PROPOSED STAFF REPORT

Rule 3.22
Stationary Internal Combustion Engines

Date of Release: February 26, 2009

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Rule 3.22 Workshop: April 16, 2009
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STAFF REPORT

Stationary Internal Combustion Engines
Date of Release: February 26, 2009
Scheduled Date of FRAQMD Adoption: June 1, 2009
Feather River AQMD, 938 14th Street,
Marysville, California 95901

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<u>Rule 3.22 STAFF REPORT</u>
Executive Summary

Feather River Air Quality Management District (District) is a Bi-County district that administers local, state and federal air quality management programs for Yuba and Sutter Counties. Under the provisions of the California Clean Air Act (CCAA) of 1988, Yuba County and the northern portion of Sutter County have been designated as "moderate" non-attainment areas for failing to meet the state ozone standard. The southern portion of Sutter County is designated as "serious" non-attainment for failing to meet the state ozone standard. Yuba and Sutter Counties are also designated "moderate" non-attainment for failing to meet the state particulate matter standard.

Ozone is formed when volatile organic compounds (VOCs) react with nitrogen oxides (NOx) in the presence of sunlight, and is one component of "smog". Ozone is a strong irritant that attacks the respiratory system, leading to damage of lung tissues. Exposure to ozone aggravates asthma, bronchitis and other respiratory diseases, as well as cardiovascular diseases. Reductions of NOx and VOCs are necessary to attain and maintain the state ambient air quality standard for ozone.

Particulate matter consists of very fine liquid and solid particles suspended in the air. Particles smaller than 10 microns in size are known as PM10, while the very smallest particles less than 2.5 microns in size are known as PM2.5. Particulate matter becomes entrained in the air due to paved road dust, wood burning, motor vehicles, diesel engines, and other combustion sources. Reducing particulate matter air pollution is one of the California's highest public health priorities because it is linked to increased frequency and severity of asthma attacks, pneumonia and bronchitis, and even premature death in people with pre-existing cardiac or respiratory disease. Reductions of PM10 and PM2.5 are necessary to attain and maintain the state ambient air quality standards.

The 2003 Air Quality Attainment Plan requires the Northern Sacramento Valley Air Basin (NSVAB) to adopt rules and regulations deemed necessary to attain and maintain the state ambient air quality standard for criteria pollutants at the earliest practical date. Senate Bill 656 addressed multiple control measures that would help reduce the particulate matter concentrations in the air. Rule 3.22, Stationary Internal Combustion Engines has been developed to fulfill the commitment made by the District and to help attain the state ambient air quality standards for ozone and particulate matter.

1.0 Purpose:

The purpose of Rule 3.22 is to limit emissions of nitrogen oxides (NOx) and carbon monoxide (CO) from stationary internal combustion engines with rated break horsepower greater than or equal to fifty (>50 hp). This rule would also bring about reductions in the particulate matter emitted from the engines.

2.0 Background:

Stationary IC engines are typically used as either primary or backup engines to generate electricity or power pumps and compressors. IC engines are fueled by diesel, natural gas, propane (LPG), refinery fuel gas, digester gas, and landfill gas. Some final products of combustion include oxides of nitrogen (NOx), carbon monoxide (CO), volatile organic compounds (VOC), and fine particulate matter (PM-10), which are all discharged into the atmosphere. Oxides of nitrogen and volatile organic compounds are recognized as precursors to ground-level ozone formation, and reductions in NOx and VOC are necessary to attain and maintain the state ambient air quality standard for ozone. Ozone can result in reduced lung function, increased respiratory symptoms, increased airway hyperactivity, and increased airway inflammation. Emissions of VOCs also react in the atmosphere to form PM10 and PM2.5. Inhalation of PM10 and PM2.5 deep into the lungs reduces human pulmonary function.

Staff proposed to adopt Rule 3.22 to achieve reasonable emission reductions from stationary internal combustion engines to help attain the state and federal ambient air quality standards for ozone and particulate matter. The proposed rule will also be consistent among the NSVAB Districts, where emission standards are based on the CARB's Determination for Reasonable Available Control Technology (RACT) and Best Available Retrofit Control Technology (BARCT) for stationary internal combustion engines.

