

11/14/08 - 02765



DEPARTMENT OF THE NAVY
NAVAL FACILITIES ENGINEERING COMMAND
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TELEPHONE NO

(757) 322-4736

IN REPLY REFER TO

6250

EV31KRC:lfm

November 14, 2008

Ms. Evelyn Rodríguez Cintron
Manager, Air Quality Area
Puerto Rico Environmental Quality Board
Piso 5 Ave. Ponce de León #1308
Carr Estatal 8838
Sector El Cinco
Rio Piedras, PR 00926

Re: LETTER FROM EQB TO THE NAVY DATED FEBRUARY 6, 2008, REGARDING
THE OPERATION OF THE OF THE CPC FOR THE TIME CRITICAL
MUNITIONS REMOVAL ACTION ON VIEQUES, PUERTO RICO

Dear Ms. Cintron:

Attached for your review is the Navy's response to the comments in your letter dated February 8, 2008, regarding the operation of the Central Processing Center (CPC) on the former Vieques Naval Training Range as part of the Time Critical Munitions Removal Action for the former Live Impact Area on Vieques, Puerto Rico.

Most of your comments have been previously addressed in a letter to you dated March 7, 2007, and incorporated into the *Final Work Plan for the Central Processing Center and MEC Support Activities at the Former Vieques Naval Training Range, Vieques Island, Puerto Rico dated January 31, 2008*. The only additional emissions source that was not previously provided was for the Emergency Power Generator (60 kW) at Camp Garcia. To facilitate your review, we are providing specific responses to your comments in the enclosed attachments.

If you have any questions regarding the attached comment responses, please don't hesitate to contact me at (757) 322-4736 or by e-mail: kevin.cloe@navy.mil.

Sincerely,

A handwritten signature in black ink, appearing to read "Kevin Cloe".

KEVIN CLOE, P.E.
Remedial Project Manager
Vieques Restoration Section
Environmental Restoration Branch

Copy to: See Page 2

Quality Performance ... Quality Results

6250
EV31KRC:lfm
November 14, 2008

Copy to:

NAVFAC Atlantic (Mr. Christopher Penny, Mr. Dan Hood, Ms. Madeline Rivera,
Mr. Pedro Ruiz)
PREQB (Ms. Wilmarie Rivera)
USEPA (Mr. Daniel Rodriguez)
DOI (Mr. Richard Henry)
CH2MHILL (Mr. John Tomik)

ATTACHMENT A

NAVY'S RESPONSE TO THE COMMENTS IN EQB LETTER DATED FEBRUARY 6, 2008 REGARDING THE OPERATION OF THE FLASHING FURNACE ON VIEQUES AS PART OF THE TIME CRITICAL MUNITIONS REMOVAL ACTION FOR THE FORMER LIVE IMPACT AREA ON VIEQUES, PUERTO RICO.

EQB Comment No. 1

Identify the construction permits granted by the Air Quality Area for each proposed location (physical location). The emissions of the permitted emission sources for each location shall be taken into account to calculate the facility-wide potential emissions including the flashing furnace emissions. Rule 206 of the Regulations for the Control of Atmospheric Pollution (RCAP), exempts stationary sources based on potential emissions on a facility-wide basis. The emissions of existent or previous permitted emission sources shall be included in this analysis. If there are no other emission sources at the proposed location, please certify so.

Navy Response to Comment 1.

Potential emissions calculations for each of the sources installed at the Central Processing Center (CPC) inside the former Vieques Naval Training Range (VNTR) have been previously provided in the Final Work Plan for the Central Processing Center and MEC Support Activities at the Former Vieques Naval Training Range, Vieques Island, Puerto Rico. Information summarizing the potential facility-wide emissions including the flashing furnace, the Hammer Mill and emergency generator emissions is included as Attachment C. Emission calculations for the EPG located at Camp Garcia are also included in Attachment C. Total emissions for the operation, including this EPG, are 2.08 tpy.

The VNTR is a CERCLA site that is on the National Priorities List. CERCLA section 121(e) states that "no Federal, state, or local permit shall be required for the portion of any removal or remedial action conducted entirely on site. Neither Federal facilities nor private parties are required to obtain permits for on-site actions at CERCLA sites, but both must still comply with the substantive requirements of permit programs." Based upon this understanding and the fact that the cumulative potential emissions for all criteria pollutants and sources is well below the regulated limits, (provided in Attachment C), it is the Navy's understanding that construction permits would not be required for this project.

