MEMORANDUM

DATE: June 29, 2010

SUBJECT: Control Costs for Existing Stationary SI RICE

FROM: Bradley Nelson, EC/R, Inc.

TO: Melanie King, EPA OAQPS/SPPD/ESG

1.0 PURPOSE

The purpose of this memorandum is to present information on the costs of control technology options for reducing hazardous air pollutants (HAP) emissions from existing stationary spark ignition (SI) reciprocating internal combustion engines (RICE). The memorandum will look at the cost of retrofitting control technology on existing engines. This information will be used to determine national impacts associated with the final rule.

2.0 INTRODUCTION

EPA has determined that oxidation catalysts for two-stroke lean burn (2SLB) and four-stroke lean burn (4SLB) engines, and non-selective catalytic reduction (NSCR) for four-stroke rich burn (4SRB) engines are applicable controls for HAP reduction from existing stationary SI RICE. To determine the capital and annual costs for these control technologies, equipment cost information was obtained from industry groups[1] and vendors and manufacturers of SI engine control technology. In some cases, the industry groups provided a breakdown of the capital and annual cost components for each of the retrofit options. Using this cost data, annualized cost and capital cost equations for oxidation catalysts and NSCR were developed.

[1] Reciprocating Internal Combustion Engine National Emission Standards for Hazardous Air Pollutants (RICE NESHAP) Proposed Revisions – Emission Control Costs Analysis Background for "Above the Floor" Emission Controls for Natural Gas-Fired RICE, Innovative Environmental Solutions Inc., October 2009. (EPA-HQ-OAR-2008-0708-0279) .

3.0 CONTROL COST METHODOLOGY

The following sections describe the methodology used to derive the total capital and total annual costs for each of the control technology options. These methodologies were used to calculate total capital and total annual costs when only purchased equipment costs were available (e.g., vendor equipment costs). The methodologies were not used for cost data provided by industry groups because they included a breakdown of the actual total capital and total annual costs. A summary of the methodologies, equations, and assumptions used to estimate the total capital and total annual costs for some of the costs data are described in the following sections.

3.1 Total Capital Costs

The total capital cost includes the direct and indirect costs of purchasing and installing the control equipment. The direct cost includes the cost of purchasing the equipment and instrumentation, cost of shipping, and the cost of installing the control equipment. The indirect cost includes the costs for engineering, contractor fees, testing costs, and also includes costs for contingencies, such as additional modifications, or delays in startup. The total capital cost equation can be summarized as follows:

Total Capital Cost (TCC) = Direct Costs (DC) + Indirect Costs (IC)

The direct costs include the costs of purchasing and installing the control equipment and can be summarized using the following equation;

DC = Purchased Equipment Cost (PEC) + Direct Installation Costs (DIC).

A summary of the cost assumptions for PEC includes the following:

- Control Device and Auxiliary Equipment (EC);
- Instrumentation (10% of EC);
- Sales Tax (3% of EC);
- Freight (5% of EC);

and can be summarized as:

PEC = 118% EC.

A summary of the cost assumptions for DIC includes the following:

- Foundations and Supports (8% of PEC);
- Handling and Erection (14% of PEC);
- Electrical (4% of PEC);
- Piping (2% of PEC);
- Insulation for Ductwork (1% of PEC);

- Painting (1% of PEC);

and can be summarized as:

DIC = 30% PEC = 0.3 PEC.

Therefore, the direct costs can be simplified using the following equation:

DC = PEC + 0.3 PEC = 1.3 PEC.

The indirect costs include the costs of engineering and contractor fees and contingencies and can be summarized using the following equation:

IC = Indirect Installation Costs (ICC) + Contingencies (C).

A summary of the cost assumptions for ICC includes the following:

- Engineering (10% of PEC);
- Construction and Field Expenses (5% of PEC);
- Contractor Fees (10% of PEC);
- Startup (2% of PEC);
- Performance Test (1% of PEC);

and can be summarized as:

IIC = 28% PEC = 0.28 PEC.

A summary of the cost assumptions for C includes the following:

- Equipment Redesign and Modifications;
- Cost Escalations;
- Delays in Startup;

and is assumed to be:

C = 3% PEC = 0.03 PEC.

Therefore, the IC can be summarized using the following equation:

IC = 0.28 PEC + 0.03 PEC = 0.31 PEC,

and the simplified TCC equation can be expressed as:

TCC = 1.3 PEC + 0.31 PEC = 1.61 PEC = 1.61 (1.18 EC) = 1.9 EC

3.2 Total Annual Costs

The total annual cost includes the direct and indirect annual costs of operating and maintaining the control equipment. The direct annual cost includes the cost of the utilities, operating labor, and control device cleaning and maintenance. The indirect annual cost includes the overhead costs such as spare parts for the control equipment, administrative charges, and the capital recovery of the control technology. The total annual cost equation can be summarized as follows:

Total Annual Cost (TAC) = Direct Annual Costs (DAC) + Indirect Annual Costs (IAC).

The DAC includes the following parameters:

- Utilities;
- Operating Labor;
- Maintenance;
- Annual Compliance Test;
- Catalyst Cleaning;
- Catalyst Replacement;
- Catalyst Disposal.

The IAC includes the following parameters:

- Overhead;
- Fuel Penalty;
- Property Tax;
- Insurance;
- Administrative Charges;
- Capital Recovery = $\{I(1+I)^n/((1+I)^n-1)*TCC\}$ where I is the interest rate, and n is the equipment life.

