

## **Appendix C: Cost Methodology**

This appendix explains methodology used by the Air Resources Board (ARB) staff to estimate the costs and savings of the proposed amendments to the *Verification Procedure, Warranty and In-Use Compliance Requirements for In-Use Strategies to Control Emissions from Diesel Engines* (the Procedure). Section A below provides an overview of the estimated costs and savings of the proposed amendments. Section B outlines the methodology used to quantify the potential savings of the proposed changes to the Procedure's in-use compliance requirements. Section C outlines the cost methodology of the proposed recall provisions. Section D outlines the cost methodology for the remaining proposed amendments and Section E lists references used.

### **A. Estimated Costs of the Proposed Amendments.**

The proposed amendments are intended to provide financial flexibility to diesel emissions control strategy's (DECS) manufacturers, referred to as applicants in the Procedure and throughout this Appendix, while maintaining the integrity of the verification program. The proposed amendments provide short-term financial savings to all applicants by reducing the amount of required in-use compliance testing by up to one-half and allowing additional sales before this testing is required. The addition of functional in-field tests and the alternative test schedule further reduces the costs associated with the in-use compliance requirements. Streamlining the in-use compliance process and providing additional time for applicants to complete their conditional verifications provides even greater financial flexibility. The addition of recall provisions and clarifications to the warranty reporting requirements are necessary to maintain the stringency of the Procedure and ensure the in-use performance of DECS, but may offset some of the cost savings provided above. Staff has analyzed each proposed amendment to determine potential economic impacts.

Overall, staff's proposal is estimated to provide a net savings to industry of approximately \$2.1 million to \$5.6 million. A summary of the estimated costs and savings of staff's proposal are shown below in Table C1. Sections B through D of this Appendix provide a detailed discussion of the methodology used to develop the estimates of the economic impacts of staff's proposal. Where practicable, several of the proposed amendments contained in staff's proposal have been grouped together for brevity.

**Table C1- Summary of the Costs or Savings to Industry of the Proposed Amendments**

Item	Amendment Description	Scenario 1 (costs) vs. savings	Scenario 2 (costs) vs. savings
1	Replace one phase of in-use compliance emissions testing with field testing	\$4.6 million	NA
2	Alternative test schedule (assumes all applicants select this option for their in-use testing)	NA	\$5.3 million
3	Allow only one test engine for in-use compliance emissions testing	\$381,000	\$381,000
<b>Subtotal – Cost savings from the proposed changes to the in-use compliance requirements</b>		\$5 million	\$5.7 million
4	Recall provisions	(\$2.8 million)	(\$0)
5	Installation warranty reporting requirements	(\$73,000)	(\$73,000)
<b>Net Savings</b>		<b>\$2.1 million</b>	<b>\$5.6 million</b>

**B. In-Use Compliance Requirements.**

The proposed amendments to the Procedures in-use compliance requirements would reduce an applicant’s in-use testing costs by up to one-half. Currently, the Procedure stipulates that all applicants must perform 2 phases of in-use emissions testing that are identical in size and scope. Staff’s proposal replaces one phase of emissions testing with a less expensive field testing option. Details of the estimates for the various types of exhaust emissions testing from independent test facilities are shown below in Table C2. As shown in Table C2, staff estimates applicants spend an average of \$82,525 per phase of exhaust emissions testing: this includes triplicate baseline testing of the test engine and triplicate control tests of a minimum of 4 candidate test units performed in an emissions testing facility, or in-situ where required.

**Table C2- In-Use Compliance Exhaust Emissions Testing Costs  
Triplicate Baseline tests and triplicate Control tests of 4 Test Units**

Test Facility	Engine Dynamometer Testing Costs, FTP Test Cycle	Engine Dynamometer Testing Costs, NRTC Test Cycle	Chassis Dynamometer Testing Costs, UDDS test Cycle	Stationary Testing Costs, Steady-State Test Cycle	Small Engine Dynamometer Testing Costs, Steady-State Test Cycle
Facility 1*	\$86,055.00	\$86,055.00	\$98,480.00	\$73,215.00	NA
Facility 2*	\$85,000.00	\$70,000.00	NA	NA	NA
Facility 3*	\$72,500.00	\$54,500.00	NA	NA	NA
Facility 4*	NA	NA	NA	NA	\$98,646.00
Facility 5*	\$94,500.00	\$58,500.00	\$79,500.00	NA	NA
Averages	\$84,513.75	\$67,263.75	\$88,990.00	\$73,215.00	\$98,646.00
<b>Overall Average</b>		<b>\$82,525.70</b>			

