Regulatory Impacts of Biogas-fired Internal Combustion Engines

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Air, Water & Energy: Sustainability for Wastewater Treatment Plants

California Water Environment Association
Santa Ana River Basin Section
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Agenda

• Background
  • Biogas use for IC engines
  • Engine type/ emissions
• Regulations
  • SCAQMD - Rule 1110.2, 1401, 1402
  • USEPA – NSPS, MACT
• Case Study – Orange County Pilot Testing
What is Biogas?

Produced from anaerobic decomposition of organic materials

Primary sources

- Landfill
- Wastewater treatment - Digester gas

Renewable fuel
Biogas Composition

- Methane (CH₄) (45 – 65 %)
- Carbon Dioxide (CO₂) (35 – 55 %)
- Contaminants:
  - VOCs
  - Sulfur
  - Siloxanes
  - Ammonia
  - Miscellaneous - PM, moisture
Where is biogas used at WWTP?

- Combustion
  - IC Engines
  - Boilers
  - Turbines
  - Flares
- Clean and compress to liquefied or compressed natural gas
- Release to atmosphere
Reciprocating Internal Combustion Engines (RICE)

Cover a broad range of output horsepower and speeds

Widespread applications

- Good fuel economy
- Durability
- Reliability
- Compactness
- Reasonable first cost
Classification of RICE

Engines are classified according to their fuel type and ignition method

- **Gas Engines** - use gaseous fuel and are spark-ignited (SI)
- **Diesel Engines** – compression ignition (CI) engines operate on liquid fuel oil
- **Dual-Fuel Engines** – two modes of operation: one is operated as a diesel engine; in the other mode a “pilot ‘injection of liquid diesel fuel ignites as in a diesel engine and subsequently ignites the main charge of fuel gas and air mixture – EPA classified as spark-ignited
Emissions from Biogas Combustion

- Criteria pollutants
  - NOx, CO, VOCs, SOx
- Hazardous air pollutants (HAPs)
  - Formaldehyde
  - Acetaldehyde
  - Acrolein
  - Methanol
- Biogas-fired engines are major contributors to facility-wide emissions from WWTP
Type of Regulations

- **Source categories**
  - Internal Combustion Engines (ICE)
- **Facility-wide emissions**
- **Existing versus new/modified sources**
- **Pollutant type**
  - Criteria (NOx, CO, SOx, VOCs)
  - Air toxics or HAPs (e.g., formaldehyde)
General Regulation for ICE

- Local – South Coast Air Quality Management District (SCAQMD)
- Federal
  - Title V – Operating Permit (facility-wide)
  - Source Categories
    - New Source Performance Standards (NSPS)
    - National Emission Standards for Hazardous Air Pollutants (NESHAPS)
      - Maximum Achievable Control Technology (MACT)
SCAQMD Regulations

- Rule 1110.2
  - Gaseous and liquid-fuel engines
  - Units > 50 BHP
- Rules 1300 to 1316
  - Criteria Pollutants (CO, NOx, PM10, SOx, VOCs)
- Rule 1401 and 1402
  - Toxic Air Contaminants (e.g., formaldehyde)
Rule 1110.2 – Biogas fired IC Engines

- Applies to IC Engines > 50 BHP
- Biogas-fired engine – requirements
  - Engines use > 90% biogas
  - Unless SCAQMD provides variance
- Existing NOx limits:
  - Natural Gas - 36 ppm
  - Biogas - 36 ppm or calculated based on efficiency correction factor (ECF)
SCAQMD Rule 1110.2

- Regulation applies to existing IC engines
- Schedule
  - Final amendment issued Feb 2008
  - **Technology Evaluation** for units operating on biogas by July 2010
  - Natural gas-fired engines meets limits by July 2011
  - Biogas-fired engines meet limits by July 2012

<table>
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<th>Concentration</th>
<th>Existing</th>
<th>Future</th>
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<tr>
<td>NOx</td>
<td>36 to ~ 45</td>
<td>11</td>
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<tr>
<td>CO</td>
<td>2000</td>
<td>250</td>
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<tr>
<td>VOC</td>
<td>100</td>
<td>30</td>
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* Concentration in units of parts per million at volume dry @ 15% O2)
Source of Siloxanes at WWTP

Siloxanes are used in personal care products.

Common isomers:
- D4 - Octamethylcyclotetrasiloxane
- D5 - Decamethylcyclopentasiloxane
Why are Siloxanes a Problem?

