

CRANKCASE EMISSIONS FOR MY2007+ HEAVY-DUTY DIESEL TRUCKS

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Crankcase Emissions (1/2)

- Open crankcase systems vent crankcase gases
 - Include unburned fuel, combustion products and lubricating oil
- Light-duty emission regulations require closed crankcase systems
- Pre-2007 MY heavy-duty crankcase emissions are unregulated
- Requirements for 2007 MY+ heavy-duty diesel engines
 - 1) Equip with closed crankcase systems
 - Or
 - 2) Include crankcase emissions from open crankcase systems in exhaust certification tests

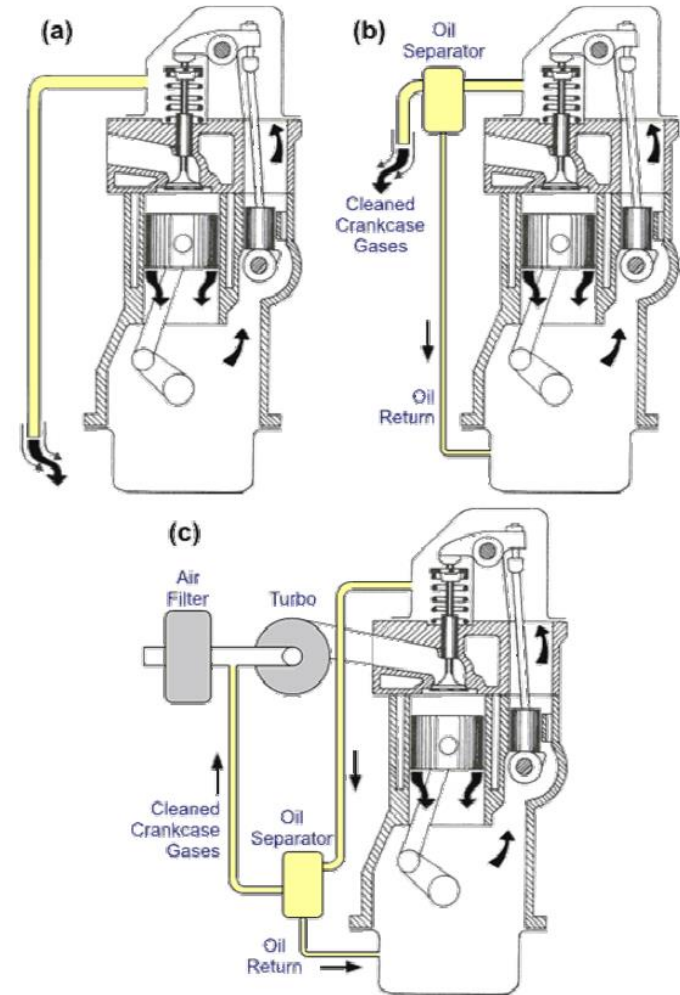


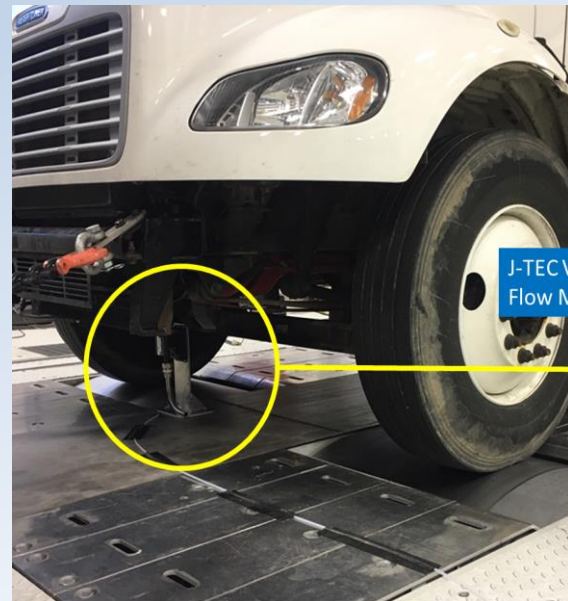
Figure 6. Crankcase Ventilation Systems
(a) Open unfiltered crankcase ("road draft tube"); (b) Open crankcase filtration system; (c) Closed crankcase ventilation (CCV)