3.0 Legal Mandate:

State Mandates: Yuba County and the northern area of Sutter County is designated as "moderate" non-attainment for the state ozone standard. The southern area of Sutter County, also known as the Sacramento Federal Non-attainment Area (SFNA), is designated "serious" non-attainment for the state ozone standard. The California Clean Air Act (CCAA) requires areas designated as non-attainment for ozone to adopt control measures required in Section 40918 & 40919 of California Health and Safety Code (CH&S). CH&S Code, Section 40918 requires the District to adopt a control measure that will use reasonable available control technology (RACT) for all existing stationary sources in the "moderate" non-attainment area. CH&S Code, Section 40919 requires the District to adopt a control measure that will use Best Available Retrofit Control Technology for all existing stationary sources in the "serious" non-attainment area. The CCAA also requires the District to develop a plan to achieve California's ambient air quality standard by the earliest practical date (CH&S Code Section 40913).

Yuba and Sutter Counties are also designated as "moderate" non-attainment for the state PM10 standard. In 2003, the Legislature passed Senate Bill 656 to reduce public exposure to PM10 and PM2.5. The legislation requires the ARB, in consultation with local air pollution control and air quality management districts, to adopt a list of the most readily available, feasible, and cost effective control measures that could be implemented by air districts to reduce PM10 and PM2.5. Pursuant to SB 656, the Board of Directors of the Feather River Air Quality Management District passed and adopted the Particulate Matter Control Measure Implementation Schedule at a meeting on August 1, 2005. Rule 3.22 was included on this implementation schedule. Measures adopted as part of SB656 will complement and support those required for the State attainment plan as well as for State ozone plans. This will ensure continuing focus on PM reduction and progress towards attaining California's more health protective standards.

Federal Mandates:
In 2004, EPA designated the Sacramento region as one of the nation's four worst 8-hour ozone nonattainment areas. This region, called the Sacramento Federal Nonattainment Area, includes all of Sacramento and Yolo counties and portions of Placer, El Dorado, Solano, and Sutter counties. Federal law and regulations set specific planning requirements for adopting and implementing a plan to meet reasonable further progress goals and demonstrate attainment of the 1997 federal ozone standard as expeditiously as practicable, but no later than our attainment deadline. This State Implementation Plan (SIP) contains a list of control measures which will help the area meet federal Clean Air Act planning requirements for the 1997 health based standards for 8-hour ozone. Rule 3.22 was included on the list as a feasible control measure.

All Feasible Measures Requirements: California Health and Safety Code Section 40914 requires the District's plan to demonstrate that the plan includes "every feasible measure" to control emissions. Accordingly, the District must adopt an effective control measures to limit NOx emissions from internal combustion engines. The District has evaluated the standards in the rule against similar requirements recently adopted by other districts. The District has determined that the standards are feasible and have been achieved in practice.

4.0 Proposed Rule Requirements:

4.1 Applicability

Rule 3.22 applies to all internal combustion engines with rated break horsepower greater than or equal to fifty (>50 hp) used in industrial, institutional, and commercial operations that operate within the boundaries of the District.

4.2 Standards

All internal combustion engines shall not be operated above the emission limitations according to the area of designation and fuel type, as shown in Table 1 and 2.

Table 1: North FRAQMD Emission Limits

	NOx (ppmv at 15% O2)	VOC (ppmv at 15% O2)	CO (ppmv at 15% O2)
Spark Ignited Rich Burn	90	250	4000
Spark Ignited Lean Burn	150	750	4000
Compression Ignited	600	750	4000

Table 2: South FRAQMD Emission Limits

	NOx (ppmv at 15% O2)	VOC (ppmv at 15% O2)	CO (ppmv at 15% O2)
Spark Ignited Rich Burn	25	250	4000
Spark Ignited Lean Burn	65	750	4000
Compression Ignited	80	750	4000

4.3 Compliance Schedule

The owner or operator of one or more stationary internal combustion engines subject to this rule shall choose one of the following compliance schedules:

4.3.a For each engine to be permanently removed from service and replaced with an electric motor:

