SDAPCD

Formaldehyde and Arsenic Emissions from Landfills and Anaerobic Digesters

District Meeting

August 7, 2019

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Outline

- Introduction
- Formaldehyde Testing
- Arsenic Testing
- Planned Revisions and Additions to District Emission Factors (EFs)
- Implications

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Introduction

- Focus is on revised District emission factors (EFs) for uncontrolled formaldehyde (CH_2O) and arsenic emissions from combustion of landfill gas (LFG) or anaerobic digester gas (DG). e.g., at waste water treatment facilities (WWTFs)
- Also fugitive arsenic emissions

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Introduction

- Primary concern is formaldehyde emissions from lean-burn IC engines and turbines
- And arsenic emissions from all types of combustion equipment
- Arsenic emissions from fugitive LFG or DG may be important is some cases (significant fugitive DG emissions are unlikely)

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Introduction

- Formaldehyde—Not known to be significant component of LFG or DG
- Created in combustion process
- Amount created dependent on type of combustion equipment
- Lean-burn engines known to create relatively large amounts—uncontrolled

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Introduction

- Arsenic—likely a component of gas from anaerobic decomposition such as LFG and DG
- Volatile organic arsenic compounds such as arsine, AsH_3, and trimethylarsine (TMA), $As(CH_3)_3$
- Expected to be converted to inorganic arsenic oxides in a combustion process
- Directly emitted in fugitive gas

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Formaldehyde Background

- Michigan (2013) brought the issue of higher than expected formaldehyde emissions from LFG-fueled engines to NACAA Air Toxics Committee and, along with other states, presented supporting source test results
- In response, the District started a test program to assess emissions from local equipment

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CH2O Source Testing

- Tested at four landfills with engines or turbines
  - Tested 19 of 23 uncontrolled lean-burn IC engines
  - Tested 3 of 3 uncontrolled gas turbines
- Tested at three WWTFs
  - Tested six of seven uncontrolled lean-burn IC DG-fueled engines

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CH2O Source Testing

- Utilized District source testing group
- Initially EPA Method 323
- Switched to modified EPA 316 impinger sampling with 323 analytical procedure
  - Comparison testing showed 316/323 about 5% higher than 323

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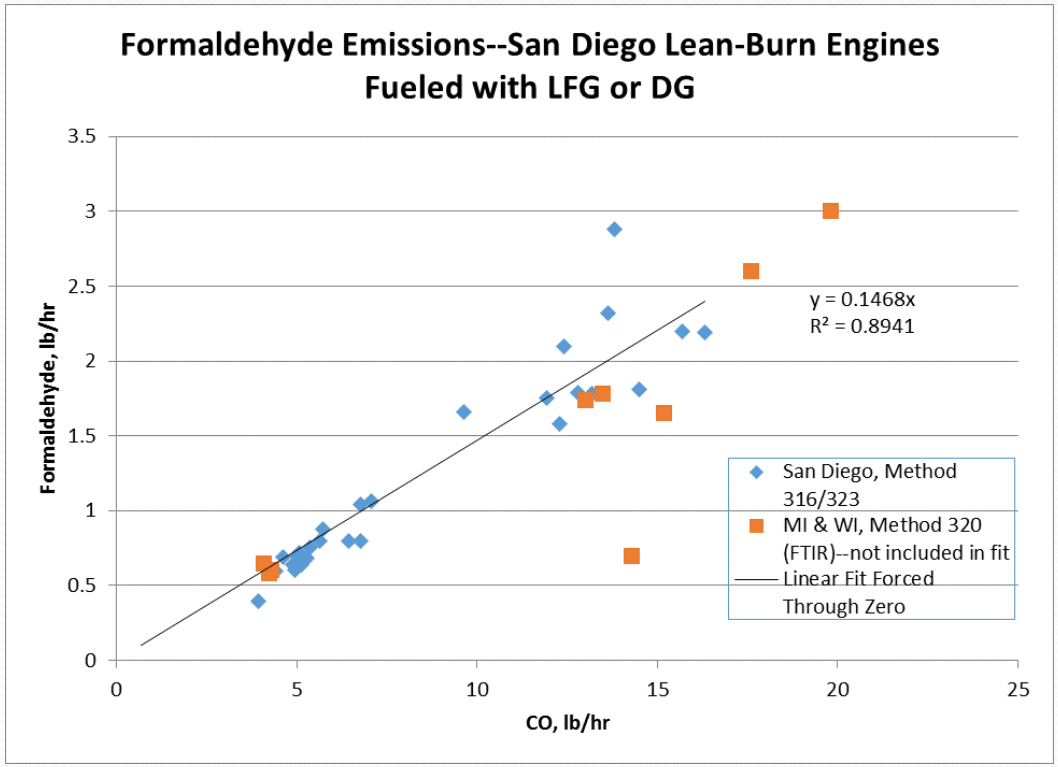
CH_2O IC Engine Results

- 29 tests
- Average about 0.15 lb CH2O / lb CO
  - Consistent with other tests



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CH2O IC Engine EF (lb/MMBtu)

- All District tested: 0.084 ± 0.012
- LFG District tested: 0.088 ± 0.014
- Existing District LFG EF:
- DG District tested: 0.077 ± 0.003
- Existing District DG EF: 0.00217
- AP-42 natural gas: 0.0528
- LFG MI & WI FTIR: 0.097 ± 0.03

