Practice Specification
Combustion System Improvement (Code 372)
Reciprocating Internal Combustion Engines

I. SCOPE

Real emission reductions are achieved when removing and permanently destroying old, high-polluting internal combustion engines and replacing with new, cleaner technologies. Retiring high-polluting engines earlier than through normal attrition assists agricultural producers with reducing oxides of nitrogen (NOx) and volatile organic compounds (VOC) [ozone precursors] and particulate matter [PM = respirable (PM10) and fine (PM2.5) particulate] emissions from the engines they operate.

Existing engines must be fully functional, operational, in-use agricultural engines that will be permanently destroyed soon after being replaced. Included are stationary, portable, auxiliary, and mobile off-road agricultural engines.

II. GENERAL

Depending on their use, agricultural engines operate at different times through the year. Irrigation engines are typically seasonal sources of emissions because the majority operate during the primary crop growing season in the spring and summer months of the year when irrigation is needed. A variety of mobile off-road agricultural engines may only operate during specific times of the year, such as during the harvest season. However, some engines that drive tractors or loaders may operate routinely all year round.

Periods of high utilization often coincides with the summer ozone season, underscoring the need to reduce NOx and VOC emissions. PM emissions may also be a seasonal issue, especially during the fall and winter months under stable metrological conditions. In general, PM is a year-round challenge as, for example, the California Air Resources Board (ARB) has identified diesel particulate exhaust as a toxic air contaminant and a carcinogenic. Replacing old diesel engines with new Tier-certified diesel engines or with engines utilizing other fuel types (i.e. natural gas, liquid petroleum gas, biogas, or renewable diesel) can substantially reduce emissions. Replacing engines with electric motors will eliminate emissions at the source.

The widespread use of new, lower-polluting engines and electric motors will assist with attaining or maintaining federal and state ambient air quality standards thereby providing significant air quality improvements in California.

III. CRITERA

An existing in-use engine must have been owned and operated in California by the producer for at least 24 consecutive months (two years) prior to commencing conservation plan development or the date of a contract application.

The engine and associated components are fully functional, in operational condition, and can start-up and power the component or equipment it is intended to operate.

Existing in-use mobile off-road agricultural equipment shall meet the following criteria:

- The tires are in good, usable condition (holds air, has sufficient tread, etc.).
- The battery is charged to start-up the engine.
- The engine self-propels the vehicle forwards and backwards.
- Buckets, blades, hydraulics, rollers, etc. are in good working order.
- Undercarriage is structurally sound.
- Fuel tank is in usable condition with no leaks.
- All parts and components are intact. No parts have been stripped.
- Equipment has not been vandalized.

Existing in-use spark-ignition engines may not be replaced with new compression-ignition engines.

Any installation of exhaust after-treatment devices must conform to the most current ARB-verified standards and be operated and maintained according to manufacturer's recommendations.

A replacement engine (including replacement mobile off-road agricultural equipment powered by an engine that self-propels the vehicle) is in new condition, has not been previously sold or associated with any rental or lease agreement, and has less than 500 operating hours recorded on a permanently mounted non-resettable hour meter.

The new replacement engine must be equipped with a non-resettable, operational time meter. The meter must be functional over the 10-year practice lifespan. The producer is responsible for repairing or replacing the time meter should it fail for any reason over the practice life.

The new engine powers equipment that serves the same function and performs equivalent work to the equipment being replaced (like-for-like, such as replacing an old tractor with a new tractor, an old irrigation engine with a new irrigation engine or electric motor, an old loader with a new loader, etc.). Replacements are intended to reduce emissions of air pollution and not for any production related purpose.

- Replacing an in-use mobile agricultural equipment due to a commodity change is a production related purpose, unless the producer can demonstrate that the in-use equipment would otherwise continue operations regardless of the commodity change.
- Replacing an in-use tracked tractor with a new-wheeled tractor is a "like-for-like" proposal if the new-wheeled tractor will replace the service and perform equivalent work as the in-use tracked tractor, and vice versa.

The rated horsepower is the manufacturer's advertised brake-horsepower (bhp) rating. For CPS 372 purposes, brake horsepower is equivalent to gross horsepower. Any aftermarket device for boosting horsepower are not included with the horsepower rating determination.

- For stationary, portable, transportable, or auxiliary engines, apply the manufacturer's horsepower rating of the engine. This may be determined by engine model specifications, power rating from an engine label, or other verifiable literature or publication.
- For mobile off-road agricultural equipment, apply the manufacturer's horsepower rating of the vehicle or equipment. If not available, apply the advertised engine horsepower rating to the in-use and new vehicles or equipment.

If rated horsepower information is not available for an in-use engine or equipment, estimate the gross engine horsepower by applying either of the lowest value of the following:

- Multiply the advertised Power Take-Off (PTO) horsepower by a factor of 1.20, if equipped with a PTO; or,
- Multiply the net horsepower by a factor of 1.087.

