

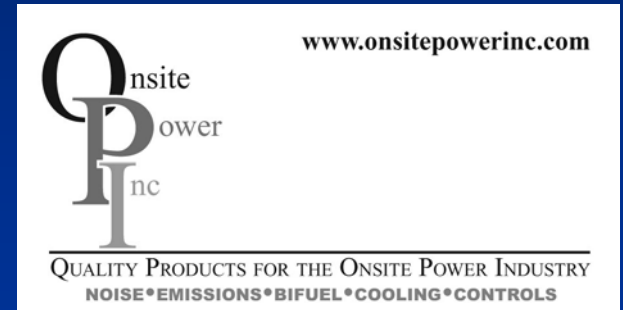
Reciprocating Engine Noise and Emissions

What Operators Need to Know

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Onsite Power Inc.

- Manufacturer's Representative for quality products and services to the onsite power and stationary engine industry
- 27 years experience in industrial engines and onsite power generation
- Headquartered in Aurora, CO, serving six Rocky Mountain states



What We'll Cover

- Emissions
 - Brief overview of national and regional regulations
 - Overview of technology options
- Noise
 - Overview of current COGCC and FERC regulations
 - Some remediation options



Emissions



Criteria Pollutants vs. HAPS

Criteria Pollutants

- NO_x (Nitrogen Oxides)
- CO (Carbon Monoxide)
- HC (Hydrocarbons)
 - Non-methane, non-ethane (NMNEHC)
- PM₁₀
 - Particulates under 10 microns

HAPS

(Hazardous Air Pollutants)

- 188 HAPS as listed by EPA
- Primary control target in engine exhaust is formaldehyde (indicator of smaller presence of other HAPS)
- Target of RICE MACT regulation
- State regulations becoming more common



REGULATIONS



Changing Landscape

- Regulations and enforcement shifting
- Individual states and jurisdictions may impose more stringent regulations, but not less stringent than Federal regulations
- Localized regulations becoming more common in Wyoming, Colorado and New Mexico



EPA Spark-Ignited Stationary Engine Regulation

- Takes effect 7/1/08
- Does not apply to existing engines
 - Future regulations regarding existing engines are under development



Natural Gas, LB LPG and Landfill Digester

TABLE 4.—NO_x, CO, AND VOC EMISSION STANDARDS FOR STATIONARY SI ENGINES ≥100 HP (EXCEPT GASOLINE AND RICH BURN LPG), STATIONARY SI LANDFILL/DIGESTER GAS ENGINES, AND STATIONARY EMERGENCY ENGINES >25 HP

Engine type and fuel	Maximum engine power	Manufacture date	Emission standards ^a					
			g/HP-hr			ppmvd at 15% O ₂		
			NO _x	CO	VOC	NO _x	CO	VOC
Non-Emergency SI Natural Gas and Non-Emergency SI Lean Burn LPG.	100≤HP<500	7/1/2008	2.0	4.0	1.0	160	540	86
		1/1/2011	1.0	2.0	0.7	82	270	60
Non-Emergency SI Lean Burn Natural Gas and LPG.	500≥HP<1,350	1/1/2008	2.0	4.0	1.0	160	540	86
		7/1/2010	1.0	2.0	0.7	82	270	60
Non-Emergency SI Natural Gas and Non-Emergency SI Lean Burn LPG (except lean burn 500≥HP<1,350).	HP≥500	7/1/2007	2.0	4.0	1.0	160	540	86
		7/1/2010	1.0	2.0	0.7	82	270	60
Landfill/Digester Gas (except lean burn 500≥HP<1,350).	HP≥500	7/1/2008	3.0	5.0	1.0	220	610	80
		1/1/2011	2.0	5.0	1.0	150	610	80
	HP<500	7/1/2007	3.0	5.0	1.0	220	610	80
		7/1/2010	2.0	5.0	1.0	150	610	80
	500≥HP<1,350	1/1/2008	3.0	5.0	1.0	220	610	80
		7/1/2010	2.0	5.0	1.0	150	610	80
Landfill/Digester Gas lean burn	500≥HP<1,350	1/1/2009	^b 10	387	N/A	N/A	N/A	N/A
Emergency	HP≥130	2.0	4.0	1.0	160	540	86

^a Owners and operators of stationary non-certified SI engines may choose to comply with the emission standards in units of either g/HP-hr or ppmvd at 15 percent O₂.

