ALPHA-GAMMA TECHNOLOGIES, INC.

MEMORANDUM

DATE: June 3, 2005

SUBJECT: Emission Reduction Associated with NSPS for Stationary CI ICE

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TO: Sims Roy, EPA OAQPS ESD Combustion Group

The purpose of this memorandum is to provide an estimate of the emission reduction of the proposed new source performance standards (NSPS) for stationary compression ignition (CI) internal combustion engines (ICE). This memorandum will also describe how emissions reductions were calculated and document the assumptions used.

The proposed NSPS is estimated to reduce nitrogen oxides (NO_x), particulate matter (PM), carbon monoxide (CO), sulfur dioxide (SO_2), non-methane hydrocarbons (NMHC), and hazardous air pollutants (HAP) in the year 2015 as shown in Table 1.

Table 1. Summary of Emissions Reductions in 2015

Pollutant	Emission Reduction in 2015 (tpy)[1]
NO_x	38,000
PM[2]	3,000
CO	18,000
SO_2	9,000
NMHC	600

[1]Note that the reductions shown in this table are not cumulative totals but are the reductions in the year 2015 only.

[2]All PM emissions are assumed to be smaller than 10 microns (PM_{10}) and $PM_{2.5}$ is assumed to compose 97 percent of PM_{10} emissions.

HAP	90

Background

The proposed NSPS for stationary CI engines will reduce emissions of NO_x, PM, CO, SO_2, NMHC, and HAP. It is estimated that NO_x adsorbers will reduce NO_x emissions by 90 percent. Similarly, it is estimated that catalyzed diesel particulate filters will reduce PM emissions by more than 90 percent and also reduce CO, NMHC, and HAP emissions by a significant amount. The emissions reductions for NO_x, PM, CO, NMHC, and HAP were estimated based on the difference between emissions with and without Tier 4 emission standards that require add-on control. Note that the proposed NSPS does not require emergency engines to meet Tier 4 emissions standards. The emission factors used to estimate the difference between controlled and uncontrolled levels for this estimate were obtained from documentation developed for the rule for nonroad diesel engines.[3] The emission factors used to estimate emissions reductions are attached to this memorandum as Appendix A. For CO, there is no emission standard based on add-on control, however, emissions of CO will be reduced through the use of other add-on controls necessary to achieve Tier 4 levels of NO_x and PM. It is estimated that CO will be reduced by about 90 percent.

Emissions of SO_2 will be reduced through the use of lower sulfur fuel. The proposed NSPS requires owners and operators to use diesel fuel containing 500 parts per million (ppm) sulfur or less starting October 1, 2007. More stringent fuel standards will be required starting October 1, 2010. Owners and operators must then use diesel fuel containing 15 ppm sulfur.

Emission Reduction

NO_x, PM, CO, NMHC

As mentioned, the emissions reductions were estimated based on the difference between emissions with and without Tier 4 emissions standards that require add-on control. For the purposes of estimating reductions associated with the NSPS, it was assumed that stationary CI engines would be emitting the same level of emissions as nonroad CI engines in the absence of a regulation up through Tier 2/3. That is, even in the absence of the NSPS, EPA would expect that stationary CI engines would be reducing the level of emissions due to the nonroad CI engine rule. For example, for engines between 75 and 100 horsepower (HP), Tier 2 for NO_x is in effect starting with the 2004 model year (MY), Tier 3 for NO_x starts with model year 2008, and Tier 4 for NO_x for these engines starts with 2014 MY engines. In this case, the emission

[3]US EPA. Exhaust and Crankcase Emission Factors for Nonroad Engine Modeling–Compression Ignition. EPA420-P-04-009. April 2004. NR-009c.

reduction would be calculated based on the difference between Tier 3 NO_x levels and Tier 4 NO_x levels. For other size engines, it may be Tier 2 that is the most stringent level prior to Tier 4, e.g., for engines greater than 750 HP, there is no Tier 3, therefore, the emission reduction would be the difference between Tier 2 NO_x levels and Tier 4 NO_x levels.

