Eastern Kern Air Pollution Control District

Rule 425
STATIONARY GAS TURBINES (OXIDES OF NITROGEN)

STAFF REPORT

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I. INTRODUCTION

The Eastern Kern Air Pollution Control District (District) is proposing to adopt amendments to Rule 425, Cogeneration Gas Turbine Engines (Oxides of Nitrogen). Rule 425 was originally adopted August 16, 1993. This proposed amendments is to reduce emissions of nitrogen oxides (NOx) by lowering the current NOx limits. NOx compounds are precursors in the formation of ground level ozone and particulate matter. The District has nonattainment status for the federal 8-hour ozone standard. This staff report presents an extensive revision of the Rule.

A majority of Rule 425 proposed amendments are modeled after California Air Resources Board (ARB)'s *Determination of Reasonably Available Control Technology and Best Available Retrofit Control Technology for the Control of Oxides of Nitrogen from Stationary Gas Turbines*[1]. Similar rules can also be found in Placer County and Yolo Solano Air Quality Management Districts.

Appendix A is the clean version of proposed Rule 425, Stationary Gas Turbines (Oxides of Nitrogen).

Appendix B shows all changes made to proposed Rule 425, Stationary Gas Turbines (Oxides of Nitrogen) in strikeout underline form.

II. PROPOSED RULE OVERVIEW

Proposed rule will lower the current NOx limits for stationary gas turbines with rated heat input of 10.0 megawatts (MW) or more and fired with gaseous or liquid fuels. Proposed rule will also have NOx limits for units rated 0.3 MW to less than 2.9 MW or units with greater than or equal to 4 MW that operate less than 877 hours per year. Additionally, units with 2.9 MW to less than 10 MW will have NOx limits. For units with 10.0 MW and greater, NOx emission levels shall not exceed 9 ppmv when operated on gaseous fuel and 25 ppmv when operated on liquid fuel.

III. EMISSIONS FROM GAS TURBINE ENGINES

Stationary gas turbines emit NOx from combustion of fuels. NOx is one of two precursors in the formation of ozone which is the primary component of smog. The second precursor is volatile organic compounds (VOCs). Because the District has nonattainment status for federal 8-hour ozone standard, the District is required to implement all feasible State and Federal measures to reduce emissions of ozone precursors, including NOx. NOx reacts photochemically with VOCs to form ozone. Ozone irritates human respiratory systems and damages plant life and property. Exposure to ozone can be associated with hospitalization for cardiopulmonary causes, asthma episodes, restrictions in physical activity, and premature death. NOx emissions from cogeneration gas turbine engines can also react with other pollutants to form airborne particles smaller than 2.5 micrometer (microns) in diameter called $PM_{2.5}$. When inhaled, $PM_{2.5}$ can travel deep into the lungs and reduce lung function.

[1] Complete Document can be found at: https://www.arb.ca.gov/research/apr/reports/l3092.pdf

IV. NOx EMISSIONS REDUCTION (CONTROL TECHNOLOGY)

Reducing NOx emissions from stationary gas turbines can be achieved by applying the following control technologies

A. Water or steam injection;
B. Dry low-NOx combustors; and
C. Selective Catalytic Reduction (SCR).

A. Water or steam injection

Injection of water or steam reduces the combustion temperature inside the turbine's combustion chamber. This temperature reduction decreases the amount of NOx produced. In most cases, the use of water or steam injection results in exhaust gas concentrations of 42 ppmv at 15% oxygen when firing on natural gas and 65 ppmv when firing on liquid fuel.

B. Dry Low-NOx Combustors

The use of dry low NOx combustors are special combustion chambers that are designed to improve the combustion process and decrease NOx emissions. Low-NOx combustors are only available for selected turbine models. Controlled NOx emission levels ranges from 9 to 15 ppmv at 15% oxygen.

C. Selective Catalytic Reduction (SCR)

Selective catalytic reduction (SCR) is a post combustion control technology. In the SCR process, ammonia (NH_3) is injected into the exhaust gas stream in the presence of a catalyst. NH_3 reacts with the NOx to form water and nitrogen. SCR is capable of over 90% NOx removal and is often combined with water or steam injection to achieve very low NOx levels when firing on gas.

V. COST-EFFECTIVENESS

ARB's *Determination of Reasonably Available Control Technology (RACT) and Best Available Retrofit Control Technology (BARCT) for the Control of Oxides of Nitrogen from Stationary Gas Turbines, 1992*, and EPA's ACT Document – *NOx Emissions from Stationary Gas Turbines, 1993*, listed cost effectiveness for control technologies mentioned above.

According to Appendix D from ARB's 1992 document, availability of SCR retrofit and cost effectiveness to install a possible SCR system to Westinghouse W251B10 was investigated. According to the report, there were no SCR manufacturer for the unit and the installation of an SCR system would not be cost-effective. The District required the unit to install low-NOx combustors and achieve 25 ppmv of NOx.

VI. APPLICABILITY

Provisions of Rule 425 are applicable to any cogeneration gas turbine engine with a rating equal to or greater than 0.3 megawatts (MW).

VII. CHANGES IN RULE 425

The following requirements have been added to Rule 425:

- The purpose of this Rule is to limit oxides of nitrogen (NOx) emissions from stationary gas turbines.

- Combined Cycle: Any stationary gas turbine operated both for the production of electrical energy from shaft work and the useful energy produced from heat recovered from its exhaust gases.

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

- Power Augmentation: An increase in the gas turbine shaft output or the decrease in turbine fuel consumption by the addition of energy recovered from exhaust heat.

- Simple Cycle: Any stationary gas turbine in which all electric generators are driven by shaft work from fuel combustion.

- Standard Conditions: As defined in Rule 102, Subsection RR.

- Stationary Gas Turbine: any gas turbine system, with or without power augmentation, which is permanently attached to a foundation, or is not a portable gas turbine. Two or more gas turbines powering a common shaft shall be treated as one gas turbine.

- Shut-Down Period: The time necessary to cease operation of a gas turbine from operating under load conditions. The time shall not exceed one (1) hour.

