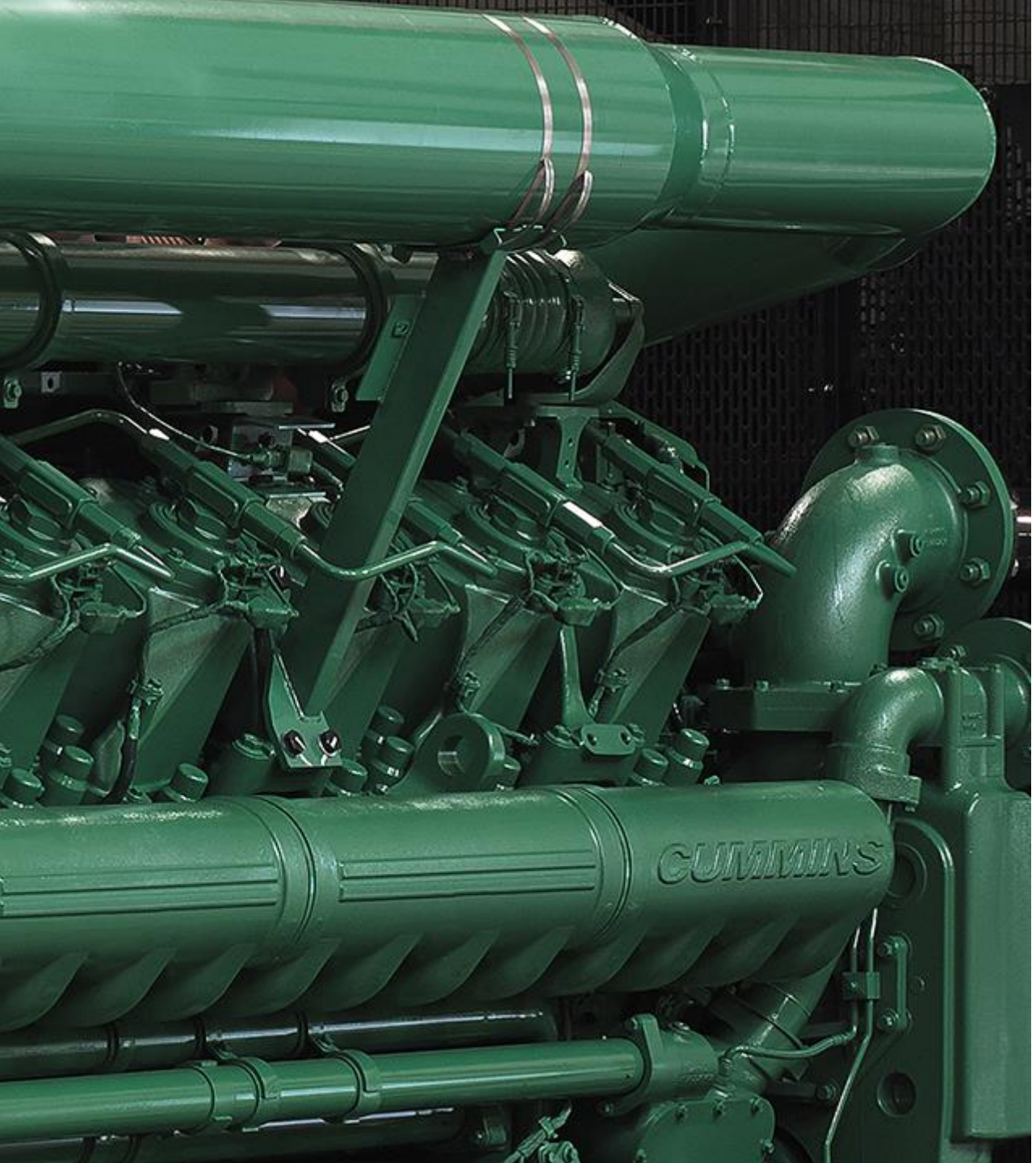

Emissions and Air Permitting Requirements for Standby Generator Sets

PowerHour webinar series for consulting engineers

Experts you trust. Excellence you count on.

August 27, 2020 2:00pm Eastern Time / 11:00am Pacific Time
(1 PDH issued by Cummins Inc.)

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- Interact with Cummins experts and gain access to ongoing technical support
- Participate at your convenience, live or on-demand
- Earn Professional Development Hours (PDH)

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Product Strategy and Sales Enablement Leader
Cummins Inc.

Rich Scroggins
Technical Advisor - Data Center Markets
Cummins Inc.

Cummins facilitator:

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Disclaimer

The views and opinions expressed in this course shall not be considered the official position of any regulatory organization and shall not be considered to be, nor be relied upon as, a Formal Interpretation.

Participants are encouraged to refer to the entire text of all referenced documents. In addition, when it doubt, reach out to the Authority Having Jurisdiction.

Course Objectives

Emissions and Air Permitting Requirements for Standby Generator Sets

Air permitting for standby generator sets can vary wildly from site to site and when misunderstood can have a major impact on project success. Although EPA regulations have stabilized and are thought to be well understood, ever-increasing local requirements are changing the criticality of air permitting for engine-driven generator sets.

This course will provide a brief overview of regulated emissions constituents and their formation in order to provide a foundational understanding of engine emissions. Next, the EPA's New Source Performance Standards (NSPS) will be reviewed as it relates to both compression ignited (diesel) and spark ignited (natural gas or propane) engine equipped generator sets. Participants will gain an awareness of common pitfalls related to emissions permitting and will be introduced to various strategies employed to meet local emissions regulations.

After completing this course, participants will be able to:

- Recognize commonly regulated exhaust emissions constituents.
- Describe EPA emissions requirements for diesel and gaseous standby generator sets.
- Identify common requirements for permitting engine-driven generator sets.

What are some common air quality permitting requirements that apply to stationary emergency generator sets?

Exhaust Emissions Formation

$C_XH_YS_Z$

+

O_2+N_2

=

$CO_2+H_2O+O_2+N_2$

+

$NO_x+HC+CO+SO_x+C$

Fuel

Air

Major Exhaust Constituents

Trace Exhaust Components

Exhaust Emissions Formation

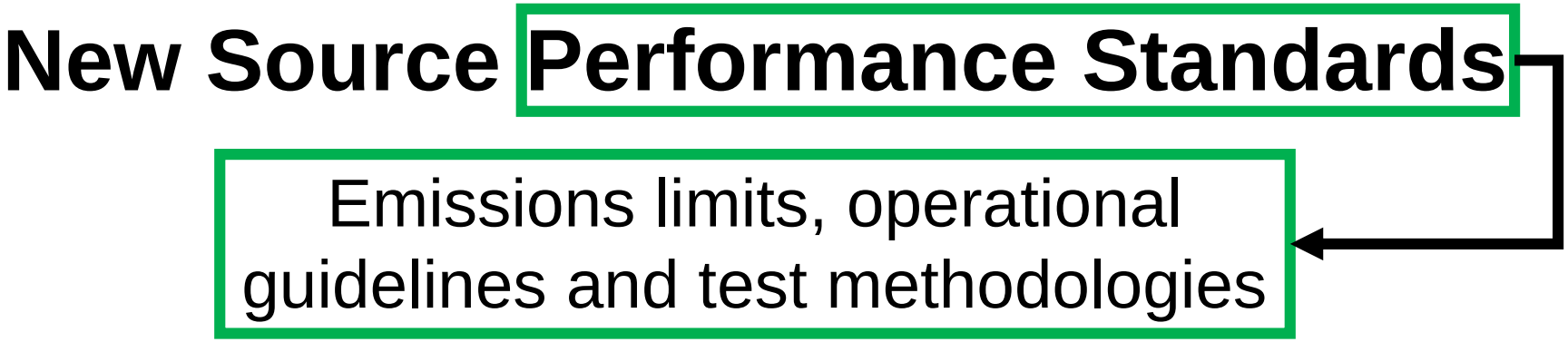
	What is it?	How is it formed?	CI	SI
NO_x	Oxides of nitrogen (NO and NO_2)	Forms at high in-cylinder temperatures, most prominent during high engine load.	✓	✓
HC	Over 100 different types of hydrocarbons	Product of incomplete combustion, most prominent during low engine load.	✓	✓
NMHC	Non-methane hydrocarbons, subset of total hydrocarbons	Product of incomplete combustion, dependent on fuel composition.	✓	✓
VOC	Volatile organic compounds	Primarily hydrocarbons but may include other compounds.		✓
PM	Anything that is trapped on or condenses onto a filter	Most prominent during low load operation.	✓	
CO	Carbon monoxide	Product of imperfect combustion, most prominent during low engine load.	✓	✓
SO_x	Oxides of sulfur (SO and SO_2)	Product of combustion process when sulfur is present. Increases linearly with fuel consumption.	✓	✓

New Source Performance Standards (NSPS) for Compression-Ignited and Spark-Ignited engines