To calculate emissions, the following general equation was used:

$$\frac{EF_{pollutant} \times Size \times \frac{hrs}{yr} \times 0.0022046 \times Pop_{year}}{2{,}000} \quad (Equation\ 1)$$

where:

$EF_{pollutant}$	=	Pollutant emission factor, in units of grams per horsepower-hour (g/HP-hr),
Size	=	Average engine size, in units of HP,
hrs/yr	=	Average hours of operation (1,000 hrs/yr for prime engines; 37 hrs/yr for emergency engines),
0.0022046	=	Conversion factor, in units of lb/g,
Pop_{year}	=	Number of affected engines in applicable year, and
2,000	=	Conversion factor, in units of ton/lb.

Baseline emissions were calculated using emission factors corresponding to the tier levels required prior to Tier 4. Controlled emissions were calculated using emission factors corresponding to Tier 4 for prime engines (shown in yellow in Tables A-1 through A-5 of Appendix A). The average size used to calculate emissions for each HP range is shown in Appendix B. A sample calculation of the reduction of NO_x emissions in the year 2011 is shown in Appendix C.

SO_2

To calculate the reductions of SO_2 emissions, it was assumed that the current level of sulfur in diesel fuel used by stationary CI engines is 500 ppm. Reductions of SO_2 would occur as a result of requiring the use of 15 ppm sulfur fuel starting October 1, 2010. The net reduction of sulfur would be (500-15) ppm = 485 ppm sulfur, or 0.0485 percent sulfur. To calculate the reductions of SO_2 from stationary CI engines subject to the proposed rule, EPA consulted AP-42, section 3.4.[4] According to Table 3.4-1 of AP-42, emissions of SO_2 are 0.00809 lb/HP-hr times the percent sulfur in the

[4]US EPA. Emission Factor Documentation for AP-42 Section 3.4. April 1993.

fuel. It was assumed that all the sulfur in the fuel is converted to SO_2. The estimated reductions of SO_2 were calculated as follows:

$$\frac{0.00809 \; x \; 0.0485 \; x \; Size \; x \; \frac{hrs}{yr} \; x \; Pop_{year}}{2{,}000} \qquad (Equation\ 2)$$

where:

0.00809	=	SO_2 emission factor from AP-42, in units of lb/HP-hr,
0.0485	=	Sulfur content difference between 500 ppm and 15 ppm fuel, percent,
Size	=	Average engine size, in units of HP,
hrs/yr	=	Average hours of operation (1,000 hrs/yr for prime engines; 37 hrs/yr for emergency engines),
Pop_{year}	=	Number of affected engines in applicable year, and
2,000	=	Conversion factor, in units of ton/lb.

For example, EPA estimates there will be 8,538 prime engines between 50 and 75 HP affected by the rule in 2011. The SO_2 reduction for these engines in the year 2011 is calculated as follows:

(0.00809 lb/HP-hr x 0.0485 x 63 HP x 1,000 hrs/yr x 8,538) / 2,000 lb/ton = 105 tpy.

The SO_2 reduction for emergency engines is calculated in a similar fashion, replacing 1,000 hrs/yr with 37 hrs/yr and 8,538 with the population of new emergency engines in 2011 (34,150), yielding an SO_2 reduction for emergency engines between 50 and 75 HP in the year 2011 of 16 tpy. The total SO_2 reduction in the year 2011 for engines between 50 and 75 HP would therefore be (105+16) tpy = 121 tpy, as shown in Table 8.

HAP

To estimate the HAP reduction that would result from requiring stationary CI engines to comply with Tier 4 emissions levels, EPA consulted the Emissions Database that was developed for the National Emission Standards for Hazardous Air Pollutants (NESHAP) for stationary reciprocating internal combustion engines (RICE). The EPA used emission factors for HAP from diesel engines based on the RICE NESHAP database and selected five main pollutants to represent the emissions of HAP from stationary CI engines. The emission factors for these five pollutants are shown in Table 2.

