Air Quality Permitting
Statement of Basis

May 12, 2005

Permit to Construct No. P-040428

Anderson Asphalt Paving
Hailey, ID

Facility ID No. 777-00286

Prepared by:

Charlie Mazzone, Permit Writer
AIR QUALITY DIVISION

FINAL

Table of Contents

Acronyms, Units, and Chemical Nomenclatures

acfm	actual cubic feet per minute
AFS	AIRS Facility Subsystem
AIRS	Aerometric Information Retrieval System
AP-42	EPA compilation of emission factors
AQCR	Air Quality Control Region
CFR	Code of Federal Regulations
CO	carbon monoxide
DEQ	Department of Environmental Quality
EI	emissions inventory
°F	degree Fahrenheit
ft	feet
gal/hr	gallons per hour
HAPs	Hazardous Air Pollutants
IDAPA	a numbering designation for all administrative rules in Idaho promulgated in accordance with the Idaho Administrative Procedures Act
in	inch
MACT	Maximum Achievable Control Technology
NAAQS	National Ambient Air Quality Standards
NESHAP	National Emission Standards for Hazardous Air Pollutants
NO_x	nitrogen oxides
NSPS	New Source Performance Standards
PBR	Permit by Rule
PM_{10}	particulate matter with an aerodynamic diameter less than or equal to a nominal 10 micrometers
PSD	Prevention of Significant Deterioration
PTC	permit to construct
Rules	Rules for the Control of Air Pollution in Idaho
SIC	Standard Industrial Classification
SO_2	sulfur dioxide
TAPs	toxic air pollutants
T/hr	tons per hour
T/yr	tons per any consecutive 12-month period
ug/m3	micrograms per cubic meter
UTM	Universal Transverse Mercator
VOC	volatile organic compound

1. PURPOSE

The purpose for this memorandum is to satisfy the requirements of IDAPA 58.01.01.200, Rules for the Control of Air Pollution in Idaho, for issuing permits to construct.

2. FACILITY DESCRIPTION

Anderson Asphalt Paving operates a stationary hot-mix asphalt plant rated at 40 T/hr. The plant was issued a permit to construct (PTC) on June 18, 1991. Anderson Asphalt Paving proposes to add a crusher and diesel-fired generator to the facility. The crusher will be used to produce aggregate for the hot-mix asphalt plant. The generator will provide electrical power for the crusher. The crusher was manufactured in 1978 and is rated at 150 T/hr.

3. FACILITY / AREA CLASSIFICATION

Anderson Asphalt Paving is defined as a true minor facility because potential emissions for all regulated air pollutants are less than or equal to 100 T/yr without consideration of any federally enforceable permit conditions. The facility is not a designated facility as defined by IDAPA 58.01.01.006.27. The facility is subject to 40 CFR 60, Supart I, Standards of Performance for Hot Mix Asphalt Plants. The facility is not subject to any other NSPS, NESHAP, or MACT requirement. The SIC code defining the facility is 2951 and the AIRS facility classification is "B". The AIRS data entry table is provided in Appendix A.

The facility is located within AQCR 63 and UTM zone 11. The facility is located in Blaine County, which is classified as unclassifiable for all regulated criteria pollutants.

4. APPLICATION SCOPE

Anderson Asphalt Paving has submitted a PTC application for the construction of a cone crusher rated at 150 T/hr and diesel-fired generator rated at 275 kilowatts. The crusher and generator have been operating under a Permit by Rule issued September 4, 2001; however, both have been operating at a single site for more than 12 consecutive months. Operations exceeding 12 months at a single site of operations is not allowed under the provisions of a PBR. As a result, Anderson Asphalt Paving proposes to modify their existing hot-mix asphalt plant permit by including the crusher and generator. The facility remains a true minor facility with the additional emissions from the generator. The fugitive emissions from the crusher do not count towards the facility's potential to emit because the crusher is not an affected facility regulated as of August 7, 1980.

4.1 Application Chronology

December 3, 2004	DEQ receives a PTC application for a cone crusher and diesel-fired generator
January 7, 2005	DEQ determines the application complete
January 19, 2005	30 day Public Notice and Opportunity for Public Comment begins.
March 8, 2005	DEQ provides a draft permit for facility review and comment and for regional office review and comment

5. PERMIT ANALYSIS

This section of the Statement of Basis describes the regulatory requirements for this PTC action.

5.1 Equipment Listing

Table 5.1 SUMMARY OF REGULATED SOURCES

Source Description	Emissions Control(s)
Crusher El Jay model 1213 cone crusher 150 T/hr capacity Manufactured in 1978 SN 42C0178 El Jay screen deck 3 decks at 5 ft by 14 ft 3 in. SN 34A0988 Manufactured 1978	None
Crusher Generator Caterpillar 3406 D1 engine #2 fuel oil 275 kW SN 2W811553 Stack data: Stack height = 13 ft 8 in. Stack diameter = 0.5 ft Stack exhaust flow rate = 2256 acfm Stack temp = 981 F	None

5.2 Emissions Inventory

Emissions from the diesel-fired generator were estimated by DEQ using emission factors from AP-42, Section 3.3, Gasoline and Diesel Industrial Engines. Generator operations are inherently limited by the production limit imposed on the hot-mix asphalt plant, which is 40 T/hr. The crusher and generator will only operate when aggregate is required for hot-mix asphalt production which is limited to 40 T/hr. Therefore, generator operations are limited by the ratio of the hot-mix asphalt production limit and the capacity of the cone crusher, or 40 T/hr ÷ 150 T/hr. An emissions inventory (EI) for criteria air pollutants is presented as Appendix B.

