RULE 425.2 Boilers, Steam Generators, and Process Heaters (Oxides of Nitrogen) - Adopted 10/13/94, Amended 4/6/95, 7/10/97

I. Purpose

The purpose of this Rule is to limit oxides of nitrogen (NOx) emissions from boilers, steam generators, and process heaters to levels consistent with Reasonably Available Control Technology (RACT) to satisfy California Health and Safety Code Section 40918(b) and 1990 Federal Clean Air Act Amendments, Section 182(f). Carbon monoxide emissions are also limited to insure efficient combustion at reduced NOx levels.

II. Applicability

This Rule shall apply, as specified, to any boiler, steam generator or process heater with rated heat input of 5 million Btu per hour or more and fired with gaseous and/or liquid fuels.

III. Definitions

A. Annual Heat Input - total heat released (therms) by fuel(s) burned in a unit during a calendar year as determined from higher heating value and cumulative annual fuel(s) usage.

B. Boiler or Steam Generator - any external combustion unit fired with liquid and/or gaseous fuel used to produce hot water or steam, but not including gas turbine engine exhaust gas heat recovery systems.

C. British Thermal Unit (Btu) - amount of heat required to raise the temperature of one pound of water from 59 F to 60 F at one atmosphere.

D. Gaseous Fuel - any fuel existing as gas at standard conditions.

E. Heat Input - total heat released (Btu's) by fuel(s) burned in a unit as determined from higher heating value, not including sensible heat of incoming combustion air and fuel(s).

F. Higher Heating Value (HHV) - total heat released per mass of fuel burned (Btu's per pound), when fuel and dry air at standard conditions undergo complete combustion and all resulting products are brought to standard conditions.

G. Liquid Fuel - any fuel, including distillate and residual oil, existing as liquid at standard conditions.

H. Natural gas curtailment - loss of natural gas supply due to action of PUC-regulated supplier. For Section V curtailment limit to apply, curtailment must not exceed 168 cumulative hours of operation per calendar year, excluding equipment testing not to exceed 48 hours per calendar year.

I. Oxides of Nitrogen (NOx) - total nitrogen oxides (expressed as NO_2).

J. Process Heater - any external combustion unit fired with liquid and/or gaseous fuel used to transfer heat from combustion gases to liquid process streams.

K. Reasonably Available Control Technology (RACT) - lowest emission limitation a particular source is capable of meeting by application of control technology reasonably available considering technological and economic feasibility.

L. Rated Heat Input - heat input capacity (Btu's/hr) specified on nameplate of unit or by manufacturer for that model number, or as limited by District permit.

M. Standard Conditions - as defined in Rule 102, Subsection DD.

N. Therm - 100,000 British thermal units (Btu's).

O. Unit - any boiler, steam generator or process heater as defined in this Rule.

IV. **Exemption**

This Rule shall not apply to any unit with rated heat input less than 5 million Btu's per hour.

V. **Requirements**

A. An owner/operator of any unit subject to this Rule with annual heat input of 90,000 therms or more during one or more of the three preceding years of operation shall comply with following applicable NOx emission limit(s):

	Gaseous Fuel	Liquid Fuel
During Normal Operation	70 ppmv, or 0.09lb/MMBtu	115 ppmv, or 0.15 lb/MMBtu
During Natural Gas Curtailment	----	150 ppmv, or 0.19 lb/MMBtu

For units subject to this Subsection, carbon monoxide (CO) emissions shall not exceed 400 ppmv.

NOx emission limit for any unit fired simultaneously with gaseous and liquid fuels shall be heat input-weighted average of applicable limits. Calculations shall be performed as prescribed in Section VIII.

NOx and CO emission limits in ppmv are referenced at dry stack gas conditions, adjusted to 3.00 percent by volume stack gas oxygen in accordance with Section VIII., and averaged over 15 consecutive minutes from no less than 5 data sets, recorded from sampling of no more than 3 minutes.

