THE CARL MOYER PROGRAM GUIDELINES

PART IV of IV

APPENDICES

TABLE OF CONTENTS

APPENDIX A

ACRONYMS

APPENDIX A

ACRONYMS

AAP	Agricultural Assistance Program
AB	Assembly Bill
ABT	Average Banking and Trading
AC	Alternating Current
AECP	Alternative Emission Control Plan
AESS	Automatic Engine Start-Stop
Ah	Amp-hour
APCD	Air Pollution Control District
APCO	Air Pollution Control Officer
APU	Auxiliary Power Unit
AQMD	Air Quality Management District
ARB	California Air Resources Board
ASM	Acceleration Simulation Mode
ATCM	Airborne Toxic Control Measure
ATE	Advanced Travel Center Electrification
AVL	Automatic Vehicle Locator
BACT	Best Available Control Technology
BAR	Bureau of Automotive Repair
bhp	Brake Horsepower
BNSF	Burlington Northern and Santa Fe Railroad
BTU	British Thermal Unit
C/E	Cost Effectiveness
CAF	Confined Animal Facility
CARL	Clean Air Reporting Log
CCR	California Code of Regulations
CI	Compression Ignition
CNG	Compressed Natural Gas
CO	Carbon Monoxide
COG	Council of Governments
CRF	Capital Recovery Factor
DC	Direct Current
DDHS	Diesel Driven Heating System
DECS	Diesel Emission Control Strategy
DMV	Department of Motor Vehicles
DOC	Diesel Oxidation Catalyst
DOE	Department of Energy
DPF	Diesel Particulate Filter
E/S	Electric Standby
ECF	Energy Consumption Factor
ECF	Energy Consumption Factor
EF	Emission Factor

EGR	Exhaust Gas Recirculation
EMFAC	ARB's On-Road Motor Vehicle Emission Inventory Model
EMU	Electronic Monitoring Unit
EO	Executive Order
EQIP	Environmental Quality Incentives Program
ERCs	Emission Reduction Credits
ES	Emission Standards
FBC	Fuel-Borne Catalyst
FCF	Fuel Correction Factor
FEL	Family Emission Limit
FTA	Federal Transit Administration
FTF	Flow-Through Filter
FTP	Federal Test Procedure
FY	Fiscal Year
g	gram
g/bhp-hr	gram per brake horsepower-hour
gal	Gallon
GPS	Geographic Positioning System
GSE	Ground Support Equipment
GTL	Gas-to-Liquid
GVWR	Gross Vehicle Weight Rating
HC	Hydrocarbons
HD	Heavy-Duty
HDDE	Heavy-Duty Diesel Engine
HDT	Heavy-Duty Truck
HDV	Heavy-Duty Vehicle
HEB	Hybrid-Electric Bus
HHDV	Heavy Heavy-Duty Vehicle
hp	Horsepower
hr	Hour
HSC	California Health and Safety Code
HVAC	Heating, Ventilation and Air Conditioning
IC	Internal Combustion
ICE	Internal Combustion Engine
ILD	Idle Limiting Device
IMO	International Maritime Organization
IPI Team	Incentive Program Implementation Team
IRS	Internal Revenue Service
ISO	International Standards Organization
kW	Kilowatt
lbs	Pounds
LDV	Light-Duty Vehicle
LETRU	Low Emission Transport Refrigeration Unit
LEV	Low Emission Vehicle
LF	Load Factor
LHD	Light Heavy-Duty

LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas – commonly called Propane
LSI	Large Spark Ignition
MDO	Marine Diesel Oil
MGO	Marine Gas Oil
MHDV	Medium Heavy-Duty Vehicle
mi	Mile
MOA	Memorandum of Agreement
MOU	Memorandum of Understanding
MV Fee	Motor Vehicle Registration Fee
MY	Model Year
NADA	National Automotive Dealership Association
NMHC	Non-Methane Hydrocarbons
NOFA	Notice of Funds Available
NOx	Oxides of Nitrogen
OBD II	On-Road Diagnostics, Phase II
OEM	Original Equipment Manufacturer
PAH	Polycyclic Aromatic Hydrocarbons
PEM	Proton Exchange Membrane
PG&E	Pacific Gas and Electric
PM	Particulate Matter
PM10	Inhalable Particulate Matter
RFP	Request for Proposals
ROG	Reactive Organic Gas
RSD	Remote Sensing Device
SB	Senate Bill
SCAB	South Coast Air Basin
SCAQMD	South Coast Air Quality Management District
SCE	Southern California Edison
SCR	Selective Catalytic Reduction
SIP	State Implementation Plan
SMAQMD	Sacramento Metropolitan Air Quality Management District
SOF	Soluble Organic Fraction
SOFC	Solid Oxide Fuel Cell
SOP	Statement of Principles
SORE	Small Off Road Engine
STB	Surface Transportation Board
STD	Standard
SULEV	Super Ultra Low Emission Vehicle
SUV	Sport-Utility Vehicle
SWCV	Solid Waste Collection Vehicle
TAC	Toxic Air Contaminant
TFV	Transit Fleet Vehicle
THC	Total Hydrocarbon
TIP	Transportation Implementation Plan
tpd	Tons Per Day

TRU	Transport Refrigeration Unit
TSE	Truck Stop Electrification
TSI	Two Speed Idle
U.S. EPA	U.S. Environmental Protection Agency
UB	Urban Bus
ULETRU	Ultra Low Emission Transport Refrigeration Unit
ULEV	Ultra Low Emission Vehicle
UP	Union Pacific Railroad
V	Volt
VAVR	Voluntary Accelerated Vehicle Retirement
VIN	Vehicle Identification Number
VMT	Vehicle Miles Traveled
VOC	Volatile Organic Compound
VVR	Voluntary Vehicle Repair
yr	Year
ZEB	Zero Emission Bus

APPENDIX B

TABLES FOR EMISSION REDUCTION AND COST-EFFECTIVENESS CALCULATIONS

APPENDIX B

TABLES FOR EMISSION REDUCTION AND COST-EFFECTIVENESS CALCULATIONS

This appendix presents tables summarizing the data needed to calculate the emission reductions and cost-effectiveness of potential projects. Included are data such as engine emission factors, load factors, and other conversion factors used in the calculations discussed in Appendix C: Cost-Effectiveness Calculation Methodology and Appendix E: Example Calculations.

Table B-1
Capital Recovery Factors (CRF) for Various Project Life
At Four Percent Discount Rate

Project Life	CRF
1*	1.040
2*	0.530
3	0.360
4	0.275
5	0.225
6	0.191
7	0.167
8	0.149
9	0.134
10	0.123
11	0.114
12	0.107
13	0.100
14	0.095
15	0.090
16	0.086
17	0.082
18	0.079
19	0.076
20	0.074

- Note: For agricultural projects only.

Table B-2
Heavy-Duty Diesel Engines 2004-2009
Converted Emission Standards (g/bhp-hr)

EO Certification Level	Converted Emission Standards		
NOx + NMHC	**Diesel NOx[(e)]**	**Diesel ROG[(e)]**	**Alternative Fuel NOx**
2.5[(a)]	2.21	0.12	2.00
1.8[(b)]	1.59	0.09	1.44
1.5[(b)]	1.33	0.07	1.20
1.2[(b)]	1.06	0.06	0.96
0.9[(b)]	0.80	0.04	0.72
0.6[(b)]	0.53	0.03	0.48
0.3[(b)]	0.27	0.01	0.24
PM10	**Diesel PM10**		**Alternative Fuel PM10**
0.10[(c)]	0.072		0.100
0.03[(b)]	0.022		0.030
0.02[(b)]	0.014		0.020
0.01[(b,d)]	0.007		0.010

a – 2004-2006 emission standard for all on-road heavy duty engines except diesel urban buses.
b – 2004-2006 optional emission standards for all on-road heavy duty engines except diesel urban buses.
c – 2004-2006 emission standard for all on-road heavy duty engines except urban buses.
d – 2004-2006 emission standard for all urban buses.
e - Emission standards were converted where appropriate, using the NMHC and NOx fraction default values and the ultra low-sulfur diesel fuel correction factors listed in Tables B-26 and B-27, respectively.

Table B-3
Heavy-Duty Alternative Fuel Engines
Converted Emission Standards (g/bhp-hr)

Model Year	NOx	PM10
1988 – 1989	6.0	0.60
1990	6.0	0.60
1991 – 1993	5.0	0.25
1994 – 1997	5.0	0.10
1998 - September 2002	4.0	0.10
October 2002 – 2006	2.0	0.10
2007	1.2	0.01
2010	0.2	0.01

Table B-4
Diesel Medium Heavy-Duty Vehicles 14,001-33,000 lbs GVWR
Emission Factors (g/mile) [(a)]

Model Year	NOx	ROG	PM10
Pre-1984	17.21	0.29	0.792
1984 – 1986	16.65	0.29	0.720
1987 – 1990	14.6	0.18	0.504
1991 – 1993	12.18	0.16	0.288
1994 – 1997	10.7	0.1	0.216
1998 – 2002	9.77	0.08	0.144
2003+	5.39	0.08	0.216
2004 – 2006	5.12	0.08	0.216
2007 – 2009	2.79	0.05	0.024
2010+	0.51	0.02	0.024

a - Emission factors were converted using the ultra low-sulfur diesel fuel correction factors listed in Table B-27.

Table B-5
Diesel Heavy Heavy-Duty Vehicles 33,000+ lbs GVWR
Emission Factors (g/mile) [(a)]

Model Year	NOx	ROG	PM10
Pre-1987	21.39	1.04	1.249
1987 – 1990	21.11	0.81	1.354
1991 – 1993	18.23	0.54	0.562
1994 – 1997	17.95	0.4	0.367
1998 – 2002	17.58	0.51	0.403
2003 – 2006	11.63	0.26	0.252
2007 – 2009	6.36	0.23	0.028
2010+	1.06	0.18	0.028

a - Emission factors were converted using the ultra low-sulfur diesel fuel correction factors listed in Table B-27.

Table B-6
Diesel Urban Buses
Converted Emission Standards (g/bhp-hr)

Model Year	NOx	ROG	PM10
1987 – 1990[a]	5.58	1.17	0.432
1991 – 1993[a]	4.65	1.17	0.072
1994 – 1995[a]	4.65	1.17	0.050
1996 – 2002[a]	3.72	1.17	0.036
2003[a,b]	2.21	0.12	0.007
2004 – 2006[c]	-	-	-
2007 – 2009	1.20	0.19	0.010
2010	0.20	0.19	0.010

a - Emission standards were converted where appropriate, using the NMHC and NOx fraction default values and the ultra low-sulfur diesel fuel correction factors listed in Tables B-26 and B-27, respectively.
b - NOx+NMHC emission standard converted to NOx and ROG.
c - No diesel buses have been certified to the 0.5 g/bhp-hr for the 2004-2006 model year emission standard.

Table B-7
Natural Gas Urban Buses
Converted Emission Standards (g/bhp-hr)

Model Year	NOx	PM10
1991 – 1993	5.00	0.100
1994 – 1995	5.00	0.070
1996 – 1997	4.00	0.050
1998 – 2002[b]	2.50	0.050
2003 – 2006[a,b,c]	1.44	0.020
2007 – 2009	1.20	0.010
2010+	0.20	0.010

a - NOx+NMHC emission standard converted to NOx only.
b - A majority of the natural gas urban buses have been certified to the optional standards. Therefore, these values are based on the optional standards.
c - Many natural gas urban buses have been certified to optional standards below this level.

Table B-8
Conversion Factors for NOx, ROG and PM10
Heavy-Duty Vehicle Projects (bhp-hr/mile)

Model Year	Medium Heavy-Duty 14,001-33,000 lbs.	Heavy Heavy-Duty 33,000 lbs. +	Urban Bus 33,000 lbs. +
Pre-1989	1.9	3.1	4.0
1990 - 1993	1.8	3.0	4.0
1994 - 1995	1.8	2.9	4.0
1996+	1.8	2.9	4.0

Table B-9
TRU and APU Default Load Factors

Category	Horsepower	Load Factor
Transport Refrigeration Units	<25	0.64
	25 – 50	0.53
Auxiliary Power Unit	<25	0.74

Table B-10
TRU and APU Emission Factors (g/bhp-hr)

Horsepower	Tier / Model Year	NOx	ROG	PM10
< 11	Pre-1995	9.30	1.80	0.720
	1995 – 1999	8.70	1.26	0.410
	Tier 1	5.76	0.82	0.376
	Tier 2	4.14	0.59	0.304
	Tier 4	4.14	0.59	0.152
11 – 24	Pre-1995	6.44	2.21	0.550
	1995 – 1999	6.44	1.08	0.413
	Tier 1	5.49	0.77	0.306
	Tier 2	4.33	0.69	0.306
	Tier 4	4.33	0.69	0.152
25 - 49	Uncontrolled pre-1988	6.51	2.21	0.547
	Uncontrolled 1988 +	6.42	2.17	0.547
	Tier 1	5.26	1.74	0.480
	Tier 2	4.63	0.29	0.280
	Tier 4 Interim	4.55	0.12	0.128
	Tier 4 Final	2.75	0.12	0.008

Table B-11
Off-Road Diesel Engines Default Load Factors

Category	Equipment Type	Load Factor
Airport Ground Support	Aircraft Tug	0.80
	Air Conditioner	0.75
	Air Start Unit	0.90
	Baggage Tug	0.55
	Belt Loader	0.50
	Cargo Loader	0.50
	Forklift	0.30
	Ground Power Unit	0.75
	Lift	0.50
	Service Truck	0.20
	Other GSE	0.50
Mobile Agricultural	Agricultural Mowers	0.43
	Agricultural Tractors	0.70
	Balers	0.58
	Combines	0.70
	Hydro Power Units	0.48
	Sprayers	0.50
	Swathers	0.55
	Tillers	0.78
	Other Agricultural	0.51
Construction	Cranes	0.43
	Crawler Tractors	0.64
	Crushing/Proc. Equipment	0.78
	Excavators	0.57
	Graders	0.61
	Off-Highway Tractors	0.65
	Off-Highway Trucks	0.57
	Pavers	0.62
	Other Paving	0.53
	Rollers	0.56
	Rough Terrain Forklifts	0.60
	Rubber Tired Dozers	0.59
	Rubber Tired Loaders	0.54
	Scrapers	0.72
	Signal Boards	0.78
	Skid Steer Loaders	0.55
	Surfacing Equipment	0.45

Table B-11
Off-Road Diesel Engines Default Load Factors
(Continued)

Category	Equipment Type	Load Factor
Construction	Tractors/Loaders/Backhoes	0.55
	Trenchers	0.75
	Other Construction Equipment	0.62
Industrial	Aerial Lifts	0.46
	Forklifts	0.30
	Sweepers/Scrubbers	0.68
	Other General Industrial	0.51
	Other Material Handling	0.59
Logging	Fellers/Bunchers	0.71
	Skidders	0.74
Oil Drilling	Drill Rig	0.75
	Lift (Drilling)	0.60
	Swivel	0.60
	Workover Rig (Mobile)	0.75
	Other Workover Equipment	0.60
Cargo Handling	Container Handling Equipment	0.59
	Cranes	0.43
	Excavators	0.57
	Forklifts	0.30
	Other Cargo Handling Equipment	0.51
	Sweeper/Scrubber	0.68
	Tractors/Loaders/Backhoes	0.55
	Yard Trucks	0.65
Non-Mobile Agricultural Engines	Irrigation Pump	0.65
	Other	0.51
Other	All	0.43

Table B-12
Uncontrolled Off-Road Diesel Engines
Emission Factors (g/bhp-hr)

Horsepower	Model Year	NOx	ROG	PM10
25 – 49	pre-1988	6.51	2.21	0.547
	1988 +	6.42	2.17	0.547
50 – 119	pre-1988	12.09	1.73	0.605
	1988 +	8.14	1.19	0.497
120+	pre-1970	13.02	1.59	0.554
	1970 – 1979	11.16	1.20	0.396
	1980 – 1987	10.23	1.06	0.396
	1988 +	7.60	0.82	0.274

Table B-13
Controlled Off-Road Diesel Engines
Emission Factors (g/bhp-hr)

Tier	Horsepower	NOx	ROG	PM10
1	25 – 49	5.26	1.74	0.480
	50 – 119	6.54	1.19	0.552
	120 – 174	6.54	0.82	0.274
	175 +	5.93	0.38	0.108
2	25 – 49	4.63	0.29	0.280
	50 – 119	4.75	0.23	0.192
	120 – 174	4.17	0.19	0.128
	175 – 250	4.15	0.12	0.088
	251+	3.79	0.12	0.088
3	50 – 120	2.74	0.12	0.160
	121 – 750	2.32	0.12	0.112
4 Interim	25 – 49	4.55	0.12	0.128
	50 – 120	2.40	0.11	0.056
	121 – 174	2.15	0.11	0.008
	175 – 750	1.29	0.08	0.008
	>750	2.24	0.12	0.048
4 Final	25 – 49	2.75	0.12	0.008
	50 – 120	1.33	0.08	0.008
	121 – 750	0.26	0.06	0.008
	>750	2.24	0.06	0.016

Emission factors were converted using the ultra low-sulfur diesel fuel correction factors listed in Table B-28.

LARGE SPARK IGNITION ENGINES

Table B-14
Off-Road LSI Equipment Default Load Factors

Category	Equipment Type	Load Factor
Agriculture	Agricultural Tractors	0.62
	Balers	0.55
	Combines	0.74
	Sprayers	0.50
	Swathers	0.52
	Other Agricultural Equipment	0.55
Airport Ground Support	A/C Tug	0.80
	Baggage Tug	0.55
	Belt Loader	0.50
	Bobtail	0.55
	Cargo Loader	0.50
	Forklift	0.30
	Ground Power Unit	0.75
	Lift	0.50
	Passenger Stand	0.59
	Other GSE	0.50
Construction	Asphalt Pavers	0.66
	Bore/Drill Rigs	0.79
	Concrete/Industrial Saws	0.78
	Cranes	0.47
	Paving Equipment	0.59
	Rollers	0.62
	Rough Terrain Forklifts	0.63
	Rubber Tired Loaders	0.54
	Skid Steer Loaders	0.58
	Tractors/Loaders/Backhoes	0.48
	Trenchers	0.66
	Other Construction	0.48
Industrial	Aerial Lifts	0.46
	Forklifts	0.30
	Sweepers/Scrubbers	0.71
	Other Industrial	0.54

Table B-15
Off-Road LSI Engines
Emission Factors (g/bhp-hr)

Horsepower	Fuel	Model Year	NOx	ROG	PM10
25 – 49	Gasoline	Uncontrolled – pre-2004	8.01	3.81	0.060
		Controlled 2001-2006	1.33	0.72	0.060
		Controlled 2007-2009	0.89	0.48	0.060
		Controlled 2010+	0.27	0.14	0.060
	Alt Fuel	Uncontrolled – pre-2004	13.00	0.90	0.060
		Controlled 2001-2006	1.95	0.09	0.060
		Controlled 2007-2009	1.30	0.06	0.060
		Controlled 2010+	0.39	0.02	0.060
50 – 120	Gasoline	Uncontrolled – pre-2004	11.84	2.66	0.060
		Controlled 2001-2006	1.78	0.26	0.060
		Controlled 2007-2009	1.19	0.18	0.060
		Controlled 2010+	0.36	0.05	0.060
	Alt Fuel	Uncontrolled – pre-2004	10.51	1.02	0.060
		Controlled 2001-2006	1.58	0.11	0.060
		Controlled 2007-2009	1.05	0.07	0.060
		Controlled 2010+	0.32	0.02	0.060
>120	Gasoline	Uncontrolled – pre-2004	12.94	1.63	0.060
		Controlled 2001-2006	1.94	0.16	0.060
		Controlled 2007-2009	1.29	0.11	0.060
		Controlled 2010+	0.39	0.03	0.060
	Alt Fuel	Uncontrolled – pre-2004	10.51	0.90	0.060
		Controlled 2001-2006	1.58	0.09	0.060
		Controlled 2007-2009	1.05	0.06	0.060
		Controlled 2010+	0.32	0.02	0.060

Table B-16
Emission Factors for Off-Road LSI Engine Retrofits
Verified to Absolute Emission Number (g/bhp-hr)

Manufacturers of LSI retrofit systems may verify to a percent emission reduction or absolute emissions. If a retrofit system is verified to a percent reduction, the emission factors will be that verified percent of the appropriate emissions factors in Table B-15. If a retrofit system is verified to an absolute emission number, use the following table for the emission factors.

Fuel	Verified Value	NOx	ROG	PM10
Gasoline	3.0 g/bhp-hr	1.78	0.26	0.060
	2.5 g/bhp-hr	1.48	0.22	0.060
	2.0 g/bhp-hr	1.19	0.18	0.060
	1.5 g/bhp-hr	0.89	0.13	0.060
	1.0 g/bhp-hr	0.59	0.09	0.060
	0.6 g/bhp-hr	0.36	0.05	0.060
	0.5 g/bhp-hr	0.30	0.04	0.060
Alt Fuel	3.0 g/bhp-hr	1.58	0.10	0.060
	2.5 g/bhp-hr	1.32	0.09	0.060
	2.0 g/bhp-hr	1.05	0.07	0.060
	1.5 g/bhp-hr	0.79	0.05	0.060
	1.0 g/bhp-hr	0.53	0.03	0.060
	0.6 g/bhp-hr	0.32	0.02	0.060
	0.5 g/bhp-hr	0.26	0.02	0.060

Table B-17
Off-Road LSI Engines Certified to Optional Standards
Emission Factors (g/bhp-hr)

Horsepower	Fuel	Optional Standard	NOx	ROG	PM10
25-50	Gasoline	1.50	0.67	0.36	0.060
		1.00	0.44	0.24	0.060
		0.60	0.27	0.14	0.060
		0.40	0.18	0.10	0.060
		0.20	0.09	0.05	0.060
		0.10	0.04	0.02	0.060
	Alt Fuel	1.50	0.98	0.05	0.060
		1.00	0.65	0.03	0.060
		0.60	0.39	0.02	0.060
		0.40	0.26	0.01	0.060
		0.20	0.13	0.01	0.060
		0.10	0.07	0.00	0.060
50-120	Gasoline	1.50	0.89	0.13	0.060
		1.00	0.59	0.09	0.060
		0.60	0.36	0.05	0.060
		0.40	0.24	0.04	0.060
		0.20	0.12	0.02	0.060
		0.10	0.06	0.01	0.060
	Alt Fuel	1.50	0.79	0.05	0.060
		1.00	0.53	0.03	0.060
		0.60	0.32	0.02	0.060
		0.40	0.21	0.01	0.060
		0.20	0.11	0.01	0.060
		0.10	0.05	0.00	0.060
>120	Gasoline	1.50	0.97	0.08	0.060
		1.00	0.65	0.05	0.060
		0.60	0.39	0.03	0.060
		0.40	0.26	0.02	0.060
		0.20	0.13	0.01	0.060
		0.10	0.06	0.01	0.060
	Alt Fuel	1.50	0.79	0.05	0.060
		1.00	0.53	0.03	0.060
		0.60	0.32	0.02	0.060
		0.40	0.21	0.01	0.060
		0.20	0.11	0.01	0.060
		0.10	0.05	0.00	0.060

LOCOMOTIVES

Table B-18a
Locomotive Emission Factors (g/bhp-hr)
Based on 1998 Federal Standards

Engine Model Year	Type	NOx[a]	ROG[b]	PM10[a]
Pre-1973	Line-haul and Passenger	12.22	0.51	0.275
	Switcher	16.36	1.06	0.378
1973-2001 Tier 0	Line-haul and Passenger	8.08	0.51	0.275
	Switcher	11.84	1.06	0.378
2002-2004 Tier 1	Line-haul and Passenger	6.30	0.49	0.275
	Switcher	9.31	1.06	0.370
2005-2011 Tier 2	Line-haul and Passenger	4.65	0.27	0.155
	Switcher	6.86	0.54	0.163

These factors are to be used for the project baseline emissions if the baseline locomotive is certified or required to be certified to the 1998 federal locomotive remanufacture standards, and for the reduced emission locomotive if the project locomotive is remanufactured to these 1998 standards. Factors are based upon Regulatory Impact Analysis: Final U.S. EPA Locomotive Regulation (2008).
a - NOx and PM10 emission factors have been adjusted by a factor of 0.94 and 0.86, respectively, to account for use of California ultra-low sulfur diesel fuel.
b - ROG = HC * 1.053

Table B-18b
Locomotive Emission Factors (g/bhp-hr)
Based on 2008 Federal Standards

Engine Model Year	Type	NOx[a]	ROG[b]	PM10[a]
1973-2001 Tier 0+	Line-haul and Passenger	6.77	0.32	0.172
	Switcher	9.98	0.60	0.198
2002-2004 Tier 1+	Line-haul and Passenger	6.30	0.31	0.172
	Switcher	9.31	0.60	0.198
2005-2011 Tier 2+	Line-haul and Passenger	4.65	0.14	0.069
	Switcher	6.86	0.27	0.095
2011-2014 Tier 3	Line-haul and Passenger	4.65	0.14	0.069
	Switcher	5.07	0.27	0.069

These factors are to be used for the project baseline emissions if the baseline locomotive is certified or required to be certified to the new (2008) federal locomotive remanufacture standards, and for the reduced emission locomotive if the project locomotive is remanufactured to the new standards or meets Tier 3 standards. Factors are based upon Regulatory Impact Analysis: Final U.S. EPA Locomotive Regulation (2008).
a - NOx and PM10 emission factors have been adjusted by a factor of 0.94 and 0.86, respectively, to account for use of California ultra-low sulfur diesel fuel.
b - ROG = HC * 1.053

Table B-19
Locomotive Idle-Limiting Device Factors

Type	Factor
Switchers	0.90
Line-Haul	0.97
Passenger	0.97

Note: Factors based on assumption ILD reduces locomotive engine idling by 50 percent.

MARINE VESSELS

Table B-20a
Uncontrolled Harbor Craft Propulsion Engine
Emission Factors (g/bhp-hr)

Horsepower	Model Year	ROG	NOx	PM
25-50	all	1.32	7.57	0.520
51-120	pre-1997	1.04	14.27	0.575
	1997+	0.71	9.70	0.524
121-250	pre-1971	0.95	15.36	0.527
	1971-78	0.79	14.27	0.451
	1979-83	0.72	13.17	0.376
	1984+	0.68	12.07	0.376
251+	pre-1971	0.91	15.36	0.506
	1971-78	0.76	14.27	0.431
	1979-83	0.68	13.17	0.363
	1984-94	0.65	12.07	0.363
251-750	1995+	0.49	8.97	0.260
751+	1995+	0.60	12.07	0.363

Table B-20b
Controlled Harbor Craft Propulsion Engine
Emission Factors (g/bhp-hr)

<table>
<tr><th>Tier</th><th>Horsepower</th><th>ROG</th><th>NOx</th><th>PM</th></tr>
<tr><td rowspan="3">1</td><td>25-50</td><td>1.30</td><td rowspan="2">6.93</td><td>0.580</td></tr>
<tr><td>51-120</td><td>0.71</td><td>0.524</td></tr>
<tr><td>121 +</td><td>0.49</td><td>8.97</td><td>0.290</td></tr>
<tr><td rowspan="5">2</td><td>25-50</td><td>1.30</td><td rowspan="2">5.04</td><td rowspan="2">0.240</td></tr>
<tr><td>51-120</td><td>0.71</td></tr>
<tr><td>121-175</td><td rowspan="3">0.49</td><td rowspan="2">4.84</td><td>0.176</td></tr>
<tr><td>176-750</td><td>0.120</td></tr>
<tr><td>751 +</td><td>5.24</td><td>0.160</td></tr>
<tr><td rowspan="5">3</td><td>25-50</td><td>1.30</td><td rowspan="2">5.04</td><td rowspan="2">0.176</td></tr>
<tr><td>51-120</td><td>0.71</td></tr>
<tr><td>121-175</td><td rowspan="3">0.49</td><td>3.60</td><td>0.077</td></tr>
<tr><td>176-1900</td><td>3.87</td><td>0.068</td></tr>
<tr><td>1901 +</td><td>4.14</td><td>0.085</td></tr>
</table>

Table B-21a
Uncontrolled Harbor Craft Auxiliary Engine
Emission Factors (g/bhp-hr)

Horsepower	Model Year	ROG	NOx	PM
25-50	all	1.58	6.42	0.460
51-120	pre-1997	1.23	12.09	0.508
	1997+	0.85	8.14	0.417
121-250	pre-1971	1.13	13.02	0.466
	1971-78	0.94	12.09	0.399
	1979-83	0.86	11.16	0.333
	1984-95	0.82	10.23	0.333
	1996+	0.59	7.75	0.255
251-750	pre-1971	1.08	13.02	0.448
	1971-78	0.90	12.09	0.381
	1979-83	0.81	11.16	0.321
	1984-94	0.77	10.23	0.321
	1995+	0.58	7.60	0.230
751 +	pre-1971	1.08	13.02	0.448
	1971-78	0.90	12.09	0.381
	1979-86	0.81	11.16	0.321
	1987-98	0.72	10.23	0.321
	1999+	0.58	7.75	0.255

Table B-21b
Controlled Harbor Craft Auxiliary Engine
Emission Factors (g/bhp-hr)

<table>
<tr><th>Tier</th><th>Horsepower</th><th>ROG</th><th>NOx</th><th>PM</th></tr>
<tr><td rowspan="3">1</td><td>25-50</td><td>1.54</td><td>6.54</td><td>0.511</td></tr>
<tr><td>51-120</td><td>0.85</td><td rowspan="2">6.93</td><td>0.464</td></tr>
<tr><td>121+</td><td>0.58</td><td>0.255</td></tr>
<tr><td rowspan="5">2</td><td>25-50</td><td>1.54</td><td rowspan="2">5.04</td><td rowspan="2">0.240</td></tr>
<tr><td>51-120</td><td>0.85</td></tr>
<tr><td>121-175</td><td rowspan="3">0.58</td><td rowspan="2">4.84</td><td>0.176</td></tr>
<tr><td>176-750</td><td>0.120</td></tr>
<tr><td>751 +</td><td>5.24</td><td>0.160</td></tr>
<tr><td rowspan="6">3</td><td>25-50</td><td>1.54</td><td rowspan="2">5.04</td><td rowspan="2">0.176</td></tr>
<tr><td>51-120</td><td>0.85</td></tr>
<tr><td>121-175</td><td rowspan="4">0.58</td><td>3.60</td><td>0.077</td></tr>
<tr><td>176-750</td><td>3.78</td><td rowspan="2">0.068</td></tr>
<tr><td>751-1900</td><td>3.87</td></tr>
<tr><td>1901+</td><td>4.14</td><td>0.085</td></tr>
</table>

Table B-22
Harbor Craft Load Factors

<table>
<tr><th>Vessel Type</th><th>Propulsion Engine</th><th>Auxiliary Engine</th></tr>
<tr><td>Commercial Fishing</td><td>0.27</td><td rowspan="8">0.43</td></tr>
<tr><td>Charter Fishing</td><td>0.52</td></tr>
<tr><td>Ferry/Excursion</td><td>0.42</td></tr>
<tr><td>Crew & Supply</td><td>0.45</td></tr>
<tr><td>Pilot</td><td>0.51</td></tr>
<tr><td>Tow</td><td>0.68</td></tr>
<tr><td>Work</td><td>0.45</td></tr>
<tr><td>Other</td><td>0.52</td></tr>
<tr><td>Tug</td><td>0.50</td><td>0.31</td></tr>
</table>

Table B-23
Shore Power
Default Emission Rates (g/kW-hr)

Pollutant	Emission Rate
NOx	13.9
ROG	0.49
PM (marine gas oil fuel with 0.11- 0.5 % sulfur content)	0.38
PM (marine gas oil fuel with <= 0.10 % sulfur content)	0.25

Table B-24
Shore Power
Default Power Requirements

Ship Category	Ship Size / Type Default (TEU)	Power Requirement (kW)
Container Vessel	<1,000	1,000
	1,000 – 1,999	1,300
	2,000 – 2,999	1,600
	3,000 – 3,999	1,900
	4,000 – 4,999	2,200
	5,000 – 5,999	2,300
	6,000 – 6,999	2,500
	7,000 – 7,999	2,900
	8,000 – 9,999	3,300
	10,000 – 12,000	3,700
Passenger Vessel	No Default Value – Use Actual Power Requirement*	
Reefer	Break Bulk	1,300
	Fully containerized	3,300

* The average power requirement for passenger vessels is 7,400 kW (ARB Oceangoing Vessel Survey, 2005)

ALL ENGINES

Table B-25
Fuel Consumption Rate Factors (bhp-hr/gal)

Category	Horsepower	Fuel Consumption Rate
Non- Mobile Agricultural Engines	> 50 hp	17.5
Other	< 750 hp	18.5
	≥ 750 hp	20.8

REFERENCES

The information in these tables has already been incorporated into the preceding emission factor tables. These tables are included for informational purposes.