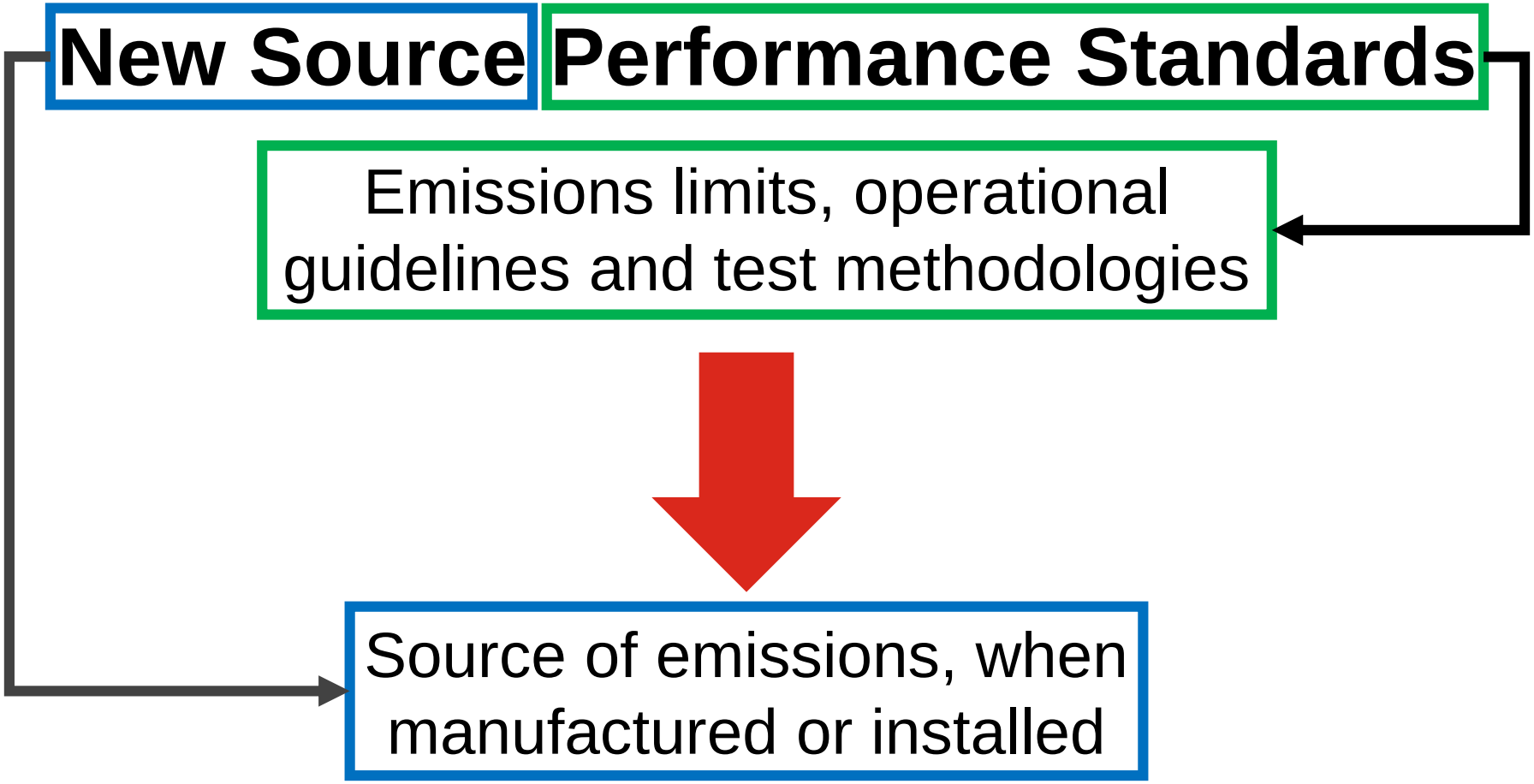
What is NSPS?

New Source Performance Standards

What is NSPS?

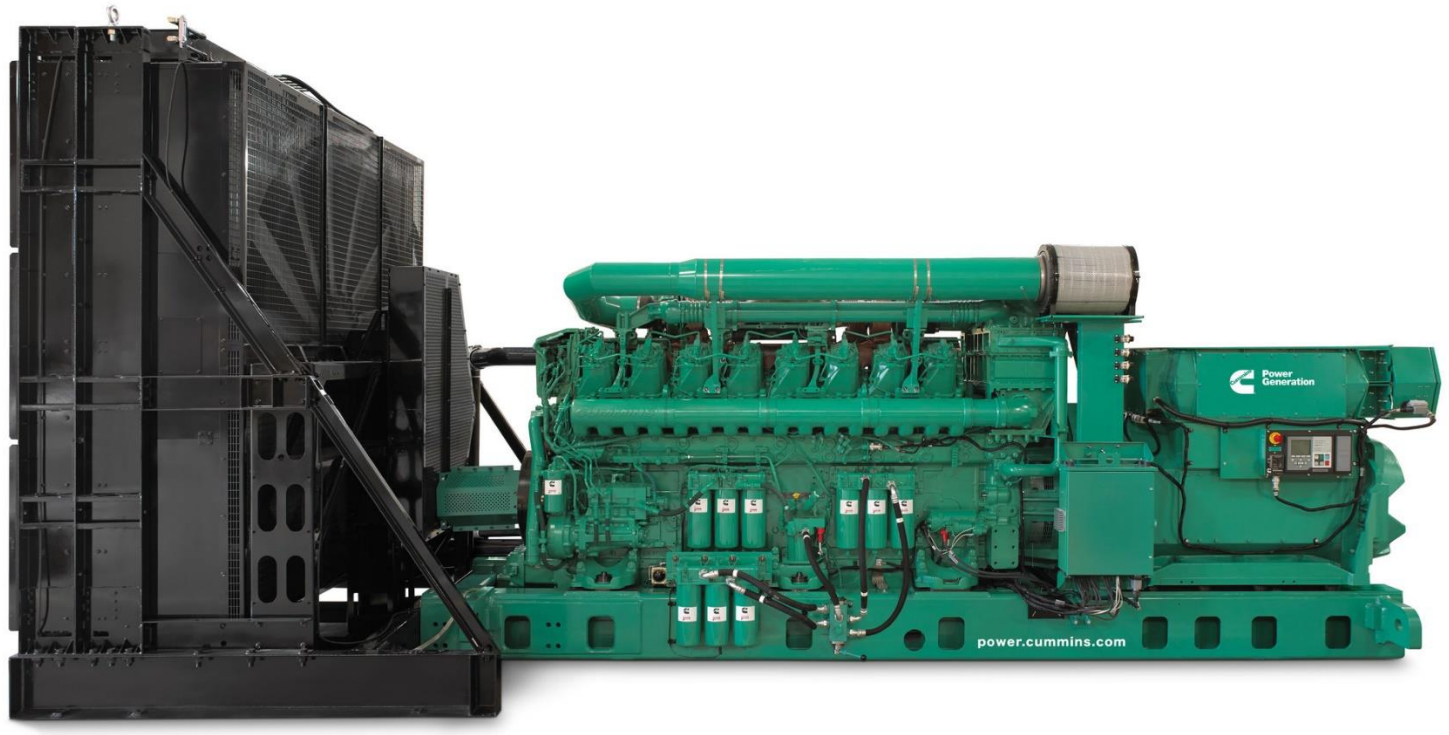

New Source Performance Standards
Emissions limits, operational guidelines and test methodologies

What is NSPS?


New Source Performance Standards
Emissions limits, operational guidelines and test methodologies
Source of emissions, when manufactured or installed

Requirements for EPA Certified Engines

- Engines are certified, not generator sets.



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kW	(hp)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
0-7	0-10	(7.5) / 8.0 / 0.40												
8-18	11-24	(7.5) / 6.6 / 0.40												
19-36	25-48	(7.5) / 5.5 / 0.30			(4.7) / 5.5 / 0.03 **Emergency: Stay at previous tier**									
37-55	49-74	*Optional T4i 0.30 PM*			(4.7) / 5.0 / 0.03 **Emergency: Stay at previous tier**									
56-129	75-173	Tier 3		3.4 / 0.19 / 5.0 / 0.02 **Tier 3**			0.40 / 0.19 / 5.0 / 0.02 **Tier 3**							
130-560	174-751	Tier 3	2.0 / 0.19 / 3.5 / 0.02 **Tier 3**			0.40 / 0.19 / 3.5 / 0.02 **Tier 3**								
> 560	> 751	Tier 2	3.5 / 0.40 / 3.5 / 0.10 **Tier 2** *0.67 / 0.40 / 3.5 / 0.10 (a)*				3.5 / 0.19 / 3.5 / 0.04 **Tier 2** *0.67 / 0.19 / 3.5 / 0.03 (b)*							
		T2	T3	Tier 4 Interim			Tier 4 Final							

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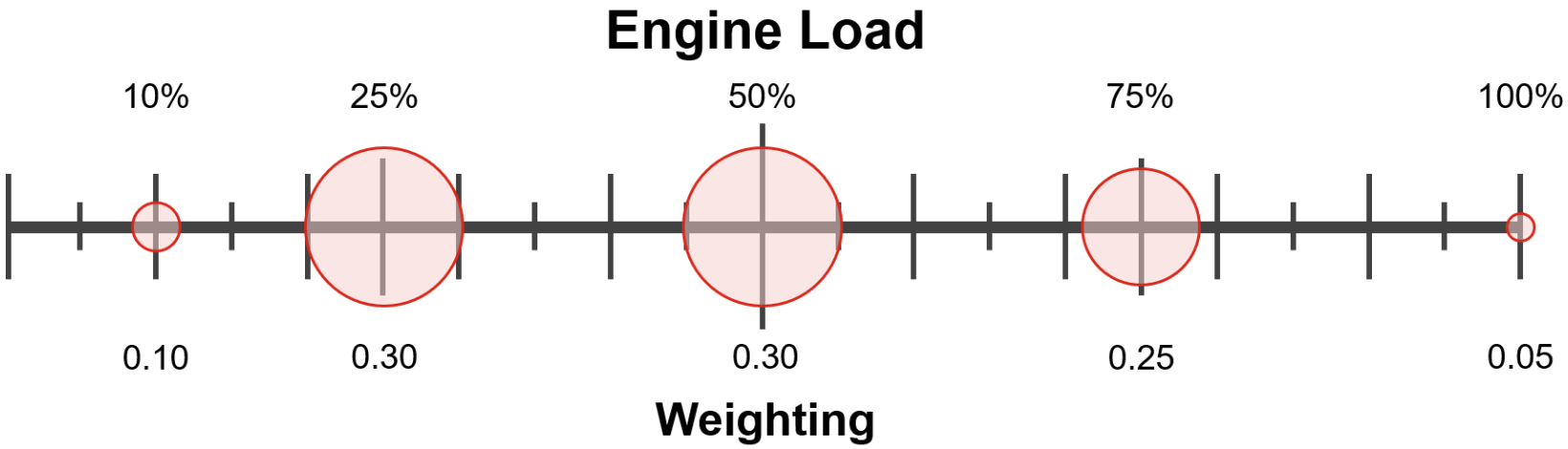

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- Engines are required to meet emissions levels based on their date of manufacture, usage and brake horsepower rating.
- Emissions levels are evaluated on a standardized test cycle including engine load and pollutant weighting following a specific test method in a test-cell environment.
- Engines and emissions control devices must be certified as a complete solution by the engine manufacture (field upfit or third-party installations cannot meet certification requirements).

Stationary and Nonroad Engines

Stationary

- On site for at least 12 consecutive months.
- Unable to be mounted on a trailer or be mobilized.

