Appendix A
Methods for Estimating Portable Fuel Container Emissions

This appendix describes how the information in the California Air Resources Board's Mail-Out MSC 99-25 can be used to estimate portable fuel container emissions in the OTC States. Most of the text and equations in this appendix are taken directly from MSC 99-25.

Introduction

Gas-can emissions rates for various emissions modes (e.g., evaporation, permeation, etc.) occurring during typical usage are determined using diurnal evaporative and gravimetric test methods. The survey of population and usage are combined with the emissions test results to produce the inventory. This inventory will be used in estimating other inventories, such as those of past and future years, and for other purposes involving planning or air-quality modeling. The gas-can surveys and emissions test methods are discussed in the following sections.

A. Residential-Gas Cans.

1. Surveys.

Residential-gas-can information can be solicited by mail from randomly selected OTC State households and directly from various agency staff.

Gas-can emissions are a function of the can material (i.e., plastic or metal) and the storage conditions. Gas cans are stored in either an "open" or a "closed" condition. An open condition, or system, exists when a can is stored with an open breathing (vent) hole and/or an uncapped main-filler opening or nozzle. A closed system exists when the vent hole is closed and the main-filler opening or spout is capped.

A sample result of an OTC State residential-gas-can-survey is presented in Table 1.

Table 1: Residential-Gas-Can-Survey Results (sample)

Percentage of Households with at Least One Gas Can	46%
Number-of-Gas-Cans per Household	1.8
Percentage of Plastic-Gas Cans/Metal-Gas Cans	76%/24%
Weighted Average Gas Can Capacity (gal.)	2.34
Percentage of Gas Cans Stored With Fuel	70%
Weighted Average Stored Fuel Volume (% of Total Capacity)	49%
Percentage of Plastic-Gas Cans Stored Open/Closed	23%/53%

Percentage of Metal-Gas Cans Stored Open/Closed	11%/13%
Percentage of All Gas Cans Stored Open/Closed	34%/66%

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2. Population.

The residential-gas-can population is calculated as follows:

$$Pop_R = (N)(A)(Count_R) \quad \text{(Eq. 1)}$$

where:

Pop_R	=	Statewide Residential-Gas-Can Population
N	=	Number of Occupied-Housing Units in OTC State (say 11,127,621 on Jan. 1, 2000)
A	=	Percentage of Households with Gas Cans (46%)
$Count_R$	=	Average Number of Residential-Gas Cans per Household (i.e., 1.8)

Substituting the appropriate values into Equation 1 yields a statewide population of **9,213,670** residential-gas cans for the 2000 calendar year.

3. Population-Growth Rate.

The 1990–2000 housing unit data from the OTC State Department of Finance can be used to estimate future gas-can growth rates until the 2010 calendar year. These projected growth rates will be normalized to the 1990 calendar year. The housing unit data can be used to extrapolate values of future annual housing units in OTC State until the 2010 calendar year.

4. Emissions.

Gas-can emissions are classified by five different emission processes:

a) Permeation;
b) Diurnal;
c) Transport;
d) Spillage; and,
e) Vapor Displacement During Equipment Refueling.

a) Permeation Emissions.

Permeation emissions are produced after fuel has been stored long enough in a can for fuel molecules to infiltrate and saturate the can material.

An average daily permeation-emission rate can be derived from test data obtained from several plastic-gas cans and metal-gas cans. Each gas can is sealed with a metal-filled epoxy and an overcoat of a non-permeable two-part epoxy resin. Additionally, any plastic caps and plugs are replaced with metal ones whenever possible. Also, all secondary vents are plugged with brass fittings and coated with sealant. Lastly, the gas cans are leak checked and reworked as necessary. The gas cans are filled with certification test fuel (i.e., reformulated gasoline), and subjected to a diurnal-variable temperature profile in a sealed housing for evaporative determination unit (SHED). This temperature profile is the same as is currently required for on-highway motor-vehicle-evaporative emissions testing (ozone episode days). Gravimetric measurements are made of the gas cans after each 24-hour test period. The average daily permeation rate from a plastic-gas can (closed system) is calculated as **grams per gallon per day** (g/gal-day). A permeation-emission rate for metal-gas cans is determined with similar test methods as **g/gal-day**.

Statewide residential-gas-can-permeation emissions are computed as follows:

$$HC_{PR} = \Sigma \left[(Pop_R)(S)(EF_P)(B_R)(Size_R)(Level) \right] \qquad \text{(Eq. 2)}$$

where:

	HC_{PR}	=	Permeation Emissions in tons per day (tpd)
	Pop_R	=	Statewide Residential-Gas-Can Population
	EF_P	=	Appropriate Permeation-Emission Factor (g/gal-day)
	S	=	Percentage of Gas Cans Stored with Fuel (70%)
	B_R	=	Percentage of Cans Stored in Closed Condition with respect to Material (Plastic 53%; Metal 13%)
	$Size_R$	=	Weighted Average Capacity of Residential-Gas Cans (2.34 gal.)
	Level	=	Weighted Average Amount of Stored Fuel (49%)

Substituting the appropriate values into Equation 2, summing the resultant products, and converting grams to tons (i.e., $9.08(10^5)$ grams per ton), produces a statewide total of residential-plastic-gas-can-permeation emissions. Similarly, a permeation-emissions total for residential-metal-gas-cans can be determined.

b) Diurnal Emissions.

Diurnal emissions result when stored fuel vapors escape to the outside of a gas can through any possible openings while the gas can is subjected to the daily cycle of increasing and decreasing ambient temperatures. Diurnal emissions are dependent on the closed- or open-storage condition of a gas can. Accordingly, emissions rates are determined for both conditions.

Closed-System. Plastic-gas-can test data are gathered from, say, several 2-gallon-8-ounce, and five-gallon, size gas cans. These gas cans are filled with certification-test fuel to one-half of the total capacity. One-half of the gas-can capacity approximates the weighted average of stored fuel volume of 49%. The cans are subjected to a diurnal-variable temperature profile in a shed. An average diurnal-emission rate is first calculated using each individual gas-can average daily-emission rate. The average-daily plastic-gas-can permeation rate is then subtracted from that value to yield the resultant diurnal-emission rate for plastic, closed-system gas cans as **g/gal-day**. Similar diurnal-SHED tests of several metal-gas cans can be performed.

Open-System. Plastic-gas-can test data are gathered from several five-gallon, and 2-gallon-8-ounce, size gas cans. Each gas can is weighed, filled with test fuel to various fractions of their total capacities, and weighed again. The gas cans are then stored with open vent and breathing holes. Each gas can is weighed after each subsequent 24-hour period for sixteen consecutive days. The average diurnal-emission rate over the test period can be measured as **g/day**. Note that this diurnal-emission rate is applicable for both plastic- and metal-gas cans that are stored in an open condition.

Diurnal emissions from both open- and closed-system-residential-gas cans are calculated as follows:

$$HC_{DR} = (Pop_R)(S)(EF_D)(B_R)(Size_R)(Level) \qquad \text{(Eq. 3)}$$

where:

	HC_{DR}	=	Diurnal Emissions (tpd) for Residential-Gas Cans with respect to Storage Condition (Open or Closed) and Material (Plastic or Metal)
	Pop_R	=	Statewide Residential-Gas-Can Population
	S	=	Percentage of Gas-Can Population Stored with Fuel (70%)
	EF_D	=	Appropriate Diurnal-Emission Factor with respect to Storage Condition and Material (g/gal-day or g/day)
	B_R	=	Percentage of Gas-Can Population with respect to Storage Condition and Material

$Size_R$	=	Weighted Average Capacity of Residential-Gas Cans (2.34 gal.)
Level	=	Weighted Average Amount of Stored Fuel (49%)

Substituting the appropriate values into Equation 3, and performing the conversion to tons, yields a statewide total residential-gas-can-diurnal emission amount in **tpd** for the 2000 calendar year.

c) Transport-Spillage Emissions.