To calculate DAC, the costs were broken up into three separate costs: operation and maintenance materials cost, operation and maintenance labor cost, and the cost for annual performance testing or downtime or allowance for catalyst washing. Actual annual cost data from the industry groups were used to estimate the DAC for each of the control technologies. The IAC was broken up into three separate costs: administrative, fuel penalty, and capital recovery. Again, cost data from the industry groups was used to estimate these costs for each of the control technologies. No fuel penalty was estimated for the oxidation catalyst control technologies, because this control technology does not increase the fuel usage of the SI engine.

4.0 CONTROL COST EQUATIONS

Control cost equations were developed for 2SLB oxidation catalyst, 4SLB oxidation catalyst, and a NSCR for 4SRB engines using the total capital cost and total annual cost data for each control technology. Control cost equations for 2SLB and 4SLB oxidation catalysts were developed separately because the 2SLB oxidation catalyst requires a premium catalyst to reduce the HAP compounds because of the low exhaust temperature of 2SLB engines.

4.1 2SLB Oxidation Catalyst

The 2SLB oxidation catalyst is an effective control technology that reduces HAP emissions from a 2SLB SI engine by oxidizing organic compounds using a catalyst. The oxidation catalyst unit contains a honeycomb-like structure or substrate with a large surface area that is coated with a premium active catalyst layer, such as, platinum or palladium. The oxidation catalyst works by oxidizing carbon monoxide (CO) and gaseous hydrocarbons (HAP) in the exhaust gas to carbon dioxide (CO_2) and water. The reduction of CO and HAP varies depending on the type of catalyst used and the exhaust temperature of the pollutant stream.

The cost of retrofitting an oxidation catalyst to an existing 2SLB engine was estimated using cost data obtained from vendors and industry groups covering engines ranging from 58 horsepower (HP) to 4,670 HP. An equipment life of 10 years and an interest rate of 7 percent were used to estimate the capital recovery of the control technology and the fuel penalty was assumed to be negligible. The cost equations are presented in 2009 dollars.

The total annualized cost equation for retrofitting an oxidation catalyst on a 2SLB engine was estimated to be:

2SLB Oxidation Catalyst Total Annual Cost = \$11.4 x HP + \$13,928

where;

HP = engine size in HP.

The linear equation has a correlation coefficient of 0.8046, which shows the data fits the equation closely. Therefore, this equation was used to estimate annualized cost for an oxidation catalyst on a 2SLB engine.

The total capital cost equation for retrofitting an oxidation catalyst on a 2SLB engine was estimated to be:

2SLB Oxidation Catalyst Total Capital Cost = \$47.1 x HP + \$41,603

where;

HP = engine size in HP.

A summary of the cost calculations, regression analyses, and graphical representations of the annual and capital cost data are presented in Appendix A.

4.2 4SLB Oxidation Catalyst

The 4SLB oxidation catalyst is an effective control technology that reduces HAP emissions from a 4SLB SI engine by oxidizing organic compounds using a catalyst. The oxidation catalyst unit contains a honeycomb-like structure or substrate with a large surface area that is coated with a premium active catalyst layer, such as, platinum or palladium. The oxidation catalyst works by oxidizing CO and gaseous hydrocarbons (HAP) in the exhaust gas to CO_2 and water. The reductions of CO and HAP vary depending on the type of catalyst used and the exhaust temperature of the pollutant stream.

The cost of retrofitting an oxidation catalyst to an existing 4SLB engine was estimated using cost data obtained from vendors and industry groups covering engines ranging from 400 HP to 8,000 HP. Again, an equipment life of 10 years and an interest rate of 7 percent were used to estimate the capital recovery of the control technology and the fuel penalty was assumed to be negligible. The cost equations are presented in 2009 dollars.

The total annualized cost equation for retrofitting an oxidation catalyst on a 4SLB engine was estimated to be:

4SLB Oxidation Catalyst Total Annual Cost = \$1.81 x HP + \$3,442

where;

HP = engine size in HP.

The linear equation has a correlation coefficient of 0.9779, which shows the data fits the equation very closely. Therefore, this equation was used to estimate annualized cost for an oxidation catalyst on a 4SLB engine.

The total capital cost equation for retrofitting an oxidation catalyst on a 4SLB SI engine was estimated to be:

4SLB Oxidation Catalyst Total Capital Cost = \$12.8 x HP + \$3,069

where;

HP = engine size in HP.

A summary of the cost calculations, regression analyses, and graphical representations of the annual and capital cost data are presented in Appendix A.

4.3 Non-Selective Catalytic Reduction

The NSCR or three-way catalyst is used to control HAP emissions from 4SRB engines. In addition to HAP reductions, NSCR also reduces the emissions of nitrogen oxides (NO_x), CO, and other hydrocarbons (HC). The reduction of HAP and CO takes place through an oxidation reaction that converts HAP to CO_2 and water and converts CO to CO_2. The conversion of NO_x takes place through a reduction of the NO_x to nitrogen gas and oxygen.

The cost of retrofitting an NSCR on an existing 4SRB engine was estimated based on cost data received from vendors and industry groups. A linear regression analysis was done on the data set and the linear equation for annualized cost was;

$$\text{NSCR Annual Cost} = \$4.77 \times \text{HP} + \$5{,}679$$

where;

HP = engine size in HP.

The linear equation has a correlation coefficient of 0.7987, which shows an acceptable representation of the cost data. Therefore, this equation was used to estimate annualized cost for retrofitting the NSCR control technology on 4SRB engines.

The capital cost equation for retrofitting an air-to-fuel ratio (AFR) controller and NSCR on a 4SRB engine was estimated to be:

$$\text{NSCR Capital Cost} = \$24.9 \times \text{HP} + \$13{,}118$$

where;

HP = engine size in HP.

A summary of the cost calculations, regression analyses, and graphical representations of the annual and capital cost data are presented in Appendix A.