Crankcase Emissions (2/2)

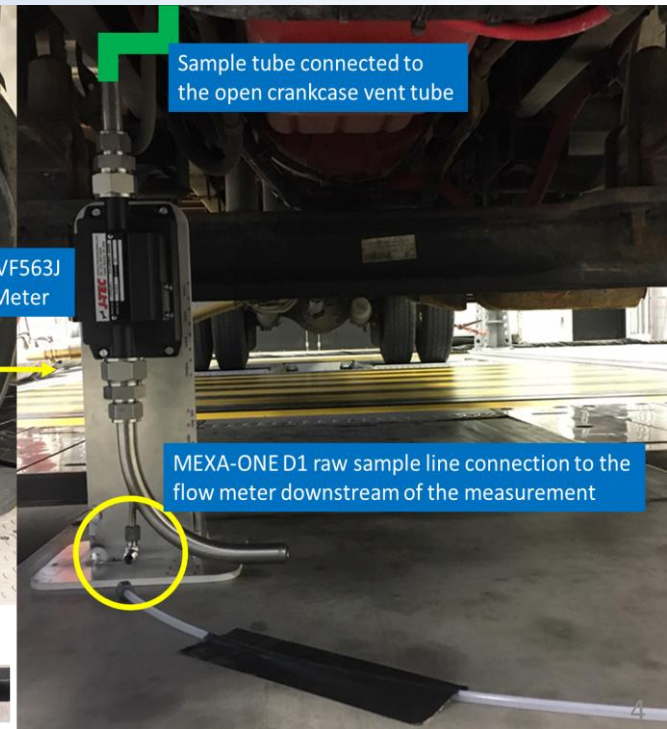
- Crankcase emissions are becoming a larger part of total heavy-duty diesel emissions as tailpipe emissions are reduced
- Limited amount of data available to estimate crankcase emissions in MOVES2014
 - MY 2007 heavy-duty engines used for MOVES2014 does not contain direct measurements of the crankcase
 - MOVES2014 does not include measurements from 2010+ MY engines
- Recent crankcase test program used to update MOVES3 for MY 2010 and later engines

US EPA Crankcase Testing

- Conducted at National Vehicle Emissions and Fuels Laboratory in Ann Arbor, MI
- Two heavy duty diesel trucks tested on a chassis dynamometer
 - Truck 1 - MY2015 14.9 L diesel engine
 - Truck 2 - MY2018 12.4 L diesel engine
- Crankcase and tailpipe were measured separately
- A minimum of 6 tests per truck
 - THC, CO, NO_x, CO₂, N₂O, CH₄
 - No PM_{2.5} measurements



