

MEMORANDUM

| DATE: | January 29, 2010 |
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| SUBJECT: | Control Costs for Existing Stationary CI 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 stationary compression ignition (CI) reciprocating internal combustion engines (RICE). These estimates will be used for the above-the-floor maximum achievable control technology (MACT) analysis and generally available control technology (GACT) regulatory alternatives for RICE at major and area sources. This memorandum presents the cost of retrofitting control technology on existing engines.

2.0 INTRODUCTION

EPA has determined that diesel oxidation catalysts (DOC), catalyzed diesel particulate filters (CDPF), closed crankcase ventilation (CCV) and open crankcase ventilation (OCV) are applicable controls for HAP reduction from stationary CI RICE. To determine the capital and annual costs for these control technologies, equipment cost information was obtained from a cost study¹ performed by the California (CA) Air Resources Board (ARB) and cost data obtained from vendors. The annualized cost and capital cost equations were used to estimate the national impacts of controlling emissions from existing stationary CI engines.

¹ Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles, California Environmental Protection Agency, Air Resources Board, Stationary Source Division, Mobile Source Control Division, October 2000. <u>http://www.arb.ca.gov/diesel/documents/rrpapp.htm</u>

3.0 METHODOLOGY FOR DETERMINING COST EQUATIONS

The following section describes the methodology used to derive the capital and annual costs for each of these control technologies. The capital and annual costs were determined using the costing methodology in the EPA Control Cost Manual.² A summary of the methodologies, equations, and assumptions used to estimate the capital and annual cost 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);

² EPA Air Pollution Control Cost Manual, Sixth Edition, January 2002, EPA/452/B-02-001.

- 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).

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

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

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

- Overhead (60% of operating labor and maintenance costs);
- Fuel Penalty;
- Property Tax (1% of TCC);
- Insurance (1% of TCC);
- Administrative Charges (2% of TCC);

- Capital Recovery = $\{I(1+I)^n/((1+I)^n-1)*TCC\}$ where I is the interest rate, and n is the equipment life.

The DAC and fuel penalty costs will be estimated using information obtained for each of the control technologies. The other annual costs will be calculated using the assumed percentages.

4.0 CONTROL COST EQUATIONS

4.1 Diesel Oxidation Catalysts

The cost of retrofitting a DOC to an existing CI engine was estimated using cost data obtained from a diesel engine control technology study performed by the California ARB.³ The study provided equipment cost ranges for 40, 100, 275, 400, and 1,400 horsepower (HP) diesel engines. The average cost in the cost range for each of the engine sizes was used to develop the capital and annual cost for each of the engines. The capital cost was calculated using the EPA Control Cost methodology and includes the direct, indirect, and contingency costs of installation of the DOC. The total annual cost was also calculated using the EPA Control Cost methodology and includes the direct and indirect annual costs of operating and maintaining the DOC. Maintenance costs were estimated using the average of the cost range provided in the California ARB study. The study estimated the maintenance costs to range from \$64 to \$712 per year; \$50 to \$100 for thermal cleaning and 1 hour labor (\$78) once every other year to 4 times a year. For estimating the annual maintenance cost, the thermal cleaning was estimated to cost \$153 (\$75 for cleaning + \$78 for 1 hour labor) and the thermal cleaning would occur twice a year for a total maintenance cost of \$306 per year. An equipment life of 10 years and an interest rate of 7 percent were used to estimate the indirect annual costs. The 10 year equipment life is consistent with the average life of control equipment. The fuel penalty associated with operating a DOC was assumed to be negligible. The capital and annual costs were adjusted to 2008 dollars using the Marshall & Swift Equipment Cost Index.

The calculated annual cost was plotted against the engine HP and the resulting graph showed a straight line relationship between the annual cost and engine HP. Therefore a linear regression was performed using the calculated annual cost and the engine HP to develop an equation that estimates annual costs when an engine HP is input into the equation. A summary of the calculated annual costs, graph, and linear regression analysis is presented in Appendix A of this memorandum. The annualized cost equation for retrofitting a DOC on a CI engine was estimated to be:

DOC Annual Cost = 4.99 HP + 480

where;

HP = engine size in HP.

The linear equation has a correlation coefficient of 0.9938, which shows the data fit the equation very closely. Therefore, this equation was used to estimate annualized cost for DOC for RICE at major and area sources.

³ Appendix IX, Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles, California Environmental Protection Agency, Air Resources Board, Stationary Source Division, Mobile Source Control Division, October 2000. <u>http://www.arb.ca.gov/diesel/documents/rrpapp9.PDF</u>

For capital cost, a graph of the calculated capital cost and the engine HP showed a straight line relationship between the two variables. Therefore a linear regression was performed using the calculated capital cost and the engine HP to develop an equation that estimates capital costs when an engine HP is input into the equation. A summary of the calculated capital costs, graph, and linear regression analysis is presented in Appendix A of this memorandum. The capital cost equation for retrofitting a DOC on a CI engine was estimated to be:

DOC Capital Cost = \$27.4*HP - \$939

where;

HP = engine size in HP.

The linear equation has a correlation coefficient of 0.9938, which shows the data fit the equation very closely. Therefore, this equation was used to estimate capital cost for DOC for RICE at major and area sources.

4.2 Catalyzed Diesel Particulate Filters

The CDPF is a control technology that reduces the emissions of HAP from CI engines. However, it is primarily installed on engines for the reduction of PM from the CI engine exhaust. The catalyst element in the CDPF is also effective in reducing the emissions of CO and volatile organic compounds (VOC). The filter system of the CDPF can be either active or passive. The passive CDPF uses heat from the engine to regenerate the filter media, whereas the active filter uses an electric heater or fuel burners to regenerate the filter media. The catalyzed coating in each of the two systems reduces emissions of CO, VOC, and HAP emissions.

The cost of retrofitting an active or passive CDPF to an existing CI engine was estimated using cost data obtained from a diesel engine control technology study performed by the California ARB.⁴ The cost study did not distinguish equipment costs between the active and passive CDPF, therefore the equipment costs were assumed to be the same for both technologies. The study provided equipment cost ranges for 40, 100, 275, 400, and 1,400 HP diesel engines. The average cost in the cost range for each of these engine HPs and the EPA Control Cost methodology were used to develop the capital and annual cost for each of the engines. An equipment life of 10 years and an interest rate of 7 percent were used to estimate the indirect annual costs. The 10 year equipment life is consistent with the average life of control equipment. The fuel penalty associated with operating a CDPF was assumed to be negligible. The capital and annual costs were adjusted to 2008 dollars using the Marshall & Swift Equipment Cost Index.