5.0 SUMMARY

The following table presents a summary of the annual and capital control costs as a function of engine size for the control technologies applicable to existing stationary SI engines, as discussed in this memorandum.

Table 1. Summary of Annual and Capital Costs Equations for Existing Stationary SI Engines

HAP Control Device	Annual Cost ($2009)	Capital Cost ($2009)
2SLB Oxidation Catalyst	$11.4 x HP + $13,928	$47.1 x HP + $41,603
4SLB Oxidation Catalyst	$1.81 x HP + $3,442	$12.8 x HP + $3,069
NSCR	$4.77 x HP + $5,679	$24.9 x HP + $13,118

6.0 References

Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment N (EPA-HQ-OAR-2008-0708-0279).

Email from Bruce Chrisman, Cameron's Compression Systems to Tanya Parise, EC/R, Subject: Existing RICE NESHAP - Information for EPA for 2SLB Engines, October 16, 2009.

Email from James Harrison, Exterran to Melanie King, EPA, Subject: 2SLB - Cameron oxidation catalyst pricing, October 20, 2009.

Anadarko Petroleum Corporation Comments on the Proposed Revisions to the National Emission Standard for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines, June 2, 2009, Case Study (EPA-HQ-OAR-2008-0708-0186).

Email from Mike Leonard, Miratech Corporation to Brenda Riddle, AGTI, RE: Clarification of SCR Cost Information for EPA, July 20, 2005. (EPA-HQ-OAR-2005-0030-0086).

Email from Antonio Santos, MECA to Tanya Parise, EC/R, Subject: EPA Proposed Existing RICE NESHAP - Cost of Aftertreatment, October 2, 2009. Response #2.

Price quote from Charles Ball, Emissions & Silencer Technology for an oxidation catalyst for a 500 HP 4SLB engine.

Memorandum from Tom McGrath, IES to Brad Nelson, EC/R, Request for Additional Cost Detail for Gas-Fired Engines Emission Controls, April 19, 2010.

Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment D (EPA-HQ-OAR-2008-0708-0279).

Email from Nick Huff, Miratech to Jennifer Synder, AGTI, SCR Questions for RICE MACT, October 23, 2003 (EPA-HQ-OAR-2005-0029-0038).

Email from Mike Leonard, Miratech to Brad Nelson, AGTI, Information Request, July 21, 2005 (EPA-HQ-OAR-2005-0030-0087).

Four Corners Air Quality Task Force Report of Mitigation Options, November 1, 2007. Mitigation Option: Use of NSCR/3-Way Catalysts and Air/Fuel Ratio Controllers on Rich Burn Stoichiometric Engines (EPA-HQ-OAR-2008-0708-0009).

Appendix A

Control Cost Summary and Linear Regression Statistics

2SLB Oxidation Catalyst Cost ($2009)

		Direct Costs		Indirect Costs			Direct Annual Costs			Indirect Annual Costs					
Engine Size (HP)	**Equipment Cost**	**PEC**	**DIC**	**IIC**	**C**	**Total Capital Cost**	**O&M Materials**	**O&M Labor**	**Total Direct Annual Cost (TDAC)**	**Administrative Charges (ADMC)**	**Fuel Penalty (FPC)**	**Capital Recovery (CRC)**	**Total Indirect Annual Cost (TIAC)**	**Total Annual Cost**	**Data Source**
296	$24,987	$29,485	$8,845	$8,256	$885	$47,470	$7,958	$875	$8,833	$225	$0	$6,759	$6,984	$15,817	Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment N (EPA-HQ-OAR-2008-0708-0279)
192	$24,987	$29,485	$8,845	$8,256	$885	$47,470	$7,958	$875	$8,833	$225	$0	$6,759	$6,759	$15,592	Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment N (EPA-HQ-OAR-2008-0708-0279)
384	$30,409	$35,883	$10,765	$10,047	$1,076	$57,771	$7,958	$875	$8,833	$225	$0	$8,225	$8,225	$17,058	Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment N (EPA-HQ-OAR-2008-0708-0279)
800	$50,901	$60,063	$18,019	$16,818	$1,802	$96,702	$7,958	$875	$8,833	$225	$0	$13,768	$13,768	$22,601	Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment N (EPA-HQ-OAR-2008-0708-0279)
58	$12,191	$14,385	$4,316	$4,028	$432	$23,160	$7,958	$875	$8,833	$225	$0	$3,298	$3,298	$12,131	Email from Bruce Chrisman, Cameron's Compression Systems to Tanya Parise, EC/R, Subject: Existing RICE NESHAP - Information for EPA for 2SLB Engines, October 16, 2009
600	$51,378	$60,626	$18,188	$16,975	$1,819	$97,608	$7,958	$875	$8,833	$225	$0	$13,897	$14,122	$22,955	Email from Bruce Chrisman, Cameron's Compression Systems to Tanya Parise, EC/R, Subject: Existing RICE NESHAP - Information for EPA for 2SLB Engines, October 16, 2009
148	$14,589	$17,215	$5,165	$4,820	$516	$27,716	$7,958	$875	$8,833	$225	$0	$3,946	$4,171	$13,004	Email from James Harrison, Exterran to Melanie King, EPA, Subject: 2SLB - Cameron oxidation catalyst pricing, October 20, 2009
296	$22,123	$26,105	$7,832	$7,309	$783	$42,029	$7,958	$875	$8,833	$225	$0	$5,984	$6,209	$15,042	Email from James Harrison, Exterran to Melanie King, EPA, Subject: 2SLB - Cameron oxidation catalyst pricing, October 20, 2009
192	$14,589	$17,215	$5,165	$4,820	$516	$27,716	$7,958	$875	$8,833	$225	$0	$3,946	$4,171	$13,004	Email from James Harrison, Exterran to Melanie King, EPA, Subject: 2SLB - Cameron oxidation catalyst pricing, October 20, 2009
384	$22,123	$26,105	$7,832	$7,309	$783	$42,029	$7,958	$875	$8,833	$225	$0	$5,984	$6,209	$15,042	Email from James Harrison, Exterran to Melanie King, EPA, Subject: 2SLB - Cameron oxidation catalyst pricing, October 20, 2009
600	$30,409	$35,883	$10,765	$10,047	$1,076	$57,771	$7,958	$875	$8,833	$225	$0	$8,225	$8,450	$17,283	Email from James Harrison, Exterran to Melanie King, EPA, Subject: 2SLB - Cameron oxidation catalyst pricing, October 20, 2009
800	$37,871	$44,688	$13,406	$12,513	$1,341	$71,947	$7,958	$875	$8,833	$225	$0	$10,244	$10,469	$19,302	Email from James Harrison, Exterran to Melanie King, EPA, Subject: 2SLB - Cameron oxidation catalyst pricing, October 20, 2009
3850						$210,000			$25,000	$225	$0	$29,899	$30,124	$55,124	Anadarko Petroleum Corporation Comments on the Proposed Revisions to the National Emission Standard for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines, June 2, 2009, Case Study (EPA-HQ-OAR-2008-0708-0186). Cost is for installation on a Clark TLAD-8 2SLB gas compressor engine.
4670						$210,000			$25,000	$225	$0	$29,899	$30,124	$55,124	Anadarko Petroleum Corporation Comments on the Proposed Revisions to the National Emission Standard for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines, June 2, 2009, Case Study (EPA-HQ-OAR-2008-0708-0186). Cost is for installation on a Cooper Bessemer 2SLB gas compressor engine.
2166						$210,000			$25,000	$225	$0	$29,899	$30,124	$55,124	Anadarko Petroleum Corporation Comments on the Proposed Revisions to the National Emission Standard for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines, June 2, 2009, Case Study (EPA-HQ-OAR-2008-0708-0186). Cost is for installation on a MEP 2SLB gas compressor engine.
1859						$210,000			$25,000	$225	$0	$29,899	$30,124	$55,124	Anadarko Petroleum Corporation Comments on the Proposed Revisions to the National Emission Standard for Hazardous Air Pollutants for Reciprocating Internal Combustion Engines, June 2, 2009, Case Study (EPA-HQ-OAR-2008-0708-0186). Cost is for installation on a MEP 2SLB gas compressor engine.