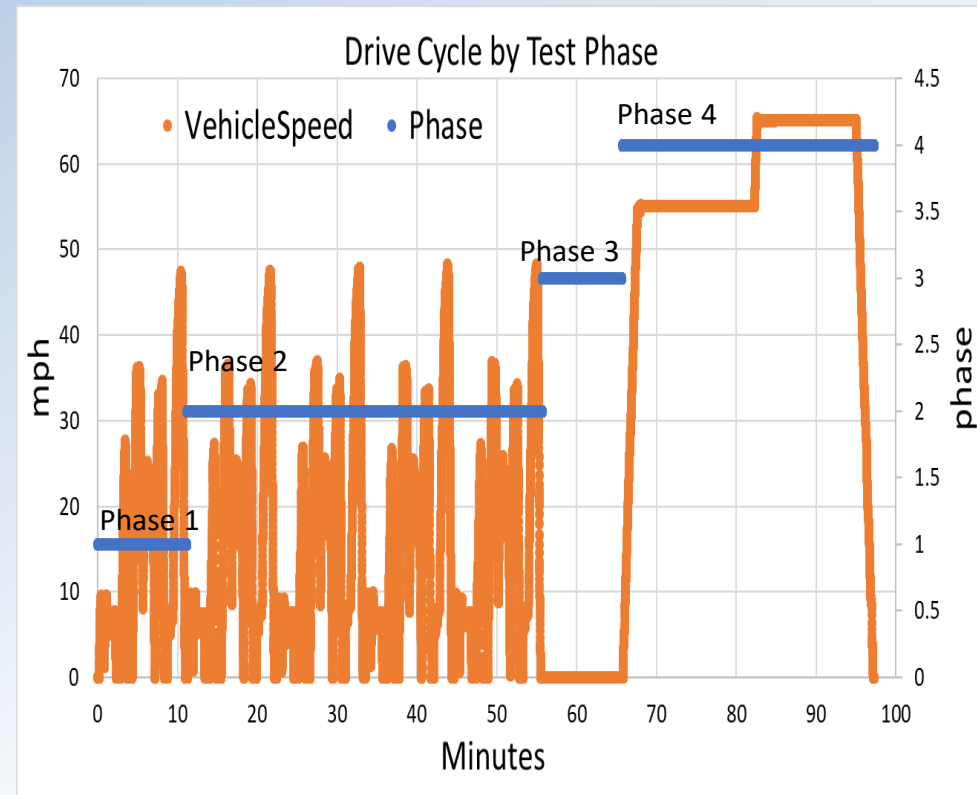
Tubing used to connect crankcase vent to flow meter