The calculated annual cost for the CDPF was plotted against the engine HP and the resulting graph showed a straight line relationship between the annual cost and engine HP.

⁴ Appendix IX, Risk Reduction Plan to Reduce Particulate Matter Emissions from Diesel-Fueled Engines and Vehicles, California Environmental Protection Agency, Air Resources Board, Stationary Source Division, Mobile Source Control Division, October 2000. <u>http://www.arb.ca.gov/diesel/documents/rrpapp9.PDF</u>

Therefore a linear regression was performed using the calculated annual cost and the engine HP to develop an equation that estimates annual costs when an engine HP is input into the equation. A summary of the calculated annual costs, graph, and linear regression analysis is presented in Appendix A of this memorandum. The annualized cost equation for retrofitting a CDPF on a CI engine was estimated to be:

CDPF Annual Cost = 11.6*HP + 1414

where;

HP = engine size in HP.

The linear equation has a correlation coefficient of 0.9897, which shows the data fit the equation very closely. Therefore, this equation was used to estimate annualized cost for retrofitting CDPF for CI at major and area sources.

For capital cost, a graph of the calculated capital cost and the engine HP showed a straight line relationship between the two variables. Therefore a linear regression was performed using the calculated capital cost and the engine HP to develop an equation that estimates capital costs when an engine HP is input into the equation. A summary of the calculated capital costs, graph, and linear regression analysis is presented in Appendix A of this memorandum. The capital cost equation for retrofitting a CDPF on a CI engine was estimated to be:

CDPF Capital Cost = 63.4*HP + 5699

where;

HP = engine size in HP.

The linear equation has a correlation coefficient of 0.9897, which shows the data fit the equation very closely. Therefore, this equation was used to estimate capital cost for CDPF for RICE at major and area sources.

4.3 Open and Closed Crankcase Ventilation

In diesel engines, the crankcase exhaust is either exhausted to the atmosphere (open crankcase) or routed to the air intake to be used as combustion air (closed crankcase). Crankcase ventilation systems use filtration or centrifugal force to remove oil mist and particulates from the crankcase exhaust stream in both open and closed crankcase diesel engines. The OCV system is installed on diesel engines with open crankcases, whereas the CCV system is installed on diesel engines with closed crankcases. The filtration or separator units used for both OCV and CCV are the same and have essentially the same cost. Therefore for this analysis, it is assumed that the capital and annual cost of OCV and CCV are the same.

The cost of retrofitting an OCV on an existing CI engine was estimated based on information obtained from a distributor of the OCV technology (see Appendix B). The distributor sells and installs three different models of the OCV system and provided information on the installation costs and maintenance required. These models were applied to engine sizes of 100, 150, 200, 300, 500, 750, 1,000, 1,250, and 1,500 HP to estimate capital and annual costs using the EPA Control Cost methodology. An equipment life of 10 years and an interest rate of 7 percent were used to estimate the indirect annual costs. The 10 year equipment life is consistent with the average life of control equipment. The calculated annual cost and engine size were graphed and a straight line relationship was observed. A linear regression analysis was done on the data set and the linear equation for annualized cost was;

OCV Annual Cost = 0.065*HP + 254

where;

HP = engine size in HP.

The linear equation has a correlation coefficient of 0.8154, which is due to the same annual cost being calculated for several different sized CI engines. This is due to the fact that the same model OCV can be retrofit on several different engine sizes, because the OCV are based on the flow rate of the crankcase exhaust. However, it is believed that the equation represents a representative average annual cost of retrofitting an OCV on a CI engine.

For capital cost, a graph of the calculated capital cost and the engine HP showed a straight line relationship between the two variables. Therefore a linear regression was performed using the calculated capital cost and the engine HP to develop an equation that estimates capital costs when an engine HP is input into the equation. A summary of the calculated capital costs, graph, and linear regression analysis is presented in Appendix A of this memorandum. The capital cost equation for retrofitting a OCV on a CI engine was estimated to be:

OCV Capital Cost =
$$0.26$$
 HP + 997

where;

HP = engine size in HP.

The linear equation has a correlation coefficient of 0.7920, where again the capital cost was calculated to be the same for several different sized CI engines. However, it is believed that the cost equation provides a representative estimate of the average capital cost of retrofitting an OCV on a CI engine.

5.0 SUMMARY

The following table presents a summary of the costs for control devices to reduce HAP emissions from stationary CI engines.

| HAP Control Device | Annual Cost (\$) | Capital Cost (\$) |
|--------------------|--------------------|--------------------|
| DOC | \$4.99*HP + \$480 | \$27.4*HP - \$939 |
| CDPF | \$11.6*HP + \$1414 | \$63.4*HP + \$5699 |
| OCV | \$0.065*HP + \$254 | \$0.26*HP + \$997 |