Table 2. HAP Emission Factors for Stationary CI ICE

Pollutant	**Emission Factor (g/HP-hr)**
Formaldehyde	0.0123
Acetaldehyde	0.00921
PAH	0.00875
Naphtalene	0.00437
Acrolein	0.00437
Total HAP	**0.0390**

The RICE NESHAP database was developed some years ago and is assumed to represent the current HAP emission level from existing engines. The EPA therefore assumed that the total HAP emission factor in Table 2 would be equivalent to a Tier 1 HAP level. To determine the HAP level from new stationary CI engines, the EPA looked at the various tier levels for HC and calculated the percent reduction between each tier for HC. The EPA expects that the technologies used to meet the various tiers for HC will reduce HC and HAP emissions by similar percentages. The EPA, therefore, believed it was appropriate to apply the reduction of HC emissions to Tier 1 HAP levels to obtain HAP levels consistent with the different tier requirements. For example, the Tier 1 level for HC for engines between 50 and 75 HP is 0.5213 g/HP-hr. The Tier 2 level for HC for these engines is 0.3672 g/HP-hr. The difference between Tier 1 and Tier 2 for HC represents a reduction of about 30 percent. To estimate the Tier 2 level of HAP, EPA applied a 30 percent reduction to the Tier 1 HAP level, yielding a Tier 2 HAP level of 0.0275 g/HP-hr. To estimate the Tier 3 HAP level, EPA again looked at the HC percent reduction between Tier 2 and Tier 3 levels, and applied the percent reduction to the Tier 2 HAP level, and so on, resulting in the HAP emission factors shown in Table A-5 of Appendix A. The reduction of HAP as a result of the proposed rule was then calculated following the same methodology as previously described in this memorandum for NO_x, PM, CO, and NMHC.

Summary

The overall estimated NO_x, PM, CO, SO_2, NMHC, and HAP reductions as a result of the proposed rule are shown in Tables 3 through 9. All PM emissions are assumed to be smaller than 10 microns (PM_{10}). Furthermore, 97 percent of the PM is assumed to be smaller than 2.5 microns ($PM_{2.5}$). These assumptions are consistent with assumptions made for emissions modeling for nonroad CI engines.[3]

Table 3. NO_x Emission Reduction

HP Range	NO_x Emission Reduction (tpy)						
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
75-100	0	0	0	796	1,620	2,472	3,352
100-175	0	0	0	1,372	2,780	4,225	5,706
175-300	0	0	0	2,482	5,044	7,686	10,406
300-600	0	0	0	1,654	3,345	5,072	6,835
600-750	0	0	0	334	673	1,018	1,368
750-1,200	0	0	0	0	1,069	2,164	3,285
1,200-3,000	3,868	7,844	11,928	16,121	20,421	24,830	29,347
>3,000	642	1,284	1,926	2,568	3,210	3,852	4,494
Total	**4,510**	**9,128**	**13,854**	**25,327**	**38,163**	**51,318**	**64,793**

*There is no estimated NO_x reduction prior to 2011 since the earliest year engine manufacturers are required to certify engines based on add-on control will be the year 2011.
**There is no estimated NO_x reduction for engines less than 75 HP because Tier 4 for NO_x is not required for these engines.