Transport-spillage emissions arise when fuel escapes (e.g., spills, etc.) from gas cans that are in transit. The transport-emission-spillage factor can be determined from data provided by the U. S. EPA's fuel transport spillage survey of hydrocarbon losses from lawn and garden equipment. Analysis of this data revealed that the emission rates for a gas can (i.e., pump-to-pump losses) were **23.0 grams per gas-can-refill-at-the-pump** (g/refill) for a closed system, and **32.5 g/refill** for an open system. Residential-transport-spillage emissions are determined as:

$$HC_{TR} = (Pop_R)(S)(Refill_R)(EF_T)(B_R) \qquad \text{(Eq. 4)}$$

where:			
	HC_{TR}	=	Residential-Gas-Can-Transport-Spillage Emissions (tpd)
	Pop_R	=	Statewide Residential-Gas-Can Population
	S	=	Percentage of Gas Cans Stored with Fuel (70%)
	$Refill_R$	=	Average Number of Residential-Gas-Cans-Pump-Refills per Day per Can (refill/day from survey)
	EF_T	=	Transport-Emission Factor with respect to Storage Condition (g/refill)
	B_R	=	Percentage of Gas Cans with respect to Storage Condition and Material

Substituting the appropriate values into Equation 4, and converting grams to tons, yields a statewide total residential-gas-can-transport-spillage emission value in **tpd**.

B. Commercial-Gas Cans.

1. Surveys.

Commercial-gas can usage and storage information can be solicited by agency staff directly from various statewide businesses. Targeted businesses may include agricultural, automotive club and tow services, service stations, lawn and garden maintenance services, general contractors, and construction and rental yards.

The results of a sample commercial-gas-can-survey may be as follows:

Table 2: Commercial-Gas-Can-Survey Results (Sample)

Percentage of Businesses with at Least One Gas Can	80%
Gas Cans per Businesses	6.9
Weighted Average Gas Can Capacity (gal.)	3.43
Percentage of Plastic-Gas Cans/Metal-Gas Cans	72%/28%
Percentage of Plastic-Gas Cans Stored Open/Closed	39%/33%
Percentage of Metal-Gas Cans Stored Open/Closed	10%/18%
Percentage of All Gas Cans Stored Open/Closed	49%/51%

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2. Population.

The populations of commercial-gas cans held by businesses can be determined using the InfoUSA database. Specific businesses that are expected to utilize gas cans in their normal operations are identified within various industrial classifications (e.g., agricultural services, general building services, etc.). Summing up the individual populations of each business group gives an estimate of the total statewide population of businesses using gas cans.

The commercial-gas-can population is calculated as follows:

$$Pop_C = (N_C)(Count_C) \qquad \text{(Eq. 5)}$$

where:
- Pop_C = Statewide Commercial-Gas-Can Population
- N_C = Number of Occupied Businesses in OTC State
- $Count_C$ = Average Number of Gas Cans per Business (6.9)

3. Emissions.

a) Permeation Emissions.

Permeation-emission rates for commercial-gas cans are assumed to be the same as those for residential-gas cans

Statewide commercial-gas-can-permeation emissions are computed as follows:

$$HC_{PC} = \Sigma \left[(Pop_C)(S)(EF_P)(B_C)(Size_C)(Level) \right] \qquad \text{(Eq. 6)}$$

where: HC_{PC} = Permeation Emissions (tpd)
Pop_C = Statewide Commercial-Gas-Can Population
EF_P = Appropriate Permeation-Emission Factor (g/gal-day)
S = Percentage of Gas Cans Stored with Fuel (70% for Residential Survey)
B_C = Percentage of Applicable Gas Cans Stored in Closed Condition
$Size_C$ = Weighted Average Capacity of Commercial-Gas Cans (3.43 gal)
Level = Weighted Average Amount of Stored Fuel (49% from Residential Survey)

Substituting the appropriate values into Equation 6, summing the resultant products, and converting grams to tons, gives a commercial-gas-can statewide permeation-emissions total in **tpd** for plastic-gas cans and for metal-gas cans.

b) Diurnal Emissions.

Diurnal-emissions rates for commercial-gas cans are expected to be the same as for residential-gas cans.
The amount of diurnal emissions from both open- and closed-system commercial-gas cans is calculated as follows:

$$HC_{DC} = (Pop_C)(S)(EF_D)(B_C)(Size_C)(Level) \qquad \text{(Eq. 7)}$$

where: HC_{DC} = Diurnal Emissions (tpd) for Commercial-Gas Cans with respect to Storage Condition (Open or Closed) and Material (Plastic or Metal)
Pop_C = Statewide Commercial-Gas-Can Population
EF_D = Appropriate Diurnal-Emission Factor with respect to Storage Condition and Material (g/gal-day or g/day)
S = Percentage of Gas Cans Stored with Fuel (70% from Residential Survey)
B_C = Percentage of Gas Cans with respect to Storage Condition and Material
$Size_C$ = Weighted Average Capacity of Commercial-Gas Cans (3.43 gal.)
Level = Weighted Average Amount of Stored Fuel (49% from Residential Survey)

Substituting the appropriate values into Equation 7, and converting grams to tons, yields commercial-gas-can-diurnal-emission values.

c) Transport-Spillage Emissions.

Transport-Spillage emissions factors for commercial-gas cans are expected to be the same as those for residential-gas cans: 23.0 g/refill per can for a closed system, and 32.5 g/refill per can for an open system. The frequency of gas-can refills at the pump for lawn-and-garden equipment is expected to be different than for all of the other types of commercial equipment. This is due to the higher level of activity for commercial lawn-and-garden equipment; hence, this equipment is expected to be refueled more often than is other commercial equipment. Accordingly, the frequency of average commercial lawn-and-garden-equipment gas-can refills at the pump is derived from the U. S. EPA's fuel transport spillage survey of hydrocarbon losses from lawn and garden equipment data.

The 2000-calendar-year frequency of non-lawn-and-garden-equipment commercial-gas-can refills at the pump is derived as follows:

$$Refill_C = \left[\frac{(\Sigma\ Fuel)}{(Size_C)(POP_{NON})(S)} \right] \qquad \text{(Eq. 8)}$$

where:

$Refill_C$ = Average Number of Non-Lawn-and-Garden Equipment Commercial-Gas-Cans Pump Refills per Day per Can (refill/day)

Fuel = Non-Lawn-and-Garden Equipment Fuel Consumption (gal/day) for 2000

$Size_C$ = Weighted Average Capacity of Commercial-Gas Cans (3.43 gal/can-refill)

POP_{NON} = Statewide Commercial-Gas-Can Population with respect to Non-Lawn-and-Garden Businesses

S = Percentage of Gas Cans Stored with Fuel (70% from Residential Survey)

The commercial-transport-spillage emissions are determine as:

$$HC_{TC} = (Pop_C)(S)(B_C)(Refill_C)(EF_{TC}) \qquad \text{(Eq. 9)}$$

where: HC_{TC} = Commercial-Gas-Can-Transport-Spillage Emissions (tpd)
Pop_C = Statewide Commercial-Gas-Can Population
S = Percentage of Gas Cans Stored with Fuel (70% from Residential Survey)
B_C = Percentage of Gas Cans with respect to Storage Condition and Material
$Refill_C$ = Average Number of Gas-Cans Pump Refills per Day per Can
EF_{TC} = Transport-Spillage Emission Factor (g/refill) with respect to Storage Condition

C. Spillage Emissions During Equipment Refueling.

Spillage emissions are produced when fuel is dispensed from a gas can to an equipment/vehicle fuel tank, another gas can, etc., and fails to either be delivered into the intended reservoir or to remain inside the reservoir. Spillage data provided by the Outdoor Power Equipment Institute (OPEI) in conjunction with the U. S. EPA's NEVES report[1] indicate that the spillage-emission rate for equipment refills from a gas can is 17 grams per refill per equipment unit. This estimate assumes that every refill results in a replenishment of the fuel tank's entire capacity. The spillage-emission rate is applied to only equipment or vehicles that are typically fueled from a gas can (e.g., lawn care equipment, sometimes recreational equipment, etc.), and not typically from a pump.

The amount of daily spillage emissions from all applicable residential- and commercial-gas cans is calculated as follows:

$$HC_S = \Sigma \left\{ \left[\frac{(Fuel)(Spill)}{(Tank)} \right] (Con) \right\} \quad \text{(Eq. 10)}$$

where: HC_S = Daily Spillage Emission from All Gas Cans (tpd)
Fuel = Applicable Equipment/Vehicle Type Fuel Consumption (gal/day)
Spill = Spillage-Emission Rate per Refill of Gas Can-Refueled Equipment/Vehicles (17 g/refill)
Tank = Applicable Equipment/Vehicle Fuel-Tank Capacity (gal/refill)

[1] "Nonroad Engine and Vehicle Emission Study – Report," U. S. Environmental Protection Agency, November 1991.