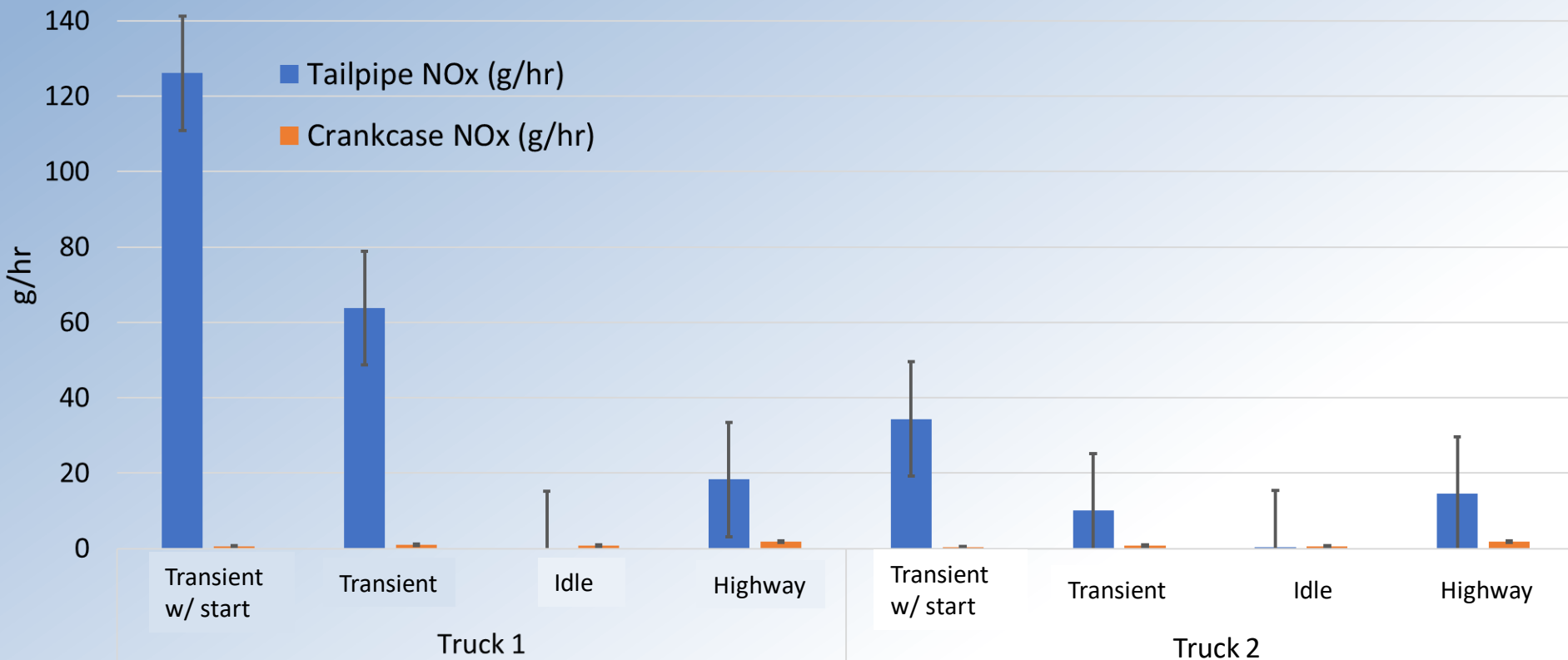
SAE 1000 PSI PETROLEUM SAE J300-4

Test Cycle

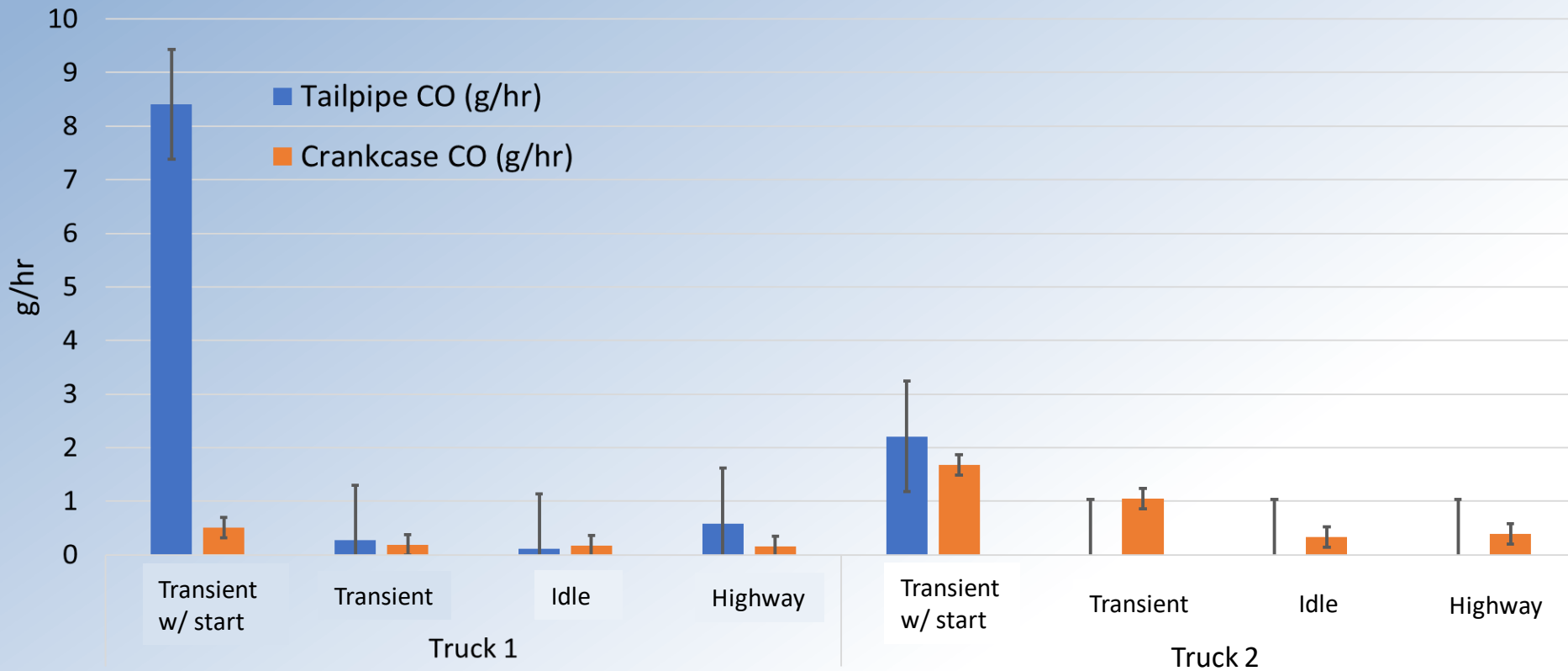
- Phase 1 – ARB transient cycle, including a start
- Phase 2 – 4x ARB transient cycle
- Phase 3 – Idle
- Phase 4 – 55mph Steady-State cycle followed by 65mph Steady-State cycle



