other 15% is released to the atmosphere as waste heat, primarily 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 drained from the boiler to prevent solids from concentrating inside the boiler and fouling the heat exchange surfaces.

Some NOx control measures may reduce overall energy efficiency. For example, any measure that requires additional fans or gas blowers (such as FGR and SCR) will reduce the overall energy efficiency of the system. Retrofitted burners that provide lower NOx emissions by reducing the average combustion temperature will also reduce heat transfer to the heated medium and therefore reduce overall energy efficiency. These efficiency reductions may be mitigated, in some cases completely, through improved maintenance and operating practices.

Heaters with Air District Permits

The Air District requires permits for all heaters currently subject to Regulation 9-7:

- natural gas or LPG fired, input heat rating of 10 million BTU/hr (10 MM BTU/hr) or more
- liquid fuel-fired, input 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 Input (MM BTU/hr)	Number of Heaters
200 and greater	2
75 to <200	20
20 to <75	125
10 to <20	164
<10 (liquid fuel-equipped)	410
Totals	**721**

Heaters Exempt from Air District Permits

Natural gas and LPG-fired heaters with heat ratings greater than 2 but less than 10 MM BTU/hr are currently exempt from Regulation 9-7 and from Air District permit requirements. For this reason, the Air District does not have precise heater population data for these devices. Based on discussions with local boiler service companies and an evaluation of commercial and industrial natural gas consumption data within the Air District, the population of devices smaller than 10 MM BTU/hr is estimated to be about 8,000, with about two-thirds of these devices smaller than 2 MM BTU/hr, and the rest, approximately 2,634, rated more than 2 but less than 10 MM BTU/hr. Thus, the expansion of Regulation 9-7 to apply to devices rated more than 2 MM BTU/hr will add about 2,634 devices to the 721 already subject to this regulation.

III Proposed Rule Amendments

Current Provisions – Regulation 9, Rule 7

Regulation 9-7 currently includes the provisions shown in Table 2:

Table 2 –Current Provisions of Regulation 9-7

Provision	Standard
1. NOx exhaust concentration limit (natural gas and LPG-fired devices with input heat rating of 10 MM BTU/hr or more)	gaseous fuel: **30 ppm** @ 3% oxygen non-gaseous fuel: **40 ppm** @ 3% oxygen
2. CO exhaust concentration limit (natural gas and LPG-fired devices with input heat rating of 10 MM BTU/hr or more)	all fuels: **400** ppm @ 3% oxygen
3. Options for heaters burning less than 90,000 therm/yr of fuel OR heaters rated less than 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

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

The proposed amendments establish a 30 ppmv NOx emission limit and a 400 ppmv CO limit for heaters burning natural gas or LPG fuel that are rated more than 2 and no more than 5 MM BTU/hr, effective January 1, 2011, and a 15 ppmv NOx emission limit and a 400 ppmv CO limit for heaters rated greater than 5 to less than 10 MM BTU/hr, effective January 1, 2012. Currently, these devices have no NOx or CO emission limits. For facilities with multiple affected heaters, up to 3 years is allowed for complete compliance, with 1/3 of the facility heaters required to be in compliance each year beginning January 1, 2011.

Retrofit burner assemblies and completed packaged boilers that will comply with a 30 or 15 ppmv NOx limit are commercially available. A 30 ppmv NOx limit has already been adopted for heaters rated from 2 to 5 MM BTU/hr by the South Coast AQMD, Sacramento Metropolitan AQMD and the San Joaquin Valley APCD, and a 15 ppmv limit has already been adopted for heaters rated from 5 to 10 MM BTU/hr by the Sacramento Metropolitan AQMD and the San Joaquin Valley APCD.

On November 7, 2007, the Air District adopted amendments to Regulation 9, Rule 6: *NOx Emissions from Natural Gas-Fired Boilers and Water Heaters* that extended the applicability of Regulation 9, Rule 6 from a maximum heat rating of 75,000 BTU/hr up to 2 MM BTU/hr and extended the regulation to boilers as well as water heaters. Extending the applicability of Regulation 9-7 to heaters rated more than 2 MM BTU/hr will provide regulation of NOx emissions from all natural gas-fired water 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.

New heaters installed on or after January 1, 2011 will be subject to the new standard upon installation. Heaters that were in service prior to January 1, 2011, will become subject to this standard upon reaching a service life of 10 years. This 10-year service life allowance will improve the cost-

effectiveness of the proposal by allowing operators to utilize much of the typical service life of an existing device before a modification or replacement is necessary to comply with the proposed standard.

A low-fuel usage exemption is proposed for heaters with annual fuel use less than 10% of their maximum capacity. Heaters eligible for this low-fuel-use exemption will have the option of meeting the new NOx limits, of maintaining a low stack-gas oxygen concentration to demonstrate good heater operation, or of performing a detailed annual inspection and tune-up. These are the same options provided in the current rule for low-fuel-use heaters with heat ratings of 10 MM BTU/hr or more.

Certification and Registration for Heaters Rated Less Than 10 MM BTU/hr

Currently, natural gas-fired heaters are subject to Regulation 9-7 and to the permitting requirements in Regulation 2 at the same heat input rating of 10 MM BTU/hr or more. Generally, sources that are subject to a prohibitory rule like Regulation 9-7 are also required to obtain permits because the permitting process and inspections triggered by this process enhance the enforceability of the prohibitory rule.

The proposal to expand Regulation 9-7 to apply to natural gas-fired heaters rated higher than 2 MM BTU/hr will more than quadruple the number of heaters subject to Regulation 9-7. To most efficiently administer enforcement of the proposed regulations for the approximately 2,600 heaters that will become subject to Regulation 9-7, registration of these heaters, rather than permitting, is proposed. Registration will be a largely automated, online process that will identify heater operators and heater locations so that they may be inspected. A one-time registration fee of $425 per facility will be assessed, with each heater after the first at the same facility subject to an additional one-time $50 fee. These fees have been set to allow the Air District to recover the costs associated with enforcement of the amended regulation.

Reduce NOx Emission Limits for Heaters Rated 10 MM BTU/hr or More

The proposed amendments reduce the current NOx emission limit for heaters with input heat ratings of 10 MM BTU/hr or more, but retains the current 400 ppmv CO limit. Since higher levels of NOx control are more cost-effective for larger devices, three different levels of control are proposed. A low-fuel usage exemption is proposed for heaters with annual fuel use less than 10% of their maximum capacity. Exempt heaters would still be subject to the existing 30 ppmv NOx emission limit, but would have the option of meeting the new NOx limits, maintaining a low stack-gas oxygen concentration to demonstrate good heater operation, or performing a detailed annual inspection and tune-up.