B. An owner/operator of any unit subject to this Rule with annual heat input rate of 90,000 therms or more shall comply, until November 30, 1997, and any unit with annual heat input rate of less than 90,000 therms shall comply with one of the following NOx minimization procedures:

1. Tune each unit at least once per year in accordance with Section IX.;

2. Operate each unit in a manner maintaining stack gas oxygen at no more than 3.00 percent by volume on dry basis; or

3. Operate each unit with an automatic stack gas oxygen trim system set at 3.00 ($\pm$0.15) percent by volume on dry basis.

C. Monitoring Requirements

1. An owner/operator of any unit simultaneously firing a combination of different fuels shall install and maintain a totalizing mass or volumetric flow rate meter in each fuel line.

2. An owner/operator of any unit utilizing equipment intended to reduce or control NOx shall install and maintain appropriate provisions to monitor operational parameters of unit and/or NOx control system that correlate to NOx emissions.

D. Compliance Demonstration

1. An owner/operator of any unit subject to Subsection V.A. shall have the option of complying with either concentration (ppmv) emission limits or heat input basis (lb/MMBtu) emission limits as specified in Subsection V.A. All compliance demonstrations shall be performed using applicable test method(s) specified in Subsection VI.B. and methods selected to demonstrate compliance shall be specified in Emission Control Plan required by Subsection VI.D.

2. All emission measurements shall be made with unit operating at conditions as close as physically possible to maximum firing rate allowed by KCAPCD Permit to Operate.

VI. Administrative Requirements

A. Recordkeeping and Reporting

1. An owner/operator of any unit subject to this Rule or limited by permit condition to firing less than 5 million Btu's/hr shall monitor and record HHV and cumulative annual use of each fuel.

2. An owner/operator of any unit operated under natural gas curtailment limit of Subsection V.A. shall monitor and record cumulative annual hours of operation on liquid fuel during curtailment and during testing.

3. An owner/operator of any identical units wishing to limit emissions testing to one unit per group of units pursuant to Subsection VI.C. shall establish correlation of NOx emissions and key operating parameters and keep records of these data for each affected unit.

4. Records shall be maintained for at least two calendar years on site and shall be made readily available to District personnel.

5. Compliance test data and results collected to satisfy Subsection VI.C. shall be submitted to District within 60 days of collection.

B. Test Methods

1. Fuel HHV shall be certified by third party fuel supplier or determined by:

   a. ASTM D 240-87 or D 2382-88 for liquid fuels; and

   b. ASTM D 1826-88 or D 1945-81 in conjunction with ASTM D 3588-89 for gaseous fuels.

2. Oxides of nitrogen (ppmv) - EPA Method 7E, or CARB Method 100.

3. Carbon monoxide (ppmv) - EPA Method 10, or CARB Method 100.

4. Stack gas oxygen - EPA Method 3 or 3A, or CARB Method 100.

5. NOx emission rate (heat input basis) - EPA Method 19, or CARB Method 100 and data from fuel flow meter.

6. Stack gas velocity - EPA Method 2.

7. Stack gas moisture content - EPA Method 4.

C. Compliance Testing

1. Any unit subject to requirements of Subsection V.A. shall be tested to determine compliance with applicable requirements not less than once every 12 months. An owner/operator of gaseous fuel-fired units demonstrating compliance for two consecutive years can, if desired, demonstrate compliance once every thirty-six months.

2. An owner/operator of any unit subject to Subsection V.B.2. shall sample and record stack gas oxygen content at least monthly.

3. Test results from an individual unit may be used for other units at the same location provided manufacturer, model number, rated capacity, fuel type, and emission control provisions are identical and key operating parameters such as stack gas oxygen, fuel consumption, etc. are monitored and established to correlate with NOx emissions from unit tested.