 Table 1. Summary of Annual and Capital Costs Equations for CI HAP Controls

Appendix A

Control Cost Summary and Linear Regression Statistics

| Capital and | | RB Appendia | | | | | Sixth Editi | on (EPA/452/ | B-02-001) | | | | | |
|---------------------|---------------------------------|-------------------------------|-----------------|---------------|-----------------|----------------|--------------------------|-------------------------------|-----------|--------------------------|----------------------------|-------------------------|------------------------------|-------------------|
| oupitur una | Annual oos | r Equations | | | | Jost manaal | | | 0 02 001) | | | | | |
| | | | Direct | Costs | Indired | t Costs | | | | | | | | |
| Engine Size (HP) | Equipment Cost (\$2000) | Equipment Cost (\$2008) | PEC | DIC | IIC | с | Total Capital Cost | Regression Capital Cost | | Direct Annual Cost | Indirect Annual Cost | Total Annual Cost | Regression Annual Cost | Annual Cost/Hp |
| 40 | | \$665 | \$785 | \$236 | \$220 | \$24 | \$1,264 | | | \$407 | \$475 | \$882 | | \$22.0 |
| 100 | | \$1,355 | \$1,599 | \$480 | \$448 | \$48 | \$2,574 | | | \$407 | \$714 | \$1,121 | 979 | \$11.2 |
| 275 | \$2,350 | \$3,128 | \$3,690 | \$1,107 | \$1,033 | \$111 | \$5,942 | \$6,587 | | \$407 | \$1,328 | \$1,735 | 1,853 | \$6.3 |
| 400 | \$3,250 | \$4,325 | \$5,104 | \$1,531 | \$1,429 | \$153 | \$8,217 | \$10,008 | | \$407 | \$1,743 | \$2,150 | 2,477 | \$5.3 |
| 1400 | \$15,000 | \$19,963 | \$23,556 | \$7,067 | \$6,596 | \$707 | \$37,925 | \$37,374 | | \$407 | \$7,161 | \$7,568 | 7,468 | \$5.4 |
| Assumptions | | | | | | | | | | | | | | \$10.0 |
| | 5. 6 of purchase | d equipment | cost (PEC) | | | | | | | | | | | |
| | of purchased e | | | includes cos | t of installati | n | | | | | | | | |
| | purchased e | | | includes cos | st of mistanati | 511. | | | | | | | | |
| | urchased equi | | | | | | | | | | | | | |
| | al Cost = 0, e | | | a manufaatu | | | | | | | | | | |
| | al Cost = 0, e ual Cost = 60 | | | | | anital recover | n/ | | | | | | | |
| | very assume | | | | | 0.1423775 | ay. | | | | | | | |
| Capital Rect | wery assume | s equipment | life of 10 year | is and 7% int | elest late. | 0.1423775 | | | | | | | | |
| SUMMARY | OUTPUT - Ar | inual Cost | | | | | | | Annual | Cost for Retrofi | t of a Diesel O | xidation Cata | livst | |
| Regression | n Statistics | | | | | | | - | | | | | ., | |
| Multiple R | 0.99687955 | | | | | | | \$8,000 | | | | | _ | |
| R Square | 0.99376884 | | | | | | | \$7,000 - | | | | | | |
| | 0.99169179 | | | | | | | \$6,000 - | | | | | | |
| Standard Err | | | | | | | | 1 6 1 | | | | | | |
| Observations | | | | | | | | \$5,000 - | | | | | | |
| | | | | | | | | & 4,000 - | | | | | | |
| ANOVA | | | | | | | | g \$3,000 - | | | | | | |
| /1101/1 | df | SS | MS | F | Significance | | | \$2,000 | | | | | | |
| Regression | | 30539570.1 | | | 0.00020915 | | | n | | | | | | |
| Residual | 3 | | 63830 | 470.40107 | 0.00020010 | | | 1 ,000 | | | | | | |
| Total | | 30731060.1 | 03030 | | | | | \$0 - | | • | • • | | · · · | |
| Totai | 4 | 30731000.1 | | | | | | . (| 200 | 400 6 | 600 800 Engine Size | 1000 | 1200 1400 | 1600 |
| | Coefficients | Standard Erro | t Stat | P-value | Lower 95% | Upper 95% | Lower 95.0% | i | | | Lingine 0ize | (()) | | |
| Intercept | 480.351703 | 151.603431 | 3.16847514 | 0.05053998 | -2.1180765 | 962.821482 | -2.1180765 | | | Total An | nual Cost | - Regression A | nnual Cost | |
| Engine Size | 4.99102525 | 0.2281764 | 21.8735381 | 0.00020915 | 4.2648661 | 5.7171844 | 4.2648661 | | | - Totali i | | - nogroodon / n | | |
| | OUTPUT - Ca | nitel Coat | | | | | | | | | | | | |
| SUMMART | 001P01 - Ca | ipital Cost | | | | | | | Capital | Cost for Retrofi | t of a Diesel O | xidation Cata | lyst | |
| | n Statistics | | | | | | |] | | | | | | |
| Multiple R | 0.99687955 | | | | | | | \$40,000 | 1 | | | | | |
| R Square | 0.99376884 | | | | | | | \$35,000 | | | | | | |
| | 0.99169179 | | | | | | | \$30,000 | | | | | | |
| | 1385.29146 | | | | | | | \$\$25,000 | | | | | | |
| Observations | 5 | | | | | | | 5 | | | - | | | |
| | | | | | | | | Š \$20,000 | 1 | | | | | |
| ANOVA | | | | | | | | \$15,000 | + | | | | | |
| | df | SS | MS | F | Significance | - | | 6 \$10,000 | + | | | | | |
| Regression | 1 | 918164273 | 918164273 | 478.45167 | 0.00020915 | | | \$5,000 | | | | | | |
| Residual | 3 | | 1919032.43 | | | | | | | | | | | |
| Total | 4 | 923921370 | | | | | | \$0 | + | | | | • • | |
| | | | | | | | | | 0 200 | 400 | 600 800 | 1000 | 1200 140 | 0 1600 |
| | Coefficients | tandard Erro | t Stat | P-value | Lower 95% | Upper 95% | Lower 95.0% | | | | Engine Siz | e (HP) | | |
| Intercept | -938,90096 | | | | | 1706.54473 | | 1 | | | | | i | |
| | | | | | | | | - | | Total C | apital Cost 🛛 🗕 | Regression C | Capital Cost | |
| | 27.3664524 | | | | | | | | | | | | | |