Table 4. PM_{10} Emission Reduction

HP Range	PM_{10} Emission Reduction (tpy)						
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
50-75	0	0	21	43	66	89	113
75-100	0	79	161	246	334	425	519
100-175	0	123	250	380	513	650	790
175-300	142	289	441	598	761	928	1,100
300-600	98	198	300	405	512	621	733
600-750	20	41	61	82	104	126	148
750-1,200	31	63	96	130	193	257	323
1,200-3,000	67	135	205	277	411	548	689
>3,000	11	22	33	44	64	84	104

HP Range	PM_{10} Emission Reduction (tpy)						
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
Total	**369**	**950**	**1,570**	**2,207**	**2,958**	**3,728**	**4,519**

*There is no estimated PM reduction prior to 2011 since the earliest year engine manufacturers are required to certify engines based on add-on control will be the year 2011.

Table 5. $PM_{2.5}$ Emission Reduction

HP Range	$PM_{2.5}$ Emission Reduction (tpy)						
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
50-75	0	0	21	42	64	86	109
75-100	0	77	156	239	324	412	503
100-175	0	119	242	368	498	631	767
175-300	138	280	428	580	738	900	1,067
300-600	95	192	291	393	497	603	711
600-750	20	39	60	80	101	122	144
750-1,200	30	62	94	126	187	249	313
1,200-3,000	65	131	199	269	399	532	668
>3,000	11	21	32	43	62	82	101
Total	**359**	**921**	**1,523**	**2,140**	**2,870**	**3,617**	**4,383**

*There is no estimated PM reduction prior to 2011 since the earliest year engine manufacturers are required to certify engines based on add-on control will be the year 2011.

Table 6. NMHC Emission Reduction

HP Range	NMHC Emission Reduction (tpy)				
	2013	**2014**	**2015**	**2016**	**2017**
50-75	7	14	22	29	37
75-100	0	15	31	47	64
100-175	0	32	65	99	134
175-300	0	58	118	180	244
300-600	0	26	53	81	109
600-750	0	5	11	16	22
750-1,200	0	0	83	168	255
1,200-3,000	0	0	177	359	545
>3,000	0	0	26	53	79
Total	**7**	**152**	**587**	**1,034**	**1,491**

*There is no estimated NMHC reduction prior to 2013 since the earliest year any engine manufacturer is required to certify engines based on add-on control that would reduce NMHC will be in the year 2013.

Table 7. CO Emission Reduction

HP Range	CO Emission Reduction (tpy)						
	2011	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**
50-75	0	0	0	257	521	793	1,071
75-100	0	579	1,179	1,801	2,445	3,111	3,798
100-175	0	455	923	1,404	1,898	2,404	2,924
175-300	679	1,381	2,108	2,858	3,633	4,432	5,254
300-600	527	1,066	1,618	2,182	2,759	3,348	3,949
600-750	171	344	520	700	882	1,067	1,255
750-1,200	344	697	1,060	1,431	1,812	2,202	2,602
1,200-3,000	731	1,483	2,255	3,048	3,861	4,695	5,549
>3,000	121	243	364	486	607	728	850

HP Range	CO Emission Reduction (tpy)						
	2011	2012	2013	2014	2015	2016	2017
Total	**2,573**	**6,249**	**10,028**	**14,168**	**18,419**	**22,780**	**27,251**

*There is no estimated CO emission reduction prior to 2011 since the earliest year any engine manufacturer is required to certify engines based on add-on control will be the year 2011.

Table 8. SO_2 Emission Reduction

HP Range	SO_2 Emission Reduction (tpy)						
	2011	2012	2013	2014	2015	2016	2017
50-75	121	144	169	193	219	245	271
75-100	279	334	392	452	514	577	643
100-175	621	739	862	988	1,117	1,250	1,386
175-300	1,088	1,298	1,519	1,747	1,983	2,225	2,475
300-600	773	916	1,064	1,216	1,372	1,530	1,692
600-750	161	191	221	251	283	314	346
750-1,200	552	655	762	873	986	1,102	1,220
1,200-3,000	1,169	1,388	1,617	1,853	2,094	2,341	2,595
>3,000	207	243	279	315	351	387	423
Total	**4,973**	**5,909**	**6,886**	**7,889**	**8,917**	**9,972**	**11,053**

*Emission reduction based on requiring the use of 15 ppm sulfur fuel from October 1, 2010.