An EI was conducted for toxic air pollutants (TAPs) for generators less than 600 horsepower. The EI was developed by DEQ for the rock crusher PBR and can be applied to this permit modification. The EI for TAPs is very conservative in that it assumes the fuel consumption rate for the proposed generator is 31.7 gal/hr. According to vendor information for the same generator, the maximum fuel consumption rate is only 20 gal/hr. Regardless, the EI indicates that preconstruction compliance for the generator has been demonstrated. The TAPs EI is presented as Appendix C along with the Caterpillar 3406 generator specification. Note, the increase in TAP emissions at 31.7 gal/hr is 5.46E-03 lb/hr or 2.4E-02 T/yr.

Fugitive emissions from affected facilities from non-metallic mineral processing plants do not count towards a facility's potential to emit because non-metallic mineral processing plants are not of a source category regulated as of August 7, 1980. The effective date of regulation of this source category is August 31, 1983.

5.3 Modeling

PM_{10}, and SO_2 emissions from the proposed generator are below DEQ modeling thresholds. VOC emissions were not modeled because there is not an ambient standard for VOCs. NO_x and CO emissions were modeled and compared to their respective ambient air quality standards. The predicted annual impact of NO_x emissions is 28.5 ug/m3 including the rural remote background concentration of 9.6 ug/m^3. This is 28.5% of the ambient air quality standard. The predicted 1-hour and 8-hour CO impacts are 32.41 ug/m^3 and 22.69 ug/m^3, respectively. The ambient air quality standards for CO for a 1-hour and 8-hour average are 10,000 ug/m^3 and 40,000 ug/m^3. The predicted ambient impacts for CO are fractions of the ambient standards. Compliance with IDAPA 58.01.01.203 has been demonstrated.

5.4 Regulatory Review

This section describes the regulatory analysis of the applicable air quality rules with respect to this PTC.

IDAPA 58.01.01.201 .... Permit to Construct Required

The generator and cone crusher are not exempt from PTC requirements in any Sections 220 through 223 of the Rules; therefore, a PTC is required.

IDAPA 58.01.01.203 .... Permit Requirements for New and Modified Stationary Sources

As discussed in this statement of basis, the modification will comply with all applicable emissions standards, ambient air quality standards (NAAQS), and TAPs standards.

5.5 Permit Conditions Review

The following changes to the existing permit are related to the generator associated with the crushing facility:

- The permit conditions restrict the generator fuel to No. 2 fuel oil (Permit Condition 3.1) at no more than 0.5% sulfur by weight (Permit Condition 3.6), verified by sulfur content analysis records (Permit Condition 3.8).
- NO_x emissions are limited to 14.3 tons per consecutive 12 month period (Permit Condition 3.3).
- Opacity is limited according to IDAPA 58.01.01.625 (Permit Condition 3.4).
- Generator power is limited to crusher use only (Permit Condition 3.7).

The following changes to the existing permit add recordkeeping requirements to the hot mix asphalt plant:

- Asphalt production shall be recorded on a daily basis.
- Scrubbing media flow rate and pressure drop across the scrubber shall be recorded on a once per day basis.

6. PERMIT FEES

The applicant paid the application fee of $1,000 when the original application was submitted. Emissions from this proposed modification are summarized below. The increase in emissions is estimated to be 20.53 T/yr, which is subject to a PTC processing fee of $5,000 as required by IDAPA 58.01.01.225. The processing fee was received May 12, 2005. The facility is not a major facility; therefore, it is not subject to Tier I operating permit fees.

Table 5.1 PTC PROCESSING FEE TABLE

Emissions Inventory			
Pollutant	**Annual Emissions Increase (T/yr)**	**Annual Emissions Reduction (T/yr)**	**Annual Emissions Change (T/yr)**
NO_X	14.29	0	14.29
SO_2	0.94	0	0.94
CO	3.10	0	3.10
PM_{10}	1.00	0	1.00
VOC	1.17	0	1.17
TAPS/HAPS	0.03	0	0.03
Total:	20.53	0	20.53
Fee Due	**$ 5,000.00**		

7. PERMIT REVIEW

7.1 Regional Review of Draft Permit

A copy of the draft permit was provided to the Twin Fall Regional Office for review and comment on March 9, 2005 (via e-mail). No changes suggested.

7.2 Facility Review of Draft Permit

A copy of the draft permit was provided to the facility for review and comment on March 8, 2005. No changes suggested.

7.3 Public Comment

An opportunity for public comment was provided in accordance with IDAPA 58.01.01.209.01.c, from January 19, 2005 to February 18, 2005. No comments were received and a request for a public comment period was not requested.

8. RECOMMENDATION

Based on review of application materials, and all applicable state and federal rules and regulations, staff recommends that Anderson Asphalt Paving, Inc. be issued final PTC No. P-040428. The project does not involve PSD requirements.