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|---------------------|---------------------------------|-------------------------------|-----------------|----------------|--------------------|-----------------|--------------------------|-------------------------------|-----------|--------------------------|----------------------------|----------------------------------|------------------------------|-------------------|
| | | | | | | | , | | , | | | | | |
| | | | Direct | Costs | Indired | t Costs | | | | | | | | |
| Engine Size (HP) | Equipment Cost (\$2000) | Equipment Cost (\$2008) | PEC | DIC | IIC | с | Total Capital Cost | Regression Capital Cost | | Direct Annual Cost | Indirect Annual Cost | Total Annual Cost | Regression Annual Cost | Annual Cost/Hp |
| 40 | \$4,150 | \$5,523 | \$6,517 | \$1,955 | \$1,825 | \$196 | \$10,493 | \$8,237 | | \$234 | \$2,054 | \$2,288 | 1,877 | \$57.2 |
| 100 | \$6,250 | \$8,318 | \$9,815 | \$2,945 | \$2,748 | \$294 | \$15,802 | \$12,043 | | \$234 | \$3,022 | \$3,256 | 2,571 | \$32.5 |
| 275 | \$7,950 | \$10,580 | \$12,485 | \$3,745 | \$3,496 | \$375 | \$20,100 | \$23,146 | | \$234 | \$3,806 | \$4,040 | 4,596 | \$14.6 |
| 400 | \$10,500 | \$13,974 | \$16,489 | \$4,947 | \$4,617 | \$495 | \$26,548 | \$31,076 | | \$234 | \$4,982 | \$5,216 | 6,042 | \$13.0 |
| 1400 | \$38,000 | \$50,572 | \$59,675 | \$17,903 | \$16,709 | \$1,790 | \$96,078 | \$94,518 | | \$234 | \$17,663 | \$17,897 | 17,612 | \$12.7 |
| Assumption | e. | | | | | | | | | | | | | \$26.0 |
| | of purchase | d equinment | cost (PEC) | | | | | | | | | | | |
| | of purchased | | | l includes cos | t of installati | on | | | | | | | | |
| | f purchased e | | · · / | i includes coa | st of mistaliation | | | | | | | | | |
| | urchased equ | | | | | | | | | | | | | |
| | al Cost = 0, e | | | no monufacti | ror | | | | | | | | | |
| | ual Cost = 0, e | | | | | conital recover | n/ | | | | | | | |
| | overy assume | | | | | | ay. | | | | | | | |
| Capital Reco | overy assume | s equipment | life of 10 year | rs and 7% int | erest rate. | 0.1423775 | | | | | | | | |
| SUMMARY | OUTPUT - Ar | nual Cost | | | | | | | Annual | Cost for Retrofi | t of a Cataluze | d Diocol Parti | culato Eiltor | |
| - · | 01.0 | | | | | | | - | Annuar | | t of a Gatalyze | | | |
| | n Statistics | | | | | | | \$20,000 | | | | | | |
| Multiple R | 0.99482924 | | | | | | | \$18,000 | | | | | | |
| R Square | 0.98968521 | | | | | | | \$16,000 | | | | | | |
| | 0.98624695 | | | | | | | \$14,000 | | | | | | |
| | 755.115259 | | | | | | | \$12,000 | | | | | | |
| Observations | 5 5 | | | | | | | \$10,000 | | | | | | |
| | | | | | | | | 8 8,000 | | | | | | |
| ANOVA | | | | | | | | \$6,000 | | | | | | |
| | df | SS | MS | | Significance I | - | | \$4,000 | | | | | | |
| Regression | 1 | | | 287.844638 | 0.00044599 | | | \$ 2,000 | | | | | | |
| Residual | 3 | 1710597.16 | 570199.054 | | | | | \$0 | | | | | | |
| Total | 4 | 165839337 | | | | | | . 0 | 200 | 400 6 | 800 800 | 1000 | 1200 1400 | 0 1600 |
| | Coefficients | tandard Erro | t Stat | P-value | Lower 95% | Upper 95% | | - | | | Engine Size | (HP) | | |
| Intercept | | 453.116477 | | 0.0524648 | | 2855.81703 | | | | | | | | |
| Engine Size | | | | 0.00044599 | | | | | | Total An | nual Cost | Regression A | nnual Cost | |
| | | | | | | | | | | | | | | |
| SUMMARY | OUTPUT - Ca | apital Cost | | | | | | | Capital | Cost for Retrofi | t of a Catalyze | d Diesel Parti | culate Filter | |
| Rearessio | n Statistics | | | | | | | | | | | | | |
| | 0.99482924 | | | | | | | \$120,000 | | | | | | |
| R Square | 0.98968521 | | | | | | | | | | | | | |
| | 0.98624695 | | | | | | | \$100,000 | + | | | | _ | |
| | 1 4140.39697 | | | | | | | \$\$80,000 | | | | | | |
| Observations | | | | | | | | 600,000 | | | | | | |
| | | | | | | | | \$\$60,000 | + | | | | | |
| ANOVA | | | | | | | | e. | | | | | | |
| | df | SS | MS | F | Significance I | - | | \$40,000 | 1 | | | | | |
| Regression | | | | 287.844638 | | | | č \$20,000 | | | | | | |
| Residual | | 4934488108 51428661.1 | 17142887 | 201.044038 | 0.00044599 | | | \$20,000 | | _ | | | | |
| Total | | 4985916769 | 1/ 14268/ | | | | | \$0 | + | | · · · | | | |
| | 4 | | | | | | | | 0 200 | 400 | 600 800 | 1000 | 1200 140 | 0 1600 |
| | Coefficients | tandard Erro | t Stat | P-value | Lower 95% | Upper 95% | | | | | Engine Siz | e (HP) | | |
| Intercept | | 2484.49765 | | 0.10557881 | -2207.6225 | | | 1 | | | | | | |
| | | | | | | | | | | | | | | |
| | 63.4423645 | 3.73938592 | 16.9659847 | 0.00044599 | 51.5419696 | 75.3427594 | | | | Total C | apital Cost 🛛 🗕 | Regression C | apital Cost | |