^b The emission standards applicable to emergency engines between 25 HP and 130 HP are in terms of NO_x+HC.

EPA RICE MACT

- Targets HAPS (primarily formaldehyde)
- Applies to engines >500 HP as follows
 - if facility is a major source of HAPS (>10 tpy single HAP or >25 tpy combined HAPS)
 - New and existing 4 stroke rich burn engines
 - New 4 stroke lean burn engines
 - Lean burn may either reduce formaldehyde OR control 93% of CO



RICE MACT: 4 Stroke Lean Burn

- Reduce CO emission by $\geq 93\%$ at 100% load or
- Limit formaldehyde concentration in exhaust to ≤ 14 ppmvd at 15% O₂ at 100% load
- Requires oxidation catalyst



RICE MACT: 4 Stroke Rich Burn

- Reduce formaldehyde emissions by $\geq 76\%$ at 100% load or
- Limit formaldehyde concentration in exhaust to ≤ 350 ppbvd at 15% O₂ at 100% load
- Requires 3 way catalyst



Colorado AQCC Regulation No. 7

Statewide Requirements

- 7/1/07: New and relocated out-of-state engines >100 HP will be required to meet the following emission limits for NO_x, CO and VOCs:

Maximum Engine hp	Construction or Relocation Date	NO _x g/hp-hr	CO g/hp-hr	NMHC g/hp-hr
100 to 500	1/1/2008	2.0	4.0	1.0
	1/1/2011	1.0	2.0	0.7
Greater than 500	7/1/2007	2.0	4.0	1.0
	7/1/2010	1.0	2.0	0.7

New Mexico

- Permitting rules still favor lean burn
- Follow Federal EPA regulations
- Only other firm published limit is San Juan BLM regulation
 - <300 BHP on new wells limited to 2 g/bhp/hr NO_x



Technology Alternatives for Gas Recip Engines

- Air/fuel ratio control
- 3-way catalyst
- Oxidation (2 way) catalyst
- Selective catalytic reduction



Summary Of Options For Lean Burn Gas Engines

Oxidation catalyst	<ul style="list-style-type: none"> •Oxidizes CO up to 90% •Oxidized HC up to 90% •Oxidizes Formaldehyde, level varies 	<ul style="list-style-type: none"> •No effect on NOx or particulates
Air/fuel ratio controller	<ul style="list-style-type: none"> •Protects catalyst from fouling, masking •Improves compliance performance •Improves fuel consumption 	<ul style="list-style-type: none"> •Not mandated in most regulations for lean burn engines
Selective catalytic reduction	<ul style="list-style-type: none"> •Can reduce NOx down to .5 g/hp/hr 	<ul style="list-style-type: none"> •No effect on other criteria pollutants or HAPS •More expensive and less convenient
Combustion catalyst	<ul style="list-style-type: none"> •(theoretical) Reduction of all criteria pollutants, effect on formaldehyde unknown 	<ul style="list-style-type: none"> •Has not been field tested

Summary of Rich Burn Gas Options

3-way catalyst with air-fuel ratio control	<ul style="list-style-type: none">•Reduces NO_x, CO, HC and Formaldehyde•Most economical option when post-treatment is required•Some benefit can be derived from AFRC alone.	Both catalyst and AFRC are required for proper compliance
Combustion catalyst	<ul style="list-style-type: none">•(theoretical) Reduction of all criteria pollutants, effect on formaldehyde unknown	<ul style="list-style-type: none">•Has not been field tested
Particulate filter	<ul style="list-style-type: none">•Reduces particulates up to 85%	Not required in most jurisdictions

Noise



New and existing regulations

- COGCC Noise Regulation
- FERC Noise Regulation
- Local Regulations
 - Pinedale Anticline



COGCC AESTHETIC AND NOISE CONTROL REGULATIONS

- Created and enforced by the Colorado Oil and Gas Conservation Commission (COGCC)
- <http://www.oil-gas.state.co.us/>, click on rules, scroll to “Aesthetics and Noise Control Regulations”, click
- Applies to noise impacts during the drilling, completion and operation of oil and gas wells and production facilities.