The new replacement engine horsepower rating is within 125 percent of the existing in-use engine original manufacturer rated horsepower. Case-by-case exceptions include:

- The manufacturer's horsepower rating is not available for the existing in-use engine; or,
- Diesel-powered off-road mobile equipment where an additional five (5.0) brake horsepower above the 125 percent limit may be applied if the producer can demonstrate that no new "like" equipment is manufactured or available within the in-use equipment horsepower range. To ensure the greatest emissions reductions possible, the new diesel engine is certified at Tier 4-Final and not associated with any Family Emissions Limit (FEL) that exceeds any pollutant standard value (STD), according to the applicable ARB Executive Order. This exception does not apply to stationary, portable, transportable, or auxiliary engines.

For in-use pumping plants, CPS 372 may apply towards repowering stationary in-use engines to new engines or electric motors. Any improvements to the pumping plant must adhere to CPS 533- Pumping Plant criteria and specifications. An engineering analysis may be required.

Fuels consumed by the new engine, whether petroleum-based, renewable, or blends of petroleum-based and renewable fuels must conform to new engine warranties and shall meet any applicable air quality standard and specification.

CPS 372 practice lifespan is 10 years. The manufacturers specify on ARB Executive Orders the expected useful life for emissions-certified engines listed under an EPA Engine Family Name designation, which for most engine families the useful life is reported as 8,000 hours (5,000 or 3,000 hours for smaller horsepower engines).

IV. EMISSION STANDARDS

Any new replacement engine and emission control system must result in at least a 30 percent NOx reduction and no increase in particulate matter emissions compared with the applicable standards or emission levels for the existing in-use engine.

The new replacement engine and emission control systems must meet the most recent California emission standards (e.g. current Tier certification for diesel engines). Certified emission standards and Tier-level determinations are by ARB Executive Order (or EPA Certificate of Conformity for federally preempted engines) based on the EPA Engine Family Name designation.

ARB Executive Orders are accessible on-line at: http://www.arb.ca.gov/msprog/offroad/cert/cert.php

EPA Annual Certification Data: https://www.epa.gov/compliance-and-fuel-economy-data/annual-certification-data-vehicles-engines-and-equipment

New compression-ignition (diesel) engines and emissions control systems certified to a Family Emissions Limit (FEL) declared by the manufacturer for use in any averaging, banking, or trading program as specified on an ARB Executive Order and/or EPA Certificate of Conformity shall not exceed any Tier 3 emission standard (STD) (Tier 2 emission standard for diesel engines rated less than 50 horsepower or greater than 750 horsepower).

- For Interim-Tier 4 or Tier 4-Final diesel engines certified to FEL values that are equal to or less than the applicable emission standard value (STD), the appropriate Interim Tier 4 (Interim-Tier 4, Tier 4 Phase-Out, Tier 4 Phase-in/Alternate NOx) or Tier 4-Final emission factors shall be used for calculating the emissions and emission reductions.
- For Interim-Tier 4 or Tier 4-Final diesel engines certified to FEL values that exceed any applicable emission standard value (STD), the appropriate emission factors for calculating emissions and emission reductions shall be equivalent to the Tier 3 emission factors (Tier 2 for engines less than 50 horsepower or greater than 750 horsepower).

New off-road mobile equipment manufactured under the California flexibility program provisions and listed under an ARB Executive Order may be installed as replacement equipment if the diesel engine and emission control systems meet Tier 3 or cleaner certification (Tier 2 or cleaner certification for diesel engines rated less than 50 horsepower or greater than 750 horsepower).

The ARB establishes emission standards and requirements that regulate the sale, purchase, rental, lease, and operation of diesel engines, including stationary and portable equipment used exclusively in agriculture. In addition, a local air quality authority may impose emission standards through a rule or require permits with emission limits that may be more restrictive than required by the ARB and may require emissions source testing.

ARB-certified independent contractors conduct the source tests using accepted testing protocols approved by the applicable air quality authority. A list of ARB-certified independent contractors is maintained and posted on-line at: https://ww2.arb.ca.gov/our-work/programs/independent-contractor-program.

V. EMISSIONS CALCULATIONS

Emissions reductions are determined by subtracting the calculated emissions of the new engine from the baseline emissions calculated for the existing in-use engines. At a minimum, emission calculations require the following data for both the existing in-use and the new replacement engine:

- Engine Model Year
- Engine Rated Brake Horsepower
- Type of equipment the engine powers (to determine the load factor)
- Annual hours the existing in-use engine operates and the annual hours the new engine operates
- Annual fuel usage data is also useful to calculate emissions. Fuel usage data must be specific to the subject engine and not representing the producer's fleet.
- Applicable emission factors. If emissions data from an approved source test is not available for the specific engine, the emission factors described in these Specifications or in the ARB Carl Moyer Program Guidelines, Appendix C and D shall be used as default values.