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|--|--|--|--|---|--|---------------------------------------|-----------------|---|--------------|---------------|---------------|--|-----------|-------|
| Japital and | Annual 60. | x Equations | | AAITTOIluu | | | | | 5 02 001) | | | | | |
| | | | Direct | Costs | Indired | t Costs | | | | | | | | |
| | Equipment | | | | | Total | Regression | | Direct | Indirect | Total | Regression | | |
| Engine | Cost | | | | | Capital | Capital | | Annual | Annual | Annual | Annual | Annual | |
| Size (HP) | (\$2008) | PEC | DIC | IIC | С | Cost | Cost | | Cost | Cost | Cost | Cost | Cost/Hp | |
| 100 | \$500 | \$590 | \$177 | \$165 | \$18 | \$950 | \$1,022 | | \$45 | \$200 | \$245 | 260 | \$2.45 | |
| 150 | \$500 | \$590 | \$177 | \$165 | \$18 | \$950 | \$1,035 | | \$45 | \$200 | \$245 | 264 | \$1.63 | |
| 200 | \$600 | \$708 | \$212 | \$198 | \$21 | \$1,140 | \$1,048 | | \$50 | \$238 | \$288 | 267 | \$1.44 | |
| 300 | \$600 | \$708 | \$212 | \$198 | \$21 | \$1,140 | \$1,074 | | \$50 | \$238 | \$288 | 273 | \$0.96 | |
| 500 | \$600 | \$708 | \$212 | \$198 | | \$1,140 | \$1,125 | | \$50 | \$238 | \$288 | | \$0.58 | |
| 750 | \$600 | \$708 | \$212 | \$198 | \$21 | \$1,140 | \$1,190 | | \$50 | \$238 | \$288 | 302 | \$0.38 | |
| 1000 | \$700 | \$826 | \$248 | \$231 | \$25 | \$1,330 | \$1,254 | | \$60 | \$279 | \$339 | 319 | \$0.34 | |
| 1250 | \$700 | \$826 | \$248 | \$231 | \$25 | \$1,330 | | | \$60 \$60 | \$279 | \$339 | 335 | \$0.27 | |
| | | | | | | | \$1,318 | | | | | | | |
| 1500 | \$700 | \$826 | \$248 | \$231 | \$25 | \$1,330 | \$1,382 | | \$60 | \$279 | \$339 | 351 | \$0.23 | |
| | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | \$0.92 | |
| ssumptions | | | | | | | | | | | | | | |
| | | d equipment | | | | | | | | | | | | |
| DIC = 30% o | f purchased | equipment co | st (PEC) and | includes cos | t of installation | on. | | | | | | | | |
| | | quipment cos | | | | | | | | | | | | |
| | | ipment cost (| | | | | | | | | | | | |
| | | | | ne manufactu | rer. | | | | | | | | | |
| | | | | 4% of total ca | | capital recover | rv | | | | | | | |
| | | | | rs and 7% inter | | 0.1423775 | •,• | | | | | | | |
| арнан кесо | wery assume | s equipment | me or ro yea | 5 anu <i>1 7</i> 0 inti | crest idle. | 0.1423/75 | | | | | | | | |
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| | | | | | | | | | | | | | | |
| SUMMARY | OUTPUT - Ar | nnual Cost | | | | | | | Annual C | | | nkaaaa Vantila | lan | |
| | | | | | | | | | Annual C | Stior Retroin | t of Open Cra | nkcase Ventila | lion | |
| Regression | Statistics | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | |
| | | | | | | | | \$400 T | | | | | | |
| /ultiple R | 0.90297617 | | | | | | | | | | | | | |
| Aultiple R R Square | 0.90297617 0.81536597 | | | | | | | \$350 - | | | | | | |
| Multiple R R Square Adjusted R S | 0.90297617 0.81536597 0.78898968 | | | | | | | | | | | | | - |
| Multiple R R Square Adjusted R S Standard Err | 0.90297617 0.81536597 0.78898968 16.909021 | | | | | | | \$350 - | _ | | - | | | • |
| Multiple R R Square Adjusted R \$ | 0.90297617 0.81536597 0.78898968 16.909021 | | | | | | | \$350 - \$300 - \$250 - | | | | | | • |
| Multiple R R Square Adjusted R Standard Err Observations | 0.90297617 0.81536597 0.78898968 16.909021 | | | | | | | \$350 - \$300 - \$250 - \$200 - | - | | J | | - | • |
| Multiple R R Square Adjusted R Standard Err Observations | 0.90297617 0.81536597 0.78898968 16.909021 9 | | | | | | | \$350 - \$300 - \$250 - \$200 - \$200 - \$150 - | - | | | | | • |
| Multiple R R Square Adjusted R Standard Err Observations | 0.90297617 0.81536597 0.78898968 16.909021 9 df | SS | MS | | Significance I | | | \$350 - \$300 - \$250 - \$200 - | | | | | | |
| Multiple R R Square Adjusted R S Standard Err | 0.90297617 0.81536597 0.78898968 16.909021 9 df | | - | F 30.9128379 | | = | | \$350 - \$300 - \$250 - \$200 - \$150 - \$100 - | | | | | | |
| Multiple R R Square Adjusted R & Standard Err Observations ANOVA | 0.90297617 0.81536597 0.78898968 16.909021 9 df 1 | | 8838.44377 | | | | | \$350 - \$300 - \$250 - \$200 - \$150 - \$150 - \$100 - \$50 - | <u>,</u> | | - | - | | |
| Multiple R R Square Adjusted R S Standard Err Observations ANOVA Regression Residual | 0.90297617 0.81536597 0.78898968 16.909021 9 df 1 7 | 8838.44377 2001.40494 | 8838.44377 | | | | | \$350 - \$300 - \$250 - \$200 - \$150 - \$100 - \$50 - \$50 - \$0 - \$0 - | | | • | | | |
| Multiple R R Square Adjusted R S Standard Err Dbservations ANOVA Regression Residual | 0.90297617 0.81536597 0.78898968 16.909021 9 df 1 7 | 8838.44377 | 8838.44377 | | | | | \$350 - \$300 - \$250 - \$200 - \$150 - \$150 - \$100 - \$50 - | 200 | 400 6 | • • • | 1000 | 1200 1400 | 0 160 |
| Multiple R R Square Adjusted R S Standard Err Dbservations ANOVA Regression Residual Total | 0.90297617 0.81536597 0.78898968 16.909021 9 df 1 7 8 | 8838.44377 2001.40494 10839.8487 | 8838.44377 285.914991 | 30.9128379 | 0.00085098 | | | \$350 - \$300 - \$250 - \$200 - \$150 - \$100 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$100 - \$50 - \$50 - \$100 - \$50 - \$50 - \$200 - \$100 - | | 400 6 | | | 1200 1400 | 0 160 |
| Aultiple R R Square Adjusted R S Standard Err Dbservations ANOVA Regression Residual Total | 0.90297617 0.81536597 0.78898968 16.909021 9 df 1 7 8 Coefficients | 8838.44377 2001.40494 10839.8487 Standard Erro | 8838.44377 285.914991 t Stat | 30.9128379 P-value | 0.00085098 Lower 95% | Upper 95% | | \$350 - \$300 - \$250 - \$200 - \$150 - \$100 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$100 - \$50 - \$50 - \$100 - \$50 - \$50 - \$200 - \$100 - | 200 | 400 6 | | | 1200 1400 | 0 160 |
| Multiple R R Square Adjusted R S Standard Err Dbservations ANOVA Regression Residual Fotal Intercept | 0.90297617 0.81536597 0.78898968 16.909021 9 df 1 7 8 Coefficients 253.982196 | 8838.44377 2001.40494 10839.8487 Standard Erro 9.3261336 | 8838.44377 285.914991 t Stat 27.233386 | 30.9128379 P-value 2.3087E-08 | 0.00085098 Lower 95% 231.929395 | Upper 95% 276.034998 | | \$350 - \$300 - \$250 - \$200 - \$150 - \$100 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$100 - \$50 - \$50 - \$100 - \$50 - \$50 - \$200 - \$100 - | 200 | | | | | 0 160 |
| Multiple R R Square Adjusted R S Standard Err Dbservations ANOVA Regression Residual Fotal Intercept | 0.90297617 0.81536597 0.78898968 16.909021 9 df 1 7 8 Coefficients 253.982196 | 8838.44377 2001.40494 10839.8487 Standard Erro 9.3261336 | 8838.44377 285.914991 t Stat 27.233386 | 30.9128379 P-value | 0.00085098 Lower 95% 231.929395 | Upper 95% 276.034998 | | \$350 - \$300 - \$250 - \$200 - \$150 - \$100 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$100 - \$50 - \$50 - \$100 - \$50 - \$50 - \$200 - \$100 - | 200 | | Engine Siz | e (HP) | | 0 160 |
