Updated Speciation Profiles in MOVES

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Summary

• Background on speciation in MOVES and SMOKE
  – Onroad
  – Nonroad

• Proposed changes to speciation
  – Heavy-duty 2010+
  – Large nonroad Tier 4 engines
Background

- MOVES VOC and PM must be allocated into constituent chemical species prior to air quality modeling
  - This is done through application of speciation profiles
- Prior to MOVES2014, mobile source VOC and PM were speciated outside of MOVES using the SMOKE emissions processor
  - For VOC, speciation profiles of individual chemical compounds were applied and these compounds were then grouped into chemical mechanism species with similar properties in the air quality model
  - For PM, simplifying chemical mechanisms not used in CMAQ, EPA’s air quality model
    - PM species input directly into model
Background: Onroad Speciation

- Speciation profiles can vary by source type, emission process (exhaust, permeation, evaporative), fuel type (diesel versus gasoline), fuel blend (e.g. E0, E10), emissions control technology
  - Mix of technologies, fuel types, etc. can also vary by location
  - SMOKE dealt with all these complexities by weighting various profiles
  - Became increasingly burdensome

- MOVES2014 included VOC and PM speciation for onroad sources
  - Since MOVES estimates emissions of individual toxic compounds, these emissions must be “integrated” into the profiles
Onroad Speciation in MOVES

MOVES

- Acetaldehyde
- Formaldehyde
- Benzene
- Other individual toxics to be integrated

TOG

- TOG – integrated toxics (NONHAPTOG)

Speciation profiles with all measured species (e.g., based on EPAct data)

Speciate Tool

Chemical mechanism for lumping measured species into CMAQ model species

New CMAQ model species profiles renormalized without integrated toxics

SMOKE

CMAQ
Background: Nonroad Speciation

• MOVES2014a updated toxic emission rates for nonroad engines based on newer data, as well as speciation profiles based on the same datasets

• Grouping individual VOC compounds into chemical mechanism species is done in SMOKE rather than MOVES
  – For nonroad, MOVES produces VOCs grouped by profile:
    • Profiles are defined by:
      – Engine Type (e.g. CI, SI 2-stroke, SI 4-stroke), Engine Tech (e.g. Tier 1), Engine Size (e.g. >75 HP), Fuel (e.g. Diesel, CNG), fuel subtype (e.g. E0, E10), emission process (e.g. exhaust, evaporative)
  – Because users can group emissions by profile, no need to weight profiles, and speciation can be easily applied in SMOKE
  – Allows application of new chemical mechanisms in SMOKE without re-running MOVES
Proposed Update to Speciation for 2010 and Later Highway Diesels

• MOVES2014a applies speciation from 2007-2009 engines to all 2007 and later engines
  – Data from HEI’s Advanced Collaborative Emissions Study (ACES) Phase 1
• Emission control technology very different for engines meeting more stringent 2010 and later standards than for 2007-2009 engines
• Data from ACES Phase II recently became available
  – Speciated emissions from 2010 on-highway heavy-duty diesel engines equipped with diesel particulate filter (DPF) and selective catalytic reduction (SCR) systems
• Large effect on VOC speciation
  – e.g. formaldehyde is a much lower fraction of VOC
• We are proposing applying these data to all 2010 and later engines
Speciation for Nonroad Diesel Tier 4 Engines

- Nonroad Diesel Tier 4 engines <56 kW
  - Tier 4 NMHC emissions standards relatively unchanged from Tier 2
  - No EPA certified engines are equipped with diesel particulate filters (DPF) or selective catalytic reduction (SCR) systems
  - Considering using the same Tier 2 VOC emission profile in the next version of MOVES as used in MOVES2014

- Nonroad Diesel Tier 4 engines > 56 kW
  - Significant reduction in NMHC and NOx emissions
  - DPF penetration ~ 40%
  - SCR penetration between 90-100% (2014 EPA Certification data)
  - MOVES2014 uses the ACES Phase I onroad profile (DPF equipped heavy-duty onroad engines)
  - Considering using ACES Phase II onroad profile (DPF+SCR equipped heavy-duty onroad engine) for next version of MOVES
VOC profiles for Nonroad emissions

• The following profiles are used in SMOKE to speciate VOC emissions from MOVES

• All of these profiles are found in SPECIATE database

  • 95327 – Spark ignition exhaust; 2-stroke off-road engines; Non-oxygenated gasoline
  • 95328 -- Spark ignition exhaust; 2-stroke off-road engines; E10 ethanol gasoline
  • 95329 -- Spark-Ignition Exhaust; 4-stroke off-road engines; Non-oxygenated gasoline
  • 95330 -- Spark-Ignition Exhaust; 4-stroke off-road engines; E10 ethanol gasoline
  • 95331 -- Diesel Exhaust Emissions; Pre-Tier 1 Off-road Engines
  • 95332 -- Diesel Exhaust Emissions; Tier 1 Off-road Engines
  • 95333 -- Diesel Exhaust Emissions; Tier 2 Off-road Engines
  • 95335 -- Diesel Exhaust; Onroad Heavy-heavy duty truck; 2011 model year
    – Proposed for Nonroad Tier 4 Diesel >56 kW
Proposed Update to PM Speciation

- **ACES Phase I PM profile (2007 HD technology)**
  - Large contribution of SO4 emissions, from regeneration events—where the accumulated particulates, including sulfur, are removed from the diesel particulate filter

- **ACES Phase II PM profile (2010 HD technology)**
  - Large reduction in PM$_{2.5}$ emissions from the ACES Phase I profile$^1$,
  - Phase II data does not include DPF regeneration events, and minimal SO$_4$ measured in Phase II

- **Considering using of the ACES Phase I PM$_{2.5}$ profile for all 2007+ trucks and Tier 4 >56 kW engines**
  - California Air Resources Board testing$^{2,3}$ has shown regeneration events occur on 2010+ technology on-highway trucks, but at a lower frequency
  - Not reflected in the ACES Phase II PM profile

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Summary

• Proposing to replace highway diesel VOC speciation for 2010 and later engines with recent data on those technology engines from ACES Phase II

• Considering using ACES Phase II onroad profile (DPF+SCR equipped heavy-duty onroad engine) for nonroad Tier 4 VOC emissions in the next version of MOVES

• Considering maintaining the use of the ACES Phase I PM2.5 profile for all 2007+ trucks and nonroad Tier 4 >56 kW engines