Assumptions:

PEC = 118% of purchased equipment cost (PEC).

DIC = 30% of purchased equipment cost (PEC).

IIC = 28% of purchased equipment cost (PEC).

C = 3% of purchased equipment cost (PEC).

Capital Recovery assumes equipment life of 10 years and 7% interest rate. 0.142377503

O&M Materials cost covers the annualized equipment cost to replace the catalyst (every 3 years), thermocouples (every 7.5 years), crankcase filters (3 months), and annual catalyst rotation for cleaning. [Source: Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment N (EPA-HQ-OAR-2008-0708-0279)]

O&M Labor cost covers the annualized labor cost to replace and rotate (for cleaning) catalyst, thermocouples, and crankcase filter. [Source: Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment N (EPA-HQ-OAR-2008-0708-0279)]

2SLB Oxidation Catalyst Cost ($2009)

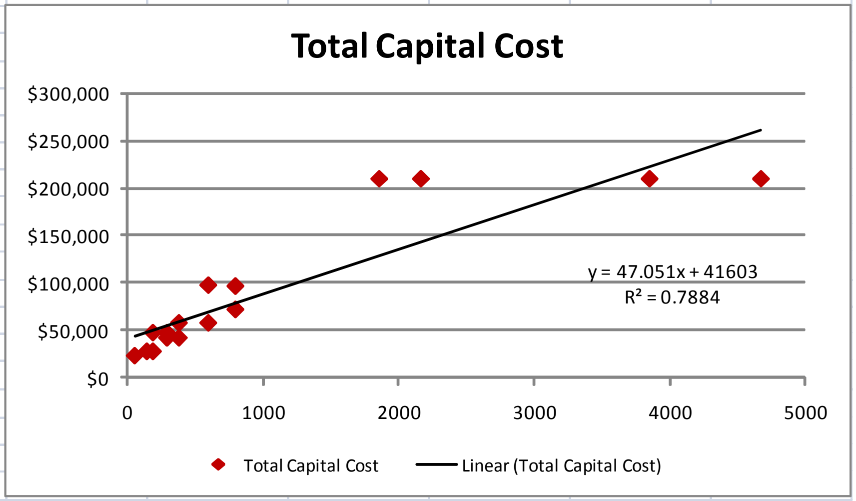
SUMMARY OUTPUT - Capital Cost

Regression Statistics	
Multiple R	0.887931512
R Square	0.788422369
Adjusted R Squa	0.773309682
Standard Error	34869.66159
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	63432625775	63432625775	52.16956604	4.40556E-06
Residual	14	17022506190	1215893299		
Total	15	80455131965			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	41602.60574	11206.04006	3.712516244	0.002319141	17568.04028	65637.1712
X Variable 1	47.0511302	6.514205394	7.222850271	4.40556E-06	33.07954923	61.02271117