- Start-Up Period: The time necessary to bring operation of a gas turbine up to the designed rating. The time shall not exceed six (6) hours for combined cycle gas turbine power plants or two (2) hours for simple cycle gas turbine power plants.

- <u>Exemptions</u>

  The provision of this Rule shall not apply to the operation of stationary gas turbines under the following conditions:

  A. Emergency standby units demonstrated to operate less than 200 hours per year.

  B. Units less than 4 MW that operate less than 877 hours per year.

  C. Laboratory units used in research and testing for the advancement of gas turbine technology.

  D. Units operated exclusively for firefighting and/or flood control.

- Emission Limits

  The owner or operator of any stationary gas turbine unit shall not operate such unit under load conditions, excluding the start-up or shut-down period which results in the measured NOx emissions concentration exceeding the compliance limit listed below, averaged over one (1) hour based on four consecutive 15-minute averages:

Unit Size Megawatt Rating (MW)	**Compliance Limit NOx, ppmv at 15% O_2**	
	Gaseous Fuel	**Liquid Fuel**
Units Rated 0.3 to Less Than 2.9 MW OR Units Greater Than or Equal to 4 MW That Operate Less Than 877 Hour/Year	42	65
2.9 MW to Less Than 10 MW	25	65
10.0 MW and Greater	9	25

- The owner or operator of Westinghouse W251B10 with Authority to Construct issued before January 1, 1983 using dry low-NOx combustors shall have the following NOx emission limits:

  1. 25 ppmv at 15% O_2 when fired with gaseous fuel or,

  2. 65 ppmv at 15% O_2 when fired with liquid fuel.

- Start-up/Shut-down Combined Cycle Units

  The NOx emissions shall meet at least one of the following averaged over the duration of the start-up or shut-down period:

  1. 70 ppmv at 15% O_2 for turbines fired with gaseous fuel or,

  2. 226 ppmv at 15% O_2 for turbines fired with liquid fuel.

- Start-up/Shut-down Simple Cycle Units

  The NOx emission shall be kept to a minimum by use of the following:

  1. Manufacturer's recommendation for operation during start-up and shut-down.

  2. Injection of water as soon as reasonably possible.

  3. Maintaining proper air to fuel ratios.

- Exempt Units

  Exempt units shall comply with the following:

  1. The owner or operator of any unit exempt under Section IV shall submit support documentation to the Air Pollution Control Officer within seven days if the hour-per-year limit is exceeded. If the hour-per-year limit is exceeded, the exemption shall be permanently withdrawn. Within 30 days after the exceedance, the owner or operator shall submit an application for Authority to Construct that details a plan to meet the applicable limits specified in Section V of this Rule. Included in the application, the owner or operator shall submit a schedule of increments of progress for the installation of the required control equipment. This schedule shall not exceed four years from the date of the receipt of Authority to Construct application.

  2. A public service unit operating during a state of emergency, when such emergency is declared by proclamation of the Governor of the State of California and when the unit is located in the specific geographical location identified in the proclamation, shall be excluded from the hour-per-year limit.

- Monitoring and Recordkeeping

  2. Submit to the Air Pollution Control Officer, prior to issuance of Permit to Operate, information correlating the control system operating parameters to the associated NOx output. This information may be used by the Air Pollution Control Officer to determine compliance when there is no continuous emission monitoring system for NOx available or when the continuous emission monitoring system is not operating properly.

  3. Provide source test information regarding the exhaust gas NOx concentration at ISO conditions corrected to 15 percent oxygen on a dry basis.

The following requirements of Rule 425 have been revised:

- Applicability of stationary gas turbine has been revised from: ~~*a rating equal to or greater than 10.0 megawatts (MW).*~~ To: a rating equal to or greater than 0.3 megawatts (MW).

- Definition of Gas Fired has been revised from: ~~*using gaseous fuel as normal (not standby) fuel.*~~ To: Gaseous Fuel: any fuel existing as gas at standard conditions.

- Definition of NOx Emission Concentration has been revised from: ~~*oxides of nitrogen concentration calculated using the equation in Section VI (or an EPA-approved correlation).*~~ To: Oxides of Nitrogen (NOx): total nitrogen oxides (expressed as NO_2).

- Definition of SCR has been revised from: ~~*exhaust gas NOx control system utilizing ammonia and a reducing catalyst to convert NOx to nitrogen and oxygen.*~~ To: Selective Catalyst Reduction (SCR): a post-combustion control technology that utilizes a reducing agent, such as ammonia, injected into the exhaust stream where it converts NOx to molecular nitrogen in the presence of a catalyst.

- Emission control plan from administrative requirements have been revised from

  ~~*The owner or operator of any existing cogeneration gas turbine engine subject to this Rule shall submit to the APCO for approval an emissions control plan, including a schedule of increments of progress to be taken to meet or exceed requirements of Section IV to comply with the compliance schedule prescribed by Section VII. An emissions control plan shall be submitted for each cogeneration gas turbine engine subject to this Rule, including:*~~

  1. ~~*KCAPCD Permit number,*~~
  2. ~~*Gas turbine manufacturer's name,*~~
  3. ~~*Gas turbine model number,*~~
  4. ~~*Rated electrical energy output (MW) and rated heat recovery (Btu/hr),*~~
  5. ~~*Type of fuel (gas, and/or liquid),*~~
  6. ~~*HHV for each fuel,*~~
  7. ~~*Last year's fuel consumption (cubic feet of gas or gallons of liquid per hour),*~~
  8. ~~*Last year's hours of operation,*~~
  9. ~~*Heat rate (Btu/kw-hr) calculated using HHV for each type of fuel,*~~
  10. ~~*Type of emissions control to be applied to engine, and*~~
  11. ~~*Documentation showing current NOx emissions concentration.*~~

  To:

  The owner or operator of any existing stationary gas turbine subject to this Rule shall submit to the APCO for approval an emissions control plan, including a schedule of increments of progress to be taken to meet or exceed requirements of Section V to comply with the compliance schedule prescribed by Section VIII.

