UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL VEHICLE AND FUEL EMISSIONS LABORATORY
2000 TRAVERWOOD ROAD
ANN ARBOR, MI 48105-2498

OFFICE OF
AIR AND RADIATION

December 9, 2020

MEMORANDUM

SUBJECT: Redline Version of EPA's Final Regulatory Amendments for Heavy-Duty Greenhouse Gas Standards and other Programs

FROM: Alan Stout
Assessment and Standards Division

TO: Docket EPA–HQ–OAR-2019-0307

EPA is adopting a wide range of amendments to the emission control program for heavy-duty highway greenhouse gas standards and many other types of engines, vehicles, and equipment. The attached files highlight the changes in the final rule. The drafting is presenting with two different methods.

- Attachment 1 includes regulatory text for 40 CFR parts 1036, 1037, 1065, and 1066. This shows proposed changes in red font, with additional changes shown in blue font to represent changes made after the proposal.
- Attachment 2 includes regulatory text for the remaining parts of the rule. This shows only the changes made to these regulatory provisions after the proposal. Where the regulatory text was not part of the proposed rule, a comment box notes that the relevant text is presented with markings to show how the text changes from the existing text in the Code of Federal Regulations.

The regulations in the attached files are intended to be the same as what will be published in the Federal Register. However, there will likely be some minor differences as a result of preparing the document for publication. The document published in the Federal Register is the official copy.

Attachments

Attachment A

Attachment B

Attachment A

PART 1036--CONTROL OF EMISSIONS FROM NEW AND IN-USE HEAVY-DUTY HIGHWAY ENGINES

97. The authority citation for part 1036 continues to read as follows:
Authority: 42 U.S.C. 7401 - 7671q.

98. Amend § 1036.1 by adding paragraph (b)(3) to read as follows:

§ 1036.1 Does this part apply for my engines?

* * * * *

(b) * * *

(3) The provisions of § 1036.501(h)(1) apply.

* * * * *

99. Amend § 1036.108 by revising paragraph (a) to read as follows:

§ 1036.108 Greenhouse gas emission standards.

* * * * *

(a) Emission standards. Emission standards apply for engines and optionally powertrains measured using the test procedures specified in subpart F of this part as follows:

(1) CO_2 emission standards in this paragraph (a)(1) apply based on testing as specified in subpart F of this part. The applicable test cycle for measuring CO_2 emissions differs depending on the engine family's primary intended service class and the extent to which the engines will be (or were designed to be) used in tractors. For medium and heavy heavy-duty engines certified as tractor engines, measure CO_2 emissions using the steady-state duty cycle specified in § 1036.501 (referred to as the Supplemental Emission Testramped-modal cycle, or SETRMC, even though emission sampling involves measurements from discrete modes)40 CFR 86.1362 (referred to as the ramped-modal cycle, or RMC, even though emission sampling involves measurements from discrete modes). This is intended for engines designed to be used primarily in tractors and other line-haul applications. Note that the use of some SETRMC-certified tractor engines in vocational applications does not affect your certification obligation under this paragraph (a)(1); see other provisions of this part and 40 CFR part 1037 for limits on using engines certified to only one cycle. For medium and heavy heavy-duty engines certified as both tractor and vocational engines, measure CO_2 emissions using the steady-state duty cycle and the transient duty cycle (sometimes referred to as the FTP engine cycle), both of which are specified in § 1036.50140 CFR part 86, subpart N. This is intended for engines that are designed for use in both tractor and vocational applications. For all other engines (including engines meeting spark-ignition standards), measure CO_2 emissions using the appropriate transient duty cycle specified in 40 CFR part 86, subpart N§ 1036.501.

(i) The CO_2 standard is 627 g/hp·-hr for all spark-ignition engines for model years 2016 through 2020. This standard continues to apply in later model years for all spark-ignition engines that are not heavy heavy-duty engines.