Table B-26
Pollutant Fractions
NOx+NMHC Standards

Diesel Engines		Alternative Fuel Engines	
NOx	NMHC	NOx	NMHC
0.95	0.05	0.80	0.20

Table B-27
Fuel Correction Factors
On-Road Diesel Engines

Model Year	NOx	PM10	HC
Pre- 2007	0.93	0.72	0.72
2007+	0.93	0.80	0.72

Table B-28
Fuel Correction Factors
Off-Road Diesel Engines

Model Year	NOx	PM10
Pre-Tier 1	0.930	0.720
Tier 1+	0.948	0.800

APPENDIX C

COST-EFFECTIVENESS CALCULATION METHODOLOGY

APPENDIX C

COST-EFFECTIVENESS CALCULATION METHODOLOGY

I. Introduction

To receive Carl Moyer Program funding, each project must meet the maximum cost-effectiveness limit of $16,000 per weighted ton of surplus NOx, ROG, and PM10 (PM10 means combustion PM) emissions reduced. Only Carl Moyer Program funding, funding under the district's fiduciary budget authority, or funding provided by a port authority (to meet the match fund requirement) are included in determining the cost-effectiveness of surplus emission reductions. For more details see Part IV: Administration of the Carl Moyer Program.

II. General Cost-Effectiveness Calculations

The cost-effectiveness of a project is determined by dividing the annual cost of the potential project by the annual weighted surplus emission reductions that will be achieved by the project as shown in formula C-1 below.

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton):

$$\frac{\textit{Annualized Cost (\$/yr)}}{\textit{Annual Weighted Surplus Emission Reductions (tons/yr)}}$$

Descriptions on how to calculate annual emission reductions and annualized cost are provided in the following sections.

A. Calculating the Annual Weighted Surplus Emission Reductions

Annual weighted emission reductions are estimated by taking the sum of the project's annual surplus pollutant reductions following formula C-2 below. This will allow projects that reduce one, two, or all three of the covered pollutants to be evaluated for eligibility to receive Carl Moyer Program funding. While NOx and ROG emissions are given equal weight; emissions of combustion PM10 (such as diesel exhaust PM10 emissions) have been identified as a toxic air contaminant and thus carry a greater weight in the calculation.

Formula C-2: Annual Weighted Surplus Emission Reductions:

*NOx reductions (tons/yr) + ROG reductions (tons/yr) + [20 * (PM10 reductions (tons/yr)]*

The result of formula C-2 is used to complete formula C-1 to determine the cost-effectiveness of surplus emission reductions.

In order to determine the annual surplus emission reductions by pollutant, formula C-3 below must be completed for each pollutant (NOx, ROG, and PM10), for the baseline technology and the reduced technology, totaling up to 6 calculations:

1. Annual emissions of NOx for the baseline technology
2. Annual emissions of NOx for the reduced technology
3. Annual emissions of ROG for the baseline technology
4. Annual emissions of ROG for the reduced technology
5. Annual emissions of PM10 for the baseline technology
6. Annual emissions of PM10 for the reduced technology

These calculations are completed for each pollutant by multiplying the engine emission factor or converted emission standard (found in Appendix B) by the annual activity level and by other adjustment factors as specified for the calculation methodologies presented.

The **baseline technology** is the technology applied under normal business practices, such as, an engine certified by ARB to the current emission standards for new purchases; or the existing engine in a vehicle or equipment for repowers and retrofits.

The **reduced technology** is the newer technology used by the applicant to obtain surplus emission reductions. The newer technology may be one of the following:

- For a new purchase it would be the engine certified by ARB to reduce NOx emissions by at least 30 percent less than the current NOx emission standard, or certified by ARB to the optional NOx or NOx+NMHC emission standard. Locomotive and marine vessel new purchases have slightly different criteria. Please see the specific source category cost-effectiveness criteria for more information.
- For a repower it would be the replacement engine certified by ARB (for locomotives and marine vessels it would be EPA verified) to a minimum of 15 percent less than the NOx emissions from the baseline technology (existing engine).
- For a NOx retrofit it would be an ARB-verified retrofit technology that will reduce NOx emissions by a minimum of 15 percent from the NOx emissions of the baseline technology.
- For a PM retrofit it would be the ARB-verified diesel emission control strategy (DECS) that reduces PM emissions as level 1 (25 percent reduction), level 2 (50 percent reduction), or level 3 (85 percent reduction).

Since the emission factor or converted standard is given in units of grams, a conversion from grams to tons is also required, as described in formula C-3 below.

Formula C-3: Estimated Annual Emissions by Pollutant (tons/yr):

*Emission Factor or Converted Emission Standard (g/bhp-hr) * Annual Activity * Adjustment Factor(s) * Percent Operation in CA * ton/907,200g*

The Carl Moyer Program allows the emissions reductions from a project to be calculated using the following activity factors on an annual basis:

- Hours of operation,
- Fuel consumption, or
- Miles traveled.

Specific activity factors allowed for each project category may differ and are identified in the source category chapters of the Carl Moyer Program Guidelines.

1. Calculating Annual Emissions Based on Hours of Operation

When actual annual hours of equipment operation are the basis for determining emission reductions, the equipment activity level must be based on a properly functioning hour meter (See Part I, Chapter 2 and the relative source category chapter for additional information on this topic). In addition, the horsepower rating of the engine and an engine load factor found in Appendix B must be used. A default load factor of 0.43 is used for those projects where no specific equipment load factor is available in Appendix B. The method for calculating emission reductions based on hours of operation is described in formula C-4 below.

Formula C-4: Estimated Annual Emissions based on hours of Operation (tons/yr):

*Emission Factor or Converted Emission Standard (g/bhp-hr) * Horsepower * Load Factor * Activity (hrs/yr) * Percent Operation in CA * ton/907,200g*

The engine load factor is an indicator of the nominal amount of work done by the engine for a particular application. It is given as a fraction of the rated horsepower of the engine and varies with engine application. For projects in which the horsepower of the baseline technology and reduced technology are different by more than 25 percent, the load factor must be adjusted following formula C-5 below. It is important to understand the replacement load factor must never exceed 100 percent in cases where the reduced technology engine is significantly smaller than the baseline technology engine.

Formula C-5: Replacement Load Factor:

$$\text{Load Factor}_{baseline} * hp_{baseline} / hp_{reduced}$$

2. Calculating Annual Emissions Based on Fuel Consumption

When annual fuel consumption is used for determining emission reductions, the equipment activity level must be based on annual fuel usage within California provided by the applicant. Fuel records must be maintained by the engine owner as described in the relative source category chapter for additional information on this topic.

An energy consumption factor (ECF) must be used to convert emissions given in g/bhp-hr to units of grams of emissions per gallon of fuel used (g/gal). The ECF is a number that combines the effects of engine efficiency and the energy content of the fuel used in that engine into an approximation of the amount of work output by an engine for each unit of fuel consumed. The ECF is found in Table B-25 in Appendix B. Formula C-6 below is the formula for calculating annual emissions based on annual fuel consumed.

Formula C-6: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr):

*Emission Factor or Converted Emission Standard (g/bhp-hr) * ECF (hp-hr/gal) * Activity (gal/yr) * Percent Operation in CA * ton/907,200g*

For on-road projects, if the emission factor is in g/mile, a unit conversion factor (bhp-hr/mile) found in Table B-8 in Appendix B must be used to convert from g/mile to g/bhp-hr. This is completed by dividing the emission factor (g/mile) by the conversion factor (bhp-hr/mile) resulting in (g/bhp-hr). Formula C-7 below is used to calculate annual emissions for fuel based on-road calculations.

Formula C-7: Estimated Annual Emissions based on Fuel Consumed using On-Road Emission Factors (tons/yr):

*[On-Road Emission Factor (g/mile)/Unit Conversion Factor (bhp-hr/mile)] * ECF (hp-hr/gal) * Activity (gal/yr) * Percent Operation in CA * ton/907,200g*

3. Calculating Annual Emissions Based on Annual Miles Traveled

Calculations based on annual miles traveled are only used for on-road projects. Mileage records must be maintained by the engine owner as described in Part 1, Chapter 3: On-road Heavy-Duty Vehicles.

Calculations Using Emission Factors: There is no conversion since the emission factors for on-road projects provided are given in units of g/mile. Formula C-8 describes the method for calculating pollutant emissions based on emission factors and miles traveled.

Formula C-8: Estimated Annual Emissions based on Mileage using Emission Factors (tons/yr):

*Emission Factor (g/mile) * Activity (miles/yr) * Percent Operation in CA * ton/907,200g*

Calculating Annual Emissions Based on Converted Standards**:** The unit conversion factor found in Table B-8 in Appendix B is used to convert the units of the converted emission standard (g/bhp-hr) to g/mile. Formula C-9 describes the method for calculating pollutant emissions using converted emission standards.

Formula C-9: Estimated Annual Emissions based on Mileage using Converted Emission Standards (tons/yr):

*Converted Emission Standard (g/bhp-hr) * Unit Conversion (bhp-hr/mile) * Activity (miles/yr) * Percent Operation in CA * ton/907,200g*

4. Calculating Annual Surplus Emission Reductions by Pollutant

The final step in this portion of the calculations is to determine the annual surplus emission reductions by pollutant. For new purchases and repower projects, subtract the annual emissions for the reduced technology from the annual emissions for the baseline technology following formula C-10 below.

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases:

Annual Emissions for the Baseline Technology –
Annual Emissions for the Reduced Technology

For retrofits, multiply the baseline technology pollutant emissions by the percent of emission reductions that the ARB-verified reduced technology is verified to following formula C-11 below.

Formula C-11: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Retrofits:

*Annual Emissions for the Baseline Technology **
Reduced Technology Verification Percent

Calculations must be done for each pollutant, NOx, PM10, and ROG, giving a total of three calculations.

For fleet modernization projects the baseline will be the newer vehicle emissions.

The annual surplus emission reductions by pollutant would be used in Formula C-2 to calculate the annual surplus emission reductions.

B. Determining the Annualized Cost

Annualized cost is the amortization of the one-time incentive grant amount for the life of the project to yield an estimated annual cost. The annualized cost is calculated by multiplying the incremental cost by the capital recovery factor (CRF). The resulting annualized cost is used to complete formula C-12 to determine the cost-effectiveness of surplus emission reductions.

Formula C-12: Annualized Cost ($):

*CRF * incremental cost ($)*

1. Calculating the CRF

The CRF is the level of earnings reasonably expected by investing state funds in various financial instruments over the length of a Carl Moyer Program project. The CRF uses an interest rate and project life to determine the rate at which earnings could reasonably be expected if the same funds were invested over a length of time equaling the project life. The CRF is calculated following formula C-13 below.

Formula C-13: Capitol Recovery Factor (CRF):

$$[(1 + i)^n (i)] / [(1 + i)^n - 1]$$

Where
i = discount rate (4 percent)
n = project life (at least 3 years see specific project criteria for default maximums)

The discount rate of 4 percent reflects the prevailing earning potential for state funds that could reasonably be expected by investing state funds in various financial instruments over the length of the minimum project life of Carl Moyer Program projects.

Table B-1 in Appendix B lists the CRF for various project lives using a discount rate of 4 percent. Use the result from formula C-13 to complete formula C-12 to determine the annualized cost of a project.

2. Calculating the Incremental Cost

In previous guidelines, incremental cost was determined by calculating the difference in cost between the new reduced technology and the baseline technology, making it necessary for the applicant to receive quotes for both the reduced and the baseline technologies. ARB staff decided to streamline this process by applying maximum eligible percent funding amounts to define incremental cost, eliminating the need to receive quotes for the baseline technology. An applicant would only need to provide an estimate of the cost of the reduced technology. Therefore, the incremental cost is determined by multiplying the cost of the reduced technology by the maximum eligible percent funding amount (from applicable chapter), as described in formula C-14 below.

Formula C-14: Incremental Cost ($):

*Cost of Reduced Technology ($) * Maximum Eligible Percent Funding Amount*

Generally the cost of the baseline vehicle for a new purchase is assumed to be a certain percentage of the cost of a new vehicle meeting reduced emissions from the standard. The cost of the baseline technology for a repower is assumed to be a percentage of the new engine. For retrofits, there is no baseline technology cost; hence the entire cost of the retrofit may be eligible for funding.

For fleet modernization projects, the incremental cost is determined by adjusting the value given to the vehicle by the National Automotive Dealership Association (N.A.D.A.), as described in formula C-15 below.

Formula C-15: Incremental Cost for Fleet Modernization Projects ($):

When the replacement vehicle is not new:

N.A.D.A value

where the N.A.D.A value is the retail value of the used vehicle * 50 percent.

When the replacement vehicle is new:

*Invoice of the New Vehicle * 50 percent*

Use the results from formula C-14 or C-15 to complete formula C-12 to determine the annualized cost of a project.

III. List of Formulas

For an easy reference, the necessary formulas to calculate the cost-effectiveness of surplus emission reductions for a project funded through the Carl Moyer Program are provided below.

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton):

$$\frac{\text{Annualized Cost (\$/yr)}}{\text{Annual Weighted Surplus Emission Reductions (tons/yr)}}$$

Formula C-2: Annual Weighted Surplus Emission Reductions:

NOx reductions (tons/yr) + ROG reductions (tons/yr) + [20 * PM10 reductions (tons/yr)]

Formula C-3: Estimated Annual Emissions by Pollutant (tons/yr):

Emission Factor or Converted Emission Standard (g/bhp-hr) * Annual Activity * Adjustment Factor(s) * Percent Operation in CA* (ton/907,200g)

Formula C-4: Estimated Annual Emissions based on hours of Operation (tons/yr):

Emission Factor or Converted Emission Standard (g/bhp-hr) * Horsepower * Load Factor * Activity (hrs/yr) * Percent Operation in CA * ton/907,200g

Formula C-5: Replacement Load Factor:

$$\text{Load Factor}_{\text{baseline}} * \text{hp}_{\text{baseline}}/\text{hp}_{\text{reduced}}$$

Formula C-6: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr):

Emission Factor or Converted Emission Standard (g/bhp-hr) * ECF (hp-hr/gal) * Activity (gal/yr) * Percent Operation in CA * ton/907,200g

Formula C-7: Estimated Annual Emissions based on Fuel Consumed using On-Road Emission Factors (tons/yr):

[On-Road Emission Factor (g/mile)/Unit Conversion Factor (bhp-hr/mile)] * ECF (hp-hr/gal) * Activity (gal/yr) * Percent Operation in CA * ton/907,200g

Formula C-8: Estimated Annual Emissions based on Mileage using Emission Factors (tons/yr):

Emission Factor (g/mile) * Activity (miles/yr) * Percent Operation in CA * ton/907,200g

Formula C-9: Estimated Annual Emissions based on Mileage using Converted Emission Standards (tons/yr):

Converted Emission Standard (g/bhp-hr) * Unit Conversion Factor (bhp-hr/mile) * Activity (miles/yr) * Percent Operation in CA * ton/907,200g

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases:

Annual Emissions for the Baseline Technology – Annual Emissions for the Reduced Technology

Formula C-11: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Retrofits:

Annual Emissions for the Baseline Technology * Reduced Technology Verification Percent

Formula C-12: Annualized Cost ($):

CRF * incremental cost ($)

Formula C-13: Capitol Recovery Factor (CRF):

$$[(1 + i)^n (i)] / [(1 + i)^n - 1]$$

Where i = discount rate (4 percent) and n = project life (at least 3 years see specific project criteria for default maximums)

Formula C-14: Incremental Cost ($):

Cost of Reduced Technology ($) * Maximum Eligible Percent Funding Amount

Formula C-15: Incremental Cost for Fleet Modernization Projects ($):

When the replacement vehicle is not new:

N.A.D.A value

where the N.A.D.A value is the retail value of the used vehicle * 50 percent.

When the replacement vehicle is new:

Invoice of the New Vehicle * 50 percent

APPENDIX D

LIGHT-DUTY VEHICLE COST-EFFECTIVENESS CALCULATION METHODOLOGY

APPENDIX D

LIGHT-DUTY VEHICLE COST-EFFECTIVENESS CALCULATION METHODOLOGY

A. Conventional VAVR Projects

Emission reductions from conventional VAVR projects were calculated using the VAVR regulation methodology. They are equal to the retired vehicle's emission rates minus those of the replacement vehicle with the difference multiplied by the average vehicle miles traveled by light duty vehicles in the year of vehicle retirement and by the three year project life. The retired vehicle's emission rates are equal to those for gasoline-powered, light-duty vehicles for the model year of the retired vehicle in the year of vehicle retirement. Replacement vehicle emissions are the fleet average emissions for all gasoline-powered light-duty vehicles for model years 1990 through the year of vehicle retirement. Emission rates and average vehicle miles traveled are generated by the ARB's motor vehicle emissions model. NOx, ROG, CO, and PM emission reductions over the 3 year project life by vehicle model year are located in Tables D-1, 2, 3, and 4.

Emission reductions for diesel-powered vehicles were estimated using a similar methodology. Because of very limited data and only minor differences in emission rates from one year to another, average emission reductions were only estimated for two model year ranges for all four calendar years. Replacement vehicle emission rates were the same as those used for gasoline-powered vehicles. Average NOx, ROG, CO, and PM emission reductions over the 3 year project life by model year range are located in Table D-15. There are no evaporative emission reductions for retiring a diesel-powered vehicle.

B. High Emitter VAVR Projects

Emission Reductions = $[ER_{retired} – ER_{replace}]$ * VMT * Life

Where:
- $ER_{retired}$ = Emission rate of retired vehicle
- $ER_{replace}$ = Emission rate of replacement vehicle
- VMT = Vehicle miles traveled
- Life = Project life = 3 years

1. Exhaust Emission Rates of Retired Vehicle

For retired vehicles exempt from Smog Check (pre-1976), ROG_{exh}, NOx, and CO emission rates for the full 3 year credit life equal the pollutant concentrations measured by the Smog Check test at the time of vehicle retirement converted to FTP emission rates using the conversions listed in Table D-5.

For year 1 of the 3 year project life, ROG_{exh}, NOx, and CO emission rates for most post-1975 retired vehicles equal the pollutant concentrations measured by the Smog Check test at the time of vehicle retirement converted to FTP emission rates as described in

Table D-5. However, Two Speed Idle (TSI) test results from high emitting vehicles that are not testable by the ASM Smog Check test may be used to estimate ROG_{exh} emission rates when converted to FTP emission rates as described in Table D-6.

For years 2 and 3 of the 3 year project life, ROG_{exh}, NOx, and CO emission rates for most post-1975 vehicles equal the Smog Check pass/fail cutpoints for the retired vehicle's model year and vehicle class converted to FTP emission rates as described in Table D-5. The most recent Smog Check pass/fail cutpoints are located at www.smobcheck.ca.gov/ftp/pdfdocs/asm_ph43.pdf and in Table D-7. For high emitting vehicles that are not testable by the ASM Smog Check test, ROG_{exh} emission rates are equal to the TSI pass/fail cutpoints for the retired vehicle's model year and vehicle class converted to FTP emission rates as described in Table D-6. The most recent TSI pass/fail cutpoints are located in Table D-8.

VMT is the average VMT of the retired vehicle's model year based on the ARB's motor vehicle emission model and is listed in Table D-9. Districts may also use the average vehicle miles traveled by the retired vehicle over the immediately prior two years as long as the district documents the mileage, and the odometer is in good working order.

2. Exhaust Emission Rates of Replacement Vehicle

Emission rates for an unknown replacement vehicle equal the fleet average emission rates of gasoline-powered light-duty vehicles for model years 1990 through the year of vehicle retirement in the year retired using the ARB's latest approved motor vehicle emissions model. Emission rates by the year of vehicle retirement are in Table D-10.

High emitting vehicle projects may also generate extra emission reductions for the documented purchase of an ARB-certified LEV or cleaner replacement vehicle as defined in Title 13, CCR, Division 3, Chapter 1, Article 1, Sections 1960.1 and 1961. Default emission rates for LEV's are located in Tables D-11, 12, 13, and 14.

3. Evaporative Emission Reductions

Districts may include an evaporative emission reduction element in a high emitting vehicle project. If no evaporative testing is conducted, default evaporative emission reductions are estimated from the retired vehicle's model year as listed in Tables D-1, 2, 3, and 4.

Districts also may conduct evaporative testing on vehicles identified as high emitting vehicles to determine if they are also high evaporative emitting vehicles.

- Low pressure evaporative testing must be conducted according to manufacturer's standard operating procedures and BAR protocols using equipment certified by BAR or submitted for BAR certification, if BAR-certified equipment is not available.

- Only high emitting vehicles that fail the low pressure evaporative test are eligible to receive extra emission reduction credit if retired or receive evaporative control repairs that result in passing the low pressure evaporative test. Extra emission reductions equal 14.5 pounds of ROG per vehicle per year.

4. Particulate Matter Emission Reductions

District project plans that include a PM emission reduction component must also include verification that the methodology for measuring PM is scientifically valid, documentation that the results are reproducible, and a complete copy of the methodology.

C. High Emitter VRV Projects

$$\text{Emission Reductions} = [ER_{pre} - ER_{post}] * VMT * Life$$

Where:			
	ER_{pre}	=	Emission rate of pre-repaired vehicle
	ER_{post}	=	Emission rate of vehicle after repair
	VMT	=	Vehicle miles traveled
	Life	=	Project life = 1 year

1. Exhaust Emissions

Emission reductions are calculated as the difference between the pre and post-repair Smog Check test results converted to FTP emission rates using the conversion equations in Table D-5 with the difference multiplied by the VMT and the one year project life. Two Speed Idle (TSI) test results from vehicles not testable by the ASM Smog Check test may be used when converted to FTP ROG_{exh} emission rates as described in Table D-6.

VMT is the average VMT of the vehicle's model year based on the ARB's motor vehicle emission model and is listed in Table D-9. Districts may also use the average of the vehicle miles traveled by the vehicle over the immediately prior two years as long as the district documents the mileage, and the odometer is in good working order.

The credit life for exhaust and evaporative repairs is one (1) year.

2. Evaporative Emission Reductions

Districts may conduct evaporative testing on vehicles identified as high emitting vehicles to determine if they are also high evaporative emitting vehicles.

- Low pressure evaporative testing must be conducted according to manufacturer's standard operating procedures and BAR protocols using equipment certified by BAR or submitted for BAR certification, if BAR-certified equipment is not available.

- Vehicles that fail low pressure evaporative tests are eligible to receive extra emission reductions where reductions equal the average emission reductions for repairing evaporative system failures or 14.5 pounds of ROG per vehicle per year.

Evaporative repairs must bring the vehicle's emissions into compliance with the low pressure fuel evaporative test to be creditable and fundable.

3. Particulate Matter Emission Reductions

District project plans that include a PM emission reduction component must also include verification that the methodology for measuring PM is scientifically valid, documentation that the results are reproducible, and a complete copy of the methodology.

D. Modifications to Calculation Methodology

Air districts may propose modifications to the calculation methodology to reflect unique project elements but must provide a technical justification to support any modification in their project plan. The district must receive written approval from the ARB prior to using the modified methodology, and emission reductions for all vehicles retired or repaired must be calculated according to the ARB-approved methodology.

E. Cost-Effectiveness Calculations

1. General Requirements

Funds spent on outreach, data analysis, and database development are administrative costs. Costs incurred to identify and diagnose high emitting vehicles may not result in any benefits, as some vehicles may not be eligible or some owners may choose to not participate. These costs are distributed across successfully retired or repaired vehicles. However, VAVR and VRV projects individually must meet the cost-effectiveness limit. Districts may propose validated modifications to the calculation methodology to reflect unique project elements that must be detailed in the district's plan which must document that the proposed modifications are technically sound. The district must have written ARB approval prior to using an alternative methodology.

State funds used for administrative costs are not included in cost-effectiveness calculations. However, they must be accounted for relative to the administrative limits associated with each funding source.

2. Additional High Emitter Project Requirements

The district must include State or DMV funds expended on project-related costs to identify and retire/repair high emitting vehicles in the cost-effectiveness calculations.

- Project-related costs are those used to identify high emitting vehicles, run Smog Check tests, diagnose vehicles, and retire or repair vehicles.

- Programmatic costs which cannot be attributed to retiring or repairing a specific vehicle shall be distributed across each vehicle repaired or retired in proportion to the programmatic costs for each vehicle within each program.

- The project cost-effectiveness shall be calculated separately for VAVR and VRV projects and for each year of project funding. The results shall be reported in the district's annual and final reports for that year of funding.

If a district has a cap on the amount paid for repairs, vehicle owners may pay for repairs that exceed the district cap. Funds contributed by vehicle owners are not included in the cost-effectiveness calculation.