  An emissions control plan shall be submitted for each stationary gas turbine subject to this Rule, including:

  1. District permit number,
  2. Gas turbine manufacturer's name and model number,
  3. Rated electrical energy output (MW) and rated heat recovery (Btu/hr),
  4. Type of fuel (gas and/or liquid),
  5. Last year's fuel consumption (cubic feet of gas or gallons of liquid),
  6. Last year's hours of operation,
  7. Type of emissions control to be applied to engine, and
  8. Documentation showing current NOx emissions concentration.

- Monitoring and Recordkeeping requirement has been revised from:

~~*1. Install, operate and maintain in calibration, equipment approved by the Control Officer, capable of continuously measuring and recording the following:*~~

~~*a. Engine and/or emissions control system operating parameters as correlated to NOx emissions,*~~
~~*b. Elapsed time of operation,*~~
~~*c. NOx emissions concentration. The NOx monitoring system shall meet EPA requirements as specified in 40 CFR Part 60, App. B, Spec. 2, or other systems approved by EPA. The owner or operator shall submit to the Control Officer information demonstrating the emission monitoring system has data gathering and retrieval capability. When this system is not operational, data gathered for Subsection a., above, shall be used to establish NOx emissions concentration. Continuous NOx monitoring for gas turbines not using SCR shall not be required until January 1, 1997.*~~

To:

1. Install, operate, and maintain in calibration equipment capable of continuously measuring and recording the following:

    a. Control system operating parameters:

        i. Periodic NOx emission concentrations,
        ii. Turbine exhaust oxygen concentration,
        iii. Air-to-fuel ratio,
        iv. Flow rate of reducing agents added to turbine exhaust,
        v. Catalyst inlet and exhaust temperature,
        vi. Catalyst inlet and exhaust oxygen concentration,
        vii. Other operational characteristics.

    b. Elapsed time of operation measured by an hourly meter.

2. For units with 10 MW or greater, the owner or operator shall monitor the exhaust gas NOx concentrations. The NOx monitoring system shall meet EPA requirements as specified in 40 CFR Part 60, Appendix B, Specification 2, or other systems approved by EPA. The owner or operator shall submit to the Air Pollution Control Officer the information demonstration that emission monitoring system has data gathering and retrieval capability.

- Monitoring and Recordkeeping requirement has been revised from:

  ~~*Maintain and make available for District inspection at any time all records for a period of two years.*~~

  To:

  Maintain and make all records available for District inspection at any time for a period of five (5) years.

- Compliance Testing requirement has been revised from:

  ~~*The owner or operator of any cogeneration gas turbine engine subject to provisions of this rule shall conduct annual testing showing NOx emissions concentration as defined in Subsection III.G, and demonstrated percent efficiency (EFF) of the gas turbine engine.*~~

  To:

  The owner or operator of any stationary gas turbine subject to provisions of this rule shall conduct annual testing using the methods specified in Section VI.D below.

- Compliance Schedule has been revised from

  ~~*An owner or operator of a cogeneration stationary gas turbine engine subject to Section IV BACT limits and not currently achieving such limits shall comply with requirements of Section IV in accordance with the following schedule:*~~

  ~~*A. By (18 months after rule adoption date), submit to the Control Officer a compliance plan, and a complete application for Authority to Construct for all necessary equipment modifications subject to Rule 201.*~~

  ~~*B. By January 1, 1997, demonstrate full compliance.*~~

  To:

  An owner or operator of a stationary gas turbine subject to Section V and not currently achieving such limits shall comply with requirements of Section V in accordance with the following schedule:

  A. By (18 months after rule adoption date), submit to the Control Officer a compliance plan, and a complete application for Authority to Construct for all necessary equipment modifications subject to Rule 201.

  B. By January 1, 2021, demonstrate full compliance.

The following requirements of Rule 425 have been deleted:

- ~~*The purpose of this Rule is to require retrofit of oxides of nitrogen (NOx) Best Available Control Technology (BACT) to cogeneration gas turbine engines subject to California Health and Safety Code Section 40918(b) and compliance with Reasonably Available Control Technology (RACT) NOx limits for cogeneration gas turbine engines subject to 1990 Federal Clean Air Act Section 182(f).*~~

- ~~*Cogeneration Gas Turbine Engine – an internal combustion gas or liquid-fueled device consisting of compressor, combustor, and power turbine used to power an electrical generator and generate steam (or useful heat).*~~

- ~~*Engine and/or emissions control system operating parameters – key indicators of gas turbine engine and/or emissions control system performance, including ammonia injection rate and catalyst bed temperature for SCR; water (or steam) injection rate; or operating conditions of a dry low NOx combustor.*~~

- ~~*HHV – higher heating value of fuel.*~~

- ~~*LHV – lower heating value of fuel.*~~

- ~~*Oil-Fired – using liquid fuel as normal (not standby) fuel*~~

- ~~*Thermal Stabilization Period – start up time necessary to bring a cogeneration system heat recovery device up to design temperature, not exceeding two hours.*~~

- ~~***Requirements***~~

  ~~*The NOx emissions concentration (ppmv) from any cogeneration gas turbine engine subject to this Rule shall not exceed the following limit while operating under load and after the thermal stabilization period:*~~

  ~~*A. Gas turbine using SCR for NOx control:*~~

	~~*Gas-Fired*~~	~~*Oil-Fired*~~
~~*RACT limit until January 1, 1997:*~~	~~*10*~~	~~*40*~~
~~*BACT limit on and after January 1, 1997:*~~	~~$9 \times \frac{EFF}{25}$~~	~~$25 \times \frac{EFF}{25}$~~

  ~~*B. Westinghouse 251B10 gas turbine with Authority to Construct issued before 1/1/83 using dry low-NOx combustor(s) to meet January 1, 1997 limit:*~~

	Gas-Fired	Oil-Fired
RACT limit until January 1, 1997:	96	114
BACT limit on and after January 1, 1997:	$20 \times \frac{EFF}{25}$	$42 \times \frac{EFF}{25}$

Percent EFF (efficiency) shall be the higher of EFF_1 or EFF_2 below. An EFF less than 25 shall be assigned a value of 25.