Table 9. HAP Emission Reduction

HP Range	HAP Emission Reduction (tpy)				
	2013	2014	2015	2016	2017
50-75	0.5	1	1	2	2
75-100	0	1	2	4	5
100-175	0	4	8	11	15
175-300	0	7	15	23	31
300-600	0	5	10	16	21

HP Range	HAP Emission Reduction (tpy)				
	2013	2014	2015	2016	2017
600-750	0	1	3	4	6
750-1,200	0	0	11	23	35
1,200-3,000	0	0	24	49	74
>3,000	0	0	18	36	54
Total	**0.5**	**20**	**93**	**168**	**244**

*There is no estimated HAP reduction prior to 2013 since the earliest year any engine manufacturer is required to certify engines based on add-on control that would reduce HAP will be in the year 2013.

Appendix A - Emission Factors

Table A-1. NO_x Emission Factors (g/HP-hr)

HP Range	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015+
50-75	4.7	4.7	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
75-100	4.7	4.7	3.0	3.0	3.0	3.0	3.0	3.0	0.276	0.276
100-175	4.1	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0.276	0.276
175-300	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0.276	0.276
300-600	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0.276	0.276
600-750	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	0.276	0.276
750-1,200	4.1	4.1	4.1	4.1	4.1	2.392	2.392	2.392	2.392	0.46
>1,200	4.1	4.1	4.1	4.1	4.1	0.46	0.46	0.46	0.46	0.46

Table A-2. PM Emission Factors (g/HP-hr)

HP Range	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015+
50-75	0.24	0.24	0.20	0.20	0.20	0.20	0.20	0.0184	0.0184	0.0184
75-100	0.24	0.24	0.30	0.30	0.30	0.30	0.0092	0.0092	0.0092	0.0092
100-175	0.18	0.22	0.22	0.22	0.22	0.22	0.0092	0.0092	0.0092	0.0092
175-300	0.15	0.15	0.15	0.15	0.15	0.0092	0.0092	0.0092	0.0092	0.0092
300-600	0.15	0.15	0.15	0.15	0.15	0.0092	0.0092	0.0092	0.0092	0.0092
600-750	0.15	0.15	0.15	0.15	0.15	0.0092	0.0092	0.0092	0.0092	0.0092
750-1,200	0.1316	0.1316	0.1316	0.1316	0.1316	0.069	0.069	0.069	0.069	0.0184
>1,200	0.1316	0.1316	0.1316	0.1316	0.1316	0.069	0.069	0.069	0.069	0.0184

Tier 2
Tier 3
Tier 4 Transitional
Tier 4 Final

Table A-3. CO Emission Factors (g/HP-hr)

HP Range	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015+
50-75	2.37	2.37	2.37	2.37	2.37	2.37	2.37	2.37	0.237	0.237
75-100	2.37	2.37	2.37	2.37	2.37	2.37	0.237	0.237	0.237	0.237
100-175	0.8667	0.8667	0.8667	0.8667	0.8667	0.8667	0.087	0.087	0.087	0.087
175-300	0.7475	0.7475	0.7475	0.7475	0.7475	0.075	0.075	0.075	0.075	0.075
300-600	0.8425	0.8425	0.8425	0.8425	0.8425	0.084	0.084	0.084	0.084	0.084
600-750	1.3272	1.3272	1.3272	1.3272	1.3272	0.133	0.133	0.133	0.133	0.133
750-1,200	0.7642	0.7642	0.7642	0.7642	0.7642	0.076	0.076	0.076	0.076	0.076
>1,200	0.7642	0.7642	0.7642	0.7642	0.7642	0.076	0.076	0.076	0.076	0.076

Table A-4. HC Emission Factors (g/HP-hr)