TABLE D-1						
Retired Vehicle Emission Reductions, CY2008 (lbs/3 yr)						
MY	ROG			CO	NOx	PM10
	Exhaust	Evap	Total	Exhaust	Exhaust	Exhaust
Pre 1966	325.9	235.1	560.9	3595.8	187.9	0.54
1966	284.1	239.9	524.0	3313.3	179.7	0.69
1967	289.2	242.7	531.9	3374.6	183.8	0.70
1968	296.5	247.3	543.8	3462.7	188.0	0.69
1969	304.1	249.8	553.9	3553.5	193.3	1.06
1970	310.4	178.6	489.0	3669.0	199.6	0.53
1971	323.4	175.6	499.1	3674.2	201.1	0.60
1972	337.8	172.2	510.0	3686.3	203.8	0.80
1973	345.4	174.2	519.6	3709.4	205.9	1.26
1974	326.6	135.2	461.8	3424.0	185.1	1.41
1975	256.5	124.8	381.4	3256.4	173.2	0.36
1976	121.7	119.6	241.3	2759.5	134.1	1.81
1977	109.7	92.7	202.4	2784.3	118.0	1.21
1978	109.3	95.5	204.8	2764.6	117.8	1.36
1979	95.3	93.8	189.1	1863.5	105.5	1.09
1980	77.3	72.6	149.8	1616.4	99.8	1.16
1981	64.2	66.2	130.4	1330.5	78.8	2.00
1982	60.8	63.1	124.0	1310.3	84.0	1.59
1983	47.6	59.1	106.7	1138.0	87.3	1.37
1984	45.7	52.9	98.6	1105.0	87.4	1.24
1985	36.7	47.7	84.4	819.1	82.5	1.44
1986	36.5	44.7	81.2	791.2	84.7	1.33
1987	35.7	57.3	93.0	739.0	81.9	1.16
1988	35.2	60.9	96.1	693.3	80.4	1.23
1989	36.8	41.5	78.4	748.3	67.2	1.13
1990	38.2	38.3	76.5	773.0	55.6	1.13
1991	38.8	34.2	72.9	766.3	57.6	1.10
1992	39.2	32.2	71.3	767.1	58.5	1.07
1993	31.7	30.8	62.5	566.5	55.3	1.05
1994	21.0	28.6	49.7	337.4	42.2	0.97
1995	16.6	23.6	40.2	242.8	29.6	0.88
1996	12.0	17.6	29.6	233.4	23.7	0.74
1997	9.3	11.4	20.8	223.6	17.9	0.64
1998	4.6	-0.7	3.9	198.1	12.5	0.57
1999	0.1	-2.1	-2.0	171.9	6.0	0.43
2000	-4.0	-3.6	-7.6	143.6	-0.6	0.29
Source: Emfac2007 V2.3 Nov 1, 2006						

TABLE D-2						
Retired Vehicle Emission Reductions, CY2009 (lbs/3 yr)						
MY	ROG			CO	NOx	PM10
	Exhaust	Evap	Total	Exhaust	Exhaust	Exhaust
Pre 1966	321.8	233.1	554.9	3499.2	186.2	0.76
1966	282.1	236.3	518.4	3229.2	178.8	0.12
1967	286.5	240.6	527.1	3288.1	182.5	0.12
1968	294.7	243.1	537.9	3373.8	186.5	0.10
1969	301.6	247.4	549.0	3465.2	192.0	0.62
1970	308.4	176.3	484.7	3577.0	197.9	0.67
1971	321.3	174.4	495.7	3581.9	200.0	0.75
1972	336.1	170.8	506.9	3593.3	202.5	0.96
1973	343.4	172.9	516.4	3612.9	204.4	0.93
1974	328.8	135.1	463.9	3352.4	186.4	0.87
1975	257.8	128.1	385.9	3213.7	176.9	0.45
1976	118.6	118.5	237.1	2658.1	131.2	2.05
1977	106.4	92.3	198.7	2667.3	116.9	1.26
1978	106.9	93.2	200.1	2644.1	116.4	1.42
1979	92.5	91.9	184.4	1740.4	103.4	1.14
1980	75.5	72.0	147.5	1520.7	98.9	1.23
1981	61.7	66.1	127.8	1230.7	77.7	2.11
1982	59.5	62.3	121.8	1216.9	83.2	1.69
1983	46.4	59.1	105.4	1042.5	86.4	1.47
1984	44.8	52.5	97.3	1012.0	86.6	1.36
1985	36.2	47.6	83.8	737.7	82.0	1.18
1986	35.5	44.4	79.9	701.9	83.4	1.32
1987	35.8	57.8	93.6	664.6	82.3	1.17
1988	35.4	63.0	98.4	619.0	80.8	1.10
1989	37.0	44.3	81.3	671.2	68.0	1.14
1990	38.1	41.1	79.2	691.4	56.4	1.17
1991	38.5	36.6	75.1	681.4	58.2	1.14
1992	39.1	34.8	73.9	681.6	59.5	1.12
1993	32.0	33.2	65.2	483.0	56.4	1.07
1994	21.5	30.9	52.4	255.8	43.4	1.00
1995	17.3	25.7	43.0	162.1	31.1	0.92
1996	13.1	19.4	32.4	151.9	25.2	0.81
1997	10.6	13.1	23.7	141.7	19.7	0.72
1998	5.9	0.7	6.5	114.2	14.5	0.64
1999	1.4	-0.7	0.7	86.2	8.3	0.52
2000	-2.7	-2.1	-4.8	56.7	2.1	0.38
Source: Emfac2007 V2.3 Nov 1, 2006						

TABLE D-3						
Retired Vehicle Emission Reductions, CY 2010 (lbs/3 yr)						
MY	**ROG**			**CO**	**NOx**	**PM10**
	Exhaust	**Evap**	**Total**	**Exhaust**	**Exhaust**	**Exhaust**
pre 1967	280.4	233.6	514.0	3200.7	176.5	0.21
1967	285.6	236.1	521.7	3258.3	180.3	0.20
1968	292.1	537.3	829.4	3342.6	185.6	0.18
1969	300.3	245.1	545.4	3433.9	191.1	0.75
1970	306.0	174.5	480.4	3547.9	196.1	0.82
1971	320.2	171.9	492.1	3551.7	199.0	0.93
1972	334.3	169.2	503.5	3562.9	201.5	1.17
1973	341.6	171.8	513.3	3583.3	202.5	1.11
1974	330.6	136.2	466.8	3338.2	187.9	0.17
1975	258.8	122.8	381.7	3230.5	179.4	0.58
1976	116.9	117.3	234.1	2636.0	129.4	1.31
1977	105.7	92.6	198.3	2635.6	114.5	1.45
1978	105.3	92.3	197.6	2600.5	115.1	1.49
1979	91.0	90.4	181.4	1706.4	103.0	1.20
1980	73.5	149.5	223.0	1481.2	97.6	1.29
1981	60.9	65.0	126.0	1213.7	77.7	1.61
1982	57.8	61.2	119.0	1194.5	82.3	1.79
1983	45.2	58.4	103.7	1029.3	85.8	1.17
1984	43.8	52.5	96.4	996.9	86.1	1.46
1985	35.8	47.4	83.2	734.5	81.3	1.30
1986	35.1	43.6	78.7	701.5	83.0	1.30
1987	35.0	59.0	93.9	658.3	81.1	1.29
1988	35.6	64.8	100.4	627.0	81.4	1.11
1989	37.1	46.7	83.9	677.5	68.8	1.20
1990	38.3	43.9	82.2	697.2	57.6	1.20
1991	38.7	39.2	77.9	686.3	59.2	1.20
1992	39.2	37.3	76.4	685.3	60.3	1.14
1993	32.2	35.8	68.1	491.0	57.5	1.14
1994	22.1	33.3	55.4	269.8	44.9	1.07
1995	17.9	27.8	45.7	176.5	32.5	0.99
1996	14.1	21.4	35.4	168.7	26.6	0.87
1997	11.6	14.7	26.4	158.8	21.3	0.79
1998	7.1	2.0	9.1	134.1	16.4	0.72
1999	2.6	0.7	3.2	107.3	10.4	0.59
2000	-1.5	-0.6	-2.1	79.8	4.5	0.46
Source: Emfac2007 V2.3 Nov 1, 2006						

Table D-4						
Retired Vehicle Emission Reductions, CY 2011 (lbs/3 yr)						
MY	**ROG**			**CO**	**NOx**	**PM10**
	Exhaust	**Evap**	**Total**	**Exhaust**	**Exhaust**	**Exhaust**
pre 1968	283.9	232.7	516.6	3229.5	179.1	0.30
1968	292.3	234.8	527.1	3310.0	183.9	0.27
1969	299.3	239.4	538.7	3400.8	188.3	0.12
1970	305.2	174.7	480.0	3514.1	194.9	0.98
1971	319.6	171.5	491.1	3519.8	196.4	1.11
1972	334.8	168.3	503.2	3530.2	199.2	0.70
1973	342.5	169.9	512.4	3550.6	200.5	0.65
1974	335.2	135.2	470.4	3321.7	188.4	0.26
1975	263.3	126.8	390.1	3233.9	180.5	0.33
1976	115.9	114.9	230.9	2611.1	128.2	0.40
1977	104.4	89.5	193.9	2609.3	113.3	1.67
1978	103.7	92.8	196.5	2566.0	113.1	1.09
1979	89.7	88.6	178.3	1676.3	101.1	1.26
1980	72.0	70.2	142.2	1457.4	96.6	1.35
1981	59.1	63.7	122.8	1189.8	76.4	1.07
1982	57.4	60.6	118.0	1182.7	82.1	1.89
1983	44.8	58.3	103.1	1014.1	85.2	1.25
1984	43.4	51.9	95.3	990.1	85.8	1.33
1985	35.5	47.2	82.8	733.1	80.9	1.22
1986	35.0	43.5	78.6	702.3	82.8	1.42
1987	34.8	60.0	94.8	661.6	80.9	1.28
1988	34.9	67.2	102.1	623.5	80.3	1.23
1989	37.5	49.3	86.9	685.6	69.6	1.26
1990	38.7	46.5	85.2	705.0	58.6	1.12
1991	39.2	41.9	81.1	695.2	60.4	1.24
1992	39.5	40.1	79.6	693.2	61.4	1.25
1993	32.6	38.7	71.2	498.4	58.6	1.24
1994	22.7	36.2	58.9	283.3	46.5	1.15
1995	18.6	30.2	48.8	192.6	34.1	1.07
1996	15.0	23.4	38.3	185.0	28.1	0.97
1997	12.6	16.6	29.2	175.4	22.8	0.86
1998	8.1	3.4	11.5	151.4	18.0	0.80
1999	3.7	2.1	5.8	127.1	12.3	0.67
2000	-0.4	0.7	0.3	100.7	6.5	0.56
Source: Emfac2007 V2.3 Nov 1, 2006						

TABLE D-5
ASM-FTP Correlation Equations

<u>Pre-1990 Model Year</u>

FTP_HC = 1.2648 * exp (- 4.67052
 + 0.46382 * hc_term
 + 0.09452 * co_term
 + 0.03577 * no_term
 + 0.57829 * wt_term
 - 0.06326 * my_term
 + 0.20932 * trk)

FTP_CO = 1.2281 * exp (- 2.65939
 + 0.08030 * hc_term
 + 0.32408 * co_term
 + 0.03324 * co_term^2
 + 0.05589 * no_term
 + 0.61969 * wt_term
 - 0.05339 * my_term
 + 0.31869 * trk)

FTP_NOX = 1.0810 * exp (- 5.73623
 + 0.06145 * hc_term
 - 0.02089 * co_term^2
 + 0.44703 * no_term
 + 0.04710 * no_term^2
 + 0.72928 * wt_term
 - 0.02559 * my_term
 - 0.00109 * my_term^2
 + 0.10580 * trk)

Where:
hc_term = ln ((ASM1_HC*ASM2_HC) ^ 0.5) - 3.72989
co_term = ln ((ASM1_CO*ASM2_CO) ^ 0.5) + 2.07246
no_term = ln ((ASM1_NO*ASM2_NO) ^ 0.5) - 5.83534
MY_Term = model_year - 1982.71
wt_term = ln (vehicle_weight in pounds)
TRK = 0 for a passenger car and 1 for a light-duty truck.

When HC and NO ASM scores = 0, set scores to 1 ppm
FTP_HC = HC FTP emission rate in g/mi
FTP_CO = CO FTP emission rate in g/mi
FTP_NO = NOx FTP emission rate in g/mi

1<u>990 and Newer Model Year</u>

FTP_HC = 1.1754 * exp (- 6.32723
 + 0.24549 * hc_term
 + 0.09376 * hc_term^2
 + 0.06653 * no_term
 + 0.01206 * no_term^2
 + 0.56581 * wt_term
 - 0.10438 * my_term
 - 0.00564 * my_term^2
 + 0.24477 * trk)

FTP_CO = 1.2055 * exp (0.90704
 + 0.04418 * hc_term^2
 + 0.17796 * co_term
 + 0.08789 * no_term
 + 0.01483 * no_term^2
 - 0.12753 * my_term
 - 0.00681 * my_term^2
 + 0.37580 * trk)

FTP_NOX = 1.1056 * exp (- 6.51660
 + 0.25586 * no_term
 + 0.04326 * no_term^2
 + 0.65599 * wt_term
 - 0.09092 * my_term
 - 0.00998 * my_term^2
 + 0.24958 * trk)

Where:
hc_term = ln ((ASM1_HC*ASM2_HC) ^ 0.5) - 2.32393
co_term = ln ((ASM1_CO*ASM2_CO) ^ 0.5) + 3.45963
no_term = ln ((ASM1_NO*ASM2_NO) ^0.5) - 3.71310
MY_Term = model_year - 1993.69
wt_term = ln (vehicle_weight in pounds)
TRK = 0 for a passenger car and 1 for a light-duty truck

When CO ASM scores = 0, set score to 0.01%.
ASM1_HC = ASM 5015 mode HC concentration in ppm
ASM2_HC = ASM 2525 mode HC concentration in ppm
ASM1_NO = ASM 5015 mode NOx concentration in ppm
ASM2_NO = ASM 2525 mode NOx concentration in ppm
ASM1_CO = ASM 5015 mode CO concentration in %
ASM2_CO = ASM 2525 mode CO concentration in %

Ref: Technical Support Document, Part 2, "Evaluation of the California Enhanced Inspection and Maintenance (Smog Check) Program", (April 2004), Bureau of Automotive Repair and Sierra Research at ww.arb.ca.gov/msprog/smogcheck/jun04/tsd_part2.pdf.

TABLE D-6
Conversion of Two Speed Idle Measurements to FTP Emission Rates

Model Inputs:

HCHT =	HC_High Term =	(ln (High-Speed Idle HC in ppm)) - 2.6995
COHT =	CO_High Term =	(ln (High-Speed Idle CO in %)) + 2.9867
HCLT =	HC_Low Term =	(ln (Low-Speed Idle HC in ppm)) -3.6573
COLT =	CO_Low Term =	(ln (Low-Speed Idle CO in %)) + 2.7987
AGE =	AGE Term =	TSI Test Date - January 1 of Vehicle Model Year - 9.0570 years
DISP =	DISP Term =	(ln (Engine Displacement in Liters)) - 0.9873
TRK =		+ 0.5 for light-duty trucks - 0.5 for passenger vehicles
ERG =		+ 0.5 if the vehicle has exhaust gas recirculation - 0.5 if it does not

IM240 Predicted Emission Rates:

IM240 HC (g/mi) = 1.0396169 * EXP(-1.0705335
+ 0.21479968 * COHT
+ 0.23151769 * HCLT
+ 0.035948587 * AGE
+ 0.083671264 * HCLT^2
+ 0.020890310 * COLT^2
+ 0.099280830 * COLT * TRK
+ 0.59513657 * DISP * ERG

FTP Predicted Emission Rate:

FTP HC (g/mi) = 0.094 + 1.194 * IM240 HC (g/mi)

Source: "Techniques for Estimating IM240 and FTP Emission Rates from Two-Speed Idle Emissions Concentrations", May 10, 2001, Technical Notes, Bureau of Automotive Repair

TABLE D-7 - ASM Table --- Phase 4.3												
ACCELERATED SIMULATION MODE EMISSION STANDARDS (Effective 01/08/2003)												
ESC	Model Year Group	Vehicle Type (by GVWR and LVW)					Pass/Fail Emission Standard					
							ASM 5015			ASM 2525		
		PC	LDT1	LDT2	MDV		HC	CO	NO	HC	CO	NO
1		X	X	X		A	235.4	2.56	1301.5	185.4	2.36	1161.5
	1974-					B	436041.7	4453.19	1192593.0	436041.7	4453.19	1192593.0
2		X				A	123.0	0.91	1016.3	90.3	0.71	876.3
	1975-1980					B	273316.7	1362.96	1043519.0	273316.7	1362.96	1043519.0
3		X				A	63.2	0.64	850.0	42.1	0.44	680.0
	1981-1983					B	234259.3	1064.81	894444.5	212963.0	1064.81	894444.5
4		X				A	67.0	0.52	850.0	42.1	0.32	680.0
	1984-1986					B	212963.0	979.63	894444.5	212963.0	979.63	894444.5
5		X				A	57.0	0.48	608.0	31.7	0.32	547.0
	1987-1992					B	191666.7	851.85	596296.3	191666.7	979.63	596296.3
6		X				A	59.0	0.29	617.1	24.3	0.23	547.0
	1993-1995					B	89951.3	724.07	271314.8	89951.3	851.85	596296.3
7		X				A	16.8	0.29	260.0	0.5	0.23	547.0
	1996-2000					B	128501.9	724.07	596296.3	128501.9	851.85	596296.3
8		X				A	16.8	0.29	260.0	0.5	0.23	547.0
	2001-2003					B	128501.9	724.07	596296.3	128501.9	851.85	596296.3
9	2004+	X				A	16.8	0.29	260.0	0.5	0.23	547.0
						B	128501.9	724.07	596296.3	128501.9	851.85	596296.3
10	1975-1978		X			A	139.4	1.08	1320.9	105.0	0.88	1180.9
						B	225000.0	2025.00	745370.4	225000.0	2025.00	745370.4
11	1979-1983		X			A	139.4	0.88	1315.7	80.0	0.68	1175.7
						B	225000.0	2025.00	596296.3	150000.0	2025.00	596296.3
12	1984-1987		X			A	91.3	0.41	945.0	63.1	0.50	840.0
						B	150000.0	1725.00	525000.0	150000.0	2250.00	1050000.0
13	1988-1992		X			A	83.0	0.27	875.0	63.1	0.43	735.0
						B	150000.0	1725.00	525000.0	150000.0	1875.00	525000.0
14	1993-1995		X			A	68.3	0.30	377.0	33.3	0.40	630.0
						B	78750.0	1350.00	525000.0	78750.0	1500.00	525000.0
15	1996-2000		X			A	22.1	0.30	377.0	5.8	0.40	630.0
						B	112500.0	1350.00	525000.0	112500.0	1500.00	525000.0
16	2001-2003		X			A	22.1	0.30	377.0	5.8	0.40	630.0
						B	112500.0	1350.00	525000.0	112500.0	1500.00	525000.0
17	2004+		X			A	22.1	0.30	377.0	5.8	0.40	630.0
						B	112500.0	1350.00	525000.0	112500.0	1500.00	525000.0
18	1975-1978			X		A	139.4	1.08	1320.9	105.0	0.88	1180.9
						B	225000.0	2025.00	745370.4	225000.0	2025.00	745370.4
19	1979-1983			X		A	139.4	0.88	1315.7	80.0	0.68	1175.7
						B	225000.0	2025.00	596296.3	150000.0	2025.00	596296.3
20	1984-1987			X		A	91.3	0.41	945.0	63.1	0.50	840.0
						B	150000.0	1725.00	525000.0	150000.0	2250.00	1050000.0
21	1988-1992			X		A	83.0	0.27	875.0	63.1	0.43	735.0
						B	150000.0	1725.00	525000.0	150000.0	1875.00	525000.0
22	1993-1995			X		A	68.3	0.30	377.0	33.3	0.40	630.0
						B	78750.0	1350.00	525000.0	78750.0	1500.00	525000.0
23	1996-2000			X		A	22.1	0.30	377.0	5.8	0.40	630.0
						B	112500.0	1350.00	525000.0	112500.0	1500.00	525000.0
24	2001-2003			X		A	22.1	0.30	377.0	5.8	0.40	630.0
						B	112500.0	1350.00	525000.0	112500.0	1500.00	525000.0
25	2004+			X		A	22.1	0.30	377.0	5.8	0.40	630.0
						B	112500.0	1350.00	525000.0	112500.0	1500.00	525000.0
26	1978-				X	A	173.3	2.90	1703.3	123.3	2.70	1563.3
						B	583333.3	3500.00	1633333.3	583333.3	3500.00	1633333.3
27	1979-1983				X	A	139.4	0.88	1315.7	80.0	0.68	1175.7
						B	225000.0	2025.00	596296.3	150000.0	2025.00	596296.3
28	1984-1987				X	A	91.3	0.41	945.0	63.1	0.50	840.0
						B	150000.0	1725.00	525000.0	150000.0	2250.00	1050000.0
29	1988-1992				X	A	83.0	0.27	875.0	63.1	0.43	735.0
						B	150000.0	1725.00	525000.0	150000.0	1875.00	525000.0
30	1993-1995				X	A	83.0	0.30	875.0	60.0	0.70	735.0
						B	150000.0	1350.00	525000.0	150000.0	1500.00	525000.0
31	1996-2000				X	A	71.2	0.30	875.0	60.0	0.70	735.0
						B	150000.0	1350.00	525000.0	150000.0	1500.00	525000.0
32	2001-2003				X	A	71.2	0.30	875.0	60.0	0.70	735.0
						B	150000.0	1350.00	525000.0	150000.0	1500.00	525000.0
33	2004+				X	A	71.2	0.30	875.0	60.0	0.70	735.0
						B	150000.0	1350.00	525000.0	150000.0	1500.00	525000.0

ESC - Emissions Standard Category
GVWR - Manufacture's Gross Vehicle Weight Rating
PC - Passenger car
LVW - Loaded vehicle weight
MDV - Medium-duty vehicle, GVWR from 6001 to 8500 lbs
HC - Hydrocarbon, ppm
LDT1 - Light-duty truck up through 3750 lbs LVW and GVWR no greater than 6000 lbs
CO - Carbon Monoxide, %
LDT2 - Light-duty truck greater than 3750 lbs LVW and GVWR no greater than 6000 lbs
NO - Nitric Oxide, ppm

Pass/Fail Emission Standards = A + B / VTW, where VTW is vehicle/truck weight

PASS/FAIL STANDARDS – Emission standards used to determine if a vehicle passes the emission inspection. A vehicle passes if the emission levels are equal to or less than the standards for HC, CO, and NOx for ASM 5015 and ASM2525.

TABLE D-8

Emission Standards, Dilution Thresholds, and Maximum Idle RPM Limits for BAR-90 Two-speed Test

(Effective with 1996 ET Software Update)

ESC	MODEL YEAR GROUP	VEHICLE TYPE (by GVWR) PC <6,001	VEHICLE TYPE (by GVWR) TRUCK (includes motorhome, minivan, sport utility) <6,001	TRUCK 6,001 to 8,500	TRUCK 8,501 to 14,000	TRUCK >14,001	AVERAGE EMISSIONS FOR PASSING VEHICLES Idle HC	Idle CO	2500 HC	2500 CO	PASS/FAIL STANDARDS Idle HC	Idle CO	2500 HC	2500 CO	MIN $CO+CO_2$	MAX IDLE RPM
1	1966-1967	X	X				212	2.3	182	1.7	700	5.5	600	4.5	8.0	1100
2	1968-1970	X	X				192	2.3	163	1.7	650	5.5	600	4.5	8.0	1100
3	1971-1974	X	X				147	1.8	123	1.4	550	5.0	400	4.0	8.0	1100
4	1975-1980	X					60	0.3	52	0.5	220	2.0	180	1.7	8.0	1100
5	1981-1983	X					42	0.1	37	0.2	120	1.5	150	1.5	8.0	1100
6	1984-1986	X					37	0.1	31	0.2	120	1.0	150	1.2	7.0	1100
7	1987-1992	X					29	0.1	20	0.1	120	1.0	140	1.0	7.0	1100
8	1993+	X					17	0.0	12	0.1	100	1.0	130	1.0	8.0	1100
9	1975-1978		X				73	0.5	67	0.9	250	2.5	200	3.0	7.0	1100
10	1979-1983		X	X			51	0.2	45	0.4	250	2.0	200	2.0	8.0	1100
11	1984-1987		X	X			40	0.1	35	0.2	150	1.2	180	1.2	7.0	1100
12	1988-1992		X	X			30	0.1	20	0.1	120	1.0	180	1.0	8.0	1100
13	1993+		X				17	0.0	13	0.1	100	1.0	170	1.0	7.0	1100
14	1993+			X			26	0.0	11	0.1	100	1.0	180	1.1	7.0	1200
15	1966-1969			X	X	X	188	2.4	241	1.9	700	5.5	750	5.0	7.0	1200
16	1970-1973			X	X	X	152	2.0	200	1.4	550	5.0	600	4.5	8.0	1200
17	1974-1978			X	X	X	99	1.1	95	0.9	300	3.0	350	3.5	7.0	1200
18	1979-1983				X	X	77	0.8	57	0.6	250	2.2	250	3.0	7.0	1200
19	1984-1986				X	X	57	0.7	33	0.3	250	1.5	200	1.6	7.0	1200
20	1987-1990				X		51	0.2	34	0.3	220	1.5	200	1.6	7.0	1100
21	1991+				X		39	0.1	20	0.2	150	1.2	150	1.5	7.0	1100
22	1987-1990					X	60	0.5	32	0.3	250	2.5	200	1.6	7.0	1100
23	1991+					X	42	0.3	17	0.2	150	1.5	150	1.5	7.0	1100

PC = passenger vehicle   ESC -- Emissions Standards Category   HC -- Hydrocarbon, ppm   CO -- Carbon monoxide, %

MIN. $CO + CO_2$ -- Minimum $CO + CO_2$ dilution threshold   MAX. IDLE RPM -- Maximum Idle RPM limits

PASS/FAIL STANDARDS -- Emission standards used to determine if a vehicle passes the emissions portion of the inspection. A vehicle passes if the emission levels are equal to or less than the hydrocarbon or carbon monoxide standard for the idle or 2500 RPM inspection.

Source: www.autorepair.ca.gov/stdhome.asp. Select “reference library”, “Publications”, then “TSI Cutpoints Table.”

Table D-9									
Vehicle Miles Traveled/Yr/Vehicle									
MY	Year of Retirement				MY	Year of Retirement			
	2008	2009	2010	2011		2008	2009	2010	2011
Pre 1967	5,896	5,793	5,709	5,618	1984	8,193	8,042	7,901	7,765
1967	6,017	5,902	5,828	5,734	1985	8,342	8,194	8,043	7,900
1968	6,167	6,074	5,975	5,886	1986	8,552	8,392	8,242	8,094
1969	6,340	6,239	6,147	6,059	1987	8,662	8,502	8,345	8,198
1970	6,518	6,422	6,337	6,243	1988	8,827	8,661	8,502	8,345
1971	6,671	6,578	6,471	6,384	1989	9,009	8,837	8,671	8,513
1972	6,831	6,730	6,635	6,521	1990	9,156	8,975	8,803	8,637
1973	6,943	6,828	6,735	6,627	1991	9,386	9,198	9,016	8,847
1974	6,915	6,806	6,709	6,604	1992	9,612	9,412	9,220	9,041
1975	7,064	6,926	6,856	6,705	1993	9,882	9,661	9,462	9,274
1976	7,104	7,002	6,898	6,806	1994	10,128	9,893	9,672	9,473
1977	7,273	7,163	7,054	6,915	1995	10,359	10,105	9,870	9,650
1978	7,372	7,254	7,133	7,019	1996	10,662	10,383	10,129	9,894
1979	7,476	7,359	7,228	7,089	1997	10,961	10,662	10,384	10,130
1980	7,610	7,484	7,360	7,239	1998	11,319	10,994	10,695	10,417
1981	7,773	7,644	7,520	7,379	1999	11,727	11,369	11,044	10,744
1982	7,906	7,769	7,629	7,518	2000	12,103	11,708	11,349	11,023
1983	7,997	7,854	7,719	7,589					
Source: Emfac2007 V2.3 Nov 1 2006									

TABLE D-10						
Fleet Average Emission Rates for Unknown Replacement Vehicle (g/VMT)**						
Year of	ROG			CO	NOx	PM10
Retirement	Exhaust	Evap	Total	Exhaust	Exhaust	Exhaust
2008	0.1417	0.1341	0.2758	3.2807	0.3430	0.0151
2009	0.1302	0.1340	0.2643	3.0801	0.3167	0.0156
2010	0.1197	0.1336	0.2533	2.8862	0.2919	0.0160
2011	0.1104	0.1328	0.2432	2.7118	0.2690	0.0166
Source: Emfac2007 V2.3 Nov 1 2006				** Fleet Ave. = 1990 through Year of Retirement		

Table D-11						
CY 2008 LDV LEV Emission Rates by MY, g/mi						
MY	ROG			CO	NOx	PM10
	EXH	EVAP	TOTAL	EXH	EXH	EXH
1997	0.1038	0.1009	0.2048	4.0607	0.3616	0.0241
1998	0.0979	0.1246	0.2225	3.8895	0.3581	0.0227
1999	0.0949	0.1070	0.2019	3.8010	0.3476	0.0207
2000	0.0911	0.0895	0.1805	3.6683	0.3355	0.0186
2001	0.0830	0.0712	0.1542	3.3853	0.3223	0.0165
2002	0.0790	0.0510	0.1300	3.2353	0.3327	0.0157
2003	0.0702	0.0380	0.1082	2.8771	0.3072	0.0137
2004	0.0405	0.0278	0.0684	1.6568	0.1522	0.0120
2005	0.0240	0.0171	0.0411	0.9777	0.0847	0.0096
2006	0.0163	0.0138	0.0301	0.6669	0.0518	0.0075
2007	0.0131	0.0113	0.0244	0.5218	0.0388	0.0052
2008	0.0103	0.0090	0.0194	0.4387	0.0342	0.0028
Source: EMFAC2007, V2.3, Nov 1, 2006						

Table D-12						
CY 2009 LDV LEV Emission Rates by MY, g/mi						
MY	ROG			CO	NOx	PM10
	EXH	EVAP	TOTAL	EXH	EXH	EXH
1997	0.1068	0.1148	0.2216	4.1592	0.3653	0.0232
1998	0.1011	0.1427	0.2438	4.0038	0.3632	0.0222
1999	0.0984	0.1248	0.2232	3.9241	0.3536	0.0205
2000	0.0949	0.1068	0.2017	3.8087	0.3436	0.0188
2001	0.0874	0.0895	0.1768	3.5328	0.3318	0.0169
2002	0.0833	0.0711	0.1544	3.3860	0.3424	0.0165
2003	0.0744	0.0491	0.1235	3.0606	0.3154	0.0147
2004	0.0448	0.0355	0.0802	1.8732	0.1678	0.0132
2005	0.0278	0.0220	0.0498	1.1468	0.0970	0.0110
2006	0.0178	0.0168	0.0346	0.7324	0.0566	0.0091
2007	0.0146	0.0138	0.0284	0.5714	0.0427	0.0071
2008	0.0120	0.0113	0.0234	0.4803	0.0380	0.0049
2009	0.0095	0.0090	0.0186	0.4051	0.0289	0.0026
Source: EMFAC2007, V2.3, Nov 1, 2006						

Table D-13						
CY 2010 LDV LEV Emission Rates by MY, g/mi						
MY	ROG			CO	NOx	PM10
	EXH	EVAP	TOTAL	EXH	EXH	EXH
1997	0.1096	0.1288	0.2384	4.2561	0.3687	0.0276
1998	0.1043	0.1615	0.2658	4.1079	0.3680	0.0262
1999	0.1018	0.1354	0.2371	4.0450	0.3591	0.0241
2000	0.0986	0.1245	0.2231	3.9379	0.3501	0.0221
2001	0.0911	0.1068	0.1979	3.6676	0.3389	0.0199
2002	0.0877	0.0893	0.1770	3.5379	0.3526	0.0194
2003	0.0787	0.0683	0.1470	3.2093	0.3251	0.0174
2004	0.0476	0.0456	0.0933	2.0013	0.1732	0.0159
2005	0.0306	0.0275	0.0581	1.2749	0.1060	0.0135
2006	0.0206	0.0208	0.0414	0.8626	0.0646	0.0116
2007	0.0160	0.0167	0.0327	0.6274	0.0465	0.0095
2008	0.0134	0.0138	0.0272	0.5261	0.0418	0.0073
2009	0.0111	0.0113	0.0224	0.4434	0.0321	0.0051
2010	0.0091	0.0090	0.0181	0.3922	0.0284	0.0027
Source: EMFAC2007, V2.3, Nov 1, 2006						

Table D-14						
CY 2011 LDV LEV Emission Rates by MY, g/mi						
MY	ROG			CO	NOx	PM10
	EXH	EVAP	TOTAL	EXH	EXH	EXH
1997	0.1128	0.1439	0.2568	4.3692	0.3736	0.0297
1998	0.1076	0.1807	0.2883	4.2222	0.3730	0.0283
1999	0.1054	0.1620	0.2675	4.1670	0.3649	0.0262
2000	0.1024	0.0000	0.1024	4.0765	0.3566	0.0241
2001	0.0950	0.1247	0.2196	3.8045	0.3459	0.0219
2002	0.0918	0.1067	0.1985	3.6882	0.3610	0.0215
2003	0.0833	0.0857	0.1689	3.3687	0.3359	0.0195
2004	0.0507	0.0636	0.1143	2.1074	0.1792	0.0180
2005	0.0326	0.0347	0.0673	1.3787	0.1102	0.0156
2006	0.0229	0.0258	0.0486	0.9643	0.0693	0.0137
2007	0.0186	0.0206	0.0393	0.7419	0.0518	0.0116
2008	0.0148	0.0167	0.0314	0.5800	0.0457	0.0095
2009	0.0124	0.0137	0.0262	0.4875	0.0354	0.0073
2010	0.0107	0.0113	0.0220	0.4313	0.0317	0.0051
2011	0.0088	0.0090	0.0179	0.3855	0.0281	0.0028
Source: EMFAC2007, V2.3, Nov 1, 2006						

Table D-15		
Retired Diesel-Powered Vehicle Emission Reductions		
Model Year Range	**Pollutant**	**lb/3 yr CY 2008-2011**
Pre 1984	ROG	6.535
	NOx	63.980
	PM	7.745
1984-1992	ROG	2.328
	NOx	50.481
	PM	6.078

Source: Emfac2007 V2.3 Nov 1 2006

APPENDIX E

EXAMPLE CALCULATIONS

APPENDIX E

EXAMPLE CALCULATIONS

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APPENDIX E

EXAMPLE CALCULATIONS

I. On-Road Heavy-Duty Vehicles

This section provides examples of calculations for determining the cost-effectiveness of surplus emission reductions for on-road projects.