\*Note: Facilities currently providing emissions testing services to verification applicants provided these estimates to staff but asked that they not be directly identified in staff's report. As shown in Table 1, not all facilities are able to provide every type of required in-use testing.

Conversely, the proposed field testing option requires relatively inexpensive opacity testing, or for applicants that must also quantify NOx reductions, Portable Emission Measurement Systems (PEMS) testing. Several service companies are available to perform opacity tests and generally charge between \$50 and \$100 per test. However, many applicants and most heavy-duty diesel fleets have the capability to perform their own opacity testing and already own a smoke meter since these meters are currently used for compliance with the California Periodic Smoke Inspection Program and as a maintenance tool by the fleets. For applicants required to use the proposed PEMS testing, staff is aware of at least one service company that will perform in-situ PEMS testing for gaseous emissions at the rate of \$5,000 per day. Since staff's proposal requires a minimum of 8 candidate test units to satisfy the field testing requirements, staff estimates that this would require 6 days of PEMS testing and \$2,000 in travel expenses. Therefore, the additional costs of the proposed PEMS tests are estimated to be approximately \$32,000 per DECS family.

Overall, replacing one phase of in-use testing with field testing is estimated to reduce an applicant's in-use compliance testing costs by approximately \$50,000 to \$82,000 for each DECS family. However, most applicants hold verifications for multiple DECS families. To determine the overall savings to industry, staff applied the estimated savings from the proposed changes to the in-use testing requirements to all currently verified DECS families. As shown below in Table C3, there are 59 DECS families currently verified by ARB<sup>1</sup>.

**Table C3- Currently Verified DECS Families by Application and Emission Reduction Type**

<b>Currently Verified DECS Families by Application</b>							<b>Totals</b>
On-Road	Off-Road	TRU	Stationary	APU	RTG Crane	Marine	
22	13	5	12	4	2	1	59
<b>Currently Verified PM DECS Families by Application</b>							
On-Road	Off-Road	TRU	Stationary	APU	RTG Crane	Marine	
19	10	5	12	4	1	1	52
<b>Currently Verified PM &amp; NO<sub>x</sub> DECS Families by Application</b>							
On-Road	Off-Road	TRU	Stationary	APU	RTG Crane	Marine	
3	3	0	0	0	1	0	7

<sup>1</sup> ARB, 2012a, ARB Verification Procedure-Currently Verified.  
<http://www.arb.ca.gov/diesel/verdev/vt/cvt.htm>. Accessed April 18, 2012

Of the currently verified strategies, only 7 DECS families provide reductions of both particulate matter (PM) and Oxides of Nitrogen (NO<sub>x</sub>). Based on staff's proposed changes, these strategies would be required to validate continuing NO<sub>x</sub> reductions and would likely utilize PEMS testing in-field. As previously stated, compared to the current in-use testing requirements, staff estimates a savings of approximately \$50,000 per DECS family for these strategies which represents total savings to industry of approximately \$350,000. Staff estimates the remaining 52 strategies would realize the full savings of \$82,000 per DECS family which represents total savings to industry of approximately \$4.3 million. Therefore, replacing one phase of emissions testing with proposed field testing is estimated to save industry over \$4.6 million for currently verified DECS families.