Con = Frequency of Refuels (per day) with respect to Equipment/Vehicle (none, always, or fraction of always)

D. Refueling-Vapor Displacement.

The refueling-displacement-vapor emissions result when fuel vapor is displaced from equipment and vehicle fuel tanks, gas cans, etc., by fuel dispensed from gas cans. The NEVES report of refueling emissions presented a formula to compute the refueling-vapor-displacement-emission factor. This formula is:

$$DISP = [-5.909 + (0.0884)(TD) + (0.485)(RVP)] \qquad \text{(Eq. 11)}$$

where:

DISP = Daily Spillage-Emission Rate for All Gas Cans (g/gal)

TD = Temperature (°F) of the Dispensed Fuel (ambient temperature)

RVP = Reid Vapor Pressure of Dispensed Fuel (psi)

The amount of daily refueling vapor-displacement emissions from all applicable residential-and commercial-gas cans is calculated as follows:

$$HC_{DISP} = \Sigma \left\{ (DISP)(Fuel)(Con) \right\} \qquad \text{(Eq. 12)}$$

where:

HC_{DISP} = Total Refueling-Vapor-Displacement Emissions from All Gas Cans (tpd)

DISP = Refueling Vapor Displacement Emission Rate (4.52 g/gal)

Fuel = Applicable Equipment/Vehicle Type Fuel Consumptions (gal/day)

Con = Frequency of Refuels (per day) with respect to Equipment/Vehicle (none, always, or fraction of always)

As with the spillage-emission-factor calculation, the vapor-displacement-emission rate is applied only to equipment or vehicles that are typically fueled from a gas can, and not from a pump dispenser.

Summary of Results.

Table 3 can be used to estimate the total emissions:

Table 3: Statewide Gas-Can Emissions for 2000 Calendar Year

Emission Type	Residential Emissions (tpd)	Commercial Emissions (tpd)	Total by Emission Type (tpd)
Permeation			
Diurnal			
Transport-Spillage			
Spillage			
Refueling-Vapor Displ.			
Subtotal:			
Total:	**-**	**-**	**XX.X**

Appendix B
Source Classification Codes affected by the NOx model rule

Source Type	SCC	SCC Description	source_cat	material
Cement Kilns				
	30500606	Industrial Processes; Mineral Products; Cement Manufacturing (Dry Process); Kilns		Cement
	30500706	Industrial Processes; Mineral Products; Cement Manufacturing (Wet Process); Kilns		Cement
	30500622	Industrial Processes; Mineral Products; Cement Manufacturing (Dry Process); Preheater Kiln		Clinker
	30500623	Industrial Processes; Mineral Products; Cement Manufacturing (Dry Process); Preheater/Precalciner Kiln		Clinker
Stationary Combustion Turbines				
	20100101	Internal Combustion Engines; Electric Generation; Distillate Oil (Diesel); Turbine		Distillate Oil (Diesel)
	20100201	Internal Combustion Engines; Electric Generation; Natural Gas; Turbine		Natural Gas
	20100801	Internal Combustion Engines; Electric Generation; Landfill Gas; Turbine		Landfill Gas
	20100901	Internal Combustion Engines; Electric Generation; Kerosene/Naphtha (Jet Fuel); Turbine		Jet Fuel
	20101001	Internal Combustion Engines; Electric Generation; Geysers/Geothermal; Steam Turbine		Steam
	20101302	Internal Combustion Engines; Electric Generation; Liquid Waste; Waste Oil - Turbine		Waste Oil
	20200101	Internal Combustion Engines; Industrial; Distillate Oil (Diesel); Turbine		Distillate Oil (Diesel)
	20200103	Internal Combustion Engines; Industrial; Distillate Oil (Diesel); Turbine: Cogeneration		Distillate Oil (Diesel)
	20200201	Internal Combustion Engines; Industrial; Natural Gas; Turbine		Natural Gas
	20200203	Internal Combustion Engines; Industrial; Natural Gas; Turbine: Cogeneration		Natural Gas
	20200701	Internal Combustion Engines; Industrial; Process Gas; Turbine		Process Gas
	20200705	Internal Combustion Engines; Industrial; Process Gas; Refinery Gas: Turbine		Process Gas
	20200901	Internal Combustion Engines; Industrial; Kerosene/Naphtha (Jet Fuel); Turbine		Jet Fuel
	20201011	Internal Combustion Engines; Industrial; Liquified Petroleum Gas (LPG); Turbine		Liquified Petroleum Gas (LPG)
	20201013	Internal Combustion Engines; Industrial; Liquified Petroleum Gas (LPG); Turbine: Cogeneration		Liquified Petroleum Gas (LPG)
	20201601	Internal Combustion Engines; Industrial; Methanol; Turbine		Methanol
	20201701	Internal Combustion Engines; Industrial; Gasoline; Turbine		Gasoline
	20300102	Internal Combustion Engines; Commercial/Institutional; Distillate Oil (Diesel); Turbine		Distillate Oil (Diesel)
	20300202	Internal Combustion Engines; Commercial/Institutional; Natural Gas; Turbine		Natural Gas
	20300203	Internal Combustion Engines; Commercial/Institutional; Natural Gas; Turbine: Cogeneration		Natural Gas
	20300701	Internal Combustion Engines; Commercial/Institutional; Digester Gas; Turbine		Digester Gas
	20300801	Internal Combustion Engines; Commercial/Institutional; Landfill Gas; Turbine		Landfill Gas
	20300901	Internal Combustion Engines; Commercial/Institutional; Kerosene/Naphtha (Jet Fuel); Turbine: JP-4		Jet Naphtha
Industrial Boilers				
	10200060	Ext Comb Boilers - Industrial;Not Classified ?: assumed as bituminous coal		
	10200101	External Combustion Boilers; Industrial; Anthracite Coal; Pulverized Coal		Anthracite
	10200102	External Combustion Boilers Industrial Anthracite Coal > 100 mmBtu Stoker (Old NAPAP)		
	10200104	External Combustion Boilers; Industrial; Anthracite Coal; Traveling Grate (Overfeed) Stoker		Anthracite
	10200107	External Combustion Boilers; Industrial; Anthracite Coal; Hand-fired		Anthracite
	10200117	External Combustion Boilers; Industrial; Anthracite Coal; Fluidized Bed Boiler Burning Anthracite-Culm Fuel		Anthracite Culm
	10200201	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Pulverized Coal: Wet Bottom		Bituminous Coal
	10200202	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Pulverized Coal: Dry Bottom		Bituminous Coal
	10200203	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Cyclone Furnace		Bituminous Coal
	10200204	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Spreader Stoker		Bituminous Coal
	10200205	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Overfeed Stoker		Bituminous Coal
	10200206	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Underfeed Stoker		Bituminous Coal
	10200210	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Overfeed Stoker **		Bituminous Coal
	10200212	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Pulverized Coal: Dry Bottom (Tangential)		Bituminous Coal
	10200213	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Wet Slurry		Bituminous Coal
	10200217	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Atmospheric Fluidized Bed Combustion: Bubbling Bed (Bitumi		Bituminous Coal
	10200218	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Atmospheric Fluidized Bed Combustion: Circulating Bed (Bitur		Bituminous Coal
	10200221	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Pulverized Coal: Wet Bottom (Subbituminous Coal)		Subbituminous Coal
	10200222	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Pulverized Coal: Dry Bottom (Subbituminous Coal)		Subbituminous Coal
	10200223	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Cyclone Furnace (Subbituminous Coal)		Subbituminous Coal
	10200224	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Spreader Stoker (Subbituminous Coal)		Subbituminous Coal
	10200225	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Traveling Grate (Overfeed) Stoker (Subbituminous Coal)		Subbituminous Coal
				Subbituminous Coal

