EPA Diesel Emissions Standards

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INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is responsible for implementing and enforcing federal regulations for pollutant emissions produced by on-highway and off-road engines.

The focus of the EPA is to reduce the six common pollutants: ozone, particulate matter, carbon monoxide, nitrogen oxides, sulfur dioxide, and lead. They do so by implementing a set of standards to reach increasingly stringent emissions levels in the United States.

This paper provides an overview of the three primary EPA regulations affecting generator set use in the United States.

EPA DIESEL ENGINE EMISSION TERMINOLOGY

CERTIFICATION TYPE

Certified Engine – New diesel engines introduced into commerce in the U. S. must be certified by the EPA for the intended use of the engine. Engine certifications are typically performed by the engine manufacturer. The process includes testing to ensure the engines meet the applicable regulations and continued testing to ensure they meet the regulations during their useful life. The EPA issues a Certificate of Conformity (CoC) to signify the engine has been tested and certified.

Compliant Engine – A compliant engine meets a given EPA regulation emission requirement but has not been certified by the EPA to meet those levels. Compliant solutions are often used to meet local requirements that have lower emissions requirements than the EPA federal regulation requirements.

USE TYPE

Emergency – Defined by EPA subpart ZZZZ as meeting the following operating requirements:

- Unlimited use for emergencies (e.g., power outage, fire, flood)
- Emergency engines may operate for 100 hours per year for maintenance/testing
- 50 hours of the 100 hours per year allocation can be used for:
    - Local reliability as part of a financial arrangement with another entity if specific criteria met (existing RICE at area sources of HAP only).
    - Nonemergency situations if no financial arrangement

Non-Emergency – Those engines that do not qualify as emergency use only.

Note: The EPA does not regulate a generator set and therefore does not recognize the generator rating as an indication of use. ISO 8528 ratings are often talked about in conjunction with required emissions compliance. It does not violate any regulations to have an emergency-use generator with a prime or continuous rating.

LOCATION

Stationary – Off-highway engines permanently mounted in a single location. Also, a movable nonroad engine is classified as stationary if it stays in one location for more than 12 months.

Nonroad – Engines used on nonhighway equipment meant to be movable, either by being propelled, such as skid-loader, or by transport, such as a mobile/towable generator.

SITE CLASSIFICATION

The site classification pertains to the entire facility or contiguous complex where the engine is located. There are two different site classifications:

Major Source – Any stationary source that emits 10 tons per year or more of any one hazardous air pollutant or 25 or more tons per year of any combination of hazardous air pollutants.

Area Sources – Sources that are not major sources.

ISO 8528 GENERATOR RATINGS

Standby – A standby generator is typically specified for generators with stationary emergency engines.

Prime – A prime rating is typically specified for generators with stationary nonemergency engines or nonroad engines for mobile applications.

RICE NESHAP

TERMINOLOGY AND DEFINITION

Title 40, Part 63, Subpart ZZZZ (63.6580) of the Code of Federal Regulations (CFR) covers the National Emission Standards for Hazardous Air Pollutants (NESHAP) for Reciprocating Internal Combustion Engines (RICE).

The regulation applies to both existing and new engines. However, new engines required to meet New Source Performance Standards (NSPS), such as a combustion ignition (CI) engine, are compliant with RICE NESHAP, and no further requirements apply. Therefore, RICE NESHAP is a primary consideration of engines built prior to model year 2007.

It is the responsibility of the engine owner to review and comply with RICE NESHAP for an existing engine.

NESHAP FOCUS

The intent of the regulation is to reduce pollutants from nonregulated nonemergency engines. Emergency engines are excluded.

The EPA has determined that carbon monoxide (CO) is the most effective indicator of the pollutants. Therefore, the regulation seeks a percent reduction of measured CO from the engine.

The applicability and compliance criteria are determined by site classification and size of the engine determined by horsepower rating. The table in *Figure 1* below provides an overview of the percent of CO reduction required to bring an affected engine into compliance.

A combustion ignition engine would typically require a field-added diesel oxidation catalyst (DOC) to become compliant.