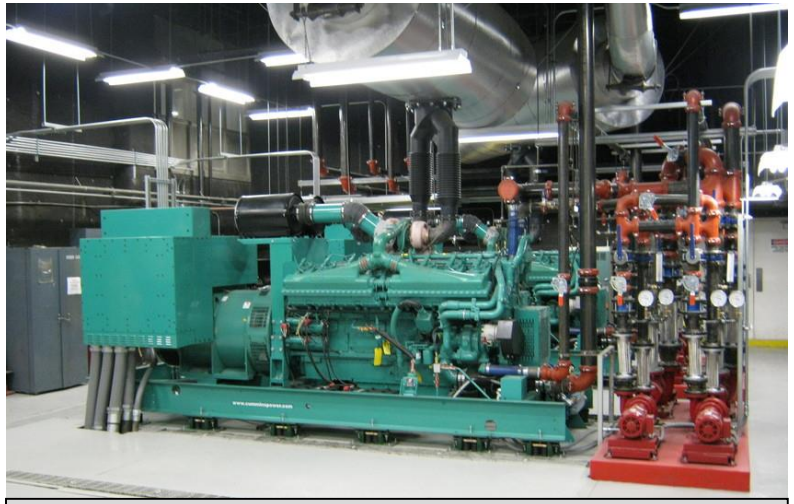
Nonroad

- No movement or operation restrictions.
- Must comply most stringent emissions requirements.

Stationary Emergency Operation

- Emergency standby (safe evacuation, life support)
- Legally required standby (fire–fighting operations)
- Optional standby (could cause an economic loss)

Standby power system including seven C2000 D6 (2000 kWe) generator sets.



Standby system including two DQGAA (1250 kWe) and one DQGAB (1500 kWe).

Stationary Emergency Operation

- Unlimited use during emergencies.

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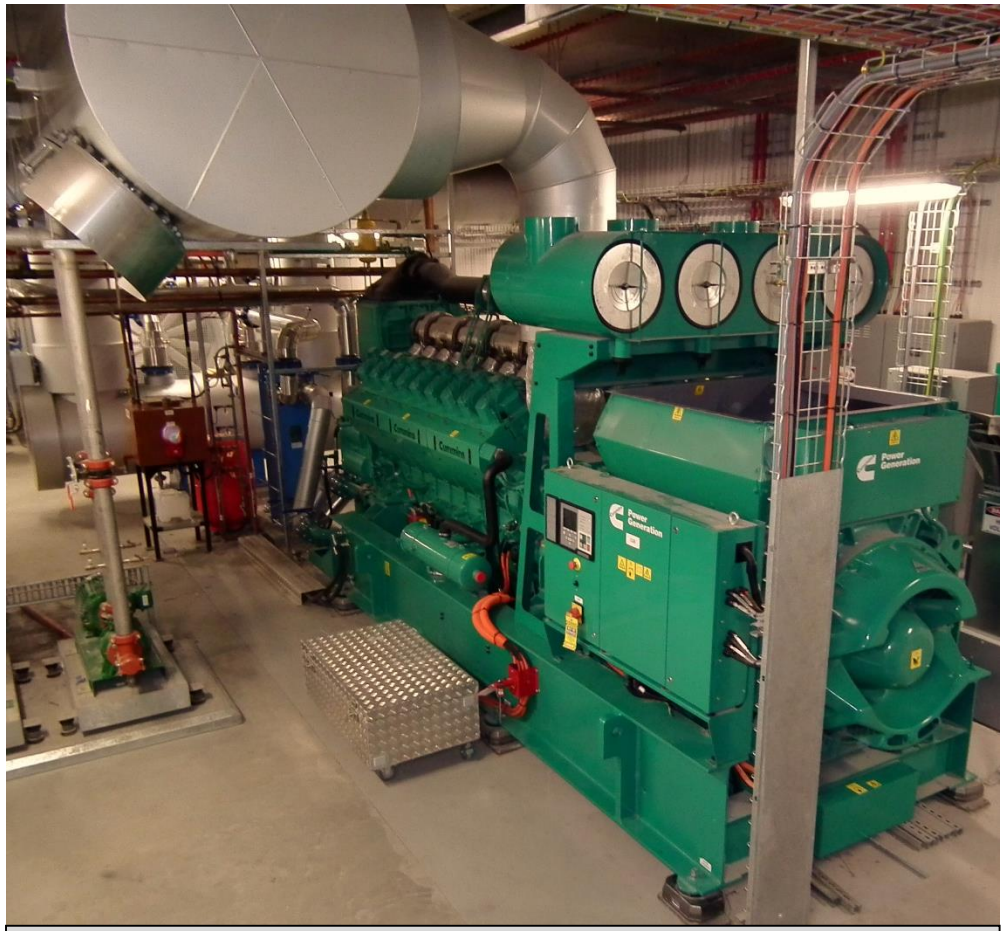
  - Emergency Demand Response (EDR) allowance vacated in May 2015

Spec Note Generator set manufacturer shall provide documentation demonstrating compliance with applicable limits of U.S. EPA New Source Performance Standards for stationary emergency engines.

Stationary Non-Emergency Operation

Remote mining site including two DQGAS (1500 kWe) generator sets.



Combined heat and power project producing steam with one C2000 N5C (2000 kWe) generator set.

Stationary Non-Emergency Operation

- Demand Response
- Peak shaving (reduce or flatten peak electricity use)
- Rate curtailment (favorable energy rates)
- Interruptible rate programs (favorable energy rates)
- Continuous base load (constant power to utility grid)
- Co-generation (capture and use waste heat)
- Prime power generator set (to be used as a primary source of power)

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- Prime power generator set (to be used as a primary source of power)

Spec Note Generator set manufacturer shall provide documentation demonstrating compliance with applicable limits of U.S. EPA New Source Performance Standards for stationary non-emergency engines.

Concept Check

The EPA designates certification requirements for _____ based on _____ and _____.

a) Generator Sets, Electrical Output, NEC Load Type
b) Engines, Brake Power, Usage
c) Power production equipment, Alternator rating, ISO 8528 rating

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b) Engines, Brake Power, Usage

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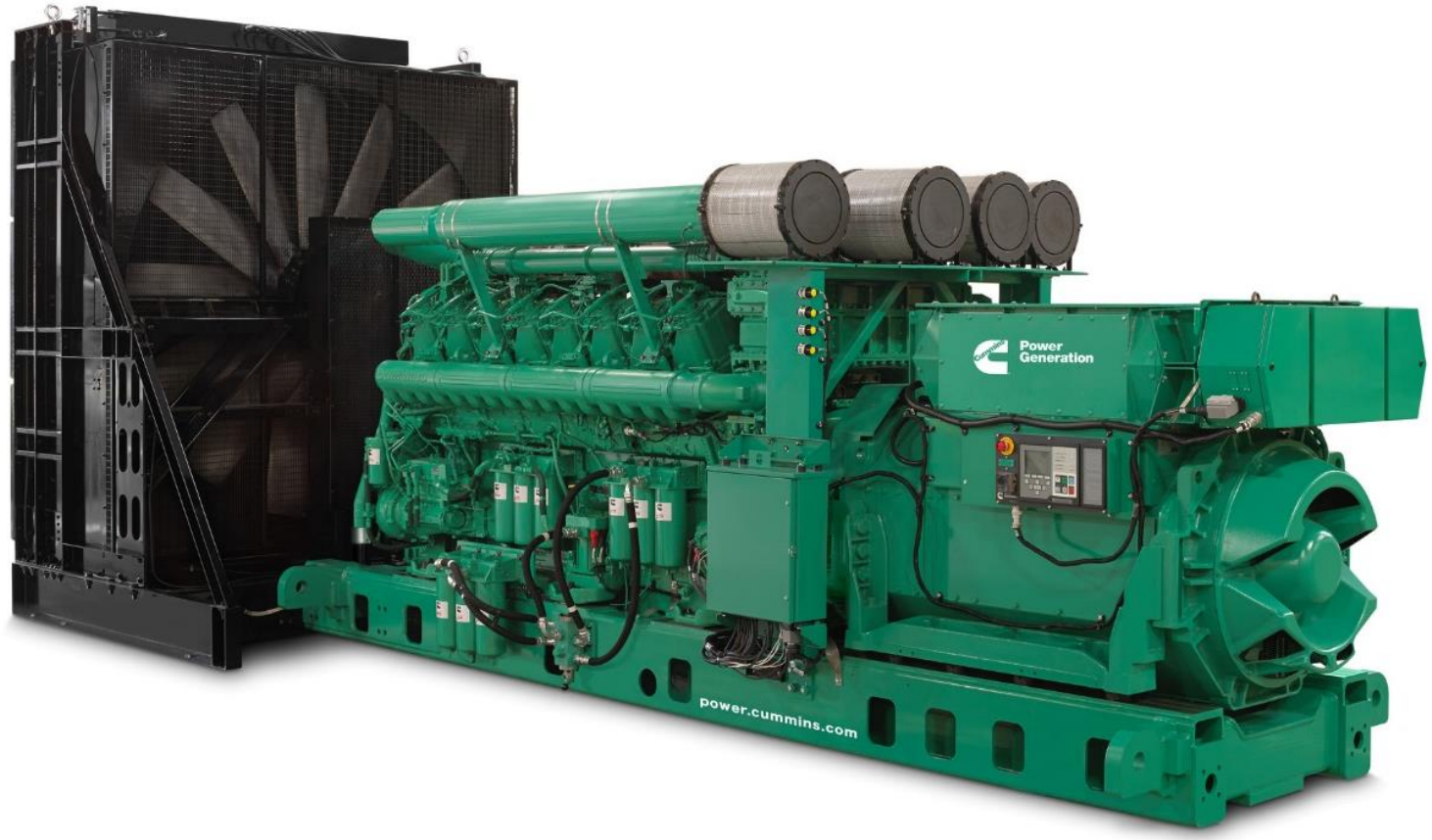
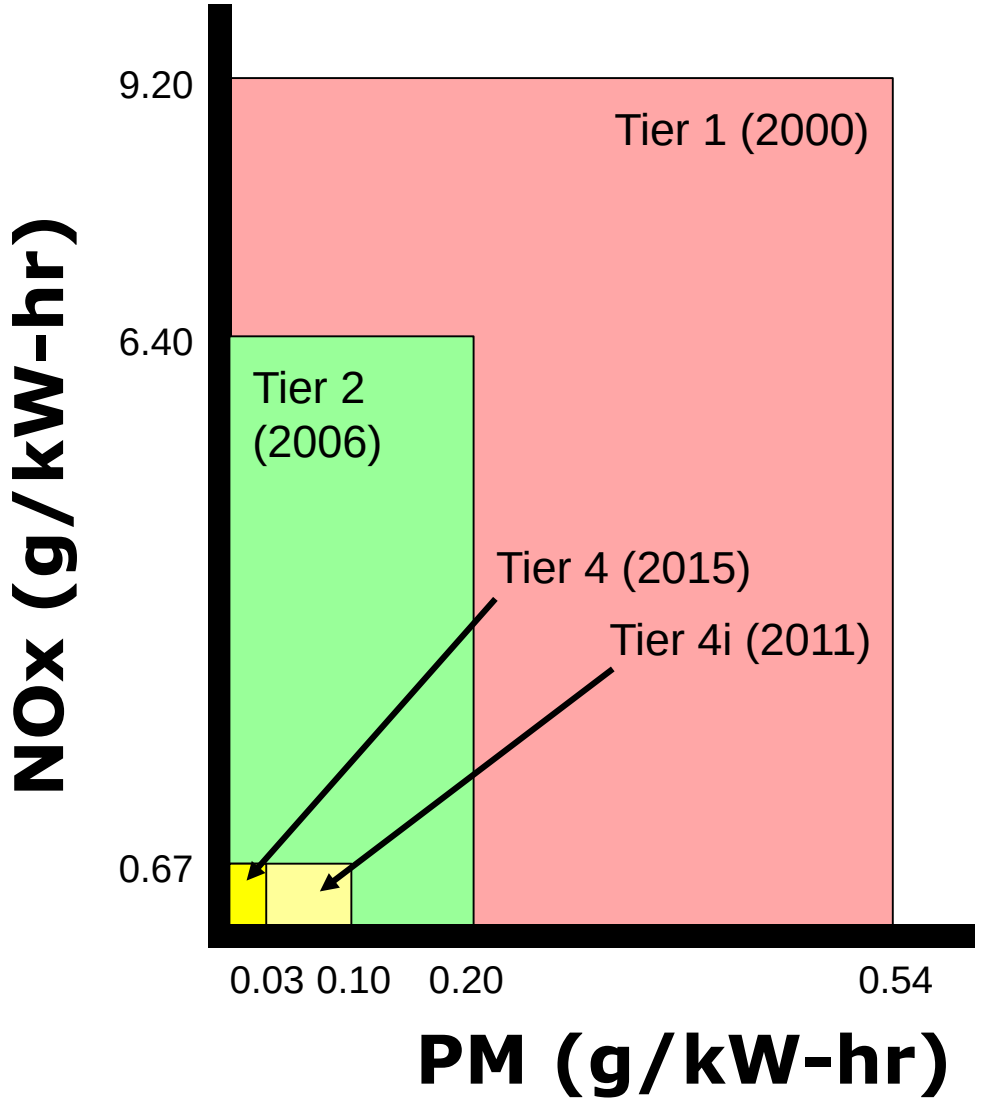
New Source Performance Standards (NSPS) for Stationary CI engines

