NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD
ARIZONA

COMBUSTION SYSTEM IMPROVEMENT

(No.)

CODE 372

DEFINITION

Installing, replacing, or retrofitting agricultural combustion systems and/or related components or devices for air quality and energy efficiency improvement.

PURPOSE

- To improve air quality by addressing the air quality resource concerns for particulate matter and ozone precursors by mitigating actual or potential emissions of oxides of nitrogen *(NOx), reactive organic gas (ROG)* and/or fine particulate matter *less than 10 microns in diameter (PM10)*
- To improve the energy efficiency of agricultural combustion systems

CONDITIONS WHERE PRACTICE APPLIES

This practice applies to any agricultural operation that operates an agricultural combustion system, including stationary, portable, mobile, and self-propelled equipment. The combustion system must be used primarily for agricultural and/or forestry activities *and shall be part of an approved and overall conservation plan to address identified resource concerns.*

For a combustion system associated with a pumping plant (i.e., pumping plant power unit), use Conservation Practice Standard, Pumping Plant, Code 533. This standard (Combustion System Improvement for Air and Energy, Code 372) may be applied in addition to the Pumping Plant standard for addressing air quality resource concerns associated with a pumping plant power unit, if applicable.

CRITERIA

Design and implementation of subsidiary measures, components and/or structures shall meet all applicable Natural Resource Conservation Service (NRCS) policies, standards, and specifications. The criteria for the design of any components not specifically addressed in NRCS practice standards or specifications shall be consistent with sound engineering principles and/or manufacturer recommendations.

General Criteria Applicable to All Purposes. Size the new or replacement combustion system and related components or devices appropriately to accomplish its intended task. *The maximum rated brake horsepower of the new engine shall not exceed 125% of the horsepower of the existing engine.*

Where required, certify that the new, replacement, or retrofit combustion system and related components or devices meets or exceeds currently-applicable Federal, State, and local standards and guidelines. *Any new, replacement or retrofit engine must report at least a 15% NOx reduction and/or no increase in PM10 emissions compared with the applicable standards or emission levels for that engine year and type of application.*

The existing engine shall have been operated in Arizona for at least 12 months prior to replacement or retrofit.

All replaced combustion systems shall be rendered inoperable or used to replace higher-emitting or lower-efficiency combustion systems. Certification of use as a replacement system can be accomplished by providing certification of inoperability of one or more higher-emitting or lower-efficiency combustion system(s).

Certification of inoperability can be accomplished by:

- Obtaining a receipt *or written certification* for the combustion system disposal from a scrap metal recycling operation *and/or dismantler* and keeping this receipt available for inspection. *The participant is responsible for providing all*

relevant requirements to the dismantler prior to disposal and the receipt/certification shall be provided to the NRCS; or

- Creating a permanent hole in the engine block or combustion chamber of the combustion system (minimum size to be determined by Federal, State, or local guidelines). The disabled engine must be kept on-farm for inspection, or a written and signed certification that a permanent hole has been created and the engine is disabled must be prepared and kept available on-farm for inspection.

***Emissions Calculations**. Annual emission reductions shall be determined for NOx, ROG and PM10 and are calculated as:*

$$AE = \frac{(\mathrm{EF}) \times (\mathrm{bhp}) \times (\mathrm{hours}) \times (\mathrm{LF})}{\mathrm{CF}}$$

where,
AE = estimated annual emissions (tons/year)
EF = emission factors (grams/bhp-hour)
hours = estimate annual hours
LF = load factor
CF = conversion factor (907,200 grams/ton)

Annual emission reductions are obtained by subtracting the estimated annual emissions of the new engines from the estimated annual emissions of the existing engines using the following formula:

$$Annual\ Emission\ Reduction\ (tons/year) = AE_{existing} - AE_{new}$$

$$Percent\ Emission\ Reductions\ (\%) = \left(\frac{Annual\ Emission\ Reduction}{AE_{existing}}\right) 100$$

At a minimum, emission calculations require the following data:

- *Engine Model Year*
- *Engine Rated Brake Horsepower*
- *Type of equipment the engine powers (to determine the load factor)*
- *Annual hours the engine operates*
- *Applicable emission factors*

If emissions data from an approved source is not available for the specific engine, the emission and load factors in the tables 1 through 5 shall be used as default values.