(ii) The following CO_2 standards apply for compression-ignition engines (in g/hp·-hr):

Table 1 of §1036.108—Compression-Ignition Engine Standards for MY 2014 – 2020

MODEL YEARS	LIGHT HEAVY-DUTY	MEDIUM HEAVY-DUTY-VOCATIONAL	HEAVY HEAVY-DUTY-VOCATIONAL	MEDIUM HEAVY-DUTY-TRACTOR	HEAVY HEAVY-DUTY-TRACTOR
2014-2016	600	600	567	502	475
2017-2020	576	576	555	487	460

(iii) The following CO_2 standards apply for compression-ignition engines and all heavy heavy-duty engines (in g/hp·-hr):

Table 2 of §1036.108—Compression-Ignition Engine Standards for MY 2021 and Later

MODEL YEARS	LIGHT HEAVY-DUTY	MEDIUM HEAVY-DUTY-VOCATIONAL	HEAVY HEAVY-DUTY-VOCATIONAL	MEDIUM HEAVY-DUTY-TRACTOR	HEAVY HEAVY-DUTY-TRACTOR
2021-2023	563	545	513	473	447
2024-2026	555	538	506	461	436
2027 and later	552	535	503	457	432

(iv) You may certify spark-ignition engines to the compression-ignition standards for the appropriate model year under this paragraph (a). If you do this, those engines are treated as compression-ignition engines for all the provisions of this part.

(2) The CH_4 emission standard is 0.10 g/hp·-hr when measured over the applicable transient duty cycle specified in 40 CFR part 86, subpart N. This standard begins in model year 2014 for compression-ignition engines and in model year 2016 for spark-ignition engines. Note that this standard applies for all fuel types just like the other standards of this section.

(3) The N_2O emission standard is 0.10 g/hp·-hr when measured over the transient duty cycle specified in 40 CFR part 86, subpart N. This standard begins in model year 2014 for compression-ignition engines and in model year 2016 for spark-ignition engines.

* * * * *

100. Amend § 1036.150 by revising paragraphs (e), (g), and (p)(2) and adding paragraph (q) to read as follows:

§ 1036.150 Interim provisions.

* * * * *

(e) Alternate phase-in standards. Where a manufacturer certifies all of its model year 2013 compression-ignition engines within a given primary intended service class to the applicable alternate standards of this paragraph (e), its compression-ignition engines within that primary intended service class are subject to the standards of this paragraph (e) for model years 2013 through 2016. This means that once a manufacturer chooses to certify a primary intended service class to the standards of this paragraph (e), it is not allowed to opt out of these standards. Engines certified to these standards are not eligible for early credits under paragraph (a) of this section.

VEHICLE TYPE	MODEL YEARS~~TRACTORS~~	LHD ENGINES	MHD ENGINES	HHD ENGINES
Tractors	~~Model Years~~ 2013-2015	NA	512 g/hphr	485 g/hphr

	~~Model Years~~ 2016 and ~~later[1]~~ later[a]	NA	487 g/hphr	460 g/hphr
	~~Vocational~~	~~LHD Engines~~	~~MHD Engines~~	~~HHD Engines~~
Vocational	~~Model Years~~ 2013-2015	618 g/hphr	618 g/hphr	577 g/hphr
	~~Model Years~~ 2016 through 2020[a]	576 g/hphr	576 g/hphr	555 g/hphr

~~[1]Note~~[a]Note: these alternate standards for 2016 and later are the same as the otherwise applicable standards for 2017 through 2020.

* * * * *

(g) Assigned deterioration factors. You may use assigned deterioration factors (DFs) without performing your own durability emission tests or engineering analysis as follows:

(1) You may use an assigned additive DF of 0.0 g/hp-hr for CO_2 emissions from engines that do not use advanced or off-cycle technologies. If we determine it to be consistent with good engineering judgment, we may allow you to use an assigned additive DF of 0.0 g/hp-hr for CO_2 emissions from your engines with advanced or off-cycle technologies.

(2) You may use an assigned additive DF of 0.01~~2~~0 g/hphr for N_2O emissions from any engine through model year 2021~~0~~, and 0.02~~1~~0 g/hp-hr for later model years.

(3) You may use an assigned additive DF of 0.020 g/hp-hr for CH_4 emissions from any engine.

* * * * *

(p) * * *

(2) You may certify your model year 2024 through 2026 engines to the following alternative standards:

MODEL YEARS	MEDIUM HEAVY-DUTY-VOCATIONAL	HEAVY HEAVY-DUTY-VOCATIONAL	MEDIUM HEAVY-DUTY-TRACTOR	HEAVY HEAVY-DUTY-TRACTOR
2024-2026	~~538~~542	~~506~~510	467	442

(q) Confirmatory testing of fuel maps defined in § 1036.503(b). For model years 2021 and later, where the results from Equation 1036.235-1 for a confirmatory test is ~~We will replace fuel maps as a result of our confirmatory testing if we determine our test results to be equivalent to the manufacturer's declared fuel maps as specified in this paragraph (q).~~