Devices Rated from 10 to less than 20 MM BTU/hr

For devices rated from 10 to less than 20 MM BTU/hr, a 15 ppmv NOx limit is proposed, effective January 1, 2012. For facilities with multiple affected heaters, up to 3 years is allowed for complete compliance, with 1/3 of the facility heaters required to be in compliance each year beginning January 1, 2012. 15 ppmv standards for devices in this size range have already been adopted by the Sacramento Metropolitan AQMD and the San Joaquin Valley APCD.

Compliance with this limit can be achieved with ultra-low NOx burners, with or without FGR, or with SCR. Of the 164 devices in this size category in the Air District, only 14 operate at NOx emission levels significantly lower than 30 ppmv, and none operate at an emission rate lower than 20 ppmv. Thus, every existing device in this size category will have to be modified or replaced if it continues to operate after January 1, 2012.

New heaters installed on or after January 1, 2012 will be subject to the new standard upon installation. Heaters that were in service prior to January 1, 2012, will become subject to this standard upon reaching a service life of 10 years. This 10-year service life allowance will improve the cost-effectiveness of the proposal by allowing operators to utilize much of the typical service life of an existing device before a modification or replacement is necessary to comply with the proposed standard.

Heaters firing digester or landfill gases, which may have low or inconsistent heat values, may not be able to reliably comply with a 15 ppmv NOx limit. Therefore, heaters rated 10 MM BTU/hr and higher that fire or co-fire digester or landfill gas at least 90% of the time are allowed a 30 ppmv NOx limit. Combustion of these fuels is very limited in the Bay Area.

Devices Rated from 20 to less than 75 MM BTU/hr

For devices rated from 20 to less than 75 MM BTU/hr, a 9 ppmv NOx limit is proposed, effective January 1, 2012. Compliance with this limit can be achieved with AULNBs with moderate levels of FGR. Some operators may elect to use SCR to comply with this standard. "Load-following" heaters that must respond to large and rapid fluctuations in load demand may not be able to reliably comply with a 9 ppmv NOx limit at all times. Therefore, load-following heaters rated 20 MM BTU/hr and higher are allowed a 15 ppmv NOx limit. 9 ppmv standards for devices in this size range, with load-following exemptions, have already been adopted by the Sacramento Metropolitan AQMD and the San Joaquin Valley APCD.

Of the 125 devices in this size category, only 19 operate at NOx emission levels significantly lower than 30 ppmv, and only one operates at an emission rate as low as 9 ppmv. Thus, potentially all but one of the devices in this size category will have to be modified or replaced if they continue to operate after January 1, 2012. However, an unknown number will qualify for the load-following standard of 15 ppmv.

New heaters installed on or after January 1, 2012 will be subject to the new standard upon installation. Heaters that were in service prior to January 1, 2012, will become subject to this standard upon reaching a service life of 5 years. This 5-year service life allowance will improve the cost-effectiveness of the proposal by allowing operators to use at least part of the typical service life of an existing device before a modification or replacement is necessary to comply with the proposed standard.

Devices Rated 75 MM BTU/hr and higher

For heaters with input heat ratings of at least 75 MM BTU/hr, a 5 ppmv NOx limit is proposed, effective January 1, 2012. Compliance with this limit can be achieved with SCR technology. Of the 22 devices in this size category, 12 are expected to be eligible for the 10% low fuel usage exemption, and 3 are expected to be eligible for the digester gas standard of 30 ppmv. Of the remaining 7 devices, those that are designated to be load-following devices would be subject to a 15 ppmv standard. A 5 ppmv standard for devices in the size range has been proposed by the South Coast AQMD.

New heaters installed on or after January 1, 2012 will be subject to the new standard upon installation. Heaters that were in service prior to January 1, 2012, will become subject to this standard upon reaching a service life of 5 years.

Devices Firing Non-Gaseous Fuel

No reduction is proposed to the 40 ppmv NOx emission limit for heaters firing non-gaseous fuel because NOx control technology for liquid fuels has not progressed as much as for gaseous fuels.

Also, there are relatively few devices that use liquid fuel in the Bay Area, in large part because most devices that use liquid fuel require a District permit and are subject to "toxic best available control technology" (TBACT) requirements, which limit the use of liquid fuel.

New Insulation Requirements

Heat loss from inadequately insulated surfaces may be a significant contributor to energy inefficiency in a heater. Energy inefficiency results in increased fuel consumption with related emissions of NOx and greenhouse gases. The proposed amendments require insulation of all heaters subject to Regulation 9-7, such that exposed surfaces on boilers and steam generators do not exceed 120°F, effective January 1, 2010. A low-fuel usage exemption is proposed for heaters with annual fuel use less than 10% of their maximum capacity.

New Stack Gas Temperature Limits

Avoidable heat loss from boiler and steam generator stacks is typically the largest contributor to energy inefficiency in a heater. Elevated stack gas temperature is an indicator of poor combustion control (high excess air) or of poor heat transfer to the heated water or steam (because of fouled heat transfer surfaces or insufficient heat transfer surface). The proposed amendments impose maximum stack gas temperature limits on boilers and steam generators, effective January 1, 2010. A low-fuel usage exemption is proposed for heaters with annual fuel use less than 10% of their maximum capacity.

Modern heaters in good operating condition are expected to be able to meet these temperature limits without modification. Low-efficiency heaters may require replacement or the installation of an economizer retrofit to comply with these limits. An economizer is a heat exchanger that recovers waste heat from the exhaust stack and uses it to pre-heat combustion air or feedwater.

New Inspection and Tune-Up Requirements

Currently, Regulation 9-7 requires periodic tune-ups only for heaters that qualify for a low fuel-usage exemption, in lieu of compliance with the 30 ppmv NOx emission limit. However, even if a heater meets the applicable NOx emission limit, it is possible that it is not operating at optimal energy efficiency, and therefore that it is consuming more fuel and generating more NOx, CO and greenhouse gases than necessary. The proposed amendments apply an annual tune-up requirement to most heaters subject to Regulation 9-7, effective January 1, 2009. The tune-up procedure in the Manual of Procedures is also proposed to be amended to include additional inspection items. These include temperature measurements of the heater surface, stack gas, and water or steam; and evaluation of the blowdown rate to ensure it complies with manufacturer specifications; and the iteration of specific steps in the tune-up procedure.