| Multiple R R Square Adjusted R S Standard Err Dbservations ANOVA Regression Residual Fotal Intercept | 0.90297617 0.81536597 0.78898968 16.909021 9 df 1 7 8 Coefficients 253.982196 | 8838.44377 2001.40494 10839.8487 Standard Erro 9.3261336 | 8838.44377 285.914991 t Stat 27.233386 | 30.9128379 P-value 2.3087E-08 | 0.00085098 Lower 95% 231.929395 | Upper 95% 276.034998 | | \$350 - \$300 - \$250 - \$200 - \$150 - \$100 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$100 - \$50 - \$50 - \$100 - \$50 - \$50 - \$200 - \$100 - | 200 | | Engine Siz | e (HP) | | 0 160 |
| Aultiple R & Square Adjusted R & Standard Err Doservations ANOVA Regression Residual Fotal Intercept Engine Size | 0.90297617 0.81536597 0.78898968 16.909021 9 df 1 7 8 <i>Coefficients</i> 253.982196 0.06466166 | 8838.44377 2001.40494 10839.8487 3 <i>tandard Erro</i> 9.3261336 0.01162994 | 8838.44377 285.914991 t Stat 27.233386 | 30.9128379 P-value 2.3087E-08 | 0.00085098 Lower 95% 231.929395 | Upper 95% 276.034998 | | \$350 - \$300 - \$250 - \$200 - \$150 - \$100 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$100 - \$50 - \$50 - \$100 - \$50 - \$50 - \$200 - \$100 - | 200 | | Engine Siz | e (HP) | | 0 160 |
| Aultiple R & Square kdjusted R & Standard Err Doservations NOVA Regression Residual Total Intercept Engine Size | 0.90297617 0.81536597 0.78898968 16.909021 9 df 1 7 8 Coefficients 253.982196 | 8838.44377 2001.40494 10839.8487 3 <i>tandard Erro</i> 9.3261336 0.01162994 | 8838.44377 285.914991 t Stat 27.233386 | 30.9128379 P-value 2.3087E-08 | 0.00085098 Lower 95% 231.929395 | Upper 95% 276.034998 | | \$350 - \$300 - \$250 - \$200 - \$150 - \$100 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$100 - \$50 - \$50 - \$100 - \$50 - \$50 - \$200 - \$100 - |] | Total An | Engine Siz | e (HP) — Regression An | nual Cost | 0 160 |
| Aultiple R & Square kdjusted R & Standard Err Doservations NOVA Regression Residual Total Intercept Engine Size | 0.90297617 0.81536597 0.78898968 16.909021 9 df 1 7 8 <i>Coefficients</i> 253.982196 0.06466166 | 8838.44377 2001.40494 10839.8487 3 <i>tandard Erro</i> 9.3261336 0.01162994 | 8838.44377 285.914991 t Stat 27.233386 | 30.9128379 P-value 2.3087E-08 | 0.00085098 Lower 95% 231.929395 | Upper 95% 276.034998 | | \$350 - \$300 - \$250 - \$200 - \$150 - \$100 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$100 - \$50 - \$50 - \$100 - \$50 - \$50 - \$200 - \$100 - |] | Total An | Engine Siz | e (HP) | nual Cost | 0 160 |
| Aultiple R & Square Idjusted R & Standard Err Observations NOVA Regression Residual otal Intercept Ingine Size SUMMARY | 0.90297617 0.81536597 0.78898968 16.909021 9 df 1 7 8 8 <i>Coefficients</i> 253.982196 0.06466166 | 8838.44377 2001.40494 10839.8487 3 <i>tandard Erro</i> 9.3261336 0.01162994 | 8838.44377 285.914991 t Stat 27.233386 | 30.9128379 P-value 2.3087E-08 | 0.00085098 Lower 95% 231.929395 | Upper 95% 276.034998 | | \$350 - \$300 - \$250 - \$200 - \$150 - \$100 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$50 - \$100 - \$50 - \$50 - \$100 - \$50 - \$50 - \$200 - \$100 - |] | Total An | Engine Siz | e (HP) — Regression An | nual Cost | 0 160 |
| Aultiple R R Square Vijusted R S Standard Err Dbservations ANOVA Regression Residual Total Total SUMMARY Regression | 0.90297617 0.81536597 0.78898966 16.909021 9 df 1 7 8 <i>Coefficients</i> 253.982196 0.06466166 OUTPUT - Ca Statistics | 8838.44377 2001.40494 10839.8487 3 <i>tandard Erro</i> 9.3261336 0.01162994 | 8838.44377 285.914991 t Stat 27.233386 | 30.9128379 P-value 2.3087E-08 | 0.00085098 Lower 95% 231.929395 | Upper 95% 276.034998 | | \$350 \$250 \$250 \$520 \$150 \$100 \$50 \$00 \$00 \$00 \$00 \$00 \$00 \$00 \$00 \$ |] | Total An | Engine Siz | e (HP) — Regression An | nual Cost | 0 160 |
| Aultiple R \$ Square \$ Square \$ standard Err > bservations NOVA Regression Residual Total | 0.90297617 0.81536597 0.78899968 16.909021 9 9 df 1 7 7 8 8 <i>Coefficients</i> 253.982196 0.06466166 0.06466166 0.004466166 0.00446166 0.0548599704 | 8838.44377 2001.40494 10839.8487 3 <i>tandard Erro</i> 9.3261336 0.01162994 | 8838.44377 285.914991 t Stat 27.233386 | 30.9128379 P-value 2.3087E-08 | 0.00085098 Lower 95% 231.929395 | Upper 95% 276.034998 | | \$350 \$250 \$250 \$150 \$150 \$100 \$50 \$00 \$100 \$1,600 |] | Total An | Engine Siz | e (HP) — Regression An | nual Cost | 0 160 |
| Aultiple R & Square Adjusted R & Standard Err Dbservations ANOVA Regression Residual fotal Intercept Engine Size SUMMARY (Regression Regression Reduction R Regression Re | 0.90297617 0.81536597 0.78896968 16.909021 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 8838.44377 2001.40494 10839.8487 3 <i>tandard Erro</i> 9.3261336 0.01162994 | 8838.44377 285.914991 t Stat 27.233386 | 30.9128379 P-value 2.3087E-08 | 0.00085098 Lower 95% 231.929395 | Upper 95% 276.034998 | | \$350 \$250 \$250 \$520 \$150 \$100 \$50 \$00 \$00 \$00 \$00 \$00 \$00 \$00 \$00 \$ |] | Total An | Engine Siz | e (HP) — Regression An | nual Cost | 0 160 |
| Aultiple R R Square Standard Err Dbservations ANOVA Regression Residual Total SUMMARY Regression Regress | 0.90297617 0.81536597 0.78898966 16.909021 9 0 df 1 7 8 Coefficients 253.982196 0.06466166 0.06466166 0.04666166 0.0466166 1.5tatistics 0.88999704 0.79209473 0.77239383 | 8838.44377 2001.40494 10839.8487 3 <i>tandard Erro</i> 9.3261336 0.01162994 | 8838.44377 285.914991 t Stat 27.233386 | 30.9128379 P-value 2.3087E-08 | 0.00085098 Lower 95% 231.929395 | Upper 95% 276.034998 | | \$350 \$250 \$250 \$150 \$150 \$100 \$50 \$00 \$150 \$1,600 |] | Total An | Engine Siz | e (HP) Regression An Regressio | nual Cost | 0 160 |
| Aultiple R Square Square dijusted R S biservations NOVA Regression tesidual otal htercept ingine Size SUMMARY <i>Regression</i> Aultiple R S quare dijusted R S tandard Er | 0.90297617 0.81536597 0.78899968 16.909021 9 9 df 1 7 8 <i>Coefficients</i> 253.982196 0.06466166 0.06466166 0.06466166 0.06466166 0.05400473 0.78293988 7.76239398 | 8838.44377 2001.40494 10839.8487 3 <i>tandard Erro</i> 9.3261336 0.01162994 | 8838.44377 285.914991 t Stat 27.233386 | 30.9128379 P-value 2.3087E-08 | 0.00085098 Lower 95% 231.929395 | Upper 95% 276.034998 | | \$350 \$250 \$250 \$250 \$250 \$100 \$100 \$1,600 \$1,400 \$1,400 \$1,400 \$1,400 |] | Total An | Engine Siz | e (HP) Regression An Regressio | nual Cost | 0 160 |