(1) Submit a statement to the Air Pollution Control Officer identifying the engine to be removed no later than six months after District adoption of the rule;
(2) Replace the engine with an electric motor no later three years after District adoption of the rule;

4.3.b For all other engines subject to this determination:

(1) Have all required applications for permits to construct submitted to the Air Pollution Control Officer no later than one year after District adoption of the rule;
(2) Have each engine demonstrate compliance with the emission limits no later than two years after District adoption of the rule;

4.4 Monitoring and Recordkeeping

The owner or operator of one or more stationary internal combustion engines subject to this rule shall meet the following requirements:

4.4.a To demonstrate on-going compliance, a unit will be source tested once every five years. During any year in which a source test is not performed, a portable analyzer shall be used to take emission readings to verify compliance with the emission limits.

4.4.b All emission readings shall be taken at an engine's actual peak load and under the engine's typical duty cycle. The analyzer shall be calibrated, maintained and operated in accordance with the manufacturer's specifications and recommendations or a protocol approved by the Air Pollution Control Officer. An instrument reading in excess of the emission compliance values shall not be considered a violation, so long as the engine is brought into compliance within 15 days of the initial out of compliance reading.

4.4.c All records shall be maintained for at least five years and made available for inspection by the Air Pollution Control Officer or the Officer's designee.

5.0 Socioeconomic Impact:

Yuba and Sutter counties have a combined population less than 500,000 persons. The Required Assessment in subsection (d) of the California Health and Safety Code (Section 40728.5) states, "This section does not apply to any district with a population of less than 500,000 persons'" A socioeconomic impact analysis is not required.

6.0 Effectiveness of Control Measures:

The reduction of NOx emissions from process equipment, such as internal combustion engines, is mainly accomplished through pre-combustion modifications and/or post-combustion exhaust controls. The application of a specific technique will depend on the type of engine, the characteristic of its primary fuel, and method of firing. Table 3 presents a summary of these technologies and other feasible options that includes affected engine type, approximate effectiveness over uncontrolled emissions, cost estimates, and a general description.

6.1 Pre-combustion Modifications

Pre-combustion modifications affect the way fuel is combusted or "burned." Some of these techniques include changing the air to fuel ratio, reducing the peak combustion temperature, shortening the residence time at high temperatures, or adjusting the ignition or injection timing.

1. Air/Fuel Ratio Changes

Stoichiometry is achieved when the air/fuel ratio is such that all the fuel can be fully oxidized with no residual oxygen remaining. NOx formation is highest when the air/fuel ratio is slightly on the lean side of stoichiometric. At this point, both CO and VOC are relatively low. Adjusting the air/fuel ratio toward either leaner or richer mixtures from the peak NOx formation air/fuel ratio will reduce NOx formation.

In the case of leaner mixtures, the excess air acts as a heat sink, reducing peak temperatures, which results in reduced NOx formation. The excess air also allows more oxygen to come into contact with the fuel, which promotes complete combustion and reduces VOC and CO emissions. As the mixture continues to be leaned out, the reduced temperatures may result in a slight increase in CO and VOC emissions. Operating the engine on the lean side of the NOx formation peak is often preferred over operating rich because of increased fuel efficiencies associated with lean operation. However, use of very lean air/fuel ratios may result in ignition problems. For this reason, techniques designed to improve ignition are often combined with lean air/fuel ratios to control NOx emissions and avoid increases in VOC emissions.

NOx formation will also decrease if the mixture is richened from the peak NOx air/fuel ratio. However, a mixture richer than stoichiometric will result in incomplete combustion. Nearly all the oxygen will then combine with the fuel and emissions of CO and VOC will increase.

2. Turbocharging and Aftercooling

Turbochargers compress the intake air of an engine before this air enters the combustion chamber. Due to compression, the temperature of this air is increased. This tends to increase peak temperatures, which increases the formation of NOx. However, the heat sink effect of the additional air in the cylinder, combined with the increased engine efficiency from turbocharging or supercharging, generally results in a minor overall decrease in NOx emissions per unit of power output. On the other hand, turbocharging can significantly increase the maximum power rating of an engine, which increases the maximum mass emissions rate for NOx. Due to the high density of oxygen in the combustion chamber, turbocharging makes the combustion process more effective, which tends to reduce emissions of CO and VOC.