Appendix B
Source Classification Codes affected by the NOx model rule

Source Type	SCC	SCC Description	source_cat	material
Industrial Boilers	10200226	External Combustion Boilers; Industrial; Bituminous/Subbituminous Coal; Pulverized Coal: Dry Bottom Tangential (Subbituminous Coal)		Lignite
	10200300	External Combustion Boilers; Industrial; Lignite; Pulverized Coal: Wet Bottom		Lignite
	10200301	External Combustion Boilers; Industrial; Lignite; Pulverized Coal: Dry Bottom, Wall Fired		Lignite
	10200302	External Combustion Boilers; Industrial; Lignite; Pulverized Coal: Dry Bottom, Tangential Fired		Lignite
	10200303	External Combustion Boilers; Industrial; Lignite; Cyclone Furnace		Lignite
	10200304	External Combustion Boilers; Industrial; Lignite; Traveling Grate (Overfeed) Stoker		Lignite
	10200306	External Combustion Boilers; Industrial; Lignite; Spreader Stoker		Residual Oil (No. 6)
	10200401	External Combustion Boilers; Industrial; Residual Oil; Grade 6 Oil		Residual Oil
	10200402	External Combustion Boilers; Industrial; Residual Oil; 10-100 Million Btu/hr **		Residual Oil
	10200403	External Combustion Boilers; Industrial; Residual Oil; < 10 Million Btu/hr **		Residual Oil (No. 5)
	10200404	External Combustion Boilers; Industrial; Residual Oil; Grade 5 Oil		
	10200406	External Combustion Boilers Industrial Residual Oil ??		Distillate Oil (No. 1 & 2)
	10200501	External Combustion Boilers; Industrial; Distillate Oil; Grades 1 and 2 Oil		Distillate Oil
	10200502	External Combustion Boilers; Industrial; Distillate Oil; 10-100 Million Btu/hr **		Distillate Oil
	10200503	External Combustion Boilers; Industrial; Distillate Oil; < 10 Million Btu/hr **		Distillate Oil (No. 4)
	10200504	External Combustion Boilers; Industrial; Distillate Oil; Grade 4 Oil		Natural Gas
	10200601	External Combustion Boilers; Industrial; Natural Gas; > 100 Million Btu/hr		Natural Gas
	10200602	External Combustion Boilers; Industrial; Natural Gas; 10-100 Million Btu/hr		Natural Gas
	10200603	External Combustion Boilers; Industrial; Natural Gas; < 10 Million Btu/hr		
	10200699	Ext Comb Boilers - Industrial;Not Classified		Process Gas
	10200701	External Combustion Boilers; Industrial; Process Gas; Petroleum Refinery Gas		
	10200702	External Combustion Boilers Industrial Process Gas ??		Process Gas
	10200704	External Combustion Boilers; Industrial; Process Gas; Blast Furnace Gas		Process Gas
	10200707	External Combustion Boilers; Industrial; Process Gas; Coke Oven Gas		Process Gas
	10200799	External Combustion Boilers; Industrial; Process Gas; Other: Specify in Comments		
	10200801	External Combustion Boilers Industrial Process Gas ??		Coke
	10200802	External Combustion Boilers; Industrial; Coke; All Boiler Sizes		Bark
	10200901	External Combustion Boilers; Industrial; Wood/Bark Waste; Bark-fired Boiler (> 50,000 Lb Steam)		Wood/Bark
	10200902	External Combustion Boilers; Industrial; Wood/Bark Waste; Wood/Bark-fired Boiler (> 50,000 Lb Steam)		Wood
	10200903	External Combustion Boilers; Industrial; Wood/Bark Waste; Wood-fired Boiler (> 50,000 Lb Steam)		Bark
	10200904	External Combustion Boilers; Industrial; Wood/Bark Waste; Bark-fired Boiler (< 50,000 Lb Steam)		Wood/Bark
	10200905	External Combustion Boilers; Industrial; Wood/Bark Waste; Wood/Bark-fired Boiler (< 50,000 Lb Steam)		Wood
	10200906	External Combustion Boilers; Industrial; Wood/Bark Waste; Wood-fired Boiler (< 50,000 Lb Steam)		Wood/Bark
	10200910	External Combustion Boilers; Industrial; Wood/Bark Waste; Fuel cell/Dutch oven boilers		Wood/Bark
	10200911	External Combustion Boilers; Industrial; Wood/Bark Waste; Stoker boilers		Wood/Bark
	10200912	External Combustion Boilers; Industrial; Wood/Bark Waste; Fluidized bed combustion boiler		Butane
	10201001	External Combustion Boilers; Industrial; Liquified Petroleum Gas (LPG); Butane		Propane
	10201002	External Combustion Boilers; Industrial; Liquified Petroleum Gas (LPG); Propane		Propane/Butane
	10201003	External Combustion Boilers; Industrial; Liquified Petroleum Gas (LPG); Butane/Propane Mixture: Specify Percent Butane in Comments		Bagasse
	10201101	External Combustion Boilers; Industrial; Bagasse; All Boiler Sizes		Solid Waste
	10201201	External Combustion Boilers; Industrial; Solid Waste; Specify Waste Material in Comments		Refuse Derived Fuel
	10201202	External Combustion Boilers; Industrial; Solid Waste; Refuse Derived Fuel		Liquid Waste
	10201301	External Combustion Boilers; Industrial; Liquid Waste; Specify Waste Material in Comments		Waste Oil
	10201302	External Combustion Boilers; Industrial; Liquid Waste; Waste Oil		Natural Gas
	10201401	External Combustion Boilers; Industrial; CO Boiler; Natural Gas		Process Gas
	10201402	External Combustion Boilers; Industrial; CO Boiler; Process Gas		Distillate Oil
	10201403	External Combustion Boilers; Industrial; CO Boiler; Distillate Oil		Residual Oil
	10201404	External Combustion Boilers; Industrial; CO Boiler; Residual Oil		Methanol
	10201601	External Combustion Boilers; Industrial; Methanol; Industrial Boiler		Gasoline
	10201701	External Combustion Boilers; Industrial; Gasoline; Industrial Boiler		
	10299997	Ext Comb Boilers - Industrial;Not Classified		

Appendix B
Source Classification Codes affected by the NOx model rule

Source Type	SCC	SCC Description	source_cat	material
Commercial/Institutional Boiler				Anthracite
	10300101	External Combustion Boilers; Commercial/Institutional; Anthracite Coal; Pulverized Coal		Anthracite
	10300102	External Combustion Boilers; Commercial/Institutional; Anthracite Coal; Traveling Grate (Overfeed) Stoker		Anthracite
	10300103	External Combustion Boilers; Commercial/Institutional; Anthracite Coal; Hand-fired		Bituminous Coal
	10300203	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Cyclone Furnace (Bituminous Coal)		Bituminous Coal
	10300205	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Pulverized Coal: Wet Bottom (Bituminous Coal)		Bituminous Coal
	10300206	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Pulverized Coal: Dry Bottom (Bituminous Coal)		Bituminous Coal
	10300207	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Overfeed Stoker (Bituminous Coal)		Bituminous Coal
	10300208	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Underfeed Stoker (Bituminous Coal)		Bituminous Coal
	10300209	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Spreader Stoker (Bituminous Coal)		Bituminous Coal
	10300211	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Overfeed Stoker **		Bituminous Coal
	10300214	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Hand-fired (Bituminous Coal)		Bituminous Coal
	10300216	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Pulverized Coal: Dry Bottom (Tangential) (Bitun		Bituminous Coal
	10300217	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Atmospheric Fluidized Bed Combustion: Bubbli		Bituminous Coal
	10300218	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Atmospheric Fluidized Bed Combustion: Circula		Subbituminous Coal
	10300221	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Pulverized Coal: Wet Bottom (Subbituminous C		Subbituminous Coal
	10300222	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Pulverized Coal: Dry Bottom (Subbituminous C		Subbituminous Coal
	10300223	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Cyclone Furnace (Subbituminous Coal)		Subbituminous Coal
	10300224	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Spreader Stoker (Subbituminous Coal)		Subbituminous Coal
	10300225	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Traveling Grate (Overfeed) Stoker (Subbitumin		Subbituminous Coal
	10300226	External Combustion Boilers; Commercial/Institutional; Bituminous/Subbituminous Coal; Pulverized Coal: Dry Bottom Tangential (Subbit		Lignite
	10300300	External Combustion Boilers; Commercial/Institutional; Lignite; Pulverized Coal: Wet Bottom		Lignite
	10300305	External Combustion Boilers; Commercial/Institutional; Lignite; Pulverized Coal: Dry Bottom, Wall Fired		Lignite
	10300306	External Combustion Boilers; Commercial/Institutional; Lignite; Pulverized Coal: Dry Bottom, Tangential Fired		Lignite
	10300307	External Combustion Boilers; Commercial/Institutional; Lignite; Traveling Grate (Overfeed) Stoker		Lignite
	10300309	External Combustion Boilers; Commercial/Institutional; Lignite; Spreader Stoker		Residual Oil (No. 6)
	10300401	External Combustion Boilers; Commercial/Institutional; Residual Oil; Grade 6 Oil		Residual Oil
	10300402	External Combustion Boilers; Commercial/Institutional; Residual Oil; 10-100 Million Btu/hr **		Residual Oil
	10300403	External Combustion Boilers; Commercial/Institutional; Residual Oil; < 10 Million Btu/hr **		Residual Oil (No. 5)
	10300404	External Combustion Boilers; Commercial/Institutional; Residual Oil; Grade 5 Oil		Distillate Oil (No. 1 & 2)
	10300501	External Combustion Boilers; Commercial/Institutional; Distillate Oil; Grades 1 and 2 Oil		Distillate Oil
	10300502	External Combustion Boilers; Commercial/Institutional; Distillate Oil; 10-100 Million Btu/hr **		Distillate Oil
	10300503	External Combustion Boilers; Commercial/Institutional; Distillate Oil; < 10 Million Btu/hr **		Distillate Oil (No. 4)
	10300504	External Combustion Boilers; Commercial/Institutional; Distillate Oil; Grade 4 Oil		Natural Gas
	10300601	External Combustion Boilers; Commercial/Institutional; Natural Gas; > 100 Million Btu/hr		Natural Gas
	10300602	External Combustion Boilers; Commercial/Institutional; Natural Gas; 10-100 Million Btu/hr		Natural Gas
	10300603	External Combustion Boilers; Commercial/Institutional; Natural Gas; < 10 Million Btu/hr		Process Gas
	10300701	External Combustion Boilers; Commercial/Institutional; Process Gas; POTW Digester Gas-fired Boiler		Process Gas
	10300799	External Combustion Boilers; Commercial/Institutional; Process Gas; Other Not Classified		Landfill Gas
	10300811	External Combustion Boilers; Commercial/Institutional; Landfill Gas; Landfill Gas		Bark
	10300901	External Combustion Boilers; Commercial/Institutional; Wood/Bark Waste; Bark-fired Boiler		Wood/Bark
	10300902	External Combustion Boilers; Commercial/Institutional; Wood/Bark Waste; Wood/Bark-fired Boiler		Wood
	10300903	External Combustion Boilers; Commercial/Institutional; Wood/Bark Waste; Wood-fired Boiler		Wood/Bark
	10300910	External Combustion Boilers; Commercial/Institutional; Wood/Bark Waste; Fuel cell/Dutch oven boilers		Wood/Bark
	10300911	External Combustion Boilers; Commercial/Institutional; Wood/Bark Waste; Stoker boilers		Wood/Bark
	10300912	External Combustion Boilers; Commercial/Institutional; Wood/Bark Waste; Fluidized bed combustion boilers		Butane
	10301001	External Combustion Boilers; Commercial/Institutional; Liquified Petroleum Gas (LPG); Butane		Propane
	10301002	External Combustion Boilers; Commercial/Institutional; Liquified Petroleum Gas (LPG); Propane		Propane/Butane
	10301003	External Combustion Boilers; Commercial/Institutional; Liquified Petroleum Gas (LPG); Butane/Propane Mixture: Specify Percent Butane		Solid Waste
	10301201	External Combustion Boilers; Commercial/Institutional; Solid Waste; Specify Waste Material in Comments		Refuse Derived Fuel
	10301202	External Combustion Boilers; Commercial/Institutional; Solid Waste; Refuse Derived Fuel		Liquid Waste
	10301301	External Combustion Boilers; Commercial/Institutional; Liquid Waste; Specify Waste Material in Comments		Waste Oil
	10301302	External Combustion Boilers; Commercial/Institutional; Liquid Waste; Waste Oil		Sewage Grease Skimmings