Title 40, Part 60: Subpart IIII



Evolution of NSPS CI Engine Regulations

EPA Non-Road / Stationary Non-Emergency Engines >751 HP



EPA NSPS for CI Engines

Regulated Emissions Levels

kW	(hp)	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
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		T2	T3	Tier 4 Interim			Tier 4 Final							

(a) Applies to non-emergency power gen engines > 900kW (> 1207hp).

(b) Applies to non-emergency power gen engines > 560kW (> 751hp).

Emergency engine tier levels shown in **RED**

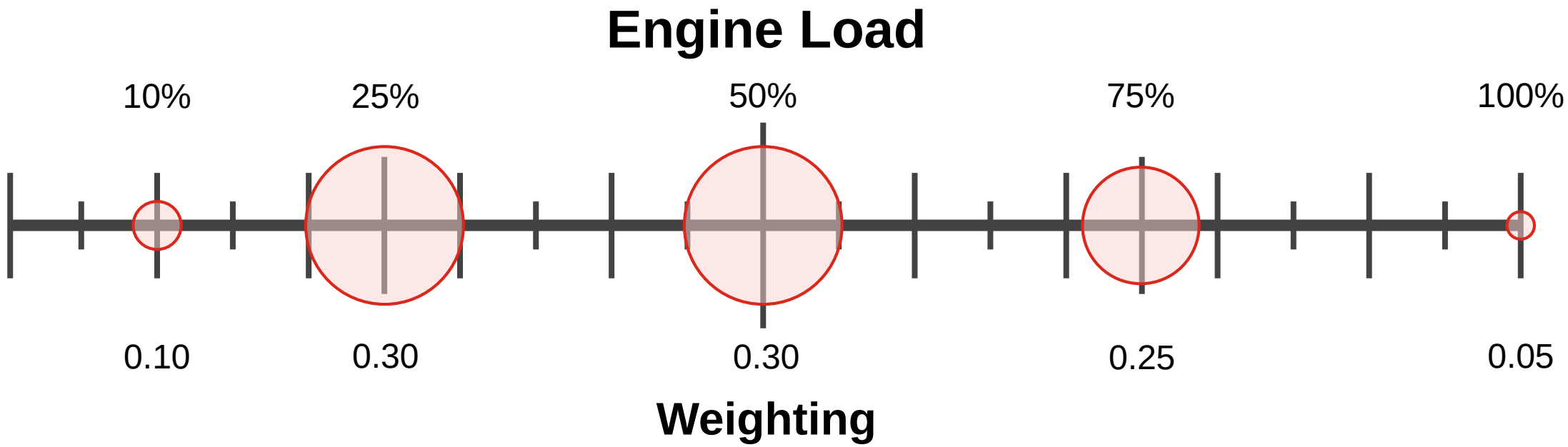
NOx / NMHC / CO / PM (g/kW-hr)

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

Certified product follows ISO 8178 D2 - 5 Mode Test Cycle for constant speed engines

EPA NSPS for CI Engines

Pollutant and Engine Load Weighting



EPA NSPS for CI Engines

Mandatory Manufacturer Certification

CI Engines including exhaust aftertreatment must be certified as a complete solution by engine manufacturer.

- Stationary Emergency (e.g. Tier 2)

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- Stationary Emergency certified with third-party provided aftertreatment meeting Stationary Non-Emergency limits (e.g. Tier 4)

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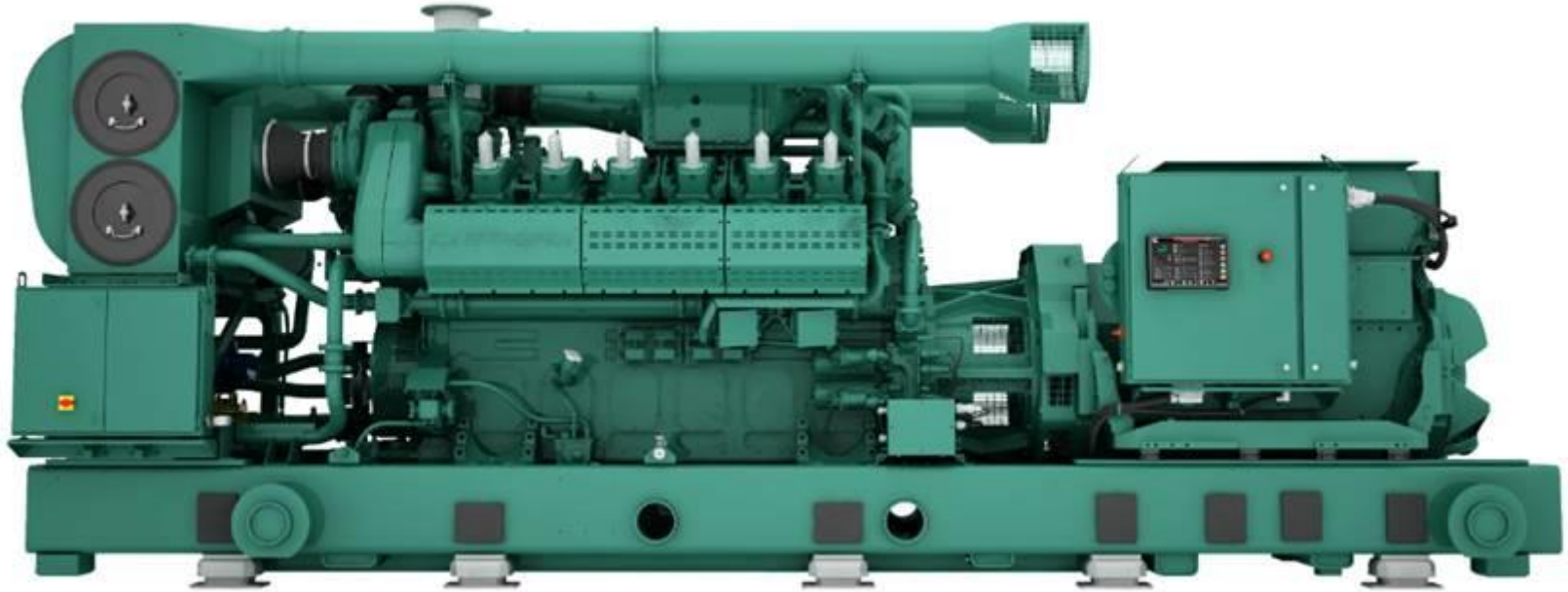
COMPLIANCE ≠ CERTIFICATION

New Source Performance Standards (NSPS) for Stationary SI engines

Title 40, Part 60: Subpart JJJJ



EPA NSPS for SI Engines

Regulated Emissions Levels

Mandatory or Voluntary			HP	NOx/CO/VOC (g/bhp-hr) (NOx + HC) / CO (g/bhp-hr) 2015	2016	2017	2018	2019	2020	2021
NG / LPG: Non-emergency										
V	NG	RB	26-99 >100	1048 or for on- site ver. use 1048.101(c) for in- field test 1.0 / 2.0 / 0.7						
V	NG	LB	26-99 >100	1048 or for on- site ver. use 1048.101(c) for in- field test 1.0 / 2.0 / 0.7						
V	LPG	LB	26-99 >100	1048 or for on- site ver. use 1048.101(c) for in- field test 1.0 / 2.0 / 0.7						
M	LPG	RB	>25	1048 cert: (2.7)/4.4						
Natural Gas / LPG: Emergency										
V	NG & LB LPG		26-129 > 130	90.103 phase 1 class II cert: (10) / 387 2.0 / 4.0 / 1.0						
M	LPG RB		26-129 > 130	90.103 phase 1 class II cert: (10) / 387 1048 full cert: 2.0 / 4.0 / 1.0						
Landfill / Digester Gas										
V	All LB & RB		All	2.0 / 5.0 / 1.0						