On turbocharged engines, the intake air temperature can be reduced by aftercooling (also known as intercooling or charge air cooling). An aftercooler consists of a heat exchanger located between the turbocharger and combustion chamber. The heat exchanger reduces the temperature of the intake air after it has been compressed by the turbocharger. Cooling the intake air reduces peak combustion temperatures, and thereby reduces NOx emissions. The cooling medium can be water, either from the radiator or from a source outside of the engine, or the cooling medium can be ambient air. The cooling effects of the aftercooler increases the density of the intake air, which results in a leaner air/fuel mixture in SI engines if no additional fuel is introduced. For engines already using lean air/fuel mixtures, this leaner mixture will lower NOx emissions further.

6.2 Post-combustion Exhaust Control

Post combustion controls generally consist of catalysts or filters that act on the engine exhaust to reduce emissions. Post combustion controls also include the introduction of agents or other substances that act on the exhaust to reduce emissions, with or without the assistance of catalysts or filters.

1. Non-Selective Catalytic Reduction (NSCR)

The NSCR catalyst promotes the chemical reduction of NOx in the presence of CO and VOC to produce oxygen and nitrogen. The 3-way NSCR catalyst also contains materials that promote the oxidation of VOC and CO to form carbon dioxide and water vapor. To control NOx, CO, and VOC simultaneously, 3-way catalysts must operate in a narrow air/fuel ratio band (15.9 to 16.1 for natural gas-fired engines) that is close to stoichiometric. An electronic controller, which includes an oxygen sensor and feedback mechanism, is often necessary to maintain the air/fuel ratio in this narrow band.

When applying NSCR to an engine, care must be taken to ensure that the sulfur content of the fuel gas is not excessive. The sulfur content of pipeline-quality natural gas and LPG is very low, but some oil field gases and waste gases can contain high concentrations. Sulfur tends to collect on the catalyst, which causes deactivation. This is generally not a permanent condition, and can be reversed by introducing higher temperature exhaust into the catalyst or simply by heating the catalyst.

The total installed cost of an NSCR system on an existing engine varies with the size of the engine. For an 80 horsepower engine, total costs for installation may range from $5,000 to $11,000. For an 1,100 horsepower engine, installed costs of $20,000 to $25,000 are typical.

2. Selective Non-Catalytic Reduction (SNCR)

SNCR reduces NOx by injecting ammonia or urea into the exhaust gas. The injected ammonia or urea reacts with the nitrogen oxides to produce nitrogen gas and water vapor. A drawback of SNCR is that it is highly dependent on temperature, which must be between the 1400°F to 2000°F range. If the temperature is below 1600°F, chemical enhancers such as hydrogen may be required to help the reaction. If the temperature is above 2000°F, the ammonia or urea tends to react with any available oxygen to form NO.

With SNCR, it is very important to control the excess un-reacted ammonia. The excess ammonia could react with other combustion by-products and form ammonia salts or may pass through the system and into the atmosphere. This is known as an ammonia slip and it is sometimes visible in the plume from the stack. Due its environmental impact, SNCR systems are restricted to not emit ammonia in excess of 20 ppmv at dry stack conditions adjusted to 3% oxygen into the atmosphere.

3. Selective Catalytic Reduction (SCR)

A Selective Catalytic Reduction unit is another post-combustion control measure and is operated similar to a SNCR. However, instead of injecting into a specific temperature zone, SCR injects ammonia into the flue gas over a catalyst bed. The catalyst bed allows the reaction to reduce NOx at a temperature range from 500^{o}F to 850^{o}F. Similar to SNCR, the ammonia slip must be regulated.

6.3 Engine Replacement

Rather than applying controls to the existing engine, another viable option it is to replace it with either a new, low emissions engine or an electric motor. However, in remote locations or where electrical infrastructure is inadequate, the costs of electrical power transportation and conditioning may be excessive.