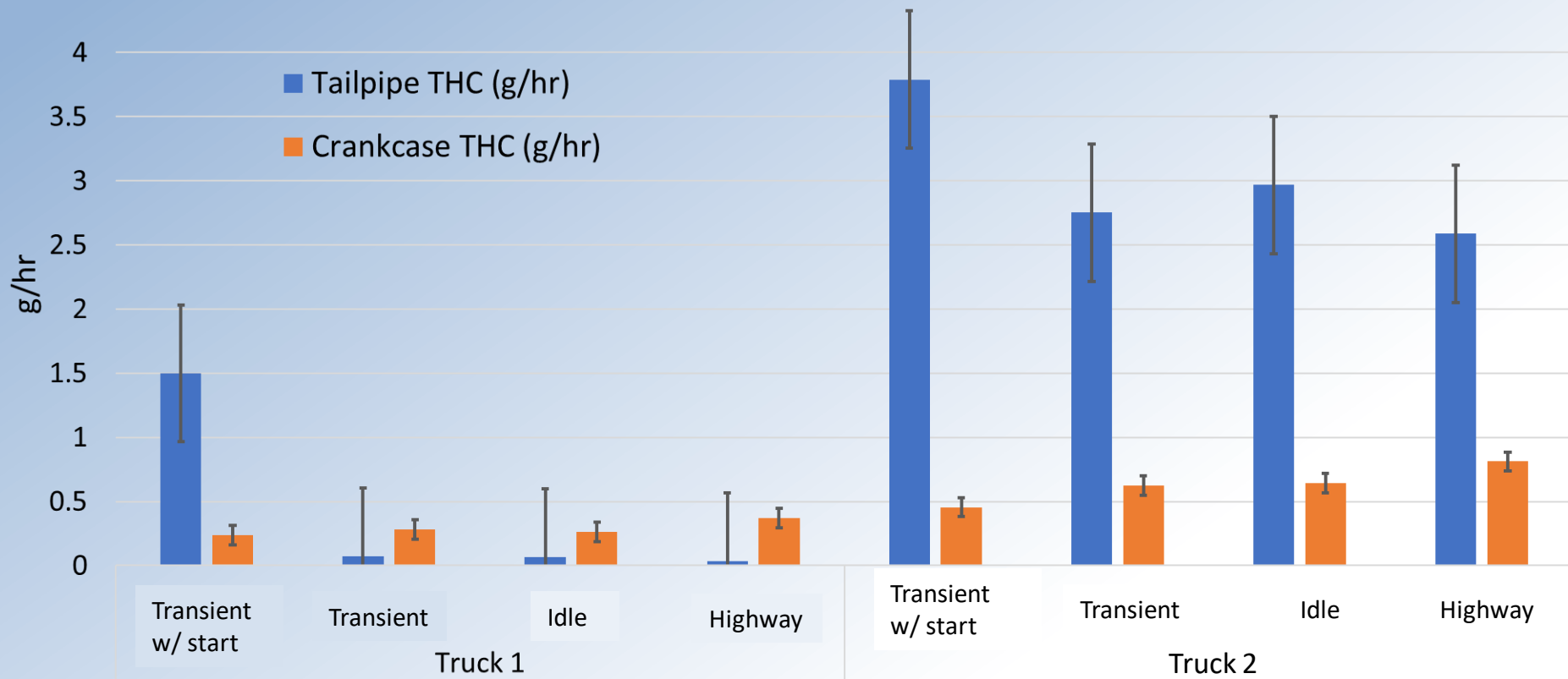
Results: Nitrogen Oxides (NOx)