Appendix B
Source Classification Codes affected by the NOx model rule

Source Type	SCC	SCC Description	source_cat	material
Stationary Internal Combustion Engines				
	10301303	External Combustion Boilers; Commercial/Institutional; Liquid Waste; Sewage Grease Skimmings		Distillate Oil (Diesel)
	20100102	Internal Combustion Engines; Electric Generation; Distillate Oil (Diesel); Reciprocating		Natural Gas
	20100202	Internal Combustion Engines; Electric Generation; Natural Gas; Reciprocating		Process Gas
	20100702	Internal Combustion Engines; Electric Generation; Process Gas; Reciprocating		Landfill Gas
	20100802	Internal Combustion Engines; Electric Generation; Landfill Gas; Reciprocating		Jet Fuel
	20100902	Internal Combustion Engines; Electric Generation; Kerosene/Naphtha (Jet Fuel); Reciprocating		Distillate Oil (Diesel)
	20200102	Internal Combustion Engines; Industrial; Distillate Oil (Diesel); Reciprocating		Distillate Oil (Diesel)
	20200104	Internal Combustion Engines; Industrial; Distillate Oil (Diesel); Reciprocating: Cogeneration		Natural Gas
	20200202	Internal Combustion Engines; Industrial; Natural Gas; Reciprocating		Natural Gas
	20200204	Internal Combustion Engines; Industrial; Natural Gas; Reciprocating: Cogeneration		Natural Gas
	20200252	Internal Combustion Engines; Industrial; Natural Gas; 2-cycle Lean Burn		Natural Gas
	20200253	Internal Combustion Engines; Industrial; Natural Gas; 4-cycle Rich Burn		Natural Gas
	20200254	Internal Combustion Engines; Industrial; Natural Gas; 4-cycle Lean Burn		Natural Gas
	20200255	Internal Combustion Engines; Industrial; Natural Gas; 2-cycle Clean Burn		Natural Gas
	20200256	Internal Combustion Engines; Industrial; Natural Gas; 4-cycle Clean Burn		Gasoline
	20200301	Internal Combustion Engines; Industrial; Gasoline; Reciprocating		Diesel
	20200401	Internal Combustion Engines; Industrial; Large Bore Engine; Diesel		Work
	20200402	Internal Combustion Engines; Industrial; Large Bore Engine; Dual Fuel (Oil/Gas)		Work
	20200403	Internal Combustion Engines; Industrial; Large Bore Engine; Cogeneration: Dual Fuel		Residual/Crude Oil
	20200501	Internal Combustion Engines; Industrial; Residual/Crude Oil; Reciprocating		Process Gas
	20200702	Internal Combustion Engines; Industrial; Process Gas; Reciprocating Engine		Process Gas
	20200706	Internal Combustion Engines; Industrial; Process Gas; Refinery Gas: Reciprocating Engine		Jet Fuel
	20200902	Internal Combustion Engines; Industrial; Kerosene/Naphtha (Jet Fuel); Reciprocating		Liquified Petroleum Gas (LPG)
	20201001	Internal Combustion Engines; Industrial; Liquified Petroleum Gas (LPG); Propane: Reciprocating		Liquified Petroleum Gas (LPG)
	20201002	Internal Combustion Engines; Industrial; Liquified Petroleum Gas (LPG); Butane: Reciprocating		Liquified Petroleum Gas (LPG)
	20201012	Internal Combustion Engines; Industrial; Liquified Petroleum Gas (LPG); Reciprocating Engine		Liquified Petroleum Gas (LPG)
	20201014	Internal Combustion Engines; Industrial; Liquified Petroleum Gas (LPG); Reciprocating Engine: Cogeneration		Methanol
	20201602	Internal Combustion Engines; Industrial; Methanol; Reciprocating Engine		Gasoline
	20201702	Internal Combustion Engines; Industrial; Gasoline; Reciprocating Engine		Distillate Oil (Diesel)
	20300101	Internal Combustion Engines; Commercial/Institutional; Distillate Oil (Diesel); Reciprocating		Natural Gas
	20300201	Internal Combustion Engines; Commercial/Institutional; Natural Gas; Reciprocating		Natural Gas
	20300204	Internal Combustion Engines; Commercial/Institutional; Natural Gas; Cogeneration		Gasoline
	20300301	Internal Combustion Engines; Commercial/Institutional; Gasoline; Reciprocating		Digester Gas
	20300702	Internal Combustion Engines; Commercial/Institutional; Digester Gas; Reciprocating: POTW Digester Gas		Landfill Gas
	20300802	Internal Combustion Engines; Commercial/Institutional; Landfill Gas; Reciprocating		Liquified Petroleum Gas (LPG)
	20301001	Internal Combustion Engines; Commercial/Institutional; Liquified Petroleum Gas (LPG); Propane: Reciprocating		Liquified Petroleum Gas (LPG)
	20301002	Internal Combustion Engines; Commercial/Institutional; Liquified Petroleum Gas (LPG); Butane: Reciprocating		