CM/sd Permit No. P-040428

G:\Air Quality\Stationary Source\SS Ltd\PTC\Anderson Asphalt Paving - Hailey\Final\P-040428 Final SB.doc

Appendix A

AIRS Information

P-040428

AIRS/AFS[a] FACILITY-WIDE CLASSIFICATION[b] DATA ENTRY FORM

Facility Name: Anderson Asphalt Paving (P-040428)
Facility Location: Hailey, ID
AIRS Number: 777-00286

AIR PROGRAM POLLUTANT	SIP	PSD	NSPS (Part 60)	NESHAP (Part 61)	MACT (Part 63)	SM80	TITLE V	AREA CLASSIFICATION A-Attainment U-Unclassified N- Nonattainment
SO_2	B							U
NO_x	B							U
CO	B							U
PM_{10}	B							U
PT (Particulate)	B		B					U
VOC	B							U
THAP (Total HAPs)	B							U
			APPLICABLE SUBPART					
			I					

[a] Aerometric Information Retrieval System (AIRS) Facility Subsystem (AFS)

[b] AIRS/AFS Classification Codes:

A = Actual or potential emissions of a pollutant are above the applicable major source threshold. For HAPs only, class "A" is applied to each pollutant which is at or above the 10 T/yr threshold, or each pollutant that is below the 10 T/yr threshold, but contributes to a plant total in excess of 25 T/yr of all HAPs.

SM = Potential emissions fall below applicable major source thresholds if and only if the source complies with federally enforceable regulations or limitations.

B = Actual and potential emissions below all applicable major source thresholds.

C = Class is unknown.

ND = Major source thresholds are not defined (e.g., radionuclides).

Appendix B

Emissions Inventory
&
Modeling Analysis

P-040428

Diesel-fired generator (600 hp) Emission Estimates ([illegible])

- Assumptions
  1. HMA THPT limit = 40 T/hr
  2. Crusher max THPT = 150 T/hr
  3. Crusher and generator operations limited by HMA limit
  4. generator emissions reduced by the ratio $\frac{40\ T/hr}{150\ T/hr}$ or 0.27.
  5. diesel heating value = 137,000 Btu/gal
  6. Max fuel consumption = 20 gal/hr.
- Emission factors from AP-42, Table 3.3-1

NO_x

$(137{,}000\ Btu/gal)(20\ gal/hr)(4.41\ lb/10^6\ Btu)(0.27) = 3.26\ lb/hr$

$(3.26\ lb/hr)(8760\ hr/yr)(1\ T/2000\ lb) = 14.29\ T/yr.$

CO

$(137{,}000\ Btu/gal)(20\ gal/hr)(0.95\ lb/10^6\ Btu)(0.27) = 0.70\ lb/hr$

$(0.70\ lb/hr)(8760\ hr/yr)(1\ T/2000\ lb) = 3.10\ T/yr.$

SO_x

$(137{,}000\ Btu/gal)(20\ gal/hr)(0.29\ lb/10^6\ Btu)(0.27) = 0.21\ lb/hr$

$(0.21\ lb/hr)(8760\ hr/yr)(1\ T/2000\ lb) = 0.94\ T/yr$

PM_{10}

(137,000 Btu/gal)(20 gal/hr)(0.31 lb/10^6 Btu)(0.27) = 0.23 lb/hr

(0.23 lb/hr)(8760 hr/yr)(1T/2000 lb) = 1.00 T/yr.

VOC as TOC (total)

(137,000 Btu/gal)(20 gal/hr)(0.36 lb/10^6 Btu)(0.27) = 0.27 lb/hr

(0.27 lb/hr)(8760 hr/yr)(1T/2000 lb) = 1.17 T/yr.

Facility PTE: T/yr

HMA Limits (Allowable)

	PM_{10}	CO	VOC	NOx	SO_2
	2.24	1.70	1.25	1.61	9.16
Generator	1.00	3.10	1.17	14.29	0.94
	3.24	4.80	2.42	15.90	10.10

Modeling Results:

Assumptions:

1. Max predicted impact = 46.3 ug/m3 @ 1.0 lb/hr
2. Regional remote background: 24-hr = 4.3 ug/m3
   Annual = 9.6 ug/m3
3. SO_x, PM_{10} below modeling thresholds
4. VOC has no NAAQS STD; therefore, no modeling

NOx

(3.26 lb/hr)(46.3 ug/m3/lb-hr)(0.125) = 18.9 ug/m3 Annual Ave.
+ 9.6 ug/m3 BKGD
28.5 ug/m3 (28.5% of NAAQS)

CO

(0.70 lb/hr)(46.3 ug/m3/lb-hr) = 32.41 ug/m3 1-hr Ave
No background available, however,
the NAAQS STD is 40,000 ug/m3 1-hr Ave

(0.70 lb/hr)(46.3 ug/m3/lb-hr)(0.7) = 22.69 ug/m3 8-hr Ave
No background
NAAQS STD is 10,000 ug/m3 8-hr Ave

p. 1 3 of 3

Toxic Air Pollutant Emissions Analysis

Diesel Generators < 447 kW (600 hp)

Grade 1 or 2	Heating Value	137000	Btu/gal
Diesel Fuel	max fueling rate	31.7	gal/hr
	max impact	46.3	ug/m3