The methodology primarily used for estimating annual emissions is based on hours of operation (tons of emissions/year). Other methods as described in the ARB Carl Moyer Program Guidelines, Appendix C and D may be used to estimate emissions and emissions reductions. For ranking purposes, estimate annual emissions based on hours of operation for each pollutant (tons/year):

$$AE = (EF \times LF \times HP \times HR) / 907{,}200$$

AE: Annual Emissions (hours/year)

EF: Emission Factor of the specific pollutant (grams/brake-horsepower)

LF: Equipment Load Factor

HP: Rated Horsepower

HR: Hours of Operation/year

907,200: Units conversion (grams/ton)

Estimate annual emission reductions for each pollutant (tons/year):

$$AER = AE_{Existing} - AE_{New}$$

AER: Annual Emission Reductions

Emission reductions from replacing two existing off-road mobile equipment for one new off-road mobile equipment are determined by subtracting the calculated emissions of the new engine from the baseline sum calculated of the two existing engines.

The new engine powers equipment that serves the same function and performs equivalent work as each of the two engines and equipment being replaced (e.g. replace two old tractors for one new tractor). The new replacement engine horsepower rating is within 125% of either one of the two existing engine original manufacturer's rated horsepower.

Estimate emission reductions for replacing two engines powering similar equipment with one new engine powering similar equipment for each pollutant (tons/year):

$$AER = (AE_{Existing1} + AE_{Existing2}) - AE_{New}$$

VI. DESTRUCTION AND DISPOSAL OF REPLACED ENGINES AND MOBILE OFF-ROAD AGRICULTURAL EQUIPMENT

After being replaced, the existing engine and equipment shall be destroyed. Destruction removes the existing high-emitting engines and equipment from service and ensures that the emission reductions are real and permanent. It also prevents the old engine and equipment from being rebuilt or moved into another locale to continue emitting high levels of air pollutants.

Under certain circumstances, an in-use Tier-certified diesel engine may be relocated and used to replace an uncontrolled (Tier 0) diesel engine. The Tier 0 engine must then be destroyed.

Engine and equipment destruction shall be performed in a safe manner that avoids any personal injury risks.

Properly dispose the in-use engine and associated components and equipment at a dismantler facility within California and approved by the NRCS. An approved dismantler facility can scrap the engine and equipment by shearing, cutting, crushing, or shredding.

No parts may be recycled. However, the producer may request an exception for the following components:

- Wheels and Tires (not tracks)
- Enclosed cabs
- Vehicle weights
- Loader buckets
- Bins from bin carriers

The producer must drain liquids from the in-use engine, components and equipment prior to destroying the equipment, which includes fuel, hydraulic oil, motor oil, and antifreeze. The producer is responsible for ensuring these liquids are properly handled and safely disposed.

The producer shall provide the NRCS with a written certification that the engine and associated equipment has been permanently destroyed and properly disposed. The dismantler will provide the producer with the written certification for submittal to the NRCS. The certification shall describe the following:

- The existing engine and equipment type,
- The existing engine serial number and equipment vehicle identification number,
- The date the existing engine and equipment were compromised,
- How the existing engine and equipment were destroyed,
- Specify that no parts or components were or will be parted-out, used or sold as parts, or used to rebuild an engine or equipment.
- Provide date-stamped photographs.

VII. CREDITABLE EMISSION REDUCTIONS FOR STATE IMPLEMENTATION PLANS

To help meet Clean Air Act objectives, emission reductions achieved through voluntary measures have the potential of becoming creditable toward meeting attainment goals under a State Implementation Plan (SIP). NRCS is committed to applying emission reductions achieved from replacing in-use off-road mobile engines and equipment towards a SIP. To be SIP creditable, emission reductions must be “surplus, quantifiable, enforceable, and permanent”. SIP creditable emission reductions must not be required by any air quality rule, regulation, or other local mandate; and not used as marketable credits or to offset any emission banking or trading program. The SIP creditability determination is made by the air quality authority responsible for implementing the SIP and the US Environmental Protection Agency.

VIII. PERFORMANCE, OPERATION AND MAINTENANCE

The producer will provide NRCS with the appropriate documents verifying ownership and operational use of the existing in-use engine and equipment over the minimum 24-consecutive month period. At least one document specific to the existing in-use engine and equipment includes, but is not limited to the following:

- Bill of Sale, such as an invoice from a dealership or auction with the transaction date
- Insurance records
- Bank appraisal
- General ledgers
- Fuel records
- Other documentation approved by NRCS on a case-by-case basis.

The producer must also provide at least one of the following documents reporting the operational status of the specific existing in-use engine and equipment over the minimum 24-month period to substantiate the baseline hours. This includes, but is not limited to:

- Maintenance or service records
- Usage records that report operation, stand-by, and down hours
- Routine inspections documenting the engine and equipment operational condition
- Hour meter reading log collected at least once per year from an installed and fully functional hour meter
- Historical fuel usage logs, purchase receipts or ledger entries
- Other documentation approved by NRCS on a case-by-case basis.

