

U.S. EPA UPDATE TO AP-42: LANDFILL EMISSION FACTORS



Presented By: David Vonasek, P.E.

Presented For:

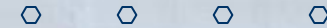
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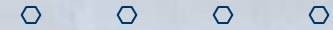
What is AP-42?



- EPA publication entitled: ***“Compilation of Air Pollutant Emission Factors”***
- First published by the U.S. Public Health Service (U.S. EPA) in 1968.
- **Comprehensive authoritative source of published emission factors for different emission sources:**
 - Volume 1 - Stationary Sources
 - Volume 2 - Mobile Sources
- **AP-42 data typically used in the:**
 - Application/issuance of air permits/authorizations
 - Preparation of estimates for air emission inventories
 - Preparation of environmental or health-based risk assessments



AP-42: Chapter 2.4 – MSW Landfills



➤ **Table 2.4-1: Default Concentrations for LFG Constituents**

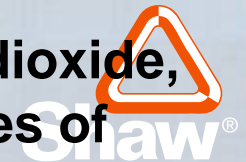
- Total 44 constituents currently identified
- 25 constituents classified as hazardous air pollutants (HAPs)
- Remaining 19 constituents classified either as volatile organic compounds (VOCs), GHGs, or other chlorinated compounds

➤ **Table 2.4-2: Default Concentrations of Benzene, NMOC, and Toluene Based on Waste Disposal History**

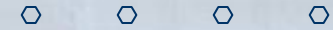
- Separate default concentrations based on co-disposal or no co-disposal of hazardous wastes by facility.

➤ **Table 2.4-3 – Specifies control efficiencies (by %) for LFG constituents based on type of control equipment.**

➤ **Tables 2.4-4 & 5 – Default emission factors for nitrogen dioxide, carbon monoxide, and particulate matter for various types of LFG-fired control equipment.**



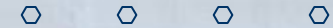
EPA Program to Update AP-42



- **Field testing to characterize raw LFG constituents, and measure landfill and LFG-fired combustion equipment emissions.**
- **Review the collected data to assess updates and possibly generate new AP-42 emission factors for MSW landfills.**
- **Publish a draft of the new proposed AP-42 emission factors for public comment.**
- **Finalize and adopt new AP-42 emission factors.**
- **Update EPA Landfill Gas Emission Model (LandGEM) with the new emission factors.**



Other EPA Landfill Emissions Testing

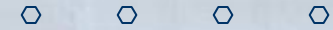


- Evaluation of potential fugitive emissions from landfills.
- Evaluation of emissions from wet/bioreactor landfills.
- Evaluation of emissions from older closed and abandoned landfills.
- Data compiled from these testing programs will also be taken into consideration by EPA when updating AP-42.

The results of these additional EPA test programs, however, will not be discussed as part of this presentation.



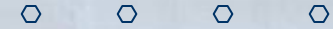
Impetus for Updating AP-42



- **Much of the existing AP-42 emission data for MSW landfills was collected more than 10 years ago as part of the NSPS/EG development.**
- **Changes made over the past 10 to 20 years in landfill design and operation have since influenced landfill air emissions.**
- **Improvements in EPA test methods and quality assurance protocols now provide lower detection limits and better analytical results.**



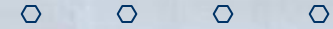
Study Participants



- **U.S. EPA**
- **Environmental Research and Education Foundation (EREF)**
- **ARCADIS G&M, Inc.**



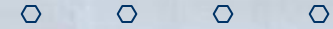
LFG Characterization Testing



- **Field testing began in November 2002.**
- **Completed in June 2005.**
- **Final Report: *Field Test Measurements at Five Municipal Solid Waste Landfills with Landfill Gas Control Technology, April 2007*, prepared for U.S. EPA by ARCADIS G&M, Inc.**
- **Five test sites; 2 in the Northeast, and 3 in the Midwest.**



Test Site Selection Criteria



- **No enforcement actions associated with the site.**
- **Must be fully compliant with all applicable EPA regulations.**
- **Must have state-of-the-art control equipment for LFG control.**
- **Control technology must be typical for most U.S. landfills.**
- **Sites incorporating leachate recirculation to accelerate waste decomposition were excluded.**