Table 3: Summary of NOx Emission Control Technologies for Stationary IC Engines

Control Technology	Engine Types	Effectiveness	Capital Costs	Description
Non-Selective Catalytic Reduction (NSCR)	Rich Burn Engines	NOx: >98% CO: >97% HC: >80%	$50-200/bhp	**Exhaust Control:** Post combustion oxidation of HC & CO by O2 and NOx over a catalyst (usually a noble metal like platinum, rhodium, or palladium). The HC & CO are converted to CO2 and water, while the NOx is reduced to N2.
Selective Catalytic Reduction (SCR)	Lean Burn Engines	NOx: >95% CO: >97% HC: >80%	$135-510/bhp	**Exhaust Control:** Ammonia or urea injected in the exhaust before a catalyst. The HC & CO are converted to CO2 and water, while the NOx is reduced to N2.
Post Combustion Oxidation & Selective Non-Catalytic Reduction	CI, Lean Burn, and Rich Burn Engines	NOx: >90% PM: 60% CO: <10 ppm	$30-155/bhp	**Exhaust Control:** • Non-Catalytic Oxidation of HC, PM, CO • Exhaust heated to 1,400 to 1,550 °F through fuel introduction to exhaust • Urea injected to reduce NOx • Ammonia Slip (2 ppm)
SCR with Diesel Particulate Filtration	CI Engines	NOx: 95% PM: 89%	$180-620/bhp	**Exhaust Control:** • Aqueous urea injected • Ammonia slip: 4.4 ppm with 30 ppm spikes
Lean + Derating	Rich and Lean Burn Engines	NOx: >80%	n/a	**Combustion Control:** Increase the air-to-fuel ratio toward lean and derate, or decrease the cylinder pressures and temperature which reduces the power output of an engine. The lower pressure and temperature reduces NOx, but may increase HC & CO.
Pre-Stratified Charge	Rich and Lean Burn Engines	NOx: >80%	$1250-1825/bhp	**Combustion Control:** Small amounts of air are introduced to the intake manifold create sequential fuel-rich and fuel-lean zones. This provides both a fuel-rich ignition zone and rapid flame cooling in the fuel-lean zone.
Low-Emission Combustion	Rich and Lean Burn Engines	NOx: >80%	$285/bhp	**Combustion Control:** Lean Burn combined with: • ignition system improvement, • turbocharging, aftercooling • air/fuel ratio controller
Engine Replacement	CI, Lean Burn, and Rich Burn Engines	60-100%	Variable	For replacement with an electric motor, emissions are reduced 100 percent at the IC engine location. For replacement with a newer engine, emissions will drop drastically.

7.0 Estimated Cost Impact:

The proposed Rule 3.22 will require all units subject to this rule to meet the associated emissions standards. Some sources may need to install additional equipment such as operational tracking devices and/or emission control devices to be exempt from the emission standards. The proposed rule will also require compliance testing to show compliance with the required emission standards. A summary of the estimated cost for equipment and testing is shown below in Table 4.

Table 4: Summary of Estimated Cost

Capital Investment	Cost (dollars)
Non-resettable Hour Meter	$400
Fuel Flow Meter	$1,500
Equipment Retrofit	
Air/Fuel Ratio & Engine Adjustments	$1,000
Turbocharging/Aftercooling	$5,000 to $40,000
NSCR & Air/Fuel Ratio Controller	$5,000 to $25,000
SCR	$90,000
Portable Analyzer	$4,000 to $8,000
Replace Unit	Variable
Compliance	**Cost (dollars)**
Initial Compliance: Source Test	$2,000-$4,000/unit
On-going Compliance Program	$500/unit

After one year of the date of adoption of the proposed rule, all internal combustion engines which need to be modified for the exemption of this rule shall install either a non-resettable hour meter or a fuel flow totalizing meter to track the annual usage of each unit. The District anticipates most owners or operators will chose to install a non-resettable hour meter, which will cost about $400. The majority of the engines in the District already have these installed, so no further work will be required.

For each unit to be in compliance with rule 3.22, the facility must show that the unit meets the emissions requirement. Most units can achieve the emission standards by retrofitting the unit with a NSCR catalytic converter, which ranges from $5,000 to $25,000, or simply by tuning the combustion controls, which costs around $1,000.

It is expected that around 40% of the engines in the District will need some sort of modification to satisfy the emissions limit. The majority of the engines which need to be phased out are the older lean burn engines. Adding emission control devices to these engines tend to be expensive. It is expected that the majority of these lean burn engines will be replaced with rich burn engines with NSCR catalytic converters.