The producer must provide accurate and concise information to the satisfaction of NRCS to ensure ownership and use. Maintenance, service records, fuel logs, and usage logs must clearly support the subject engine and equipment usage for at least 24-months of operation. For example, a single document dated two months ago does not support 24 months or more of operation.

Producers are to maintain records of new engine and equipment usage over the ten years of operation. At a minimum, producers shall record the annual hours of operation based on the reading from the non-resettable time meter and the percent of time the new engine was used within a pertinent air district, air basin, or air quality planning area.

Records for other operating parameters may include gallons of fuel or kilowatts consumed (if electric) annually over the practice lifespan. Records should also record routine maintenance performed on the engine and equipment. The objective is to determine engine usage and the resulting emissions in comparison with the baseline emissions.

For San Joaquin Valley producers or others intended to generate SIP credit, the producer's recorded information gathered from the non-resettable hour meter shall be submitted annually to the NRCS. The report shall include the total hour meter reading, hours of operations over the calendar year, and the percent usage within the San Joaquin Valley or other Clean Air Act non-attainment area over the calendar year.

REFERENCES

Air Resources Board, Carl Moyer Program Guidelines, http://www.arb.ca.gov/msprog/moyer/guidelines/current.htm

Air Resources Board, Off-Road Engine Certification Database, www.arb.ca.gov/msprog/offroad/cert/cert.php

Air Resources Board, Verified Diesel Emission Control Strategies, www.arb.ca.gov/diesel/verdev/vt/cvt.htm

Air Resources Board, Independent Contractors Approved under Section 91207, Title 17, CCR, https://ww2.arb.ca.gov/our-work/programs/independent-contractor-program

San Joaquin Valley Air Pollution Control District, Grants and Incentives, Ag Pump Replacement, Off-Road Replacement, and Tractor Replacement Program, http://www.valleyair.org/grants/

San Joaquin Valley Air Pollution Control District, Rule 9610-State Implementation Plan Credit for Emission Reductions Generated through Incentive Programs, adopted June 20, 2013

US EPA, Annual Certification Data for Vehicles, Engines, and Equipment, https://www.epa.gov/compliance-and-fuel-economy-data/annual-certification-data-vehicles-engines-and-equipment

US EPA, EPA Emission Standards for Nonroad Engines and Vehicles, https://www.epa.gov/emission-standards-reference-guide/epa-emission-standards-nonroad-engines-and-vehicles

US EPA, "Incorporating Emerging and Voluntary Measures in a State Implementation Plan (SIP)", September 2004, https://www.epa.gov/technical-air-pollution-resources

US EPA and USDA NRCS, "Implementation Principles for Addressing Agriculture Equipment under the Clean Air Act", July 2012

US EPA-Region 9, Air Resources Board, San Joaquin Valley APCD and USDA NRCS; “Statement of Principles Regarding the Approach to State Implementation Plan Creditability of Agricultural Equipment Replacement Incentive Programs Implemented by the USDA Natural Resources Conservation Service and the San Joaquin Valley Air Pollution Control District”; December 2010

US EPA-Region 9, Air Resources Board, San Joaquin Valley APCD and USDA NRCS; “Addendum to the December 2010 Statement of Principles Regarding the Approach to State Implementation Plan Creditability of Agricultural Equipment Replacement Incentive Programs Implemented by the USDA Natural Resources Conservation Service and the San Joaquin Valley Air Pollution Control District”; March 2010

USDA Natural Resource Conservation Service, “Glossary for California Off-Road Agricultural Engines”, California Air Quality Technical Note 1, April 2014, Updated November 2016

USDA Natural Resource Conservation Service, “Estimating Emission Reductions for the California State Implementation Plan Annual Report”, California Air Quality Technical Note 4, March 2018

Appendix A

NRCS Engine Emissions Calculation Methodology

Based on the 2017 Carl Moyer Program Guidelines, Appendix C

Estimating Annual Emissions based on Hours of Operation per Pollutant (tons/year)

$$\text{Tons/year} = \frac{[(EF\ (g/bhp\text{-}hr) + DP^*\ (g/bhp\text{-}hr)) \times \text{Horsepower (bhp)} \times \text{Annual Activity (hours/year)} \times \text{Load Factor}]}{907{,}200\ g/ton}$$

Calculating a Deterioration Product (DP)* Value

$$DP\ (g/bhp\text{-}hr) = DR\ (g/bhp\text{-}hr\text{-}hr) \times \text{Total Equipment Activity (hours)}$$

1. Total Equipment Activity (hours) = Annual Activity (hours/year) x DL (years)
   Note: Total Equipment Activity is limited to a maximum of 12,000 hours for diesel engines, 3,500 hours for larger spark ignition engines with a model year of 2006 or older, or 5,000 hours for large spark ignition engines with a model year of 2007 or newer.
2. Baseline Equipment DL (years) =

   Expected 1st Year of Operation – Baseline Engine Model-Year + (Project Life / 2)
3. Reduced Equipment DL (years) = Project Life / 2

   Note: Project Life is 10 years - equivalent to the 10-year CPS 372 practice lifespan.