TOXIC AIR POLLUTANTS	EMISSION FACTOR lb/MMBtu	EMISSION RATE lb/hr	SCREENING LEVEL lb/hr	CAS	MODELING REQUIRED? YES/NO	AMBIENT LIMIT ug/m3	PREDICTED IMPACT ug/m3	DEMONSTRATE COMPLIANCE? YES/NO
benzene	9.33E-04	4.05E-03	8.00E-04	71-43-2		0.12	2.35E-02	YES
toluene	4.09E-04	1.78E-03	25	108-88-3				
xylene	2.85E-04	1.24E-03	29	1330-20-7				
propylene	2.58E-03	1.12E-02						
1,3-butadiene	3.91E-05	1.70E-04	2.40E-05	106-99-0	YES	3.60E-03	9.83E-04	YES
formaldehyde	1.18E-03	5.12E-03	5.10E-04	50-00-0	YES	7.70E-02	2.97E-02	YES
acetaldehyde	7.67E-04	3.33E-03	3.00E-03	75-07-0	YES	4.50E-01	1.93E-02	YES
acrolein	9.25E-05	4.02E-04	0.017	107-02-8				
naphthalene	8.48E-05	3.68E-04	3.33	91-20-3				
acenaphthylene	5.06E-06	2.20E-05						
acenaphthene	1.42E-06	6.17E-06						
fluorene	2.92E-05	1.27E-04	0.133	7782-41-4	NO			
phenanthrene	2.94E-05	1.28E-04						
anthracene	1.87E-06	8.12E-06						
fluoranthene	7.61E-06	3.30E-05						
pyrene	4.78E-06	2.08E-05						
benz(a)anthracene	1.68E-06	7.30E-06						
chrysene	3.53E-07	1.53E-06						
benzo(b)fluoranthene	9.91E-08	4.30E-07						
benzo(k)fluoranthene	1.55E-07	6.73E-07						
benzo(a)pyrene	1.88E-07	8.16E-07	2.00E-06	50-32-8	NO			
indeno(1,2,3-cd)pyrene	3.75E-07	1.63E-06						
dibenz(a,h)anthracene	5.83E-07	2.53E-06						
benzo(g,h,l)perylene	4.89E-07	2.12E-06						

Appendix C

AP-42 Emission Factors

P-040428

3.4 Large Stationary Diesel And All Stationary Dual-fuel Engines

3.4.1 General

The primary domestic use of large stationary diesel engines (greater than 600 horsepower [hp]) is in oil and gas exploration and production. These engines, in groups of 3 to 5, supply mechanical power to operate drilling (rotary table), mud pumping, and hoisting equipment, and may also operate pumps or auxiliary power generators. Another frequent application of large stationary diesels is electricity generation for both base and standby service. Smaller uses include irrigation, hoisting, and nuclear power plant emergency cooling water pump operation.

Dual-fuel engines were developed to obtain compression ignition performance and the economy of natural gas, using a minimum of 5 to 6 percent diesel fuel to ignite the natural gas. Large dual-fuel engines have been used almost exclusively for prime electric power generation. This section includes all dual-fuel engines.

3.4.2 Process Description

All reciprocating internal combustion (IC) engines operate by the same basic process. A combustible mixture is first compressed in a small volume between the head of a piston and its surrounding cylinder. The mixture is then ignited, and the resulting high-pressure products of combustion push the piston through the cylinder. This movement is converted from linear to rotary motion by a crankshaft. The piston returns, pushing out exhaust gases, and the cycle is repeated.

There are 2 ignition methods used in stationary reciprocating IC engines, compression ignition (CI) and spark ignition (SI). In CI engines, combustion air is first compression heated in the cylinder, and diesel fuel oil is then injected into the hot air. Ignition is spontaneous because the air temperature is above the autoignition temperature of the fuel. SI engines initiate combustion by the spark of an electrical discharge. Usually the fuel is mixed with the air in a carburetor (for gasoline) or at the intake valve (for natural gas), but occasionally the fuel is injected into the compressed air in the cylinder. Although all diesel- fueled engines are compression ignited and all gasoline- and gas-fueled engines are spark ignited, gas can be used in a CI engine if a small amount of diesel fuel is injected into the compressed gas/air mixture to burn any mixture ratio of gas and diesel oil (hence the name dual fuel), from 6 to 100 percent diesel oil.

CI engines usually operate at a higher compression ratio (ratio of cylinder volume when the piston is at the bottom of its stroke to the volume when it is at the top) than SI engines because fuel is not present during compression; hence there is no danger of premature autoignition. Since engine thermal efficiency rises with increasing pressure ratio (and pressure ratio varies directly with compression ratio), CI engines are more efficient than SI engines. This increased efficiency is gained at the expense of poorer response to load changes and a heavier structure to withstand the higher pressures.[1]

3.4.3 Emissions And Controls

Most of the pollutants from IC engines are emitted through the exhaust. However, some total organic compounds (TOC) escape from the crankcase as a result of blowby (gases that are vented from the oil pan after they have escaped from the cylinder past the piston rings) and from the fuel tank and carburetor because of evaporation. Nearly all of the TOCs from diesel CI engines enter the atmosphere from the exhaust. Crankcase blowby is minor because TOCs are not present during compression of the charge. Evaporative losses are insignificant in diesel engines due to the low volatility of diesel fuels. In general, evaporative losses are also negligible in engines using gaseous fuels because these engines receive their fuel continuously from a pipe rather than via a fuel storage tank and fuel pump.