Example 1 –Purchase of a New CNG Bus
A transit agency proposes to purchase a new 2008 CNG bus certified to 0.9 g/bhp-hr NOx + NMHC and 0.01 g/bhp-hr PM10 instead of a new bus certified to the current standard of 1.2 g/bhp-hr NOx and 0.01 g/bhp-hr PM10. This new CNG bus is surplus to the ARB Fleet Rule for Transit Agencies. The new bus will operate 100 percent of the time in California.

<u>Baseline Technology Information</u>:

- Baseline technology (application): 2008 urban bus
- Emission standard (Table B-6): 1.2 g/bhp-hr NOx and 0.010 g/bhp-hr PM10
- Activity (application): 60,000 mi/yr
- Percent operated in California (application): 100 percent

<u>Reduced Technology Information</u>:

- Reduced technology (application): 2008 CNG urban bus
- Certified to optional emission standard:
  0.9 g/bhp-hr NOx + NMHC and 0.01 g/bhp-hr PM10
- Converted emission standard for alternative fuel (Table B-2):
  0.72 g/bhp-hr NOx and 0.010 g/bhp-hr PM10
- Conversion factor to convert the standard in g/bhp-hr to g/mi (Table B-8):
  4.0 bhp-hr/mi
- Cost (quote provided with application): $350,000
- New purchase projects are eligible for up to 25 percent of the cost of the new vehicle.

<u>Emission Reduction Calculations:</u>
Formula C-9: Estimated Annual Emissions Based on Mileage using Converted Emission Standards

1. Annual NOx baseline technology emissions
   (1.2 g/bhp-hr *4.0 bhp-hr/mi)(60,000 mi/yr)(ton/907,200 g) = 0.32 tons/yr NOx
2. Annual NOx reduced technology emissions
   (0.72 g/bhp-hr * 4.0 bhp-hr/mi)(60,000 mi/yr)(ton/907,200 g) = 0.19 tons/yr NOx

ROG converted emission standards are not available for the reduced technology, therefore, ROG emission reductions cannot be calculated.

PM 10 converted emission standards are the same for the baseline engine and the reduced technology, therefore there is no change in PM10 emissions.

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

- NOx emission benefits = 0.32 tons/yr – 0.19 tons/yr = 0.13 tons/yr NOx

Formula C-2: Annual Weighted Surplus Emission Reductions
0.13 = 0.13 weighted tons/yr

<u>Annualized Cost:</u>
Project Life: 12 years
CRF (Table B-1) = 0.107

Transit agencies receive an 80 percent grant from the Federal Transportation Agency for most new vehicle purchases. This grant must be subtracted before calculating the incremental cost.

Transit agency's cost for reduced technology: $350,000 * 0.20 = $70,000

Formula C-14: Incremental Cost
$70,000 * 25 percent = $17,500

Formula C-12: Annualized Cost
0.107 * $17,500 = $1873/yr

<u>Cost-Effectiveness</u>:
Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)
($1873/yr)/(0.13 weighted tons/yr) =
$14,408/ton of weighted surplus emissions reduced

The cost-effectiveness for the example is less than $16,000 per ton of pollutants reduced. This project qualifies for up to $17,500 in grant funds requested.

Example 2 – Diesel to Diesel Heavy-Duty Truck Repower
A line haul trucking company proposes to repower a 1994 heavy heavy-duty diesel truck with a model year 2008 certified diesel engine. This vehicle operates 90 percent of the time in California. The applicant is proposing to use fuel use instead of mileage to determine cost-effectiveness.

<u>Baseline Technology Information</u>:
- Baseline technology (application): 1994 diesel heavy heavy-duty engine
- Emission factors (Table B-5):
  17.95 g/mi NOx, 0.40 g/mi ROG, 0.367 g/mi PM10
- Energy consumption factor (Table B-25): 18.5 g/bhp-hr

- Activity (application): 14,330 gal/yr, 60,000 mi/yr
- Percent operated in California (application): 90 percent
- Unit conversion factor: 2.9 bhp-hr/mi (Table B-8)

<u>Reduced Technology Information</u>:
- Reduced technology (application): 2007 diesel heavy heavy-duty engine
- Repower projects are eligible for up to 80 percent of the repower cost.
- Repower cost (quote provided with application): $70,000
- Emission factors (Table B-5):
  6.36 g/mi NOx, 0.23 g/mi ROG, 0.028 g/mi PM10
- Unit conversion factor: 2.9 bhp-hr/mi (Table B-8)

<u>Emission Reduction Calculations</u>:
Formula C-7: Estimated Annual Emissions based on Fuel Usage using Emission Factors
<u>Fuel Based Calculation</u>
1. Annual NOx baseline technology emissions
   [17.95 (g/mi) / 2.9 (bhp-hr/mi)] * (18.5 bhp-hr/gal) * (14,330 gal/yr) * (0.90) * (ton/907,200 g) = 1.63 tons/yr NOx
2. Annual NOx reduced technology emissions
   [6.36 (g/mi) / 2.9 (bhp-hr/mi)] * (18.5 bhp-hr/gal) * (14,330 gal/yr) * (0.90) * (ton/907,200 g) = 0.58 tons/yr NOx
3. Annual ROG baseline technology emissions
   [0.40 (g/mi) / 2.9 (bhp-hr/mi)] * (18.5 bhp-hr/gal) * (14,330 gal/yr) * (0.90) * (ton/907,200 g) = 0.04 tons/yr ROG
4. Annual ROG reduced technology emissions
   [0.23 (g/mi) / 2.9 (bhp-hr/mi)] * (18.5 bhp-hr/gal) * (14,330 gal/yr) * (0.90) * (ton/907,200 g) = 0.02 tons/yr ROG
5. Annual PM10 baseline technology emissions
   [0.367 (g/mi) / 2.9 (bhp-hr/mi)] * (18.5 bhp-hr/gal) * (14,330 gal/yr) * (0.90) * (ton/907,200 g) = 0.03 tons/yr PM10
6. Annual PM10 reduced technology emissions
   [0.028 (g/mi) / 2.9 (bhp-hr/mi)] * (18.5 bhp-hr/gal) * (14,330 gal/yr) * (0.90) * (ton/907,200 g) = 0.003 tons/yr PM10

<u>Mileage based calculation</u>
Formula C-8: Estimated Annual Emissions Based on Mileage using Emission Factors
1. Annual NOx baseline technology emissions
   (17.95 g/mi * 0.90 * 60,000 mi/yr)(ton/907,200 g) = 1.07 tons/yr NOx
2. Annual NOx reduced technology emissions
   (6.36 g/mi * 0.90 * 60,000 mi/yr)(ton/907,200 g) = 0.38 tons/yr NOx
3. Annual ROG baseline technology emissions
   (0.40 g/mi * 0.90 * 60,000 mi/yr)(ton/907,200 g) = 0.02 tons/yr ROG
4. Annual ROG reduced technology emissions
   (0.23 g/mi * 0.90 * 60,000 mi/yr)(ton/907,200 g) = 0.01 tons/yr ROG
5. Annual PM10 baseline technology emissions

(0.367 g/mi * 0.90 * 60,000 mi/yr)(ton/907,200 g) = 0.022 tons/yr PM10

6. Annual PM10 reduced technology emissions
   (0.028 g/mi * 0.90 * 60,000 mi/yr)(ton/907,200 g) = 0.002 tons/yr PM10

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

<u>From fuel based calculation above</u>

- NOx emission benefits = 1.63 tons/yr – 0.58 tons/yr = 1.05 tons/yr NOx
- ROG emission benefits = 0.04 tons/yr – 0.02 tons/yr = 0.02 tons/yr ROG
- PM10 emission benefits= 0.03 tons/yr – 0.003 tons/yr = 0.027 tons/yr PM10

<u>From mileage based calculation above</u>

- NOx emission benefits = 1.07 tons/yr – 0.38 tons/yr = 0.69 tons/yr NOx
- ROG emission benefits = 0.02 tons/yr – 0.01 tons/yr = 0.01 tons/yr ROG
- PM10 emission benefits= 0.022 tons/yr – 0.002 tons/yr = 0.02 tons/yr PM10

<u>Fuel Based Calculation</u>	*<u>Mileage Based Calculation</u>*
Total NOx Emission Benefits	*Total NOx Emission Benefits*
1.05 tons/yr NOx	0.69 tons/yr NOx
Total ROG Emission Benefits	*Total ROG Emission Benefits*
0.02 tons/yr ROG	0.01 tons/yr ROG
Total PM10 Emission Benefits	*Total PM10 Emission Benefits*
0.027 tons/yr PM10	0.020 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions

<u>Fuel Based Calculation</u>

1.05 + 0.02 + 20(0.027) = 1.61 weighted tons/yr

<u>Mileage based calculation</u>

0.69 + 0.01 + 20(0.02) = 1.1 weighted tons/yr

<u>Annualized Cost:</u>

Project Life: 7 years

CRF (Table B-1) = 0.167

Formula C-14: Incremental Cost

$70,000 *80 percent = $56,000

Formula C-12: Annualized Cost

$56,000 * 0.167 = $9,352/yr

Cost-Effectiveness:

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)

Fuel Based Calculation

($9,352/yr)/(1.61 weighted tons/yr) =

$5,809/ton of weighted surplus emissions reduced

Mileage based calculation

($9,352/yr)/(1.1 weighted tons/yr) =

$8,502/ton of weighted surplus emissions reduced

[($5,809-8502)/$8,502] * 100 = 32% more cost-effective.

In this example, fuel usage proved to be greater then 30% more cost-effective. The cost-effectiveness for the example for both fuel- and mileage-based calculations is less than $16,000 per ton of weighted pollutants reduced. This project qualifies for up to $56,000 of grant funds requested and can use a fuel based calculation for cost-effectiveness.

Example 3 – Diesel Heavy-Duty Truck Retrofit

A trucking company proposes to retrofit a 2005 heavy heavy-duty diesel truck with a Level 3 retrofit that is verified for both PM and NOx reductions. This vehicle operates 80 percent of the time in California.

Baseline Technology Information:

- Baseline technology (application): 2005 heavy heavy-duty diesel truck
- Baseline diesel vehicle emission rates (Table B-5):
  11.63 g/mi NOx; 0.252 g/mi of PM10
- Activity (application): 100,000 mi/yr
- Percent operated in California (application): 80 percent

Reduced Technology Information:

- Retrofit verification emission levels (executive order):
  25 percent reduction of NOx and 85 percent reduction of PM10. ROG is not counted since the retrofit device is not verified for ROG.
- Retrofit cost (quote provided with application):
  $18,000 + $600 annual filter maintenance (5 years)
- Retrofits are eligible for 100 percent of the cost unless being installed to meet regulatory requirements
- For retrofit projects that only take credit for NOx reductions from a Level 3 DECS (because the PM reductions are required by regulation) the cost is one-half the project cost.

Emission Reduction Calculations:

Formula C-8: Estimated Annual Emissions Based on Mileage using Emission Factors

1. Annual NOx baseline technology emissions
   (11.63 g/mi * 0.80 * 100,000 mi/yr)(ton/907,200 g) = 1.03 tons/yr NOx

2. Annual PM10 baseline technology emissions
   (0.252 g/mi * 0.80 * 100,000 mi/yr)(ton/907,200 g) = 0.022 tons/yr PM10

Formula C-11: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Retrofits

1.03 * 0.25	= 0.26 tons/yr NOx
0.022 * 0.85	= 0.019 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions

0.26 + 20(0.019)	=0.64 weighted tons/yr

<u>Annualized Cost:</u>
Project Life: 5 years

CRF (Table B-1):	= 0.225

Formula C-14: Incremental Cost

[$18,000 + ($600*5)] * 100 percent	= $21,000

Formula C-12: Annualized Cost

0.225 * 21,000	= $4,725/yr

<u>Cost-Effectiveness</u>:
Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)
($4,725/yr)/(0.64 weighted tons/yr) =
$7,383/ton of weighted surplus emissions reduced

The cost-effectiveness for the example is less than $16,000 per ton of pollutants reduced. This project qualifies for up to $21,000 of grant funds requested.

Example 4 - APU Retrofit
An operator of a 2006 line haul truck proposed to install Level 3 diesel particulate filter on a 2006 MY 24 horsepower Tier 2 APU. The cost of the retrofit is $5,000 and is verified for 85 percent reduction of PM10. The APU operates 1500 hours per year, 100 percent of the time in California. This project is eligible for a 5 year project life.

<u>Baseline Technology Information:</u>
- Engine (application): 2006 MY Tier 2
- HP (application): 24
- Annual hours of operation (application): 1500
- Load factor (Table B-9): 0.74
- Emission factors (Table B-10): 0.306 g/bhp-hr PM10

<u>Reduced Technology Information:</u>
- Level 3 verified reductions (executive order): 85 percent PM10
- Cost of retrofit (quote provided with application): $5,000
- Retrofits are eligible for up to 100 percent of the total retrofit costs
- Percent operating in California (application): 100 percent

Emission Reduction Calculations:
Formula C-4: Estimated Annual Emissions based on Hours of Operation (tons/yr)

- Annual PM10 baseline technology emissions
  0.306 g/bhp-hr *24 hp*0.74*1500 hr*(ton/907,200 g) = 0.009 tons/yr PM10

Formula C-11: Annual Surplus Emission Reductions by Pollutant (tons/yr) for retrofits

- 0.009 tons/yr * 0.85 = 0.008 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions
20(0.008 tons/yr) = 0.15 weighted tons/yr PM10

Annualized Cost:
Project Life: 5 years
CRF (Table B-1): = 0.225

Formula C-14: Incremental Cost
$5,000 * 100 percent = $5,000

Formula C-12: Annualized Cost
0.225 * $5,000 = $1,125

Cost-Effectiveness:
Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)
($1,125/yr)/(0.15 weighted tons/yr)
= $7,362/tons of weighted surplus emissions reduced

The Cost Effectiveness for this Example is less than $16,000 per ton of pollutants reduced. This project qualifies for up to $5,000 in grant funds requested.

Example 5 - Truck Stop Electrification (TSE) On-board System
An operator plans to idle a heavy-duty diesel truck, that has a standard heating and cooling system, 1500 hours a year at truck stops in California equipped with TSE infrastructure. To meet the regulatory requirements of the ATCM for heavy duty trucks idling in California the operator would be required to install a new 2008 MY Tier 4 Diesel Auxiliary Power Unit (DAPU) on the Truck. The DAPU would also have to be retrofitted with a level 3 Verified Diesel Emission Control System (VDECS). The cost of the APU and VDECS, including installation of the DAPU and VDECS would be $6,500.

The operator proposes to instead install a TSE system on the truck, consisting of an electrical plug, inverter/charger, battery pack and electrical HVAC. There would be no NOx, ROG and PM10 emissions under this zero emission technology option and the difference in emission from the DAPU with a level 3 VDEC would qualify as reduced surplus emissions for Carl Moyer Program funding purposes. The cost of the TSE system, including installation, would be $8,500.

Baseline Technology Information

- Engine (application): 2008 DAPU engine, retrofitted with verified level 3 (85% PM10 reduction) VDECS
- HP: 24
- Load factor (Application): 0.69
- Hours of operation in California (Application): 1,500 hrs/yr
- Emission factors (Table B-10): 4.33g/bhp-hr NOx, 0.69g/bhp-hr ROG, 0.152 g/bhp-hr PM
- DAPU, retrofitted with verifiable 85% VDECS, PM10 emission factor: 0.152 g/bhp-hr * 15% = 0.023 g/bhp-hr
- Cost (quote provide with application): $6,500
- Project Life (Application): 3 years

Reduced Technology Information

- TSE System (Application)
- Annual hours of operation in California (Application): 1500 hrs/yr
- Emission factors: 0 g/bhp-hr NOx, 0 g/bhp-hr ROG, 0 g.bhp-hr PM
- Cost (quote provided with application): $8,500

Emission Reduction Calculations

Formula C-4: Estimated Annual Emissions Based on Hours of Operation (tons/yr)

1. Annual NOx Baseline Technology Emissions
   4.33g/hp-hr*24hp*0.69*1500hr*(ton/907200g) = 0.12 ton/yr
2. Annual NOx Reduced Technology Emissions = 0.00 ton/yr
3. Annual ROG Baseline Technology Emissions
   0.69g/hp-hr*24hp*0.69*1500hr*(ton/907200g) = 0.02 ton/yr
4. Annual ROG Reduced Technology Emissions = 0.00 ton/yr
5. Annual PM10 Baseline Technology Emissions
   0.023g/hp-hr*24hp*0.69*1500hr*(ton/907200g) = 0.001 ton/yr
6. Annual PM10 Reduced Technology Emissions = 0.000 ton/yr

Formula C-10: Annual Surplus Emissions Reduction by Pollutant (tons/yr).

1. Emission benefits NOx: 0.12 ton/yr – 0.00 ton/yr = 0.12 ton/yr
2. Emission benefits ROG: 0.02 ton/yr – 0.00 ton/yr = 0.02 ton/yr
3. Emission benefits PM10: 0.001 ton/yr – 0.00 ton/yr = 0.001 ton/yr

Formula C-2: Annual Weighted Average Surplus Emission Reductions

0.12 ton/yr + 0.02 ton/yr + 20*0.001 ton/yr = 0.16 ton/yr

Annualized Cost:

Project Life (Application): 3 years
CRF (Table B-1): 0.360

In this case the incremental cost is the difference between the cost of the TSE system and DAPU with retrofit.

Incremental Cost: $8,500 -$6.500 = $2,000

Formula C-12: Annualized Cost
0.360 * $2,000 = $720

Formula C-1: Cost-Effectiveness of Annual Weighted Surplus Emission Reductions ($/ton)
($720/yr)/(0.16 weighted tons/yr) = $4,500/ton of weighted surplus emissions

The Cost Effectiveness for this Example is less than $16,000 per ton of pollutants reduced. This project qualifies for up to $2,000 in grant funds requested.

Example 6 - Transport Refrigeration Unit (TRU) Retrofit
A TRU owner plans to retrofit a 24 horsepower model year 2002 diesel TRU Tier 1 engine with a Verified Level 3 Diesel Particulate Filter (DPF) system. The cost for the DPF system is $2,800, including installation. The TRU is operated 2,000 hours per year, 100 percent of the time in California. The retrofit would be installed and in operation prior by December 31, 2009, therefore the project is eligible for up to a five-year project life. However, the applicant is willing to commit to a three-year project life.

Baseline Technology Information

- Engine (application): MY 2002 TRU engine with a level 2 retrofit (50% PM10 reduction)
- HP (application): 24
- Load factor (Table B-9): 0.64
- Hours of operation in California (application): 2,000 hr/yr
- PM 10 emission factor (Table B-10): 0.306 g/bhp-hr

Reduced Technology Information

- Retrofit (executive order): Level 3 DPF (verified to an 85% reduction in PM10)
- Cost of retrofit (quote provided with application): $2800
- Retrofit is eligible for up to 100 percent of the cost
- Percent operating in California (application): 100 percent

Emissions Reduction Calculation

Formula C-4: Estimated Annual PM10 Emissions Based on Hours of Operation (tons/yr)

Annual PM baseline technology emissions

0.306 g/hp-hr*24hp*0.64*2000 hr/yr*(ton/907200 g) = 0.010 tons/yr

Airborne Toxic Control Measure (ATCM) Early Compliance Credit

Model year 2002 engines must comply with the TRU ATCM's Low Emission TRU In-Use Performance Standard (50 % PM 10 reduction) by December 31, 2009. Model year 2002 TRU engines must also comply with the TRU ATCM's Ultra Low Emission TRU standard (85% PM10 reduction) by the end of 2016. Therefore, the surplus PM10 emissions reduced for each year of the project life (2010-2012) would be 35 percent (85 percent – 50 percent). Because the TRU was not already retrofitted with a level 2 DPF, the project is eligible for up to 50% of the cost of the level 3 DPF.

Formula C-11 Annual Surplus Emission Reductions by Pollutant (tons/yr) for Retrofits (PM only)

(85%-50%)*0.010 tons/yr = 0.004 tons/yr

Formula C-2 Annual Weighted Surplus Emissions Reductions (PM only)

20(0.004tons/yr) = 0.07 tons/yr

Annualized Cost

Project Life: 3 years

CRF: 0.360

Formula C-14: Incremental Cost

$2,800 * 50 percent = $1,400

Formula C-12: Annualized Cost

0.360 * $1,400 =$504

Cost Effectiveness Calculations

Formula C-1: Cost Effectiveness

($504/yr)/(0.07 tons/yr) = $7,200/ton of weighted surplus emissions reduced

The Cost-Effectiveness is less than $16,000 per ton of pollutants reduced. This project qualifies for up to $1,400 in grant funds requested.

II. On-Road Heavy-Duty Fleet Modernization

This section provides examples of calculations for determining the cost-effectiveness of surplus emission reductions for fleet modernization projects.

Example 1 – Used Replacement of a Heavy-Heavy Duty Truck from a Targeted Vocation

A participant wants to scrap an old, heavy heavy-duty truck used to haul lumber from northern California and replace it with a newer, used truck. The participant has provided conclusive documentation that for the last three years the old truck operated 100 percent of the time in and around the Northern California area. The OEM of the replacement truck will already be equipped with a Level 3 diesel emission control system (DECS) and the truck engine has been certified to a NOx FEL level of 1.2 g/bhp-hr. An electronic monitoring unit (EMU) will be installed. The replacement truck is also required to continue operating in the same vocation and location for the life of the project.

<u>Baseline Technology Information</u>

- Baseline technology (application): 1983 heavy heavy-duty diesel truck
- Emission rates (Table B-5): 21.39 g/mi NOx, 1.04 g/mi ROG, 1.249 g/mi PM10
- Activity (application): 42,000 miles/year
- Percent operated in California (application): 100 percent
- Vocation (application): Lumber

<u>Reduced Technology Information</u>

- Reduced technology (application): 2007 MY used, heavy heavy-duty diesel truck
- Emission rates (Table B-5): 6.36 g/mi NOx, 0.23 g/mi ROG, 0.028 g/mi PM10
- Cost (N.A.D.A. used retail value provided with application): $80,000
- Maximum eligible amount for a used replacement truck: 50% of N.A.D.A. value
- EMU cost: $1,150 (Includes installation and monitoring for five years)

<u>Emission Reduction Calculations:</u>
Formula C-8: Estimated Annual Emissions Based on Mileage Using Emission Factors

1. Annual NOx baseline technology emissions
   (21.39 g/mi * 42,000 mi)(ton/ 907,200 g) = 0.990 tons/yr NOx
2. Annual NOx reduced technology emissions
   (6.36 g/mi * 42,000 mi)(ton/ 907,200 g) = 0.294 tons/yr NOx
3. Annual ROG baseline technology emissions
   (1.04 g/mi * 42,000 mi) (ton/ 907,200 g) = 0.048 tons/yr ROG
4. Annual ROG reduced technology emissions
   (0.23 g/mi * 42,000 mi)(ton/ 907,200 g) = 0.011 tons/yr ROG

5. Annual PM10 baseline technology emissions
   (1.249 g/mi * 42,000 mi)(ton/ 907,200 g) = 0.058 tons/yr PM10
6. Annual PM10 reduced technology emissions
   (0.028 g/mi * 42,000 mi)(ton/ 907,200 g) = 0.001 tons/yr PM10

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases:

- NOx Emission Benefits = 0.990 tons/yr - 0.294 tons/yr = 0.696 tons/yr NOx
- ROG Emission Benefits = 0.048 tons/yr - 0.011 tons/yr = 0.038 tons/yr ROG
- PM10 Emission Benefits = 0.058 tons/yr - 0.001 tons/yr = 0.057 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions

0.696 tons/yr + 0.038 tons/yr + 20(0.057 tons/yr) = 1.864 weighted tons/yr

Annualized Cost

Project Life = 5 Years

CRF (Table B-1) = 0.225

Formula C-15: Incremental Cost

Maximum Percent Funding for Used Replacement Vehicle:

0.50 * $80,000 = $40,000

Replacement Truck + EMU:

$40,000 + $1,150 = $41,150

Formula C-12: Annualized Cost

$41,150 * 0.225 = $9,259/yr

Cost-Effectiveness

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions

= ($9,259/yr) / (1.864 weighted tons/yr)

= $4,959 weighted tons/yr

In this example, the cost-effectiveness is less than threshold of $16,000 per weighted ton of pollutants reduced. This project qualifies for up to $41,150 in grant funds requested (50% of the N.A.D.A. value + EMU cost).

Example 2 – New Replacement of a Heavy-Heavy Duty Truck from a Targeted Vocation

A participant wants to scrap an old, heavy heavy-duty truck used to haul lumber from northern California and replace it with a new truck. The participant has provided conclusive documentation that for the last three years the old truck operated 100 percent of the time in and around the Northern California area. The OEM of the replacement truck will already be equipped with a Level 3 diesel emission control system (DECS) and the truck engine has been certified to a NOx FEL level of 1.2 g/bhp-hr. An electronic monitoring unit (EMU) will be installed. The replacement truck is also required to continue operating in the same vocation and location for the life of the project.

Baseline Technology Information

- Baseline technology (application): 1983 heavy heavy-duty diesel truck
- Emission rates (Table B-5): 21.39 g/mi NOx, 1.04 g/mi ROG, 1.249 g/mi PM10
- Activity (application): 42,000 miles/year
- Percent operated in California (application): 100 percent
- Vocation (application): Lumber

Reduced Technology Information

- Reduced technology (application): 2008 new heavy heavy-duty diesel truck
- Emission rates (Table B-5): 6.36 g/mi NOx, 0.23 g/mi ROG, 0.028 g/mi PM10
- Cost (quote provided with application): $120,000
- Maximum eligible amount for a new replacement truck: 50% of invoiced price
- EMU cost: $1,150 (Includes installation and monitoring for five years)

Emission Reduction Calculations:

Formula C-8: Estimated Annual Emissions Based on Mileage Using Emission Factors

1. Annual NOx baseline technology emissions
   (21.39 g/mi * 42,000 mi)(ton/ 907,200 g) = 0.990 tons/yr NOx
2. Annual NOx reduced technology emissions
   (6.36 g/mi * 42,000 mi)(ton/ 907,200 g) = 0.294 tons/yr NOx
3. Annual ROG baseline technology emissions
   (1.04 g/mi * 42,000 mi) (ton/ 907,200 g) = 0.048 tons/yr ROG
4. Annual ROG reduced technology emissions
   (0.23 g/mi * 42,000 mi)(ton/ 907,200 g) = 0.011 tons/yr ROG
5. Annual PM10 baseline technology emissions
   (1.249 g/mi * 42,000 mi)(ton/ 907,200 g) = 0.058 tons/yr PM10
6. Annual PM10 reduced technology emissions
   (0.028 g/mi * 42,000 mi)(ton/ 907,200 g) = 0.001 tons/yr PM10

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases:

- NOx Emission Benefits = 0.990 tons/yr - 0.294 tons/yr = 0.696 tons/yr NOx
- ROG Emission Benefits = 0.048 tons/yr - 0.011 tons/yr = 0.038 tons/yr ROG
- PM10 Emission Benefits = 0.058 tons/yr - 0.001 tons/yr = 0.057 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions

0.696 tons/yr + 0.038 tons/yr + 20(0.057 tons/yr) = 1.864 weighted tons/yr

<u>Annualized Cost</u>

Project Life = 5 Years

CRF (Table B-1) = 0.225

Formula C-15: Incremental Cost

Maximum Percent Funding for New Replacement Vehicle:

0.50 * $120,000 = $60,000

New Replacement Truck + EMU:

$60,000 + $1,150 = $61,150

Formula C-12: Annualized Cost

$61,150 * 0.225 = $13,759/yr

<u>Cost-Effectiveness</u>

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions

= ($13,759/yr) / (1.864 weighted tons/yr)

= $7,370 weighted tons/yr

In this example, the cost-effectiveness is less than threshold of $16,000 per weighted ton of pollutants reduced. This project qualifies for up to $61,150 in grant funds requested (50% of the invoice price + EMU cost).

III. Off-Road Compression-Ignition Engines

This section provides examples of calculations for determining the cost-effectiveness of surplus emission reductions for off-road compression-ignition projects.

Example 1 – Repower with a Tier 3 Engine and Retrofit with a Level 3 DECS
A construction company meeting the definition of a medium fleet in the Off-Road Regulation wants to repower a scraper with a Tier 3 engine. The baseline technology is a model year 1987 300 hp uncontrolled engine that operates for 1,500 hours per year. The applicant is proposing to install a 300 hp Tier 3 engine that costs $80,000. This equipment operates 100 percent of the time in California. A Level 3 diesel particulate filter has been verified for use on the engine and has a cost of $25,000. This project will be installed and in operation prior to March 1, 2009 and thus is surplus to the Off-Road Regulation and can be given a project life of 4 years.

