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MEMORANDUM

SUBJECT: Development version of GEM3.9 and adjustment factors

FROM: Brian Nelson

TO: Improvements for Heavy-Duty Engine and Vehicle Test Procedures, and Other Technical Amendments - Docket EPA-HQ-OAR-2019-0307

This memo documents the release of a development version of GEM (GEM 3.9) which incorporates some fixes and improvements relative to the unofficial version (GEM 3.8) that was released on June 29, 2021, with the Supplemental Notice of Proposed Rulemaking (“SNPRM”) titled *“Improvements for Heavy-Duty Engine and Vehicle Test Procedures”* (86 FR 34189).¹ The SNPRM proposes certain additional modifications to GEM, compared to version GEM 3.5.1 adopted in EPA’s final rulemaking issued on the same date as the SNPRM, titled *“Improvements for Heavy-Duty Engine and Vehicle Test Procedures, and Other Technical Amendments”* (86 FR 34308), after consideration of comments received on the original proposed rule titled *“Improvements for Heavy-Duty Engine and Vehicle Test Procedures, and other Amendments – Proposed Rule”* (85 FR 28140). The SNPRM proposed corrections, clarifications, additional flexibilities, and provided adjustment factors to improve the Greenhouse gas Emissions Model (“GEM”) compliance tool for heavy-duty vehicles while more closely matching the outputs produced by the original version of GEM (GEM 3.0) that was used to establish the CO₂ standards for Model Years 2021 and later in the 2016 Heavy-duty Phase 2 final rule (“Phase 2”).²

As a part of the SNPRM, EPA released an updated version of the model, GEM 3.8. This version is considered official only for use with the hardware in loop (HIL) test procedure defined in 40 CFR 1037.550, but is otherwise not an official version of GEM and it cannot be used for compliance with EPA emission standards.³ EPA has made additional changes to GEM3.8 after consideration of comments received on the SNPRM. This additional unofficial version GEM 3.9 is now available and includes the following changes relative the GEM 3.8:

¹ <https://www.govinfo.gov/content/pkg/FR-2021-06-29/pdf/2021-05305.pdf>

² See 81 FR 73478 and <https://www.epa.gov/regulations-emissions-vehicles-and-engines/regulations-greenhouse-gas-emissions-commercial-trucks> for more information on our Phase 2 program

³ <https://www.epa.gov/regulations-emissions-vehicles-and-engines/greenhouse-gas-emissions-model-gem-medium-and-heavy-duty>

- Incorporates adjustment factors in GEM
- Allows input files from previous versions of GEM
- Fixes an error with the transmission shift model
- Changes GEM to not merge drive idle fuel map with default steady-state fuel map
- Fixes an error with the default fuel maps that are used for Custom Chassis vehicles
- Changes the regression model that is used for interpolating the cycle average fuel maps for the cruise cycles
- Modifies GEM to reflect stop-start and AESS technologies when powertrain testing is used
- Applies mass of CO₂ to gallons of fuel conversion factor by combustion type instead of fuel type
- Includes changes to the carbon mass fraction for E85 to value in Table 1 of 40 CFR 1036.530
- Includes increased tolerance for idle target speed vs idle fuel maps
- Changes how GEM models powertrain accessory work

EPA has also updated the adjustment factors released with the GEM 3.8 version to accommodate the changes made in the development of GEM 3.9 and to the updated method of creating these factors using unrounded GEM results versus using the rounded GEM results as was done with GEM 3.8. The revised adjustment factors are included below and are a function of regulatory subcategory and model year (i.e., 2021-to-2023; 2024-to-2026; and 2027-and-later). One exception this is tractors with automatic transmission. For tractors with automatic transmissions, GEM 3.9 includes an adjustment factor of zero. In GEM 3.9, the adjustment factors in Table 1 are applied to the composite GEM result within the program itself using the following equation.

$$e_{CO2_{Corrected}} = \frac{e_{CO2}}{1 + AF}$$

Where:

e_{CO2} = unrounded composite CO₂ emissions from GEM

AF = the applicable adjustment factor from Table 1

Table 1 GEM 3.9 Adjustment Factors

Regulatory Subcategory	Adjustment Factor		
	MY 2021-2023	MY 2024-2026	MY 2027-and-later
Class 7 Day Cab Low Roof	-0.0107	-0.0094	-0.0097
Class 7 Day Cab Mid Roof	-0.0105	-0.0091	-0.0091
Class 7 Day Cab High Roof	-0.0090	-0.0094	-0.0093
Class 8 Day Cab Low Roof	-0.0062	-0.0074	-0.0069
Class 8 Sleeper Cab Low Roof	-0.0010	-0.0013	-0.0010
Class 8 Day Cab Mid Roof	-0.0064	-0.0070	-0.0065
Class 8 Sleeper Cab Mid Roof	-0.0010	-0.0011	-0.0010
Class 8 Day Cab High Roof	-0.0061	-0.0071	-0.0067
Class 8 Sleeper Cab High Roof	-0.0011	-0.0010	-0.0009
Class 8 Heavy Haul	-0.0068	-0.0067	-0.0070
Multi-Purpose Light HDV Compression-ignition	-0.0006		
Regional Light HDV Compression-ignition	0.0005		
Urban Light HDV Compression-ignition	0.0000		
Multi-Purpose Medium HDV Compression-ignition	-0.0030		
Regional Medium HDV Compression-ignition	0.0008		
Urban Medium HDV Compression-ignition	-0.0036		
Multi-Purpose Heavy HDV Compression-ignition	0.0097		
Regional Heavy HDV Compression-ignition	0.0006		
Urban Heavy HDV Compression-ignition	0.0132		
Multi-Purpose Light HDV Spark-ignition	0.0001		
Regional Light HDV Spark-ignition	0.0008		
Urban Light HDV Spark-ignition	0.0011		
Multi-Purpose Medium HDV Spark-ignition	0.0015		
Regional Medium HDV Spark-ignition	0.0005		
Urban Medium HDV Spark-ignition	0.0028		
School bus	-0.0031		-0.0030
Motor home	0.0001		0.0001
Coach bus	0.0018		0.0019
Other bus	0.0132		0.0135
Refuse hauler	0.0124		0.0126
Concrete mixer	0.0124		0.0125
Mixed-use vehicle	0.0124		0.0125
Emergency vehicle	0.0122		0.0124

EPA is not requesting comment on, or reopening the comment period regarding, any of the information documented as being made available or made available in this memo. Links to a Windows executable file and the source code for GEM 3.9 can be found at the following website:

<https://www.epa.gov/regulations-emissions-vehicles-and-engines/greenhouse-gas-emissions-model-gem-medium-and-heavy-duty>