NRCS Natural Resources Conservation Service

Combustion System Improvement

New Jersey Conservation Practice Job Sheet 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 mitigating actual or potential emissions of oxides of nitrogen and/or fine particulate matter
- To improve the energy efficiency of agricultural combustion systems

Where used

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.

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, 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.

Resource management system

This practice is normally applied to address air or energy resource concerns as a part of a broader resource management system.

Criteria

Size the new or replacement combustion system and related components or devices appropriately to accomplish the intended work. Guidance is provided for determining minimum brake horsepower requirements for pumping plants.

When installing a replacement combustion system for air quality improvement, the new replacement engine must emit fewer oxides of nitrogen and/or fine particulate matter than the replaced combustion system.

When installing a replacement combustion system for energy efficiency improvement, the new replacement engine shall be certified to be at least 20% more energy efficient than the system being replaced. Efficiency can be determined based on fuel consumption under

operating conditions as compared to the performance standard for the particular fuel type. Guidance for efficiency calculations is provided.

Emission Calculation

Document air pollutant emissions of the existing system and the proposed replacement.

Determine emission reductions by calculating the emissions from the existing engine to establish a baseline. Calculate and subtract the emissions of the new engine from the baseline, to report the estimated emission reductions. An emissions inventory will report the estimated annual emissions and track the emission reductions as a result of implementing this conservation practice.

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 test is not available for the specific engine, use the emission factors in the job sheet tables.

Certification of engine disposal

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

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

Destruction of the engine may be accomplished by one of the following methods:

1. Disposal by a scrap metal recycling operation or dismantler; or
2. Permanently disabling the old engine block by puncturing a hole in the engine block or combustion chamber. The disabled engine or a copy of the written certification must be kept on-farm for inspection.

The producer must provide the NRCS with a written and signed certification that the engine and associated equipment has been permanently destroyed. If destruction was performed by an approved dismantler or scrap metal recycler, the dismantler will provide the producer with the written certification for submittal to the NRCS. The certification should describe the following:

- The existing engine and equipment type,
- The existing engine serial number,
- The date the existing engine and equipment were decommissioned ,
- 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 and engine or equipment intended for destruction.

Operation and Maintenance

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

NRCS recommends that producers maintain records of new engine usage for at least five years of operation. Recommended records include the annual hours of operation and gallons of fuel used or kilowatts consumed (if electric) over a calendar year. Records should also record routine maintenance performed on the engine and equipment. The objective is to determine engine usage and the resulting emissions. A form for record keeping is attached.

Emissions Calculations

$$\text{Emissions}_{\text{Tons/year}} = \frac{[(\text{EF } g/bhp\text{-}hr) \times (\text{engine max rated bhp}) \times (\text{annual hours}) \times (\text{load factor})]}{(907{,}200\ g/ton)}$$

Where: Emissions = emissions of NO_x, VOC, or PM
EF = Emission Factor (from Table 1, 2 or 4)

Table 1
Uncontrolled Off-Road Compression-Ignition (Diesel) Engines
Emission Factors (g/bhp-hr)

Horsepower	Model Year	NOx	VOC*	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: NRCS-CA Specification 372

**For purposes of determining average annual air emissions, Reactive Organic Gases (ROG) are considered equivalent to Volatile Organic Compounds (VOC).*

Table 2
Controlled Off-Road Compression-Ignition (Diesel) Engines
Emission Factors (g/bhp-hr) *(see also Figure 1)*

Tier	Horsepower	NOx	VOC	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 (4i)	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: NRCS-CA Specification 372

Table 3
Diesel Agricultural Equipment Default Load Factors

Hydro Power Units	0.48	Other Agricultural	0.51

Source: NRCS-CA Specification 372

Table 4
Off-Road Large Spark-Ignited Engines
Emission Factors (g/bhp-hr)

Horsepower	Fuel	Model Year	NOx	VOC	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: NRCS-CA Specification 372

Table 5
Off-Road Large Spark-Ignited Equipment Default Load Factor

Other Agricultural	0.55

Source: NRCS-CA Specification 372

Figure 1
Summary of EPA Emission Standards for Nonroad Compression Ignition Engines

(Tier by model year)

Horsepower	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
<25	1	1	2	2	2	4	4	4	4	4	4	4	4
25-74	1	2	2	2	2	4i	4i	4i	4i	4i	4	4	4
75-99	1	2	2	2	2	3	3	3	3	4i	4i	4	4
100-174	2	2	2	2	3	3	3	3	3	4i	4i	4	4
175-750	2	2	2	3	3	3	3	3	4i	4i	4i	4	4
>750	1	1	1	2	2	2	2	2	4i	4i	4i	4i	4

Minimum Brake Horsepower Calculations

Calculate Total Pumping Head, TH, in feet

TH = Pumping Lift (ft) + Discharge Pressure (ft)

Calculate Water Horsepower, WHP

WHP = (GPM x TH) / 3960

Calculate Break Horsepower, BHP

BHP = WHP / (E_p x E_d)

Typically, assume pump efficiency, E_p, is 75% (enter as decimal, 0.75)

Drive Efficiency, E_d ; See Table 1 (enter as decimal)

Table 1

Type of Drive	Normal Efficiency
Direct	100%
Flat Belt, straight	85%
Flat Belt, ¼ to ½ turn	75%
V Belt	95%
Right Angle Gear Head	95%

Note: Where manufacturer's engine rating is based on factory conditions, other adjustments may be necessary:

Adjustment for ancillary equipment (muffler, radiator, fan, etc): 5% de-rating

Adjustment for continuous operation: 20% de-rating

Efficiency Calculations

Determine Power Unit Performance

From operating test or data, determine fuel consumed (gal) for the operating test duration (hrs):

Power Unit Performance (BHP x hr/gal) = BHP x (Test Duration, hrs / Fuel Consumed, gal)

Calculate Power Unit Efficiency, EFF:

EFF = (Power Unit Performance x 100%) / Performance Unit Performance Standard (Table 2)

Table 2

FUEL	PERFORMANCE STANDARD
Diesel	14.75 BHP x hr/gal
Gasoline	11.30 BHP x hr/gal
LP Gas	8.92 BHP x hr/gal

Based on 75% pump efficiency, direct drive

Combustion System Improvement – Job Sheet

Plan view or aerial photograph combustion system improvement installation site(s) shown below.