<u>Baseline Technology Information:</u>
- Engine (application): 1987 Model Year
- HP (application): 300
- Annual Hours of operation (application): 1,500
- Load factor (Table B-11): 0.72
- Emission factors (Table B-12): 10.23 g/bhp-hr NOx; 1.06 g/bhp-hr ROG; 0.396 g/bhp-hr PM10

<u>Reduced Technology Information:</u>
- Engine: Tier 3 (ARB executive order)
- HP (application): 300
- Hours of operation (application): 1,500
- Cost of new engine (quote provided with application): $80,000
- Tier 3 repowers are eligible for up to 85% of the cost of the repower
- Load factor (Table B-11): 0.72
- Emission factors (Table B-13): 2.32 g/bhp-hr NOx; 0.12 g/bhp-hr ROG; 0.112 g/bhp-hr PM10
- Percent operating in California (application): 100 percent
- Retrofit: Level 3 verified reductions: 85 percent PM10
- Cost of retrofit (quote provided with application): $25,000
- Retrofits are eligible for up to 100% of total retrofit costs

<u>Emission Reduction Calculations:</u>
Formula C-4: Estimated Annual Emissions based on Hours of Operation (tons/yr)
1. Annual NOx baseline technology emissions
   10.23 g/bhp-hr *300 hp*0.72*1500 hr*(ton/907,200 g) = 3.65 tons/yr NOx
2. Annual NOx reduced technology emissions
   2.32 g/bhp-hr *300 hp*0.72*1500 hr*(ton/907,200 g) = 0.83 tons/yr NOx
3. Annual ROG baseline technology emissions
   1.06 g/bhp-hr *300 hp* 0.72*1500 hr*(ton/907,200 g) = 0.38 tons/yr ROG

4. Annual ROG reduced technology emissions
   0.12 g/bhp-hr *300 hp*0.72*1500 hr*(ton/907,200 g) = 0.04 tons/yr ROG
5. Annual PM10 baseline technology emissions
   0.396 g/bhp-hr *300 hp*0.72*1500 hr*(ton/907,200 g) = 0.141 tons/yr PM10
6. Annual PM10 reduced technology emissions
   0.112 g/bhp-hr *300 hp*0.72*1500 hr*(ton/907,200 g) = 0.040 tons/yr PM10

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

- Emission benefits NOx = 3.65 tons/yr - 0.83 tons/yr = 2.82 tons/yr NOx
- Emission benefits ROG = 0.38 tons/yr - 0.04 tons/yr = 0.34 tons/yr ROG
- Emission benefits PM10 = 0.141 tons/yr - 0.040 tons/yr = 0.101 tons/yr PM10

Formula C-11: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Retrofits
0.040 tons/yr PM10 * 0.85 = 0.034 tons/yr PM10

Total PM10 Emission Benefits
0.101 tons/yr + 0.034 tons/yr = 0.135 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions
2.82 tons/yr + 0.34 tons/yr + 20(0.135 tons/yr) = 5.86 weighted tons/yr

Annualized Cost:
Project Life: 4 years
CRF (Table B-1): = 0.275

Formula C-14: Incremental Cost
($80,000 * 85 percent) + ($25,000 * 100 percent) = $93,000

Formula C-12: Annualized Cost
0.275 * $93,000 = $25,575

Cost-Effectiveness:
Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)
($25,575/yr)/(5.86 weighted tons/yr)
= $4,364/tons of weighted surplus emissions reduced

The cost-effectiveness for the example is less than $16,000 per ton of pollutants reduced. This project qualifies for up to $93,000 in grant funds requested.

Example 2 – Retrofit of a Tier 1 Engine with a Level 3 DECS
A local municipality proposed to install Level 3 diesel particulate filter on a rubber tired loader with a Tier 1 160 hp engine. The cost of the retrofit is $20,000 and is verified for 85 percent reductions of PM10. The loader operates 500 hours per year, 100 percent of the time in California. The local municipality meets the definition of a small fleet

under the Off-Road Regulation. This project will be installed and in operation prior to March 1, 2009 and thus is eligible for a 5 year project life.

Baseline Technology Information:

- Engine (application): Tier 1
- HP (application): 160
- Annual hours of operation (application): 500
- Load factor (Table B-11): 0.54
- Emission factors (Table B-13): 0.274 g/bhp-hr PM10

Reduced Technology Information:

- Level 3 verified reductions: 85 percent PM10
- Cost of retrofit (quote provided with application): $20,000
- Percent operating in California (application): 100 percent

Emission Reduction Calculations:

Formula C-4: Estimated Annual Emissions based on Hours of Operation (tons/yr)

- Annual PM10 baseline technology emissions
  0.274 g/bhp-hr *160 hp*0.54*500 hr*(ton/907,200 g) = 0.013 tons/yr PM10

Formula C-11: Annual Surplus Emission Reductions by Pollutant (tons/yr) for retrofits

- 0.013 tons/yr * 0.85 = 0.011 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions

20(0.011 tons/yr) = 0.22 weighted tons/yr PM10

Annualized Cost:

Project Life: 5 years

CRF (Table B-1): = 0.225

Formula C-14: Incremental Cost

$20,000 * 100 percent = $20,000

Formula C-12: Annualized Cost

0.225 * $20,000 = $4,500

Cost-Effectiveness:

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)

($4,500/yr)/(0.22 weighted tons/yr)

= $20,454/tons of weighted surplus emissions reduced

The cost-effectiveness for this example is greater than the $16,000 per ton weighted cost-effectiveness requirement. In order to meet the $16,000 per ton weighted cost-effectiveness requirement, this project would only qualify for a fraction of the incremental cost – $15,644. This amount is determined by multiplying the maximum allowed cost-effectiveness by the estimated annual emission reductions and dividing by the capital recovery factor:

($16,000 * 0.22)/0.225 = $15,644

IV. Large Spark-Ignition Off-Road Equipment

This section provides examples of calculations for determining the cost-effectiveness of surplus emission reductions for large spark-ignition engine projects.

Example 1 – New Electric Purchase

A lumber company applied for a Carl Moyer grant to purchase a new counter balanced sit down rider electric forklift (Class I, lift code 6) costing $30,000 (including one battery pack). The owner has decided to purchase new electric forklift instead of purchasing a 55 horsepower 2008 model year propane fueled forklift certified to the 2.0 g/bhp-hr NOx + HC. The company is a small fleet and thus exempt for the off-road LSI in-use fleet regulations. The equipment will operate 1900 hours annually and 100 percent of the time in California. This equipment is eligible for a project life of 10 years.

Baseline Technology Information:

- Engine (application): 2008 model year
- HP (application): 55
- Load factor (Table B14): 0.3
- Activity (from application): 1900 hours/year
- Emission factors (Table B-15): 1.05 g/bhp-hr NOx; 0.07 g/bhp-hr ROG; 0.06 g/bhp-hr PM10

Reduced Technology Information:

- Technology (application): Electric forklift
- Forklift cost: $30,000
- Electric equipment is eligible for up to 30% of the total cost
- Percent operated in California (application): 100 percent
- Emission factors: Electric equipment are zero emission (0 g/bhp-hr NOx; 0 g/bhp-hr ROG; 0 g/bhp-hr PM10)

Emission Reduction Calculations:

Formula C-4: Estimated Annual Emissions based on Hours using Off-Road LSI Emission Factors

1. Annual NOx baseline technology emissions
   (1.05 g/bhp-hr * 55 HP * 0.30 * 1900 hr/yr)/907,200 g/ton = 0.04 ton/yr NOx
2. Annual NOx reduced technology emissions = 0 ton/yr
3. Annual ROG baseline technology emissions
   (0.07 g/bhp-hr * 55 HP * 0.3 * 1900 hr/yr)/907,200 g/ton = 0.00 ton/yr
4. Annual ROG reduced technology emissions = 0 ton/yr
5. Annual PM10 baseline technology emissions
   (0.06 g/bhp-hr * 55 HP * 0.3 * 1900 hr/yr)/907,200 g/ton = 0.002 ton/yr
6. Annual PM10 reduced technology emissions = 0 ton/yr

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for new purchases and repowers

- NOx emission benefits = 0.04 tons/yr - 0 tons/yr = 0.04 tons/yr NOx
- ROG emission benefits = 0.00 tons/yr - 0 tons/yr = 0.00 tons/yr ROG
- PM10 emission benefits = 0.002 tons/yr - 0 tons/yr = 0.002 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions
0.04 tons/yr + 0.00 tons/yr + 20(0.002 tons/yr) = 0.08 weighted tons/yr

Annualized Cost:
Project Life: 10 years (from application)
CRF (Table B-1): = 0.123

Formula C-14: Incremental Cost
$30,000 * 0.30 = $9,000

Formula C-12: Annualized Cost
0.123 * $9,000 = $1,107yr

Cost-Effectiveness:
Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)
($1,107/yr / (0.08 weighted tons/yr) =
$13,837/ton of weighted surplus emissions

The cost-effectiveness for the example is less than $16,000 per ton of pollutants reduced. This project qualifies for up to $9000 in grants requested.

Example 2 – LSI Engine Retrofit

A forklift owner proposes to retrofit an existing forklift. The existing forklift is an uncontrolled 55 horsepower propane fueled Toyota MY 1998. A level 3a retrofit has been verified for use on this engine. The cost of the retrofit is $3,300. The company is a small fleet and thus exempt for the off-road LSI in-use fleet regulations. The applicant operates equipment 600 hours per year and will operate 100 percent of the time in California. This equipment is eligible for a project life of 3 years.

Baseline Technology Information:

- Engine (application): MY 1998
- HP (application): 55
- Load factor (Table B-14): 0.3
- Annual hours (application): 600 hours
- Emission factors (Table B-15): 10.51 g/bhp-hr NOx; 1.02 g/bhp-hr ROG; 0.06 g/bhp-hr PM10

Reduced Technology Information:

- Technology (application): Level 3a LSI retrofit verified to an absolute emission value of 1.0 g/bhp-hr

- HP (application): 55
- Load factor (Table B-15): 0.3
- Annual hours (application): 600 hours
- Cost of retrofit: ($3,300 – quote from applicant):
- Retrofit emission factors from (Table B16): 0.53 g/bhp-hr NOx; 0.03 g/bhp-hr ROG

<u>Emission Reduction Calculations:</u>
Formula number C-4: Estimated Annual Emissions based on Hours using Emission Factors

1. Annual NOx baseline technology emissions
   (10.51 g/bhp-hr * 55 HP * 0.3 * 600 hr/yr)/907,200 g/ton = 0.12 ton/yr NOx
2. Annual NOx reduced technology emissions
   (0.53 g/bhp-hr * 55 HP * 0.30 * 600 hr/yr)/907,200 g/ton **=** 0.01 ton/yr NOx
3. Annual ROG baseline technology emissions
   (1.02 g/bhp-hr * 55 HP * 0.3 * 600 hr/yr)/907,200 g/ton = 0.01 ton/yr ROG
4. Annual ROG reduced technology emissions
   (0.03 g/bhp-hr * 55 HP * 0.3 * 600 hr/yr)/907,200 g/ton **=** 0.000 ton/yr ROG
5. Annual PM10 baseline technology emissions
   (0.06 g/bhp-hr * 55 HP * 0.3 * 600 hr/yr)/907,200 g/ton = 0.001 ton/yr PM10
6. Annual PM10 reduced technology emissions
   (0.06 g/bhp-hr * 55 HP * 0.3 * 600 hr/yr)/907,200 g/ton = 0.001 ton/yr PM10

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr)

- Emission benefits NOx = 0.12 tons/yr - 0.01 tons/yr = 0.11 tons/yr NOx
- Emission benefits ROG = 0.01 tons/yr - 0.000 tons/yr = 0.01 tons/yr ROG
- Emission benefits PM10 = 0.001 tons/yr - 0.001 tons/yr = 0.00 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions
0.11 tons/yr + 0.01 tons/yr + 20(0.00 tons/yr) = 0.12 weighted tons/yr

<u>Annualized Cost:</u>

Project Life: 3 years
CRF (Table B-1): = 0.360

Formula C-14: Maximum Eligible Funding
= $3,300

Formula C-12: Annualized Cost
0.360 * $3,300 = $1,188/yr

<u>Cost-Effectiveness:</u>
Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)
($1,188/yr) / (0.12 tons/yr) =
$9,900/ton of surplus emissions reduced

The cost-effectiveness for the example is less than $16,000 per ton of pollutants reduced. This project qualifies for up to $3,300 in grants requested.

V. Off-Road Equipment Replacement

This section provides examples of calculations for determining the cost-effectiveness of surplus emission reductions for off-road equipment replacement projects.

Example 1 – Replacement of a 1985 agricultural tractor
A farmer proposes to replace an uncontrolled 1985 175 hp agricultural tractor with a new 175 hp Tier 3 agricultural tractor. The new equipment will cost $100,000. This equipment operates 1000 hours per year, 100 percent of the time in California. A Level 3 diesel particulate filter has been verified for use on the engine and has a cost of $25,000. There is no available Tier 3 repower for this specific equipment, so the applicant is eligible for up to 80 percent of the new equipment cost. This equipment is eligible for a project life of 5 years.

Baseline Technology Information:
- Engine (application): 1985 Model Year
- HP (application): 175
- Hours of operation (application): 1000
- Load factor (Table B-11): 0.70
- Emission factors (Table B-12): 10.23 g/bhp-hr NOx; 1.06 g/bhp-hr ROG; 0.396 g/bhp-hr PM10

Reduced Technology Information:
- Engine: Tier 3 (ARB executive order)
- HP (application): 175
- Hours of operation (application): 1000
- Equipment replacement is eligible for up to 80 percent of the new equipment cost.
- Cost of new equipment (quote provided with application): $100,000
- Load factor (Table B-11): 0.70
- Emission factors (Table B-13): 2.32 g/bhp-hr NOx; 0.12 g/bhp-hr ROG; 0.112 g/bhp-hr PM10
- Percent operating in California (application): 100 percent
- Retrofit: Level 3 verified reductions- 85 percent PM10
- Retrofits are eligible for up to 100% of total cost.
- Cost of retrofit (quote provided with application): $25,000

Emission Reduction Calculations:
Formula C-4: Estimated Annual Emissions based on Hours of Operation (tons/yr)
7. Annual NOx baseline technology emissions
   10.23 g/bhp-hr *175 hp*0.70*1000 hr*(ton/907,200 g) = 1.38 tons/yr NOx
8. Annual NOx reduced technology emissions
   2.32 g/bhp-hr *175 hp*0.70*1000 hr*(ton/907,200 g) = 0.31 tons/yr NOx
9. Annual ROG baseline technology emissions
   1.06 g/bhp-hr *175 hp*0.70*1000 hr*(ton/907,200 g) = 0.14 tons/yr ROG
10. Annual ROG reduced technology emissions
   0.12 g/bhp-hr *175 hp*0.70*1000 hr*(ton/907,200 g) = 0.02 tons/yr ROG

11. Annual PM10 baseline technology emissions
0.396 g/bhp-hr *175 hp*0.70*1000 hr*(ton/907,200 g) = 0.053 tons/yr PM10
12. Annual PM10 reduced technology emissions
0.112 g/bhp-hr *175 hp*0.70*1000 hr*(ton/907,200 g) = 0.015 tons/yr PM10

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

- Emission benefits NOx = 1.38 tons/yr - 0.31 tons/yr = 1.07 tons/yr NOx
- Emission benefits ROG = 0.14 tons/yr - 0.02 tons/yr = 0.12 tons/yr ROG
- Emission benefits PM10 = 0.053 tons/yr - 0.015 tons/yr = 0.038 tons/yr PM10

Formula C-11: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Retrofits
0.015 tons/yr PM10 * 0.85 = 0.013 tons/yr PM10

Total PM10 Emission Benefits
0.038 tons/yr + 0.013 tons/yr = 0.051 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions
1.07 tons/yr + 0.12 tons/yr + 20(0.051 tons/yr) = 2.21 weighted tons/yr

<u>Annualized Cost:</u>
Project Life: 5 years
CRF (Table B-1): = 0.225

Formula C-14: Incremental Cost
($100,000 * 80 percent) + ($25,000 * 100 percent) = $105,000

Formula C-12: Annualized Cost
0.225 * $105,000 = $23,625

<u>Cost-Effectiveness:</u>
Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)
($23,625/yr)/(2.21 weighted tons/yr)
= $10,690/tons of weighted surplus emissions reduced

The cost-effectiveness for the example is less than $16,000 per ton of pollutants reduced. This project qualifies for up to $105,000 in grant funds requested.

Example 2 – Replacement of two rubber tired loaders
A construction company meeting the definition of a medium fleet in the Off-Road Regulation wants to replace two uncontrolled rubber tired loaders with one Tier 3 rubber tired loader. The baseline technologies are: 1) a model year 1987 210 hp uncontrolled engine that operates for 750 hours per year and 2) a model year 1978 180 hp uncontrolled engine that operates for 350 hours per year. The applicant is proposing to purchase a 210 hp Tier 3 rubber tired loader that costs $275,000. This equipment

operates 100 percent of the time in California. A Level 3 diesel particulate filter has been verified for use on the engine and has a cost of $25,000. There are no available Tier 3 repowers for this specific equipment, so the applicant is eligible for up to 80 percent of the new equipment cost. This project will be in operation prior to March 1, 2009 and thus be surplus to the Off-Road Regulation and can be given a maximum project life of 4 years.

<u>Baseline Technology Information, Equipment 1:</u>

- Engine (application): 1987 Model Year
- HP (application): 210
- Annual Hours of operation (application): 750
- Load factor (Table B-11): 0.54
- Emission factors (Table B-12): 10.23 g/bhp-hr NOx; 1.06 g/bhp-hr ROG; 0.396 g/bhp-hr PM10

<u>Baseline Technology Information, Equipment 2:</u>

- Engine (application): 1978 Model Year
- HP (application): 180
- Annual Hours of operation (application): 350
- Load factor (Table B-11): 0.54
- Emission factors (Table B-12): 11.16 g/bhp-hr NOx; 1.20 g/bhp-hr ROG; 0.396 g/bhp-hr PM10

<u>Reduced Technology Information:</u>

- Engine: Tier 3 (ARB executive order)
- HP (application): 210
- Hours of operation (application): 1,100
- Cost of new equipment (quote provided with application): $275,000
- Equipment replacement is eligible for up to 80 percent of the new equipment cost.
- Load factor (Table B-11): 0.54
- Emission factors (Table B-13): 2.32 g/bhp-hr NOx; 0.12 g/bhp-hr ROG; 0.112 g/bhp-hr PM10
- Percent operating in California (application): 100 percent
- Retrofit: Level 3 verified reductions- 85 percent PM10
- Cost of retrofit (quote provided with application): $25,000
- Retrofits are eligible for up to 100% of total retrofit costs

<u>Emission Reduction Calculations:</u>

Formula C-4: Estimated Annual Emissions based on Hours of Operation (tons/yr)

1. Annual NOx baseline technology emissions, equipment 1
   10.23 g/bhp-hr *210 hp*0.54*750 hr*(ton/907,200 g) = 0.96 tons/yr NOx
2. Annual NOx baseline technology emissions, equipment 2
   11.16 g/bhp-hr *180 hp*0.54*350 hr*(ton/907,200 g) = 0.42 tons/yr NOx
3. Annual NOx reduced technology emissions
   2.32 g/bhp-hr *210 hp*0.54*1100 hr*(ton/907,200 g) = 0.32 tons/yr NOx

4. Annual ROG baseline technology emissions, equipment 1
   1.06 g/bhp-hr *210 hp*0.54*750 hr *(ton/907,200 g) = 0.10 tons/yr ROG
5. Annual ROG baseline technology emissions, equipment 2
   1.20 g/bhp-hr *180 hp*0.54*350 hr*(ton/907,200 g) = 0.05 tons/yr ROG
6. Annual ROG reduced technology emissions
   0.12 g/bhp-hr *210 hp*0.54*1100 hr*(ton/907,200 g) = 0.02 tons/yr ROG
7. Annual PM10 baseline technology emissions, equipment 1
   0.396 g/bhp-hr *210 hp*0.54*750 hr*(ton/907,200 g) = 0.037 tons/yr PM10
8. Annual PM10 baseline technology emissions, equipment 2
   0.396 g/bhp-hr *180 hp*0.54*350 hr*(ton/907,200 g) = 0.015 tons/yr PM10
9. Annual PM10 reduced technology emissions
   0.112 g/bhp-hr *210 hp*0.54*1100 hr*(ton/907,200 g) = 0.015 tons/yr PM10

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

- Emission benefits NOx = (0.96+0.42 tons/yr) - 0.32 tons/yr = 1.06 tons/yr NOx
- Emission benefits ROG = (0.10+0.05 tons/yr) - 0.02 tons/yr = 0.13 tons/yr ROG
- Emission benefits PM10 = (0.037+0.015 tons/yr) - 0.015 tons/yr = 0.037 tons/yr PM10

Formula C-11: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Retrofits

0.015 tons/yr PM10 * 0.85 = 0.013 tons/yr PM10

Total PM10 Emission Benefits

0.037 tons/yr + 0.013 tons/yr = 0.050 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions

1.06 tons/yr + 0.13 tons/yr + 20(0.050 tons/yr) = 2.19 weighted tons/yr

<u>Annualized Cost:</u>

Project Life: 4 years

CRF (Table B-1): = 0.275

Formula C-14: Incremental Cost

($275,000 * 85 percent) + ($25,000 * 100 percent) = $245,000

Formula C-12: Annualized Cost

0.275 * $245,000 = $67,375

<u>Cost-Effectiveness:</u>

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)

($67,375/yr)/(2.19 weighted tons/yr)

= $30,764/tons of weighted surplus emissions reduced

The cost-effectiveness for this example is greater than the $16,000 per ton weighted cost-effectiveness requirement. In order to meet the $16,000 per ton weighted cost-effectiveness requirement, this project would only qualify for a fraction of the incremental cost – $127,418 (or 52% of the incremental cost). This amount is determined by multiplying the maximum allowed cost-effectiveness by the estimated annual emission reductions and dividing by the capital recovery factor:

($16,000 * 2.19)/0.275 = $127,418

Example 3 – Replacement of a 1993 LSI forklift with a new LSI forklift
An applicant proposes to replace a 1993 60 hp LPG forklift with a new 2008 Model Year 70 hp LPG forklift. The new equipment will cost $22,000. This equipment operates 750 hours per year, 100 percent of the time in California. This equipment belongs to a small fleet and is eligible for a project life of 3 years.

Baseline Technology Information:
- Engine (application): Model Year 1993
- HP (application): 60
- Hours of operation (application): 750
- Load factor (Table B-14): 0.30
- Emission factors (Table B-15): 10.51 g/bhp-hr NOx; 1.02 g/bhp-hr ROG; 0.060 g/bhp-hr PM10

Reduced Technology Information:
- Engine: Model Year 2007
- HP (application): 70
- Hours of operation (application): 750
- Cost of new equipment (quote provided with application): $22,000
- Equipment replacement is eligible for up to 80 percent of the new equipment cost.
- Load factor (Table B-14): 0.30
- Emission factors (Table B-15): 1.05 g/bhp-hr NOx; 0.07g/bhp-hr ROG; 0.060 g/bhp-hr PM10
- Percent operating in California (application): 100 percent

Emission Reduction Calculations:
Formula C-4: Estimated Annual Emissions based on Hours of Operation (tons/yr)
1. Annual NOx baseline technology emissions
   10.51 g/bhp-hr *60 hp*0.30*750 hr*(ton/907,200 g) = 0.16 tons/yr NOx
2. Annual NOx reduced technology emissions
   1.05 g/bhp-hr *70 hp*0.30*750 hr*(ton/907,200 g) = 0.02 tons/yr NOx
3. Annual ROG baseline technology emissions
   1.02 g/bhp-hr *60 hp*0.30*750 hr*(ton/907,200 g) = 0.051 tons/yr ROG
4. Annual ROG reduced technology emissions
   0.07 g/bhp-hr *70 hp*0.30*750hr*(ton/907,200 g) = 0.001 tons/yr ROG
5. Annual PM10 baseline technology emissions
   0.060 g/bhp-hr *60 hp*0.30*750 hr*(ton/907,200 g) = 0.001 tons/yr PM10
6. Annual PM10 reduced technology emissions
   0.060 g/bhp-hr *70 hp*0.30*750 hr*(ton/907,200 g) = 0.001 tons/yr PM10

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

- Emission benefits NOx = 0.16 tons/yr - 0.02 tons/yr = 0.14 tons/yr NOx
- Emission benefits ROG = 0.051 tons/yr - 0.001 tons/yr = 0.050 tons/yr ROG
- Emission benefits PM10 = 0.001 tons/yr - 0.001 tons/yr = 0.0 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions

0.14 tons/yr + 0.050 tons/yr + 20(0.0 tons/yr) = 0.19 weighted tons/yr

<u>Annualized Cost:</u>

Project Life: 3 years

CRF (Table B-1): = 0.360

Formula C-14: Incremental Cost

($22,000 * 80 percent) = $17,600

Formula C-12: Annualized Cost

0.360 * $17,600 = $6,336

<u>Cost-Effectiveness:</u>

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)

($6,336/yr)/(0.19 weighted tons/yr)

= $33,347/tons of weighted surplus emissions reduced

The cost-effectiveness for this example is greater than the $16,000 per ton weighted cost-effectiveness requirement. In order to meet the $16,000 per ton weighted cost-effectiveness requirement, this project would only qualify for a fraction of the incremental cost – $8,444 (or 48% of the incremental cost). This amount is determined by multiplying the maximum allowed cost-effectiveness by the estimated annual emission reductions and dividing by the capital recovery factor:

($16,000 * 0.19)/0.360 = $8,444

Example 4 – Replacement of a 1993 LSI forklift with a new electric forklift

An applicant proposes to replace a 1993 60 hp LPG forklift with a new electric 70 hp (52 KW) forklift in 2008. The new equipment will cost $34,000. This equipment operates 750 hours per year, 100 percent of the time in California.

When calculating emission benefits for replacement with electric equipment, SB 467 requires that calculations are done from two transactions:

- Transaction 1: Existing equipment to be scrapped to zero emission (maximum of 3 year project life attributed to this transaction)
- Transaction 2: New piece of equipment that would be purchased in 3 years, or the time of normal attrition, to zero emission (maximum of 7 year project life attributed to this transaction)

This equipment belongs to a small fleet and is eligible for a maximum total project life of 10 years.

Baseline Technology Information-Transaction 1:

- Engine (application): Model Year 1993
- HP (application): 60
- Hours of operation (application): 750
- Load factor (Table B-14): 0.30
- Emission factors (Table B-15): 10.51 g/bhp-hr NOx; 1.02 g/bhp-hr ROG; 0.060 g/bhp-hr PM10

Baseline Technology Information-Transaction 2:

- Engine (application): Model Year 2011
- HP (application): 60
- Hours of operation (application): 750
- Load factor (Table B-14): 0.30
- Emission factors (Table B-15): 0.32 g/bhp-hr NOx; 0.02 g/bhp-hr ROG; 0.060 g/bhp-hr PM10

Reduced Technology Information:

- Engine: electric
- HP (application): 70
- Hours of operation (application): 750
- Cost of new equipment (quote provided with application): $34,000
- Equipment replacement is eligible for up to 80 percent of the new equipment cost.
- Load factor (Table B-14): 0.30
- Emission factors (Table B-15): 0 g/bhp-hr NOx; 0 g/bhp-hr ROG; 0 g/bhp-hr PM10
- Percent operating in California (application): 100 percent

Emission Reduction Calculations:

Formula C-4: Estimated Annual Emissions based on Hours of Operation (tons/yr)

1. Annual NOx baseline technology emissions- Transaction 1
   10.51 g/bhp-hr *60 hp*0.30*750 hr*(ton/907,200 g) = 0.16 tons/yr NOx
2. Annual NOx baseline technology emissions- Transaction 2
   0.32 g/bhp-hr *60 hp*0.30*750 hr*(ton/907,200 g) = 0.005 tons/yr NOx
3. Annual NOx reduced technology emissions
   0 g/bhp-hr *70 hp*0.30*750 hr*(ton/907,200 g) = 0.0 tons/yr NOx
4. Annual ROG baseline technology emissions- Transaction 1
   1.02 g/bhp-hr *60 hp*0.30*750 hr*(ton/907,200 g) = 0.051 tons/yr ROG
5. Annual ROG baseline technology emissions- Transaction 2
   0.02 g/bhp-hr *60 hp*0.30*750 hr*(ton/907,200 g) = 0.0003 tons/yr ROG
6. Annual ROG reduced technology emissions
   0.0 g/bhp-hr *70 hp*0.30*750hr*(ton/907,200 g) = 0.0 tons/yr ROG
7. Annual PM10 baseline technology emissions- Transaction 1
   0.060 g/bhp-hr *60 hp*0.30*750 hr*(ton/907,200 g) = 0.001 tons/yr PM10
8. Annual PM10 baseline technology emissions- Transaction 2
   0.060 g/bhp-hr *60 hp*0.30*750 hr*(ton/907,200 g) = 0.001 tons/yr PM10
9. Annual PM10 reduced technology emissions
   0.0 g/bhp-hr *70 hp*0.30*750 hr*(ton/907,200 g) = 0.0 tons/yr PM10

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

Transaction 1

- Emission benefits NOx = 0.16 tons/yr - 0.0 tons/yr = 0.16 tons/yr NOx
- Emission benefits ROG = 0.051 tons/yr - 0.0 tons/yr = 0.051 tons/yr ROG
- Emission benefits PM10 = 0.001 tons/yr - 0.0 tons/yr = 0.001 tons/yr PM10

Transaction 2

- Emission benefits NOx = 0.005 tons/yr - 0.0 tons/yr = 0.005 tons/yr NOx
- Emission benefits ROG = 0.0003 tons/yr - 0.0 tons/yr = 0.0003 tons/yr ROG
- Emission benefits PM10 = 0.001 tons/yr - 0.0 tons/yr = 0.001 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions

Transaction 1

0.16 tons/yr + 0.051 tons/yr + 20(0.001 tons/yr) = 0.213 weighted tons/yr

Transaction 2

0.005 tons/yr + 0.0003 tons/yr + 20(0.001 tons/yr) = 0.025 weighted tons/yr

Only a fraction of each of the annual weighted surplus emission reductions from the two transactions is used to determine the total annual weighted surplus emission reductions for cost effectiveness. This fraction is the project life associated with each transaction over the total project life.