Table C-1
NOx Control Methods for Industrial Boilers

NOx Control Method	Boiler Size (MMBtu/hr)	Fuel Type	Baseline NOx (lb/MMBtu)	Base NOx (t/day)	Controlled NOx (lb/MMBtu)	Control NOx (t/day)	% NOx Reduction	Cost Effectiveness $/ton NOx Removed	
								Ozone Season	Annual
Low NOx Burners									
	10	*gas*					*50%*	*$9,030-$11,300*	
	50	*gas*					*50%*	*$2,560-$3,200*	
	150	*gas*					*45-50%*	*$800-$3,500*	
	350	gas	0.20	0.84	0.15	0.63	25%	$454-$857	$189-$357
	350	gas	0.20	0.84	0.10	0.42	50%	$3,783-$7,145	$1,576-$2,977
	10	*distillate oil*					*45%*	*$5,310-$6,640*	
	50	*distillate oil*					*45%*	*$2,750-$3,440*	
	150	*distillate oil*					*45%*	*$600-$750*	
	10	*residual oil*					*45%*	*$2,910-$3,640*	
	50	*residual oil*					*45%*	*$990-$1,240*	
	150	*residual oil*					*45%*	*$490-$610*	
	680	residual oil	0.43	3.51	0.39	3.18	10%	$38-$72	$16-$30
	350	coal	0.60	2.52	0.45	1.89	25%	$2,522-$4,763	$1,051-$1,985
	350	coal	0.60	2.52	0.38	1.6	36.6%	$1,751-$3,308	$730-$1,378
	500	*coal-pul.*					*50%*	*$760-$2,900*	
SNCR									
	50	*gas*					*30-60%*	*$4,720-$5,910*	
	150	*gas*					*30-60%*	*$3,100-$6,800*	
	50	*distillate oil*					*30-70%*	*$5,040-$6,310*	
	150	*distillate oil*					*30-70%*	*$2,450-$3,060*	
	50	*residual oil*					*30-70%*	*$2,190-$2,740*	
	150	*residual oil*					*30-70%*	*$2,100-$2,630*	
	350	wood	0.45	1.89	0.29	1.22	35%	$2,101-$3,303	$1,300-$1,814
	500	*coal-pul.*					*30-70%*	*$870-$1,450*	
	500	*coal-stok.*					*30-70%*	*$940-$1,170*	

Data taken from "Status Report on NOx Controls for Gas Turbines, Cement Kilns, Industrial Boilers, and I.C. Engines - Technologies & Cost Effectiveness", NESCAUM, December 2000.

Data in italics taken from draft "Assessment of Control Technologies for Reducing Nitrogen Oxides from Non-Utility Point Sources and Major Area Sources", OTAG (2/27/96).

Table C-1 (continued)
NOx Control Methods for Industrial Boilers

NOx Control Method	Boiler Size (MMBtu/hr)	Fuel Type	Baseline NOx (lb/MMBtu)	Base NOx (t/day)	Controlled NOx (lb/MMBtu)	Control NOx (t/day)	% NOx Reduction	Cost Effectiveness $/ton NOx Removed: Ozone Season	Cost Effectiveness $/ton NOx Removed: Annual
SCR									
	50	*gas*					*80-90%*	*$4,830-$5,480*	
	150	*gas*					*80-90%*	*$2,060-$5,600*	
	50	*distillate oil*					*80-90%*	*$5,200-$5,890*	
	150	*distillate oil*					*80-90%*	*$1,560-$1,780*	
	50	*residual oil*					*80-90%*	*$2,070-$2,360*	
	150	*residual oil*					*80-90%*	*$1,290-$1,480*	
	100	gas	0.15	0.18	0.03	0.04	80%	$7,919-$14,479	$3,376-$6,110
	350	gas	0.15	0.63	0.03	0.13	80%	$4,764-$8,519	$2,062-$3,626
	350	coal	0.45	1.89	0.09	0.38	80%	$2,953-$5,046	$1,307-$2,179
	350	coal	0.45	1.89	0.09	0.38	80%	$4,004-$7,030	$1,745-$3,006
	500	*coal-pul.*					*80-90%*	*$1,790-$6,800*	
	500	*coal-stok.*					*80-90%*	*$1,980-$2,230*	
Conventional Gas Reburn									
	500	coal	1.20	7.20	0.60	3.60	50%		$1,215
	500	coal	1.20	7.20	0.60	3.60	50%		$1,482
	640	coal	1.36	8.16	0.685	4.11	50%		$1,246
Fuel Lean Gas Reburn (FLGR)									
	350	coal	0.45	1.89	0.293	1.23	35%	$1,330-$2,000	$890-$1,170
	350	coal	0.45	1.89	0.293	1.23	35%	$1,523-$2,220	$1,083-$1,362
Amine Enhanced FLGR									
	350	coal	0.45	1.89	0.18	0.76	60%	$1,700-$2,455	$1,210-$1,520
	350	coal	0.45	1.89	0.18	0.76	60%	$1,812-$2,604	$1,316-$1,631

Data taken from "Status Report on NOx Controls for Gas Turbines, Cement Kilns, Industrial Boilers, and I.C. Engines - Technologies & Cost Effectiveness", NESCAUM, December, 2000.

Data in italics taken from draft "Assessment of Control Technologies for Reducing Nitrogen Oxides from Non-Utility Point Sources and Major Area Sources", OTAG (2/27/96).

Table C-2
NOx Control Methods for Turbines

NOx Control Method	Turbine Size	Fuel Type	Baseline NOx (ppm)	Controlled NOx (ppm)	% NOx Reduction	Cost Effectiveness $/ton NOx Removed	
						Ozone Season	Annual
In-Combustor Methods							
Dry Low NOx							
	7000 HP	gas	135	50	63%	$4,492-$9,483	$1,872-$3,951
	13,000 HP	gas	167	50	70%	$3,145-$6,640	$1,311-$2,767
	75 MW	gas	154	15	90%	$533-$1,126	$222-$469
	5 MW (Cont.)	*gas*			*60-90%*	*$530-$800*	
	25 MW (Cont.)	*gas*			*60-90%*	*$240-$370*	
	100 MW (Cont.)	*gas*			*60-90%*	*$130-$200*	
	25 MW (2000 P)	*gas*			*60-90%*	*$960-$1,470*	
	100 MW (2000 P)	*gas*			*60-90%*	*$530-$800*	
Diluent Injection							
	21 MW	gas	125	50	60%	$867-$1,217	$638-$784
	21 MW	distillate oil	180	50	72%	$829-$1,031	$697-$781
Water Injection							
	5 MW (Cont.)	*gas*			*70-90%*	*$1,390-$1,780*	
	25 MW (Cont.)	*gas*			*70-90%*	*$690-$880*	
	100 MW (Cont.)	*gas*			*70-90%*	*$500-$640*	
	25 MW (2000 P)	*gas*			*70-90%*	*$1,670-$2,150*	
	100 MW (2000 P)	*gas*			*70-90%*	*$1,050-$2,150*	
	5 MW (Cont.)	*oil*			*70-90%*	*$1,000-$1,300*	
	25 MW (Cont.)	*oil*			*70-90%*	*$560-$710*	
	100 MW (Cont.)	*oil*			*70-90%*	*$440-$560*	
	25 MW (2000 P)	*oil*			*70-90%*	*$1,190-$1,520*	
	100 MW (2000 P)	*oil*			*70-90%*	*$800-$1,020*	

Data taken from "Status Report on NOx Controls for Gas Turbines, Cement Kilns, Industrial Boilers, and I.C. Engines - Technologies & Cost Effectiveness", NESCAUM, December, 2000.

Data in italics taken from draft "Assessment of Control Technologies for Reducing Nitrogen Oxides from Non-Utility Point Sources and Major Area Sources", OTAG (2/27/96).

Table C-2 (continued)
NOx Control Methods for Turbines

NOx Control Method	Turbine Size	Fuel Type	Baseline NOx (ppm)	Controlled NOx (ppm)	% NOx Reduction	Cost Effectiveness $/ton NOx Removed Ozone Season	Cost Effectiveness $/ton NOx Removed Annual
In-Combustor Methods							
Diluent Injection (Continued)							
Steam Injection							
	5 MW (Cont.)	*gas*			*70-90%*	*$1,560-$2,000*	
	25 MW (Cont.)	*gas*			*70-90%*	*$760-$970*	
	100 MW (Cont.)	*gas*			*70-90%*	*$520-$670*	
	25 MW (2000 P)	*gas*			*70-90%*	*$2,150-$2,760*	
	100 MW (2000 P)	*gas*			*70-90%*	*$1,370-$1,760*	
	5 MW (Cont.)	*oil*			*70-90%*	*$1,010-$1,300*	
	25 MW (Cont.)	*oil*			*70-90%*	*$520-$670*	
	100 MW (Cont.)	*oil*			*70-90%*	*$380-$480*	
	25 MW (2000 P)	*oil*			*70-90%*	*$1,520-$1,820*	
	100 MW (2000 P)	*oil*			*70-90%*	*$930-$1,190*	
Exhaust Treatment							
SCR							
Simple Cycle Turbines	75 MW	gas	15	3	80%	$12,227-$20,075	$5,171-$8,441
	75 MW	gas	42	7	83%	$4,278-$6,969	$1,859-$2,980
	75 MW	gas	154	15	90%	$1,176-$1,853	$566-$849
	7000 HP	gas	42	5	88%	$16,031-$27,020	$6,756-$11,335
	7000 HP	gas	142	15	89%	$4,763-$7,965	$2,061-$3,395
Combined Cycle Turbines	75 MW	gas	15	3	80%	$8,680-$13,376	$3,693-$5,650
	75 MW	gas	42	7	83%	$3,062-$4,673	$1,353-$2,024
	75 MW	gas	154	15	90%	$869-$1,275	$439-$608
	7000 HP	gas	42	5	88%	$10,023-$15,672	$4,253-$6,607
	7000HP	gas	142	15	89%	$3,013-$4,659	$1,332-$2,018

Data taken from "Status Report on NOx Controls for Gas Turbines, Cement Kilns, Industrial Boilers, and I.C. Engines - Technologies & Cost Effectiveness", NESCAUM, December, 2000.