| Aultiple R Square Square dijusted R S biservations NOVA Regression tesidual otal htercept ingine Size SUMMARY <i>Regression</i> Aultiple R S quare dijusted R S tandard Er | 0.90297617 0.81536597 0.78899968 16.909021 9 9 df 1 7 8 <i>Coefficients</i> 253.982196 0.06466166 0.06466166 0.06466166 0.06466166 0.05400473 0.78293988 7.76239398 | 8838.44377 2001.40494 10839.8487 3 <i>tandard Erro</i> 9.3261336 0.01162994 | 8838.44377 285.914991 t Stat 27.233386 | 30.9128379 P-value 2.3087E-08 | 0.00085098 Lower 95% 231.929395 | Upper 95% 276.034998 | | \$350 \$250 \$250 \$250 \$250 \$100 \$100 \$1,600 \$1,400 \$1,400 \$1,200 \$1,000 |] | Total An | Engine Siz | e (HP) Regression An Regressio | nual Cost | 0 160 |
| Aultiple R Square Square dijusted R S biservations NOVA Regression tesidual otal htercept ingine Size SUMMARY <i>Regression</i> Aultiple R S quare dijusted R S tandard Er | 0.90297617 0.81536597 0.78899968 16.909021 9 9 df 1 7 8 <i>Coefficients</i> 253.982196 0.06466166 0.06466166 0.06466166 0.06466166 0.06466166 0.06466166 0.06466166 0.064693910 0.75293988 7.75239308 | 8838.44377 2001.40494 10839.8487 3 <i>tandard Erro</i> 9.3261336 0.01162994 | 8838.44377 285.914991 t Stat 27.233386 | 30.9128379 P-value 2.3087E-08 | 0.00085098 Lower 95% 231.929395 | Upper 95% 276.034998 | | \$350 \$250 \$250 \$250 \$250 \$100 \$100 \$1,600 \$1,400 \$1,400 \$1,200 \$1,000 |] | Total An | Engine Siz | e (HP) Regression An Regressio | nual Cost | 0 160 |
| Aultiple R Square Square dijusted R S standard Err bbservations NOVA Regression tesidual otal standard Err bbservations | 0.90297617 0.81536597 0.78899968 16.909021 9 9 df 1 7 8 <i>Coefficients</i> 253.982196 0.06466166 0.06466166 0.06466166 0.06466166 0.06466166 0.06466166 0.06466166 0.064693910 0.75293988 7.75239308 | 8838.44377 2001.40494 10839.8487 3 <i>tandard Erro</i> 9.3261336 0.01162994 | 8838.44377 285.914991 t Stat 27.233386 | 30.9128379 P-value 2.3087E-08 | 0.00085098 Lower 95% 231.929395 | Upper 95% 276.034998 | | \$350 \$250 \$250 \$250 \$100 \$1,600 \$1,600 \$1,400 \$1,200 \$1,000 \$1,000 |] | Total An | Engine Siz | e (HP) Regression An Regressio | nual Cost | 0 160 |
| Aultiple R S quare S quare S quare S quare S quare S quare S quare A quare A quare A quare A quare S quare A quare S quare | 0.90297617 0.81536597 0.78898968 16.909021 9 df 1 7 7 8 8 Coefficients 253.982196 0.06466166 0.06466166 0.06466166 0.07209473 0.76239389704 0.76239388 72.3930199 9 | 8838.44377 2001.40494 10839.8487 <i>itandard Erro</i> 9.3261336 0.01162994 apital Cost | 8838.44377 285.914991 <i>t Stat</i> 27.233386 5.55993147 | 30.9128379 <i>P-value</i> 2.3087E-08 0.00085098 | 0.00085098 Lower 95% 231.929395 0.03716122 | Upper 95% 276.034998 0.09216209 | | \$350 \$250 \$250 \$250 \$150 \$100 \$1,600 \$1,600 \$1,400 \$1,400 \$1,400 \$1,400 \$1,400 \$1,400 \$1,400 \$1,400 \$1,600\$\$1,600\$ |] | Total An | Engine Siz | e (HP) Regression An Regressio | nual Cost | 0 160 |
| Aultiple R & Square & Square & Square & Square basen & Square ANOVA Regression Regression Aultiple R & Square Adjusted R & Standard Er Deservations NNOVA | 0.90297617 0.81536597 0.78898968 16.909021 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 8838.44377 2001.40494 10839.8487 <i>Standard Error</i> 9.3261336 0.01162994 apital Cost | 8838.44377 285.914991 t Stat 27.233386 5.55993147 | 30.9128379 P-value 2.3087E-08 0.00085098 F | 0.00085098 | Upper 95% 276.034998 0.09216209 | | \$350 \$250 \$250 \$250 \$250 \$100 \$1,600 \$1,600 \$1,400 \$1,400 \$1,000 \$1 |] | Total An | Engine Siz | e (HP) Regression An Regressio | nual Cost | 0 166 |
| Aultiple R S quare S quare S quare S tandard Err Deservations NOVA Regression Residual Tercept Engine Size BUMMARY Regression Regression Regression Regression Regression Regression Regression Regression | 0.90297617 0.81536597 0.78898968 16.909021 9 df 1 7 8 Coefficients 253.982196 0.06466166 0.04666166 0.04666166 0.047047 0.78209473 0.76239398 72.3930199 9 df df 1 1 1 1 1 1 1 1 1 1 1 1 1 | 8838.44377 2001.40494 10839.8487 <i>Nandard Erro</i> 9.3261336 0.01162994 apital Cost spital Cost SS 139766.49 | 8838.44377 285.914991 <i>t</i> Stat 27.233386 5.55993147 | 30.9128379 <i>P-value</i> 2.3087E-08 0.00085098 | 0.00085098 | Upper 95% 276.034998 0.09216209 | | \$350 \$250 \$250 \$250 \$150 \$100 \$1,600 \$1,600 \$1,400 \$1,400 \$1,400 \$1,400 \$1,400 \$1,400 \$1,400 \$1,400 \$1,600\$\$1,600\$ |] | Total An | Engine Siz | e (HP) Regression An Regressio | nual Cost | 0 16 |
| Aultiple R Square Square djusted R S bitandard Err bbservations NOVA Regression tesidual otal htercept ngine Size suMMARY <i>Regression</i> Aultiple R Regression Aultiple R Square djusted R S bitandard Err bbservations NOVA | 0.90297617 0.81536597 0.78898968 16.909021 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 8838.44377 2001.40494 10839.8487 <i>itandard Erro</i> 9.3261336 0.01162994 apital Cost SS 139766.49 36685.2453 | 8838.44377 285.914991 <i>t</i> Stat 27.233386 5.55993147 | 30.9128379 P-value 2.3087E-08 0.00085098 F | 0.00085098 | Upper 95% 276.034998 0.09216209 | | \$350 \$250 \$250 \$250 \$250 \$250 \$50 \$50 \$50 \$50 \$50 \$50 \$50 \$ |] | Total An | Engine Siz | e (HP) Regression An Regressio | nual Cost | 0 167 |
| fultiple R Square djusted R S itandard Err ibservations NOVA legression tesidual otal tercept ingine Size UMMARY <i>Regression</i> fultiple R Square djusted R S tandard Err bbservations NOVA | 0.90297617 0.81536597 0.78898966 16.909021 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 8838.44377 2001.40494 10839.8487 <i>Nandard Erro</i> 9.3261336 0.01162994 apital Cost spital Cost SS 139766.49 | 8838.44377 285.914991 <i>t</i> Stat 27.233386 5.55993147 | 30.9128379 P-value 2.3087E-08 0.00085098 F | 0.00085098 | Upper 95% 276.034998 0.09216209 | | \$350 \$250 \$250 \$500 \$100 \$100 \$1,000 \$1,400 \$1,200 \$1,400 \$1,400 \$1,200 \$1,400 \$1,200 \$1,400 \$1,200 \$1,400 \$1,200 \$1,000\$ \$1,0 | Capital C | Total An | Engine Siz | e (HP) Regression An Regressio | tion | |
| fultiple R Square djusted R S tandard Err bservations NOVA tegression tesidual tercept ingine Size UMMARY Regression fultiple R Square djusted R S tandard Err bservations NOVA tegression tesidual | 0.90297617 0.81536597 0.78898966 16.909021 9 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 | 8838.44377 2001.40494 10839.8487 <i>itandard Erro</i> 9.3261336 0.01162994 apital Cost SS 139766.49 36685.2453 | 8838.44377 285.914991 <i>t</i> Stat 27.233386 5.55993147 | 30.9128379 P-value 2.3087E-08 0.00085098 F | 0.00085098 | Upper 95% 276.034998 0.09216209 | | \$350 \$250 \$250 \$500 \$100 \$100 \$1,000 \$1,400 \$1,200 \$1,400 \$1,400 \$1,200 \$1,400 \$1,200 \$1,400 \$1,200 \$1,400 \$1,200 \$1,000\$ \$1,0 |] | Total An | Engine Siz | e (HP) Regression An Regression An Recase Ventila | nual Cost | |
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Appendix B