An emissions inventory will report the estimated annual emissions and track the emission reductions as a result of implementing this conservation practice.

Additional Criteria Applicable to Improving Air Quality. A new or replacement combustion system and related components or devices shall utilize a non-combustion power source or a combustion power source that utilizes cleaner-burning technologies, techniques, and/or fuels.

When installing a new combustion system that is not a replacement system, the new combustion system shall emit fewer oxides of nitrogen*, reactive organic gas* and/or less fine particulate matter than the most commonly-installed alternative system. When installing a new or replacement diesel-powered engine, use the newest-available EPA engine TIER technology.

When installing a replacement combustion system and related components or devices, the replacement system shall emit less oxides of nitrogen*, reactive organic gas* and/or fine particulate matter than the replaced combustion system and related components or devices.

Retrofit can include actions or combinations of actions that reduce emissions of oxides of nitrogen*, reactive organic gas* and/or fine particulate matter. Examples of individual retrofit actions include:

- Adding one or more emissions control device(s),
- Altering air/fuel mixtures to achieve more complete combustion and less emissions,
- Adding a device that allows for reduced combustion of fuel to accomplish the same intended task,
- Accommodating the use of a cleaner-burning fuel, and/or
- Other physical modifications or changes in combustion techniques that reduce emissions formation or release.

Additional Criteria Applicable to Improving Energy Efficiency. Only the replacement or retrofit of an existing combustion system is allowed under this practice standard for the energy efficiency purpose. Installation of new combustion systems where none existed prior are not allowed if energy efficiency is the sole purpose.

Replacement combustion systems shall be certified to be at least 20% more energy efficient than the systems they replace.

Retrofit to improve energy efficiency may involve adding a device that allows for reduced operation of an existing combustion system, such as a variable frequency drive or automated sensors and controls.

Investigations, Surveys and Design Criteria*. Documentation requirements will be as outlined below, in addition to the documentation requirements of the practice components used in the system.*

Preliminary site assessment, investigation or reconnaissance to identify and document the following:

1. *Time stamped photographs, labeled with engine serial number, along with detailed narrative and certification that the existing engine(s) are fully-functional and operational agricultural engines*
2. *Description of the type of equipment the existing engine powers (tractor, tiller, baler, pump, loader, etc.) and equipment VIN or model number, if applicable*
3. *Location of equipment or description of how the equipment is currently used*
4. *Years operating at this location and/or year equipment/engine was purchased*
5. *Primary fuel type (diesel, bio-diesel, natural gas, LPG, bio-gas, other)*
6. *Engine type (non-tier diesel, tier 1, tier 2, spark ignited, other)*
7. *Engine manufacturer, year, model and serial number, and maximum rated brake horsepower, if applicable*
8. *Annual fuel usage and/or annual hours of operation*
9. *Planned location where engine/equipment will be scrapped and/or destroyed*

The design and implementation of a practice is the application of Field Office Technical Guide practice standards, practical experience and judgment in the development of a solution to the problem or the objective. In addition to the information described above, the cost of the new engine and/or equipment and planned fuel source shall also be considered.

CONSIDERATIONS

Installation of new or replacement combustion systems with non-combustion renewable energy sources, such as solar, wind, and water, are preferred means of reducing air emissions associated with agricultural combustion systems. Non-combustion renewable energy sources do not release air emissions directly and do not increase air emissions from off-site electricity generation. The impacts of non-combustion renewable energy sources on other resources should also be considered to analyze their overall conservation benefit.

Service Life*. A properly operated and maintained practice should have a service life in excess of ten years. Where feasible, other components of the system, as well as the installation methods, should be of sufficient quality to maintain comparable performance.*

PLANS AND SPECIFICATIONS

Development of plans and Specifications for application of this practice *will be in accordance with Part 650 of National Engineering Handbook and the National Engineering Manual, Parts 541 and 542,* be prepared for each site or planning unit according to the criteria *and shall describe the requirements for applying the practice to achieve its intended purpose. If the practice is a component of a system that includes additional conservation practices, the information necessary to implement any additional practices will also be clearly conveyed on the plans and specifications.* Specifications shall be recorded using State-developed specification sheets, job sheets, practice requirement sheets, narrative statements in conservation plans, or other acceptable documents.