(3/10 * 0.213) + (7/10 * 0.025) = 0.081

<u>Annualized Cost:</u>

Project Life: 10 years

CRF (Table B-1): = 0.123

Formula C-14: Incremental Cost

($34,000 * 80 percent) = $27,200

Formula C-12: Annualized Cost

0.123 * $27,200 = $3,346

<u>Cost-Effectiveness:</u>

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)

($3,346/yr)/(0.081 weighted tons/yr)

= $41,309/tons of weighted surplus emissions reduced

The cost-effectiveness for this example is greater than the $16,000 per ton weighted cost-effectiveness requirement. In order to meet the $16,000 per ton weighted cost-effectiveness requirement, this project would only qualify for a fraction of the incremental cost – $10,537 (or 39% of the incremental cost). This amount is determined by multiplying the maximum allowed cost-effectiveness by the estimated annual emission reductions and dividing by the capital recovery factor:

($16,000 * 0.081)/0.123 = $10,537

VI. Locomotives

This section provides examples of calculations for determining cost-effectiveness of surplus emission reductions for locomotive projects.

Example 1 – Switch Locomotive Engine Remanufacture Kit (Class 3 Railroad)
A Class 3 railroad operator opts to remanufacture an existing 1971 model year switch locomotive engine with a U.S. EPA-certified Tier 0 Engine Remanufacture Kit. The existing locomotive consumes 40,000 gallons of fuel per year, with 100 percent operation in California. The cost of the remanufacture kit plus installation of the kit costs $400,000. The cost to purchase and install an automatic engine start-stop ILD is $11,000. The railroad company will commit to a 10 year project life. Emission reductions are calculated as follows:

<u>Baseline Technology Information:</u>

- Locomotive model year (application): 1971
- Locomotive emission rate (Table B-18a): 16.36 g/bhp-hr NOx, 1.06 g/bhp-hr ROG, 0.378 g/bhp-hr PM10
- Activity (application): 40,000 gal/year
- Energy consumption factor = 20.8 bhp-hr/gal (Table B-25)

<u>Reduced Technology Information:</u>

- Emission Factors (Table B-18a): 11.84 g/bhp-hr NOx, 1.06 g/bhp-hr ROG, 0.378 g/bhp-hr PM10[1]
- Activity (application): 40,000 gal/year
- Energy consumption factor = 20.8 bhp-hr/gal (Table B-25)
- ILD emission reduction factor (Table B-19): 0.90
- Locomotive project criteria allow for the Carl Moyer Program to pay for up to 85 percent of the remanufacture kit cost and 50 percent of ILD cost

<u>Emission Reduction Calculations:</u>

Formula C-6: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr):

1. Annual NOx baseline technology emissions
(16.36 g/bhp-hr*40,000 gal/yr*20.8 bhp-hr/gal)*(ton/907,200g) = 15.00 ton/yr NOx
2. Annual NOx reduced technology emissions
(11.84 g/bhp-hr*40,000 gal/yr*20.8 bhp-hr/gal*0.90)*(ton/907,200g)=9.77 ton/yr NOx
3. Annual ROG baseline technology emissions
(1.06 g/bhp-hr *40,000 gal/yr*20.8 bhp-hr/gal)*(ton/907,200g) = 0.97 ton/yr ROG
4. Annual ROG reduced technology emissions
(1.06 g/bhp-hr*40,000 gal/yr*20.8 bhp-hr/gal *0.90)*(ton/907,200g)=0.87 ton/yr ROG
5. Annual combustion PM10 baseline technology
(0.378 g/bhp-hr*40,000 gal/yr*20.8 bhp-hr/gal)*(ton/907,200g) = 0.347 ton/yr PM10
6. Annual combustion PM10 reduced technology emissions
(0.378 g/bhp-hr*40,000 gal/yr*20.8 bhp-hr/gal *0.90)*(ton/907,200g)
= 0.312 ton/yr PM10

[1] For information regarding how to calculate reduced engine emission factors, refer to the Supplemental Documents webpage at: www.arb.ca.gov/msprog/moyer/guidelines/supplemental-docs.htm

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

- NOx emission benefits = 15.00 tons/yr – 9.77 tons/yr = 5.23 tons/yr NOx
- ROG emission benefits = 0.97 tons/yr - 0.87 tons/yr = 0.10 tons/yr ROG
- PM10 emission benefits= 0.347 tons/yr - 0.312 tons/yr = 0.035 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions

5.23 tons/yr + 0.10 tons/yr + 20(0.035 tons/yr) = 6.02 weighted tons/yr

Annualized Cost:

Project Life: 10 years

CRF (Table B-1): = 0.123

Formula C-14: Incremental Cost

($400,000 * 85 percent) + ($11,000 * 50 percent) = 345,500

Formula C-12: Annualized Cost

0.123 * $345,500 = $42,497/yr

Cost-Effectiveness:

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)

($42,497/yr)/(6.02 weighted tons/yr)

= $7,057/tons of weighted surplus emissions reduced

The project cost-effectiveness is below $16,000 per weighted ton of emissions reduced. Therefore, the project qualifies for $305,500 in Carl Moyer Program funding.

Example 2 – Multiple Engine Switcher Purchase (Class 1 Railroad)

A Class 1 railroad operator has the opportunity to purchase an alternative technology switch locomotive. Because this is a multiple engine switcher (Engine Family Number 7NREG0060LOC) with new electronics, a new battery, and other components, the project is evaluated as a new locomotive purchase. Fuel receipts indicate other switch locomotives with the same activity in the rail yard consume 45,000 gallons of fuel per year. The cost of the new alternative technology switcher is $1.2 million. The project life is 10 years. Emission reductions are calculated as follows:

Baseline Technology Information:

- Locomotive model year: none
- Locomotive emission factor (Tier 0, Table B-18a)[2]: 11.84 g/bhp-hr NOx, 1.06 g/bhp-hr ROG, 0.378 g/bhp-hr PM10
- Activity (application): 45,000 gal/year
- Energy consumption factor = 20.8 bhp-hr/gal (Table B-25)

Reduced Technology Information:

- Engine model year: 2007
- Emission factors (Engine Family 7NREG0060LOC)[1]: 2.54 g/bhp-hr NOx, 0.105 g/bhp-hr ROG, 0.060 g/bhp-hr PM10
- Activity (application): 45,000 gal/year

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[2] For information regarding how to determine reduced engine emission factors, refer to the Supplemental Documents webpage at: www.arb.ca.gov/msprog/moyer/guidelines/supplemental-docs.htm

- Energy consumption factor = 18.5 bhp-hr/gal (Table B-25)
- Locomotive project criteria allow for the Carl Moyer Program to pay for up to 50 percent of Class 1 railroad alternative switcher locomotive purchase cost

<u>Emission Reduction Calculations:</u>

Formula C-6: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr):

1. Annual NOx baseline technology emissions
   (11.84 g/bhp-hr * 45,000 gal/yr * 20.8 bhp-hr/gal) *(ton/907,200g) = 12.21 ton/yr NOx
2. Annual NOx reduced technology emissions
   (2.54 g/bhp-hr * 45,000 gal/yr * 18.5 bhp-hr/gal) *(ton/907,200g) = 2.33 ton/yr NOx
3. Annual ROG baseline technology emissions
   (1.06 g/bhp-hr * 45,000 gal/yr * 20.8 bhp-hr/gal) *(ton/907,200g) = 1.09 ton/yr ROG
4. Annual ROG reduced technology emissions
   (0.105 g/bhp-hr * 45,000 gal/yr * 18.5 bhp-hr/gal) *(ton/907,200g) = 0.10 ton/yr ROG
5. Annual combustion PM10 baseline technology
   (0.378 g/bhp-hr * 45,000 gal/yr * 20.8 bhp-hr/gal) *(ton/907,200g)=0.390 ton/yr PM10
6. Annual combustion PM10 reduced technology emissions
   (0.060 g/bhp-hr * 45,000 gal/yr * 18.5 bhp-hr/gal) *(ton/907,200g)=0.055 ton/yr PM10

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

- Emission benefits NOx = 12.21 tons/yr – 2.33 tons/yr = 9.88 tons/yr NOx
- Emission benefits ROG = 1.09 tons/yr – 0.10 tons/yr = 1.00 tons/yr ROG
- Emission benefits PM10 = 0.390 tons/yr – 0.055 tons/yr = 0.335 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions

9.88 tons/yr +1.00 tons/yr + 20(0.335 tons/yr) = 17.59 weighted tons/yr

<u>Annualized Cost:</u>

Project Life: 10 years

CRF (Table B-1): = 0.123

Formula C-14: Incremental Cost

$1,200,000 * 0.50 = $600,000

Formula C-12: Annualized Cost

0.123 * $600,000 = $73,800/yr

<u>Cost-Effectiveness:</u>

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)

($73,800/yr)/(17.59 weighted tons/yr)

= $4,197/tons of weighted surplus emissions reduced

The project cost-effectiveness is below $16,000 per weighted ton of emissions reduced. Therefore, the project qualifies for $600,000 in Carl Moyer Program funding.

Example 3 – Idle-Limiting Device Installation (Class 3 Railroad)

A Class 3 railroad wants to purchase and install an AESS ILD on one of its 1970 uncontrolled switch locomotives. Fuel receipts indicate other switch locomotives with the same activity in the rail yard consume 25,000 gallons of fuel per year. The cost to purchase and install the AESS is $14,000. The project life is 3 years. Emission reductions are calculated as follows:

Baseline Technology Information:

- Locomotive model year: 1970
- Locomotive emission rate (uncontrolled, Table B-18): 16.36 g/bhp-hr NOx, 1.06 g/bhp-hr ROG, 0.378 g/bhp-hr PM10
- Activity (application): 25,000 gal/year
- Energy consumption factor = 20.8 bhp-hr/gal (Table B-25)
- ILD emission reduction factor (Table B-19): 0.90
- Locomotive project criteria allow for the Carl Moyer Program to pay for up to 50 percent of ILD cost

Emission Reduction Calculations:

Formula C-6: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr):

1) Annual NOx emission reductions
   (16.36 g/bhp-hr * 25,000 gal/yr * 20.8 bhp-hr/gal) *(ton/907,200g) = 9.38 ton/yr NOx
2) Annual NOx reduced technology emissions
   (16.36 g/bhp-hr*25,000 gal/yr*20.8 bhp-hr/gal*0.90)*(ton/907,200g)=8.44 ton/yr NOx
3) Annual ROG baseline technology emissions
   (1.06 g/bhp-hr * 25,000 gal/yr * 20.8 bhp-hr/gal) *(ton/907,200g) = 0.61 ton/yr ROG
4) Annual ROG reduced technology emissions
   (1.06 g/bhp-hr*25,000 gal/yr*20.8 bhp-hr/gal*0.90)*(ton/907,200g) =0.55 ton/yr ROG
5) Annual combustion PM10 baseline technology
   (0.378 g/bhp-hr * 25,000 gal/yr * 20.8 bhp-hr/gal)*(ton/907,200g) =0.217 ton/yr PM10
6) Annual combustion PM10 reduced technology emissions
   (0.378 g/bhp-hr*25,000 gal/yr*20.8 bhp-hr/gal*0.90)*(ton/907,200g)=0.195ton/yr PM10

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

- Emission benefits NOx = 9.38 tons/yr – 8.44 tons/yr = 0.94 tons/yr NOx
- Emission benefits ROG = 0.61 tons/yr – 0.55 tons/yr = 0.06 tons/yr ROG
- Emission benefits PM10 = 0.217 tons/yr – 0.195 tons/yr = 0.022 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions

0.94 tons/yr +0.06 tons/yr + 20(0.022 tons/yr) = 1.43 weighted tons/yr

Annualized Cost:

Project Life: 3 years

CRF (Table B-1): = 0.360

Formula C-14: Incremental Cost

$14,000 * 0.50 = $7,000

Formula C-12: Annualized Cost

0.360 * $7,000 = $2,520/yr

Cost-Effectiveness:

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)

($2,520/yr)/(1.43 weighted tons/yr)

= **$1,760/tons of weighted surplus emissions reduced**

The project cost-effectiveness is below $16,000 per weighted ton of emissions reduced. Therefore, the project qualifies for $7,000 in Carl Moyer Program funding.

VII. Marine Vessels

This section provides examples of calculations for determining the cost-effectiveness of surplus emission reductions for marine vessel projects.

Example 1 – Tow Boat Auxiliary Engine Repower
A tow boat owner in San Diego wishes to repower a 125 horsepower 1987 auxiliary engine with a new Tier 2 200 horsepower marine engine. The vessel owner has documented that the vessel auxiliary engine operates for 900 hours annually in California waters. The cost to repower the existing engine is $50,000. Since the vessel is subject to ARB's Harbor Craft Diesel Engine Regulation, the repower must be complete by December 31, 2011, and the project life may not extend beyond December 31, 2014 (See Table 1 in the marine vessel chapter for details). Since the repower shall be complete by December 31, 2009, the operator opts to commit to the maximum five year project life (i.e. the time between project completion and the rule implementation deadline). Emission reductions are calculated as follows:

<u>Baseline Technology Information:</u>
- Baseline technology (application): 1987
- Engine horsepower (application): 125 hp
- Engine emission rate (Table B-21): 10.23 g/bhp-hr NOx, 0.82 g/bhp-hr ROG, 0.333 g/bhp-hr PM10
- Activity (application): 900 hr/yr
- Engine load factor (Table B-22): 0.43

<u>Reduced Technology Information:</u>
- Reduced technology (application): Tier 2 marine engine
- Engine horsepower (application) = 200 hp
- Emission rate (Table B-21): 4.84 g/bhp-hr NOx, 0.58 g/bhp-hr ROG, 0.120 g/bhp-hr PM10
- Activity (application): 900 hr/yr
- Load factor adjustment (*Formula C-5: Replacement Load Factor*):
  = 0.43*(125 hp/200 hp) = 0.27
- Marine vessel project criteria allow for the Carl Moyer Program to pay for up to 50 percent of the repower cost for this type of vessel

<u>Emission Reduction Calculations:</u>
Formula C-4: Estimated Annual Emissions based on Hours of Operation (tons/yr)
1. Annual NOx baseline technology emissions
   (10.23 g/bhp-hr * 900 hr/yr * 125 hp * 0.43)(ton/907,200 g)
   = 0.55 ton/yr NOx
2. Annual NOx reduced technology emissions
   (4.84 g/bhp-hr * 900 hr/yr * 200 hp * 0.27)(ton/907,200 g)
   = 0.26 ton/yr NOx
3. Annual ROG baseline technology emissions
   (0.81 g/bhp-hr * 900 hr/yr * 125 hp * 0.43)(ton/907,200 g)

= 0.04 ton/yr ROG

4. Annual ROG reduced technology emissions
   (0.58 g/bhp-hr * 900 hr/yr * 200 hp * 0.27)(ton/907,200 g)
   = 0.03 ton/yr ROG
5. Annual PM10 baseline technology emissions
   (0.333 g/bhp-hr * 900 hr/yr * 125 hp * 0.43)(ton/907,200 g
   = 0.018 ton/yr PM10
6. Annual PM10 reduced technology emissions
   (0.120 g/bhp-hr * 900 hrs/year * 200 hp * 0.27)(ton/907,200 g)
   = 0.006 ton/yr PM10

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

- NOx emission reductions = 0.55 tons/yr – 0.26 tons/yr = 0.29 tons/yr NOx
- ROG emission reductions = 0.04 tons/yr – 0.03 tons/yr = 0.01 tons/yr ROG
- PM10 emission reductions = 0.018 tons/yr – 0.006 tons/yr= 0.011 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions

0.28 tons/yr + 0.01 tons/yr + 20(0.011 tons/yr) = 0.53 weighted tons/yr

<u>Annualized Cost:</u>
Project life = 5 years

CRF (Table B-1) = 0.225

Formula C-14: Incremental Cost

$50,000 * 50 percent = $25,000

Formula C-12: Annualized Cost

($25,000 * .225) = $5,625/yr

<u>Cost-Effectiveness:</u>
Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/ton)

($5,625/year)/ (0.53 weighted tons/yr)

= $10,666/ton of weighted surplus emissions reduced

The project cost-effectiveness is below $16,000 per weighted ton of emissions reduced. Therefore, the project qualifies for $25,000 in Carl Moyer Program funding.

Example 2 – Fishing Vessel Propulsion Engine Repower (Wet Exhaust System)

A commercial fishing vessel owner wishes to repower a 1973 250 horsepower propulsion engine with a new Tier 2 250 horsepower marine engine. The vessel has a wet exhaust system. The vessel owner has documented that the vessel propulsion engine operates 1,200 hours per year in California waters. The cost to purchase and install a new engine is $51,300. The applicant will commit to a 5 year project life. Emission reductions are calculated as follows:

Baseline Technology Information:

- Baseline technology (application): 1973
- Engine horsepower (application): 250 hp
- Engine emission rate (Table B-20): 14.27 g/bhp-hr NOx, 0.79 g/bhp-hr ROG, 0.451 g/bhp-hr PM10
- Activity (application): 1,200 hr/yr
- Engine load factor (Table B-22): 0.27
- Wet exhaust emission factor (from marine repower project criteria): 0.80

Reduced-Emission Technology Information:

- Reduced technology (application): Tier 2 marine engine
- Engine horsepower (application): 250 hp
- Emission rate (Table B-20): 4.84 g/bhp-hr NOx, 0.49 g/bhp-hr ROG, 0.120 g/bhp-hr PM10
- Activity (application): 1,200 hr/yr
- Engine load factor (Table B-22): 0.27
- Wet exhaust emission factor (from marine repower project criteria): 0.80
- Marine vessel project criteria allow for the Carl Moyer Program to pay for up to 50 percent of the repower cost for this type of vessel

Emission Reduction Calculations:

Formula C-6: Estimated Annual Emissions based on Fuel Consumed using Emission Factors or Converted Emission Standard (tons/yr)

1. Annual NOx baseline technology emissions
   (14.27 g/bhp-hr * 1,200 hr/yr * 250 hp * 0.27 * 0.80)(ton/907,200 g)
   = 1.02 ton/yr NOx
2. Annual NOx reduced technology emissions
   (4.84 g/bhp-hr * 1,200 hr/yr * 250 hp * 0.27 * 0.80)(ton/907,200 g)
   = 0.35 ton/yr NOx
3. Annual ROG baseline technology emissions
   (0.79 g/bhp-hr * 1,200 hr/yr * 250 hp * 0.27 * 0.80)(ton/907,200 g)
   = 0.06 ton/yr ROG
4. Annual ROG reduced technology emissions
   (0.49 g.bhp-hr * 1,200 hr/yr * 250 hp * 0.27 * 0.80)(ton/907,200 g)
   = 0.04 ton/yr ROG
5. Annual PM10 baseline technology emissions
   (0.451 g/bhp-hr * 1,200 hr/yr * 250 hp * 0.27 * 0.80)(ton/907,200 g)
   = 0.032 ton/yr PM10
6. Annual PM10 reduced technology emissions
   (0.120 g/bhp-hr * 1,200 hr/yr * 250 hp * 0.27 * 0.80)(ton/907,200 g)
   = 0.009 ton/yr PM10

Formula C-10: Annual Surplus Emission Reductions by Pollutant for Repowers and New Purchases

- NOx Emission Reductions = 1.02 tons/yr – 0.35 tons/yr = 0.67 tons/yr NOx
- ROG Emission Reductions = 0.06 tons/yr – 0.04 tons/yr = 0.02 tons/yr ROG
- PM10 Emission Reductions = 0.032 tons/yr – 0.009 tons/yr = 0.024 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions

0.67 + 0.02 +20(0.024) = 1.17 weighted tons/yr

<u>Annualized Cost:</u>

Project life = 5 years

CRF (Table B-1) = 0.225

Formula C-14: Incremental Cost

$51,300 * 50 percent = $25,650

Formula C-12: Annualized Cost

$25,650 * 0.225 = $5,771/yr

<u>Cost Effectiveness:</u>

Formula C-1: Cost-Effectiveness of Surplus Emission Reductions

($5,771/year)/(1.17 weighted tons/yr) =
$4,942 ton of weighted surplus emissions reduced

The project cost-effectiveness is below $16,000 per weighted ton of emissions reduced. Therefore, the project qualifies for $25,650 in Carl Moyer Program funding.

Example 3 – Passenger Terminal Shore Power

The Port of Los Angeles wants to install shore power at one of its terminals. The shore-side transformer for the project costs $2 million, and will be installed by December 31, 2009. The port will begin complying with ARB's Shore Power Regulation in 2014 by ensuring at least 50 percent of vessels use shore power when at berth. The port has contracts with three cruise ships committing them to use the shore power at the terminal for ten visits each per year, and for eight hours per visit. The vessels typically use marine gas oil with a sulfur content of less that 0.10 percent. Emission reductions are calculated as follows:

<u>Project Information:</u>

- Type of Shore Power Berth: Passenger vessel
- Vessel emission rate (Table B-23): 13.9 g/kW-hr NOx, 0.49 g/kW-hr ROG, 0.25 g/kW-hr PM10
- Average Berthing Time: 8 hours per visit
- Number of Visits: 3 ships x 10 visits = 30 visits per year

- Ship Power Requirement: 7,200 kW (weighted average for vessels as provided by applicant)
- Control Factor: 0.10 (Chapter 9, Section IV(c)(12))

<u>Emission Reduction Calculations:</u>

1. Annual NOx emission reductions
   (13.9 g/kW-hr * 8 hr/visit * 30 visits/yr * 7,200 kW *0.9)(ton/907,200 g)
   = 23.83 ton/yr NOx

2. Annual ROG emission reductions
   (0.49 g/kW-hr * 8 hr/visit * 30 visits/yr * 7,200 kW *0.9)(ton/907,200 g)
   = 0.84 ton/yr ROG

3. Annual PM10 emission reductions
   (0.25 g/kW-hr * 8 hr/visit * 30 visits/yr * 7,200 kW *0.9)(ton/907,200 g)
   = 0.429 ton/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions
23.83 + 0.84 +20(0.429) = 33.241 weighted tons/yr

<u>Annualized Cost:</u>
Project life = 4 years
CRF (Table B-1) = 0.275

Formula C-14: Incremental Cost
$2 million * 50 percent = $1 million

Formula C-12: Annualized Cost
$1 million * 0.275 = $275,000/yr

<u>Cost Effectiveness:</u>
Formula C-1: Cost-Effectiveness of Surplus Emission Reductions
($275,000/year) / (33.24 weighted tons/yr) =
$8,273 / ton of weighted surplus emissions reduced

The project cost-effectiveness is below $16,000 per weighted ton of emissions reduced. Therefore, the project qualifies for $1 million in Carl Moyer Program funding.

VIII. Agricultural Sources

This section provides examples of calculations for determining the cost-effectiveness of surplus emission reductions for agricultural source projects.

Example 1 – Repower (diesel to diesel)
An applicant wants to replace an existing 1977 182 hp diesel stationary irrigation pump engine with a new 184 hp diesel stationary engine. The existing engine is subject to the Stationary Diesel In-Use Agricultural Engines Air Toxics Control Measure, and must be replaced with an engine meeting Tier 3 emission standards by 12/31/10. The project must use a 2 year project life to ensure emission reductions surplus to the compliance date.

Baseline Technology Information:
- Baseline technology (application): 1977 MY (uncontrolled)
- Engine horsepower (application): 182 hp
- Activity (application): 3,000 hours per year
- Load factor (Table B-11): 0.65
- Emission factors (Table B-12): 11.16 g/bhp-hr NOx; 1.20 g/bhp-hr ROG; 0.396 g/bhp-hr PM10

Reduced Technology Information:
- Reduced technology (application): 2008 MY (Tier 3)
- Engine horsepower (application): 184 hp
- Activity (application): 3,000 hr/yr
- Load factor (Table B-11): 0.65
- Emission factors (Table B-13): 2.32 g/bhp-hr NOx; 0.12 g/bhp-hr ROG; 0.112 g/bhp-hr PM10
- New engine cost (quote provided with application): $20,320 (includes hour meter)
- Tier 3 engine repowers are eligible for up to 85% of repower cost.

Emission Reduction Calculations:
Formula C-4: Estimated Annual Emissions Based on Hours of Operation (tons/yr)
1. Annual NOx baseline technology emissions
   (11.16 g/bhp-hr * 182 hp * 0.65 * 3,000 hrs)(ton/907,200 g) = 4.37 tons/yr NOx
2. Annual NOx reduced technology emissions
   (2.32g/bhp-hr * 184 hp * 0.65 * 3,000 hrs)(ton/907,200 g) = 0.92 tons/yr NOx
3. Annual ROG baseline technology emissions
   (1.20 g/bhp-hr * 182 hp * 0.65 * 3,000 hrs)(ton/907,200 g) = 0.47 tons/yr ROG
4. Annual ROG reduced technology emissions
   (0.12 g/bhp-hr * 184 hp * 0.65 * 3,000 hrs)(ton/907,200 g) = 0.05 tons/yr ROG
5. Annual PM10 baseline technology emissions
   (0.396 g/bhp-hr * 182 hp * 0.65 * 3,000 hrs)(ton/907,200 g) = 0.155 tons/yr PM10
6. Annual PM10 reduced technology emissions
   (0.112 g/bhp-hr * 184 hp * 0.65 * 3,000 hrs)(ton/907,200 g) = 0.044 tons/yr PM10

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases

- NOx emission benefits = 4.37 tons/yr – 0.92 tons/yr = 3.45 tons/yr NOx
- ROG emission benefits = 0.47 tons/yr – 0.05 tons/yr = 0.42 tons/yr ROG
- PM10 emission benefits = 0.155 tons/yr – 0.044 tons/yr = 0.101 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions

3.45 tons/yr + 0.42 tons/yr + 20(0.101 tons/yr) = 5.89 weighted tons/yr

Annualized Cost:

Project life: 2 years

CRF (Table B-1): =0.530

Formula C-14: Incremental Cost

$20,320 * 0.85 = $17,272

Formula C-12: Annualized Cost

0.530 * $17,272 = $9,154/yr

Cost-Effectiveness:

Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions

($9,154/yr)/(5.89 weighted tons/yr)

= $1,554/tons of weighted surplus emissions reduced

The cost-effectiveness for this project is less than $16,000 per weighted ton of emissions reduced. This project qualifies for up to $17,272 of grant funds requested.

Example 2 – Repower (diesel engine to electric motor)

An applicant wants to replace an existing 1991 120 hp diesel stationary irrigation pump engine with a new 100 hp (75 kW) electric motor. The existing engine is subject to the Stationary Diesel In-Use Agricultural Engines Air Toxics Control Measure, and must be replaced with an engine meeting Tier 3 emission standards by 12/31/10. The project may use up to a 10 year project life for this project; the applicant and district choose to use a 5 year project life. The emission reductions provided by this project are calculated in two transactions following the "Stationary Diesel In-Use Agricultural Engine Air Toxic Control Measure Carl Moyer Program Implementation Chart" (http://www.arb.ca.gov/msprog/moyer/guidelines/supplemental-docs.htm):

- o Transaction 1: two years of emission reductions are calculated for the existing engine being replaced with the electric motor.
- o Transaction 2: three years of emission reductions are calculated for a Tier 3 diesel engine being replaced with the electric motor.

Baseline Technology Information- Transaction 1:

- Engine (application): 1991 MY (uncontrolled)
- Engine horsepower (application): 120 hp

- Load factor (Table B-11): 0.65
- Activity (application): 2,000 hours per year
- Emission factors (Tables B-12): 7.60 g/bhp-hr NOx; 0.82 g/bhp-hr ROG; 0.274 g/bhp-hr PM10

Baseline Technology Information- Transaction 2:
- Engine (application): 2008 MY (Tier 3)
- Engine horsepower (application): 120 hp
- Load factor (Table B-11): 0.65
- Activity (application): 2,000 hours per year
- Emission factors (Tables B-13): 2.74 g/bhp-hr NOx; 0.12 g/bhp-hr ROG; 0.160 g/bhp-hr PM10

Reduced Technology Information:
- Motor (application): 2008 electric motor
- Motor horsepower (application): 100 hp (75 kW)
- Activity (application): 2,000 hours per year
- Cost of new motor and necessary peripheral equipment (itemized quote provided with application): $18,000
- Project eligible for up to 85% of cost
- Emissions: 0 g/bhp-hr NOx; 0 g/bhp-hr ROG; 0 g/bhp-hr PM10

Emission Reduction Calculations:
Formula C-4: Estimated Annual Emissions Based on Hours of Operation
1. Annual NOx baseline technology emissions- Transaction 1
   (7.60 g/hp-hr *120 hp * 0.65 * 2,000 hrs)/(907,200 g/ton) = 1.31 tons/yr NOx
2. Annual NOx baseline technology emissions- Transaction 2
   (2.74 g/hp-hr *120 hp * 0.65 * 2,000 hrs)/(907,200 g/ton) = 0.47 tons/yr NOx
3. Annual NOx reduced technology emissions = 0 tons/yr NOx
4. Annual ROG baseline technology emissions- Transaction 1
   (0.82 g/hp-hr *120 hp * 0.65 * 2,000 hrs)/(907,200 g/ton) = 0.14 tons/yr ROG
5. Annual ROG baseline technology emissions- Transaction 2
   (0.12 g/hp-hr *120 hp * 0.65 * 2,000 hrs)/(907,200 g/ton) = 0.02 tons/yr ROG
6. Annual ROG reduced technology emissions = 0 tons/yr ROG
7. Annual PM10 baseline technology emissions- Transaction 1
   (0.274 g/hp-hr *120 hp *0.65 * 2,000 hrs)/(907,200 g/ton) = 0.047 tons/yr PM
8. Annual PM10 baseline technology emissions- Transaction 2
   (0.160 g/hp-hr *120 hp *0.65 * 2,000 hrs)/(907,200 g/ton) = 0.028 tons/yr PM
9. Annual PM10 reduced technology emissions = 0 tons/yr PM

Formula C-10: Annual Surplus Emission Reductions by Pollutant (tons/yr) for Repowers and New Purchases
Transaction 1

- Emission benefits NOx = 1.31 tons/yr - 0 tons/yr = 1.31 tons/yr NOx
- Emission benefits ROG = 0.14 tons/yr - 0 tons/yr = 0.14 tons/yr ROG
- Emission benefits PM10 = 0.047 tons/yr - 0 tons/yr = 0.047 tons/yr PM10

Transaction 2

- Emission benefits NOx = 0.47 tons/yr - 0 tons/yr = 0.47 tons/yr NOx
- Emission benefits ROG = 0.02 tons/yr - 0 tons/yr = 0.02 tons/yr ROG
- Emission benefits PM10 = 0.028 tons/yr - 0 tons/yr = 0.028 tons/yr PM10

Formula C-2: Annual Weighted Surplus Emission Reductions
Transaction 1

1.31 tons/yr + 0.14 tons/yr + 20(0.047) tons/yr = 2.39 weighted tons/yr

Transaction 2

0.47 tons/yr + 0.02 tons/yr + 20(0.028) tons/yr = 1.05 weighted tons/yr

Only a fraction of each of the annual weighted surplus emission reductions from the two transactions is used to determine the total annual weighted surplus emission reductions for project cost effectiveness. This fraction is the project life associated with each transaction over the total project life.