Figure 1

CO Reduction – NESHAP for Stationary Diesel (CI) Engines		
Area Sources		
Nonemergency 300 < hp ≤ 500	49 ppmvd CO	70%
Nonemergency > 500 hp	23 ppmvd CO	70%
Major Sources		
Nonemergency 100 ≤ hp ≤ 300	230 ppmvd CO	
Nonemergency 300 < hp ≤ 500	49 ppmvd CO	70%
Nonemergency > 500 hp	23 ppmvd CO	70%

NONROAD DIESEL ENGINES

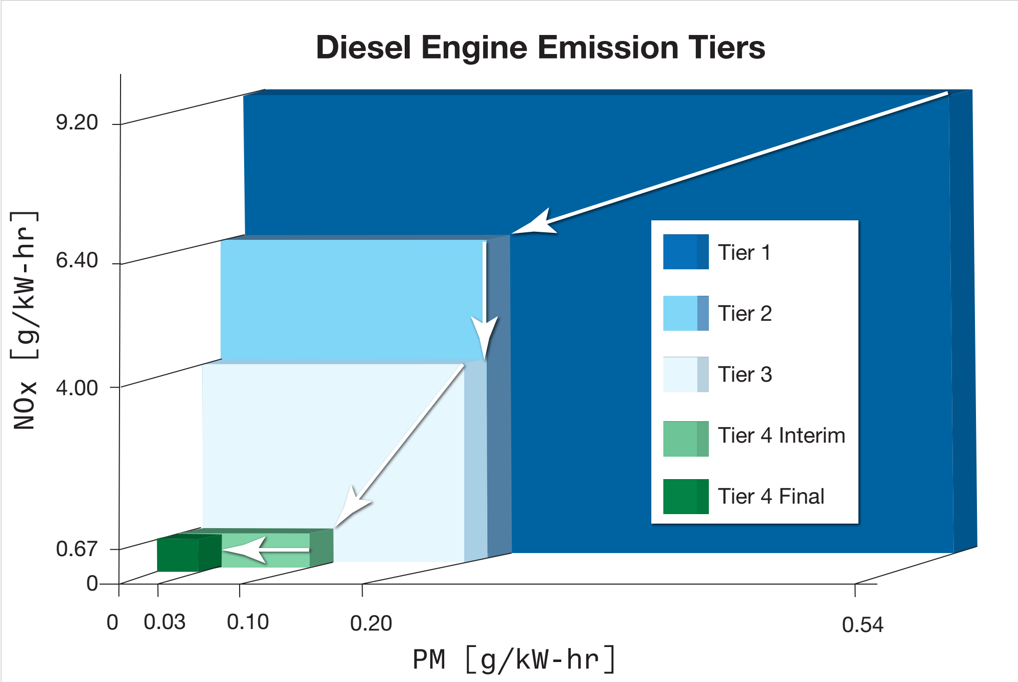
Title 40, Part 1039, formerly 89, of the CFR covers the EPA emission standards for nonroad diesel engines. The standard is applicable to a wide range of construction, agricultural, and industrial equipment.

Diesel generators mounted on either a trailer or a skid meant for transport must abide by nonroad diesel emission regulations, not the stationary emissions discussed later in this paper. The standard classifies stationary engines by brake horsepower and use type.

Depending on the classification of the engine, it must be below or at levels of emissions for nitrogen oxides (NOx), particulate matter (PM), CO, and hydrocarbons (HC).

The standards for nonroad diesel engines were first introduced in 1994. Multiple iterations were made to enforce increasingly stringent regulations. This phased approach has taken on an industry designation as tiers. Tiers 1–3, phased in by 2008, were met by advanced engine design to limit the creation of the pollutants. See *Figure 2*.

Figure 2



TIER 4 REGULATIONS

The latest Tier 4 regulation was announced in 2004 with a phase-in period from 2008 to 2015 to allow engine and equipment manufacturers time to prepare products to meet the stringent requirements. See *Figure 3*.

Tier 4 regulations require the NOx and PM levels of diesel engines to be reduced upwards of 90% from previous tiers. To achieve such levels, exhaust aftertreatment systems are required.

The primary reason is NOx and PM formation has an inverse relationship. PM forms from partial combustion of diesel fuel in cooler parts of the cylinder. NOx is the result of high cylinder temperatures oxidizing some of the nitrogen from the air.