As a minimum, the plans and specifications shall provide the following:

- Identification and description of the existing combustion system and related components or devices, if applicable, and the new or replacement combustion system and related components or devices. If the combustion system is being retrofitted, identification and description of the type of modifications being made to the existing system.
- Requirements on disposal of replaced combustion system and related components or

devices, including assuring permanent disabling and rendering inoperable.

- Documentation requirements to determine combustion system usage and resulting air emissions from the new, replacement, or retrofit combustion system and related components or devices. Average annual air emissions for the existing combustion system (for replacements and retrofits) or alternative combustion system (for new installations) shall be calculated prior to the installation of the new combustion system or replacement or retrofit of the existing combustion system to determine the expected air emissions reductions from the application of this practice and to serve as a baseline for later air emissions calculations.
- *Use Arizona Construction and Material Specifications for each item of work and material, as applicable. Additional language may need to be provided to fully document practice installation. Fill in blanks and add or delete items from the specifications to make them fit the job as needed.*

All designs completed by non-NRCS personal shall meet minimum State licensing board requirements and NRCS requirements and criteria as outlined in the General Manual, the National Engineering Manual (including Arizona Supplements), and the National Engineering Handbook.

ONCE ALL PARTIES HAVE ACCEPTED AND SIGNED THE PLANS AND SPECIFICATIONS, NO CHANGES SHALL BE MADE TO THE DRAWINGS OR SPECIFICATIONS WITHOUT PRIOR APPROVAL OF NRCS.

OPERATION AND MAINTENANCE

An operation and maintenance plan shall be developed that is consistent with the purposes of this practice, its intended life, safety requirements, and the criteria used for its design.

The new, replacement, or retrofit combustion system and related components or devices shall be operated and maintained in accordance with the manufacturer's recommendations.

NRCS recommends that records be retained and updated for a minimum of five years from the beginning of operation of a new, replacement, or retrofitted combustion system.

The recommended records to be retained include:

- Total actual hours operated
- Types and amounts of fuel used in the combustion system(s), or electricity used for electric motors that have replaced an existing combustion system
- Documentation of maintenance conducted on the new, replacement, or retrofitted combustion system and related components or devices

REFERENCES

- United States Environmental Protection Agency (U.S. EPA) National Clean Diesel Campaign for Agriculture (Clean Agriculture USA) website.
- *United States Environmental Protection Agency, Non-Road Diesel Equipment, http://www.epa.gov/nonroad-diesel/index*
- *Arizona Department of Environmental Quality, Air Quality Division, http://www.azdeq.gov/environ/air/*
- California Environmental Protection Agency Air Resources Board (CARB) Diesel Programs and Activities website.
- *California Air Resources Board, Carl Moyer Program Guidelines, April 22, 2008, Tables B11 through B15*
- *California Air Resources Board, Off-Road Engine Certification Database, http://www.arb.ca.gov/msprog/offroad/cert/*
- *National Environmental Compliance Handbook*
- *General Manual, Title 420-Part 401, Title 450-Part 401, Title 190-Parts 410.22 and 410.26*
- *National Planning Procedures Handbook*

Table 1
Diesel Agricultural Equipment Default Load Factors

Tillers	0.78	Balers	0.53
Combines	0.70	Sprayers	0.50
Tractors	0.70	Hydro Power Units	0.48
Irrigation Pumps	0.65	Mowers	0.43
Loaders/Backhoes	0.55	Forklifts	0.30
Swathers	0.55	Other Agricultural	0.51

Source: 2008 Carl Moyer Program Guidelines, Table B-11

Table 2
Off-Road Large Spark-Ignited Equipment Default Load Factors

Combines	0.74	Sprayers	0.50
Tractors	0.62	Loaders/Backhoes	0.48
Balers	0.55	Forklifts	0.30
Swathers	0.52	Other Agricultural	0.55

Source: 2008 Carl Moyer Program Guidelines, Table B-14

Table 3
Uncontrolled Off-Road Compression-Ignition (Diesel) Engines
Emission Factors (g/bhp-hr)

Horsepower	Model Year	NOx	ROG	PM10
50 – 119	Pre 1988	12.09	1.73	0.547
	1988 – 1995	8.14	1.19	0.497
120 +	Pre 1970	13.02	1.59	0.554
	1970 – 1979	11.19	1.20	0.396
	1980 – 1987	10.23	1.06	0.396
	1988 – 1995	7.60	0.82	0.274