The primary pollutants from internal combustion engines are oxides of nitrogen (NO_x), hydrocarbons and other organic compounds, carbon monoxide (CO), and particulates, which include both visible (smoke) and nonvisible emissions. Nitrogen oxide formation is directly related to high pressures and temperatures during the combustion process and to the nitrogen content, if any, of the fuel. The other pollutants, HC, CO, and smoke, are primarily the result of incomplete combustion. Ash and metallic additives in the fuel also contribute to the particulate content of the exhaust. Sulfur oxides also appear in the exhaust from IC engines. The sulfur compounds, mainly sulfur dioxide (SO_2), are directly related to the sulfur content of the fuel.[2]

3.4.3.1 Nitrogen Oxides -

Nitrogen oxide formation occurs by two fundamentally different mechanisms. The predominant mechanism with internal combustion engines is thermal NO_x which arises from the thermal dissociation and subsequent reaction of nitrogen (N_2) and oxygen (O_2) molecules in the combustion air. Most thermal NO_x is formed in the high-temperature region of the flame from dissociated molecular nitrogen in the combustion air. Some NO_x, called prompt NO_x, is formed in the early part of the flame from reaction of nitrogen intermediary species, and HC radicals in the flame. The second mechanism, fuel NO_x, stems from the evolution and reaction of fuel-bound nitrogen compounds with oxygen. Gasoline, and most distillate oils, have no chemically-bound fuel N_2 and essentially all NO_x formed is thermal NO_x.

3.4.3.2 Total Organic Compounds -

The pollutants commonly classified as hydrocarbons are composed of a wide variety of organic compounds and are discharged into the atmosphere when some of the fuel remains unburned or is only partially burned during the combustion process. Most unburned hydrocarbon emissions result from fuel droplets that were transported or injected into the quench layer during combustion. This is the region immediately adjacent to the combustion chamber surfaces, where heat transfer outward through the cylinder walls causes the mixture temperatures to be too low to support combustion.

Partially burned hydrocarbons can occur because of poor air and fuel homogeneity due to incomplete mixing, before or during combustion; incorrect air/fuel ratios in the cylinder during combustion due to maladjustment of the engine fuel system; excessively large fuel droplets (diesel engines); and low cylinder temperature due to excessive cooling (quenching) through the walls or early cooling of the gases by expansion of the combustion volume caused by piston motion before combustion is completed.[2]

3.4.3.3 Carbon Monoxide -

Carbon monoxide is a colorless, odorless, relatively inert gas formed as an intermediate combustion product that appears in the exhaust when the reaction of CO to CO_2 cannot proceed to completion. This situation occurs if there is a lack of available oxygen near the hydrocarbon (fuel) molecule during combustion, if the gas temperature is too low, or if the residence time in the cylinder is too short. The oxidation rate of CO is limited by reaction kinetics and, as a consequence, can be accelerated only to a certain extent by improvements in air and fuel mixing during the combustion process.[2-3]

3.4.3.4 Smoke, Particulate Matter, and PM-10 -

White, blue, and black smoke may be emitted from IC engines. Liquid particulates appear as white smoke in the exhaust during an engine cold start, idling, or low load operation. These are formed in the quench layer adjacent to the cylinder walls, where the temperature is not high enough to ignite the fuel. Blue smoke is emitted when lubricating oil leaks, often past worn piston rings, into the combustion chamber and is partially burned. Proper maintenance is the most effective method of preventing blue smoke emissions from all types of IC engines. The primary constituent of black smoke is agglomerated carbon particles (soot).[2]

3.4.3.5 Sulfur Oxides -

Sulfur oxide emissions are a function of only the sulfur content in the fuel rather than any combustion variables. In fact, during the combustion process, essentially all the sulfur in the fuel is oxidized to SO_2. The oxidation of SO_2 gives sulfur trioxide (SO_3), which reacts with water to give sulfuric acid (H_2SO_4), a contributor to acid precipitation. Sulfuric acid reacts with basic substances to give sulfates, which are fine particulates that contribute to PM-10 and visibility reduction. Sulfur oxide emissions also contribute to corrosion of the engine parts.[2,3]

Table 3.4-1 contains gaseous emission factors for the pollutants discussed above, expressed in units of pounds per horsepower-hour (lb/hp-hr), and pounds per million British thermal unit (lb/MMBtu). Table 3.4-2 shows the particulate and particle-sizing emission factors. Table 3.4-3 shows the speciated organic compound emission factors and Table 3.4-4 shows the emission factors for polycyclic aromatic hydrocarbons (PAH). These tables do not provide a complete speciated organic compound and PAH listing because they are based only on a single engine test; they are to be used only for rough order of magnitude comparisons.

Table 3.4-5 shows the NO_x reduction and fuel consumption penalties for diesel and dual-fueled engines based on some of the available control techniques. The emission reductions shown are those that have been demonstrated. The effectiveness of controls on a particular engine will depend on the specific design of each engine, and the effectiveness of each technique could vary considerably. Other NO_x control techniques exist but are not included in Table 3.4-5. These techniques include internal/external exhaust gas recirculation, combustion chamber modification, manifold air cooling, and turbocharging.