The trade-off, unfortunately, is an inverse relationship when it comes to in-cylinder engine management for performance and emissions. See *Figure 4*.

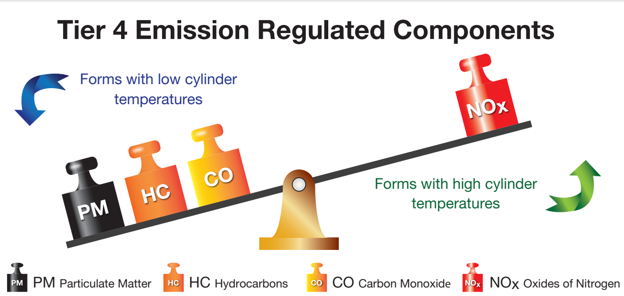
Figure 3

Phase-In Program for Nonroad Engines

Year	2008	2009	2010	2011	2012	2013	2014	2015
kW <8	0.40/7.5/8.0 (Table 1 1039.102 & Table 1 1039.101)							
8 ≤ kW ≤ 19	0.40/7.5/6.6 (Table 1 1039.102 & Table 1 1039.101)							
19 ≤ kW ≤ 37	0.30/7.5/5.5 (Table 2 1039.102)					0.03/4.5/5.5 (Table 2 1039.102 & Table 1 1039.101)		
37 ≤ kW ≤ 56	0.30/4.7/5.0 (Table 3 1039.102)					0.03/4.7/5.0 (Table 3 1039.102 & Table 1 1039.101)		
56 ≤ kW ≤ 75					0.02/4.7/5.0 (Table 4 1039.102)		0.02/0.40 + 0.19/5.0 (Table 4 1039.102 & Table 1 1039.101)	
75 ≤ kW ≤ 130					0.02/4.0/5.0 (Table 5 1039.102)		0.02/0.40 + 0.19/5.0 (Table 5 1039.102 & Table 1 1039.101)	
130 ≤ kW ≤ 560				0.02/4.0/3.5 (Table 6 1039.102)			0.02/0.40 + 0.19/3.5 (Table 6 1039.102 & Table 1 1039.101)	
560 ≤ kW ≤ 900				0.10/3.5 + 0.40/3.5 (Table 7 1039.102)				0.03/0.67 + 0.19/3.5 (Table 1 1039.101)
kW >900				0.10/0.67 + 0.40/3.5 (Table 7 1039.102)				

Chart Legend PM/NOx + NMHC/CO — Tier 4i — Tier 4

Figure 4



NSPS FOR CI STATIONARY ENGINES

NEW SOURCE PERFORMANCE STANDARDS

Title 40, Part 60, Subpart IIII of the CFR covers the New Source Performance Standards (NSPS) for stationary reciprocating internal combustion engines.

The emissions levels of the various categories are based off emission levels enforced for various types of mobile equipment; therefore, no new engines emission levels were instituted with the ruling. Much of the ruling is based on the content of Title 40, Part 89, that governs nonroad diesel engines.

The standards were first introduced in 2005 and phased in completely by 2015. The phase-in program for the stationary nonemergency engines can be seen in *Figure 5*.

By the end of 2014, the phase in was complete meaning all stationary nonemergency engines model year 2015 or newer are required to be Tier 4-certified to be sold into or operated in the U.S. To meet Tier 4 levels, a diesel engine will typically require a least one form of exhaust aftertreatment.

Advanced engines, such as the KD Series™, are able to reduce the formation of the majority of the pollutants in the cylinder and only leave NOx to be addressed with an aftertreatment device. Engines not capable of this will require the use of multiple aftertreatment devices.

For an explanation of diesel engine exhaust aftertreatment systems, refer to Rehlko Power Systems white paper *Diesel Generator Emissions Technologies and Aftertreatment Devices.*