EFF_1 = 3,412 Btu/kw-hr x 100% / Actual Heat Rate at HHV, Btu/kw-hr

EFF_1 is the demonstrated percent thermal efficiency of the gas turbine engine only, calculated from the actual heat input (using HHV) without consideration of any downstream energy recovery; calculated at ISO conditions; and measured at peak load.

$EFF_2 = EFF_{mfr}$ x LHV/HHV

Where EFF_{mfr} is the manufacturer's continuous rated percent thermal efficiency of the gas turbine engine with air pollution control equipment in operation and using fuel LHV. EFF_2 is EFF_{mfr} after correction from LHV to HHV at peak load

- Compliance Test Methods

3. HHV and LHV of liquid fuels shall be determined using:

   a. ASTM D240-87, Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter, or

   b. ASTM D2382-88, Standard Test Method for Heat of Combustion of Hydrocarbon Fuels by Bomb Calorimeter (High-precision Method).

4. HHV and LHV of gaseous fuels shall be determined using:

   a. ASTM D3588-91, Standard Practice for Calculating Heat Value, Compressibility Factor, and Relative Density (Specific Gravity) of Gaseous Fuels, or

   b. ASTM 1826-88, Standard Test Method for Calorific (Heating) Value of Gases in Natural Gas Range by Continuous Recording Calorimeter, or

   c. ASTM 1945-81, Standard Method for Analysis of Natural Gas by Gas Chromatography.

~~5. *Percent efficiency of the gas turbine engine shall be determined using actual field measurements for gas turbine fuel consumption and power output.*~~

E. IMPACTS

A. Economic

The proposed regulations would impose costs on turbine owners for which they will receive no corresponding revenue. Owners may experience any combination of the following costs: downtime for retrofit, retrofit, increased maintenance costs, and increased water consumption. These costs could result in increased energy prices. Sectors which would experience an economic stimulus include pollution control manufacturers, engineering firms, and plumbing, electrical, and other contractors.

B. Air Quality

Imposing NOx controls would reduce NO_2 levels, PM_{10} emissions, and acid deposition. Visibility should improve. The reduction of NOx should also result in a decrease in ozone levels, depending upon a number of parameters including the NOx/HC ratio. Carbon monoxide emissions can increase from the use of water/steam injection. Mitigation measures include modifications to the combustion parameters (oxygen, temperature, time), equipment (fuel nozzles, combustion chamber), and the addition of post combustion controls.

C. Hazards

The use of SCR will result in free ammonia, PM_{10}, and SO_3 emissions. Ammonia emissions at high concentrations can create an odor nuisance. However, the impact can be mitigated by proper stack design. Free ammonia emissions in the exhaust can form PM_{10} constituents such as ammonium sulfate or ammonium nitrate aerosols. Most areas in California are in violation of the state and federal ambient PM_{10} standard. The risk of ammonia slip could be partially mitigated (to at least below 20 ppm) by specifying ammonia discharge limits on the operating permits and by carefully controlling ammonia injection with monitoring equipment. However, this determination has no requirement for ammonia monitors or ammonia slip limits. Nevertheless, because ammonia slip cannot be completely mitigated, the risk of ammonia emissions must be weighed against the benefits of NOx reduction.

Ammonia is a hazardous (flammable) and toxic compound and its production, use, storage, and transport can be hazardous, especially in the case of worker contact with liquid ammonia or exposure to highly concentrated ammonia vapor. The risk of accidental ammonia releases and associated health impacts can be reduced significantly by proper design practices, alarm systems, safety programs, and worker training programs.

Such programs have be developed by the chemical industry and are set forth in various publications. SCR related ammonia storage and handling will also create a potential increase in work place hazards form possible feedline ruptures during earthquakes.

Also, there is speculation that conditions in the SCR system may encourage the conversion of ammonia into nitrosamines, which are toxic, carcinogenic, and mutagenic. However, two independent source tests for nitrosamines have been conducted on the flue gas of units equipped with SCR. Neither source test detected the presence of nitrosamines.

Ammonia emissions at high enough concentrations can also create an odor nuisance if there is not adequate stack dispersion. Nuisance impacts can be completely mitigated by proper stack design. The amount of SO_3 emissions can be minimized by using low sulfur fuel. It should be noted that total SOx emissions are not increased. The amount of directly emitted SO_3 is increased as a ratio of total SOx emitted and corresponding a reduction in SO_2 emissions occurs.

SCR catalyst materials may contain small amounts of hazardous materials, including vanadium pentoxide. This compound is toxic if inhaled. Also, spent catalyst material must be safely disposed of. The first issue, particle inhalation from catalyst erosion, can be minimized by modifying the catalyst chamber to protect the catalyst from direct exposure to exhaust particulates. The second issue, catalyst disposal, is minimal because the spent catalyst is returned to the catalyst vendors for proper disposal or recycling the catalyst.

D. Energy

The use of NOx reduction technologies would generally have some level of fuel energy penalty or may require small amounts of energy for their operation. For example, the conversion of natural gas to methanol or ammonia requires natural gas for feedstock and fuel. The diversion of natural gas to make methanol and ammonia could impact the availability of natural gas for utility fuel. For methanol, however, the energy loss is partially offset by an improvement of turbine efficiency. An example of operational energy is the energy required to operate the SCR system. The use of SCR results in a 0.7 percent fuel penalty.

F. SOCIOECONOMIC IMPACTS

CHSC Section 40728.5 exempts districts with a population of less than 500,000 persons from the requirement to assess the socioeconomic impacts of proposed rules. Eastern Kern County population is below 500,000 persons.

G. RULE APPROVAL PROCESS

The District will be accepting written comments and concerns from persons interested in Rule 425 for a period of 30 days following the November 2, 2017 workshop. District anticipates that Rule 425 will be considered for adoption by the Board at the January 2018 Board Hearing.

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APPENDIX A:

AMENDED RULE 425

STATIONARY GAS TURBINES (OXIDES OF NITROGEN)

CLEAN VERSION

RULE 425 Stationary Gas Turbines (Oxides of Nitrogen) - Adopted 8/16/93, XX/XX/XX.

I. Purpose

The purpose of this Rule is to limit oxides of nitrogen (NOx) emissions from stationary gas turbines.