ZONE	7:00 am to next 7:00 pm	7:00 pm to next 7:00 am
Residential	55 db(A)	50 db(A)
Commercial	60 db(A)	55 db(A)
Light industrial	70 db(A)	65 db(A)
Industrial	80 db(A)	75 db(A)

How Measurements are Taken

- Sound level meters equipped with wind screens, and readings taken when the wind velocity is not more than five (5) miles per hour.
- Measurements taken four (4) feet above ground level.
- Levels determined by averaging measurements made over a fifteen (15) minute sample duration
- Existing ambient noise level is to be considered to determine contribution from source.



Where Measurements are taken

Old Rule	New Rule
<p>If there are no occupied building units impacted, sound levels are measured at a distance of twenty-five (25) feet from property line radiating the noise.</p>	<ul style="list-style-type: none">• 350 ft. from noise source, or farther if complainant believes it is more representative of noise impact• Closer if topography makes 350 ft, impractical. Formula is provided to calculate equivalent to 350 ft.• On surface property owned, leased or controlled by operator, 350 ft. from noise source or at property line, whichever greater
<p>Sound levels at occupied building units measured as near as practicable to the exterior edge of the occupied building unit closest to the area radiating the noise.</p>	<p>25 ft. from occupied structure toward noise source</p>

Exceptions

- Between 7 a.m. and next 7 p.m., permitted noise levels may be increased by 10 db (A) for 15 minutes each hour
- In remote areas (no “reasonably proximate occupied structure or designated outside activity area”) light industrial standard “may” apply
- Periodic, impulsive or shrill noises decreased by 5 db (A) from levels shown.



Low Frequency Noise

- Triggered by complaint or Commission onsite inspection
- Reading taken 25 ft. from exterior wall of occupied structure toward noise source
- If it exceeds 65 db (C), operator must obtain low frequency noise impact analysis by qualified expert, including ID of control measures
- Study “provided to the Commission for consideration and possible action”.



And They Included Some Good Advice.....

“Operators should be aware that noise control is most effectively addressed at the siting and design phase, especially with respect to centralized compression and other downstream gas facilities”



The Key Points

- Enforcement will be **COMPLAINT DRIVEN**
- Avoiding complaints will be much less expensive and intrusive than responding to complaints
 - *Remediation after the fact will be difficult and expensive*
 - *Complainants are more sensitized*
 - *Measured levels in compliance with the regulation may be very expensive and time consuming to achieve*



FERC Noise Regulation

- Applies to all gas transmission facilities under FERC jurisdiction (interstate transportation)
- CFR Title 18 Part 157.206 Standard Conditions
 - **Must not exceed a day-night level (Ldn) of 55 dBA at the site property boundary.**
 - **Specific level mandated for night drilling near noise sensitive areas**



Differences from COGCC Regulation

- Reference is to property line rather than specific distances
- L_{dn} calculates to a different level
- If property line within 350 ft., this is tougher
- No specifics on enforcement, measurement methods, etc.



Compliance

- Required on any addition or modification
- Initial compliance must be demonstrated by third party testing
- Complaints will generate new testing and compliance requirements



L_{dn} ?

- L_{dn} : Day-night level. It is a descriptor of noise level based on energy equivalent noise level (L_{eq}) over the whole day with a penalty of 10 dB(A) for night time noise (22.00-7.00 hrs).
- Obtained by averaging the 24-hour sound level, in decibels, after the addition of ten decibels to night time levels
- Reducing noise 10 dB(A) at night not practical in most reciprocating engine installations
- Steady Noise of 48.6 dB(A) equals $L_{dn} = 55$ dB(A)



Other Regulations

- Localized and field-specific regulations becoming more common
 - Example: Pinedale Anticline limit of 65 dB(A) at 30 ft.
 - County and city regulations may apply