HP Range	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015+
50-75	0.3672	0.3672	0.1836	0.1836	0.1836	0.1836	0.1836	0.1314	0.1314	0.1314
75-100	0.3672	0.3672	0.1836	0.1836	0.1836	0.1836	0.1836	0.1836	0.1314	0.1314
100-175	0.3384	0.1836	0.1836	0.1836	0.1836	0.1836	0.1836	0.1836	0.1314	0.1314
175-300	0.1836	0.1836	0.1836	0.1836	0.1836	0.1836	0.1836	0.1836	0.1314	0.1314
300-600	0.1669	0.1669	0.1669	0.1669	0.1669	0.1669	0.1669	0.1669	0.1314	0.1314
600-750	0.1669	0.1669	0.1669	0.1669	0.1669	0.1669	0.1669	0.1669	0.1314	0.1314
750-1,200	0.1669	0.1669	0.1669	0.1669	0.1669	0.2815	0.2815	0.2815	0.2815	0.1314
>1,200	0.1669	0.1669	0.1669	0.1669	0.1669	0.2815	0.2815	0.2815	0.2815	0.1314

Tier 2
Tier 3
Tier 4 Transitional
Tier 4 Final

Table A-5. HAP Emission Factors (g/HP-hr)

HP Range	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015+
50-75	2.75E-02	2.75E-02	1.37E-02	1.37E-02	1.37E-02	1.37E-02	1.37E-02	9.84E-03	9.84E-03	9.84E-03
75-100	2.75E-02	2.75E-02	1.37E-02	1.37E-02	1.37E-02	1.37E-02	1.37E-02	1.37E-02	9.84E-03	9.84E-03
100-175	3.90E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	2.12E-02	1.52E-02	1.52E-02
175-300	2.32E-02	2.32E-02	2.32E-02	2.32E-02	2.32E-02	2.32E-02	2.32E-02	2.32E-02	1.66E-02	1.66E-02
300-600	3.22E-02	3.22E-02	3.22E-02	3.22E-02	3.22E-02	3.22E-02	3.22E-02	3.22E-02	2.53E-02	2.53E-02
600-750	4.42E-02	4.42E-02	4.42E-02	4.42E-02	4.42E-02	4.42E-02	4.42E-02	4.42E-02	3.48E-02	3.48E-02
750-1,200	2.28E-02	2.28E-02	2.28E-02	2.28E-02	2.28E-02	3.84E-02	3.84E-02	3.84E-02	3.84E-02	1.79E-02
>1,200	2.28E-02	2.28E-02	2.28E-02	2.28E-02	2.28E-02	3.84E-02	3.84E-02	3.84E-02	3.84E-02	1.79E-02

Tier 2
Tier 3
Tier 4 Transitional
Tier 4 Final

Appendix B - Average HP

Table B-1. Average HP

HP Range	Average HP
50-75	63
75-100	88
100-175	135
175-300	238
300-600	450
600-750	675
750-1,200	975
1,200-3,000	2,100
>3,000	5,000

Appendix C - Sample Calculation

Sample Calculation

The following calculation describes the methodology for estimating the reduction of NO_x emissions in the year 2011 from engines greater than 3,000 HP.

All stationary CI engines greater than 3,000 HP must meet Tier 2 emissions standards for NO_x starting with 2006 MY engines. Starting with the 2011 MY, non-emergency engines greater than 3,000 HP must meet Tier 4 emissions standards for NO_x. Emergency engines greater than 3,000 HP will continue to be required to meet Tier 2 NO_x emissions standards. As noted in the memorandum, it is assumed that in the absence of the proposed rule, stationary CI engines would still meet Tier 2 levels for NO_x, therefore, Tier 2 for NO_x for engines greater than 3,000 HP is considered the baseline level.