II. Applicability

The provisions of this Rule shall apply to any stationary gas turbine with a rating equal to or greater than 0.3 megawatts (MW) operating in the Eastern Kern Air Pollution Control District (District).

III. Definitions

A. Combined Cycle: Any stationary gas turbine operated both for the production of electrical energy from shaft work and the useful energy produced from heat recovered from its exhaust gases.

B. Dry Low-NOx Combustor: Any gas turbine engine combustor using staging, air/fuel premixing or other design features to reduce NOx emissions.

C. Gaseous Fuel: Any fuel existing as gas at standard conditions.

D. Liquid Fuel: Any fuel, including distillate and residual oil, existing as liquid at standard conditions.

E. Oxides of Nitrogen (NOx): Total nitrogen oxides (expressed as NO_2).

F. Power Augmentation: An increase in the gas turbine shaft output and/or the decrease in gas turbine fuel consumption by the addition of energy recovered from exhaust heat.

G. Rating: Manufacturer's continuous electrical output megawatt (MW) specification for a gas turbine system.

H. Simple Cycle: Any stationary gas turbine in which all electric generators are driven by shaft work from fuel combustion.

I. Selective Catalytic Reduction (SCR): A post-combustion control technology that utilizes a reducing agent, such as ammonia, injected into the exhaust gas stream where it converts NOx to molecular nitrogen in the presence of a catalyst.

J. Standard Conditions: As defined in Rule 102, Subsection RR.

K. Stationary Gas Turbine: Any gas turbine system, with or without power augmentation, which is permanently attached to a foundation, or is not a portable gas turbine. Two or more gas turbines powering a common shaft shall be treated as one gas turbine.

L. Shut-Down Period: The time necessary to cease operation of a gas turbine from operating under load conditions. The time shall not exceed one (1) hour.

M. Start-Up Period: The time necessary to bring operation of a gas turbine up to the designed rating. The time shall not exceed six (6) hours for combined cycle gas turbine power plants or two (2) hours for simple cycle gas turbine power plants.

IV. Exemptions

The provision of this Rule shall not apply to the operation of stationary gas turbines under the following conditions:

A. Emergency standby units demonstrated to operate less than 200 hours per year.

B. Units less than 4 MW that operate less than 877 hours per year.

C. Laboratory units used in research and testing for the advancement of gas turbine technology.

D. Units operated exclusively for firefighting and/or flood control.

V. Requirements

A. Emission Limits

The owner or operator of any stationary gas turbine unit shall not operate such unit under load conditions, excluding the start-up or shut-down period which results in the measured NOx emissions concentration exceeding the compliance limit listed below, averaged over one (1) hour based on four consecutive 15-minute averages:

Unit Size Megawatt Rating (MW)	**Compliance Limit NOx, ppmv at 15% O_2**	
	Gaseous Fuel	**Liquid Fuel**
Units Rated 0.3 to Less Than 2.9 MW OR Units Greater Than or Equal to 4 MW That Operate Less Than 877 Hour/Year	42	65
2.9 MW to Less Than 10 MW	25	65
10.0 MW and Greater	9	25

B. The owner or operator of Westinghouse W251B10 with Authority to Construct issued before January 1, 1983 using dry low-NOx combustors shall have the following NOx emission limits:

1. 25 ppmv at 15% O_2 when fired with gaseous fuel or,

2. 65 ppmv at 15% O_2 when fired with liquid fuel.

C. Start-up/Shut-down Combined Cycle Units

The NOx emissions shall meet at least one of the following averaged over the duration of the start-up or shut-down period:

1. 70 ppmv at 15% O_2 for turbines fired with gaseous fuel or,

2. 226 ppmv at 15% O_2 for turbines fired with liquid fuel.

D. Start-up/Shut-down Simple Cycle Units

The NOx emission shall be kept to a minimum by use of the following:

1. Manufacturer's recommendation for operation during start-up and shut-down.

2. Injection of water as soon as reasonably possible.

3. Maintaining proper air to fuel ratios.

VI. Administrative Requirements

A. Emission Control Plan

The owner or operator of any existing stationary gas turbine subject to this Rule shall submit to the APCO for approval an emissions control plan, including a schedule of increments of progress to be taken to meet or exceed requirements of Section V to comply with the compliance schedule prescribed by Section VIII.

An emissions control plan shall be submitted for each stationary gas turbine subject to this Rule, including:

1. District permit number,
2. Gas turbine manufacturer's name and model number,
3. Rated electrical energy output (MW) and rated heat recovery (Btu/hr),
4. Type of fuel (gas and/or liquid),
5. Last year's fuel consumption (cubic feet of gas or gallons of liquid),
6. Last year's hours of operation,
7. Type of emissions control to be applied to engine, and
8. Documentation showing current NOx emissions concentration.

B. Monitoring and Recordkeeping

The owner or operator of any stationary gas turbine subject to the provisions of this rule shall perform the following actions:

1. Install, operate, and maintain in calibration equipment capable of continuously measuring and recording the following:

    a. Control system operating parameters:

        i. Periodic NOx emission concentrations,
        ii. Turbine exhaust oxygen concentration,
        iii. Air-to-fuel ratio,
        iv. Flow rate of reducing agents added to turbine exhaust,
        v. Catalyst inlet and exhaust temperature,
        vi. Catalyst inlet and exhaust oxygen concentration,
        vii. Other operational characteristics.

    b. Elapsed time of operation measured by an hourly meter.

2. For units with 10 MW or greater, the owner or operator shall monitor the exhaust gas NOx concentrations. The NOx monitoring system shall meet EPA requirements as specified in 40 CFR Part 60, Appendix B, Specification 2, or other systems approved by EPA. The owner or operator shall submit to the Air Pollution Control Officer the information demonstration that emission monitoring system has data gathering and retrieval capability.

3. Submit to the Air Pollution Control Officer, prior to issuance of Permit to Operate, information correlating the control system operating parameters to the associated NOx output. This information may be used by the Air Pollution Control Officer to determine compliance when there is no continuous emission monitoring system for NOx available or when the continuous emission monitoring system is not operating properly.