Staff's proposed alternative test schedule represents an even greater savings to DECS industry. As identified in Chapter II of the staff report, the proposed amendments contain a provision that would allow an applicant to move directly to emissions testing bypassing field testing entirely, thus cutting their in-use testing costs in half. While it is not clear how many applicants may select this option, staff used the best available data to quantify the cost savings to industry. Assuming all 59 currently verified DECS families selected the alternative test schedule option which would reduce their in-use testing costs by one-half, based on the average testing costs shown in Table C2, this represents a savings to industry of approximately \$4.9 million. Also, since the alternative test schedule eliminates one phase of testing entirely, applicants would have no need to conduct field visits to select and identify the required 10 candidate test units. Based on verbal discussions with industry, staff estimates that this work costs applicants between \$5,000 and \$10,000 in labor and travel costs for each DECS family. Assuming an average savings of \$7,500 per DECS family by eliminating the need to select and identify 10 candidate test units, this represents an additional savings to industry of over \$440,000. Therefore, the total savings to industry of the proposed alternative test schedule is over \$5.3 million. While it is unlikely that all applicants would select this option, this does provide an upper bound estimate of the potential savings of the proposed provision.

Staff's proposed change allowing applicants to use only one emissions test engine would also provide savings for some applicants. Because the emission control groups associated with Truck Refrigeration Unit (TRU), Stationary, Auxiliary Power Unit (APU), RTG Crane, and Marine verifications are generally narrow, staff does not anticipate that these strategies would require more than one test engine for their required in-use emissions testing. However, strategies verified for use with on-road and off-road engines usually have broad emission control groups which results in applicants offering products in multiple sizes and configurations. These generally require multiple test engines to fulfill their in-use emissions testing obligations. In developing the estimates shown in Table C2, several emissions testing facilities provided cost estimates for engine rental and set-up. While applicants could elect to purchase an additional test engine, renting a "house" engine from a test facility is by far the most cost-effective way to accomplish this. Based on the information provided to staff, the average cost for test engine rental and set up is approximately \$15,250 per DECS family. Staff estimates

that this would likely apply to the 25 currently verified on-road and off-road DECS family names shown in Table C3. Therefore, the proposed change represents an additional savings to industry of over \$381,000.

In addition to these estimated savings, the proposed amendments to increase the sales triggers will allow all applicants to sell additional units before beginning their in-use testing. This will significantly lower the current fixed per-unit overhead costs associated with the Procedure's in-use compliance requirements and allow applicants to realize additional profits to better enable them to prepare for the mandatory testing. Though this is difficult to quantify, it will result in additional economic benefits and financial flexibility for all applicants.

Finally, staff's proposal includes functional testing that would allow applicants to test "in-field" various parts of their systems, thus eliminating the need to remove and replace the entire system for emissions testing. While these potential savings are also not quantifiable due to the range of costs associated with verified DECS and the unique make-up of each verified product, for most applicants this will result in additional economic benefits and financial flexibility.

In summary, the proposed changes to the Procedures in-use compliance testing requirements will result in reduced testing costs and added financial flexibility for all applicants while maintaining the stringency provided by the current in-use testing requirements. While the flexibility provided by staff's proposal makes quantifying the individual savings realized by each applicant difficult, staff estimates the savings to DECS industry from the proposed changes to the in-use compliance requirements will be approximately \$5 million to \$5.7 million for the currently verified DECS families.

In addition, once verified, all applicants are subject to the in-use compliance requirements. In conversations with applicants, staff estimates that the cost of verification is approximately \$500,000 to \$1 million per DECS family. Therefore, the changes to the in-use compliance requirements are estimated to provide a 10 percent savings to future applicants over the current cost of verification.

### **C. Recall Provisions.**

The proposed recall provisions could potentially increase long-term costs for all applicants and have the potential to create a significant economic impact for any applicant subject to a recall action. However, because of the uncertainty of a recall event and the diversity of systems currently verified it is not possible to quantify the potential costs to an individual applicant. However, by using the best available data and some general assumptions staff was able to quantify a range of costs to DECS industry due to a potential recall event.

As discussed in the staff report in Chapter II, applicants are required to submit annual warranty reports to the Executive Officer which include confidential sales data. While this sales data is not complete for all categories, credible data exist for on-road, off-

road, and TRU DECS sales. Based on best available data staff selected these categories as they represent approximately 70 percent of all currently verified DECS families and are therefore representative of the majority of currently deployed systems. Staff analyzed the data to determine average annual sales for each category as shown in Table C4.