Source: 2008 Carl Moyer Program Guidelines, Table B-12

Table 4
Controlled Off-Road Compression-Ignition (Diesel) Engines
Emission Factors (g/bhp-hr)

Tier	Horsepower	NOx	ROG	PM10
1	50 - 119	6.54	1.19	0.552
	120 - 174	6.54	0.82	0.274
	175 +	5.93	0.38	0.108
2	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	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	50 - 120	1.33	0.08	0.008
	121 – 750	0.26	0.06	0.008
	>750	2.24	0.06	0.016

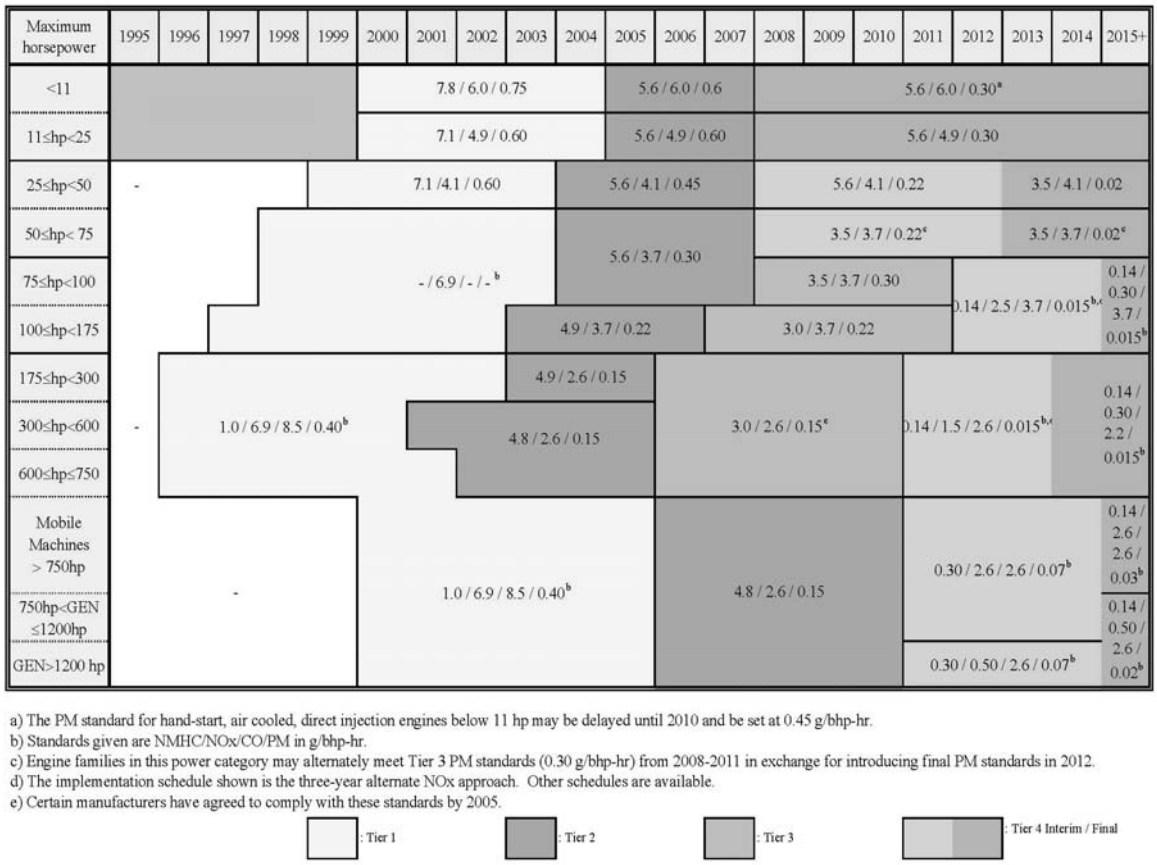
Source: 2008 Carl Moyer Program Guidelines, Table B-13

Table 5
Off-Road Large Spark-Ignited Engines
Emission Factors (g/bhp-hr)

Horsepower	Fuel	Model Year	NOx	ROG	PM10
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

Source: 2008 Carl Moyer Program Guidelines, Table B-15

Table 6
ARB and USEPA Off-Road Compression-Ignition (Diesel) Engine Standards*



** When ARB and USEPA standards differ, the standards shown here represent the more stringent of the two*