Exemptions from New Requirements

District Regulation 9, Rule 9: *Nitrogen Oxides from Stationary Gas Turbines* ("Regulation 9-9") was amended in 2006 and requires turbine retrofits or replacements to comply with reduced NOx emission limits. Fourteen facilities in the Bay Area that operate turbines subject to Regulation 9-9 are also subject to Regulation 9-7 and may be required to make significant capital expenditures to comply with both rules. In response to a comment from one of the affected facilities, an extension of up to 24 months is proposed for compliance with new NOx standards in Regulation 9-7 for heaters at facilities that must also modify or replace a turbine to comply with the new requirements of Regulation 9-9.

There is one heater in the Bay Area in the 75 MM BTU/hr and higher size range that is already required to meet a 9 ppmv NOx emission limit by its Air District Permit to Operate and that will not be exempt from the proposed 5 ppmv limit because it will not have low fuel use. The cost of compliance with a 5 ppmv standard is high for this heater because the operator will have to install an SCR system to comply with the 5 ppmv limit, but will only realize a relatively small emission reduction. In consideration of the fact that this heater has operated for several years at a relatively low emission rate of 9 ppmv, an exemption is proposed from compliance with the 5 ppmv limit. This exemption will only apply to one heater at one facility.

Table 3 summarizes the proposed amendments:

Table 3 – Summary of Proposed Amendments

Size Range (MM BTU/hr)	Current NOx Limit (ppmv)	New NOx Limit (ppmv)	Current Inspection, Tune-Up, Monitoring	New Inspection, Tune-Up, Monitoring & Other	Effective Date
>2 to 5	None	30	None	• manufacturer certification • annual inspection & tune-up • insulation requirements and stack gas temperature limits	NOx limit: 1/1/2011 OR 10 years after manufacture date for existing devices inspection & tune-up: 1/1/2009 insulation: 1/1/2010 stack gas temperature: 1/1/2011
>5 to <10	None	15	None		
10 to <20	30	15	• no annual inspection • annual tune-up only for low-fuel devices • no periodic monitoring of emissions	• annual inspection & tune-up • semi-annual source test for 10 to <20 MM BTU/hr devices; annual test for larger devices • insulation requirements and stack gas temperature limits	NOx limit: 1/1/2012 OR 10 years after manufacture date for existing devices inspection & tune-up: 1/1/2009 insulation: 1/1/2010 stack gas temperature: 1/1/2011
20 or more, load-following unit	30	15			NOx limit: 1/1/2012 OR 5 years after manufacture date for existing devices inspection & tune-up: 1/1/2009 insulation: 1/1/2010 stack gas temperature: 1/1/2011
20 to <75	30	9			
75 or more	30	5			

IV Emissions and Emission Reductions

NOx emissions for heaters with a heat rating greater than 2 but less than 10 MM BTU/hr have been estimated to be about 4.28 ton/day based on natural gas consumption data provided by Pacific Gas and Electric Company and an emission factor from U.S. EPA's AP-42 document (75 ppmv). The number of devices in this size range has been estimated using assumptions derived from the sample (285 devices) of heaters in the Air District permit database within this size range, including average size and average utilization, and has been estimated to be about 2,634. The population size and current emissions for devices 10 MM BTU/hr and larger has been taken from the Air District permit database, since all of these devices are required to have permits.

The emissions and potential emission reductions for each heater size category are shown in Table 4.

Table 4 – Summary of Emissions and Emission Reductions

Heater Size Range (MM BTU/hr)	Devices	Current NOx (ton/day)	Current NOx (ppmv)	Proposed NOx (ppmv)	NOx Reduction (ton/day)
>2 to 5	1238	2.01	75	30	1.15
>5 to <10	1396	2.27	75	15	1.72
>2 to <10 TOTALS	2634	4.28			2.87
10 to <20	164	0.26	30	15	0.06
20 to <75	125	0.56	30	9	0.19
75 to <410	21	0.09	27	5	0.07
410	1	0.02	12	5	0.01
10 and larger TOTALS	311	0.93			0.33
TOTALS	**2945**	**5.21**			**3.2**

Therefore, it appears that the proposal has the potential to reduce emissions about 61% from the heaters that are proposed to be subject to Regulation 9-7. Some devices in the 20 to less than 75 MM BTU/hr category may be able to qualify for a 15 ppmv NOx limit rather than a 9 ppmv limit if they are determined to be load-following units that cannot meet a 9 ppmv limit. However, even if all units in

this size category only comply with a 15 ppmv limit, the potential emission reduction will be about 60%.

Also, because NOx contributes to the formation of secondary particulate matter (PM), the NOx reduction will also result in a reduction of PM. Secondary PM is formed from the conversion of NOx to ammonium nitrate (NH_4NO_3). District staff has estimated the ratio between NH_4NO_3 formation to NOx emissions to range between 1:6 and 1:10. At a conversion rate of 1:8, secondary particulate matter will be reduced by as much as 0.4 tons/day by the proposed amendments.

Greenhouse Gas Emissions

It is widely accepted that the accumulation of increasing amounts of greenhouse gases (GHG) in the Earth's atmosphere is a cause of global climate change. Due to the complexity of conditions and interactions affecting global climate change, it is not possible to predict the specific impact, if any, attributable to GHG emissions associated with a single project. The proposed amendments to Regulation 9, Rule 7 would extend the rule to apply to certain classes of heaters currently not regulated in the District and would generally make the emission limits in the rule more stringent. The proposed amendments also include requirements to maximize energy efficiency among heaters that would be subject the rule. The net effect the proposed amendments would have on GHG emissions will depend upon the technologies applied to meet the new emissions limits and on the effect of the energy efficiency measures proposed in the rule.

The proposed amendments include measures to maximize the energy efficiency of heaters that would be subject the rule. They include:

- A requirement to install insulation on most heaters subject to the rule, with some safety related exceptions, such that exposed surfaces do not exceed 120°F.
- An annual tune-up requirement for most heaters subject to the rule, effective in 2009.
- Maximum limits on stack gas temperatures, from 100 to 150 degrees Fahrenheit over the saturated steam or hot water temperature, to ensure good heat transfer.

Insulation can increase energy efficiency in a heater by up to 5%. Over time, insulation degrades, or is removed for heater repairs and servicing and not replaced. Some heaters have inadequate insulation and older heaters may never have been insulated. If all heaters were to be able to increase energy efficiency by 5%, CO_2 emissions would be decreased by 2781 tons per day. Elevated stack gas temperature is an indication of poor heat transfer within a heater, because of insufficient residence time for heat transfer to occur (possibly because of excessive excess air), or because of fouled or corroded heat transfer surfaces. In the first case, heater design or operation is at fault; a replacement heater, better burner controls or the addition of an economizer will improve heat transfer. In the second, cleaning the heat transfer surfaces and maintaining an optimal liquid blowdown rate to keep the transfer surfaces clean will improve heat transfer and lower stack gas temperatures. As a rule of thumb, overall heater efficiency can be improved 1% every 40^oF reduction in flue gas temperature. Tune-up requirements can increase heater efficiency by up to 10% by optimizing air-fuel ratios. This also ensures that NOx emissions are not increasing beyond the proposed limits. A tune-up will also check blowdown rates, so that heat is not lost from excessive blowdown. If all heaters in the smallest size range, (greater than 2 but less than 10 MM BTU/hr), could increase their efficiency by 10%, CO_2 emissions would be decreased by 4809 tons per day.