Data in italics taken from draft "Assessment of Control Technologies for Reducing Nitrogen Oxides from Non-Utility Point Sources and Major Area Sources", OTAG (2/27/96).

Table C-2 (continued)
NOx Control Methods for Turbines

NOx Control Method	Turbine Size	Fuel Type	Baseline NOx (ppm)	Controlled NOx (ppm)	% NOx Reduction	Cost Effectiveness $/ton NOx Removed	
						Ozone Season	Annual
Exhaust Treatment							
SCR (Continued)							
	5 MW (Cont.)	*gas*			*90%*	*$2,180-$2,450*	
	25 MW (Cont.)	*gas*			*90%*	*$1,230-$1,390*	
	100 MW (Cont.)	*gas*			*90%*	*$920-$1,030*	
	25 MW (2000 P)	*gas*			*90%*	*$3,480-$3,920*	
	100 MW (2000 P)	*gas*			*90%*	*$2,400-$2,700*	
	5 MW (Cont.)	*oil*			*90%*	*$1,390-$1,560*	
	25 MW (Cont.)	*oil*			*90%*	*$820-$920*	
	100 MW (Cont.)	*oil*			*90%*	*$630-$710*	
	25 MW (2000 P)	*oil*			*90%*	*$2,170-$2,440*	
	100 MW (2000 P)	*oil*			*90%*	*$1,530-$1,720*	

Data taken from "Status Report on NOx Controls for Gas Turbines, Cement Kilns, Industrial Boilers, and I.C. Engines - Technologies & Cost Effectiveness", NESCAUM, December, 2000.

Data in italics taken from draft "Assessment of Control Technologies for Reducing Nitrogen Oxides from Non-Utility Point Sources and Major Area Sources", OTAG (2/27/96).

Table C-3
NOx Control Methods for IC Engines

NOx Control Method	Engine Type	Engine Size	Fuel Type	Baseline NOx (gm/hp-hr)	Controlled NOx (gm/hp-hr)	% NOx Reduction	Cost Effectiveness $/ton NOx Removed	
							Ozone Season	Annual
In-Cylinder Methods								
Ignition Timing Retard								
	SI Rich Burn	*250 HP*	*gas*			*0-40%*	*$680-$1,130*	
	SI Rich Burn	*1000 HP*	*gas*			*0-40%*	*$370-$610*	
		1100 HP	gas	10	9	10%	$1,476-$1,640	$615-$685
		1100 HP	gas	10	7.5	25%	$589-$657	$274-$245
	SI Rich Burn	*4000HP*	*gas*			*0-40%*	*$270-$450*	
	SI Lean Burn	*250 HP*	*gas*			*0-20%*	*$980-$4,930*	
	SI LeanBurn	*1000 HP*	*gas*			*0-20%*	*$490-$1,470*	
	SI LeanBurn	*4000HP*	*gas*			*0-20%*	*$340-$1,020*	
	CI Diesel (Cont.)	*250 HP*	*diesel*			*20-30%*	*$760-$1,140*	
	CI Diesel (Cont.)	*1000 HP*	*diesel*			*20-30%*	*$420-$630*	
	CI Diesel (Cont.)	*4000 HP*	*diesel*			*20-30%*	*$310-$470*	
	CI Diesel (2000 P)	*250 HP*	*diesel*			*20-30%*	*$1,900*	
	CI Diesel (2000 P)	*1000 HP*	*diesel*			*20-30%*	*$830*	
	CI Diesel (2000 P)	*4000 HP*	*diesel*			*20-30%*	*$515*	
	CI Diesel (200 P)	*250 HP*	*diesel*			*20-30%*	*$13,400*	
	CI Diesel (200 P)	*1000 HP*	*diesel*			*20-30%*	*$4,600*	
	CI Diesel (200 P)	*4000 HP*	*diesel*			*20-30%*	*$2,010*	
	CI Dual Fuel	*250 HP*	*dual fuel*			*20-30%*	*$950-$1,420*	
	CI Dual Fuel	*1000 HP*	*dual fuel*			*20-30%*	*$470-$700*	
	CI Dual Fuel	*4000 HP*	*dual fuel*			*20-30%*	*$320-$480*	

Data taken from "Status Report on NOx Controls for Gas Turbines, Cement Kilns, Industrial Boilers, and I.C. Engines - Technologies & Cost Effectiveness", NESCAUM, December, 2000.

Data in italics taken from draft "Assessment of Control Technologies for Reducing Nitrogen Oxides from Non-Utility Point Sources and Major Area Sources", OTAG (2/27/96).

Table C-3 (continued)
NOx Control Methods for IC Engines

NOx Control Method	Engine Type	Engine Size	Fuel Type	Baseline NOx (gm/hp-hr)	Controlled NOx (gm/hp-hr)	% NOx Reduction	Cost Effectiveness $/ton NOx Removed	
							Ozone Season	Annual
In-Cylinder Methods (Continued)								
High Energy Ignition/ A-F Ratio		2500 HP	gas	15	7	53%	$280-$385	$115-$160
	SI Rich Burn	*250 HP*	*gas*			*10-40%*	*$580-$870*	
	SI Rich Burn	*1000 HP*	*gas*			*10-40%*	*$350-$520*	
	SI Rich Burn	*4000HP*	*gas*			*10-40%*	*$270-$400*	
	SI Lean Burn	*250 HP*	*gas*			*5-30%*	*$980-$4,930*	
	SI LeanBurn	*1000 HP*	*gas*			*5-30%*	*$490-$1,470*	
	SI LeanBurn	*4000HP*	*gas*			*5-30%*	*$340-$1,020*	
Low Emission Combustion Retrofit								
Low Speed Engine		3400 HP	gas	13	3	77%	$1,222-$2,296	$509-$957
Medium Speed Engine		2500 HP	gas	15	3	80%	$585-$1,100	$245-$460
Dual-Fuel Engine		2500 HP	gas/oil	15	3	80%	$1,794-$3,388	$747-$1,412
	SI Rich Burn	*250 HP*	*gas*			*70-90%*	*$4,500-$5,010*	
	SI Rich Burn	*1000 HP*	*gas*			*70-90%*	*$1,850-$2,090*	
	SI Rich Burn	*4000HP*	*gas*			*70-90%*	*$1,190-$1,340*	
	SI Lean Burn	*250 HP*	*gas*			*80-93%*	*$3,970-$4,460*	
	SI LeanBurn	*1000 HP*	*gas*			*80-93%*	*$1,610-$1,820*	
	SI LeanBurn	*4000HP*	*gas*			*80-93%*	*$1,030-$1,150*	

Data taken from "Status Report on NOx Controls for Gas Turbines, Cement Kilns, Industrial Boilers, and I.C. Engines - Technologies & Cost Effectiveness", NESCAUM, December, 2000.

Data in italics taken from draft "Assessment of Control Technologies for Reducing Nitrogen Oxides from Non-Utility Point Sources and Major Area Sources", OTAG (2/27/96).