Silica Formation

**D4 and D5 - exist in the gas phase of biogas**

**Oxidation**

**Forms Silica: a particulate**

Fouls fuel systems, combustion chambers and post-combustion controls.
SCAQMD Regulations – All Sources

- Rules 1300 to 1316
  - Criteria Pollutants (CO, NOx, PM10, SO2, VOCs)
  - Best Available Control Technology (BACT)

- Rule 1401 and 1402
  - Toxic Air Contaminants (formaldehyde)
  - Rule 1401 – new/modified source
  - Rule 1402 – existing facility-wide

- Biogas engines included
Federal Regulations – Source Categories

- **40 CFR 60 - New Source Performance Standard (NSPS)**
  - Emissions limits for new sources (NOx, CO, VOCs)
- **40 CFR 63 - Maximum Achievable Control Technology (MACT) – Air Toxics**
  - List of 187 hazardous air pollutants (HAPs)
  - Major or non major (area) source
  - 10 tpy of individual and 25 tpy of total HAPS
  - Emissions limits for existing and new engines
- **Emissions limits**
  - Engine type, size and usage
• Subpart JJJJ – SI Engines (1/18/08)
  • Gaseous fuels – biogas and natural gas
  • Emissions limits for NOx, CO, VOCs
  • Dual fuel – diesel fuel, biogas, natural gas
• Subpart IIII – CI Engines (7/11/06)
  • Diesel fuel
Subpart JJJJJ Requirements for Biogas-fired Engines

• New and modified units after 6/12/06
• Emissions limits are based on engine type and fuel type
• Emission limits:
  • NOx – 150 to 220 ppmvd*
  • CO – 610 ppmvd*
  • VOC – 80 ppmvd*

* ppmvd – parts per million by volume dry @ 15% O2
• Existing Rule – (7/15/04)
  • > 500 HP engines at major source
• Proposed Amendments (3/5/09)
  • < 500 HP at major source
  • All engines at non-major (area) sources
• Additional provisions:
  • Emergency engines
  • Startup, shutdown, and maintenance conditions
Existing rule – (6/15/04)

> 500 HP at major source

Formaldehyde primary air toxic

Emission limit based on engine type:

- CO: Reductions range from 58% to 93% ; or
- Formaldehyde emission limit from 0.35 to 12 ppmvd

No emission limits or controls required for biogas-fired engines
Proposed amendments to rule (3/5/009)
- IC engines < 500 HP at major source
- All engines at non-major (area) sources
- Additional provisions for:
  - Emergency engines
  - Startup, shutdown, and maintenance
- Use carbon monoxide as surrogate for formaldehyde
40 CFR 63 – Subpart ZZZZZ – Biogas Engines

- No limit for engines >500 hp at major source (final Rule)
- Proposed Amendment (3/5/09)
  - CO Limit: 177 ppmvd
    - From 50 to 500 HP at major sources
    - > 500 hp at no-major sources
Orange County Sanitation District

- Two Wastewater Treatment Plants
  - Plant 1 – Fountain Valley ~ 90 MGD
  - Plant 2 – Huntington Beach ~ 160 MGD
- Central Generation System
  - Plant 1 – 3 ICE (2,500 KW each)
  - Plant 2 – 5 ICE (3,000 KW each)
AB2588 and Rule 1402 Control of Toxic Air Contaminants

- Existing facilities
- Specified risk limits
- Facility-wide emissions
- Public notification and inventory requirements
Pilot Testing: Reduce Formaldehyde and CO

- Catalytic oxidizer performance
  - Emission Reduction: formaldehyde, CO
  - No vendor guarantees for performance
- Impact of digester gas contaminants on catalytic oxidizers
- Digester gas cleaning system performance
- Feasibility of operating catalytic oxidizer with digester gas cleaning
Catalytic Oxidizer and Digester Gas Cleaning System
Catalytic Oxidizer: Emissions Testing

- **Portable Analyzer – Weekly Testing**
  - Real-time
  - CO
  - NOx
- **EPA Method 323 – Monthly Testing**
  - Wet chemistry method
  - Formaldehyde
- **Fourier Transform Infrared (FTIR)**
  - Real Time
  - NOx, CO, formaldehyde
  - Speciated VOCs and amines
Method 323: Sampling and Set-up
Sampling Port Locations

Cat Oxd Inlet

Cat Oxd Outlet

Stack Outlet
Pilot Testing Summary – Catalytic Oxidizer with Digester Gas Cleaning System

• Emissions
  • CO: 90 - 95 % reduction
  • NOx : 15 -20 % increase
    • Limitation of sampling measurements
    • Catalyst Rx with other nitrogen-bound compounds
  • Formaldehyde: 55 to 75% reduction
Pilot Testing Summary – Catalytic Oxidizer with Digester Gas Cleaning System

- Engine performance
  - No issues with temperature increase or pressure drops
  - Reduced engine maintenance
- Catalytic oxidizer currently still operating with no catalyst replacement (> 1 year)
What’s Next for OCSD?

- Future SCAQMD Rule 1110.2 requirements
- Technology evaluation for meeting new limits
- Second pilot testing program to control NOx, CO and air toxics emissions
- Information to SCAQMD by May 2010
Summary

- SCAQMD Rules are more restrictive than existing NSPS and MACT regulations
- Proposed MACT regulations affects IC engines at non-major facilities.
- Facilities needs to be plan for the future requirements.
QUESTIONS AND ANSWERS