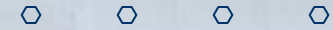
Summary of Test Sites

Description	Landfill A (Phase 1)	Landfill B (Phase 1)	Landfill C (Phase 2)	Landfill D (Phase 2)	Landfill E (Phase 2)
Location	Northeast	Northeast	Midwest	Midwest	Midwest
Year of Initial Waste Placement	1972	1967	1992	1991	1971
Area of Waste Footprint (acres)	56	40	63	31	240
Waste In-Place (ton)	2,700,000	4,000,000	6,400,000	2,350,000	14,500,000
Estimated LFG Extraction Rate (scfm)	1,700	1,500	600	400	4,800
Combustion Control Technology	IC Engine	Flare	IC Engine	Flare	Boiler
Field Test Dates	11/1/2002 to 11/2/2002	11/4/2002 to 11/5/2002	5/12/2004 to 5/13/2004	5/15/2004 to 5/16/2004	6/22/2005 to 6/23/2005

Source Final Report: *Field Test Measurements at Five Municipal Solid Waste Landfills with Landfill Gas Control Technology*, April 2007, prepared for U.S. EPA by ARCADISG&M, Inc.



Pollutants of Interest (POIs) for Raw LFG



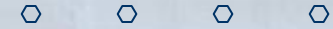
- Volatile Organic Compounds (VOCs, including HAPs)
- Non-methane Organic Compounds (NMOCs)
- Hydrogen Sulfide (H₂S)
- Mercury (Hg)
 - Total
 - *Elemental
 - *Organo
- *Polycyclic Aromatic Hydrocarbons (PAHs)
- *Polychlorinated Biphenyls (PCBs)
- *Carbonyls (acetaldehyde, formaldehyde)

**The non-AP-42 compounds included because of their being classified by EPA as HAPs*



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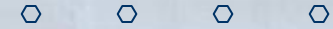
POIs for Combustion Outlet Exhaust



- **Carbon Monoxide (CO)**
- **Nitrogen Oxides (NO_x)**
- **Sulfur Dioxide (SO₂)**
- **NMOCs as total hydrocarbons (THCs)**
- **Hydrogen Chloride (HCl)**
- **Polychlorinated Dibenzodioxins (PCDDs)**
- **Polychlorinated Dibenzofurans (PCDFs)**
- **Polycyclic Aromatics Hydrocarbons (PAHs)**
- **Toxic Heavy Metals, including Hg**



Other Testing Not Included in AP-42



➤ Raw LFG

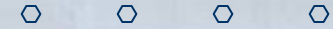
- Methane
- Oxygen
- Carbon dioxide
- Moisture

➤ Combustion Outlet Exhaust

- Oxygen
- Carbon dioxide



Field Sampling Locations



➤ Raw LFG Samples:

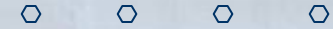
- Collected from main LFG header upstream of any condensate removal systems, LFG pretreatment systems or the blower/compression equipment.

➤ Exhaust Gas from LFG-fired Control Equipment:

- Collected from the exhaust stack.



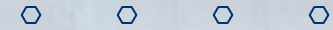
Test Results – Raw LFG



- **70 total trace volatile compounds analyzed.**
- **29 of the 44 default AP-42 constituents had an average concentration of half or lower of their corresponding current AP-42 default value.**
- **One landfill was found to have 16 constituents with an average concentration above current AP-42 default value.**
- **NMOC concentrations ranged between 233 and 5870 ppm as hexane, with an average concentration of 1568 ppm. Current AP-42 default is 595 ppm as hexane.**
- **Average hydrogen sulfide concentration from all the test landfills was 2.7 times higher than the current AP-42 default value.**



Test Results – Raw LFG (cont)



- **Average total Hg concentration at each landfill was less than half of the current AP-42 default value.**
- **PAH/PCB testing was attempted during Phase 1 testing at Landfills A and B. Excessive dilution required of the Phase 1 samples for safe GC/MS analysis resulted in “non-detects” at the high detection limits. Decision was made to discontinue further PAH/PCB testing.**
- **Carbonyl analysis consistently found acetaldehyde concentrations 6 to 8 times higher than that for formaldehyde at all five sites.**