Table C-3 (continued)
NOx Control Methods for IC Engines

NOx Control Method	Engine Type	Engine Size	Fuel Type	Baseline NOx (gm/hp-hr)	Controlled NOx (gm/hp-hr)	% NOx Reduction	Cost Effectiveness $/ton NOx Removed	
							Ozone Season	Annual
Exhaust Treatment								
SCR								
Gas Engine		1800 HP	gas	10	1	90%	$1,104-$8,245	$533-$3,508
Gas Engine		3130 HP	gas	10	1	90%	$591-$3,884	$319-$1,691
	SI Lean Burn	*250 HP*	*gas*			*90%*	*$4,280-$4,810*	
	SI LeanBurn	*1000 HP*	*gas*			*90%*	*$1,320-$1,490*	
	SI LeanBurn	*4000HP*	*gas*			*90%*	*$580-$660*	
Diesel Engine		1800 HP	diesel oil	10	1	90%	$922-$6,866	$453-$2,929
Diesel Engine		3130 HP	diesel oil	10	1	90%	$614-$4,246	$324-$1,838
	CI Diesel (Cont.)	*250 HP*	*diesel*			*80-90%*	*$4,170-$4,690*	
	CI Diesel (Cont.)	*1000 HP*	*diesel*			*80-90%*	*$1,460-$1,640*	
	CI Diesel (Cont.)	*4000 HP*	*diesel*			*80-90%*	*$780-$880*	
	CI Diesel (2000 P)	*250 HP*	*diesel*			*80-90%*	*$8,750*	
	CI Diesel (2000 P)	*1000 HP*	*diesel*			*80-90%*	*$3,000*	
	CI Diesel (2000 P)	*4000 HP*	*diesel*			*80-90%*	*$1,560*	
	CI Diesel (200 P)	*250 HP*	*diesel*			*80-90%*	*$61`,000*	
	CI Diesel (200 P)	*1000 HP*	*diesel*			*80-90%*	*$20,000*	
	CI Diesel (200 P)	*4000 HP*	*diesel*			*80-90%*	*$10,000*	
	CI Dual Fuel	*250 HP*	*dual fuel*			*80-90%*	*$5,800-$6,530*	
	CI Dual Fuel	*1000 HP*	*dual fuel*			*80-90%*	*$1,970-$2,210*	
	CI Dual Fuel	*4000 HP*	*dual fuel*			*80-90%*	*$1,010-$1,140*	

Data taken from "Status Report on NOx Controls for Gas Turbines, Cement Kilns, Industrial Boilers, and I.C. Engines - Technologies & Cost Effectiveness", NESCAUM, December, 2000.

Data in italics taken from draft "Assessment of Control Technologies for Reducing Nitrogen Oxides from Non-Utility Point Sources and Major Area Sources", OTAG (2/27/96).

Table C-3 (continued)
NOx Control Methods for IC Engines

NOx Control Method	Engine Type	Engine Size	Fuel Type	Baseline NOx (gm/hp-hr)	Controlled NOx (gm/hp-hr)	% NOx Reduction	Cost Effectiveness $/ton NOx Removed: Ozone Season	Cost Effectiveness $/ton NOx Removed: Annual
Exhaust Treatment (Continued)								
Mobile-Source Derivative SCR								
Diesel Engine		1971 HP	diesel oil	7.62	1.91	75%	$769-$3,080	$528-$1,491
Diesel Engine		1971 HP	diesel oil	15	3.75	75%	$577-$1,751	$455-$944
NSCR								
	SI Rich Burn	*250 HP*	*gas*			*90-98%*	*$290-$310*	
	SI Rich Burn	*1000 HP*	*gas*			*90-98%*	*$200-$220*	
	SI Rich Burn	*4000HP*	*gas*			*90-98%*	*$180-$190*	

Data taken from "Status Report on NOx Controls for Gas Turbines, Cement Kilns, Industrial Boilers, and I.C. Engines - Technologies & Cost Effectiveness", NESCAUM, December, 2000.

Data in italics taken from draft "Assessment of Control Technologies for Reducing Nitrogen Oxides from Non-Utility Point Sources and Major Area Sources", OTAG (2/27/96).

Table C-4
NOx Control Methods for Cement Kilns

NOx Control Method	Kiln Type	Kiln Size (tons/hour)	Baseline NOx (lb/ton clinker)	Controlled NOx (lb/ton clinker)	% NOx Reduction	Cost Effectiveness $/ton NOx Removed	
						Ozone Season	Annual
Low NOx Burners							
	Long Wet	*30*			*20-30%*	*$1,130*	
	Long Wet	*50*			*20-30%*	*$880*	
	Long Dry	*25*			*20-30%*	*$1,270*	
	Long Dry	*40*			*20-30%*	*$970*	
	Preheater	*40*			*20-30%*	*$1,330*	
	Preheater	*70*			*20-30%*	*$970*	
	Precalciner	*100*			*20-30%*	*$1,010*	
	Precalciner	*150*			*20-30%*	*$830*	
Mid-Kiln Tire Firing with LNB							
	Long Wet	*30*			*20-40%*	*$550*	
	Long Wet	*50*			*20-40%*	*$450*	
	Long Dry	*25*			*20-40%*	*$610*	
	Long Dry	*40*			*20-40%*	*$470*	
Indirect Firing & Mid-Kiln Tire Firing							
No tipping fee		96	5.0	2.55	49%	$1,766-$4,385	$736-$1,827
With $20 tipping fee		96	5.0	2.55	49%	$1,231-$3,850	$513-$1,604
With $75 tipping fee		96	5.0	2.55	49%	($242)-$2,377	($101)-$991
Mid-Kiln Tire Firing Only							
No tipping fee		40	5.0	4.0	20%	($2,326)-($4,035)	($969)-($1,681)
With $20 tipping fee		40	5.0	4.0	20%	($5,164)-($6,873)	($2,151)-($2,864)
With $75 tipping fee		40	5.0	4.0	20%	($12,966)-($14,675)	($5,403)-($6,115)

Numbers in ( ) mean company is realizing a savings instead of a cost by using control method.
Data taken from draft "Status Report on NOx Controls for Gas Turbines, Cement Kilns, Industrial Boilers, and I.C. Engines - Technologies & Cost Effectriveness", NESCAUM, December, 2000.
Data in italics taken from draft "Assessment of Control Technologies for Reducing Nitrogen Oxides from Non-Utility Point Sources and Major Area Sources", OTAG (2/27/96).

Table C-4 (continued)
NOx Control Methods for Cement Kilns

NOx Control Method	Kiln Type	Kiln Size (tons/hour)	Baseline NOx (lb/ton clinker)	Controlled NOx (lb/ton clinker)	% NOx Reduction	Cost Effectiveness $/ton NOx Removed: Ozone Season	Cost Effectiveness $/ton NOx Removed: Annual
CemStar Process							
net clinker value = $15/ton		40	*200 lb NOx/hr*	*160 lb NOx/hr*	20%	$664-$1,120	$365-$555
net clinker value = $30/ton		40	*200 lb NOx/hr*	*160 lb NOx/hr*	20%	($1,156)-($1,611)	($1,721)-($1,910)
net clinker value = $50/ton		40	*200 lb NOx/hr*	*160 lb NOx/hr*	20%	($4,190)-($4,646)	($4,755)-($4,945)
SNCR							
pre-calciner kiln		<150	*700 lb NOx/hr*	*385 lb NOx/hr*	45%	$890-$1,215	$675-$810
SNCR (Urea)							
	Preheater	*40*			*30-70%*	*$930*	
	Preheater	*70*			*30-70%*	*$790*	
	Precalciner	*100*			*30-70%*	*$880*	
	Precalciner	*150*			*30-70%*	*$800*	
SNCR (Ammonia)							
	Preheater	*40*			*30-70%*	*$1,100*	
	Preheater	*70*			*30-70%*	*$910*	
	Precalciner	*100*			*30-70%*	*$980*	
	Precalciner	*150*			*30-70%*	*$880*	
SCR							
	Long Wet	*30*			*80-90%*	*$3,600*	
	Long Wet	*50*			*80-90%*	*$3,140*	
	Long Dry	*25*			*80-90%*	*$3,630*	
	Long Dry	*40*			*80-90%*	*$3,170*	
	Preheater	*40*			*80-90%*	*$4,120*	
	Preheater	*70*			*80-90%*	*$3,490*	
	Precalciner	*100*			*80-90%*	*$4,870*	
	Precalciner	*150*			*80-90%*	*$4,400*	

Numbers in ( ) mean company is realizing a savings instead of a cost by using control method.
Data taken from draft "Status Report on NOx Controls for Gas Turbines, Cement Kilns, Industrial Boilers, and I.C. Engines - Technologies & Cost Effectiveness", NESCAUM, December, 2000.
Data in italics taken from draft "Assessment of Control Technologies for Reducing Nitrogen Oxides from Non-Utility Point Sources and Major Area Sources", OTAG (2/27/96).