(2/5 * 2.39 tons/yr) + (3/5 * 1.05 tons/yr) = 1.59 tons/yr

<u>Annualized Cost:</u>
Project Life: 5 years

CRF (Table B-1) = 0.225

Formula C-14: Incremental Cost

$18,000 * 0.85 = $15,300

Formula C-12: Annualized Cost

$15,300 * 0.225 = $3,443/yr

<u>Cost-Effectiveness</u>:
Formula C-1: Cost-Effectiveness of Weighted Surplus Emission Reductions ($/weighted ton)

($3,433/yr)/(1.59 weighted ton/yr)
= $2,165/weighted ton of surplus emissions reduced

The cost-effectiveness for the example is less than $16,000 per weighted ton of pollutants reduced. This project qualifies for up to $15,300 of grant funds requested.

IX. Light-Duty Vehicles

This section provides examples of calculations for determining the cost-effectiveness of surplus emission reductions for light-duty vehicle projects.

Example 1 - Conventional VAVR Project

A district pays $750 to an enterprise operator to retire a 1980 light-duty vehicle in 2008. Added district costs including vehicle identification and testing are $125 for a total cost of $875.

Emissions Reduction: Table D-1 lists the default emission reductions over the 3 year project life in pounds for 2008.

- ROG_{Total} = 149.8 pounds over 3 years
  = (149.8 lb)/[(3 yrs)*(2000 lb/ton)]
  = 0.02497 tons/yr ROG

- NOx = 99.8 pounds over 3 years
  = (99.8 lb)/[(3 yrs)*(2000 lb/ton)]
  = 0.01663 tons/yr NOx

- PM10 = 1.16 pounds over 3 years
  = (1.16 lb)/[(3 yrs)*(2000 lb/ton)]
  = 0.000193 tons/yr PM10

Annual Weighted Surplus Emission Reductions: 0.02497 + 0.01663 + 20*(0.000193)
= 0.04546 weighted tons/yr

Project Life: 3 years   CRF: 0.360 **based on 4% interest**   Total Cost: $875

Annualized Cost: 0.360 * $875 = $315/yr

Cost-Effectiveness: ($315/yr)/(0.04546 weighted tons/yr) = **$6,929**/weighted ton

Example 2 – High Emitter VAVR Project, Unknown Replacement Vehicle

ASM test results completed in 2008 on a 1986 high emitting passenger vehicle weighing 3,400 lbs are listed below. Total district costs for vehicle retiring was $1,500 including costs for identifying the vehicle and stranded costs. The replacement vehicle model year was unknown. The district program did not include PM measuring protocols but included a BAR-approved protocol for measuring evaporative emissions. Default PM emission reductions were obtained from Table D-1. Evaporative emission reductions include both the default emission reductions from Table D-1 and extra emission reductions as the vehicle failed the evaporative emissions test. The vehicle miles traveled were taken from Table D-9 and listed as 8,552 mi/yr.

Pollutant	HC_{Exh}	NOx	CO
ASM5015	1750	771	0.200
ASM2525	1600	660	0.100

Using Table D-5 conversion equations, the retired vehicle's year 1 emission rates were:

HC_{Exh}	6.1023 g/mi
NOx	2.1303 g/mi

The emission rates for the 1986 retired vehicle in years 2&3 were derived from the ASM cut points found in Table D-7 and determined as follows.

	5015			2525		
	HC_{Exh}	CO	NOx	HC_{Exh}	CO	NOx
A	67.0	0.52	850	42.1	0.32	680.0
B	212963.0	979.63	894444.5	212963.0	979.63	894444.5

Using the equation: Std. = A + B/(weight), the ASM cut points for a 3,400 lb vehicle were:

5015			2525		
HC_{Exh}	CO	NOx	HC_{Exh}	CO	NOx
129.64	0.8081	1113.07	104.74	0.6081	943.07

Using Table D-5 conversion equations, the retired vehicle's years 2&3 emission rates were:

HC_{Exh}	2.0899 g/mi
NOx	2.0633 g/mi

The fleet average emission rates for an unknown replacement vehicle in 2008 were taken from Table D-11 and are:

HC_{Exh}	0.1417 g/mi
NOx	0.3430 g/mi

<u>Emission Reductions:</u> (Yr 1)

HC_{Exh} = (6.1023 – 0.1417) x 8,552)/454 = 112.28 lb/yr

NOx = (2.1303 – 0.3430) x 8,552)/454 = 33.67 lb/yr

<u>Emission Reductions:</u> (Yr 2 & 3)

HC_{Exh} = (2.0899 – 0.1417) x 8,552)/454 = 36.70 lb/yr

NOx = (2.0633 – 0.3430) x 8,552)/454 = 32.41 lb/yr

<u>Emission Reductions:</u> (Yr 1, 2, & 3)

HC_{Evap} = 44.7lb/3 yr + 3*14.5/yr = 88.2 lb/3 yr

PM = 1.33 lb/3 Yr

Total Reductions:	HC_{Exh}	=	112.28 + 2 x 36.70	= 185.68 lb/3yr
	HC_{Evap}	=	88.2 lb/3 yr	
	NOx	=	33.67 + 2 x 32.41	= 98.49 lb/3yr
	PM	=	1.33 lb/3yr	

Annual Weighted Surplus Emission Reductions: (185.68/3 + 88.2/3 + 98.49/3 + 20*(1.33/3))/2000 = 0.0665 weighted tons/yr

Project Life: 3 years   CRF: 0.360   Total Cost: $1,500

Annualized Cost: 0.360 * $1,500 = $540/yr

Cost Effectiveness: $540/0.0665 tons = **$8,121** per weighted ton

Example 3 – High Emitter VAVR Project, LEV Replacement Vehicle

In 2009, a 1984 high emitting vehicle weighing 3,400 lbs was retired and replaced by a 2004 ARB-certified low emission vehicle (LEV), as specified in the district contract with the owner. The results of the retired vehicle's ASM test are noted below. The district's VAVR program did not include protocols for measuring PM but included a BAR-approved protocol for measuring evaporative emissions. Default PM emission reductions were obtained from Table D-2. Evaporative emission reductions include both the default emission reductions from Table D-2 and extra emission reductions as the vehicle failed the evaporative emissions test. The vehicle miles traveled averaged over the last prior two years were documented by the district to be 10,042 mi/yr. The total cost to the district was $2,650 which included an extra $1,000 incentive toward the purchase of the LEV.

Pollutant	HC_{Exh}	NOx	CO	
	ASM5015	1750	771	0.200
	ASM2525	1600	660	0.100

Using Table D-5 conversion equations, the retired vehicle's year 1 emission rates were:

HC_{Exh}	6.1023 g/mi
NOx	2.1303 g/mi

The emission rates for the 1984 retired vehicle in years 2&3 were derived from the ASM cut points found in Table D-7 and were determined to be:

	5015			2525		
	HC_{Exh}	CO	NOx	HC_{Exh}	CO	NOx
A	67.0	0.52	850	42.1	0.32	680.0
B	212963.0	979.63	894444.5	212963.0	979.63	894444.5

Using the equation Std. = A + B/(weight), ASM cut points for a 3,400 lb vehicle were:

5015			2525		
HC_{Exh}	CO	NOx	HC_{Exh}	CO	NOx
129.64	0.8081	1113.07	104.74	0.6081	943.07

Using Table D-5 conversion equations, the retired vehicle's years 2&3 emission rates were:

HC_{Exh}	2.0899 g/mi
NOx	2.0633 g/mi

The 2004 LEV replacement vehicle emission rates in 2009 were from Table D-12 and are:

HC_{Exh}	0.0448 g/mi
NOx	0.1678 g/mi

<u>Emission Reductions:</u> (Yr 1)	HC_{Exh}	=	(6.1023 – 0.0448) x 10,042)/454 = 133.99 lb/yr
	NOx	=	(2.1303 – 0.1678) x 10,042)/454 = 43.41 lb/yr
<u>Emission Reductions:</u> (Yr 2 & 3)	HC_{Exh}	=	(2.0899 – 0.0448) x 10,042)/454 = 45.24 lb/yr
	NOx	=	(2.0633 – 0.1678) x 10,042)/454 = 41.93lb/yr
<u>Emission Reductions:</u> (Yr 1, 2, & 3)	PM	=	1.36 lb/3 Yr
	HC_{Evap}	=	52.5 lb/3 yr + 3*14.5/yr = 96.0 lb/3 yr
<u>Total Reductions:</u>	HC_{Exh}	=	133.99 + 2 x 45.24 = 224.47 lb/3yr
	HC_{Evap}	=	96.0 lb/3 yr
	NOx	=	43.41 + 2 x 41.93 = 127.27 lb/3yr
	PM	=	1.36 lb/3yr

<u>Annual Weighted Surplus</u>: (224.47/3 + 96.0/3 + 127.27/3 + 20*(1.36/3))/2000
<u>Emission Reductions</u> = 0.07916 weighted tons/yr

<u>Project Life:</u> 3 years <u>CRF:</u> 0.360 <u>Total Cost:</u> $2,650

<u>Annualized Cost:</u> 0.360 * $2,600 = $936/yr

<u>Cost Effectiveness:</u> $936/0.07916 weighted tons = **$11,824** per weighted ton

Example 4 – High Emitter VRV Project

A 3,800 lb high emitting 1994 passenger vehicle was brought in for repair assistance in 2008. The repair brought the vehicle into compliance with the Smog Check emissions standards for the vehicle's model year and vehicle class. The total cost of repair was $637. Additional program costs of $1,300 per vehicle included remote sensing for vehicle identification and a systematic diagnosis prior to repair. As this program did not include protocols for measuring PM or evaporative emissions, PM reductions were not quantified. Default evaporative emission reductions were added pursuant to section C.2. of Chapter VIII The vehicle miles traveled of 10,128 mi/yr were from Table D-9. ASM Standards were calculated following the methodology used in Example 2. The pre and post ASM test results and standard were:

	ASM 2525			ASM 5015		
	HC_{Exh}	NOx	CO	HC_{Exh}	NOx	CO
Pre	1870	945	0.178	2070	854	0.306
Post	45	437	0.090	75	487	0.150
Std.	48	704	0.454	83	688	0.481

Using the conversion equations from Table D-5, the pre-repair ASM test results converted to emission rates were:

HC	14.5658 g/mi
NOx	1.1784 g/mi

Using the conversion equations from Table D-5, the post-repair ASM test results converted to emission rates were:

HC	0.5527 g/mi
NOx	0.8477 g/mi

<u>Emission Reductions:</u>
HC_{Exh} = (14.5658 – 0.5527) x 10,128/454 = 312.61 lb/yr
HC_{Evap} = 14.5 lb/yr
NOx = (1.1784 – 0.8477) x 10,128/454 = 7.38 lb/yr

<u>Annual Weighted Surplus Emission Reductions</u>: (312.61 + 14.5 + 7.38 + 20*(0))/2000
= 0.1672 weighted tons/yr

<u>Project Life:</u> 1 year <u>CRF:</u> 1.00 <u>Total Cost:</u> $1,937

<u>Annualized Cost:</u> 1 x $1,937 = $1,937/yr

<u>Cost Effectiveness:</u> $1,937/0.1672 tons = **$11,585** per weighted ton reduced

Example 5 High Emitter VAVR Projects – Two Speed Idle

An un-tampered 1981 passenger vehicle with exhaust gas recirculation, a 268 cid engine, and a VMT of 6,632 mi/yr is tested by the TSI test on June 2, 2008. The total cost for scrapping was $1,500. As TSI tests do not measure PM and NOx, no NOx emission reductions are included, and default PM emission reductions are assumed. No evaporative emission testing is done, so default evaporative emission reductions are assumed. The following TSI test results were obtained after dilution corrected according to the BAR protocol. TSI pass/fail standards were obtained from Table D-8.

TSI Test	Results	Standards
High Speed Idle HC	650 ppm	120 ppm
High Speed Idle CO	3.0 %	1.5 %
Low Speed Idle HC	2000 ppm	150
Low Speed Idle CO	0.0000 %	1.5 %

TSI test results exceed TSI standards, and the vehicle is a high emitter. Consistent with BAR's TSI protocol, the low speed idle CO value of 0.0000% is replaced by 0.0100 % before using Table D-6 equations to convert TSI readings to an FTP HC_{exh} emission rate. The predicted FTP HC_{Exh} emission rate is 24.7013 g/mi. Note: Using an exel spreadsheet to calculate the AGE term, vehicles "birth" date, 01/01/1981, is subtracted from the TSI test date, 06/02/2008, and divided by 365 before subtracting 9.0570. The retired vehicle's years 2&3 predicted FTP HC emission rate is derived from Table D-8's TSI standard HC_{Exh} emission rate, calculated using Table D-6 equations, and is 3.4275 g/mi.

The fleet average HC emission rate for an unknown replacement vehicle in 2008 is taken from Table D-11 and is:

HC_{Exh} = 0.1417 g/mi

<u>Emission Reductions:</u> (Yr 1) HC_{Exh} = (24.7013 – 0.1417) x 6,632/454 = 358.76 lb/yr

<u>Emission Reductions:</u> (Yr 2 & 3) HC_{Exh} = (3.4275 – 0.1417) x 6,632)/454 = 48.00 lb/yr

<u>Emission Reductions:</u> (Yr 1, 2, & 3)
PM = 1.33 lb/3 yr
HC_{Evap} = 58.9 lb/3 yr

<u>Total Reductions:</u>
HC_{Exh} = 358.76 + 2 x 48.00 = 454.76 lb/3yr
HC_{Evap} = 58.9 lb/3 yr
PM = 1.33 lb/3yr

<u>Annual Weighted Surplus Emission Reductions</u>: (454.76/3 + 58.9/3 + 20*(1.33/3))/2000
= 0.09004 weighted tons/yr

Project Life: 3 years CRF: 0.360 Total Cost: $1,500

Annualized Cost: 0.360 * $1,500 = $540/yr

Cost Effectiveness: $540/0.09004 tons = **$5,997** per weighted ton reduced

Example 6 High Emitter VRV Projects – Two Speed Idle

Using the information in Example 5, evaporative emissions and emission control repairs brought the vehicle into compliance with both the low-pressure evaporative test and the TSI emission standard for hydrocarbon. The total cost to the district for the repair of the vehicle was $637. Default PM and evaporative emission reductions are assumed. The pre-repair TSI test result converted to an emission rate is:

HC_{Exh} = 24.7013 g/mi

Using the conversion equations from Table D-6, the post-repair emission rate is derived from the TSI standard from Table D-8 and is:

HC_{Exh} = 3.4275 g/mi

Emission Reductions:
HC_{Exh} = (24.7013 – 3.4275) x 6,632/454 = 310.77 lb/yr
HC_{Evap} = 14.5 lb/yr

Annual Weighted Surplus Emission Reductions: (310.77 + 14.5)/2000
= 0.1626 weighted tons/yr

Project Life: 1 year CRF: 1.00 Total Cost: $637

Annualized Cost: 1 x $637 = $637/yr

Cost Effectiveness: $637/0.1626 tons = **$3,917** per weighted ton

APPENDIX F

DESCRIPTION OF CERTIFICATION AND VERIFICATION EXECUTIVE ORDERS

APPENDIX F

DESCRIPTION OF CERTIFICATION AND VERIFICATION

I. New Engine Certification

The Air Resources Board (ARB) certifies engines destined for sale in California and provides the engine manufacturers with an Executive Order (EO) for each certified engine family. An example of an EO is shown in Figure F-1. The EO includes general information about the certified engine such as engine family, displacement, horsepower rating(s), intended service class, and emission control systems. It also shows the applicable certification emission standards as well as the average emission levels measured during the actual certification test procedure. For the purpose of the Carl Moyer Program, the certification emission standards are used to calculate emission reductions. The certification emission standards are shown in the row titled "(DIRECT) STD" under the respective "FTP" column headings for each pollutant. For instance, the Cummins 8.3 liter natural gas engine illustrated in Figure F-1 was certified to a combined oxides of nitrogen plus non-methane hydrocarbon (NOx+NMHC) emission standard of 1.8 g/bhp-hr, a carbon monoxide (CO) emission standard of 15.5 g/bhp-hr, and a particulate matter (PM) emission standard of 0.03 g/bhp-hr.

In the case where an EO shows emission values in the rows labeled "AVERAGE STD" and/or "FEL", the engine is certified for participation in an averaging, banking, and trading (AB&T) program. AB&T engines (i.e., all FEL-certified engines) are not eligible to participate in the CMP for new vehicle purchase projects since emission benefits from an engine certified to an FEL level are not surplus emissions.

II. Retrofit System Verification

The ARB's verification procedures provide a way to thoroughly evaluate the emission reduction capabilities and durability of a variety of emission control strategies as part of a retrofit in-use program. It ensures that emission reductions achieved by a control strategy are both real and durable and that production units in the field are achieving emission reductions which are consistent with their verification.

The ARB has a verification procedure for in-use strategies to control emissions from diesel engines (diesel emission control systems or DECS). The verification procedure requires a minimum PM reduction of at least 25 percent. If a diesel emission control strategy also reduces NOx emissions by at least 15 percent, that reduction can also be verified. Emission control strategies for diesel engines are verified based on a tiered verification classification shown in Table F-1 below. It is the responsibility of the diesel emission control strategies manufacturer to provide data to verify emission reduction claims. The ARB issues Executive Orders for verified emission control strategies destined for sale in California. An example of an EO for a retrofit emission control system for diesel engines is shown in Figure F-2.

Figure F-1
Sample Executive Order

ARB Executive Order for Heavy-Duty On-Road Engines

California Environmental Protection Agency AIR RESOURCES BOARD	CUMMINS INC.	EXECUTIVE ORDER A-021-0340 New On-Road Heavy-Duty Engines

Pursuant to the authority vested in the Air Resources Board (ARB) by Health and Safety Code (HSC) Division 26 Part 5, Chapter 2; and pursuant to the authority vested in the undersigned by HSC Sections 39515 and 39516 and Executive Order (EO) G-02-003; and

Pursuant to the December 15, 1998 Settlement Agreement (SA) between ARB and the manufacturer, and any modifications thereof to the Settlement Agreement;

IT IS ORDERED AND RESOLVED: That the engine and emission control systems produced by the manufacturer are certified as described below for use in on-road motor vehicles with a manufacturer's GVWR over 14,000 pounds. Production engines shall be in all material respects the same as those for which certification is granted.

MODEL YEAR	ENGINE FAMILY	ENGINE SIZE (liter)	FUEL TYPE (CNG/LNG=compressed/liquefied natural gas; LPG=liquefied petroleum gas)	STANDARDS & TEST PROCEDURE	INTENDED SERVICE CLASS (L/M/H HDD=light/medium/heavy heavy-duty [HD] diesel; UB=urban bus; HDO=HD Otto)
2003	3CEXH0505CBK	8.3	CNG / LNG	Diesel	UB
SPECIAL FEATURES & EMISSION CONTROL SYSTEMS	ENGINE MODELS / CODES (rated power in horsepower, hp)				
TBI, OC, HO2S, TC, CAC, PCM	CG-280 / 8012 (280 hp), CG-275 / 8009 (275 hp), CG-250 / 8006 (250 hp), CG-250 / 8003 (250 hp)				

GVWR=gross vehicle weight rating TWC/OC=three-way/oxidizing catalyst WU (prefix) =warm-up cat. O2S=oxygen sensor HO2S=heated O2S TBI=throttle body fuel injection MFI=multi port fuel injection SFI=sequentialMFI DDI/IDI=direct /indirect diesel injection TC/SC=turbo/super charger CAC=charge air cooler EGR=exhaust gas recirculation AIR=secondary air injection PAIR=pulsed AIR SPL=smoke puff limiter ECM/PCM=engine /powertrain control module EM=engine modification 2 (prefix)=parallel (2) (suffix)=in series HC=hydrocarbon NMHC=non-methane HC NOx=oxides of nitrogen CO=carbon monoxide PM=particulate matter HCHO=formaldehyde g/bhp-hr=grams per brake horsepower-hour

The following are the exhaust emission standards (STD), or family emission limit(s) (FEL) as applicable, and certification levels (CERT) for this engine family under the "Federal Test Procedure" (FTP) (Title 13, California Code of Regulations, (13 CCR) Section 1956.1 (urban bus) or 1956.8 (other than urban bus)), and under the "Euro III Test Procedure" (EURO) in the Settlement Agreement, including EURO's "Not-to-Exceed" standard(s). "Diesel" CO certification compliance may have been demonstrated pursuant to Code of Federal Regulations, Title 40, Part 86, Subpart A, Section 86.091-23(c)(2)(i) in lieu of testing. (For flexible- and dual-fueled engines, the CERT values in brackets [ ] are those when tested on conventional test fuel. For multi-fueled engines, the STD and CERT values for default operation permitted in 13 CCR Section 1956.1 or 1956.8 are in parentheses.)

			EURO'S NOT-TO-EXCEED STD				NMHC: *		NOx: *		NMHC+NOx: 2.25		PM: 0.0375	
* = not applicable	HC		NMHC		NOx		NMHC+NOx		CO		PM		HCHO	
	FTP	EURO	FTP	EURO	FTP	EURO	FTP	EURO	FTP	EURO	FTP	EURO	FTP	EURO
(DIRECT) STD	*	*	*	*	*	*	1.8	1.8	15.5	15.5	0.03	0.03	*	*
AVERAGE STD	*	*	*	*	*	*	*	*	*	*	*	*	*	*
FEL	*	*	*	*	*	*	*	*	*	*	*	*	*	*
CERT	*	*	*	*	*	*	1.7	1.4	2.0	1.3	0.01	0.005	*	*

BE IT FURTHER RESOLVED: That certification to the FEL(s) listed above, as applicable, is subject to the following terms, limitations and conditions. The FEL(s) is the emission level declared by the manufacturer and serves in lieu of an emission standard for certification purposes in any averaging, banking, or trading (ABT) programs. It will be used for determining compliance of any engine in this family and compliance with such ABT programs.

BE IT FURTHER RESOLVED: That the listed engine models have been certified to the FTP optional NOx, or NMHC+NOx as applicable, and PM emission standard(s) listed above pursuant to 13 CCR Section 1956.1 or 1956.8.

BE IT FURTHER RESOLVED: That for the listed engine models, the manufacturer has submitted the materials to demonstrate certification compliance with 13 CCR Sections 1965 (emission control labels), and 2035 et seq. (emission control warranty).

BE IT FURTHER RESOLVED: That the listed engine models are conditionally certified subject to the following conditions: (**1**) The SA is in effect; (**2**) The manufacturer is in compliance with all applicable California emission regulations, and all SA's applicable requirements and any modifications thereof; (**3**) This EO is void with respect to any engine within this family determined to have a defeat device as that term is defined in the test procedures and SA. Any engine produced under the voided EO remains subject to stipulated penalties under the SA. Such penalties would begin to accrue upon manufacture of the first engine under this EO; (**4**) This EO expires at midnight on December 31, 2002; (**5**) Production of any engine within this family under this EO is acceptance of all conditions in this EO; and (**6**) ARB reserves the right to disapprove certification of this family, or any families using the same or similar auxiliary emission control device (AECD) strategies as this family is employing, based on all available information.

The Bureau of Automotive Repair will be notified by copy of this Executive Order.
Executed at El Monte, California on this 2ND day of October 2002.

Allen Lyons, Chief
Mobile Source Operations Division

Table F-1
Verification Levels for Diesel Emission Control Strategies

Pollutant	Emission Reduction	Classification
PM	< 25%	Not Verified
	≥ 25%	Level 1
	≥ 50%	Level 2
	≥ 85%, or ≤ 0.01 g/bhp-hr	Level 3
NOx	< 15%	Not Verified
	≥ 15%	Verified in 5% Increments

ARB staff also has a retrofit verification procedure for large spark-ignited engines (LSI). This procedure can be used to verify retrofit systems to reduce NOx and HC emissions from LSI engines. Emission control strategies for LSI engines are verified based on a tiered verification classification shown in Table F-2 below.

Table F-2
LSI Emission Control System Verification Levels

Classification	Percentage Reduction (HC+NOx)	Absolute Emissions (HC+NOx)
LSI Level 1 [(1)]	> 25% [(2)]	Not Applicable
LSI Level 2 [(1)]	> 75%[(3)]	3.0 g/bhp-hr [(3)]
LSI Level 3a [(1)]	> 85% [(4)]	0.5, 1.0, 1.5, 2.0, 2.5 g/bhp-hr
LSI Level 3b [(5)]	Not Applicable	0.5, 1.0, 1.5, 2.0 g/bhp-hr

Notes:
(1) Applicable to uncontrolled engines only
(2) The allowed verified emissions reduction is capped at 25% regardless of actual emission test values
(3) The allowed verified reduction for LSI Level 2 is capped at 75% or 3.0 g/bhp-hr regardless of actual emission test values
(4) Verified in 5% increments, applicable to LSI Level 3a classifications only
(5) Applicable to emission-controlled engines only

Figure F-2
Example of an EO for a Retrofit Emission Control System

State of California
AIR RESOURCES BOARD

EXECUTIVE ORDER DE-04-006-05

Pursuant to the authority vested in the Air Resources Board (ARB) by Health and Safety Code, Division 26, Part 5, Chapter 2; and pursuant to the authority vested in the undersigned by Health and Safety Code Section 39515 and 39616 and Executive Order G-02-003;

Relating to Exemptions under Section 27156 of the Vehicle Code, and Verification under Sections 2700 through 2710 of Title 13 of the California Code of Regulations

Johnson Matthey, Inc.
Continuously Regenerating Technology (CRT®) Particulate Filter

ARB has reviewed Johnson Matthey, Inc.'s request for verification of the CRT® Particulate Filter. Based on an evaluation of the data provided, and pursuant to the terms and conditions specified below, the Executive Officer of ARB hereby finds that the CRT® Particulate Filter reduces emissions of diesel particulate matter (PM) consistent with a Level 3 device (greater than or equal to 85 percent reductions) (Title 13 California Code of Regulations (CCR) Sections 2702 (f) and (g) and Section 2708). Accordingly, the Executive Officer determines that the system merits verification and, subject to the terms and conditions specified below, classifies the CRT® Particulate Filter as a Level 3 system, for the applications listed in Table 1 and engine families listed in Attachment 1.

Table 1: Appropriate Applications for the CRT® Particulate Filter

Diesel Emission Control Strategy	Application
CRT® Particulate Filter	All On-Road Applications only

The aforementioned verification is subject to the following terms and conditions:

- The engines are originally manufactured from model year 1994 through 2006 having the engine family numbers listed in Attachment 1.
- The engines do not employ exhaust gas recirculation, except for those engine families specified in Table 2 of Attachment 1.
- The engines are not used in a hybrid (e.g., diesel/electric) configuration.
- The application must have a duty cycle with an average temperature profile greater than 260 degrees Celsius for 40 percent of the operating cycle.
- The engine may or may not have a pre-existing original equipment manufacturer oxidation catalyst.
- The engine must not have a pre-existing diesel particulate filter.

1

- The engine must be certified in California for on-road applications.
- The engine must be certified at a PM emission level of at most 0.1 grams per brake horsepower-hour (g/bhp-hr), and greater than 0.01 g/bhp-hr.
- The engine must be four-stroke.
- The engine must be turbocharged.
- The engine can be mechanically or electronically injected.
- The engine should be well maintained and not consume lubricating oil at a rate greater than that specified by the engine manufacturer.
- Lube oil, or other oil, should not be mixed with the fuel.
- The engine must be operated on:
  - diesel fuel (e.g. not alternative diesel fuels) with a sulfur content of no more than 15 parts per million by weight or
  - B20 defined, based on volume, as a mixture of 20 percent neat biodiesel (B100) that complies with ASTM D6751 and 80 percent diesel (e.g. not alternative diesel fuels) with a sulfur content of no more than 15 parts per million by weight.
- The other terms and conditions specified below.

IT IS ALSO ORDERED AND RESOLVED: That installation of the CRT® Particulate Filter, manufactured by Johnson Matthey, Inc. of 380 Lapp Road, Malvern, Pennsylvania 19355, has been found not to reduce the effectiveness of the applicable vehicle pollution control system, and therefore, the CRT® Particulate Filter is exempt from the prohibitions in Section 27156 of the Vehicle Code for installation on heavy-duty on-road vehicles listed in Attachment 1.

This exemption is only valid provided the engines meet the aforementioned conditions.

The CRT® Particulate Filter basic design is a diesel oxidation catalyst followed by a diesel particulate filter and a backpressure monitor. The major components of the CRT® Particulate Filter are identified in Attachment 2.

This Executive Order is valid provided that installation instructions for the CRT® Particulate Filter do not recommend tuning the vehicle to specifications different from those of the vehicle manufacturer.

Changes made to the design or operating conditions of the CRT® Particulate Filter, as exempted by ARB, which adversely affect the performance of the vehicle's pollution control system, shall invalidate this Executive Order.

No changes are permitted to the device. The ARB must be notified in writing of any changes to any part of the CRT® Particulate Filter. Any changes to the device must be evaluated and approved by ARB. Failure to do so shall invalidate this Executive Order.

Marketing of the CRT® Particulate Filter using identification other than that shown in this Executive Order or for an application other than that listed in this Executive Order shall be prohibited unless prior approval is obtained from ARB.

This Executive Order shall not apply to any CRT® Particulate Filter advertised, offered for sale, sold with, or installed on a motor vehicle prior to or concurrent with transfer to an ultimate purchaser.

As specified in the Diesel Emission Control Strategy Verification Procedure (Title 13 CCR Section 2706 (g)), the ARB assigns each Diesel Emission Control Strategy a family name. The designated family name for the verification as outlined above is: CA/JMI/2001/PM3/N00/ON/DPF01.

Additionally, as stated in the Diesel Emission Control Strategy Verification Procedure, Johnson Matthey, Inc. is responsible for honoring the required warranty (Section 2707) and conducting in-use compliance testing (Section 2709).