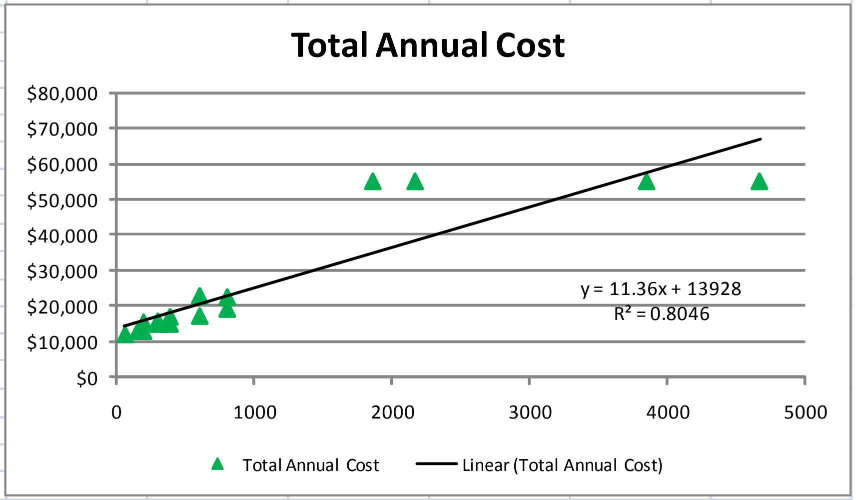
SUMMARY OUTPUT - Annual Cost

Regression Statistics	
Multiple R	0.896978958
R Square	0.804571251
Adjusted R Squa	0.790612055
Standard Error	8009.912446
Observations	16

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	3697938056	3697938056	57.63736182	2.5054E-06
Residual	14	898221763.5	64158697.39		
Total	15	4596159819			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	13928.11988	2574.140259	5.410785147	9.1811E-05	8407.138137	19449.10162
X Variable 1	11.3603976	1.496378585	7.591927411	2.5054E-06	8.150984738	14.56981046



4SLB Oxidation Catalyst Cost ($2009)

		Direct Costs		Indirect Costs			Direct Annual Costs			Indirect Annual Costs					
Engine Size (HP)	Equipment Cost	PEC	DIC	IIC	C	Total Capital Cost	O&M Materials	O&M Labor	Total Direct Annual Cost (TDAC)	Administrative Charges (ADMC)	Fuel Penalty (FPC)	Capital Recovery (CRC)	Total Indirect Annual Cost (TIAC)	Total Annual Cost	Data Source
500	$6,361	$7,505	$2,252	$2,102	$225	$12,084	$1,891	$1,053	$2,944	$225	$0	$1,720	$1,945	$4,889	Email from Mike Leonard, Miratech Corporation to Brenda Riddle, AGTI, RE: Clarification of SCR Cost Information for EPA, July 20, 2005. (EPA-HQ-OAR-2005-0030-0086). Costs converted from $2005 to $2009 using the Marshall and Swift Equipment Cost Index.
1000	$8,178	$9,650	$2,895	$2,702	$289	$15,536	$1,891	$1,053	$2,944	$225	$0	$2,212	$2,212	$5,156	Email from Mike Leonard, Miratech Corporation to Brenda Riddle, AGTI, RE: Clarification of SCR Cost Information for EPA, July 20, 2005. (EPA-HQ-OAR-2005-0030-0086). Costs converted from $2005 to $2009 using the Marshall and Swift Equipment Cost Index.
2000	$13,193	$15,568	$4,670	$4,359	$467	$25,064	$1,891	$1,053	$2,944	$225	$0	$3,569	$3,569	$6,513	Email from Mike Leonard, Miratech Corporation to Brenda Riddle, AGTI, RE: Clarification of SCR Cost Information for EPA, July 20, 2005. (EPA-HQ-OAR-2005-0030-0086). Costs converted from $2005 to $2009 using the Marshall and Swift Equipment Cost Index.
3000	$16,769	$19,787	$5,936	$5,540	$594	$31,857	$1,891	$1,053	$2,944	$225	$0	$4,536	$4,536	$7,480	Email from Mike Leonard, Miratech Corporation to Brenda Riddle, AGTI, RE: Clarification of SCR Cost Information for EPA, July 20, 2005. (EPA-HQ-OAR-2005-0030-0086). Costs converted from $2005 to $2009 using the Marshall and Swift Equipment Cost Index.
5000	$33,608	$39,658	$11,897	$11,104	$1,190	$63,849	$1,891	$1,053	$2,944	$225	$0	$9,091	$9,091	$12,035	Email from Mike Leonard, Miratech Corporation to Brenda Riddle, AGTI, RE: Clarification of SCR Cost Information for EPA, July 20, 2005. (EPA-HQ-OAR-2005-0030-0086). Costs converted from $2005 to $2009 using the Marshall and Swift Equipment Cost Index.
8000	$58,697	$69,262	$20,779	$19,393	$2,078	$111,512	$1,891	$1,053	$2,944	$225	$0	$15,877	$15,877	$18,821	Email from Mike Leonard, Miratech Corporation to Brenda Riddle, AGTI, RE: Clarification of SCR Cost Information for EPA, July 20, 2005. (EPA-HQ-OAR-2005-0030-0086). Costs converted from $2005 to $2009 using the Marshall and Swift Equipment Cost Index.
1000	$8,500	$10,030	$3,009	$2,808	$301	$16,148	$1,891	$1,053	$2,944	$225	$0	$2,299	$2,524	$5,468	Email from Antonio Santos, MECA to Tanya Parise, EC/R, Subject: EPA Proposed Existing RICE NESHAP - Cost of Aftertreatment, October 2, 2009. Response #2
500	$3,700	$4,366	$1,310	$1,222	$131	$7,029	$1,891	$1,053	$2,944	$225	$0	$1,001	$1,001	$3,945	Price quote from Charles Ball, Emissions & Silencer Technology for an oxidation catalyst for a 500 HP 4SLB engine.
400		$6,575	$2,961	$2,005		$11,541	$1,958	$1,143	$3,101	$225	$0	$1,643	$1,643	$4,744	Memorandum from Tom McGrath, IES to Brad Nelson, EC/R, Request for Additional Cost Detail for Gas-Fired Engines Emission Controls
400		$6,575	$2,961	$2,005		$11,541	$1,958	$1,143	$3,101	$225	$0	$1,643	$1,643	$4,744	Memorandum from Tom McGrath, IES to Brad Nelson, EC/R, Request for Additional Cost Detail for Gas-Fired Engines Emission Controls
425		$7,149	$3,025	$2,005		$12,179	$1,756	$875	$2,631	$225	$0	$1,734	$1,734	$4,365	Memorandum from Tom McGrath, IES to Brad Nelson, EC/R, Request for Additional Cost Detail for Gas-Fired Engines Emission Controls