Apart from the energy efficiency measures described above, the proposed amendments would affect GHG emissions depending on the means used by heater operators to comply with the proposed

emission standards. For the proposed NOx emission limits for heaters rated from greater than 2 up to 20 MM BTU/hr, and for units rated 75 MM BTU/hr and above, a significant overall loss in efficiency is not expected. In fact, better air-fuel controls on heaters that are required to maintain low NOx levels will increase efficiency in most heaters affected by the proposed amendments.

For some heaters, installation of ultra-low-NOx burners (ULNBs) in conjunction with fuel-gas recirculation (FGR) may require that the maximum firing capacity of the heater be reduced or may result in an overall loss of efficiency. The heaters most likely to require both these technologies are in the 20 to less than 75 MM BTU/hr range. The proposed amendments would subject each heater in this range to a NOx emission limit of 9 ppmv, unless the heater is a load-following unit, as defined in the amendments. Heaters subject to the proposed 9 ppmv NOx limit may install ULNBs in conjunction with FGR. The 20 to less than 75 MM BTU/hr heaters with ULNBs and FGR may require up to 40% of the flue gas to be re-circulated. However, one burner manufacturer states that, with state-of-the-art controls, no more than 15% of flue gas would need to be re-circulated to achieve NOx emissions lower than 9 ppmv.[1] Other boiler and burner manufacturers state that 9 ppmv can be achieved in new heater designs without loss of efficiency.[2,3] Finally, applications are being developed for combined heat and power units, wherein a micro-turbine provides combustion air and power to run elements of the NOx control system, resulting in an overall net energy decrease. One such system is slated for installation at Hitachi Systems in the Bay Area.[4] Re-circulation of 40% of the flue gas would result in about a 10% loss in overall heater efficiency. If all heaters in this size range were to suffer a 10% loss in efficiency, there would be an increase in CO_2, the primary GHG, of 565 tons per day. Re-circulation of 15% of the flue gas would result in less than 5% loss in efficiency.

It is difficult to assess the overall greenhouse gas impacts of the energy efficiency measures, which reduce CO_2, and the proposed NOx limit for the 20 to 75 MM BTU/hr size category, which may increase CO_2. The reason for this difficulty is that the number of heaters that will opt for the ultra-low NOx burners in conjunction with high flue gas recirculation is unknown because a considerable number are expected to be load-following units which will be subject to a 15 ppmv limit, which is unlikely to result in a loss of overall efficiency, rather than a 9 ppmv limit. Some may opt for SCR, which does not significantly reduce energy efficiency, and some may install advanced controls that may limit the amount of flue gas recirculation needed. Also, the number of heaters that will need insulation is unknown. Most heaters are installed with insulation, but, over time, insulation degrades, and repair or replacement of old insulation could be of considerable value. Finally, the number of heaters that do not now receive annual tune-ups, and thus would benefit from the tune-up requirement, is unknown.

It is likely that the reduction in greenhouse gases from energy efficiency measures, overall, far outweighs a possible increase in greenhouse gases from NOx control equipment in the 20 to 75 MM BTU/hr size category. Staff developed a spreadsheet to calculate overall increases or reductions in

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[1] Weideman, Dan, Demonstration of an Ultralow NOx Burner on a Firetube Boiler, ST Johnson Co., Jan.12, 2004, http://www.johnstonboiler.com/fir_burner.php

[2] Connor, S. "Low Emissions and High Efficiency, A Dichotomy?", Cleaver-Brooks, http://www.cbboilers.com/Emissions/Technical%20Articles/Efficiency,%20a%20dichotomy%20S%20Connor.pdf

[3] Delta-NOx Ultra Low NOx Burner Achieves 9 PPM, Coen Company, Inc. July 2005

[4] Castaldini, Carlo, CMC Engineering, telephone conversation and Industrial Technologies Program/Energy Efficiency and Renewable Energy, www1.eere.energy.gov/industry/bestpractices/pdfs/steam3_recovery.pdf

CO_2 from the proposed amendments based on numbers of heaters that would require insulation and tune-ups, and numbers in the 20 to 75 MM BTU/hr range that would suffer an energy efficiency loss. Staff used a 10% reduction in efficiency for the 20 to 75 MM BTU/hr heaters, a 5% benefit from insulating heaters, and a 10% benefit from tune-ups to heaters. For purposes of the calculations, staff only assumed benefit from tune-ups to the smallest size heaters (greater than 2 but less than 10 MM BTU/hr). These are the heaters most likely to be in institutional or commercial use, or in places like apartment buildings, office buildings and hotels. The large heaters tend to be in industrial use and staff assumed that, because their fuel usage is relatively high, they would be more likely to be tuned up at least annually. PG&E estimates a 10% to 20% energy efficiency increase from tune-ups, so the 10% benefit used for the calculation is conservative. Also, a variety of sources estimates that insulation can improve a heater's efficiency by 5% to 10%. Five percent has been used for these calculations.

The most conservative calculations show that, if 90% of the heaters are already insulated with insulation that has not degraded due to age, and if 90% of the heaters in the smallest size range already have annual tune-ups (as noted above, the calculations assume all larger heaters are tuned up annually), and all the 20 to 75 MM BTU/hr heaters suffer a 10% energy efficiency loss, then there would still be a net CO_2 reduction of 194 tons per day. It is likely that the net reduction of greenhouse gases is much greater, for the reasons described below.

First, based on information gathered from boiler service companies in the District, it is unlikely that 90% of heaters in the District are adequately insulated. According to at least one boiler service company, most heaters have had insulation degradation, as described above, so that the majority of heaters could benefit from upgrading insulation.

Second, it is also unlikely that 90% of all heaters have annual inspection and maintenance (tune-ups). Although heaters are inspected periodically for safety, and insurance companies require these inspections, air-fuel optimization is not necessarily a part of these inspections. Many operators in the commercial service sector will not tune-up to maximize efficiency routinely, although larger operators are more likely to do so.