4. Provide source test information regarding the exhaust gas NOx concentration at ISO conditions corrected to 15 percent oxygen on a dry basis.

5. Maintain a stationary gas turbine engine operating log, including, on a daily basis, actual start-up and stop times, total hours of operation, and type and quantity of fuel used (liquid/gas).

6. Maintain and make all records available for District inspection at any time for a period of five (5) years.

C. Compliance Testing

The owner or operator of any stationary gas turbine subject to provisions of this rule shall conduct annual testing using the methods specified in Section VI.D below.

D. Test Methods

1. Oxides of nitrogen (NOx) emissions shall be determined using EPA Method 7E or EPA Method 20.

2. Oxygen (O_2) concentrations shall be determined using EPA Method 3A or ARB Method 100.

E. Exempt Units

Exempt units shall comply with the following:

1. The owner or operator of any unit exempt under Section IV shall submit support documentation to the Air Pollution Control Officer within seven days if the hour-per-year limit is exceeded. If the hour-per-year limit is exceeded, the exemption shall be permanently withdrawn. Within 30 days after the exceedance, the owner or operator shall submit an application for Authority to Construct that details a plan to meet the applicable limits specified in Section V of this Rule. Included in the application, the owner or operator shall submit a schedule of increments of progress for the installation of the required control equipment. This schedule shall not exceed four years from the date of the receipt of Authority to Construct application.

2. A public service unit operating during a state of emergency, when such emergency is declared by proclamation of the Governor of the State of California and when the unit is located in the specific geographical location identified in the proclamation, shall be excluded from the hour-per-year limit.

VII. Calculations

NOx emissions concentrations shall be calculated using the following equation:

$$NOx = (NOx_{obs})\ (P_{ref}/P_{obs})^{0.5}\ (288\ K/T_{amb})^{1.53}(e^{19(Hobs-0.00633)})$$

where:

NOx	=	NOx emissions concentration (ppmv) corrected to 15 percent oxygen and ISO standard conditions on a dry basis.
NOx_{obs}	=	Measured stack gas NOx emissions concentration (ppmv) corrected to 15 percent oxygen on a dry basis.
P_{ref}	=	standard atmospheric pressure (14.7 psia).
P_{obs}	=	atmospheric pressure measured at site during testing, psia.
H_{obs}	=	absolute ambient humidity measured at site during testing, pounds water per pound dry air.
e	=	transcendental constant (2.718).
T_{amb}	=	ambient air temperature in K and measured at site during testing.

VIII. Compliance Schedule

An owner or operator of a stationary gas turbine subject to Section V and not currently achieving such limits shall comply with requirements of Section V in accordance with the following schedule:

A. By (18 months after rule adoption date), submit to the Control Officer a compliance plan, and a complete application for Authority to Construct for all necessary equipment modifications subject to Rule 201.

B. By January 1, 2021, demonstrate full compliance.

APPENDIX B:

AMENDED RULE 425

STATIONARY GAS TURBINES (OXIDES OF NITROGEN)

STRIKEOUT UNDERLINE VERSION

RULE 425 ~~Cogeneration~~Stationary Gas Turbines ~~Engines~~ (Oxides of Nitrogen) - Adopted 8/16/93, XX/XX/XX.

I. Purpose

The purpose of this Rule is to limit oxides of nitrogen (NOx) emissions from stationary gas turbines.~~require retrofit of oxides of nitrogen (NOx) Best Available Control Technology (BACT) to cogeneration gas turbine engines subject to California Health & Safety Code Section 40918 (b) and compliance with Reasonably Available Control Technology (RACT) NOx limits for cogeneration gas turbine engines subject to 1990 Federal Clean Air Act Section 182(f).~~

II. Applicability

The provisions of this Rule shall apply to any ~~cogeneration~~stationary gas turbine ~~engine~~ with a rating equal to or greater than ~~10.0~~0.3 megawatts (MW) operating in the Eastern Kern Air Pollution Control District (District).

III. Definitions

~~A. Cogeneration Gas Turbine Engine - an internal combustion gas or liquid-fueled device consisting of compressor, combustor, and power turbine used to power an electrical generator and generate steam (or useful heat).~~

A. Combined Cycle: Any stationary gas turbine operated both for the production of electrical energy from shaft work and the useful energy produced from heat recovered from its exhaust gases.

B. Dry Low-NOx Combustor: - A~~a~~ny gas turbine engine combustor using staging, air/fuel premixing or other design features to reduce NOx emissions.

~~C. Engine and/or emissions control system operating parameters - key indicators of gas turbine engine and/or emissions control system performance, including ammonia injection rate and catalyst bed temperature for SCR; water (or steam) injection rate; or operating conditions of a dry low-NOx combustor.~~

~~D.~~C. Gaseous Fuel: ~~Fired - using gaseous fuel as normal (not standby) fuel~~Any fuel existing as gas at standard conditions.

~~E. HHV - higher heating value of fuel.~~

~~F. LHV - lower heating value of fuel.~~

~~F.~~D. Liquid Fuel: Any fuel, including distillate and residual oil, existing as liquid at standard conditions.

~~G.~~E. Oxides of Nitrogen (NOx): ~~Emissions Concentration -~~ Total ~~oxides of~~ nitrogen oxides (expressed as NO_2). ~~concentration calculated using the equation in Section VI (or an EPA-approved correlation).~~

F. Power Augmentation: An increase in the gas turbine shaft output and/or the decrease in gas turbine fuel consumption by the addition of energy recovered from exhaust heat.

~~H. Oil-Fired - using liquid fuel as normal (not standby) fuel.~~

~~I.~~G. Rating: ~~-~~ M~~m~~anufacturer's continuous electrical output megawatt (MW) specification for a gas turbine ~~powered cogeneration~~ system.

H. Simple Cycle: Any stationary gas turbine in which all electric generators are driven by shaft work from fuel combustion.

I. Selective Catalytic Reduction (SCR): ~~- Exhaust gas NOx control system utilizing ammonia and a reducing catalyst to convert NOx to nitrogen and oxygen.~~A post-combustion control technology that utilizes a reducing agent, such as ammonia, injected into the exhaust gas stream where it converts NOx to molecular nitrogen in the presence of a catalyst.