**Table C4- Average Annual Sales of On-Road, Off-Road, and TRU DECS**

Sales Year	On-Road Units (Total Sales by Year)	Off-Road Units (Total Sales by Year)	TRU (Total Sales by Year)
2010	5452	752	2577
2009	3557	1660	2575
<b>Average Annual Sales</b>	4505	1206	2576

Only 2 years of data were analyzed due to the recent changes in the Procedure’s Nitrogen Oxide (NO<sub>2</sub>) requirements. Because of the required changes, most applicants verified new products in advance of the January 1, 2009 implementation date, leaving only 2 full years of sales data for currently verified systems available for analysis. This provides average total annual sales in each category that could potentially be affected by a recall.

Staff’s analysis uses a conservative but reasonable approach by assuming that a potential recall would affect only part of each verified system. This is a reasonable assumption as a potential recall event is unlikely to result in replacement of the entire DECS. Therefore, staff selected the diesel particulate filter (DPF) core as the part of each verified system that would require replacement due to recall as this is generally the most expensive part of DECS. Staff contacted retrofit manufacturers and reviewed grant expenditures to collect average DPF core replacement costs and grouped them according to substrate type for on-road, off-road, and TRU systems. The average costs are shown below in Table C5 (Haas, 2012b, Brown, 2012c, Machado, 2012d, Luksik, 2012e, Simons, 2012f, Sem, 2012g, Babineau, 2012h, Swenson, 2012i, Lassen, 2012j, Grylls, 2012k, Jennings, 2012l).

**Table C5- Average DPF Core Replacement Costs for On-Road, Off-Road, and TRU DECS**

Substrate Type	On-Road DPF Core, (average replacement costs)	Off-Road DPF Core, (average replacement costs)	TRU DPF Core (average replacement costs)
Silicon Carbide - Uncatalyzed	\$2,948	\$6,231	\$1,310
Silicon Carbide - Catalyzed	\$6,349	\$5,984	NA
Cordierite - Uncatalyzed	\$3,000	NA	NA
Cordierite - Catalyzed	\$5,500	\$9,559	NA
Metal - Uncatalyzed	\$4,191	\$4,204	\$1,600

Metal - Catalyzed	NA	NA	\$2,300
Average Replacement DPF Core Costs	\$4,398	\$6,494	\$1,737

However, since this represents the costs to end-users and not applicants, staff reduced the average replacement DPF core price for each category by 30 percent to represent each manufacturers assumed profit margin. Staff then used this adjusted cost and the average annual sales for each category to calculate the average annual costs to DECS industry for the replacement of DPF cores of deployed systems.

Staff assumed that a recall event could potentially occur every 5 years. Based on this assumption, the costs for DPF core replacement would be 5 times the average annual costs to DECS industry for the replacement of DPF cores of deployed systems in each category. This provides an estimate of the costs to replace all DPF cores due to a potential recall event in each category.

However, a potential recall would not require replacement of all DPF cores in each category. Based on the implementation history of the Procedure, staff believes that a recall event is unlikely to affect more than 2 DECS families during the 5 year period. Based on 59 currently verified DECS families, 2 DECS families represent approximately 4 percent of all currently verified families. Therefore, to estimate the costs of a potential recall event to DECS industry in each category, staff assumed that 4 percent of the total DPF core replacement costs would be representative of the cost of a potential recall event. Again, staff believes that this represents a reasonable estimate and the results of this analysis are shown in Table C6.

**Table C6- Estimated Potential Recall Costs for On-Road, Off-Road, and TRU DECS**

Category	On-Road	Off-Road	TRU
Average Annual Sales (DECS Units)	4505	1206	2576
Average DPF Core Replacement Costs to End-Users	\$4,398	\$6,494	\$1,737
Adjusted DPF Core Replacement Costs (average costs less 30%)	\$3,079	\$4,546	\$1,216
Average Annual Costs of DPF Core Replacement (average annual sales x adjusted DPF Core Replacement costs)	\$13,867,544	\$5,482,235	\$3,132,158
Total Costs of DPF Core Replacement to DECS Industry (average annual costs x 5 years)	\$69,337,769	\$27,411,174	\$15,660,792
Potential Recall Costs by Category (4% of Total Costs of DPF Core Replacement)	\$2,773,510	\$1,096,447	\$626,432
<b>Total Potential Recall Costs</b>	<b>\$2,773,510</b>	<b>\$1,096,447</b>	<b>\$626,432</b>