It is probable that the assumption of a 10% energy efficiency reduction from all heaters in the 20 to less than 75 MM BTU/hr size range is an over-estimate because it is unlikely that all these heaters will suffer a 10% loss in efficiency. As discussed above, technology is available to reduce the energy efficiency loss in this size range. At current high energy costs, it is reasonable to assume that this technology would become more economically attractive. The proposed NOx limit could also be met with other technology, such as SCR. SCR, while generally more expensive than ultra-low NOx burners and FGR, does not significantly degrade efficiency. Finally, a number of heaters are likely load-following units, so would be subject to a less stringent standard.

Finally, researchers are developing what are known as Super Boilers[5] that incorporate several efficiency-improving technologies. These devices, currently in the testing stage, have shown energy efficiencies of 94% and NOx emissions of less than 5 ppmv. The individual technologies that contribute to these high efficiency levels may be commercialized as the proposed amendments become

[5] US Department of Energy, Energy Efficiency and Renewable Energy, Super Boiler, First Generation, Ultra-High Efficiency Firetube Boiler, June, 2007, http://www1.eere.energy.gov/industry/combustion/pdfs/superboiler.pdf

mandatory. Operators who choose to retrofit one or more of these technology could ultimately realize cost savings and further reduce greenhouse gas emissions.

Table 5 shows a range of expected CO_2 reductions from various percentages of heaters that are able to gain energy efficiency if all the 20 to 70 MM BTU/hr heaters were to suffer a 10% energy efficiency loss.

Table 5

CO2 Reductions from Insulation and Small Boiler Tune-Ups Including Efficiency Loss, 20 to less than 75 MM BTU/hr Heaters (ton/day)

	Percentage of heaters that already get annual tune-ups		
Percentage of heaters that are already insulated	50% already get annual tune-ups	75% already get annual tune-ups	90% already get annual tune-ups
10% insulated	4342	3140	2418
25% insulated	3925	2723	2001
50% insulated	3230	2027	1306
75% insulated	2534	1332	611
90% insulated	2117	915	194

V Economic Impacts

Implementation Costs and Cost Effectiveness

Table 6 summarizes the capital costs and related cost effectiveness for NOx control measures for those devices that will be subject to a new NOx standard. Population numbers are lower than in Table 5 because some devices are expected to qualify for a low-fuel use exemption (less than 10% of maximum annual fuel use), and therefore will not be subject to a new NOx limit and will have no capital implementation costs. The number of exempt devices rated less than 10 MM BTU/hr has been estimated based on an assumption that they occur in the same proportion as they do in the sample (285 devices) of heaters in the Air District permit database within this size range. This assumption may overestimate the number of heaters that will be subject to the amended rule, based on a comparison with heater populations reported in Sacramento Metropolitan AQMD's (SMAQMD) 2005 staff report for an amendment of that district's heater rule (Rule 411). Similarly, the number of affected devices rated 10 MM BTU/hr and higher (for which the Air District has annual fuel use data from permit submittals) has been determined by excluding from the total permitted population (shown in Table 5) those devices that have reported current fuel use that would make them eligible for a low-fuel use exemption.

Devices rated less than 10 MM BTU/hr are assumed to be replaced in order to comply with the new NOx limits, since they tend to be "packaged units" that may be problematic to retrofit. This is a conservative assumption since some newer packaged units may be able to be retrofitted at a lower cost than the cost for replacement. Devices rated 10 MM BTU/hr and higher are assumed to be retrofitted rather than replaced. Installed capital costs for devices less than 75 MM BTU/hr are taken from SMAQMD's Staff Report for the amendment of Rule 411, Attachment D-1 in October 2005. The values in SMAQMD's Attachment D-1 are interpolated to correspond to the average device size for each size category. These costs are applicable because Sacramento Metropolitan AQMD adopted in 2005 the same NOx limits that are proposed for Regulation 9-7. However, because of comments to the Air District from several affected heater operators that actual costs for 15 ppmv heaters in the greater than 5 but less than 10 size category had previously been grossly underestimated, costs for heaters in this size range were doubled. Retrofit costs for heaters in the 75 to less than 410 MM BTU/hr size range are based on the costs for the device with the average size in this size range taken from CARB's 2002 report *"Report to the Legislature: Implications of Future Oxides of Nitrogen Controls From Seasonal Sources in the San Joaquin Valley"*. Retrofit costs for the single 410 MM BTU/hr heater were taken from the heater operator. However, since the estimate provided was to comply with a 9 ppmv limit, the costs were increased by 25%. CARB's 2002 report noted that costs for an SCR retrofit to comply with a sub-9 ppmv limit were reported to be 25% greater than for an ULNB retrofit to comply with a 9 ppmv limit.

Cost effectiveness is calculated in accordance with the "levelized cash flow method" described in the Air District BACT/TBACT guidelines, with a capital recovery factor of 0.09 and other costs equivalent to 0.09. Because heaters in each size category are allowed a "service life allowance", before which they are not required to retrofit or replace a heater, the cost is reduced to reflect the fact that some fraction of the cost of the existing equipment allowed to be recovered. The service life for all devices is assumed to be 20 years based on CARB's 2002 report.

Table 6 – Capital Costs and Cost-Effectiveness					
Heat Rating (MM BTU/hr)	**Affected Devices**	**Installed Cost Per Device**	**Annualized Cost Effectiveness ($/ton NOx)**	**Service Life Allowance (years)**	**Cost Effectiveness, including Service Life Allowance ($/ton NOx)**
>2 to 5	879	$91,000	$34,400	10	$17,200
>5 to <10	670	$182,000	$34,900	10	$17,400
10 to <20	79	$87,600	$55,400	10	$27,700
20 to <75	61	$117,600	$18,400	5	$13,800
75 to <410	6	$429,000	$32,000	5	$24,000
410	1	$1.5 MM	$63,400	5	$47,600

Additional Costs to Operators

Operators of heaters rated less than 10 MM BTU/hr will be charged a one-time registration fee of $425 per facility, with each heater after the first subject to an additional one-time $50 fee. There are 410 permitted heaters in the Air District rated less than 10 MM BTU/hr located at 169 facilities (2.4 heaters per facility). The 2,634 heaters that are rated greater than 2 but less than 10 MM BTU/hr that will become subject to Regulation 9-7 will also be assumed to be distributed in this way, and therefore will be assumed to be located at 1,098 facilities. Based on these assumptions, the total registration cost will be approximately:

(1,098) ($425) + (1,098) ($50) + (1,098)(0.4)($50) = $543,510, or $495 per facility

Cost-Benefit of Energy Efficiency Measures

Some of the proposed requirements are expected to have costs that will provide a payback to heater operators within a relatively short period of time. These include insulation requirements, stack gas temperature limits, and annual inspection and tune-up requirements.