Carbon Monoxide (CO)



Total Hydrocarbon (THC)



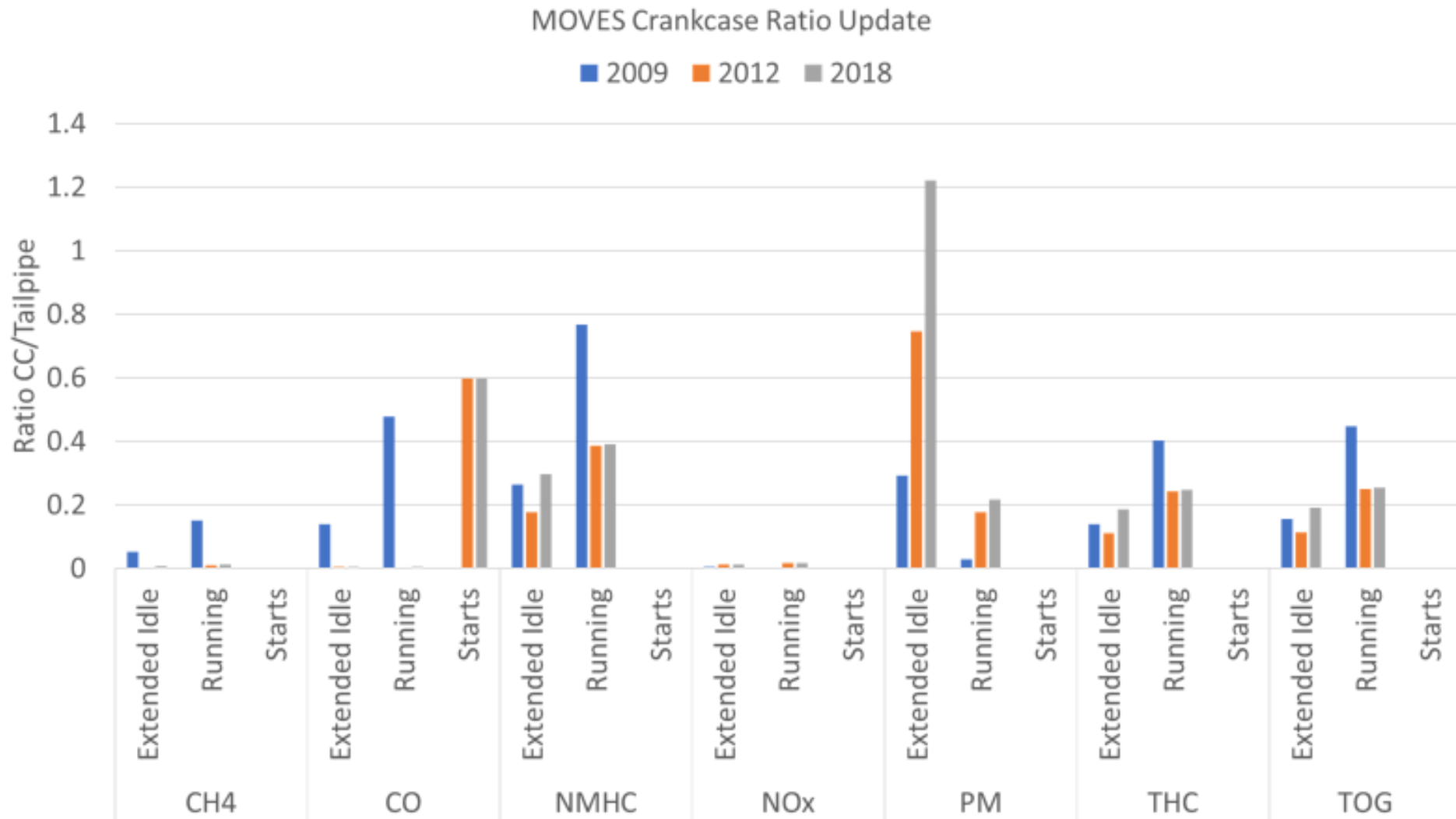
Updates to 2007-2009 Crankcase Emission Rates