Assumptions:
PEC = 118% of purchased equipment cost (PEC).
DIC = 30% of purchased equipment cost (PEC).
IIC = 28% of purchased equipment cost (PEC).
C = 3% of purchased equipment cost (PEC).
Capital Recovery assumes equipment life of 10 years and 7% interest rate. 0.142377503
O&M Materials cost covers the annualized equipment cost to replace the catalyst (every 3 years), thermocouples (every 7.5 years), crankcase filters (3 months), and annual catalyst rotation for cleaning. [Source: Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment L (EPA-HQ-OAR-2008-0708-0279)]
O&M Labor cost covers the annualized labor cost to replace and rotate (for cleaning) catalyst, thermocouples, and crankcase filter. [Source: Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment L (EPA-HQ-OAR-2008-0708-0279)]

4SLB Oxidation Catalyst Cost ($2009)

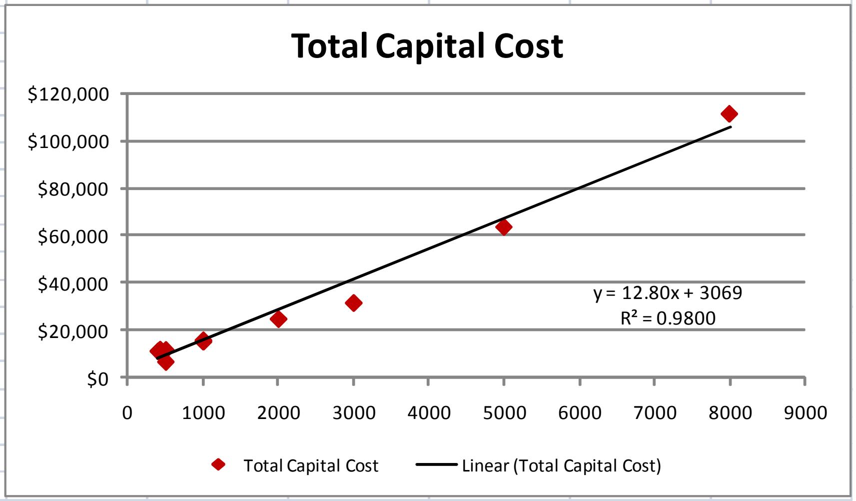
SUMMARY OUTPUT - Total Capital Cost

Regression Statistics	
Multiple R	0.989944875
R Square	0.979990856
Adjusted R Squa	0.977767618
Standard Error	4727.892942
Observations	11

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	9853063606	9853063606	440.7943494	5.91417E-09
Residual	9	201176745.1	22352971.68		
Total	10	10054240351			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	3069.26319	1884.275356	1.62888252	0.137778178	-1193.263795	7331.790175
Engine Size (HP)	12.80450452	0.609880529	20.99510299	5.91417E-09	11.42485892	14.18415013



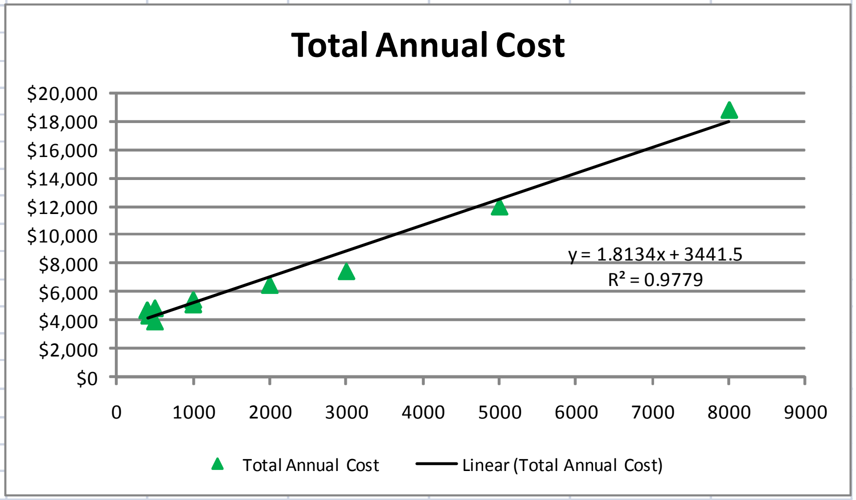
SUMMARY OUTPUT - Total Annual Cost

Regression Statistics	
Multiple R	0.988903698
R Square	0.977930524
Adjusted R Squa	0.97547836
Standard Error	703.9457563
Observations	11

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	197622721.6	197622721.6	398.8030634	9.20031E-09
Residual	9	4459856.651	495539.6279		
Total	10	202082578.3			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	3441.504829	280.553654	12.26683303	6.38308E-07	2806.848372	4076.161285
X Variable 1	1.81340819	0.090806373	19.97005417	9.20031E-09	1.607989903	2.018826477