J. Standard Conditions: As defined in Rule 102, Subsection RR.

~~J.~~K. Stationary Gas Turbine: Any gas turbine system, with or without power augmentation, which is permanently attached to a foundation, or is not a portable gas turbine. Two or more gas turbines powering a common shaft shall be treated as one gas turbine.

~~K.~~L. Shut-Down Period: The time necessary to cease operation of a gas turbine from operating under load conditions. The time shall not exceed one (1) hour.

~~K. Thermal Stabilization Period - start up time necessary to bring a cogeneration system heat recovery device up to design temperature, not exceeding two hours.~~

M. Start-Up Period: The time necessary to bring operation of a gas turbine up to the designed rating. The time shall not exceed six (6) hours for combined cycle gas turbine power plants or two (2) hours for simple cycle gas turbine power plants.

IV. Exemptions

The provision of this Rule shall not apply to the operation of stationary gas turbines under the following conditions:

A. Emergency standby units demonstrated to operate less than 200 hours per year.

B. Units less than 4 MW that operate less than 877 hours per year.

C. Laboratory units used in research and testing for the advancement of gas turbine technology.

D. Units operated exclusively for firefighting and/or flood control.

~~IV.~~ V. Requirements

A. Emission Limits

The owner or operator of any stationary gas turbine unit shall not operate such unit under load conditions, excluding the start-up or shut-down period which results in the measured NOx emissions concentration exceeding the compliance limit listed below, averaged over one (1) hour based on four consecutive 15-minute averages:~~NOx emissions concentration (ppmv) from any cogeneration gas turbine engine subject to this Rule shall not exceed the following limit while operating under load and after the thermal stabilization period:~~

~~A. Gas turbine using SCR for NOx control:~~

	~~Gas-Fired~~	~~Oil-Fired~~
~~RACT limit until January 1, 1997:~~	~~10~~	~~40~~
~~BACT limit on and after January 1, 1997:~~	$~~9 \times \frac{EFF}{25}~~$	$~~25 \times \frac{EFF}{25}~~$

~~B. Westinghouse 251B10 gas turbine with Authority to Construct issued before 1/1/83 using dry low-NOx combustor(s) to meet January 1, 1997 limit:~~

	~~Gas-Fired~~	~~Oil-Fired~~
~~RACT limit until January 1, 1997:~~	~~96~~	~~114~~
~~BACT limit on and after January 1, 1997:~~	$~~20 \times \frac{EFF}{25}~~$	$~~42 \times \frac{EFF}{25}~~$

~~Percent EFF (efficiency) shall be the higher of EFF_1 or EFF_2 below. An EFF less than 25 shall be assigned a value of 25.~~

~~EFF_1 = 3,412 Btu/kw-hr x 100% / Actual Heat Rate at HHV, Btu/kw-hr~~

~~EFF_1 is the demonstrated percent thermal efficiency of the gas turbine engine only, calculated from the actual heat input (using HHV) without consideration of any downstream energy recovery; calculated at ISO conditions; and measured at peak load.~~

~~$EFF_2 = EFF_{mfr}$ x LHV/HHV~~

~~Where EFF_{mfr} is the manufacturer's continuous rated percent thermal efficiency of the gas turbine engine with air pollution control equipment in operation and using fuel LHV. EFF_2 is EFF_{mfr} after correction from LHV to HHV at peak load.~~

Unit Size Megawatt Rating (MW)	Compliance Limit NOx, ppmv at 15% O_2	
	Gaseous Fuel	Liquid Fuel
Units Rated 0.3 to Less Than 2.9 MW OR Units Greater Than or Equal to 4 MW That Operate Less Than 877 Hour/Year	42	65
2.9 MW to Less Than 10 MW	25	65
10.0 MW and Greater	9	25

B. The owner or operator of Westinghouse W251B10 with Authority to Construct issued before January 1, 1983 using dry low-NOx combustors shall have the following NOx emission limits:

1. 25 ppmv at 15% O_2 when fired with gaseous fuel or,

2. 65 ppmv at 15% O_2 when fired with liquid fuel.

C. Start-up/Shut-down Combined Cycle Units

The NOx emissions shall meet at least one of the following averaged over the duration of the start-up or shut-down period:

1. 70 ppmv at 15% O_2 for turbines fired with gaseous fuel or,

2. 226 ppmv at 15% O_2 for turbines fired with liquid fuel.

D. Start-up/Shut-down Simple Cycle Units

The NOx emission shall be kept to a minimum by use of the following:

1. Manufacturer's recommendation for operation during start-up and shut-down.

2. Injection of water as soon as reasonably possible.

3. Maintaining proper air to fuel ratios.

~~V.~~ VI. Administrative Requirements

A. Emission Control Plan

The owner or operator of any existing ~~cogeneration~~stationary gas turbine ~~engine~~ subject to this Rule shall submit to the APCO for approval an emissions control plan, including a schedule of increments of progress to be taken to meet or exceed requirements of Section ~~I~~V to comply with the compliance schedule prescribed by Section VIII.

An emissions control plan shall be submitted for each ~~cogeneration~~stationary gas turbine ~~engine~~ subject to this Rule, including:

1. ~~KCAPCD~~District ~~P~~permit number,
2. Gas turbine manufacturer's name and model number,
3. ~~Gas turbine model number,~~
4.3. Rated electrical energy output (MW) and rated heat recovery (Btu/hr),
5.4. Type of fuel (gas~~,~~ and/or liquid),
6. ~~HHV for each fuel,~~
7.5. Last year's fuel consumption (cubic feet of gas or gallons of liquid ~~per hour~~),
8.6. Last year's hours of operation,
9. ~~Heat rate (Btu/kw-hr) calculated using HHV for each type of fuel,~~
10.7. Type of emissions control to be applied to engine, and
11.8. Documentation showing current NOx emissions concentration.