In addition to the foregoing, ARB reserves the right in the future to review this Executive Order and the exemption and verification provided herein to assure that the exempted and verified add-on or modified part continues to meet the standards and procedures of CCR, Title 13, Section 2222, et seq and CCR, Title 13, Sections 2700 through 2710.

Systems verified under this Executive Order shall conform to all applicable California emissions regulations.

This Executive Order does not release Johnson Matthey from complying with all other applicable regulations.

Violation of any of the above conditions shall be grounds for revocation of this Executive Order.

Executed at El Monte, California, this 15th day of August 2005.

//s//

Robert H. Cross, Chief
Mobile Source Control Division

Attachment 1: ARB Approved Model Year 1994 to 2006 Engine Families for the CRT® Particulate Filter

Attachment 2: Part Numbers and Model Numbers of the CRT® Particulate Filter and Standard Part Numbers of Backpressure Monitor

Figure F-3
Example of U.S. EPA Certificate of Conformity for a Locomotive Engine Remanufacture Kit

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

2004 Model Year Certificate of Conformity

Manufacturer:	General Motors Electro-Motive Division
Certificate Number:	GMX-LOC-04-03
Effective Date:	DEC 04 2003
Date Issued:	DEC 04 2003

Merrylin Zaw-Mon, Director
Certification and Compliance Division
Office of Transportation and Air Quality

Pursuant to Section 213 of the Clean Air Act (42 U.S.C. section 7547) and 40 CFR 92, and subject to the terms and conditions prescribed in those provisions, this certificate of conformity is hereby issued with respect to the remanufacturing kit which has been found to conform to applicable requirements and which may be utilized with only the following locomotive engines, by engine family, locomotive model, and model year, more fully described in the documentation required by 40 CFR Part 92 and produced in the stated model year.

Locomotive Engine Family (Remanufacturing Kit): 4GMXK0645EAL

Locomotive Models:

SW 1000 W/8-645E	
SW1001W/8-645E	
SW1500,MP15,MP15DC,MP15ACGP15-1, & GP15-2 W/12-645E	
GP38-2 & SD38-2 W1/16-645E	

Locomotive Model Years: 1973 to 1985

The rebuild kit includes:

- FUEL INJECTORS
- OIL SEPARATOR ELEMENT
- LOCOMOTIVE EMISSIONS LABEL AND LAMINATE
- ENGINE EMISSIONS LABEL AND LAMINATE
- INSTALLATION INSTRUCTIONS
- REGISTRATION CARD

In addition, parties who install this remanufacturing kit must also ensure that the base engine contains the following parts, more fully described in the Application for Certification for this kit:

SCAVENGING BLOWER ASSEMBLIES	CYLINDER LINERS	
GOVERNOR	PISTON RING SETS	
PISTONS	CYLINDER HEAD ASSEMBLIES	

This certificate of conformity is conditional upon compliance of said manufacturer with the provisions of 40 CFR Part 92, Subpart D. Failure to comply with these provisions may render this certificate void ab initio.

Figure F-4
Example of U.S. EPA Certificate of Conformity for a New Locomotive Engine

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, DC 20460

2007 Model Year Certificate of Conformity

Manufacturer: Electro-Motive Diesel, Inc.
Certificate Number: EMD-LOC-07-01
Effective Date: AUG 22 2006
Date Issued: AUG 22 2006

Karl J. Simon
Acting Director
Compliance and Innovative Strategies Division

Pursuant to Section 213 of the Clean Air Act (42 U.S.C. section 7547) and 40 CFR 92, and subject to the terms and conditions prescribed in those provisions, this certificate of conformity is hereby issued with respect to the test engine which has been found to conform to applicable requirements and which represents the following locomotive engines, by engine family, more fully described in the documentation required by 40 CFR 92 and produced in the stated model year.

Locomotive Engine Family (New engine): 7EMDG0710ES1

This certificate of conformity covers only those new locomotive engines which conform in all material respects to the design specifications that applied to those engines described in the Application for Certification required by 40 CFR 92 and which are produced during the model year stated on this certificate of the said manufacturer, as defined in 40 CFR 92.

It is a term of this certificate that the manufacturer shall consent to all inspections described in 40 CFR 92.215(d)(1) and 92.504 and authorized in a warrant or court order. Failure to comply with the requirements of such a warrant or court order may lead to revocation or suspension of this certificate for reasons specified in 40 CFR 92. It is also a term of this certificate that this certificate may be revoked or suspended or rendered void ab initio for other reasons specified in 40 CFR 92.

APPENDIX G

MINIMUM REQUIREMENTS FOR ELECTRONIC MONITORING DEVICES

APPENDIX G

MINIMUM REQUIREMENTS FOR ELECTRONIC MONITORING DEVICES

This appendix provides the minimum required specifications for electronic monitoring units (EMU) required to be installed on fleet modernization and locomotive projects. Although not required by the Carl Moyer Program Guidelines, districts may choose to require the installation of an EMU system with each new engine for other source categories.

The full purchase of the EMU (including warranty, data retrieval, compilation, and transmission to the district, and the installation cost) is eligible for Carl Moyer Program funding, and may be included when calculating project cost-effectiveness. The following are minimum specifications for the districts to follow. Districts may allow projects with EMUs installed that meet these minimum specifications to complete all reporting through the electronic data system. A district may require additional specifications and/or more stringent specifications at its discretion.

<u>Minimum Specifications</u>

When is the EMU required to operate?

The EMU must be powered at all times during vehicle/equipment operation. If the EMU is battery powered, the battery life must be long enough to ensure the EMU is charged and functional each time the vehicle/equipment is operated.

What will the EMU track?

The EMU must track the geographic position and either the operated hours or the mileage traveled, or both, of the vehicle/equipment.

All data must be recorded while the vehicle/equipment is in operation. The vehicle/equipment position must be updated upon startup and at least once every 30 minutes during vehicle/equipment operation. The time-to-first-fix should be no longer than five minutes.

How must the EMU store and transmit collected data?

The collected data must be provided to the district on a periodic basis, or, at the discretion of the district, the data may be transmitted directly to the district in real-time. The EMU must include either the capability to automatically transmit the stored data from the vehicle/equipment, or enable downloading of the stored data through a port in the device. If the storage method is used, the EMU must have the capacity to store as much data as is necessary to ensure that data is not over-written prior to any scheduled data retrieval. At the discretion of the district, the stored data may be encrypted, or otherwise protected, and require a password distributed only to the district and ARB.

What data must be recorded?

The EMU must store the time, date, position, elapsed time since last recorded position, elapsed operated hours since last recorded position, and accrued mileage since last recorded position (required for fleet modernization projects). The positional data stored and transmitted must either be accompanied by software which will code raw positional data using the following codes, or directly transmit the positional data pre-coded into these zones;

1. Whether or not the position is in the district boundary (including district coastal boundary for marine projects).
2. Whether or not the position is in California (including its coastal waters).
3. Whether or not the position is outside California (including its coastal waters).
4. Other zones within the district, or other districts in California, may be specified at the discretion of the district.

How often must the collected data be provided to the district?

Periodically (preferably on a monthly basis, but at least quarterly for fleet modernization projects and annually for all other projects), the data must be downloaded and transmitted to the district in an electronic format specified by the district.

What information must be provided to the district?

For each vehicle/equipment the submitted data shall include at least:

- Grant ID number. *(Optional)*
- Vehicle ID, Equipment ID, or Vessel ID.
- Date of download.
- Total accumulated miles and/or hours operated by coded zone described above. All data collected must be reported regardless of whether hours or miles or both were recorded.
- Date and time that any failure or malfunction of the EMU occurred.
- Time periods, if any, that the EMU was not operational.
- Fuel consumption. This is optional, and is not required to be monitored by the EMU. However, liquefied natural gas-diesel and other dual fuel locomotive projects, marine projects, and other fuel based projects are required to monitor and report fuel consumption in their annual reports, as specified in the revised Carl Moyer Guidelines.

How long must the collected data be submitted to the district?

Data collected must be submitted to the district for the lesser of five years or the project life. As noted above, districts may allow projects with EMUs installed to complete all reporting through the electronic data system. For the remainder of the projects life, if any, reporting may continue to be completed through the electronic system, although this is not required. However, reporting must continue to be completed as required in the revised Carl Moyer Guidelines.

How rugged must the EMU be?

The EMU must be tamperproof and be rugged enough to withstand the operating environment of the vehicle/equipment for the expected life of the project, if installed per the manufacturer's instructions.

What are the warranty requirements?

The EMU must have a full repair or equivalent replacement warranty for 5 years. If the project life is less than five years, the warranty may equal the project life. It the project life is longer than 5 years the contract may also contain an option for the participant to extend the warranty beyond the minimum amount (with district approval). This extended warranty may be included when calculating cost-effectiveness for Carl Moyer funding eligibility. The reporting must continue to be completed through the electronic system for the extent of the warranty.

What data must be provided in the event the EMU fails?

The EMU must accurately track vehicle/equipment position and activity during the operation of the vehicle/equipment. If the unit fails to record as described above for a period exceeding 5 percent of the annual reporting period the participant is required to submit as part of the annual report documentation of the vehicle/equipment activity during the missing time period.

Can these minimum specifications be modified by the district?

It will be the responsibility of the district to assure that participants install, operate and report data using the EMU in accordance with these specifications and the requirements contained in the revised Carl Moyer Guidelines. On a case-by-case basis, and with ARB's approval, for projects in which an EMU meeting these specifications is either not available for the vehicle/equipment, or results in additional costs exceeding 10 percent of the project cost (excluding the cost of the EMU), some of these specifications may be modified or deleted, or monitoring and reporting may be allowed using prior ARB approved methods. The district must justify the request for such an exemption, including a demonstration that a reasonable effort (such as an RFP or other means) was made to contract with a supplier for an EMU meeting the minimum specifications.

What about projects in which an EMU is already installed on the vehicle/equipment?

On a case-by-case basis, for projects in which an EMU is already in place on the vehicle/equipment, at the option of the participant and the district, that EMU may be utilized and some of these specifications may be modified or deleted, as approved by ARB. In such cases, it will be the responsibility of the participant to provide information on the specifications of the EMU system and to maintain the EMU system in working condition for the lesser of five years or the project life.

APPENDIX H

BEST PRACTICES
FOR PROGRAM ADMINISTRATION

APPENDIX H

BEST PRACTICES FOR PROGRAM ADMINISTRATION

I. Background

This Appendix complements 'Chapter 2 – Program Administration' by describing voluntary Best Practices that go beyond minimum Carl Moyer Program administrative requirements, and which districts can use to run more effective programs. While ARB encourages districts to include these Best Practices in their local programs where possible, not all Best Practices are equally applicable to all air districts. For example, consolidated post-inspections may not be feasible for a rural district with few projects.

Some of following Best Practices are based on Department of Finance and Bureau of State Audits recommendations provided to ARB as part of their reviews of the Carl Moyer Program. Some were requirements that have been moved from the 2005 Guidelines administration chapter to simplify district administration of the Program and provide greater operational flexibility to the districts. Others are practices being used by air districts to improve their implementation of the Carl Moyer Program. All Best Practices identified in this Addendum have end notes with their source. While the end notes may include information on districts that implement the associated best practice, the end notes are not exhaustive in listing every district that implements every best practice.

II. Responding to ARB's Carl Moyer Program Solicitation

<u>Best Practice #1</u>
Districts that have sufficient demand, may request Carl Moyer Program funds in excess of the tentative allocation for their district, as long as the district has sufficient district funds available to match the State Carl Moyer Program funds being requested.

Thus, if and when funds become available from other districts that are unable to accept and keep their tentative allocation, the districts requesting an excess amount are in a position to accept additional funds.[1]

<u>Best Practice #2</u>
The ARB encourages districts to have the district Board approve a multi-year resolution to accept Carl Moyer Program funding and implement the program consistent with the current Guidelines. Since the Carl Moyer Program is now funded through 2015, a multi-year resolution saves the district from having to draft and pass a new resolution each year.[2]

III. Reporting to ARB

Best Practice #3
Districts that commit and expend their Carl Moyer Program funds early (commit with fully executed contracts before June 30 of the first year, expend before June 30 of the second year) may complete the required annual/final report before the due date (August 31). In addition, if a district has completed the commitment (with fully executed contracts) and expenditure of Carl Moyer Program funds by June 30 of the first year, the district may complete one combined annual/final report.[3]

IV. Fiscal Tracking

Best Practice #4
While districts are required to maintain Carl Moyer Program funds in a way that tracks earned interest, the methods for doing so are left to each district. The ARB encourages districts to maintain a segregated depository account for Carl Moyer Program funds. Such an account will draw interest on only the Carl Moyer funds without the need for district staff to compute earned interest.[4]

V. District Outreach

Best Practice #5
While districts are required to market the Carl Moyer Program to all sectors in their community, the methods for doing so are left to each district. The ARB strongly encourages districts to vigorously outreach to all sectors of the community. Below are brief descriptions of the types of practices that can be included as part of a district's outreach activities.[5]

A. List of Interested Parties

Districts can maintain a list of interested parties throughout the year and mail a notification to the parties on the list when funds are available. This list should also include prior applicants, public agencies (e.g. public works departments, sanitation departments, school districts), engine dealers/distributors, and, where appropriate, port authorities and farm bureaus.

B. Local Newspaper Announcement

Districts can put a notification of funds available in local newspapers, in locally-based trade newsletters, including the local farm bureau, and in the trade journals of organizations representing zero-emission technologies such as the Clean Cities Coalition and WestStart-CALSTART.

C. Notification through District Mediums

If the district has a website, the Carl Moyer Program solicitation can be advertised on the district's website. Similarly, if the district has a newsletter, the Carl Moyer Program solicitation can be advertised in the district's newsletter. And, if the district maintains a 24-hour message line, the solicitation can also be advertised there[6]

D. Prior Participants

Districts can solicit additional projects from prior participants with successfully implemented projects, especially during monitoring visits.

E. Small Business

Districts can expand the participation of small business by advertising to targeted industries, offering workshops to the engine dealer network, and offering to assist small business owners with the completion of the application. For example, many urban districts have found the construction industry to be a viable source of projects, when the districts provide outreach, training and technical assistance to the many small businesses that own qualifying equipment.

F. Agricultural Community

Districts with agricultural communities can contact the local agricultural department and request that a flyer be posted that will be visible to farmers when they come in to get their pesticide use permits.

G. Public Presentations

Districts can distribute a brochure or other informational hand-out at events and industry workshops attended.

H. Advertising

Districts can require their grantees to place a logo or decal on the new engine(s) advertising that the engine was funded by the district and ARB with Carl Moyer Program funds.

Best Practice #6

While the ARB strongly encourages districts to outreach to all sectors of their community to increase and improve the applicant pool, districts are also encouraged to develop and implement techniques to measure the effectiveness of their outreach activities.[6]

A. Districts can identify business sectors from which they will obtain applications for more cost-effective projects, evaluate whether their current outreach efforts are reaching those sectors, implement outreach activities to target sectors not being reached, and assess whether their outreach efforts enable them to select projects with more cost effective emission reductions.

B. Districts may conduct incentive program surveys to identify how applicants/participants heard about the incentive programs.

VI. District Applications for Projects

It is not possible for districts to implement both best practices 7 and 8. Each district must assess their implementation of the Carl Moyer Program and decide which (if either) of these practices best suits their district.

Best Practice #7

For consistency throughout the Carl Moyer Program, to assist applicants statewide and to limit confusion, ARB encourages districts to use the same application form for the Carl Moyer Program. The application is available on the Carl Moyer Program web site at http://www.arb.ca.gov/msprog/moyer/admin_forms/admin.htm.[7]

Best Practice #8

When districts operate more then one incentive program, districts may use one application form for all of the incentive programs. This streamlines and simplifies the application process for potential applicants.[8]

VII. Tracking

Districts have a number of best practices for tracking applications, proposed projects and the status of funded projects. The following best practices (numbers 9, 10 and 11) can be used separately or all in conjunction with each other.

Best Practice #9

Districts may use a contract signature tracking sheet which follows the contract from initiation through signing and filing. The tracking sheet may list each staff person (i.e. the APCO, the Administrative Analyst, the Contracts and Records Management Coordinator and the Carl Moyer Program Manager) who must review and approve the contract, and includes spaces for initials and date of review.[9]

Best Practice #10
The ARB encourages districts to maintain a hard copy or electronic contract log of all district contracts that tracks the status and location of each contract. An electronic contract log has the advantage of being accessible to all district staff.[10]

Best Practice #11
The ARB strongly encourages districts to maintain a checklist in their project folders to make sure all of the appropriate documentation is there. The check list may define where the specific documentation may be found in the folder or in electronic files. The ARB encourages districts to have another staff member (project manager and field inspector) cross check these folders to verify that the folder is complete. Such a checklist makes it easier for staff (current and new) and auditors to know project status and where documentation may be found.[11]

VIII. Environmental Justice

Environmental Justice refers to the requirement (HSC section 43023.5) that districts, with a population of over one million residents, distribute Program funds in a manner that directly benefits low-income communities and/or communities of color that are disproportionately impacted by air pollution. The Program requirements for environmental justice may be found at section 28(m) of the administration chapter of these Guidelines. Districts may enhance environmental justice implementation using best practices 12 through 16.

Best Practice #12
The ARB encourages districts with a population of less than one million inhabitants to incorporate an environmental justice component in their local Carl Moyer Program. [12]

Best Practice #13
The ARB encourages districts to periodically reassess their environmental justice policies and procedures, particularly their definition of environmental justice areas.[13]

Best Practice #14
To target communities with greater exposure to air pollutants, districts may include a measure of pollution (i.e. level of particulate matter in the community) or the effects of pollution (i.e. cancer hot spots) in the districts' approach for identifying disproportionately impacted communities.[14]

Best Practice #15
To maximize emission reductions in districts that competitively rate and rank their applications, districts may include a measure of the cost per ton of emission reductions when selecting projects in disproportionately impacted communities.[15]

Best Practice #16

To ensure funds from the environmental justice set-aside continue to benefit disproportionately impacted communities, districts may include a contract requirement that the projects selected from disproportionately-impacted areas continue to provide benefits from reduced emissions to those communities through the end of the project life.[16]

IX. Project Selection

Best Practice #17

To expand the applicant pool and provide an opportunity for engine owners that operate in more than one district, the ARB encourages districts to refrain from setting a minimum percent operation in the district and to jointly fund inter-district projects.[17]

Best Practice #18

To ensure the district is not providing a grant to a company that has outstanding permit violations, districts may check their Program applications against their list of companies that have a notice of violation with the district. Using this practice, one district was able to get a potential grantee to pay the outstanding fine.[18]

Best Practice #19

To expand the applicant pool to include more small businesses and to capture the emission reductions from an otherwise under-represented group, districts may provide a preference (in the form of scoring or as a set-aside) for small businesses.[19] For the purpose of this best practice a small business might be defined as in the following examples:

- An owner-operated business for the on-road and marine categories
- The same as in the applicable fleet rule (if any). For example, in ARB's Off-Road Fleet Rule a small business is defined as one with total fleet horsepower less than or equal to 2500 horsepower.
- A Class 3 railroad for the locomotive category.

Best Practice #20

To assist districts in their determination of credible and/or good faith applications, districts may refer to the Carl Moyer Program Status Report which contains category specific averages for costs, usage, etc. It can be found at http://www.arb.ca.gov/msprog/moyer/status/status.htm. Districts may also refer to their own or neighboring districts' averages from past projects.[20]

X. Commitment of Funds to Projects

Best Practice #21
ARB strongly encourages districts to commit funds to projects and fully execute contracts as soon as possible, prior to the June 30th deadline. This allows more time for completing projects. This may also allow for projects to be completed before the deadline, thus maximizing the ability to gain early emissions reductions.[21]

Best Practice #22
To reduce the administrative burden resulting from multiple contracts for one project owner with more than one funded engine/vehicle/piece of equipment, districts may use one contract per project owner.[22]

Best Practice #23
To more easily track the progress of Carl Moyer funded projects and provide the ability of the district to take appropriate action if a project veers off track, the ARB encourages districts to include detailed project milestones in contracts.[23]

Best Practice #24
To help districts ensure that they have sufficient time to perform the required post inspections and pay project owners before the two-year availability of Program funds expires, ARB strongly encourages districts to require projects to be completed before the statutory limit for expending the funds. Districts have had good results with requiring completion of projects within six to twelve months of contract execution.[24]

Best Practice #25
The ARB encourages districts to obtain delegated authority from their governing boards to approve Carl Moyer Program projects and execute contracts. As an alternative for district governing boards that prefer to maintain approval authority over higher-risk projects, districts are encouraged to obtain delegated authority to approve more routine projects or projects costing less then a certain amount. This allows districts to commit funds to projects expeditiously, providing more time for project implementation. [25]

Best Practice #26
For districts where the governing board desires retaining approval of contracts, district staff may invite the engine owners to attend the governing board meeting and have the board representative and engine owners execute the contracts as part of or right after the board meeting. This expedites the execution process and provides a positive forum for the governing board.[26]

Best Practice #27
Districts can require engine owners to attend an informational training prior to signing their contracts. This ensures the engine owners understand their

contractual obligations and may be used as an efficient process for the districts to get contracts fully executed and distributed.[27]

Best Practice #28
To ensure contracts are fully executed in a timely fashion, the ARB encourages districts to include a term that cancels the contract if it is not executed by the engine owner in a specified time frame (e. g. 30 days). [28]

Best Practice #29
For all categories where insurance is not otherwise required, districts may include insurance requirements that would cover the cost of the engine, equipment, and/or vehicle. This reduces the risk of emission reductions being lost if projects are destroyed.[29]

XI. Inspections

Best Practice #30
To make the administration of the program more efficient and effective, districts may conduct consolidated inspections whenever practicable. For example, a district may perform multiple inspections at the same site on the same day.[30]

XII. Engine Destruction

Best Practice #31
To ensure old engines are not reintroduced into the California market, they must be destroyed in a way that renders them useless.[31] Therefore, ARB recommends districts use one of the following methods of rendering the engine useless:

A. With a blow torch heat up the part of the engine to be broken. Break a 5-inch jagged-edged hole in the engine with a sledge hammer. The hole should catch a water jacket or oil galley. Alternatively, take off the oil pan and break the hole right above the oil pan lip or rail.

B. Using a plasma (or an oxy-acetylene) torch, cut a hole of at least four inches in diameter over at least one crank shaft journal sufficient to destroy the crank bearing and mount. To prevent the reuse of the engine heads, using the same torch, cut a line to a depth of ¼ to ½ inch around the entire accessible mating surface between the engine block and each head.

XIII. Project Owner Reporting

Best Practice #32
To better track the progress of projects, districts may require progress reports during the project completion phase of the contract.[32]

Best Practice #33
To increase engine owners' responsiveness to reporting requirements, districts may withhold payments of a small, set proportion (five or ten percent) of the contract amount until the project owner satisfactorily submits all required progress and annual reports.[33]

Best Practice #34
To minimize the information required from engine owners and make the format for annual reporting simple and convenient, districts may use the sample forms provided on the Carl Moyer Program website at http://www.arb.ca.gov/msprog/moyer/moyer.htm. In addition, ARB encourages districts to make the reporting forms and timetables for reporting part of their contracts.[34]

XIV. District Responses to Non Performing Projects

The administrative chapter requires districts to work with nonperforming grantees to ensure Program requirements are met and emission reductions are achieved. The chapter also requires districts to make all reasonable efforts to recoup Program funds from nonperforming grantees to ensure funded emission reductions are achieved. Best practices 35 and 36 relate to those requirements.

Best Practice #35
In the event a project is not meeting the terms of a contract, a district can use the following best practices for maintaining the agreement and obtaining the emission reductions.[35] Please note that each best practice is based on particular conditions.

A. If an applicant sells an engine or vehicle during the project completion term, the district can execute a new (novation) agreement with the new owner. The agreement should incorporate the original agreement (with a copy), so the new owner is fully informed and the State's interest is protected. A sample novation agreement is posted on the ARB Carl Moyer Program website at http://www.arb.ca.gov/msprog/moyer....

B. If an applicant's usage is below the amount listed in the application/contract, the district can extend the term of the contract to capture the required usage. This practice may be used only if the emission reductions, during the extended term, are surplus to any regulatory requirement.

<u>Best Practice #36</u>
In the rare event that the district is unable to secure the emission reductions through the means listed in best practice # 35 (above), section 36(b) of the administration chapter of these Guidelines requires districts to make all reasonable efforts to recoup the funds. In doing so, the ARB strongly encourages districts to follow a progressive course of action, devised in consultation with their legal counsel. Districts should document the course of action and results in the project file. A progressive course of action may include, but is not limited to, the following steps:[36]

A. Program staff attempts to negotiate an appropriate resolution with the engine owner.

B. Legal counsel writes the engine owner a letter demanding repayment of the funds or some other suitable resolution.

C. The district takes legal action against the engine owner for noncompliance, especially if fraud or malfeasance is involved. If a district plans to take legal action against an engine owner, the district should inform ARB. This information is especially important if fraud or malfeasance is involved.

XV. Transparency of the Program

<u>Best Practice #37</u>
To provide the public with information on the Carl Moyer Program in each district, ARB strongly encourages districts to report annually to their governing board and to post the annual report on the district's website. Such a report should include the following topic areas:[37]

A. Total applications received for current year's funds

B. Efforts and results of outreach to potential environmental justice, and small business project owners

C. A list of the funded projects

D. The status of the commitment and expenditure of the current year's funds

E. The status of the commitment and expenditure of previous years' funds

F. District monitoring and auditing efforts and results, including any audits completed by independent third parties

G. The status of emissions reductions by projects in the implementation phase of their contracts, including reasons for and solutions to shortfalls for projects that do not perform as projected

H. Outstanding features and accomplishments of the district

I. Challenges for the district in implementing the Carl Moyer Program

J. The district's policies and procedures

XVI. Forms and Formats

Best Practice #38

Several districts have been recognized for having model forms and formats that other districts may want to use. These forms and formats have been made electronically available on the Carl Moyer Program webpage at http://arb.ca.gov/. These forms and formats include, but are not limited to, the following:

- An incomplete application notification letter
- A sample notification of award letter
- A pre- and post-inspection form
- A Novation of Agreement

Before using any of the posted forms or formats the district should be contacted to check for updated forms and formats that may have not been posted.

[1] Recommendation from the Administration Chapter of the 2005 Carl Moyer Program Guidelines
[2] Sacramento Metropolitan Air Quality Management District practice
[3] Recommendation from the Administration Chapter of the 2005 Carl Moyer Program Guidelines
[4] Butte County Air Quality Management District and Glenn County Air Quality Management District practice
[5] Department of Finance audit recommendation and Health and Safety Code section 44290; 5a-common practice among districts: 5b-trade journals San Luis Obispo Air Pollution Control District practice & Farm Bureau Newsletter Monterey Bay Air Pollution Control District practice; 5c-common practice in districts' newsletters & solicitation on 24-hour message line San Joaquin Valley Air Pollution Control District practice; 5d-common practice among districts; 5e-workshops with engine dealers San Joaquin Valley Air Pollution Control District practice & outreach, training and technical assistance to construction industry Sacramento Metropolitan Air Quality Management District practice; 5f-common practice among districts; 5g-San Joaquin Valley Air Pollution Control District practice; and, 5-h- Sacramento Metropolitan Air Quality Management District and Ventura County Air Pollution Control District (for boats) practice

[6] Bureau of State Audits audit recommendation; 6A- Bureau of State Audits audit recommendation; and, 6B- Sacramento Metropolitan Air Quality Management District practice

[7] Department of Finance audit recommendation

[8] Bureau of State Audits audit recommendation

[9] Butte County Air Quality Management District, San Joaquin Valley Unified Air Pollution Control District and Santa Barbara Air Pollution Control District practice

[10] Butte County Air Quality Management District and San Joaquin Valley Unified Air Pollution Control District practices

[11] Sacramento Metropolitan Air Quality Management District and San Joaquin Valley Unified Air Pollution Control District practice

[12] Recommendation from the Administration Chapter of the 2005 Carl Moyer Program Guidelines

[13] Bureau of State Audits audit recommendation and South Coast Air Quality Management District practice

[14] Bureau of State Audits audit recommendation and Bay Area Air Quality Management District and South Coast Air Quality Management District practice

[15] Bureau of State Audits audit recommendation and South Coast Air Quality Management District practice

[16] Bureau of State Audits audit recommendation and Bay Area Air Quality Management District practice

[17] Bureau of State Audits audit recommendation

[18] Sacramento Metropolitan Air Quality Management District practice

[19] Recommendation from the Administration Chapter of the 2005 Carl Moyer Program Guidelines

[20] San Joaquin Valley Unified Air Pollution Control District practice

[21] South Coast Air Quality Management District practice and Bureau of State Audits audit recommendation

[22] Bureau of State Audits audit recommendation

[23] Bureau of State Audits audit recommendation and Bay Area Air Quality Management District practice

[24] Bureau of State Audits audit recommendation and Bay Area Air Quality Management District practice

[25] Bureau of State Audits audit recommendation

[26] Ventura County Air Pollution Control District practice

[27] South Coast Air Quality Management District practice

[28] Recommendation from the Administration Chapter of the 2005 Carl Moyer Program Guidelines

[29] Requirement from the Administration Chapter of the 2005 Carl Moyer Program Guidelines, which has been reduced to a Best Practice based on cost benefit analysis for particular source categories (i.e. marine and ag pumps)

[30] Bureau of State Audits audit recommendation

[31] Requirement from the Administration Chapter of the 2005 and 2008 Carl Moyer Program Guidelines 31a- San Joaquin Valley Unified Air Pollution Control District practice

[32] South Coast Air Quality Management District and Ventura County Air Pollution Control District practice

[33] South Coast Air Quality Management District practice

[34] Department of Finance audit recommendation

[35] To fulfill this requirement of the Administration Chapter of the 2008 Carl Moyer Program Guidelines 35a-a common practice for districts though the posted novation agreement is from San Joaquin Valley Air Pollution Control District; and 35b- common practice among districts

[36] To fulfill this requirement of the Administration Chapter of the 2008 Carl Moyer Program Guidelines 36b- San Luis Obispo Air Pollution Control District's staff worked with a non-Moyer grantee when his vessel's mooring released during a storm, ran aground and was destroyed. The engine that was submerged in sea water was overhauled and the grantee agreed to use the engine to replace an old engine in a different vessel. Even though the district had good results with this negotiated settlement, the district has since strengthened their contract language to provide more contractual rather than negotiated resolutions.

[37] Recommendation from the Administration Chapter of the 2005 Carl Moyer Program Guidelines