Evaporative Emission Impacts of Ethanol in Gasoline

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Overview

• Background
  • Contribution of evaporative emissions to total VOC
  • Evaporative emission trends

• Evaporative Modes and Mechanisms

• CRC Studies
  • Permeation: E-65 and E-65-3
  • Evaporative mechanisms: E-77

• Inventory Impacts

• Conclusions
Mobile Source TOG Emissions, NESCAUM States

Source: SMOKE Model, based on MOBILE6 Emission Factors.

August 15, 2002
LDV Summer Evaporative Emissions, California

Vehicle Evaporative Emissions: Modes vs. Mechanisms

Emission Mechanisms
- Leaks (liquid & vapor)
- Canister losses (“Venting”)
- Permeation

Operation Modes
- Diurnal
  - Breathing (Temp Rise)
  - Resting (Temp falling or stable)
- Hot soak
- Running losses
- Refueling

Each mechanism may occur during any mode.

Evaporative Emission Mechanisms

• Leaks and venting
  – Functions of:
    – Fuel volatility (RVP)
    – Fuel system integrity
    – Canister capacity and efficiency
  – *NO ETHANOL EFFECT (with constant RVP)*

• Permeation
  – Migration of fuel molecules through fuel system components
  – Not RVP-dependent
  – Not captured in Complex model
  – Strongly influenced by presence of ethanol in low concentrations (6% and 10%)
  – Temperature dependent: rate doubles with each 10ºC.
Recent CRC Permeation Studies

CRC E-65 (2004)
- 10 Vehicles, MY 1978 – 2001
- 3 Fuels: MtBE, E6, Non-oxygenated
- Average permeation rate for all vehicles increased 65% with E6 compared to MtBE blend
- Average permeation rates on post-1996 vehicles increased 157% with E6 compared to E0

CRC E-65-3 (2006 – preliminary results only)
- 5 Vehicles: 2 ‘enhanced’, LEV-2, PZEV, Flex-Fuel
- 5 Fuels: E0, E6, E6-Hi, E10, E85
- Average 200% increase with E10
- Permeation decreased by 50% with E85 compared to E0
- Average specific reactivities were ~30% lower per gram of permeate with E6 and E10 compared to E0
- Ethanol appears to promote permeation of non-ethanol species
CRC E-65 Results

CRC E-65-3 Results

Permeation Emissions (mg/day)

- 2001 Tacoma
- 2000 Odyssey
- 2004 Taurus LEV II
- 2004 Sebring PZEV

CARB’s Estimated Impacts (Draft): South Coast Air Basin

- 17.4 tpd increase for typical ozone day (84ºF peak)
- 20.5 tpd increase for high-ozone day (98ºF peak)
- Statewide: 45 tpd from cars, 10tpd from small engines
- Based on EMFAC modeling assumptions:
  - 6% of running losses, 13% of hot soak, 66% of diurnal emissions
  - 26% of total evaporative emissions
- Total impact is *highly dependent* on permeation fraction!

What is the contribution of permeation effects to total evaporative emissions?

• No data available (E77 should provide some insight)

• Historically probably very low
  • Carburetors were a major source of evaporative emissions
  • Basic controls (pre-1996) much less effective at capturing venting emissions

• Likely increasing as venting losses are better controlled
What is the contribution of permeation effects to total evaporative emissions?

“…now that carburetors are no longer in production, fuel volatility is under control, and the enhanced evaporative emissions regulations have forced the vehicle to actively and aggressively purge the canister during driving, the only mechanism of significance is the permeation.” (emphasis added)


CRC E-77

• First step toward characterizing evaporative emissions for enhanced-evap and later vehicles
• Pilot study to validate test method
• Sponsors include ARB, EPA
• Results expected early 2007.
Conclusions

- E6 and E10 shown to significantly increase permeation from some vehicles
  - Increase is less pronounced with PZEV systems
- Permeation greatest at high temperatures
- VOC increase partially offset by lower ozone-forming potential of permeate
- Fleet mix and meteorological conditions are major factors
- Insufficient data to predict impact on emissions inventory
- Increase in permeation fraction may cause upward revision of ethanol evaporative impact estimates
- TIER-2 and LEV-2 vehicles certified with ethanol (durability testing), so permeation increase should not be long-term issue
- May remain issue for nonroad equipment
Questions?