Notes

1. Gasoline engine requirements are same as those for RB LPG.
2. All new engines ≤ 25 hp must be certified to Part 90 on July 1, 2008.
3. Engines ≤ 40 hp that are ≤ 1000 cc may instead comply with Part 90.
4. Emergency engines limited to 100 hours per year for maintenance and testing.
5. O/O of new non-emergancy LB SI engines ≥250hp at a major source complying with 40 CFR 63 ZZZZ Table 2a do not have to comply with CO emissions of above table

EPA NSPS for SI Engines

Regulated Emissions Levels

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	LPG	LB	26-99	1048 or for on- site ver. use 1048.101(c) for in- field test						
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EPA NSPS for SI Engines

Certification Summary

- Mandatory factory certification of rich burn propane engines
- Optional factory certification of all natural gas engines and lean burn propane engines
- If not factory certified, the owner/operator must perform certain tasks:

Engine Power	Maintenance plan and records, maintain/operate engine in a way to minimize emissions	Initial performance testing within 1 year of engine startup	Subsequent performance testing every 8,760 hours or 3 years, whichever comes first
< 100 hp	✓		
100-500 hp	✓	✓	
> 500 hp	✓	✓	✓

Air Permitting for Standby Generator Sets

"State and local agencies are not prevented from providing additional regulations beyond these regulations and such agencies may institute additional testing requirements independent of EPA related actions."

Response to Public Comments on Proposed Standards of Performance for Stationary Compression Ignition Internal Combustion Engines

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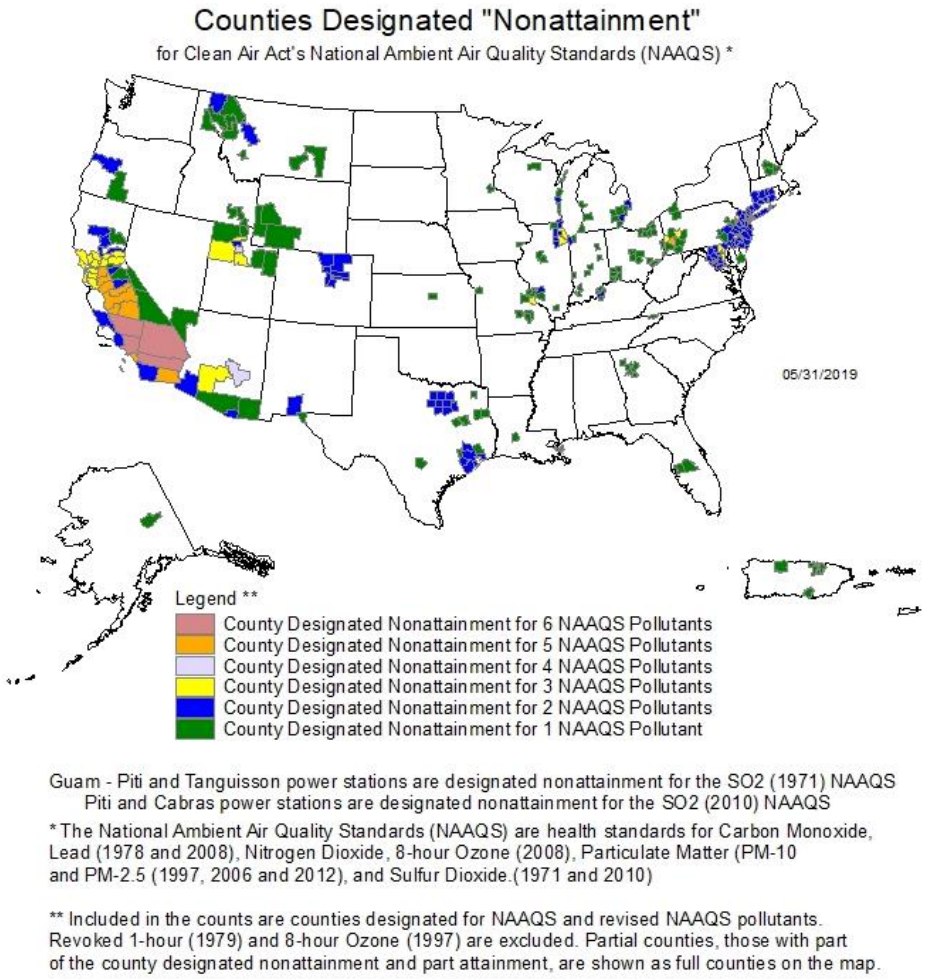
Air permitting for standby generator sets **can vary wildly from site to site** and when misunderstood can have a **major impact on project success**. Although EPA regulations have stabilized and are thought to be well understood, **ever-increasing local requirements are changing the criticality of air permitting** for engine-driven generator sets.

Air Permitting for Standby Generator Sets

National Ambient Air Quality Standards (NAAQS)

- Identifies pollutants that are harmful to human health.
- Establishes criteria pollutant limits for geographical areas:
  - CO, Pb, NO_2, O_3, PM and SO_2



Source: https://www3.epa.gov/airquality/greenbook/mapnpoll.html

Air Permitting for Standby Generator Sets

State / City / County Requirements

[redacted]

a. Emissions testing for each selected emergency engine-generator set shall consist of three one-hour test runs under load. The average of the three runs shall be reported as the short-term emission rate for that emergency engine-generator set.

b. Testing shall be conducted while operating at greater than ninety percent of the engine-generator set's standby rated capacity, unless multiple load band testing is approved by DEQ.

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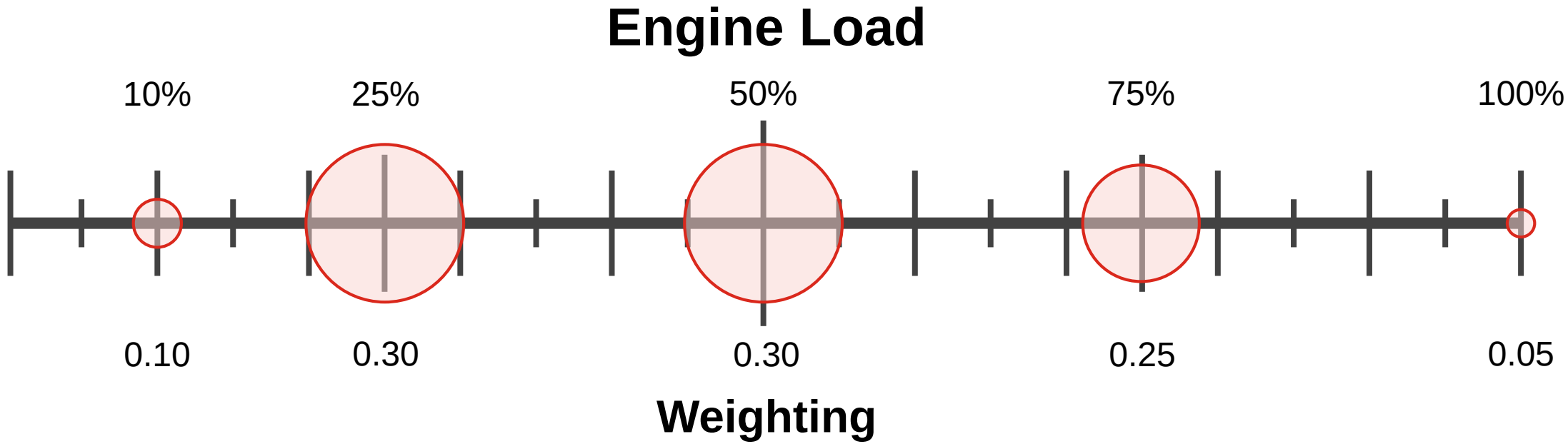

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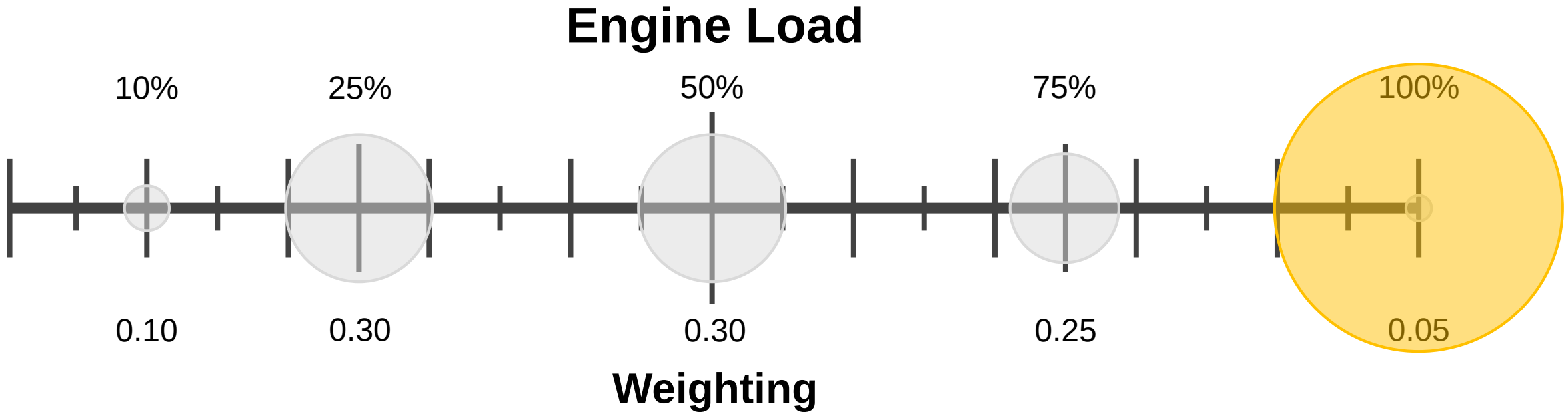

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Spec Note Generator set manufacturer shall provide documentation demonstrating compliance with specific emissions level requirement and applicable test methodology.