The proposed insulation requirement requires boilers and steam generators to be insulated so that surface temperature do not exceed 120°F. The requirement includes a number of exemptions to ensure that new insulation is only required where it is most cost-effective and does not conflict with safety requirements. Also, an engineering firm contracted by the Pacific Gas & Electric Company to implement efficiency incentive programs for heater operators, has indicated that insulation is one of the most cost-effective efficiency improvements that is available to heater operators in the Bay Area. The estimated cost for insulating a small boiler rated less than 10 MM BTU/hr (assume 5 MM BTU/hr) and associated ducting is roughly 8% of the capital cost ($90,000) for a boiler of this size. Assuming 30% utilization, $1.10/therm for natural gas (PG&E summer commercial rate) and a modest 1% improvement in efficiency resulting from the insulation, simple payback would occur in about 4 years. Larger boilers would be expected to have a faster payback because the area to be insulated (and

therefore the cost) will not increase as quickly as the energy consumption and the potential energy and cost savings.

The proposed stack gas temperature limits are intended to ensure that heaters operate with normal heat transfer efficiency. Inadequate heat transfer, most commonly caused by fouled or corroded heat transfer surfaces, causes combustion heat to be wasted through the stack rather than being transferred to the heated water or steam. Cleaning of fouled or corroded heat transfer surfaces is expected to cost less than $5,000 for a small boiler rated 5 MM BTU/hr, while the potential increase in efficiency is substantial, from 3 to 5%. Again, assuming 30% utilization, $1.10/therm for natural gas and a 3% improvement in efficiency resulting from an improvement in heat transfer, simple payback would occur in less than 6 months. Although cleaning costs are higher for larger devices, the payback is expected to be just as good for a larger device.

Stack gas temperatures may be reduced by a greater amount, and overall efficiency improved beyond that of the original heater design, by installing an economizer. An economizer is a heat exchanger that recovers waste heat from exhaust gas and transfers it to heater feedwater or combustion air, thereby reducing the amount of fuel used to bring the feedwater or combustion air up to operating temperature. Economizers typically improve efficiency from 3 to 10%. Installed cost for an economizer for a 5 MM BTU/hr heater is roughly $15,000 to $20,000. Assuming a $20,000 installed economizer cost on a boiler rated 5 MM BTU/hr and operated at 30% utilization, $1.10/therm for natural gas and a 7% improvement in efficiency resulting from a reduction in waste heat, simple payback would occur in less than 2 years. Although capital and installation costs would be higher for larger devices, economizers typically have fast payback periods of less than five years.

The proposed annual inspection and tune-up includes a number of elements, including minimization of excess air. Too much excess air provides excess nitrogen gas in the combustion zone that can form into NOx and also reduces the residence time of combustion gases, decreasing heat transfer efficiency. An annual inspection for a small boiler rated less that 10 MM BTU/hr (assume 5 MM BTU/hr) is expected to cost less than $1,500. Modern boilers can typically be operated at 10% excess air, although it would not be unusual for an out-of-tune boiler to operate at 25% excess air or more. Each 15% reduction in excess air is generally considered to result in a 1% improvement in efficiency. Again, assuming 30% utilization, $1.10/therm for natural gas (PG&E summer commercial rate) and a 1% improvement in efficiency resulting from a reduction of excess air from 25% to 10%, simple payback would occur in less than one year, paying for the cost of the annual tune-up. Because the cost of a tune-up is not expected to be significantly higher for a larger boiler, while the potential energy savings do increase with boiler size, payback is expected to be better for larger devices.

Cost to Manufacturers – Gas-fired heaters rated greater than 2 but less than 10 MM BTU/hr

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 $2,000 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 in the greater than 2 but less than 10 MM BTU/hr size category, to administer the registration of 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 inspected on a periodic basis.

Socioeconomic Impacts

Section 40728.5 of the California 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 of Walnut Creek, California has prepared a socioeconomic analysis of the proposed amendments to Regulation 9-7. The analysis concludes that the cost of the proposed amendments will not have a significant socio-economic impact on affected businesses.

Incremental Costs

Background

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."

Staff identified six control technologies (including the option of having no emission controls) that could be used by heaters subject to Regulation 9-7 to comply with any required level of NOx control. In every case, more effective NOx controls have higher overall costs. Staff then divided the heaters subject to Regulation 9-7 into five size categories, identified the control technology currently used in each size category, and then proposed a new NOx emission limit for each size category (which implies, but does not require, a specific NOx control technology). The proposed emission limit (and probable control technology) was based on an incremental cost analysis between the probable control technology and the next-most-effective control technology. Table 7 summarizes the current and probable control technologies for each size range.

Table 7 – Current and Probable NOx Control Technology				
Size Range (MM BTU/hr)	**Current NOx Limit (ppmv)**	**Current Control Technology**	**Proposed NOx Limit (ppmv)**	**Probable Control Technology**
>2 to 5	None	None (Conventional burners producing at least 75 ppmv NOx)	30	LNB, no FGR
>5 to <10	None	None (Conventional burners producing at least 75 ppmv NOx)	15	Ultra-Low-NOx Burners (ULNB), possibly FGR
10 to <20	30	Low-NOx Burners (LNB), possibly Flue Gas Recirculation (FGR)	15	ULNB, possibly FGR
20 to <75	30	LNB, possibly FGR	9	ULNB and FGR
75 or more	30	LNB, possibly FGR	5	Selective Catalytic Reduction

Greater than 2 up to 5 MM BTU/hr heaters:

For the smallest size category, the most basic and inexpensive level of NOx control has been proposed: standard, 30 ppmv, low-NOx burners (LNB). These heaters are currently not subject to a NOx standard. The next-most-effective level of control would be to have no emission limit and to use "uncontrolled" burners emitting at least 75 ppmv NOx. Although the heaters in this size category are small, they are numerous, comprising about 42% of the total number of heaters rated greater than 2 MM BTU/hr and accounting for about 36% of the total proposed emission reduction. Since 30 ppmv-compliant heaters are in such widespread use compared to any other level of NOx control, there is no significant cost difference between a 30 ppmv-compliant heater and a heater with a slightly reduced level of NOx control (40 or 50 ppmv). Therefore, a NOx standard that was relaxed from 30 ppmv to the point that would provide significant cost reductions to heater operators would also significantly reduce the effectiveness of the proposed rule. Therefore, the next-least-costly control option for these heaters will not provide the required emission reductions.