EQB Comment No. 2.

Clarify the proposed location (Camp Garcia, NVTR Live Impact Area or other) for the Jet Edge Cutter, flashing furnace, hammer mill, and the electric generator.

Navy Response to Comment No. 2

The locations for the flashing furnace, hammer mill and the electric generator are shown in the Final Work Plan for the Central Processing Center and MEC Support Activities at the Former Vieques Naval Training Range and is included as Attachment B. The jet edge cutter is no longer being used on the site.

EQB Comment No. 3

For the hammer mill, verify the emissions for NO_x and VOC. These emissions are reported as zero even though there is a combined factor for NMHC and NO_x.

Navy Response to Comment No. 3

The NO_x emissions were reported as per the manufacturer's emissions report at 4 g/KW-hr which was converted to 2.98 g/hp-hr which is the combined NMHC and NO_x (Attachment C). The VOC emissions were shown as zero since they were already included in the combined NMHC and NO_x emissions.

EQB Comment No. 4

For the hammer mill, the AP-42 Section 3.4 (Large Stationary Diesel and All Stationary Dual-fuel Engines) shall be used to calculate Sox emissions instead of Section 3.3

Navy Response to Comment No .4.

The spreadsheet in Attachment C includes Sox emissions from Section 3.4 of the AP-42 instead of Section 3.3 of the AP-42.

EQB Comment No. 5

Copy of the manufacturers data for the emission factors used for the flashing furnace.

Navy Response to Comment No .5.

A copy of the manufacturers report showing the emissions calculations is provided in Attachment D.

EQB Comment No. 6

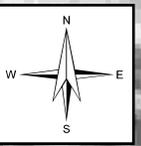
Supporting document for the assumptions made for VOC and lead emissions for the flashing furnace

Navy Response to Comment No 6.

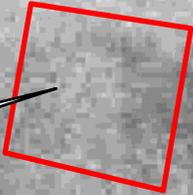
A spreadsheet including Sox emissions from Section 3.4 of the AP-42 is provided in Attachment B. The only potential source of lead as a criteria pollutant would be from placing lead-containing items into the Flashing Furnace. However, the operating conditions of the Flashing Furnace for this project are not conducive to such a release. The target temperature for this project is 650 O F to ensure complete flashing of any residual explosive in the items. In addition, the maximum operating temperature range for the Flashing Furnace is 1000O F to 1600O F, which is well below the boiling point (and point of vaporization) of Lead (bp = 3164O F). Therefore, Lead emissions from this operation are not expected.

VOC emissions have been provided where data was available.

ATTACHMENT B



Northern Fenced Compound



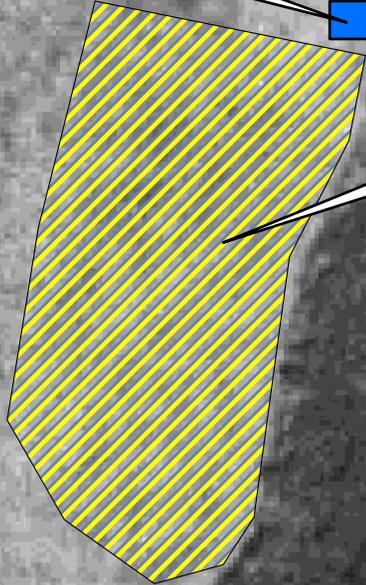
Hammer Mill



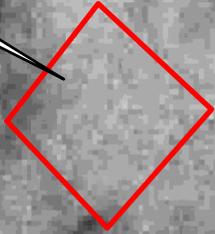
Shear



Area for Stockpiling Sheared MD and Downsized RRD



Southern Fenced Compound



Generator



Petrogen Torch Cutting



4000 Gallon Fuel Tank



Flashing Furnace



Cool Down Area for the Processed Trays



ATTACHMENT C

**Total Emissions from CPC Operations
(Petrogen Torch, Flashing Furnace, Generator and the HammerMill)**

Criteria Pollutants	Annual Emissions (tpy)
Carbon Monoxide (CO)	0.19
Nitrogen Oxides (NOx)	1.01
Particulate Matter (PM)	0.03
Sulfur Dioxide (SO ₂)	0.41
VOC	0.01
TOTAL	1.65