Figure 5

Phase-In Program for Stationary Non-Emergency Engines

Engine Generator											
kWm	kWe	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
8 -<19	10-15		6.6/7.5/0.40								
19 -<37	15-20		5.5/7.5/0.30					5.5/4.7/0.03			
37 -<56	20-40		5.0/7.5/0.30					5.0/4.7/0.03			
56 -<75	40-60		5.0/4.7/0.40				5.0/2.3/0.02			5.0/0.19/0.40/0.02	
75 -<130	80-100	5.0/4.0/0.30					5.0/2.3/0.02			5.0/0.19/0.40/0.02	
130 -<560	125-450	3.5/4.0/0.20				3.5/2.0/0.02				3.5/0.19/0.40/0.02	
560 -<900	500-800	3.5/6.4/0.20				3.5/0.40/0.67/0.10				3.5/0.19/0.67/0.03	
>900	900-2000	3.5/6.4/0.20				3.5/0.40/0.67/0.10				3.5/0.19/0.67/0.03	
>2200	>=2000	11.4/1.3/9.2/0.54				3.5/0.40/0.67/0.10				3.5/0.19/0.67/0.03	

CO/NMHC+NOx/PM (g/kW-hr)
CO/NMHC/NOx/PM (g/kW-hr)

TIER 1 Effective
TIER 2 Effective
TIER 3 Effective
TIER 4 Interim Effective
TIER 4 Effective

The NSPS regulation has special exemptions for emergency-use engines, for instance, a standby generator only meant to operate during power outages or service and maintenance activities. The phase-in program for stationary emergency engines is shown in *Figure 6*.

The highest levels reached were selected to avoid the use of aftertreatment equipment due to the low runtime hours of emergency engines. The environmental and health impacts are negligible from these sources.

The stationary power generation market is primarily focused on providing backup power to a reliable utility grid. However, utilizing a diesel generator in a nonemergency application such as peak shaving or curtailment has many financial benefits. When doing so, there are certain provisions to Tier 4 regulations that a specifying engineer or end customer needs to be aware of.

Figure 6

Phase-In Program for Stationary Emergency Engines

Engine Generator											
kWm	kWe	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
8 -<19	10-15		6.6/7.5/0.40								
19 -<37	15-20		5.5/7.5/0.30								
37 -<56	20-40		5.0/4.7/0.40								
56 -<75	40-60		5.0/4.7/0.40								
75 -<130	80-100	5.0/4.0/0.30									
130 -<560	125-450	3.5/4.0/0.20									
560 -<900	500-800	3.5/6.4/0.20									
>900	900-2000	3.5/6.4/0.20									
>2200	>=2000	11.4/1.3/9.2/0.54				3.5/6.4/0.20					

CO/NMHC+NOx/PM (g/kW-hr)
CO/NMHC/NOx/PM (g/kW-hr)

TIER 1 Effective
TIER 2 Effective
TIER 3 Effective
TIER 4 Interim Effective
TIER 4 Effective

INDUCEMENT

The aftertreatment system is considered integral to a Tier 4 system. The EPA therefore dictates that a failure of the aftertreatment system constitutes a failure of the entire engine.

Instead of forcing an immediate shutdown, the engine enters Inducement. The intent is to induce the operator to fix the issue with the aftertreatment system. If the failure is not corrected in the allotted time, the engine power is limited until the issue is fixed. Examples of issues that may lead to inducement include poor diesel emission fluid (DEF) quality, sensor failures, or running out of DEF.

DEF REFILL INTERVAL

DEF must not run out before diesel fuel under normal operating conditions. Therefore, sizing of DEF storage must correlate to the amount of diesel fuel storage.

For a stationary generator this can require calculating the size of multiple tanks, as day tanks are commonplace, especially for indoor installations.

CRANKCASE VENTILATION

Tier 4 engines do not require the use of closed crankcase ventilation (CCV). However, the emissions from open crankcase systems are included in the total emissions of the engine. Therefore, most Tier 4 engines will include a CCV to reduce the overall emissions.

DIESEL ENGINE EMISSION TEST CYCLES

EMISSIONS VALUES DEFINED

Emission values are referred to as either meeting a Tier level (nominal values) or a Potential to Emit (not to exceed) level. The two classifications are both important but relate to two different reported values, nominal and not to exceed.

NOMINAL VALUES

According to EPA ISO 8178 Constant Speed D2 5-Mode Cycle, the emissions levels previously referenced throughout this white paper all are values related to the ISO 8178 Constant Speed Test Cycle. Nominal data is captured in a test cell under controlled conditions (e.g., controlled environment test conditions). The testing is completed by taking a weighted average of the engine emissions at five steady state points. The five modes are weighted and averaged as shown in *Figure 7.* The weighted levels are then used to measure compliance against an EPA standard.