- Crankcase emissions are modeled as a ratio of tailpipe exhaust emissions
- MOVES2014
 - Assumed MY 2007+ crankcase gaseous emissions were incorporated into the tailpipe emission rates
 - $PM_{2.5}$ emissions are modeled as a fraction of the tailpipe emissions because 2007-2009 $PM_{2.5}$ emission rates are based on certification testing
- MOVES3
 - MY 2007-2009 crankcase gaseous emissions updated because gaseous tailpipe emission rates are based on tailpipe testing (not certification)
 - $PM_{2.5}$ emissions continue to be modeled as a fraction of the tailpipe emissions
 - Gaseous and $PM_{2.5}$ crankcase ratios updated to be consistent with methodology used to derive the 2010+ rates
- MY 2007-2009 gaseous and $PM_{2.5}$ crankcase ratios updated based on:
 - ACES Phase 1 Emission rates that tested MY 2007 engines
 - MOVES3 tailpipe exhaust rates
 - Fraction of closed crankcase systems

Updates to MY 2010+ Crankcase Emission Rates

- MY 2010+ gaseous crankcase ratios updated based on:
 - US EPA Crankcase Testing
 - MOVES3 tailpipe exhaust rates
 - Fraction of closed crankcase systems
 - 67.2% of Model Year 2016-2018 heavy-duty vehicles are certified with closed crankcase systems
- MY 2010+ crankcase emission rates for THC, CO, and NO_x calculated by averaging the two trucks in US EPA Crankcase Testing
 - Running crankcase emissions calculated as weighted average of Phase 2 (<50 mph) (36.7%) and Phase 4 (>50 mph) (63.3%).
 - Matched the speed distribution of operating mode distribution for HHDD vehicles in MOVES
 - Start emissions = Phase 1 – $\frac{\text{Phase 2}}{4}$
 - Extended idle crankcase emissions using Phase 3 (idle)
- MY 2010+ PM_{2.5} crankcase ratios
 - Continue to be based on ACES Phase 1 emission rates
 - PM_{2.5} emissions are NOT modeled as a fraction of the tailpipe emissions, because MY 2010+ PM tailpipe exhaust rates are based on PEMS tailpipe testing