3.4.4 Control Technologies

Control measures to date are primarily directed at limiting NO_x and CO emissions since they are the primary pollutants from these engines. From a NO_x control viewpoint, the most important distinction between different engine models and types of reciprocating engines is whether they are rich-burn or lean-burn. Rich-burn engines have an air-to-fuel ratio operating range that is near stoichiometric or fuel-rich of stoichiometric and as a result the exhaust gas has little or no excess oxygen. A lean-burn engine has an air-to-fuel operating range that is fuel-lean of stoichiometric; therefore, the exhaust from these engines is characterized by medium to high levels of O_2. The most common NO_x control technique for diesel and dual fuel engines focuses on modifying the combustion process. However, selective catalytic reduction (SCR) and nonselective catalytic reduction (NSCR) which are post-combustion techniques are becoming available. Control for CO have been partly adapted from mobile sources.[5]

Combustion modifications include injection timing retard (ITR), preignition chamber combustion (PCC), air-to-fuel ratio, and derating. Injection of fuel into the cylinder of a CI engine initiates the combustion process. Retarding the timing of the diesel fuel injection causes the combustion process to occur later in the power stroke when the piston is in the downward motion and combustion chamber volume is increasing. By increasing the volume, the combustion temperature and pressure are lowered, thereby lowering NO_x formation. ITR reduces NO_x from all diesel engines; however, the effectiveness is specific to each engine model. The amount of NO_x reduction with ITR diminishes with increasing levels of retard.[5]

Improved swirl patterns promote thorough air and fuel mixing and may include a precombustion chamber (PCC). A PCC is an antechamber that ignites a fuel-rich mixture that propagates to the main combustion chamber. The high exit velocity from the PCC results in improved mixing and complete combustion of the lean air/fuel mixture which lowers combustion temperature, thereby reducing NO_x emissions.[5]

The air-to-fuel ratio for each cylinder can be adjusted by controlling the amount of fuel that enters each cylinder. At air-to-fuel ratios less than stoichiometric (fuel-rich), combustion occurs under conditions of insufficient oxygen which causes NO_x to decrease because of lower oxygen and lower temperatures. Derating involves restricting engine operation to lower than normal levels of power production for the given application. Derating reduces cylinder pressures and temperatures thereby lowering NO_x formation rates.[5]

SCR is an add-on NO_x control placed in the exhaust stream following the engine and involves injecting ammonia (NH_3) into the flue gas. The NH_3 reacts with the NO_x in the presence of a catalyst to form water and nitrogen. The effectiveness of SCR depends on fuel quality and engine duty cycle (load fluctuations). Contaminants in the fuel may poison or mask the catalyst surface causing a reduction or termination in catalyst activity. Load fluctuations can cause variations in exhaust temperature and NO_x concentration which can create problems with the effectiveness of the SCR system.[5]

NSCR is often referred to as a three-way conversion catalyst system because the catalyst reactor simultaneously reduces NO_x, CO, and HC and involves placing a catalyst in the exhaust stream of the engine. The reaction requires that the O_2 levels be kept low and that the engine be operated at fuel-rich air-to-fuel ratios.[5]

3.4.5 Updates Since the Fifth Edition

The Fifth Edition was released in January 1995. Revisions to this section since that date are summarized below. For further detail, consult the memoranda describing each supplement or the background report for this section.

Supplement A, February 1996

No changes.

Supplement B, October 1996

- The general text was updated.
- Controlled NO_x factors and PM factors were added for diesel units.
- Math errors were corrected in factors for CO from diesel units and for uncontrolled NO_x from dual fueled units.

Table 3.4-1. GASEOUS EMISSION FACTORS FOR LARGE STATIONARY DIESEL AND ALL STATIONARY DUAL-FUEL ENGINES[a]

	Diesel Fuel (SCC 2-02-004-01)			Dual Fuel[b] (SCC 2-02-004-02)		
Pollutant	Emission Factor (lb/hp-hr) (power output)	Emission Factor (lb/MMBtu) (fuel input)	EMISSION FACTOR RATING	Emission Factor (lb/hp-hr) (power output)	Emission Factor (lb/MMBtu) (fuel input)	EMISSION FACTOR RATING
NO_x						
Uncontrolled	0.024	3.2	B	0.018	2.7	D
Controlled	0.013[c]	1.9[c]	B	ND	ND	NA
CO	5.5 E-03	0.85	C	7.5 E-03	1.16	D
SO_x[d]	8.09 E-03S_1	1.01S_1	B	4.06 E-04S_1 + 9.57 E-03S_2	0.05S_1 + 0.895S_2	B
CO_2[e]	1.16	165	B	0.772	110	B
PM	0.0007[c]	0.1[c]	B	ND	ND	NA
TOC (as CH_4)	7.05 E-04	0.09	C	5.29 E-03	0.8	D
Methane	f	f	E	3.97 E-03	0.6	E
Nonmethane	f	f	E	1.32 E-03	0.2[g]	E

[a] Based on uncontrolled levels for each fuel, from References 2,6-7. When necessary, the average heating value of diesel was assumed to be 19,300 Btu/lb with a density of 7.1 lb/gallon. The power output and fuel input values were averaged independently from each other, because of the use of actual brake-specific fuel consumption (BSFC) values for each data point and of the use of data possibly sufficient to calculate only 1 of the 2 emission factors (e. g., enough information to calculate lb/MMBtu, but not lb/hp-hr). Factors are based on averages across all manufacturers and duty cycles. The actual emissions from a particular engine or manufacturer could vary considerably from these levels. To convert from lb/hp-hr to kg/kw-hr, multiply by 0.608. To convert from lb/MMBtu to ng/J, multiply by 430. SCC = Source Classification Code.

[b] Dual fuel assumes 95% natural gas and 5% diesel fuel.

[c] References 8-26. Controlled NO_x is by ignition timing retard.

[d] Assumes that all sulfur in the fuel is converted to SO_2. S_1 = % sulfur in fuel oil; S_2 = % sulfur in natural gas. For example, if sulfer content is 1.5%, then S = 1.5.