4SRB NSCR Costs ($2009)

			Direct Costs		Indirect Costs			Direct Annual Costs			Indirect Annual Costs					
Engine Size (HP)	Equipment Cost	AFRC Cost	PEC	DIC	IIC	C	Total Capital Cost	O&M Materials	O&M Labor	Total Direct Annual Cost (TDAC)	Administrative Charges (ADMC)	Fuel Penalty (FPC)	Capital Recovery (CRC)	Total Indirect Annual Cost (TIAC)	Total Annual Cost	Data Source
50			$8,935				$11,945	$664	$1,275	$1,939	$225	$379	$1,701	$2,305	$4,244	Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment D (EPA-HQ-OAR-2008-0708-0279)
100			$10,099				$13,363	$664	$1,275	$1,939	$225	$379	$1,903	$2,507	$4,446	Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment D (EPA-HQ-OAR-2008-0708-0279)
100			$10,827				$15,139	$1,071	$1,320	$2,391	$225	$695	$2,155	$3,075	$5,466	Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment D (EPA-HQ-OAR-2008-0708-0279)
175			$12,284				$17,132	$1,071	$1,320	$2,391	$225	$695	$2,439	$3,359	$5,750	Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment D (EPA-HQ-OAR-2008-0708-0279)
175			$10,667				$16,165	$1,706	$1,360	$3,066	$225	$1,200	$2,302	$3,727	$6,793	Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment D (EPA-HQ-OAR-2008-0708-0279)
300			$16,119				$22,117	$1,706	$1,360	$3,066	$225	$1,200	$3,149	$4,574	$7,640	Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment D (EPA-HQ-OAR-2008-0708-0279)
300			$11,777				$17,240	$2,384	$1,380	$3,764	$225	$2,021	$2,455	$4,701	$8,465	Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment D (EPA-HQ-OAR-2008-0708-0279)
500			$16,689				$24,502	$2,384	$1,380	$3,764	$225	$2,021	$3,489	$5,735	$9,499	Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment D (EPA-HQ-OAR-2008-0708-0279)
167	$2,588	$7,017	$11,334	$3,400	$3,173	$340	$18,247	$1,071	$1,320	$2,391	$225	$695	$2,598	$3,518	$5,909	Email from Nick Huff, Miratech to Jennifer Synder, AGTI, SCR Questions for RICE MACT, October 23, 2003 (EPA-HQ-OAR-2005-0029-0038). Cost for NSCR/AFRC on a Caterpillar G3306 adjusted from $2003 to $2009.
255	$6,091	$7,017	$15,467	$4,640	$4,331	$464	$24,902	$1,706	$1,360	$3,066	$225	$1,200	$3,545	$4,970	$8,036	Email from Nick Huff, Miratech to Jennifer Synder, AGTI, SCR Questions for RICE MACT, October 23, 2003 (EPA-HQ-OAR-2005-0029-0038). Cost for NSCR/AFRC on a Caterpillar G3408 adjusted from $2003 to $2009.
300	$6,039	$7,017	$15,405	$4,622	$4,314	$462	$24,803	$2,384	$1,380	$3,764	$225	$2,021	$3,531	$5,777	$9,541	Email from Nick Huff, Miratech to Jennifer Synder, AGTI, SCR Questions for RICE MACT, October 23, 2003 (EPA-HQ-OAR-2005-0029-0038). Cost for NSCR/AFRC on a Caterpillar G3408 adjusted from $2003 to $2009.
300	$6,113	$7,500	$16,063	$4,819	$4,498	$482	$25,862	$2,384	$1,380	$3,764	$225	$2,021	$3,682	$5,928	$9,692	Email from Mike Leonard, Miratech to Brad Nelson, AGTI, Information Request, July 21, 2005 (EPA-HQ-OAR-2005-0030-0087). Cost for NSCR/AFRC on a generic 300 HP rich-burn engine adjusted from $2005 to $2009.
500	$7,800	$7,500	$18,054	$5,416	$5,055	$542	$29,067	$2,384	$1,380	$3,764	$225	$2,021	$4,139	$6,385	$10,149	Email from Mike Leonard, Miratech to Brad Nelson, AGTI, Information Request, July 21, 2005 (EPA-HQ-OAR-2005-0030-0087). Cost for NSCR/AFRC on a generic 500 HP rich-burn engine adjusted from $2005 to $2009.
800	$9,924	$7,500	$20,561	$6,168	$5,757	$617	$33,103	$2,384	$1,380	$3,764	$225	$2,021	$4,713	$6,959	$10,723	Email from Mike Leonard, Miratech to Brad Nelson, AGTI, Information Request, July 21, 2005 (EPA-HQ-OAR-2005-0030-0087). Cost for NSCR/AFRC on a generic 500 HP rich-burn engine adjusted from $2005 to $2009.
1500	$15,778	$7,500	$27,468	$8,240	$7,691	$824	$44,223	$2,384	$1,380	$3,764	$225	$2,021	$6,296	$8,542	$12,306	Email from Mike Leonard, Miratech to Brad Nelson, AGTI, Information Request, July 21, 2005 (EPA-HQ-OAR-2005-0030-0087). Cost for NSCR/AFRC on a generic 500 HP rich-burn engine adjusted from $2005 to $2009.
3000	$39,686	$7,500	$55,679	$16,704	$15,590	$1,670	$89,644	$2,384	$1,380	$3,764	$225	$2,021	$12,763	$15,009	$18,773	Email from Mike Leonard, Miratech to Brad Nelson, AGTI, Information Request, July 21, 2005 (EPA-HQ-OAR-2005-0030-0087). Cost for NSCR/AFRC on a generic 500 HP rich-burn engine adjusted from $2005 to $2008.
48	$3,735	$2,950	$7,762	$4,080			$11,842	$480	$540	$1,020	$225	$0	$1,686	$1,911	$2,931	Four Corners Air Quality Task Force Report of Mitigation Options, November 1, 2007. Mitigation Option: Use of NSCR/3-Way Catalysts and Air/Fuel Ratio Controllers on Rich Burn Stoichiometric Engines (EPA-HQ-OAR-2008-0708-0009). TCC includes cost of catalyst housing ($2,385), catalyst element ($1,000), AFRC ($2,950), installation of catalyst housing and support ($1,380), installation and setup of AFRC ($2,160), solar panel electricity for AFRC control ($350), installation of solar panel electricity to AFRC ($540), and taxes/freight ($1,077). TDAC includes annual cost for quarterly change of O2 sensor and emissions monitoring ($320), labor and travel to site ($540), and annualized cost of catalyst replacement 5 year life ($160). Cost quoted for a Compressco Ford 460.
23	$2,925	$2,950	$6,952	$4,080			$11,032	$480	$540	$1,020	$225	$0	$1,571	$1,796	$2,816	Four Corners Air Quality Task Force Report of Mitigation Options, November 1, 2007. Mitigation Option: Use of NSCR/3-Way Catalysts and Air/Fuel Ratio Controllers on Rich Burn Stoichiometric Engines (EPA-HQ-OAR-2008-0708-0009). TCC includes cost of catalyst housing ($1,775), catalyst element ($800), AFRC ($2,950), installation of catalyst housing and support ($1,380), installation and setup of AFRC ($2,160), solar panel electricity for AFRC control ($350), installation of solar panel electricity to AFRC ($540), and taxes/freight ($1,077). TDAC includes annual cost for quarterly change of O2 sensor and emissions monitoring ($320), labor and travel to site ($540), and annualized cost of catalyst replacement 5 year life ($160). Cost quoted for a Waukesha 220/330.