MOVES Crankcase Ratio by Model Year



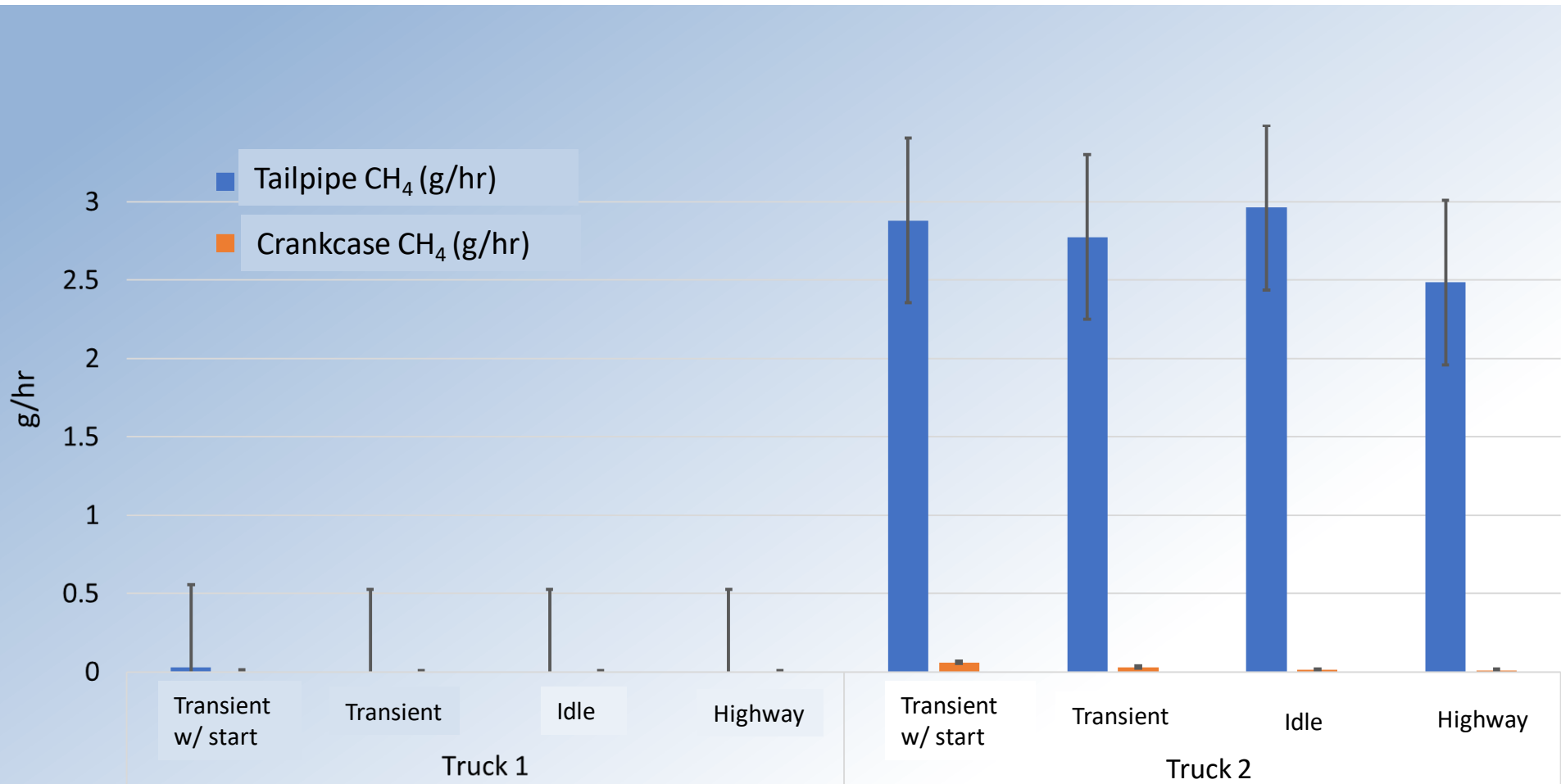
NMHC= non-methane hydrocarbons, THC = total hydrocarbons, TOG = total organic gases

Conclusions

- MOVES3 Crankcase emissions
 - CO, THC, and PM_{2.5} crankcase emissions are a significant fraction of total exhaust emissions from MY 2007+ heavy-diesel trucks
 - Includes individual VOC species calculated as a fraction of total hydrocarbon emissions
 - Minor contributor to NOx emissions
- Comparisons to MOVES2014b
 - Small impact on total onroad inventory of CO and THC (<3%)
 - Emissions inventory dominated by gasoline light-duty vehicles
 - More significant impact for total onroad inventory for PM_{2.5}
 - Testing showed varied impact
 - 1% increase in 2017, 8% increase in 2035
 - Results will vary with individual scenarios

APPENDIX

Methane (CH₄)



Carbon Dioxide (CO₂)