D. Emission Control Plan

An owner/operator of any unit subject to this Rule shall submit to Control Officer an Emission Control Plan including:

1. List of units subject to Rule, including rated heat inputs, anticipated annual heat input, applicable Section V. requirements, and control option chosen, if applicable;

2. Description of actions to be taken to satisfy requirements of Section V. Such plan shall identify actions to be taken to comply, including any type of emissions control to be applied to each unit and construction schedule, or shall include test results to demonstrate unit already complies with applicable requirements; and

3. Specification of proposed test methods.

VII. **Compliance Schedule**

A. An owner/operator of any unit subject to Section V. shall comply with following schedule:

1. By March 1, 1995, submit to Control Officer an Emission Control Plan pursuant to Subsection VI.D., and a complete application for Authority to Construct emission control equipment, if necessary;

2. By May 31, 1995 demonstrate compliance with Subsection V.B.; and

3. By November 30, 1997 demonstrate full compliance with all additional and applicable provisions of this Rule.

B. An owner/operator of any unit becoming subject to requirements of Subsection V.A. by exceeding the annual heat input exemption threshold shall comply with following increments of progress:

1. On or before December 31st of calendar year immediately following year annual heat input threshold was exceeded, submit an Emission Control Plan containing information prescribed in Subsection VI.D.; and

2. No later than three calendar years following submission of Emission Control Plan, demonstrate final compliance with all applicable standards and requirements of this Rule.

VIII. **Calculations**

A. All ppmv emission limits specified in Section V.A. are referenced at dry stack gas conditions and 3.00 percent by volume stack gas oxygen. Emission concentrations shall be corrected to 3.00 percent oxygen as follows:

$$[\text{ppmvNOx}]_{\text{corrected}} = \frac{17.95\%}{20.95\% - [\%O_2]_{\text{measured}}} \times [\text{ppmvNOx}]_{\text{measured}}$$

$$[\text{ppmCO}]_{\text{corrected}} = \frac{17.95\%}{20.95\% - [\%O_2]_{\text{measured}}} \times [\text{ppmCO}]_{\text{measured}}$$

B. All lb/MMBtu NOx emission rates shall be calculated as pounds of nitrogen dioxide per million Btu's of heat input (HHV).

C. Heat input-weighted average NOx emission limit for combination of natural gas and liquid fuel shall be calculated as follows:

$$\text{NOx Emission Limit} = \frac{(70\text{ppmv} \times X) + (115\text{ppmv} \times Y)}{X + Y}$$

Where X = heat input from gaseous fuel and Y = heat input from liquid fuel.

IX. NOx Minimization Tuning Procedures

A. Purpose

The purpose of these procedures is to provide a reasonable, cost-effective method to minimize NOx emissions from smaller, or low-fire/low use-rate combustion units subject to this Rule. These procedures not only minimize NOx emissions, but also result in reduced operating costs.

B. Equipment Tuning Procedure[1] for Mechanical Draft Boilers, Steam Generators, and Process Heaters

Nothing in this Tuning Procedure shall be construed to require any act or omission that would result in unsafe conditions or would be in violation of any regulation or requirement established by Factory Mutual, Industrial Risk Insurers, National Fire Prevention Association, California Department of Industrial Relations (Occupational Safety and Health Division), Federal Occupational Safety and Health Administration, or other relevant regulations and requirements.

1. Operate unit at firing rate most typical of normal operation. If unit experiences significant load variations during normal operation, operate at its average firing rate.

2. At this firing rate, record stack gas temperature, oxygen concentration, and CO concentration (for gaseous fuels) or smoke spot number[2] (for liquid fuels), and observe flame conditions after unit operation stabilizes at firing rate selected.
   If excess oxygen in the stack gas is at lower end of range of typical minimum values[3]; and if CO emissions are low and there is no smoke, unit is probably operating at near optimum efficiency - at this particular firing rate. However, complete remaining portion of this procedure to determine whether still lower oxygen levels are practical.