Air Permitting for Standby Generator Sets

Site Air Permitting Requirements

Permits are written to limit genset operation to keep site emissions within the limit

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Air Permitting for Standby Generator Sets

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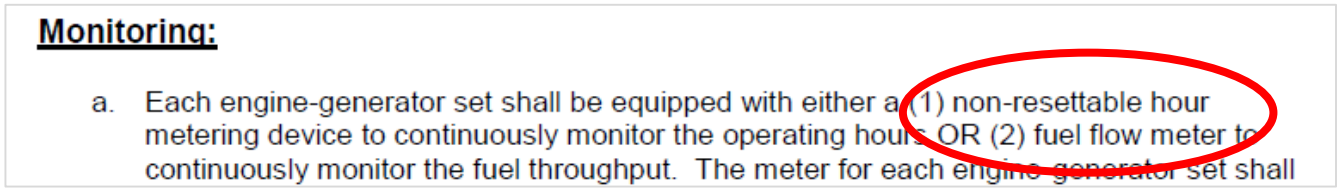
- Run hour monitoring typically assumes all generator sets are always operating at 100% of rated load
- Fuel consumption monitoring gives a more accurate representation of load profile and emissions and may allow for more flexibility in operation



Monitoring:

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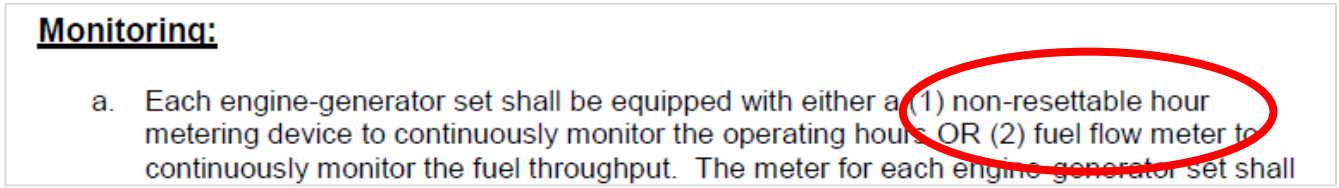

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"Exceedance of operating limits may be considered credible evidence of the exceedance of emission limits"

Air Permitting for Standby Generator Sets

Best Available Controls Technology (BACT)

"Emission limitation based on the maximum degree of emission reduction (**considering energy, environmental, and economic impacts**) achievable through application of production processes and available methods, systems and techniques." – EPA NSR Fact Sheet

Air Permitting for Standby Generator Sets

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  - Exhaust aftertreatment may be considered not available due to its economic impact

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- Local air quality boards have discretion in defining **BACT**
  - Exhaust aftertreatment may be considered not available due to its economic impact
- 6 g/hp-hr NOx at 100% generator set rated load is becoming a common BACT target
  - This target is typically considered "**Guaranteed**" or "**Maximum Potential to Emit**"
  - Most generator set manufacturer data sheets present **Nominal** values
  - Consult generator set manufacturer for potential to emit values

Air Permitting for Standby Generator Sets

Site Air Permit Example

Project Considerations:

Site requires 25 generator sets

Max NOx to be allowed = 80 tons per year

Performance Data	1/4 Standby	1/2 Standby	3/4 Standby	Full Standby
BHP @ 1800 RPM (60 Hz)	1145	2185	3225	4308
Fuel Consumption L/Hr (US Gal/Hr)	254 (67)	443 (117)	602 (159)	787 (208)
Exhaust Gas Flow m³/min (CFM)	282 (9963)	45 (15921)	55 (19592)	662 (23369)
Exhaust Gas Temperature °C (°F)	331 (628)	354 (670)	377 (711)	443 (830)
Exhaust Emission Data				
HC (Total Unburned Hydrocarbons)	0.3 (114)	0.18 (76)	0.1 (48)	0.07 (33)
NOx (Oxides of Nitrogen as NO_2)	3.4 (1290)	3.3 (1350)	4.2 (1900)	5.2 (2440)

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g/hp-hr Nominal

Note: Use Potential to Emit value

Resulting permit allowance:

- To meet 80 tons per year generator set operation is limited to 100 hours per year
- 25 generators running for 100 hours at full standby rating consume 520,000 gallons of fuel per year
- Permit would limit operation to 100 hours of operation or 520,000 gallons of fuel per year

Air Permitting for Standby Generator Sets

Application of Exhaust Aftertreatment

Project Considerations:

- Hyperscale project requires 100 X 3MW generator sets when fully built
- Built in 5 phases of 20 gens each
- Max NOx allowed = **80 tons per year**
- Permit written for 50 hours per year
- Each generator set has a potential to emit 1.6 tons per year

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- **Phase 1**
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- **Phases 1 & 2**
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- **Phase 1 through 3**
  - 60 gens – Total NOx emissions = 96 tons per year

Expansion after the second phase would not have been permitted

Air Permitting for Standby Generator Sets

Application of Exhaust Aftertreatment

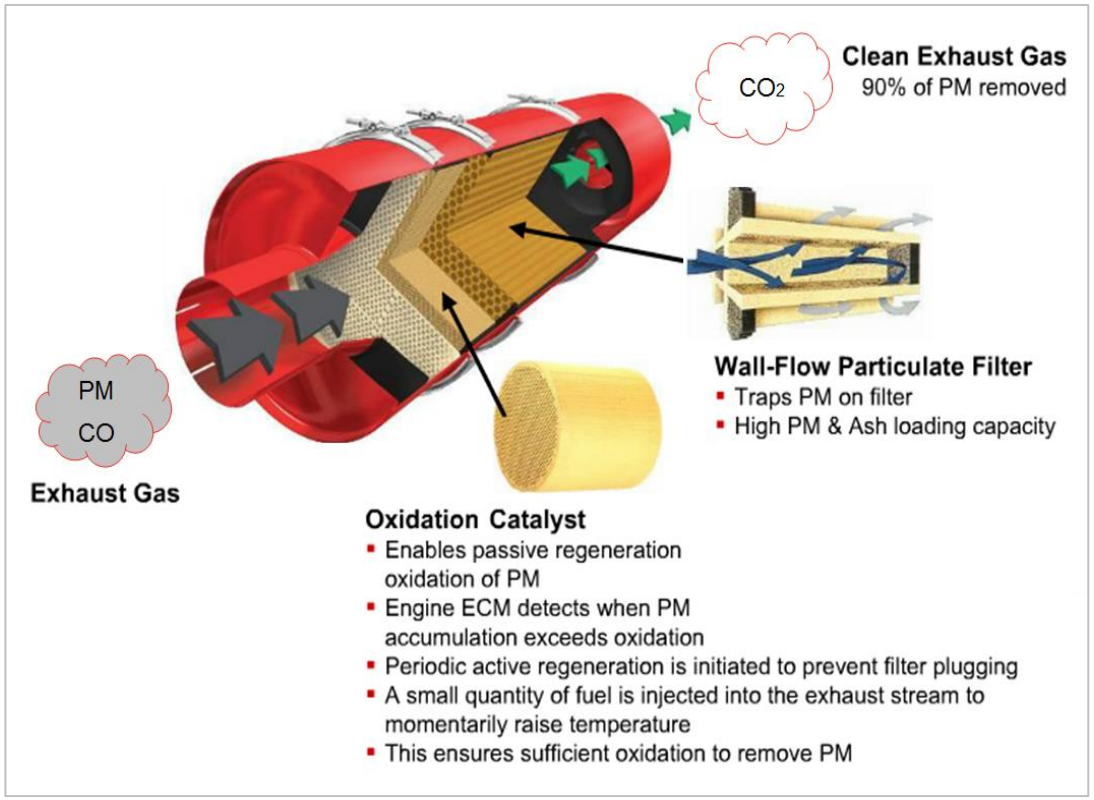
Selective Catalytic Reduction (SCR) can
reduce NOx by up to 90%

Air Permitting for Standby Generator Sets

Application of Exhaust Aftertreatment

Selective Catalytic Reduction (SCR) can reduce NOx by up to 90%

Diesel Particulate Filter (DPF) can reduce Particulate Matter



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- **Phase 1 through 3**
  - 60 gens – Total NOx emissions = 67.2 tons per year
- **Phase 1 through 4**
  - 80 gens – Total NOx emissions = 70.4 tons per year
- **Phase 1 through 5**
  - 100 gens – Total NOx emissions = 73.6 tons per year

Air Permitting for Standby Generator Sets

On-Site Testing Considerations

- Non-standard equipment may be needed to secure air-permit / conduct on-site testing:
  - Fuel flow meter(s)
  - Pollutant monitor(s)
  - Exhaust sample port(s)
  - Load banks
- Test methodology and permit data must be approved by equipment manufacturer.
- Applicable environmental correction factors allowable by AHJ must be identified.
- Costs and time associated with on-site testing requirements must be considered.
- Review air permit requirements early in the project in order to accommodate lead times.
- Leverage experience of third-party testing companies and engine manufacturers.
- Review implications of failing on-site test including penalties and project delays.
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CONSULT THE ENGINE MANUFACTURER

Concept Check

Facility owners with stationary engines installed on-site are obligated to meet which of the following:

a) EPA guidelines for engine operation, as applicable
b) State guidelines for engine operation, as applicable
c) Local air permitting requirements, as applicable
d) All of the above

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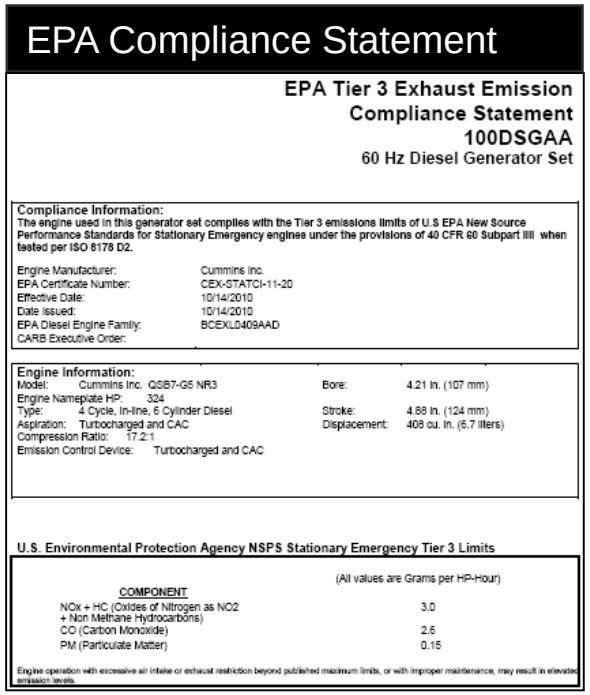


EPA Compliance Statement

EPA Tier 3 Exhaust Emission Compliance Statement
100DSGAA
60 Hz Diesel Generator Set

Compliance Information:
The engine used in this generator set complies with the Tier 3 emissions limits of U.S EPA New Source Performance Standards for Stationary Emergency engines under the provisions of 40 CFR 60 Subpart IIII when tested per ISO 8178 D2.