2017 Carl Moyer Guidelines, Formula C-6

*ARB applies the DP values *"as applicable"*. For NRCS purposes, the DP values are not applied for ranking project applications but are applicable to the emissions calculations for SIP reporting.

Variables

- **Deterioration Life (DL):** a factor calculated from the period the engine has deteriorated, plus half the project life, to estimate deterioration of the entire project life.
- **Deterioration Product (DP):** the result of multiplying the deterioration rate, equipment activity, and the deterioration life for a technology.
- **Deterioration Rate (DR):** rates that estimate increased NOx, ROG and PM emissions from engine wear and tear and other variables that increase engine emissions over time.
- **Emission Factor (EF):** a category specific estimate of NOx, ROG and PM emissions per unit of activity.
- **Horsepower (bhp):** is the manufacture-advertised brake horsepower (bhp) rating of the engine or equipment the engine powers (see CA Air Quality Technical Note 1).
- **Load Factor:** is a fraction of the rated engine horsepower based on the nominal work performed by the engine for an application.

Appendix B

NRCS Compression-Ignition (Diesel) Engine Load Factors and Emission Factors

Based on the 2017 Carl Moyer Program Guidelines, Appendix D

Table B-1
NRCS Default Load Factors for Off-Road Diesel-Powered Equipment used in Agriculture

Equipment Type	Load Factor	Category
Ag-Baggers	0.51	Agricultural - "Other Agriculture" Load Factor
Backhoe Loaders	0.37	Construction
Balers	0.53	Agricultural
Bin Carrier	0.51	Agricultural - "Other Agriculture" Load Factor
Chippers/Stump Grinders	0.73	Agricultural
Combines/Choppers	0.70	Agricultural
Conditioners	0.51	Agricultural - "Other Agriculture" Load Factor
Cranes	0.29	Construction
Crawler Tractor/Dozers	0.43	Construction
Excavators	0.38	Construction
Fellers/Bunchers	0.71	Logging
Forage Harvesters	0.70	Agricultural - "Combines/Choppers" Load Factor
Forklifts	0.20	Industrial
Generator Sets	0.74	Agricultural
Graders	0.41	Construction
Harrowbed/Bale Wagons	0.51	Agricultural - "Other Agriculture" Load Factor
Hydro Power Units	0.48	Agricultural
Irrigation Pumps	0.65	Agricultural
Mowers	0.43	Agricultural
Nut Bankouts	0.51	Agricultural - "Other Agriculture" Load Factor
Nut Harvesters	0.51	Agricultural - "Other Agriculture" Load Factor
Other Agriculture	0.51	Agricultural
Rough Terrain Forklifts	0.40	Construction
Rubber Tired Loaders	0.36	Construction
Shakers	0.51	Agricultural - "Other Agriculture" Load Factor
Shredders	0.40	Agriculture
Shuttles	0.51	Agricultural - "Other Agriculture" Load Factor
Skid Steer Loaders	0.37	Construction
Skidders	0.74	Logging
Sprayers	0.50	Agricultural
Swathers	0.55	Agricultural
Sweepers	0.51	Agricultural - "Other Agriculture" Load Factor
Tillers	0.78	Agricultural
Tractors	0.70	Agricultural
Trenchers	0.50	Construction

Based on 2017 Carl Moyer Program Guidelines – Table D-7

Table B-2
Uncontrolled Off-Road Compression-Ignition Engine Model Years

Horsepower	Engine Model Year
Greater than 750	1999 and earlier
25-49	1998 and earlier
50-99	1997 and earlier
100-174	1996 and earlier
175-750	1995 and earlier

NRCS California Air Quality Technical Note 1

Table B-3
Uncontrolled Off-Road Diesel Engines
Emission Factors (g/bhp-hr) (EF) and Deterioration Rates (g/bhp-hr-hr) (DR)

Horsepower	Model Year	NOx		ROG		PM10	
		EF	DR	EF	DR	EF	DR
25-49	Pre 1988	6.51	0.000098	1.68	0.000210	0.547	0.0000424
	1988+	6.42	0.000097	1.64	0.000210	0.547	0.0000424
50-119	Pre 1988	12.09	0.000280	1.31	0.000061	0.605	0.0000440
	1988+	8.17	0.000190	0.90	0.000042	0.497	0.0000361
120+	Pre 1970	13.02	0.000300	1.20	0.000056	0.554	0.0000403
	1970-1979	11.16	0.000260	0.91	0.000042	0.396	0.0000288
	1980-1987	10.23	0.000240	0.80	0.000037	0.396	0.0000288
	1988+	7.60	0.000180	0.62	0.000029	0.274	0.0000199