B. Monitoring and Recordkeeping

The owner or operator of any ~~cogeneration~~stationary gas turbine ~~engine~~ subject to the provisions of this rule shall perform the following actions:

1. Install, operate, and maintain in calibration~~,~~ equipment ~~approved by the Control Officer,~~ capable of continuously measuring and recording the following:

   a. ~~Engine and/or emissions control system operating parameters as correlated to NOx emissions~~Control system operating parameters:~~,~~
   b. ~~Elapsed time of operation,~~
   c. ~~NOx emissions concentration. The NOx monitoring system shall meet EPA requirements as specified in 40 CFR Part 60, App. B, Spec. 2, or other systems approved by EPA. The owner or operator shall submit to the Control Officer information demonstrating the emission monitoring system has data gathering and retrieval capability. When this system is not operational, data gathered for Subsection a., above, shall be used to establish NOx emissions concentration. Continuous NOx monitoring for gas turbines not using SCR shall not be required until January 1, 1997.~~

   i. Periodic NOx emission concentrations,
   ii. Turbine exhaust oxygen concentration,
   iii. Air-to-fuel ratio,
   iv. Flow rate of reducing agents added to turbine exhaust,
   v. Catalyst inlet and exhaust temperature,
   vi. Catalyst inlet and exhaust oxygen concentration,
   vii. Other operational characteristics.

   b. Elapsed time of operation measured by an hourly meter.

2. For units with 10 MW or greater, the owner or operator shall monitor the exhaust gas NOx concentrations. The NOx monitoring system shall meet EPA requirements as specified in 40 CFR Part 60, Appendix B, Specification 2, or other systems approved by EPA. The owner or operator shall submit to the Air Pollution

Control Officer the information demonstration that emission monitoring system has data gathering and retrieval capability.

3. Submit to the Air Pollution Control Officer, prior to issuance of Permit to Operate, information correlating the control system operating parameters to the associated NOx output. This information may be used by the Air Pollution Control Officer to determine compliance when there is no continuous emission monitoring system for NOx available or when the continuous emission monitoring system is not operating properly.

4. Provide source test information regarding the exhaust gas NOx concentration at ISO conditions corrected to 15 percent oxygen on a dry basis.

~~3.~~5. Maintain a stationary~~cogeneration~~ gas turbine engine operating log, including, on a daily basis, actual start-up and stop times, total hours of operation, and type and quantity of fuel used (liquid/gas).

~~4.~~6. Maintain and make all records available for District inspection at any time ~~all records~~ for a period of ~~two years~~ five (5) years.

C. Compliance Testing

The owner or operator of any stationary~~cogeneration~~ gas turbine ~~engine~~ subject to provisions of this rule shall conduct annual testing using the methods specified in Section VI.D below.~~showing NOx emissions concentration as defined in Subsection III.G, and demonstrated percent efficiency (EFF) of the gas turbine engine.~~

D. ~~Compliance~~ Test Methods

1. Oxides of nitrogen (NOx) emissions shall be determined using EPA Method 7E or EPA Method 20.

2. ~~Exhaust gas o~~Oxygen (O_2) concentrations~~content~~ shall be determined using EPA Method 3A or ARB Method 100.

~~3. HHV and LHV of liquid fuels shall be determined using:~~

~~a. ASTM D240-87, Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter, or~~

~~b. ASTM D2382-88, Standard Test Method for Heat of Combustion of Hydrocarbon Fuels by Bomb Calorimeter (High-precision Method).~~

~~4. HHV and LHV of gaseous fuels shall be determined using:~~

a. ~~ASTM D3588-91, Standard Practice for Calculating Heat Value, Compressibility Factor, and Relative Density (Specific Gravity) of Gaseous Fuels, or~~

~~b. ASTM 1826-88, Standard Test Method for Calorific (Heating) Value of Gases in Natural Gas Range by Continuous Recording Calorimeter, or ASTM 1945-81, Standard Method for Analysis of Natural Gas by Gas Chromatography.~~

~~5. Percent efficiency of the gas turbine engine shall be determined using actual field measurements for gas turbine fuel consumption and power output.~~

E. Exempt Units

Exempt units shall comply with the following:

1. The owner or operator of any unit exempt under Section IV shall submit support documentation to the Air Pollution Control Officer within seven days if the hour-per-year limit is exceeded. If the hour-per-year limit is exceeded, the exemption shall be permanently withdrawn. Within 30 days after the exceedance, the owner or operator shall submit an application for Authority to Construct that details a plan to meet the applicable limits specified in Section V of this Rule. Included in the application, the owner or operator shall submit a schedule of increments of progress for the installation of the required control equipment. This schedule shall not exceed four years from the date of the receipt of Authority to Construct application.

2. A public service unit operating during a state of emergency, when such emergency is declared by proclamation of the Governor of the State of California and when the unit is located in the specific geographical location identified in the proclamation, shall be excluded from the hour-per-year limit.

~~VI.~~ VII. Calculations

NOx emissions concentrations shall be calculated using the following equation:

$$NOx = (NOx_{obs})\ (P_{ref}/P_{obs})^{0.5}(288\ K/T_{amb})^{1.53}(e^{19(Hobs-0.00633)})$$

where:

NOx	=	NOx emissions concentration (ppmv) corrected to 15 percent oxygen and ISO standard conditions on a dry basis.
NOx_{obs}	=	Measured stack gas NOx emissions concentration (ppmv) corrected to 15 percent oxygen on a dry basis.
P_{ref}	=	standard atmospheric pressure (14.7 psia).
Pobs	=	atmospheric pressure measured at site during testing, psia.
H_{obs}	=	absolute ambient humidity measured at site during testing, pounds water per pound dry air.

e = transcendental constant (2.718).

T_{amb} = ambient air temperature in K and measured at site during testing.

~~VII.~~ VIII. Compliance Schedule ~~for Section IV BACT Limits~~

An owner or operator of a ~~cogeneration~~ stationary gas turbine ~~engine~~ subject to Section ~~I~~V ~~BACT limits~~ and not currently achieving such limits shall comply with requirements of Section ~~I~~V in accordance with the following schedule:

A. By (18 months after rule adoption date), submit to the Control Officer a compliance plan, and a complete application for Authority to Construct for all necessary equipment modifications subject to Rule 201.

B. By January 1, 2021~~1997~~, demonstrate full compliance.