Engine Manufacturer:	Cummins Inc.
EPA Certificate Number:	CEX-STATCI-11-20
Effective Date:	10/14/2010
Date Issued:	10/14/2010
EPA Diesel Engine Family:	BCEXL0409AAD
CARB Executive Order:	

Engine Information:

Model:	Cummins Inc. QSB7-G5 NR3	Bore:	4.21 in. (107 mm)
Engine Nameplate HP:	324		
Type:	4 Cycle, In-line, 6 Cylinder Diesel	Stroke:	4.88 in. (124 mm)
Aspiration:	Turbocharged and CAC	Displacement:	408 cu. in. (6.7 liters)
Compression Ratio:	17.2:1		
Emission Control Device:	Turbocharged and CAC		

U.S. Environmental Protection Agency NSPS Stationary Emergency Tier 3 Limits

(All values are Grams per HP-Hour)

COMPONENT	
NOx + HC (Oxides of Nitrogen as NO2 + Non Methane Hydrocarbons)	3.0
CO (Carbon Monoxide)	2.6
PM (Particulate Matter)	0.15

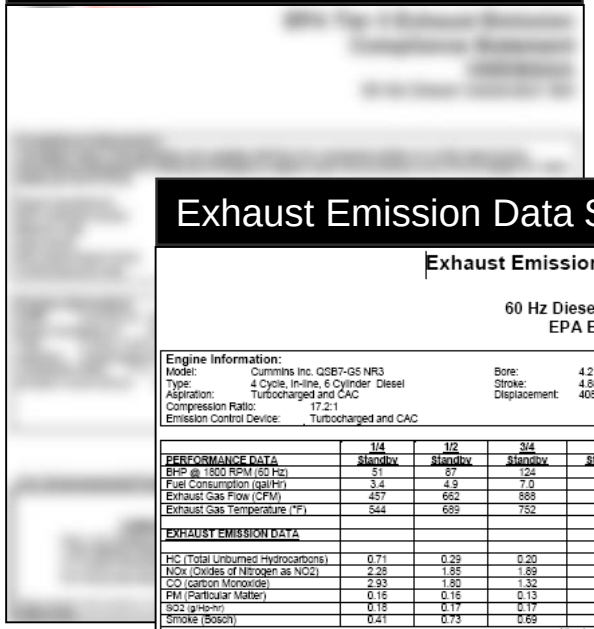
Engine operation with excessive air intake or exhaust restriction beyond published maximum limits, or with improper maintenance, may result in elevated emission levels.

EPA Compliance Statement

Manufacturer statement certifying the generator set's engine compliance with EPA regulations for a specific model year

Compliance Documentation

EPA Compliance Statement



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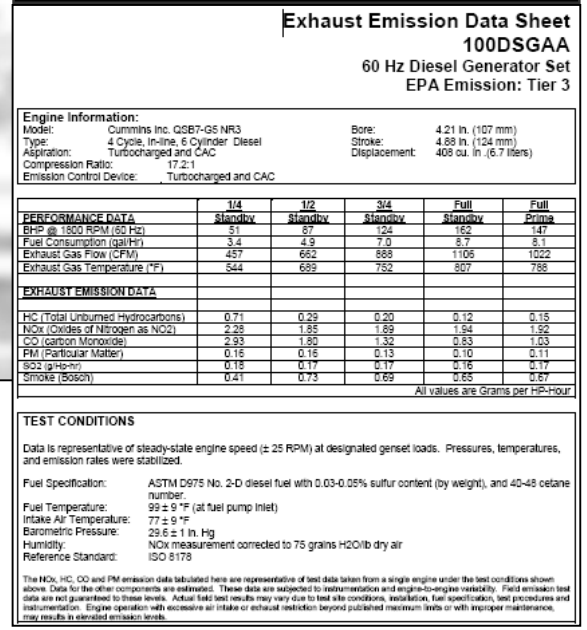
Exhaust Emission Data Sheet



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PERFORMANCE DATA	1/4 Standby	1/2 Standby	3/4 Standby	Full Standby	Full Prime
BHP @ 1800 RPM (60 Hz)	51	87	124	162	147
Fuel Consumption (gal/Hr)	3.4	4.9	7.0	8.7	8.1
Exhaust Gas Flow (CFM)	457	662	888	1106	1022
Exhaust Gas Temperature (°F)	544	689	752	807	788
EXHAUST EMISSION DATA					
HC (Total Unburned Hydrocarbons)	0.71	0.29	0.20	0.12	0.15
NOx (Oxides of Nitrogen as NO2)	2.28	1.85	1.69	1.54	1.52
CO (carbon Monoxide)	2.93	1.80	1.32	0.83	1.03
PM (Particular Matter)	0.16	0.16	0.13	0.10	0.11
SO2 (g/Hp-hr)	0.18	0.17	0.17	0.16	0.17
Smoke (Bosch)	0.41	0.73	0.69	0.65	0.67

All values are Grams per HP-Hour

TEST CONDITIONS

Data is representative of steady-state engine speed (± 25 RPM) at designated genset loads. Pressures, temperatures, and emission rates were stabilized.

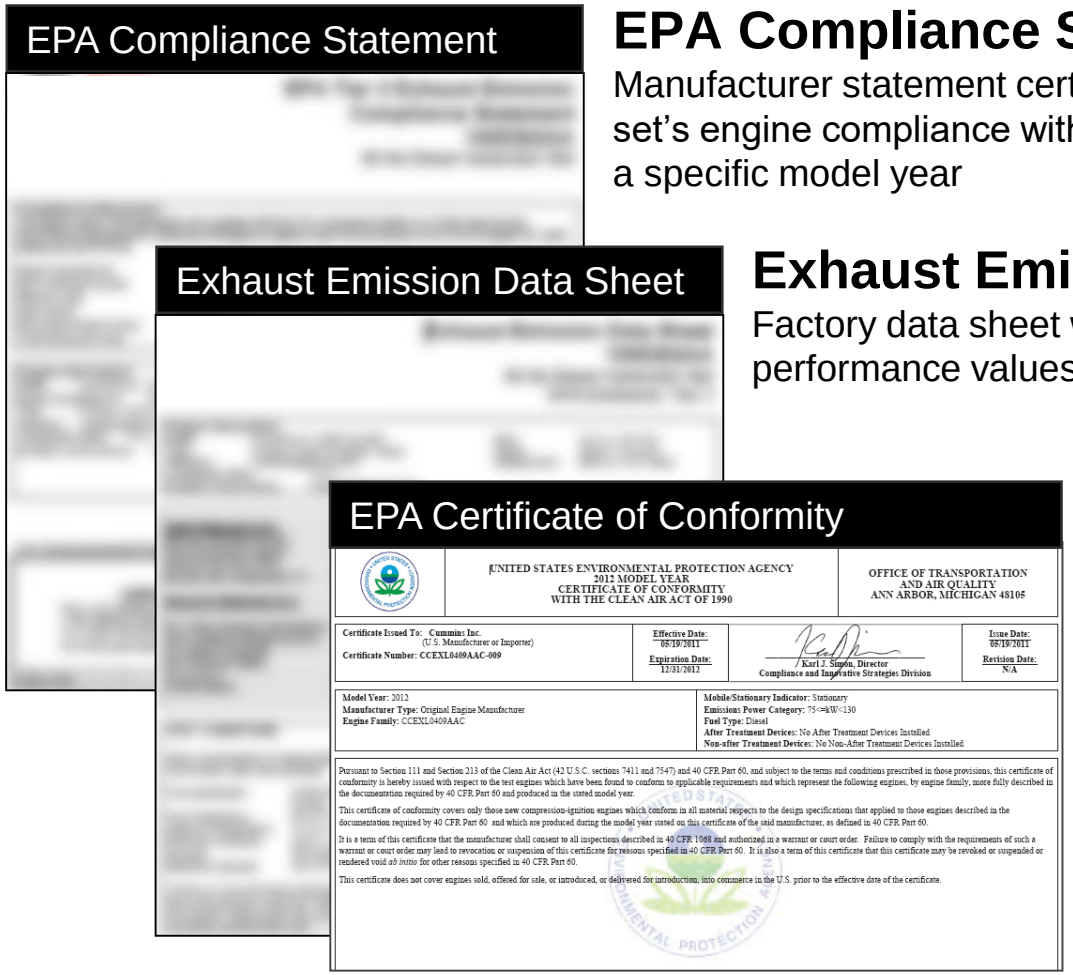
Fuel Specification:	ASTM D975 No. 2-D diesel fuel with 0.03-0.05% sulfur content (by weight), and 40-48 cetane number.
Fuel Temperature:	99 ± 9 °F (at fuel pump inlet)
Intake Air Temperature:	77 ± 9 °F
Barometric Pressure:	29.6 ± 1 In. Hg
Humidity:	NOx measurement corrected to 75 grains H2O/lb dry air
Reference Standard:	ISO 8178

The NOx, HC, CO and PM emission data tabulated here are representative of test data taken from a single engine under the test conditions shown above. Data for the other components are estimated. These data are subjected to instrumentation and engine-to-engine variability. Field emission test data are not guaranteed to these levels. Actual field test results may vary due to test site conditions, installation, fuel specification, test procedures and instrumentation. Engine operation with excessive air intake or exhaust restriction beyond published maximum limits or with improper maintenance, may results in elevated emission levels.

Exhaust Emission Data Sheet

Factory data sheet with recorded emissions and performance values at different load levels.