From Table A-1 of Appendix A, the Tier 2 NO_x emission factor for engines greater than 3,000 HP is 4.1 g/HP-hr. The total number of new stationary CI engines greater than 3,000 HP in 2006 is 160, of which 32 are prime and 128 are emergency. It is assumed that this growth is constant and will continue through the year 2015. It is assumed that an estimated 75 percent of 2006 MY engines will be subject to rule and that all 2007 through 2011 MY engines will be subject to the rule. The average size of engines greater than 3,000 HP from Table B-1 of Appendix B is 5,000 HP. As noted in the memorandum, the average hours of operation for prime engines is 1,000 hrs/yr and for emergency engines it is 37 hrs/yr.

1) The baseline emissions of NO_x for prime engines in 2006 are calculated as follows:

   4.1 g/HP-hr x 5,000 HP x 1,000 hrs/yr x 0.0022046 lb/g x 32 engines x 0.75 / 2,000 lb/ton

   = 542 tpy

2) The baseline emissions of NO_x for emergency engines in 2006 are calculated as follows:

   4.1 g/HP-hr x 5,000 HP x 37 hrs/yr x 0.0022046 lb/g x 128 engines x 0.75 / 2,000 lb/ton

   = 80 tpy

3) The total baseline emissions in the year 2006 is therefore:

   (542 + 80) tpy

= 623 tpy

4) The baseline emissions of NO_x in the year 2007 consist of NO_x emitted by 75% of 2006 MY engines (calculated in step 3) plus NO_x emitted by 2007 MY engines. NO_x emitted by 2007 MY engines are calculated as shown above in steps 1) through 3) replacing the number of 2006 MY engines with the number of 2007 MY engines, yielding 723 tpy for prime engines and 107 tpy for emergency engines, for a total of 830 tpy of NO_x emitted by 2007 MY engines. The baseline NO_x emissions in the year 2007 is (623+830) tpy = 1,453 tpy. The baseline NO_x emissions in the year 2008, 2009, etc. were calculated in the same manner using the Tier 2 NO_x level.

5) To calculate the controlled emissions of NO_x, the steps outlined above were followed, except that a Tier 4 NO_x level of 0.46 g/HP-hr (see Table A-1 of Appendix A) was used to calculate NO_x emissions from prime engines of 2011 MY. The baseline emissions (uncontrolled) of NO_x in the year 2010 was estimated at 3,943 tpy following the steps described above. The baseline emissions (uncontrolled) of NO_x in the year 2011 would be 4,773 tpy, in the absence of the rule requiring Tier 4 standards for 2011 MY prime engines.

6) The controlled emissions of NO_x for 2011 MY prime engines are calculated as follows:

0.46 g/HP-hr x 5,000 HP x 1,000 hrs/yr x 0.0022046 lb/g x 32 engines / 2,000 lb/ton

= 81 tpy

7) The emissions of NO_x for 2011 MY emergency engines are calculated as (remembering that emergency engines are not subject to Tier 4 levels):

4.1 g/HP-hr x 5,000 HP x 37 hrs/yr x 0.0022046 lb/g x 128 engines / 2,000 lb/ton

= 107 tpy

8) The total controlled emissions with the rule in effect from 2011 MY engines are therefore:

81 tpy + 107 tpy

= 188 tpy

9) Total emissions in the year 2011 with the rule in effect, which consists of 2006-2010 MY engines emitting 4.1 g/HP-hr of NO_x (Tier 2), 2011 MY prime engines emitting 0.46 g/HP-hr of NO_x (Tier 4) (calculated in step 6), and 2011 MY emergency engines emitting 4.1 g/HP-hr of NO_x (Tier 2) (calculated in step 7) are calculated as:

(3,943 + 188) tpy

= 4,131 tpy

10) The net NO_x reduction in the year 2011 as a result of implementing the rule is the difference between the emissions in 2011 without the rule (baseline) and the emissions in 2011 with the rule (calculated in step 9) as follows:

(4,773 - 4,131) tpy

= 642 tpy

as shown in Table 3 of this memorandum.