3. Increase combustion air flow to unit until stack gas oxygen levels increase by one to two percent over level measured in Step 2. As in Step 2, record stack gas temperature, CO concentration (for gaseous fuels) or smoke spot number (for liquid fuels), and observe flame conditions for these higher oxygen levels after unit operation stabilizes.

1. This tuning procedure is based on a tune-up procedure developed by KVB, Inc. for U.S. EPA.
2. The smoke-spot number can be determined with ASTM Test Method D-2156 or with the Bacharach method.
3. Typical minimum oxygen levels for boilers at high firing rates are:
   For natural gas: 0.5% to 3% and For liquid fuels: 2% to 4%.

4. Decrease combustion air flow until stack gas oxygen concentration is at level measured in Step 2. From this level gradually reduce combustion air flow, in small increments. After each increment, record stack gas temperature, oxygen concentration, CO concentration (for gaseous fuels) and smoke-spot number (for liquid fuels). Also, observe flame and record any changes in its condition.

5. Continue to reduce combustion air flow stepwise, until one of these limits is reached:

   a. Unacceptable flame conditions- such as flame impingement on furnace walls or burner parts, excessive flame carryover, or flame instability,

   b. Stack gas CO concentrations greater than 400 ppm,

   c. Smoking at the stack, or

   d. Equipment-related limitations such as low windbox/furnace pressure differential, built in air-flow limits, etc.

6. Develop O_2/CO curve (for gaseous fuels) or O_2/smoke curve (for liquid fuels) similar to those shown in Figures 1 and 2 on Page 425-13 using excess oxygen and CO or smoke-spot number data obtained at each combustion air flow setting.

7. From curves prepared in Step 6, find stack gas oxygen levels where CO emissions or smoke-spot number equal following values:

Fuel	Measurement	Value
Gaseous	CO Emissions	400 ppm
#1 and #2 Oils	smoke-spot number	number 1
#4 Oil	smoke-spot number	number 2
#5 Oil	smoke-spot number	number 3
Other Oils	smoke-spot number	number 4

   Above conditions are referred to as CO or smoke thresholds, or as minimum excess oxygen levels.

   Compare this minimum value of excess oxygen to expected value provided by combustion unit manufacturer. If minimum level found is substantially higher than value provided by combustion unit manufacturer, burner adjustments can probably be made to improve fuel and air mix, thereby allowing operations with less air.

8. Add 0.5 to 2.0 percent to minimum excess oxygen level determined in Step 7 and reset burner controls to operate automatically at this higher stack gas oxygen level. This margin above minimum oxygen level accounts for fuel variations, variations in atmospheric conditions, load changes, and nonrepeatability or "play" in automatic controls.

9. If load of unit varies significantly during normal operation, repeat Steps 1-8 for firing rates that represent upper and lower limits of range of the load. Because control adjustments at one firing rate may affect conditions at other firing rates, it may not be possible to establish optimum excess oxygen level at all firing rates. If this is the case, choose burner control settings that give best performance over range of firing rates. If one firing rate predominates, setting should optimize conditions at that rate.

10. Verify that new settings can accommodate sudden load changes that may occur in daily operation without adverse effects. Do this by increasing and decreasing load rapidly while observing flame and stack. If any of conditions in Step 5 result, reset combustion control to provide slightly higher level of excess oxygen at affected firing rates. Next verify these new settings in a similar fashion. Then make sure that final control settings are recorded at steady-state operating conditions for future reference.

C. Equipment Tuning Procedure[1] for Natural and Induced-Draft Boilers, Steam Generators, and Process Heaters

Nothing in this Tuning Procedure shall be construed to require any act or omission that would result in unsafe conditions or would be in violation of any regulation or requirement established by Factory Mutual, Industrial Risk Insurers, National Fire Prevention Association, the California Department of Industrial Relations (Occupational Safety and Health Division), the Federal Occupational Safety and Health Administration, or other relevant regulations and requirements.