Compliance Documentation



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EPA Certificate of Conformity

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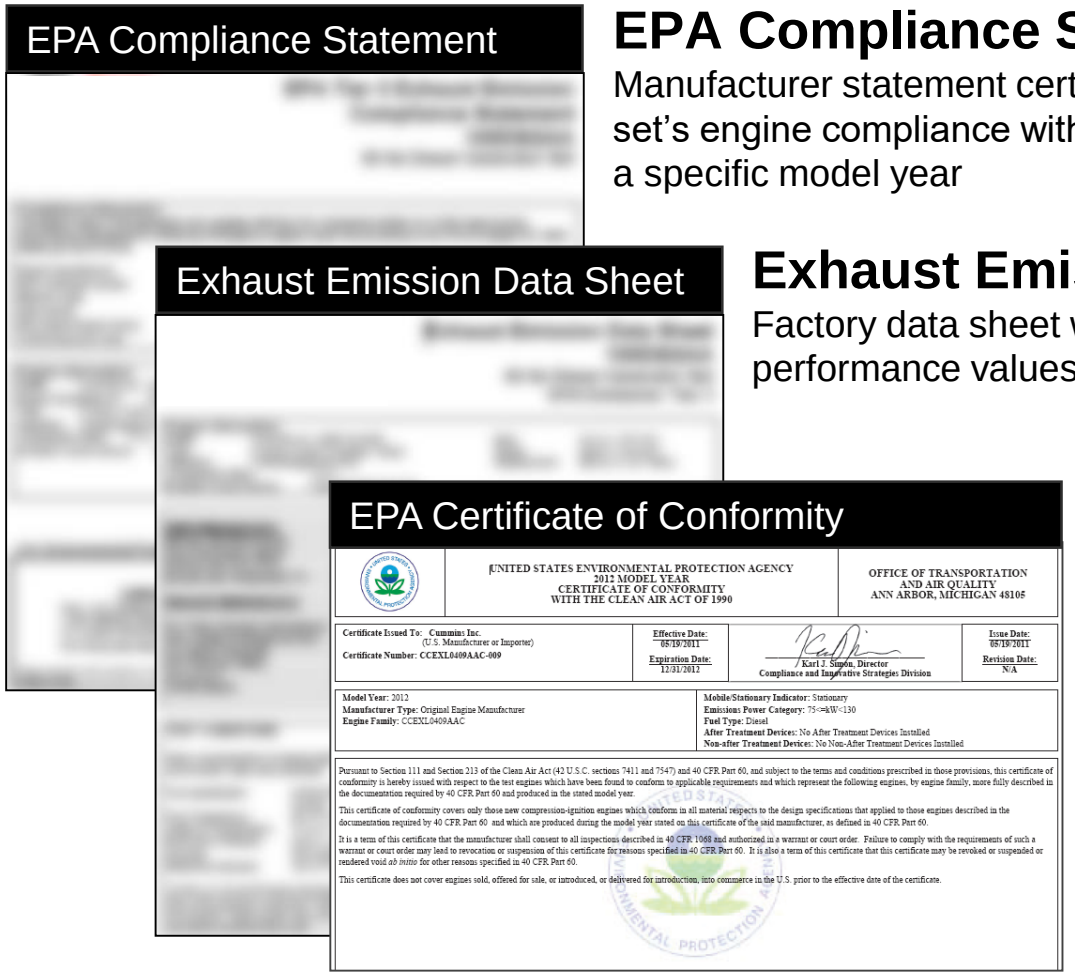

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Spec Note Generator set manufacturer shall provide documentation of engine EPA certification including EPA Family name and generator set model.

Course Summary

Emissions and Air Permitting Requirements for Standby Generator Sets

- Recognize commonly regulated exhaust emissions constituents.
- Describe EPA emissions requirements for diesel and gaseous standby generator sets.
- Identify common requirements for permitting engine-driven generator sets.

Specify:

- Generator set shall include engine which complies with U.S. EPA New Source Performance Standards (NSPS) for **Stationary Emergency** engines under the provisions of [40 CFR Part 60 Subpart IIII or 40 CFR Part 60 Subpart JJJJ] when tested per ISO 8178 D2.
- Engine shall meet emissions limits as defined for **Stationary Emergency** engines in [40 CFR Part 60 Subpart IIII or 40 CFR Part 60 Subpart JJJJ] when tested per ISO 8178 D2.

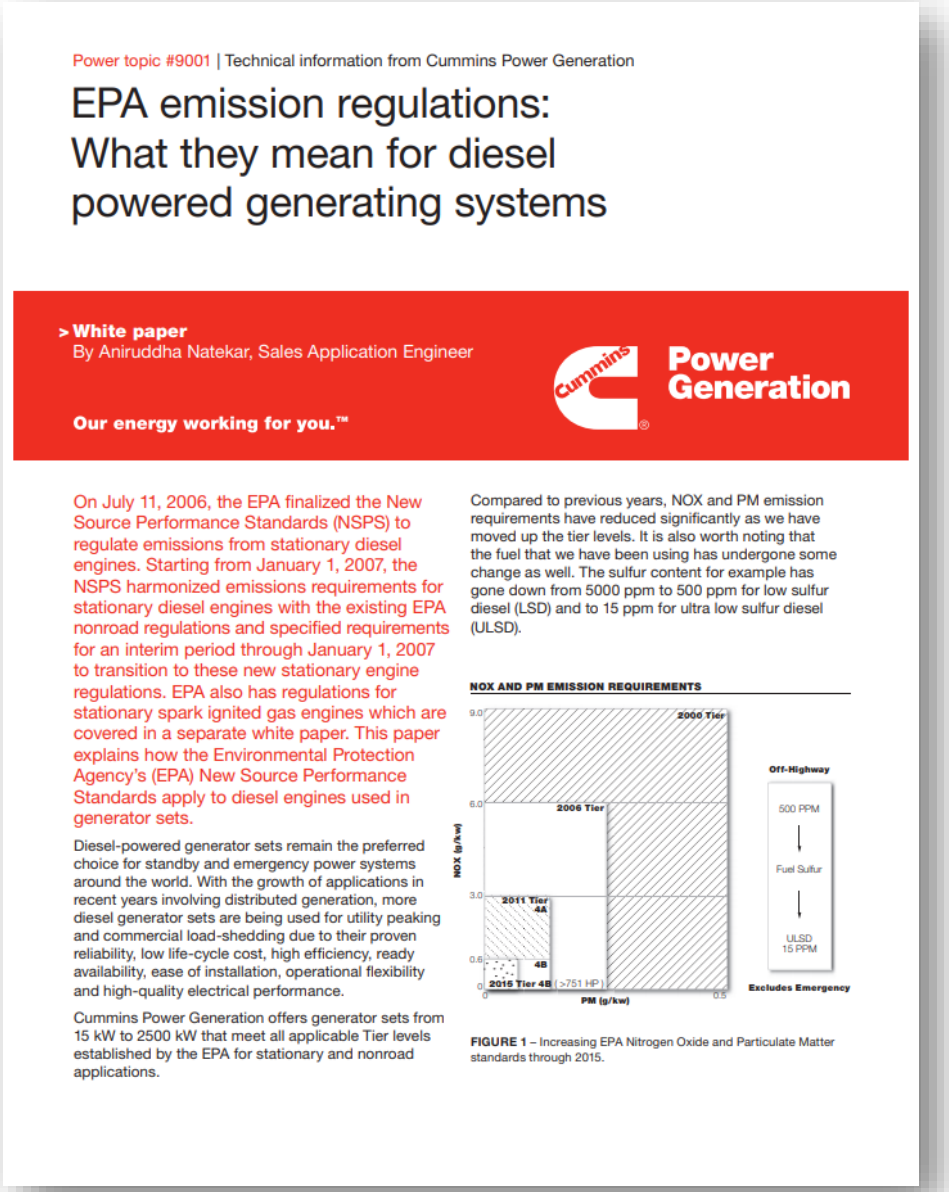
Additional Resources

Cummins White Papers

- EPA Emission Regulations: What they mean for diesel powered generating systems
- The Impact of Tier 4 Emission Regulations on the Power Generation Industry
- Understanding RICE NESHAP regulations and their impact on stationary diesel generator sets
- Understanding EPA NSPS Emissions Regulations For Stationary Spark Ignited Engines

Cummins PowerHour On-Demand Webinars

- Emissions Requirements for Compression Ignition Engines in EPA Non-Emergency Operation
- Emissions and Air Permitting Requirements for Standby Generator Sets



Power topic #9001 | Technical information from Cummins Power Generation

EPA emission regulations: What they mean for diesel powered generating systems

> White paper
By Aniruddha Natekar, Sales Application Engineer

Our energy working for you.™

Power Generation

On July 11, 2006, the EPA finalized the New Source Performance Standards (NSPS) to regulate emissions from stationary diesel engines. Starting from January 1, 2007, the NSPS harmonized emissions requirements for stationary diesel engines with the existing EPA nonroad regulations and specified requirements for an interim period through January 1, 2007 to transition to these new stationary engine regulations. EPA also has regulations for stationary spark ignited gas engines which are covered in a separate white paper. This paper explains how the Environmental Protection Agency's (EPA) New Source Performance Standards apply to diesel engines used in generator sets.

Diesel-powered generator sets remain the preferred choice for standby and emergency power systems around the world. With the growth of applications in recent years involving distributed generation, more diesel generator sets are being used for utility peaking and commercial load-shedding due to their proven reliability, low life-cycle cost, high efficiency, ready availability, ease of installation, operational flexibility and high-quality electrical performance.

Cummins Power Generation offers generator sets from 15 kW to 2500 kW that meet all applicable Tier levels established by the EPA for stationary and nonroad applications.

Compared to previous years, NOX and PM emission requirements have reduced significantly as we have moved up the tier levels. It is also worth noting that the fuel that we have been using has undergone some change as well. The sulfur content for example has gone down from 5000 ppm to 500 ppm for low sulfur diesel (LSD) and to 15 ppm for ultra low sulfur diesel (ULSD).

NOX AND PM EMISSION REQUIREMENTS

FIGURE 1 – Increasing EPA Nitrogen Oxide and Particulate Matter standards through 2015.

Q&A

Please type your questions, comments and feedback in the **Zoom Q&A** window.

After the PowerHour, a complete list of questions and answers will be published on powersuite.cummins.com.

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Closing

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