2017 Carl Moyer Program Guidelines – Table D-8

Table B-4
Controlled Off-Road Diesel Engines
Emission Factors (g/bhp-hr) (EF) and Deterioration Rates (g/bhp-hr-hr) (DR)

Horsepower	Tier	NOx		ROG		PM10	
		EF	DR	EF	DR	EF	DR
25-49	1	5.26	0.0000980	1.32	0.000170	0.480	0.0000372
	2	4.63	0.0000930	0.22	0.000050	0.280	0.0000218
	4 Interim	4.55	0.0000950	0.09	0.000036	0.128	0.0000096
	4 Final	2.75	0.0000570	0.09	0.000036	0.009	0.0000010
50-74	1	6.54	0.0001500	0.90	0.000042	0.552	0.0000402
	2	4.75	0.0000710	0.17	0.000025	0.192	0.0000141
	3	2.74	0.0000360	0.09	0.000023	0.192	0.0000141
	4 Interim	2.74	0.0000360	0.09	0.000023	0.112	0.0000080
	4 Final	2.74	0.0000360	0.09	0.000023	0.009	0.0000009
75-99	1	6.54	0.0001500	0.90	0.000042	0.552	0.0000402
	2	4.75	0.0000710	0.17	0.000025	0.192	0.0000141
	3	2.74	0.0000360	0.09	0.000023	0.112	0.0000080
	4 Phase-Out	2.74	0.0000360	0.09	0.000030	0.009	0.0000009
	4 Phase-In/Alt NOx	2.15	0.0000270	0.08	0.000021	0.009	0.0000009
	4 Final	0.26	0.0000035	0.05	0.000015	0.009	0.0000009
100-174	1	6.54	0.0001500	0.62	0.000029	0.304	0.0000221
	2	4.15	0.0000600	0.15	0.000023	0.128	0.0000094
	3	2.32	0.0000300	0.09	0.000030	0.112	0.0000080
	4 Phase-Out	2.32	0.0000300	0.09	0.000030	0.009	0.0000004
	4 Phase-In/Alt NOx	2.15	0.0000270	0.08	0.000020	0.009	0.0000004
	4 Final	0.26	0.0000040	0.05	0.000011	0.009	0.0000004
175-299	1	5.93	0.0001400	0.29	0.000013	0.120	0.0000064
	2	4.15	0.0000600	0.11	0.000022	0.088	0.0000046
	3	2.32	0.0000300	0.09	0.000023	0.088	0.0000046
	4 Phase-Out	2.32	0.0000300	0.09	0.000023	0.009	0.0000003
	4 Phase-In/Alt NOx	1.29	0.0000170	0.06	0.000017	0.009	0.0000003
	4 Final	0.26	0.0000036	0.05	0.000011	0.009	0.0000003
300-750	1	5.93	0.0000990	0.29	0.000010	0.120	0.0000064
	2	3.79	0.0000500	0.09	0.000023	0.088	0.0000044
	3	2.32	0.0000300	0.09	0.000023	0.088	0.0000044
	4 Phase-Out	2.32	0.0000300	0.09	0.000023	0.009	0.0000003
	4 Phase-In/Alt NOx	1.29	0.0000170	0.06	0.000017	0.009	0.0000003
	4 Final	0.26	0.0000036	0.05	0.000011	0.009	0.0000003
751+	1	5.93	0.0000990	0.29	0.000010	0.120	0.0000064
	2	3.79	0.0000500	0.09	0.000023	0.088	0.0000044
	4 Interim	2.24	0.0000280	0.06	0.000017	0.051	0.0000021
	4 Final	2.24	0.0000280	0.05	0.000011	0.017	0.0000009

2017 Carl Moyer Program Guidelines – Table D-9

Appendix C

NRCS Spark-Ignition Engine Load Factors and Emission Factors

Based on the 2017 Carl Moyer Program Guidelines, Appendix D

Table C-1
NRCS Default Load Factors for Off-Road Spark-Ignition Equipment used in Agriculture

Equipment Type	Load Factor	Category
Ag-Baggers	0.55	Agricultural - "Other Agriculture" Load Factor
Backhoe Loaders	0.48	Construction
Balers	0.55	Agricultural
Bin Carrier	0.55	Agricultural - "Other Agriculture" Load Factor
Chippers/Stump Grinders	0.78	Agricultural
Combines/Choppers	0.74	Agricultural
Conditioners	0.55	Agricultural - "Other Agriculture" Load Factor
Cranes	0.47	Construction
Forklifts	0.30	Industrial
Generator Sets	0.55	Agricultural - "Other Agriculture" Load Factor
Harrowbed/Bale Wagons	0.55	Agricultural - "Other Agriculture" Load Factor
Irrigation Pumps	0.65	Agricultural
Mowers	0.55	Agricultural - "Other Agriculture" Load Factor
Nut Bankouts	0.55	Agricultural - "Other Agriculture" Load Factor
Nut Harvesters	0.55	Agricultural - "Other Agriculture" Load Factor
Other Agriculture	0.55	Agricultural
Rough Terrain Forklifts	0.63	Construction
Rubber Tired Loaders	0.54	Construction
Shakers	0.55	Agricultural - "Other Agriculture" Load Factor
Shredders	0.55	Agricultural - "Other Agriculture" Load Factor
Shuttles	0.55	Agricultural - "Other Agriculture" Load Factor
Skid Steer Loaders	0.58	Construction
Sprayers	0.50	Agricultural
Swathers	0.52	Agricultural
Sweepers	0.55	Agricultural - "Other Agriculture" Load Factor
Tillers	0.75	Agricultural - "Other Agriculture" Load Factor
Tractors	0.62	Agricultural - "Other Agriculture" Load Factor
Trenchers	0.66	Construction