[e] Assumes 100% conversion of carbon in fuel to CO_2 with 87 weight % carbon in diesel, 70 weight % carbon in natural gas, dual-fuel mixture of 5% diesel with 95% natural gas, average BSFC of 7,000 Btu/hp-hr, diesel heating value of 19,300 Btu/lb, and natural gas heating value of 1050 Btu/scf.

[f] Based on data from 1 engine, TOC is by weight 9% methane and 91% nonmethane.

[g] Assumes that nonmethane organic compounds are 25% of TOC emissions from dual-fuel engines. Molecular weight of nonmethane gas stream is assumed to be that of methane.

Table 3.4-2. PARTICULATE AND PARTICLE-SIZING EMISSION FACTORS FOR LARGE UNCONTROLLED STATIONARY DIESEL ENGINES[a]

EMISSION FACTOR RATING: E

Pollutant	Emission Factor (lb/MMBtu) (fuel input)
Filterable particulate[b]	
< 1 μm	0.0478
< 3 μm	0.0479
< 10 μm	0.0496
Total filterable particulate	0.0620
Condensable particulate	0.0077
Total PM-10[c]	0.0573
Total particulate[d]	0.0697

[a] Based on 1 uncontrolled diesel engine from Reference 6. Source Classification Code 2-02-004-01. The data for the particulate emissions were collected using Method 5, and the particle size distributions were collected using a Source Assessment Sampling System. To convert from lb/MMBtu to ng/J, multiply by 430. PM-10 = particulate matter ≤ 10 micrometers (μm) aerometric diameter.

[b] Particle size is expressed as aerodynamic diameter.

[c] Total PM-10 is the sum of filterable particulate less than 10 μm aerodynamic diameter and condensable particulate.

[d] Total particulate is the sum of the total filterable particulate and condensable particulate.

Table 3.4-3. SPECIATED ORGANIC COMPOUND EMISSION FACTORS FOR LARGE UNCONTROLLED STATIONARY DIESEL ENGINES[a]

EMISSION FACTOR RATING: E

Pollutant	Emission Factor (lb/MMBtu) (fuel input)
Benzene[b]	7.76 E-04
Toluene[b]	2.81 E-04
Xylenes[b]	1.93 E-04
Propylene	2.79 E-03
Formaldehyde[b]	7.89 E-05
Acetaldehyde[b]	2.52 E-05
Acrolein[b]	7.88 E-06

[a]Based on 1 uncontrolled diesel engine from Reference 7. Source Classification Code 2-02-004-01. Not enough information to calculate the output-specific emission factors of lb/hp-hr. To convert from lb/MMBtu to ng/J, multiply by 430.
[b]Hazardous air pollutant listed in the *Clean Air Act*.

Table 3.4-4. PAH EMISSION FACTORS FOR LARGE UNCONTROLLED STATIONARY DIESEL ENGINES[a]

EMISSION FACTOR RATING: E

PAH	Emission Factor (lb/MMBtu) (fuel input)
Naphthalene[b]	1.30 E-04
Acenaphthylene	9.23 E-06
Acenaphthene	4.68 E-06
Fluorene	1.28 E-05
Phenanthrene	4.08 E-05
Anthracene	1.23 E-06
Fluoranthene	4.03 E-06
Pyrene	3.71 E-06
Benz(a)anthracene	6.22 E-07
Chrysene	1.53 E-06
Benzo(b)fluoranthene	1.11 E-06
Benzo(k)fluoranthene	<2.18 E-07
Benzo(a)pyrene	<2.57 E-07
Indeno(1,2,3-cd)pyrene	<4.14 E-07
Dibenz(a,h)anthracene	<3.46 E-07
Benzo(g,h,l)perylene	<5.56 E-07
TOTAL PAH	<2.12 E-04

[a] Based on 1 uncontrolled diesel engine from Reference 7. Source Classification Code 2-02-004-01. Not enough information to calculate the output-specific emission factors of lb/hp-hr. To convert from lb/MMBtu to ng/J, multiply by 430.
[b] Hazardous air pollutant listed in the *Clean Air Act*.

Table 3.4-5. NO_x REDUCTION AND FUEL CONSUMPTION PENALTIES FOR LARGE STATIONARY DIESEL AND DUAL-FUEL ENGINES[a]

Control Approach		Diesel (SCC 2-02-004-01) NO_x Reduction (%)	Diesel (SCC 2-02-004-01) ΔBSFC[b] (%)	Dual Fuel (SCC 2-02-004-02) NO_x Reduction (%)	Dual Fuel (SCC 2-02-004-02) ΔBSFC (%)
Derate	10%	ND	ND	<20	4
	20%	<20	4	ND	ND
	25%	5 - 23	1 - 5	1 - 33	1 - 7
Retard	2°	<20	4	<20	3
	4°	<40	4	<40	1
	8°	28 - 45	2 - 8	50 - 73	3 - 5
Air-to-fuel	3%	ND	ND	<20	0
	±10%	7 - 8	3	25 - 40	1 - 3
Water injection (H_2O/fuel ratio)	50%	25 - 35	2 - 4	ND	ND
SCR		80 - 95	0	80 - 95	0

[a] References 1,27-28. The reductions shown are typical and will vary depending on the engine and duty cycle. SCC = Source Classification Code. ΔBSFC = change in brake-specific fuel consumption. ND = no data.