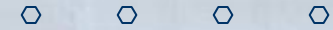
Control Equipment Operating Parameters

Description	Landfill A (Phase 1)	Landfill B (Phase 1)	Landfill C (Phase 2)	Landfill D (Phase 2)	Landfill E (Phase 2)
Control Technology	IC Engine	Enclosed Flare	IC Engine	Enclosed Flare	Boiler
Size or Capacity	1649 in ³ displacement 470KW	10.8 to 54 MMBtu/hr	4210 in ³ displacement 800KW	4.0 to 20.9 MMBtu/hr	80,000 lb/hr 250 psi steam
LFG Flowrate into Equipment (scfm)	150	1500	300	400	2430
Exit Flowrate (dscfm)	1290 – 1340	19700 – 22000	1890 – 2000	7830 – 8290	26820 – 30400
Exit Gas Temp (°F)	732 – 738	1359 – 1419	997 – 1038	1412 – 1446	476 – 488

Source Final Report: *Field Test Measurements at Five Municipal Solid Waste Landfills with Landfill Gas Control Technology*, April 2007, prepared for U.S. EPA by ARCADISG&M, Inc.



Test Results – Control Equipment

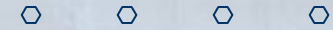


➤ Continuous Emission Monitoring (CEM) Parameters:

- The average measured outlet CEM concentrations for O₂, CO, CO₂, SO₂, NO_x, and THC, were consistent with most other MSW landfill sites and described in the final EPA report as being “unremarkable”.
- The IC engines produced substantially higher concentrations of CO, THC and NO_x than the other control devices.
- The CO, SO₂ and NO_x emissions for the flares and boiler were found to be similar.
- The boiler was found to be most efficient with the lowest CO and THC concentrations.



Test Results – Control Equipment (cont)

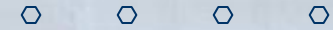


- **Hydrogen chloride (HCl) concentrations ranged between 0.9 to 14.0 ppmv; consistent with other MSW landfills**

- **Polychlorinated Dibenzodioxin (PCDD) and Dibenzofuran (PCDF):**
 - Generated during reduced combustion efficiency and when the combustion products are allowed to cool down slowly.
 - Testing conducted only at Landfills A, B, C and E.
 - Landfill D excluded because of the non-detect results for the flare at Landfill B.
 - Results were mostly below the detection limits, with the exception of the boiler which potentially have the conditions to favor PCDD/PCDF formation.



Test Results – Control Equipment (cont)



➤ **Polycyclic Aromatics Hydrocarbon (PAH):**

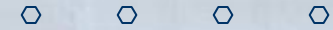
- PAH emission rates from the IC engine outlet were found to be 2 to 3 times higher than that for the flares and boiler.

➤ **Toxic Heavy Metals:**

- Compared to the boiler, the IC engines and flares had low metal emissions.
- The metal emissions from the boiler were noticeably higher.



Conclusions



➤ Raw LFG:

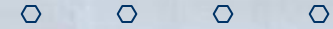
- 29 of the existing 44 AP-42 constituents were found to have average concentrations that are half or lower than corresponding AP-42 defaults values.
- 12 of these 29 constituents had average concentrations that were no more than one-tenth of their AP-42 value.

➤ Control Technologies:

- The boiler destroyed the LFG most effectively; but did have a high affinity to form PCDDs and PCDFs.
- IC engines did not appear to destroy the LFG as effectively as flares or boilers; however they do offset fossil fuel usage.
- Fine tuning IC engines to minimize CO and NO_x emissions result in decreased NMOC destruction efficiency.



Conclusions (cont)



➤ **Control Technologies:**

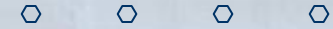
- Enclosed flares are simple devices and east to operate and maintain.
- Flares were found to effectively control hydrocarbons and organic constituents.
- Flares do not offset fossil fuel usage as do IC engines or boilers.

➤ **Mercury Analysis:**

- The technology for mercury analysis of LFG is progressing, but still needs improvement.



Schedule for Updating AP-42



➤ Original schedule:

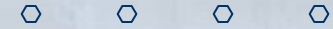
- A draft of the new AP-42 LFG emission factors to be ready by Spring 2007
- Draft emission factors available for 60-day public comment
- Publish final LFG emission factors by Fall 2007

➤ Revised schedule:

- The draft AP-42 LFG emission factors to be ready by June/July 2008
- Draft emission factors available for 60-day public comment
- Publish final LFG emission factors by end of 2008



EPA LFG Publication



- <http://www.epa.gov/ORD/NRMRL/publications.html>
- **Report: *Field Test Measurements at Five Municipal Solid Waste Landfills with Landfill Gas Control Technology, April 2007***
(Publication EPA-600/R-07/043)



QUESTIONS?