Based on 2017 Carl Moyer Program Guidelines – Table D-10

Table C-2
Off-Road Large Spark-Ignition Engines
Gasoline Emission Factors (g/bhp-hr) (EF) and Deterioration Rates (g/bhp-hr-hr) (DR)

Horsepower	Model Year	NOx		ROG		PM10	
		EF	DR	EF	DR	EF	DR
25-50	Pre-2004 (uncontrolled)	8.01	0.0000406	3.760	0.000412	0.060	0.000
	2001-2006 (controlled)	1.33	0.0004710	0.710	0.000169	0.060	0.000
	2007-2009 (controlled)	0.89	0.0001192	0.473	0.000064	0.060	0.000
	2010+ (controlled)	0.27	0.0000250	0.142	0.000013	0.060	0.000
51-120	Pre-2004 (uncontrolled)	11.84	0.0000601	2.630	0.000287	0.060	0.000
	2001-2006 (controlled)	1.78	0.0002070	0.260	0.000081	0.060	0.000
	2007-2009 (controlled)	1.17	0.0000660	0.130	0.000074	0.060	0.000
	2010+ (controlled)	0.35	0.0000300	0.030	0.000014	0.060	0.000
121+	Pre-2004 (uncontrolled)	12.94	0.0001270	1.610	0.000042	0.060	0.000
	2001-2006 (controlled)	1.94	0.0002780	0.160	0.000102	0.060	0.000
	2007-2009 (controlled)	1.17	0.0000660	0.130	0.000074	0.060	0.000
	2010+ (controlled)	0.35	0.0000330	0.030	0.000014	0.060	0.000

2017 Carl Moyer Program Guidelines – Table D-11a

Table C-3
Off-Road Large Spark-Ignition Engines
Alternative Fuels Emission Factors (g/bhp-hr) (EF) and Deterioration Rates (g/bhp-hr-hr) (DR)

Horsepower	Model Year	NOx		ROG		PM10	
		EF	DR	EF	DR	EF	DR
25-50	Pre-2004 (uncontrolled)	13.00	0.0000662	1.380	0.000151	0.060	0.000
	2001-2006 (controlled)	1.95	0.0002760	0.140	0.000106	0.060	0.000
	2007-2009 (controlled)	1.30	0.0000011	0.093	0.000172	0.060	0.000
	2010+ (controlled)	0.39	0.0000002	0.028	0.000036	0.060	0.000
51-120	Pre-2004 (uncontrolled)	10.53	0.0000533	1.550	0.000169	0.060	0.000
	2001-2006 (controlled)	1.58	0.0003500	0.160	0.000103	0.060	0.000
	2007-2009 (controlled)	1.04	0.0000125	0.100	0.000047	0.060	0.000
	2010+ (controlled)	0.31	0.0000380	0.030	0.000014	0.060	0.000
121+	Pre-2004 (uncontrolled)	10.51	0.0001040	1.380	0.000035	0.060	0.000
	2001-2006 (controlled)	1.58	0.0002640	0.140	0.000106	0.060	0.000
	2007-2009 (controlled)	1.04	0.0000125	0.100	0.000047	0.060	0.000
	2010+ (controlled)	0.31	0.0000380	0.030	0.000014	0.060	0.000

2017 Carl Moyer Program Guidelines – Table D-11a

NRCS

CALIFORNIA RANKING EMISSIONS CALCULATION WORKSHEET
Air Quality – 372 Combustion System Improvement

Producer Name: _____ Date: _____

Existing In-Use Engine Emissions Calculations

Existing Engine:
Manufacturer: _____
Model Year Engine: _____ Fuel Type: _____
Equipment Type: _____
Serial Number: _____

Baseline Emissions		NOx	ROG	PM10	
Maximum Rated Brake Horsepower:					$bhp_{maximum}$
Annual Hours of Operation:	x				Hours/Year
Emission Factors:	x				g/bhp-hr
Load Factor:	x				
Conversion to Tons:	÷	907,200	907,200	907,200	Grams/Ton
Annual Emissions (EE)	=				Tons/Year