References For Section 3.4

1. H. I. Lips, *et al.*, *Environmental Assessment Of Combustion Modification Controls For Stationary Internal Combustion Engines*, EPA-600/7-81-127, U. S. Environmental Protection Agency, Cincinnati, OH, July 1981.

2. *Standards Support And Environmental Impact Statement, Volume I: Stationary Internal Combustion Engines*, EPA-450/2-78-125a, U. S. Environmental Protection Agency, Research Triangle Park, NC, July 1979.

3. M. Hoggan, et. al., *Air Quality Trends in California's South Coast and Southeast Desert Air Basins, 1976-1990*, "Air Quality Management Plan, Appendix II-B", South Coast Air Quality Management District, July 1991.

4. *Limiting Net Greenhouse Gas Emissions In the United States, Volume II: Energy Responses*, report for the Office of Environmental Analysis, Office of Policy, Planning and Analysis, Department of Energy (DDE), DOE/PE-0101 Volume II, September 1991.

5. Snyder, R. B., *Alternative Control Techniques Document—NO_x Emissions from Stationary Reciprocating Internal Combustion Engines*, EPA-453/R-93-032, U. S. Environmental Protection Agency, Research Triangle Park, July 1993.

6. C. Castaldini, *Environmental Assessment Of NO_x Control On A Compression Ignition Large Bore Reciprocating Internal Combustion Engine, Volume I: Technical Results*, EPA-600/7-86/001a, U. S. Environmental Protection Agency, Cincinnati, OH, April 1984.

7. *Pooled Source Emission Test Report: Oil And Gas Production Combustion Sources, Fresno And Ventura Counties, California*, ENSR # 7230-007-700, Western States Petroleum Association, Bakersfield, CA, December 1990.

8. *Final Report For An Emission Compliance Test Program On Two Standby Generators Located At American Car Company*, Greenwich, CT, York Services Corp., 1987.

9. *Final Report For An Emission Compliance Test Program On A Standby Diesel Generator At South Central Connecticut Regional Water Authority*, West Haven, CT, York Services Corp., 1988.

10. *Air Emission From Stationary Diesel Engines For The Alaska Rural Electric Cooperative Association*, Environmetrics, 1992.

11. *Compliance Test Report For Particulate Emissions From A Caterpillar Diesel Generator*, St. Mary's Hospital, Waterburg, CT, TRC Environmental Consultants, 1987.

12. *Compliance Measured Particulate Emissions From An Emergency Diesel Generator, Silorsky Aircraft, United Technologies*, Stratford, CT, TRC Environmental Consultants, 1987.

13. *Compliance Test Report For Particulate Emissions From A Cummins Diesel Generator*, Colonial Gold Limited Partnership, Hartford, CT, TRC Environmental Consultants, 1988.

14. *Compliance Test Report For Particulate Emissions From A Cummins Diesel Generator*, CIGNA Insurance Company, Bloomfield, CT, TRC Environmental Consultants, 1988.

15. *Compliance Test Report For Particulate Emission From A Waukesha Diesel Generator*, Bristol Meyers, Wallinsford, CT, TRC Environmental Consultants, 1987.

16. *Compliance Test Report For Particulate Emissions From A Cummins Diesel Generator*, Connecticut General Life Insurance, Windsor, CT, TRC Environmental Consultants, 1987.

17. *Compliance Measured Particulate Emissions From An Emergency Diesel Generator*, Danbury Hospital, Danbury, CT, TRC Environmental Consultants, 1988.

18. *Compliance Test Report For Particulate Emissions From A Caterpillar Diesel Generator*, Colonial Metro Limited Partnership, Hartford, CT, TRC Environmental Consultants, 1988.

19. *Compliance Test Report For Particulate Emissions From A Caterpillar Diesel Generator*, Boehringer -Ingelheim Pharmaceuticals, Danbury, CT, TRC Environmental Consultants, 1988.

20. *Compliance Test Report For Emissions Of Particulate From An Emergency Diesel Generator*, Meriden - Wallingford Hospital, Meriden, CT, TRC Environmental Consultants, 1987.

21. *Compliance Test Report Johnson Memorial Hospital Emergency Generator Exhaust Stack*, Stafford Springs, CT, ROJAC Environmental Services, 1987.

22. *Compliance Test Report Union Carbide Corporation Generator Exhaust Stack*, Danbury, CT, ROJAC Environmental Services, 1988.

23. *Compliance Test Report Hartford Insurance Company Emergency Generator Exhaust Stack*, Bloomfield, CT, ROJAC Environmental Services, 1987.

24. *Compliance Test Report Hartford Insurance Group Emergency Generator Exhaust Stack*, Hartford, CT, ROJAC Environmental Services, 1987.

25. *Compliance Test Report Southern New England Telephone Company Emergency Generator Exhaust Stack*, North Haven, CT, ROJAC Environmental Services, 1988.

26. *Compliance Test Report Pfizer, Inc. Two Emergency Generator Exhaust Stacks*, Groton, CT, ROJAC Environmental Services, 1987.

27. L. M. Campbell, *et al.*, *Sourcebook: NO_x Control Technology Data, Control Technology Center*, EPA-600/2-91-029, U. S. Environmental Protection Agency, Cincinnati, OH, July 1991.

28. *Catalysts For Air Pollution Control*, Manufacturers Of Emission Controls Association (MECA), Washington, DC, March 1992.