Petrogen Torch - Emission Calculations

Basis:

<i>Gasoline Usage:</i>	0.09	gallons/hr
<i>Hours of Operation:</i>	480	hr/yr (40 hours/month, 12 months/year)

Criteria Pollutants	Average Emission (lb/hr)	Annual Emissions (tpy)
Carbon Monoxide (CO)	0.02	0.00
Nitrogen Oxides (NOx)	0.02	0.00
Particulate Matter (PM)	0.00	0.00
Sulfur Dioxide (SO ₂)	0.06	0.01
VOC	0.00	0.00
Total	0.09	0.02

Flashing Furnace - Emission Calculations

Basis:

<i>Hours of Operation:</i>	72	hrs/yr (6 hours/month, 12 months/year)
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	Hourly Emissions	Yearly Emissions	
	Average Emission (lb/hr)	Annual Emissions (lbs/yr)	Annual Emissions (tpy)
Carbon Monoxide (CO)	0.05	3.60	0.00
Nitrogen Oxides (NOx)	0.22	15.84	0.01
Particulate Matter (PM)	0.33	23.76	0.01
Sulfur Dioxide (SO ₂)	0.60	43.20	0.02
Total	1.20	86.40	0.04

NOTES:

- * The TPU/Flashing Furnace, when flashing munitions debris (MD) or range related debris (RRD) will have only minimal emissions to the environment
- * The emissions data shown in the Table are provided by the Manufacturer and are based on previous emissions testing performed on similar projects

Diesel Generator - Emission Calculations

Basis:

<i>Engine Output:</i>	402	hp ¹
<i>Hours of Operation:</i>	480	hrs/yr (6 hours/day, 4 days/week, 20 weeks/year)

Criteria Pollutants	Emission Factor (g/hp-hr) ¹	Emission Factor (lb/hp-hr) ²	Average Emission (lb/hr)	Annual Emissions (tpy)
Carbon Monoxide (CO)	2.60E-01	0.001	0.23	0.06
Nitrogen Oxides (NOx)	4.02	0.009	3.56	0.86
Particulate Matter (PM)	7.50E-02	1.65E-04	0.07	0.02
Sulfur Dioxide (SO ₂)		2.05E-03	0.82	0.20
VOC	6.00E-02	1.32E-04	0.05	0.01
Total	4.42	0.01	4.74	1.14

¹Engine output was provided on Vendor Specification as 300kW. This was converted to hp.

²NOx, CO, PM-10, and VOC Emission Factors taken from Vendor Specifications dated April 16, 2006. SO₂ Emission Factor taken from AP-42, Section 3.3, Gasoline and Diesel Industrial Engines, Table 3.3.1, October 1996.

Hammer Mill - Emission Calculations

Basis:

<i>Engine Output:</i>	603	hp ¹
<i>Hours of Operation:</i>	72	hrs/yr (6 hours/month, 12 months/year)

Criteria Pollutants	Emission Factor (g/hp-hr)	Emission Factor (lb/hp-hr)	Average Emission (lb/hr)	Annual Emissions (tpy)
Carbon Monoxide (CO)	2.61E+00	0.006	3.47	0.12
Nitrogen Oxides (NOx)	2.98E+00	0.007	3.96	0.14
Particulate Matter (PM)	1.49E-01	3.28E-04	0.20	0.01
Sulfur Dioxide (SO2)	0.00E+00	8.09E-03	4.88	0.18
VOC	0.00E+00	0.00E+00	0.00	0.00
Total	5.74	0.02	12.51	0.45

¹Engine output was provided on Vendor Specification as 450kW. This was converted to hp.

**Emission Calculations for Diesel Generator at Camp Garcia
NAVFAC ATL Vieques Clean Up Program**

Intent: To calculate emissions from emergency or non-emergency generators rated less than 600 hp.