Contact Report

CONTACT REPORT

| Date/Time | Project Name | Project Number | | | | | |
|------------------------------|---|----------------|--|--|--|--|--|
| November 20, 2009 10:00pm | RICE NESHAP | MME-304 | | | | | |
| EC/R Originator | Contact | Phone Number | | | | | |
| Bradley Nelson | Chuck Cook – Mid-Atlantic Engine Supply | (800) 257-8133 | | | | | |
| General Subject | | | | | | | |

The purpose of the telephone call was to discuss the feasibility of retrofitting existing stationary diesel engines with an open or closed crankcase ventilation system, and obtain equipment and installation costs for the retrofit. I spoke with General Manager of the company who stated that their company had installed numerous open and closed crankcase ventilation systems on both stationary and nonroad engines. He stated that the OCV and CCV systems are the same products with the only difference being the installation kit needed to retrofit the unit. The OCV system is installed in the open crankcase ventilation port, whereas the CCV is installed somewhere along the crankcase exhaust line before it reaches the intake manifold. He noted that engines that are enclosed in a housing or other shelter emit an oil mist from the crankcase that accumulates on the radiator and reduces the radiators effectiveness in cooling the engine. He noted that the Racor systems they sell reduce oil mist emissions by 95% using a filtration system. The equipment costs for the systems are;

CCV4500 Series – Maximum Flow 10 CFM (< 160 HP diesel engines) \$500

CCV6000 Series – Maximum Flow 20 CFM (160-800 HP diesel engines) \$600

CCV8000 Series – Maximum Flow 40 CFM (> 800 HP diesel engines) \$700

The filter needs to be replaced every 750 hours and the replacement cost is \$45 for the 4500, \$50 for the 6000, and \$60 for the 8000. The contact also stated it takes roughly 1-2 hours for installation, therefore at \$80 per hour, installation would cost roughly \$160.

http://www.maesco.com/products/racor/r ccv intro.html