As shown in Table C6, the estimated potential recall costs to DECS industry for these categories range from \$2.8 million for an on-road system to \$626,000 for TRU systems. It is important to note that the proposed recall provisions, along with the warranty reporting requirements, represent possible tools that may be used by the Executive Officer in the event that an applicant fails to meet their warranty obligations or deploys a product that fails to perform either as verified or at its verified level. To stay competitive in the marketplace, most applicants seek to develop equitable relationships with their customers and have verified robust products that perform as verified. Therefore, for most applicants, the additional costs associated with a recall may not represent an additional economic impact as they may never be subject to the proposed provisions.

The Procedure currently includes provisions that provide for remedial measures in the event of a failure associated with an applicant’s DECS family, so even without the addition of the proposed recall provisions it is assumed that applicants have made appropriate financial preparations and that such costs are already being incurred. In addition, in talking with applicants, staff understands that most “set aside” a portion of each sale to accommodate potential warranty claims. Eventually, if these monies are not used to reimburse end-users for valid warranty claims or to address remedial actions, this money becomes profit.



Since the proposed recall provisions are not imposing direct costs on industry, staff questioned applicants to determine if the level currently set aside for potential warranty claims would be increased to offset the potential financial liability of staff's proposed recall provisions. Only one manufacturer stated that they would hold-back additional sales revenue to offset any potential financial liability associated with the proposed recall provisions. Therefore, staff estimates that the economic impact from the proposed recall provisions to DECS industry ranges from \$0 to \$2.8 million.

#### **D. Other Proposed Amendments**

*Installation Warranty Reporting.* Staff's proposal requiring authorized installers to submit an annual installation warranty report will result in an additional cost for each installer. Applicants have stated that their annual product warranty reports generally take approximately one to three days to prepare annually and require some level of management oversight. Since each installer is required to warrant the installation of a DECS and not the product itself, staff anticipates that there will be fewer valid warranty claims for installers. Therefore, compiling an annual report should be significantly less time intensive for installers when compared to applicants. Assuming a management level employee is required to compile the report and is paid \$60 per hour<sup>2</sup>, and this work takes 2 full days, this would cost each installer approximately \$960 per year. Staff has identified 76 businesses<sup>3</sup> (on-road, off-road, TRU installers) that are currently installing ARB verified retrofits. Staff estimates an additional \$73,000 in statewide reporting costs from the addition of the proposed installer warranty reporting requirements. However, better and earlier identification of remedial actions may offset the costs and actually provide cost savings to DECS installers.

*Pre-Installation Compatibility Assessment, Installer Requirements, and End-User training.* The proposal requiring applicants to specify a smoke opacity limit, or alternate criterion, to help determine the state of maintenance of the candidate engine prior to retrofit should not result in any significant economic impacts. Several installers have informed staff that they are already performing this additional assessment of their own accord. The smoke meters necessary to determine opacity are readily available to most fleets and are already required by other regulatory programs. A determination of the state of maintenance of the candidate engine prior to retrofit will reduce the number of in-field problems for both applicants and installers, likely lowering on-going costs for remedial actions.

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<sup>2</sup> State of California Employment Development Department, OES Employment and Wages by Occupation, State of California, 2011 1<sup>st</sup> Quarter, Sales Manager Mean Hourly Wage, SOC Code 11-2021, <http://www.labormarketinfo.edd.ca.gov/Content.asp?pageid=152>

<sup>3</sup> ARB, 2012m, *Frequently Asked Questions - Heavy-Duty DECS Installation and Maintenance*, List of Verified DECS Installers, on-road, off-road, and TRU. <http://www.arb.ca.gov/msprog/decsinstall/faq.htm#8>. Accessed March 3, 2012