Greater than 5 but less than 10 MM BTU/hr heaters:

For the next-largest size category, a higher level of control has been proposed: 15 ppmv achieved with ultra-low-NOx burners (ULNB). These heaters are currently not subject to a NOx standard. The next-most-effective level of control would be a 30 ppmv LNB. The heaters in this size category comprise about 47% of the total number of heaters rated greater than 2 MM BTU/hr and account for about 54% of the total proposed emission reduction. If these heaters were allowed to operate at 30 ppmv rather than 15 ppmv, the resulting emission reduction from this size category would be reduced by 25%. The installed cost of complying with a 15 ppmv limit was conservatively estimated to be twice that of complying with a 30 ppmv limit based on comments from the public that compliance with a 15 ppmv limit in this size category was substantially more costly than for a 30 ppmv limit, with the most extreme example of this increased cost being quoted by a supplier at a 100% increase ($182,000 installed cost for the average size device in this size category).

Based on these costs and emission reductions, and using the "levelized cash flow" method of

calculating cost effectiveness as described in the Air district's BACT/TBACT Guidelines, the incremental cost-effectiveness for a 15 ppmv limit, compared to a 30 ppmv limit, with 670 affected devices, is:

• $69,900 per ton of NOx, if installed costs double for a 15 ppmv device;

• $35,000 per ton of NOx, if installed costs are 50% higher for a 15 ppmv device.

10 to less than 20 MM BTU/hr heaters:

For this size category a 15 ppmv NOx limit has been proposed. These heaters are currently subject to a 30 ppmv NOx limit. If these heaters were allowed to continue to operate at 30 ppmv rather than 15 ppmv, the resulting emission reduction from this size category would be entirely eliminated.

The installed cost of complying with a 15 ppmv limit for heaters in this size range was estimated to be $87,600. Then, the incremental cost-effectiveness for a 15 ppmv limit, compared to a 30 ppmv limit, with 79 affected devices, is $56,900 per ton of NOx.

20 to less than 75 MM BTU/hr heaters:

For this size category, a 9 ppmv limit has been proposed, which may be achieved with ultra-low-NOx burners (ULNB) and flue gas recirculation (FGR). The next-most-effective level of control would be a 15 ppmv ULNB system. The heaters in this size category comprise about 4% of the total number of heaters rated greater than 2 MM BTU/hr and account for about 6% of the total proposed emission reduction. If these heaters were allowed to operate at 15 ppmv rather than 9 ppmv, the resulting emission reduction from this size category would be reduced by about 26%.

For 50 MM BTU/hr devices (the average size of heaters is this size category is 32 MM BTU/hr), CARB in its 2002 report found a reported total cost difference between a 15 ppmv ULNB system and a 9 ppmv ULNB/FGR system of $47,500. Then, the incremental cost-effectiveness for a 9 ppmv limit, compared to a 15 ppmv limit, with 61 affected devices, is $28,600 per ton of NOx.

75 MM BTU/hr and higher heaters:

For this size category, a 5 ppmv limit has been proposed, which may be achieved with selective catalytic reduction (SCR). The next-most-effective level of control would be a 9 ppmv ULNB/FGR system. The heaters in this size category comprise less than 1% of the total number of heaters rated greater than 2 MM BTU/hr and account for about 2.5% of the total proposed emission reduction. If these heaters were allowed to operate at 9 ppmv rather than 5 ppmv, the resulting emission reduction from this size category would be reduced by about 16%.

For 150 MM BTU/hr devices (the average size of heaters is this size category is less than 150 MM BTU/hr), CARB in its 2002 report found a reported total cost difference between a 9 ppmv ULNB/FGR system and a 9 ppmv ULNB/FGR of $96,000. Then, the incremental cost-effectiveness for a 5 ppmv limit, compared to a 9 ppmv limit, with 7 affected devices, is $25,500 per ton of NOx.

VI Environmental Impacts

Pursuant to the California Environmental Quality Act, the Air 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 Air District Board of Directors. The initial study and negative declaration is to be circulated for public comment during the period from June 30, 2008 to July 21, 2008.

VII 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 Air District air pollution control requirements for the equipment or source type affected by the proposed change in air district rules. The air district must then note any differences between these existing requirements and the requirements imposed by the proposed change.

Air District Regulation 9 for NOx sources is structured so that no source is subject to more than one rule under Regulation 9. Therefore, the heaters that are currently subject to Regulation 9, Rule 7 and those that are proposed to be made subject to Regulation 9, Rule 7 are not subject to any other Air District regulation that establishes specific emission limits or monitoring requirements, although they may be subject to other Air District regulations that establish permitting requirements or fees.

U.S. EPA has established New Source Performance Standards (NSPS) for several categories of heaters in Part 60 of the Code of Federal Regulations (CFR) as listed in Table 8:

Table 8 – New Source Performance Standards (NSPS)

NSPS	Affected Heaters	Requirements
60 CFR Subpart D	Steam Generator; input rating >250 MM BTU/hr; constructed after 1971	• 0.20 lb NOx/MM BTU gaseous fuel • 0.30 lb NOx/MM BTU liquid fuel
60 CFR Subpart Db	Steam Generator; input rating >100 MM BTU/hr; constructed after 1984	• 0.20 lb NOx/MM BTU gaseous fuel • 0.30 lb NOx/MM BTU liquid fuel
60 CFR Subpart Dc	Steam Generator; input rating 10-100 MM BTU/hr; constructed after 1989	• No NOx emission limit

These regulations include particulate and SO2 emission limits as well as NOx limits. The least restrictive proposed NOx emission limit in Regulation 9-7 (40 ppmv) is equivalent to 0.052 lb NOx per million BTU of heat input. Therefore, Regulation 9-7 already has, and will continue to have, much more restrictive NOx emission limits than the NSPS. The other proposed elements of Regulation 9-7, including insulation, stack gas temperature, inspection and tune-up requirements, do not appear in the NSPS.

VIII Rule Development Process

The Air District reviewed heater rules at all California air districts and considered all known NOx control technologies to establish the appropriate NOx and CO emission limits for heaters subject to Regulation 9, Rule 7 ("Regulation 9-7"). The Air District also considered energy efficiency measures that could be adopted in Regulation 9-7 to reduce fuel consumption, with associated reductions of emissions of NOx, CO and greenhouse gases. A draft regulation was completed in May 2007.

On June 29, 2007, the Air District conducted a public workshop to solicit comments on the draft regulation. A notice for this workshop was posted on the Air District website and individual notices were mailed to all operators of heaters that are currently subject to Regulation 9-7 as well as to heater service companies and manufacturer representatives. Based on comments provided by the public and the California Air Resources Board, and further staff evaluation of potential control measures, an amended draft regulation was prepared.