Assumptions:
PEC = 118% of purchased equipment cost (PEC).
DIC = 30% of purchased equipment cost (PEC).
IIC = 28% of purchased equipment cost (PEC).
C = 3% of purchased equipment cost (PEC).
Direct Annual Cost = ($5 x Hp) + (14.26 x 5).
Indirect Annual Cost = 60% of direct annual cost + 4% of total capital cost + capital recovery.
Capital Recovery assumes equipment life of 10 y 0.142377503
O&M Materials cost covers the annualized equipment cost to replace the catalyst (every 3 years), thermocouples (every 7.5 years), crankcase filters (3 months), and annual catalyst rotation for cleaning. [Source: Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment D (EPA-HQ-OAR-2008-0708-0279)]
O&M Labor cost covers the annualized labor cost to replace and rotate (for cleaning) catalyst, thermocouples, and crankcase filter. [Source: Technical Report: RICE NESHAP Control Costs Background for "Above the Floor Analysis", October 2009, Attachment D (EPA-HQ-OAR-2008-0708-0279)]

4SRB NSCR Costs ($2009)

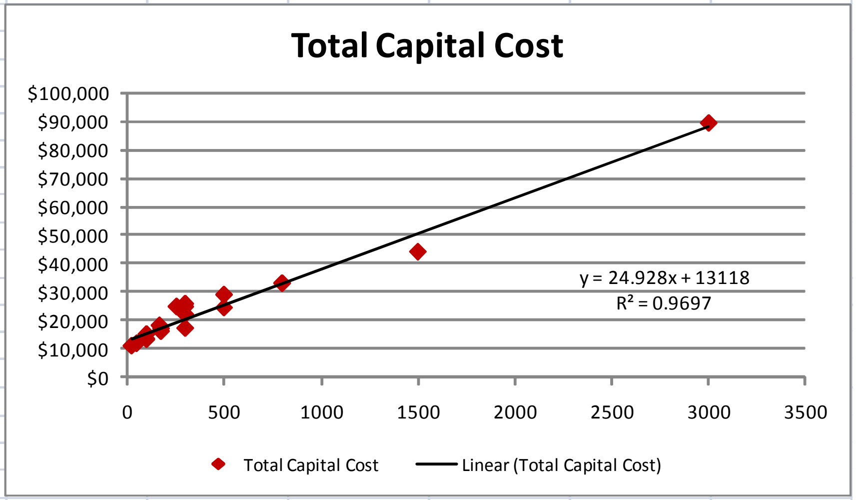
SUMMARY OUTPUT - Total Capital Cost

Regression Statistics	
Multiple R	0.984731321
R Square	0.969695774
Adjusted R Squa	0.96780176
Standard Error	3273.282484
Observations	18

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	5485538418	5485538418	511.9791654	1.41597E-13
Residual	16	171430051.5	10714378.22		
Total	17	5656968469			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	13117.61245	933.7363075	14.0485192	2.03296E-10	11138.17991	15097.04498
Engine Size (HP)	24.92848169	1.101716069	22.62695661	1.41597E-13	22.59294798	27.26401541



SUMMARY OUTPUT - Total Annual Cost

Regression Statistics	
Multiple R	0.893674092
R Square	0.798653382
Adjusted R Squa	0.786069219
Standard Error	1777.457825
Observations	18

ANOVA

	df	*SS*	*MS*	*F*	*Significance F*
Regression	1	200508408.1	200508408.1	63.46495544	5.85557E-07
Residual	16	50549701.12	3159356.32		
Total	17	251058109.2			

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*
Intercept	5679.133777	507.0374813	11.20061926	5.54849E-09	4604.262341	6754.005214
X Variable 1	4.765983033	0.59825385	7.96648953	5.85557E-07	3.497741535	6.034224532