Technology Options



Sound Remediation Options

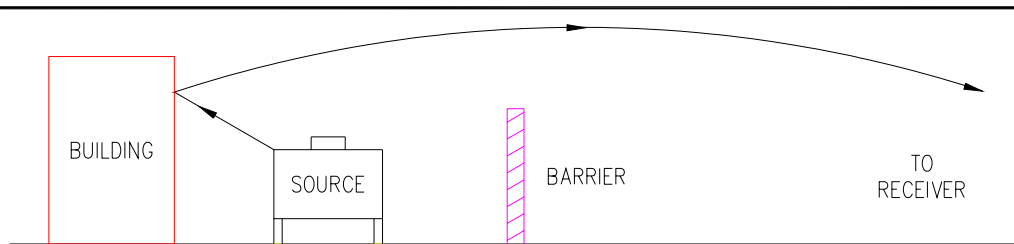
- Three sources of noise in engine-driven equipment
 - Exhaust
 - Mechanical noise
 - Cooling equipment



Barriers

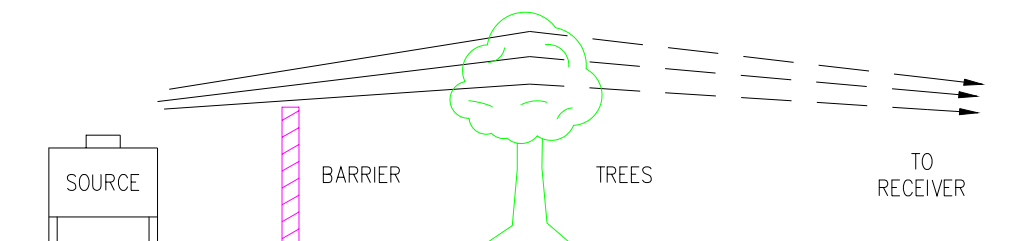
- If not carefully designed and properly installed, they can be ineffective
- Must not hamper airflow
- Can be rendered ineffective by changing rules and environmental conditions





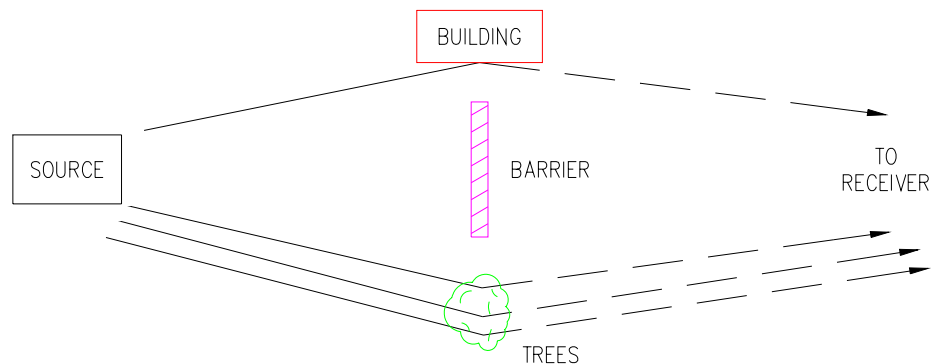
ELEVATION

PART A: REFLECTION FROM A WALL BEHIND THE BARRIER.



ELEVATION

PART B: REFLECTION FROM TREES OVER THE TOP OF THE BARRIER.



PLAN

PART C: REFLECTION FROM TREES OR OTHER STRUCTURES
AROUND THE END OF THE BARRIER.



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DRAWN BY:

BD

DATE:

12-2-97

JOB #:

DRAWING NAME:

FIGURE-16

Exhaust Silencing

- No accepted industry standards for grade designations i.e. “Critical”, “Hospital”. Also, this specifies a REDUCTION level, NOT a RESULT
- Output sound level is dependent on INPUT sound level.
- Reduction across sound spectrum varies widely—review the attenuation curve
- There is no substitute for size for low frequency sound



Mechanical Noise

- Least difficult issue to deal with
- Barriers and absorption techniques work best
- Pre-fabricated sound attenuating enclosures are a good option



Cooling System

- Factors affecting cooler noise levels:
 - Fan tip speed
 - Fan horsepower
 - Static pressure across coil
 - Air volume required
 - Style of cooler:
Forced or induced draft
 - Drive type: V-belt/cog belt/gear



Reducing Cooling System Noise

- Much more easily achieved if designed in instead of added on
- Remediation attempts often result in impeded operation, especially at high altitude
- Options:
 - Round-tube coolers
 - Slower fan speed (larger fans and/or larger core)
 - Lower static restriction (larger core)
 - Foot on blade tip



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