On April 14, 2008, the Air District conducted a workshop to solicit comments on the amended draft regulation. The notice for this workshop was posted on the Air District website. Notices were mailed to all previously notified parties and notice was also provided to all parties who attended or provided comments following the first workshop. In addition, e-mail notification was provided to commercial property management associations, lodging industry associations, and several dozen school districts, from elementary to community college level. At this workshop, and during the public comment period that followed, the Air District received comments from several different parties. Several parties made similar comments and these are summarized below.

1. Load-Following Devices

Staff recognizes that achieving compliance with a 9 ppmv NOx limit is difficult for boilers, steam generators and process heaters equipped with ultra-low-NOx burner technology, if these devices must respond to rapid and significant load changes. Therefore, the draft rule imposed a 15 ppmv NOx limit on load-following devices, as long as the Air District verified that the device could not comply with a 9 ppmv limit because of load changes. Several parties indicated that this arrangement did not provide sufficient certainty because an operator would only know after-the-fact whether a particular device was subject to a 15 ppmv, 9 ppmv or 5 ppmv limit, depending on the Air District's determination. These parties requested that a clear criterion be included in the rule so that operators could easily determine the standard that would apply to their devices. To address these comments, more guidance has been added to the administrative section of the rule to clarify the criteria the District will use to determine whether a heater will be designated a load-following device.

2. Implementation Schedule

Several parties requested that an extended effectiveness period be provided so that operators with multiple affected devices could implement the new NOx standards over a period of time. To accommodate this request, an implementation period of up to three years has been incorporated into the proposed rule. Also, several parties requested that the effectiveness dates for the new insulation requirements, and for the new NOx limits for devices rated 20 MM BTU/hr and higher be extended by one year. These requests have been incorporated into the proposed rule.

3. Costs and Negative Impacts Associated with 9 ppmv and 5 ppmv NOx limits

Several parties requested that the Air District carefully consider the costs and potential negative

impacts associated with compliance with 9 ppmv and 5 ppmv NOx limits. In particular, the cost-effectiveness of 9 ppmv and 5 ppmv NOx limits was questioned, in the context of cost-effectiveness levels for past NOx rules. Also, the Air District was asked to consider the impacts associated with SCR systems (required to comply with 5 ppmv NOx limits), including emissions of ammonia, secondary emissions resulting from transportation of ammonia and construction activities associated with SCR construction. To address this concern, staff has reviewed capital and operating costs for SCR systems as reported jointly by the Manufacturer's Council of the Central Valley and the California League of Food Processors in the San Joaquin Valley air district in response to a 2008 proposal to further reduce NOx limits. The costs provided by the industrial associations indicated that the proposed 9 ppmv and 5 ppmv NOx standards would be cost-effective. Other impacts are evaluated in the CEQA document and have been found to be less than significant.

4. Efficiency Measures

Several parties submitted comments noting the high cost of compliance for the proposed insulation requirement in some specific cases, as well as several instances where the insulation requirement and stack gas temperature limits were not appropriate. To address these comments, several exemptions to the insulation requirements and clarifications to the stack gas temperature limits have been incorporated into the proposed rule amendments.

Twenty parties submitted written comments following the April 2008 workshop. Most of these parties were contacted in order to discuss their comments, and meetings were held with two parties that requested to meet with Air District staff. Comments were provided by:

- NRG Energy Center, San Francisco (heater operator)
- Enovity, Inc (energy engineering consulting firm)
- Cleaver-Brooks, CB-Nebraska Boiler (heater manufacturer)
- R.F. MacDonald Company (heater distributor)
- Georgia-Pacific (heater operator)
- Calpine Corporation (heater operator)
- Genentech, Inc (heater operator)
- Western States Petroleum Association (WSPA) – (heater operator trade association)
- CRI / Criterion (heater operator)
- Interstate Brands (heater operator)
- NASA Ames Research Center (heater operator)
- Frank M Booth, Inc (heater distributor)
- Central Contra Costa Sanitary District (heater operator)
- United Airlines (heater operator)
- AHM Associates (heater distributor)
- Controltech (heater distributor)
- Anheuser-Busch, Inc (heater operator)
- Northrop Grumman Marine Systems (heater operator)
- University of California, Berkeley (heater operator)
- United Airlines (heater operator)

Subsequent to the April 2008 workshop, staff individually contacted the 10 largest school districts in the Bay Area to ensure that they were aware of the proposed new requirements and to determine the impact the rule would have on their equipment. Most school districts have recently undertaken

modernization projects to replace boilers with more efficient hot water heaters, which will reduce the number of boilers that will need to be retrofitted or replaced at schools to comply with the proposed amendments. However, some of the older school districts continue to operate large numbers of relatively inefficient boilers. For example, the San Francisco Unified School District operates about 300 boilers at 120 schools. Although many of these boilers are rated no greater than 2 MM BTU/hr, and therefore will not be affected by the proposed amendments, many others will need retrofit or replacement.

Staff contacted each of the facilities that operate heaters rated 75 MM BTU/hr or higher, and that were potentially subject to the strictest NOx emission limit (5 ppmv) in order to ensure that they were aware of the proposed new requirements and to obtain information about these large heaters in order to be able to estimate as accurately as possible the costs of compliance with the proposed amendments.

Several discussions were held with Enovity, a firm contracted by the Pacific Gas & Electric Company to implement efficiency incentive programs for heater operators, as well as with several boiler service companies in order to establish the typical operating condition, level of insulation and general efficiency of the boiler stock in the Bay Area.

Several discussions were held with staff of the San Joaquin Valley APCD and the South Coast AQMD to discuss their experience in implementing NOx control measures included in the proposed amendments to Regulation 9-7.

Additional discussions were held with a burner manufacturer, an SCR distributor and boiler distributors to address technical comments made subsequent to the April 2008 workshop.

In addition, staff responded to numerous inquiries from potentially affected heater operators about the provisions of the proposed amendments to Regulation 9-7.

IX 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 amendments to Regulation 9, Rule 7 are:

- Necessary to limit emissions of NOx, a primary precursor to ground-level ozone formation, and to meet the requirements of the Bay Area 2005 Ozone Strategy;
- Authorized under Sections 40000, 40001, 40702, and 40725 through 40728 of the California Health and Safety Code;
- Written or displayed so that its meaning can be easily understood by the persons directly affected by it;
- Consistent with other BAAQMD rules, and not in conflict with state or federal law;
- Non-duplicative of other statutes, rules or regulations; and
- Implementing, interpreting or making specific the provisions of the California Health and Safety Code Sections 40000 and 40702.

The proposed new rule has met all legal noticing requirements, has been discussed with the regulated community, and it reflects the input and comments of many affected and interested parties. BAAQMD staff recommends adoption of proposed amendments to Regulation 9-7.

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