1. Preliminary analysis

   a. Check operating pressure or temperature. Operate unit at lowest acceptable pressure or temperature that will satisfy load demand. Determine pressure or temperature that will be used as basis for comparative combustion analysis before and after tuneup.

   b. Check operating hours. Plan workload so that unit operates only the minimum hours and days necessary to perform work required.

[1] This tuning procedure is based on a tune-up procedure developed by Parker Boiler for South Coast AQMD.

c. Check air supply. Area of air supply openings must be in compliance with applicable codes and regulations. Air openings must be kept wide open when burner is firing and clean from restriction to flow.

d. Check vent. Check to be sure vent is in good condition, sized properly and with no obstructions.

e. Perform combustion analysis. Perform an "as is" flue gas analysis (O_2, CO, CO_2, etc.) at high and low fire, if possible. In addition to data obtained from combustion analysis, also record following:

1) Inlet fuel pressure at burner (at high and low fire),
2) Draft at inlet of draft hood or barometric damper at high, medium, and low settings, if applicable,
3) Steam pressure, water temperature, or process fluid pressure or temperature entering and leaving unit, and
4) Unit rate, if meter is available.

With above conditions recorded, make following checks and corrective actions as necessary.

2. Checks and Corrections

a. Check burner condition. Clean burners and burner orifices thoroughly. To clean burners effectively all burners must be removed, blown out with high pressure air and checked for obstructions. All accumulated sediment, dirt, and carbon must be removed. Check for smooth lighting and even flame. Also, ensure that fuel filters and moisture traps are in place, clean, and operating properly, to prevent plugging of gas orifices. Confirm proper location and orientation of burner diffuser spuds, gas canes, etc. Look for any burned-off or missing burner parts, and replace as needed.

b. Check for clean boiler, steam generator, or process heater tubes and heat transfer surfaces. Clean tube surfaces, remove scale and soot, assure proper fluid flow, and flue gas flow.

c. Check water treatment and blowdown program. Employ timely flushing and periodic blowdown to eliminate sediment and scale build-up in heat exchange tubes.

d. Check for steam hot water or process fluid leaks. Repair all leaks immediately. Be sure there are no leaks through the blow-off drains, safety valve, by-pass lines or at the feed pump, if used.

3. Safety Checks

   a. Test primary and secondary low water level controls.

   b. Check operating and limit pressure and temperature controls.

   c. Check safety valve pressure and capacity to meet boiler, steam generator, or process heater requirements.

   d. Check limit safety control and spill switch.

4. Adjustments

   While taking combustion readings with unit at operating temperature and at high fire perform checks and adjustments as follows:

   a. Adjust unit to fire at rated capacity. Record fuel manifold pressure.

   b. Adjust draft and/or fuel pressure to obtain efficient, clean combustion at both high, medium and low fire. Carbon monoxide value should always be below 400 ppm at 3% O_2. If CO is high make necessary adjustment such as increasing draft. Check to ensure burner light offs are smooth and safe. A reduced fuel pressure test at both high and low fire should be conducted in accordance with manufacturer's instructions and maintenance manuals.

   c. Check and adjust operation of modulation controller. Insure proper, efficient and clean combustion through range of firing rates. When above adjustments and corrections have been made, record all data.

5. Final Test

   Perform final combustion analysis with unit at operating temperature and at high, medium, and low fire, whenever possible. In addition to data from combustion analysis, also check and record:

   a. Fuel pressure at burner (high, medium, and low settings, if applicable).

   b. Draft at inlet or above draft hood or barometric damper (high, medium, and low settings, if applicable).

   c. Steam pressure or water temperature entering and leaving unit.

   d. Unit rate, if fuel meter is available.

When above checks and adjustments have been made, record data and attach combustion analysis data to boiler, steam generator, or process heater records indicating name and signature of person, title, company name, company address and date tuneup was performed.