The proposed changes to the pre-installation compatibility requirements for temperature dependent DECS are simply clarifications of the existing requirements and as such, will not result in any economic impacts. Likewise, the additional requirements for installers, such as performing a smoke test prior to DECS installation, are already in use by several applicants and will not result in any economic impacts. The development of on-line or other electronic training materials for end-users will represent a cost to all applicants if not already planned or provided. Some applicants are already planning on-line training to provide better availability of training classes and help cut the costs of some of the currently provided in-house training. Overall, staff believes that this initial expense will be offset by reduced personnel costs and savings in travel expenses in ongoing training as applicants or their representatives may no longer need to provide in-person training to affected fleets.

The requirement that applicants develop criteria that will be used to authorize their installers may lead to economic impacts for all applicants. However, these costs should be short-term and minimal as they represent only an initial one-time expenditure of staff time. Also, most of the proposed installation training is included in an applicant's Installation Manual which is already required as part of the verification process. Overall, staff believes that the economic impact of these proposed changes will not be significant.

*Application and Review Process.* The proposed changes to the application and review process should have no economic impact. Staff's proposal merely defines the application and review process to better define the requirements for verification and the process used by staff in reviewing verification applications. In the event that an applicant is required by the Executive Officer to submit a market-ready DECS, a minor cost may be incurred with respect to shipping or transportation as the system will be returned to the applicant upon completion, rejection, or withdrawal from the review process. However, this cost is not expected to be significant.

*Impacts of Other Clarifications.* None of the remaining proposed clarifications to the Procedure are expected to result in any additional costs or savings, because they implement the original intent of the regulation.

## **E. References.**

ARB, 2012a. California Air Resources Board. ARB Verification Procedure-Currently Verified, List of Currently Verified Diesel Emission Control Strategies. California Air Resources Board, April 3, 2012. <http://www.arb.ca.gov/diesel/verdev/vt/cvt.htm>. Last accessed April 18, 2012.

Haas, 2012b. Personal communication between Frank Haas of ESW Canada, and Dean Bloudoff, ARB; April 24, 2012.

Brown, 2012c. Personal communication between Kevin Brown of Engine Control Systems Limited, and Dean Bloudoff, ARB; April 24, 2012.

Machado, 2012d. Personal communication between Crystal Machado of HUSS Inc., and Dean Bloudoff, ARB; April 25, 2012.

Luksik, 2012e. Personal communication between Glenn Luksik of Caterpillar Inc., and Dean Bloudoff, ARB; April 24, 2012.

Simons, 2012f. Personal communication between Gary Simons of Donaldson Company Inc., and Yong Yu, ARB; April 24, 2012.

Sem, 2012g. Personal communication between Tom Sem of Proventia Americas, LLC., and Dean Bloudoff, ARB; April 25, 2012.

Babineau, 2012h. Personal communication between Tom Babineau of Rypos Inc., and Dean Bloudoff, ARB; April 25, 2012.

Swenson, 2012i. Personal communication between Tom Swenson of Cleaire Advanced Emissions Controls, LLC., and Paul Henderick, ARB; April 24, 2012.

Lassen, 2012j. Personal communication between Marty Lassen of Johnson Matthey Inc., and Dean Bloudoff, ARB; April 25, 2012.

Grylls, 2012k. Personal communication between Paul Grylls of DCL International Inc., and Yong Yu, ARB; April 24, 2012.

Jennings, 2012l. Personal communication between Lisa Jennings, ARB, and Dean Bloudoff, ARB; April 24, 2012.

State of California Employment Development Department, OES Employment and Wages by Occupation, State of California, 2011 1<sup>st</sup> Quarter, Sales Manager Mean Hourly Wage, SOC Code 11-2021. California Employment Development Department. <http://www.labormarketinfo.edd.ca.gov/Content.asp?pageid=152>. Last accessed March 3, 2012.

ARB, 2012m, *Frequently Asked Questions - Heavy-Duty DECS Installation and Maintenance*, List of Verified DECS Installers, on-road, off-road, and TRU. <http://www.arb.ca.gov/msprog/decsinstall/faq.htm#8>. Last accessed March 3, 2012.