Scale 1"=_____ ft. (NA indicates sketch not to scale: grid size=1/2" by 1/2")

Additional Specifications and Notes:

Combustion System Improvement (372)
Engine Replacement Implementation Record

Name _____ County _____ Planned By _____ Date _____

Location _____ Plan Checked _____ Date _____

Purpose: Improve air quality by reducing emissions ☐. Improve energy efficiency ☐. Plan Approved _____ Date _____

Existing Engine Information and Decommissioning

Existing Engine	Purpose / Location on Farm	Fuel Type	Make/Model	Model Year	Serial No.	Rated BHP	Annual Hours Used	Decommissioning	
								Method	Date
1									
2									
3									

After being replaced, the existing engine must be rendered inoperable by one of the following methods:
1. Disposing for scrap metal. A dated receipt is required, identifying the engine and certifying that no parts or components were or will be parted-out, used or sold as parts, or used to rebuild an engine intended for destruction.
2. Creating a permanent hole at least six inches in diameter to include a portion of the oil pan rail (sealing surface), or by cutting the engine block into multiple pieces. The disabled engine (or written, signed and dated certification that the engine has been disabled as required) must be kept on-farm for inspection.

*3. Other*_____

Replacement Engine Information

New Engine	Purpose / Location on Farm	Fuel Type	Make/Model	Model Year	Serial No.	Rated BHP	Minimum BHP	Date Installed
1								
2								
3								

Emissions and Efficiency Information *(Emissions in Tons/Yr; Efficiency in %)*

Engine 1	Existing	Replacement	Improvement	Engine 2	Existing	Replacement	Improvement	Engine 3	Existing	Replacement	Improvement
NO_x				NO_x				NO_x			
VOC				VOC				VOC			
PM10				PM10				PM10			
Eff. %				Eff. %				Eff. %			

USDA Program Participant Certification:
To the best of my knowledge these records accurately reflect the actual combustion system improvement(s) implemented.

NRCS Acceptance:
Completed practice meets NRCS standards and specifications.

_____ _____ _____ _____
USDA Program Participant Signature *Date* *NRCS Representative Signature* *Date*

NATURAL RESOURCES CONSERVATION SERVICE
New Jersey
COMBUSTION SYSTEM IMPROVEMENT
OPERATING RECORD

Follow the operation and maintenance plan (attached) to keep your combustion system improvements functioning as intended:

- Follow all operation and maintenance instructions provided by the manufacturer of the new engine(s) installed.

- Maintain records to document new engine usage for at least 5 years of operation.

Dates	Engine 1		Engine 2		Engine 3	
	Hours Operated	Fuel/kW Used	Hours Operated	Fuel/kW Used	Hours Operated	Fuel/kW Used

- Retain records of maintenance conducted on the engine(s).

Additional Details:

_____
_____
_____
_____
_____
_____

OPERATION AND MAINTENANCE PLAN
COMBUSTION SYSTEM IMPROVEMENT

Combustion system improvement measures help to improve air quality. Combustion systems installed to improve air quality including new, replacement, or retrofit combustion systems and related components and devices have an estimated service life consistent with that of the associated conservation system or a minimum of 15 years. The life of this conservation practice can be assured and usually increased by developing and carrying out a good inspection and maintenance program including the following requirements:

GENERAL REQUIREMENTS

- Combustion systems must be installed in conformance with the manufacturer's requirements in order to insure proper operation.
- Monitoring devices such as power usage meters shall be installed as specified by the manufacturer.
- As a minimum, inspect combustion systems annually and after major storm events.
- Follow proper start-up procedures for operation of the combustion systems.
- Operate combustion systems within the design requirements.
- Maintain all electrical and mechanical equipment in good operating condition by following the manufacturer's recommendations.
- Maintain grounding rods and wiring for all electrical equipment in good condition.
- Maintain all safety devices and signage.
- Routinely test and inspect all automation components to assure proper functioning.
- Check all base slabs and mountings for durability and ability to hold the equipment in place without vibration. Repair when necessary.
- Replace, repack or tighten any seals or connections when leakage is in excess of the manufactures' specifications.
- Service equipment or components that are subject to freezing.
- Check fuel storage and supply lines for leakage. Repair as needed.
- Inspect and maintain any screening or housing structures.

- Maintain surface drainage around the combustion system to avoid ponding of water.
- Immediately repair any vandalism, vehicular or livestock damage to the combustion system, earthen areas surrounding the facility, or any appurtenances.
- Prior to repairing or retrofitting any electrically powered equipment, check that electrical service has been disconnected and verify the absence of stray electrical current.
- Record keeping, when recommended, should include hours of operation, fuel usage, and a log of maintenance activities.

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Practice Checkout:

Amount completed: _____units Mark as-built location on plan map and attach photos.

Remarks_____

This practice meets NRCS standards and specifications ☐ Yes ☐ No

Clear

Check out completed by: _____ Date: _____

Certified by:_____ Date:_____