To show initial compliance, the proposed rule requires the facility to perform a source test on the engine or provide results verifying the engine meets the emissions limits. The cost of a source test is about

$2,000-$4,000 per engine using a reference method such as ARB Method 100. Costs are less if multiple engines are tested at the same time. If the engine is already certified to the emission limits, there won't be any costs to achieve initial compliance. It is expected that around 80% of the engines will need to be source tested.

To show ongoing compliance, a hand-held portable NOx analyzer will be needed. The cost of an analyzer ranges from $4,000 to $8,000. Many engine operators who perform their own maintenance and maintain several engines already use portable analyzers. Smaller operators generally contract out engine maintenance, and nearly all maintenance contractors already have analyzers. The expected cost of the on-going compliance program is around $500 per engine per year due to labor costs.

There are currently around 76 stationary prime internal combustion engines larger than 50 bhp located within the District, which are summarized in Table 5. If left uncontrolled, these engines generally pollute between 3 to 10 tons per year of NOx depending on the size of the engine. This corresponds to around 360 tons of NOx emissions per year within the District. However, about 60% of the engines already have NSCR catalytic converters. After the control technologies are implemented for the remaining engines, the engines are expected to pollute at least 70% less than their current emission levels. This would decrease NOx emissions within the District by 100 tons per year.

360 tons/yr * 40% needing modifications * 70% reduction = 100 ton/yr less pollution

Table 5: Summary of Prime Stationary Engines over 50 hp in Yuba and Sutter Counties

Fuel	Number of Engines
Spark Ignited Rich Burn	44
Spark Ignited Lean Burn	21
Compression Ignited	11
Total	76

8.0 Environmental Review and Compliance:

The adoption of rule 3.22 is categorically exempt from the California Environmental Quality Act (CEQA) under Sections 15307 and 15308 of the State CEQA Guidelines and no exceptions to these exemptions apply. This exemption is allowed when the rule will help improve air quality in Yuba and Sutter County. California Public Resources Code (Section 21159) requires an environmental analysis of the reasonably foreseeable methods of compliance. The District has concluded that no reasonably foreseeable adverse environmental impacts will be caused by adoption of the proposed rule.

9.0 Required Findings:

The California Health and Safety Code, Division 26, Air Resources, requires local Districts to comply with a rule adoption protocol as set forth in Section 40727 of the Code. This section has been revised through legislative mandate to contain 6 findings that the District must make when developing, amending, or repealing a rule. These findings and their definitions are listed in the following table.

Table 6: Required Findings

FINDING	DEFINITION	REFERENCE
Authority	A district shall adopt rules and regulations and do such acts as may be necessary or proper to execute the powers and duties granted to, and imposed upon, the district by this division and other statutory provisions	California Health and Safety Code, Sections 40000, 40001, and 40702 are provisions of law that provide air districts with the authority to adopt these proposed rules.
Necessity	The District has demonstrated that a need for the rule, or for rule amendment or repeal.	It is necessary for districts to adopt these amendments to comply with state law and to ensure consistency with neighboring air districts.
Clarity	The rule is written or displayed so that its meaning can easily be understood by the persons directly affected by it	There is no indication, at this time, that the proposed rules are written in such a manner that it cannot be easily understood by persons affected by the rule.
Consistency	This rule is in harmony with, and not in conflict with or contradictory to, existing statutes, court decisions, or State or federal regulations.	These rules are consistent with applicable statutory requirements.
Non-Duplication	The rule does not impose the same requirements as an existing State or federal regulation, unless the District finds that the requirements are necessary and proper to execute the powers and duties granted to, and imposed upon, the district	The proposed rule does not impose requirements that duplicate existing laws or regulations.
Reference	Any statute, court decision, or other provision of law that the district implements, interprets, or makes specific by adopting, amending, or repealing a regulation.	The proposed rule has been developed to meet the requirements of the 2003 State Implementation Plan.

ATTACHMENT A

Rule Analysis

ATTACHMENT B

Public Notice

ATTACHMENT C

Comments and Responses