Process Data:	1) Emission Unit ID:	60 KW EPG		
	2) Location:	Camp Garcia, VQ		
	3) Quantity:	1		
	4) Maximum rated capacity (kW) :	60		
	5) Actual operation (hrs/yr)	100		
	6) Maximum operation (hrs/yr)	240		
	7) Maximum sulfur in fuel oil (% by wgt):	0.05%		
	8) Maximum rated capacity (hp) :	80	(kW * 1.341 hp/kW)	
	9) Actual/Maximum Design Capacity (MMBtu/hr):	0.561	(hp * (2547.16 Btu/hr-hp) / (1.0E+06 Btu/MMBtu)) / (0.3)	60
	10) Actual/Maximum Fuel Usage (gal/hr):	4.1	((7000 Btu/hp-hr) / (137080 btu/gal) x hp)	
	11) Actual Annual Consumption (gal/yr):	411	(actual/maximum fuel usage (gal/hr) x actual operation (hrs/yr))	

Methodology: 1) Apply AP-42 emission factors to given or calculated process data to estimate emissions.
Maximum operating hours based on 20 hrs per month.

References: 1) U.S. EPA, "Compilation of Air Pollutant Emission Factors, Volume I: Stationary Point and Area Sources; Fifth Edition," January 1995. (Tables 3.3-2 & 3.3-3).

Calculations:

Pollutants	Fuel Oil		Total for		1 generators	
	Emission Factor	Units	Actual Emissions		Potential Emissions	
			(lb/hr)	(ton/yr)	(lb/hr)	(ton/yr)
Particulate matter (PM10)^a	2.20E-03	lb/hp-hr	1.77E-01	8.85E-03	1.77E-01	2.12E-02
Sulfur oxides (SOx)	2.05E-03	lb/hp-hr	1.65E-01	8.25E-03	1.65E-01	1.98E-02
Nitrogen oxides (NOx)	0.031	lb/hp-hr	2.49E+00	1.25E-01	2.49E+00	2.99E-01
Carbon monoxide (CO)	6.68E-03	lb/hp-hr	5.37E-01	2.69E-02	5.37E-01	6.45E-02
Volatile organic compounds (VOC)	2.51E-03	lb/hp-hr	2.02E-01	1.01E-02	2.02E-01	2.43E-02
Benzene	9.33E-04	lb/MMBtu	5.25E-04	2.63E-05	5.25E-04	6.31E-05
Toluene	4.09E-04	lb/MMBtu	2.30E-04	1.15E-05	2.30E-04	2.76E-05
Xylenes	2.85E-04	lb/MMBtu	1.61E-04	8.03E-06	1.61E-04	1.93E-05
Naphthalene	8.48E-05	lb/MMBtu	4.78E-05	2.39E-06	4.78E-05	5.73E-06
1,3 Butadiene	3.91E-05	lb/MMBtu	2.20E-05	1.10E-06	2.20E-05	2.64E-06
Formaldehyde	1.18E-03	lb/MMBtu	6.65E-04	3.32E-05	6.65E-04	7.98E-05
Acetaldehyde	7.67E-04	lb/MMBtu	4.32E-04	2.16E-05	4.32E-04	5.18E-05
Acrolein	9.25E-05	lb/MMBtu	5.21E-05	2.60E-06	5.21E-05	6.25E-06
Total PAH	1.68E-04	lb/MMBtu	9.46E-05	4.73E-06	9.46E-05	1.14E-05
Total HAPs			1.70E-03	8.52E-05	1.70E-03	2.04E-04

0.43

^a All particulate is assumed to be equal to or less than 1 micron in size.

NOTE: When necessary, the average brake-specific fuel consumption value used to convert from lb/MMBtu to lb/hp-hr was 7,000 Btu/hp-hr.

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

Pollutant	Diesel Fuel (SCC 2-02-004-01)			Dual Fuel ^b (SCC 2-02-004-02)		
	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 SO₂. S₁ = % sulfur in fuel oil; S₂ = % sulfur in natural gas. For example, if sulfur content is 1.5%, then S = 1.5.

^e Assumes 100% conversion of carbon in fuel to CO₂ 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

^aBased 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.

^bHazardous 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)		Dual Fuel (SCC 2-02-004-02)	
		NO _x Reduction (%)	ΔBSFC ^b (%)	NO _x Reduction (%)	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 ₂ O/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.