Figure 7

ISO 8173 Constant Speed D2 5-Mode Cycle					
Mode Number	1	2	3	4	5
Speed	Rated Speed				
Torque	100%	75%	50%	25%	10%
Weighting	5%	25%	30%	30%	10%

NOT TO EXCEED VALUES

Not to exceed data adds a safety factor to the nominal data for field conditions that cannot be controlled in a lab (e.g., ambient, humidity, production engine tolerances, and field emission test methods). It is important to work with regional requirements for permitting stationary engines to understand which emissions data—nominal or not to exceed/potential to exceed (NTE/PTE)—and which engine operating loads are requested for the permit data. If there will be stack-testing requirements, the NTE data would be required.

REHLKO ADVANTAGES

KD SERIES™ EMISSION TECHNOLOGY

Rehlko Power Systems has 100 years of experience in industrial on-site power generation. Our industry experts are constantly monitoring and adjusting to new regulations.

You can be assured that a Rehlko® generator set is powered by an engine compliant with all applicable federal U.S. EPA exhaust emissions regulations. Utilizing this expertise, Rehlko KD Series engines were developed to offer industry leading emissions technology making them a top choice for all market segments including data centers, healthcare, and water and wastewater treatment.

In addition, the 2000 kW and larger KD Series emergency standby (Tier 2 emissions) generators also have low-NOx calibrations that can be utilized –to avoid using aftertreatment equipment in many nonattainment areas with NOx concerns.

SUMMARY

Understanding emission requirements is an important step to ensure the correct generator set is selected for an application. This white paper covered federal emission standards for diesel engines powering generator sets in the U.S. In addition to these regulations, local or regional regulations that enforce limits more stringent than the federal standards, may exist. It remains the responsibility of the specifying engineer to understand both the federal and the local requirements.

A local Rehlko representative is ready and willing help with questions and provide explanations. Each Rehlko representative works with both federal and local regulations on a regular basis and is backed by Rehlko's factory emissions experts.

ADDITIONAL RESOURCES

INTERNET LINKS

1. EPA Emissions Standards: https://www.epa.gov/regulatory-information-topic/regulatory-and-guidance-information-topic-air#stationarysources

2. Electronic Code of Federal Regulations (eCFR): https://www.ecfr.gov/

3. CARB California Air Resources Board (CARB) Emergency Backup Generators: https://ww2.arb.ca.gov/our-work/programs/emergency-backup-generators

4. South Coast AQMD Emergency Generator Fact Sheet: https://www.aqmd.gov/home/permits/emergency-generators

ABOUT THE AUTHOR

Justin Loritz, Product Manager–Large Diesel Generators, has more than 16 years of experience with Rehlko in various roles within the organization. After graduating from Michigan Technological University with a B.S. in mechanical engineering, he began his career supporting the large diesel assembly team as process engineer and progressed through a variety of roles, including lead design engineer for the Rehlko diesel marine product line, production manager for large generator assembly, and principal engineer of manufacturing systems. Justin has extensive knowledge of Rehlko KD Series™ products and the needs of customers within this product category.

ABOUT POWER SYSTEMS

Power Systems, Rehlko's largest division, delivers worldwide energy solutions designed to ensure resilience for mission-critical applications of all sizes. Building on more than a century of expertise and dedication, the company offers complete power systems, including industrial backup generators (HVO, diesel, gaseous), enclosures, hydrogen fuel cells systems, automatic transfer switches, switchgear, monitoring controls, genuine parts and end-to-end services. As a global company with service partners in every country, Power Systems provides reliable, cutting-edge technology to keep industries and businesses running.
www.powersystems.rehlko.com

ABOUT REHLKO

A global leader in energy resilience, Rehlko delivers innovative energy solutions critical to sustain and improve life across home energy, industrial energy systems, and powertrain technologies, by delivering control, resilience and innovation. Leveraging the strength of its portfolio of businesses – Power Systems, Home Energy, Uninterruptible Power, Clarke Energy, Heila Technologies, Curtis Instruments, and Engines, and more than a century of industry leadership, Rehlko builds resilience where and when the grid cannot, and goes beyond functional, individual recovery to create better lives and communities, and a more durable and reliable energy future.

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