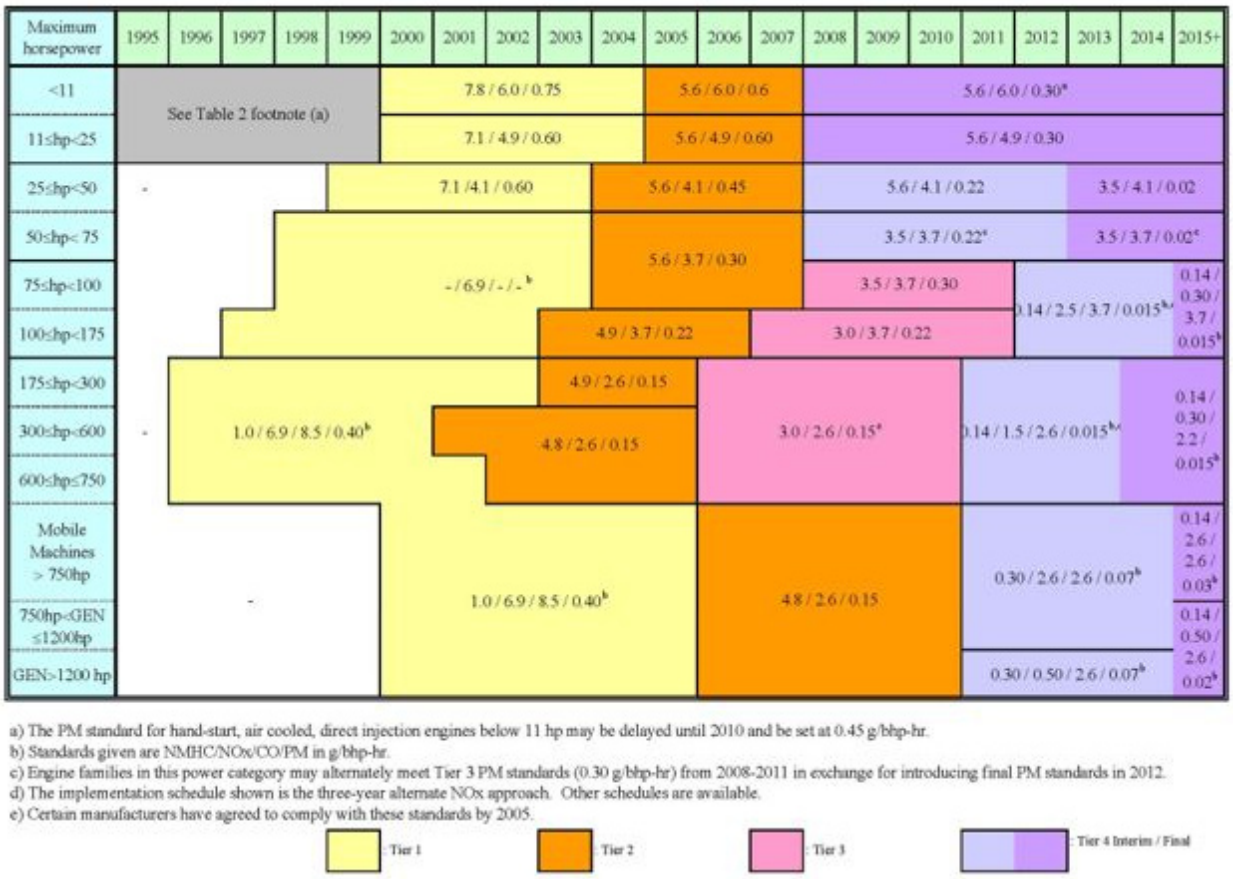
New Engine Emissions Calculations (Report as zero emissions if electric)

New Engine:
Manufacturer: _____
Model Year Engine: _____ Fuel Type: _____
Equipment Type: _____
Serial Number (if available): _____

New Engine Emissions		NOx	ROG	PM10	
Maximum Rated Brake Horsepower:					$bhp_{maximum}$
Annual Hours of Operation:	x				Hours/Year
Emission Factors:	x				g/bhp-hr
Load Factor:	x				
Conversion to Tons:	÷	907,200	907,200	907,200	Grams/Ton
Annual Emissions (NE)	=				Tons/Year

Calculation Results

	NOx	ROG	PM10	
Annual Emission Reductions: (EE) – (NE) =				Tons/Year
Percent Emission Reductions: [(EE – NE) / (EE)] x 100 =				%



a) The PM standard for hand-start, air cooled, direct injection engines below 11 hp may be delayed until 2010 and be set at 0.45 g/bhp-hr.
b) Standards given are NMHC/NOx/CO/PM in g/bhp-hr.
c) Engine families in this power category may alternately meet Tier 3 PM standards (0.30 g/bhp-hr) from 2008-2011 in exchange for introducing final PM standards in 2012.
d) The implementation schedule shown is the three-year alternate NOx approach. Other schedules are available.
e) Certain manufacturers have agreed to comply with these standards by 2005.

11. Specific Site Requirements