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ATTACHMENT D

MASS AND MATERIAL BALANCE
ON EDE TPU

December 4, 2001

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Air Emission Calculations and Test Data on the Operation of the TPU

The Transportable Processing Unit (TPU), when flashing explosive contaminated metal will have only minimal emissions to the environment. The estimated emissions numbers shown in Table 1 below are based on past operating experience of a Contaminated Waste Processor (CWP, a different name for a similar system) and test data. It shows the particulate output of each substance in pounds per hour and per 8-hour. The basis for this data is attached.

Table 1. Estimated Emissions Rated From TPU

Emission Rate	Pounds / Hours	Pounds / 8 Hours
Particulate	0.33	2.6
Sulfur Dioxide (#2 Fuel Oil)	0.6	4.8
Sulfur Dioxide (#1 Fuel Oil)	0.4	3.0
Nitrogen Oxides	0.22	1.8
Organics	N/D	N/D
Carbon Monoxide	0.05	0.4
Lead	N/D	N/D
Other	N/D	N/D

N/D – Non-Detectable

ESTIMATED EMISSION LEVELS FROM A CONTAMINATED WASTE PROCESSOR (CWP)

1. Particulate

Based on attached test report, particulate emission levels on CWP burning waste were less than 0.032 gr/scf. For a natural draft system, exhaust rate is estimated at <1200 scfm. For flashing metal, emissions will be less than 25% that of combustibles.

$$\dot{m} = 0.032 \text{ gr/scf} \times 1200 \text{ ft}^3/\text{min} \times 60 \text{ min/hr} \times 1 \text{ lb}/7000\text{gr}$$

$$\begin{aligned} \text{Particulate: } \dot{m} &= 0.33 \text{ lb/hr} \\ \dot{m}_8 &= 2.6 \text{ lb/8 hrs} \\ \dot{m}_{24} &= 7.9 \text{ lb/24 hrs} \end{aligned}$$

Note: The actual emissions are generally 25% of listed values.

2. Carbon Monoxide

During above reference testing, CO emissions were "below detectable limits". Based on past experience on similar furnaces, the CO emissions are anticipated to be less than 10 ppm (or 11.6 mg/m³).

$$\dot{m} = 11.6 \text{ mg/m}^3 \times 0.0283 \text{ m}^3/\text{ft}^3 \times 1200 \text{ ft}^3/\text{min} \times 60 \text{ min/hr} \times 1 \text{ lb}/454,000 \text{ mg}$$

$$\begin{aligned} \text{CO Emissions: } \dot{m} &= 0.05 \text{ lb/hr} \\ \dot{m}_8 &= 0.4 \text{ lb/8 hrs} \\ \dot{m}_{24} &= 1.2 \text{ lb/24 hrs} \end{aligned}$$

3. Nitrogen Oxides

The NO_x levels measured during the test averaged 20 – 30 ppm and at no time did the peak exceed 40 ppm (or 50 mg/m³).

$$\dot{m} = 50 \text{ mg/m}^3 \times 0.0283 \text{ m}^3/\text{ft}^3 \times 1200 \text{ ft}^3/\text{min} \times 60 \text{ min/hr} \times 1 \text{ lb}/454,000 \text{ mg}$$

$$\begin{aligned} \text{NO}_x \text{ Emissions: } \dot{m} &= 0.05 \text{ lb/hr} \\ \dot{m}_8 &= 0.4 \text{ lb/8 hrs} \\ \dot{m}_{24} &= 1.2 \text{ lb/24 hrs} \end{aligned}$$

4. Sulfur Dioxide

The only sulfur for SO₂ emissions will come from the fuel oil being used. Typical fuel usage for this size system is 20 gal/hr.