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CH_2O Turbine Results

- 7 tests, all LFG
- Average: 0.02 ± 0.004 lb CH2O / lb CO
- Some indication older turbines emit less than newer turbines

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CH_2O Turbine EF (lb/MMBtu)

- Average of District tests: 0.015 ± 0.008
- Existing District EF: 0.000334
- AP-42 (natural gas): 0.00071

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Arsenic Background

- In evaluating an application for a new landfill, investigated potential metal emissions from flares fueled with LFG
- Arsenic (and other metals) have been measured in the exhausts from LFG-fueled combustion devices (flares, boilers, engines) and in one case LFG itself

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Arsenic Background

- Materials of construction are unlikely source of arsenic in the exhaust
- Volatile organic arsenic compounds are well-known as products of anaerobic (and aerobic) microbial processes
- Scientific research has identified volatile organic arsenic compounds in LFG and from sewage sludge anaerobic digestion

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Arsenic Background

- Combustion converts volatile organic arsenic to more toxic inorganic arsenic
- Inorganic arsenic is an important component in health risk assessments
- In response, the District started test program for volatile arsenic in LFG and DG

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Arsenic Source Testing

- Scientific literature indicated arsenic likely primarily present in fuel gas as trimethylarsine (TMA) or arsine
- Standard metal test methods likely not suitable for organic arsenic
- Utilized nearby laboratory that had developed a method (GC/MS) to measure TMA and arsine in LFG

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Arsenic Source Testing

- Sampled LFG and DG fuel at engine and turbine inlets
- Tested at three active landfills, one closed landfill, and three WWTF
- Total of ten tests with results reported

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Arsenic LFG and DG Results

- Wide variability between SD landfills
  - 1.2×10^{-6} to 4.6×10^{-5} lb/MMBtu
  - Main species is TMA (all but one > 90%)
- Similar variability in other testing (EPA and CA landfills)
  - 2.0×10^{-6} to 1.4×10^{-5} lb/MMBtu
- Digester gas (only three tests)
  - 8.6×10^{-7} to 2.8×10^{-6} lb/MMBtu
  - Main species is arsine (55–75%)
  - Not aware of any other testing

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Arsenic Existing EFs

- AP-42 does not have EFs for arsenic (or other metals) for LFG or DG or from combustion devices using those fuels
- District has no existing arsenic EFs for these fuels or combustion processes

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CH_2O Revised Emission Factors

- For formaldehyde District plans to revise uncontrolled EFs for lean-burn IC engines and turbines fueled with DG and LFG based on test results
- Formaldehyde emissions will significantly increase (about 40–250x)
  - One Caterpillar 3520 can emit > 10 tpy

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Arsenic Added Emission Factors

- For arsenic, District plans to adopt new uncontrolled EFs based on source testing
- For existing facilities, may need to be site-specific, which would require source testing for untested sites
- Plan to revise LFG and DG EFs to include arsine

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Implications

- Emission Inventory
- Regulation Applicability
- Prioritization Scores
- Health Risk Assessments
- New Sources
- Compliance

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Regulation Applicability

- Higher formaldehyde emissions may cause existing sources to be a major source for HAPs (10 tpy, one HAP)and/or a major source for VOCs (50 tpy)
  - Title V permit (new or reopened) or Synthetic Minor
  - RICE MACT (ZZZZ) applicability
    - No emission limits, no testing required for biogas fired engines
  - WWTF MACT (VVV) applicability

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Prioritization Scores

- Formaldehyde has risk factors for cancer, chronic, and acute health impacts

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Prioritization Scores

- Trimethylarsine has no official risk factors for health impacts
- Arsine has acute and chronic risk factors
- Both TMA and arsine are expected to be converted to inorganic arsenic in a combustion process
- Inorganic arsenic has cancer, chronic, and acute risk factors

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Prioritization Scores

- Higher formaldehyde and arsenic emissions will increase prioritization score for existing facilities

Species	Amount, lb	Cancer	NonCancer
CH_2O	10000	462	31
Arsenic	10	254	11.5
Arsine	10	N/A	11.5

  - Potential for more HRAs for existing facilities.

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HRAs

- Both formaldehyde and arsenic will contribute significantly to risk from lean-burn IC engines with the new EFs
- Arsenic health impacts would equal or exceed formaldehyde's for IC engines at the high end of measured arsenic levels in LFG

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HRAs

- Arsenic likely to drive cancer risk from LFG- and DG-fueled turbines and flares (lower formaldehyde)

- Arsine would contribute to fugitive LFG and DG acute and chronic health impacts

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HRAs

- Actual risk depends on context (e.g., emissions, receptor locations, terrain, meteorology, release parameters)

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New Sources

- Default uncontrolled fomaldehyde EF will likely be 0.15 lb CH_2O per lb of CO for lean-burn IC engines
- Manufacturer guarantees another option
- For arsenic, District is still considering an appropriate default EF for new sources

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New Sources

- For lean-burn IC engines formaldehyde emissions will be significant in determining major sources or major modification with respect to VOCs
- Both formaldehyde and arsenic will be significant in HRAs for Rule 1200

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Compliance

- Compliance with existing permit VOC limits under review by District
- Some limits may have to be revised
- Depends on the form of the limit and the test procedures specified
- District recognizes that the existing limits did not consider formaldehyde

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