(a) #2 Fuel Oil has sulfur content of 0.21%

$$\dot{m}_{s(\#2)} = 0.0021 \times 20 \text{ gal/hr} \times 7.21 \text{ lb/gal} = 0.30 \text{ lbs/hr}$$

$$\begin{aligned} \dot{m}_{\text{SO}_2} &= \dot{m}_s \times MW_{\text{SO}_2}/MW_s &= 0.30 \text{ lbs/hr} \times 64/32 \\ & &= 0.60 \text{ lbs/hr} \end{aligned}$$

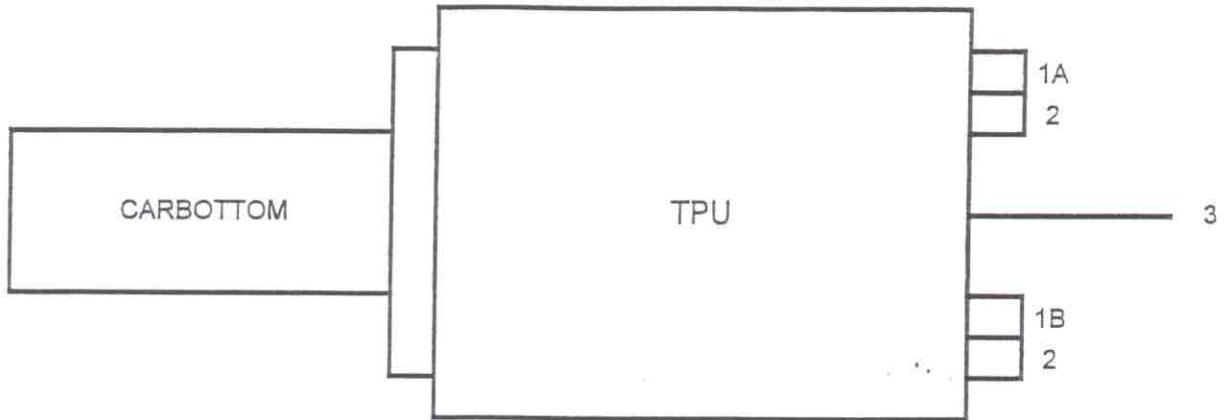
$$\begin{aligned} \text{\#2 Fuel Oil: } \dot{m} &= 0.6 \text{ lb/hr} \\ \dot{m}_8 &= 4.8 \text{ lb/8 hrs} \\ \dot{m}_{24} &= 14.4 \text{ lb/24 hrs} \end{aligned}$$

(b) #1 Fuel Oil has sulfur content of 0.14%

$$\dot{m}_{s(\#1)} = 0.0014 \times 20 \text{ gal/hr} \times 6.79 \text{ lb/gal} = 0.19 \text{ lbs/hr}$$

$$\begin{aligned} \dot{m}_{\text{SO}_2} &= \dot{m}_s \times MW_{\text{SO}_2}/MW_s &= 0.19 \text{ lbs/hr} \times 64/32 \\ & &= 0.38 \text{ lbs/hr} \end{aligned}$$

$$\begin{aligned} \text{\#1 Fuel Oil: } \dot{m} &= 0.38 \text{ lb/hr} \\ \dot{m}_8 &= 3.0 \text{ lb/8 hrs} \\ \dot{m}_{24} &= 9.1 \text{ lb/24 hrs} \end{aligned}$$



MASS BALANCE FOR TPU SYSTEM AT KAHO'OLAWA		STANDARD CONDITIONS			
Stream Number	-	1A	1B	2	3
Parameter	Units	Burner (S-1)	Burner (S-2)	Injector / Infiltr. Air	Stack
Fuel Oil (normal cond)	gph	10	10		
Combustion Air	SCFM	250	250		
Temperature	°F	70	70	70	1400
Density	lb/ft ³			0.075	0.0213
Design Flow	SCFM			~950	1200
Actual Flow	ACFM			~3961	4211
Design Mass Flow	lb/hr			~4210	5382

Assuming worst case contamination of 10 lbs propellant and 10 lbs explosive per batch –
estimated emissions from energetic materials

Calculations for 10 lbs. of propellant and 10 pounds of explosives are provided followed by
updated mass and material balance previously provided.

Reference Tactical Missile Static Firing Chamber August 2000 Report for Day & Zimmerman

Typical tactical missile propellant

- Chaparral: NG/HMX based propellant
- Dragon: double base propellant
- Hellfire: NG/HMX propellant
- Javelin: double base propellant
- Roland: double base propellant
- SS-11: double base propellant
- TOW: double base propellant
- TOW-2: double base propellant

Reference propellant combustion chemistry computer program based on NASA/Lewis Program. See attached computer run for double base propellant.

For 10 lbs. of propellant emission products are

CO ₂	8.3 lbs.
H ₂ O	2.4 lbs.
NO	0.16 lbs.
N ₂	55 lbs.
O ₂	14 lbs.

Note products include combustion air

No products of concern

TNT and Comp B have very similar products – see NASA/Lewis computer run for Comp B Donovan Detonation Chamber modeling attached.

10 lb. Explosive emission products

CO	.02 lbs. ¹
CO ₂	8.9 lbs.
H ₂ O	12.2 lbs.
N ₂	17 lbs.
O ₂	7 lbs.

No products of concern

¹ Modeling was for detonation chamber and does not include sufficient combustion air. CO will go to zero with sufficient air.

Hawthorn Run #2 NC/NG - 50 lbs

PROP	HF	DENSITY	WEIGHT	MOLES	VOLUME
NC	-173.7770	1.0000	.600	.0023	.60000E+00
NG	-90.7500	1.0000	.400	.0018	.40000E+00
AIR	.0000	1.0000	7.000	.0510	.70000E+01

GRAM ATOMS C H N O
/100 GRAMS .2366 .3301 4.9217 1.7431

ENTHALPY = -6.93746
DENSITY = 1.000
CHAMBER PRESSURE(PSIA) 14.700
EPSILON .000
ISP .000
ISP (VACUUM) .000
TEMPERATURE(K) 1216.908
MOLECULAR WGT 29.283
MOLES GAS/100G 3.415
CF .000
PEAE/M (SEC) .000
GAMMA 1.298
CP-PR C/100G-K 29.529
ENTROPY (*) 202.252
ENTH KCAL/100G -6.937
DENSITY (G/CC) 2.93334E-04
PROD MOL WT 29.283
GAS MOL WT 29.283
MOL PROD/100G 3.415
CP-G C/100G-K 29.529
RHO PROD(#/F3) .018
RHO GAS (#/F3) .018
ITERATIONS 19

GRAMS OF PRODUCT FOR 50.00 LBS OF MATERIAL BURNED

CO2	18892.40000000
H2O	5394.27700000
NO	38.24424000
N2	125061.00000000
O2	32052.50000000

BURN RATE = 1640.80 KCAL/SEC

Comp B Explosive

COMPUTER RUN DATE 10/ 8/1996

PROPELLANT	HF	DENSITY	WEIGHT	MOLES	VOLUME
COMP	1.2500	1.0000	1.000	.0100	.10000E+01
H2O	-68.3140	1.0000	1.000	.0555	.10000E+01
AIR	.0000	1.0000	1.850	.0135	.18500E+01

GRAM ATOMS	C	H	N	O
/100 GRAMS	.5307	3.5332	3.1895	2.8370
ENTHALPY =	-98.16824			
	DENSITY = 1.000			

CHAMBER

PRESSURE (PSIA)	14.700
EPSILON	.000
ISP	.000
ISP (VACUUM)	.000
TEMPERATURE (K)	1760.007
MOLECULAR WGT	25.650
MOLES GAS/100G	3.899
CF	.000
PEAE/M (SEC)	.000
GAMMA	1.226
CP-PR C/100G-K	41.990
ENTROPY (")	249.787
ENTH KCAL/100G	-98.168
DENSITY (G/CC)	1.77653E-04
PROD MOL WT	25.650
GAS MOL WT	25.650
MOL PROD/100G	3.899
CP-G C/100G-K	41.990
RHO PROD (#/F3)	.011
RHO GAS (#/F3)	.011
ITERATIONS	27

GRAMS OF PROD.
FOR 300.00 LBS OF MATERIAL BURNED

CO	274.39880000
CO2	121930.00000000
H	.10909080
HNO	.00118614
HNO2	.00221675
HNO2	.00187192
HO	110.89580000
HO2	.01528649
H2	18.11403000
HCOOH	.00009645
H2N	.00000839
H2O	166515.70000000
H2O2	.00910625
H3N	.00006246
NO	140.65430000
NO2	.04586704
N2	233983.50000000
N2O	.00767848
O	1.00971900
O2	928.16560000