~~(1) We will weight our individual duty cycle results using the appropriate vehicle category weighting factors in Table 1 of §1037.510 to determine a composite CO_2 emission value for that vehicle configuration; then repeat the process for the manufacturer's fuel maps.~~

~~(2) The average percent difference between fuel maps is calculated as:~~

$$difference = \left(\frac{\sum_{i=1}^{N} \frac{e_{CO2compEPAi} - e_{CO2compManui}}{e_{CO2compManui}}}{N} \right) \cdot 100\ \%$$

~~**Eq. 1036.150-1**~~

~~Where:~~

i = an indexing variable that represents one individual weighted duty cycle result for a vehicle configuration.
N = total number of vehicle configurations.
$e_{CO2compEPA}$ = total composite mass of CO_2 emissions in g/ton-mile for the EPA confirmatory test, rounded to the nearest whole number for vocational vehicles and to the first decimal place for tractors.
$e_{CO2compManu}$ = total composite mass of CO_2 emissions in g/ton-mile for the manufacturer test, rounded to the nearest whole number for vocational vehicles and to the first decimal place for tractors.
(3) Where the average difference between our composite weighted fuel map and the manufacturer's is less than or equal to 2.0 %, w We will not replace the manufacturer's fuel maps.

101. Amend § 1036.225 by revising paragraphs (e) and (f)(1) to read as follows:

§ 1036.225 Amending my application for certification.

* * * * *

(e) The amended application applies starting with the date you submit the amended application, as follows:

(1) For engine families already covered by a certificate of conformity, you may start producing a the new or modified engine configuration any time after you send us your amended application and before we make a decision under paragraph (d) of this section. However, if we determine that the affected engines do not meet applicable requirements, we will notify you to cease production of the engines and may require you to recall the engines at no expense to the owner. Choosing to produce engines under this paragraph (e) is deemed to be consent to recall all engines that we determine do not meet applicable emission standards or other requirements and to remedy the nonconformity at no expense to the owner. If you do not provide information required under paragraph (c) of this section within 30 days after we request it, you must stop producing the new or modified engines.

(2) [Reserved]

(f) * * *

(1) You may ask to raise your FEL for your engine family at any time before the end of the model year. In your request, you must show that you will still be able to meet the emission standards as specified in subparts B and H of this part. Use the appropriate FELs/FCLs with corresponding production volumes to calculate emission credits for the model year, as described in subpart H of this part.

* * * * *

102. Amend § 1036.230 by revising paragraph (d) and adding paragraph (f) to read as follows:

§ 1036.230 Selecting engine families.

* * * * *

(d) Except as described in paragraph (f) of this section, eEngine configurations within an engine family must use equivalent greenhouse gas emission controls. Unless we approve it, you may not produce nontested configurations without the same emission control hardware included on the tested configuration. We will only approve it if you demonstrate that the exclusion of the hardware does not increase greenhouse gas emissions.

* * * * *

(f) Engine families may be divided into subfamilies with respect to compliance with CO_2 standards.

103. Amend § 1036.235 by revising the introductory text and paragraphs (b) and (c) to read as follows:

§ 1036.235 Testing requirements for certification.

This section describes the emission testing you must perform to show compliance with the greenhouse gas emission standards in §1036.108. When testing hybrid powertrains substitute "hybrid powertrain" for "engine" as it applies to requirements for certification.

* * * * *

(b) Test your emission-data engines using the procedures and equipment specified in subpart F of this part. In the case of dual-fuel and flexible-fuel engines, measure emissions when operating with each type of fuel for which you intend to certify the engine. (Note: measurement of criteria emissions from flexible-fuel engines generally involves operation with the fuel mixture that best represents in-use operation, or with the fuel mixture with the highest emissions.)Measure CO_2, CH_4, and N_2O emissions using the specified duty cycle(s), including cold-start and hot-start testing as specified in 40 CFR part 86, subpart N. The following provisions apply regarding test cycles for demonstrating compliance with tractor and vocational standards:

(1) If you are certifying the engine for use in tractors, you must measure CO_2 emissions using the applicable SET ramped-modal cycle specified in § 1036.501505, and measure CH_4, and N_2O emissions using the specified transient cycle.

(2) If you are certifying the engine for use in vocational applications, you must measure CO_2, CH_4, and N_2O emissions using the specified transient duty cycle, including cold-start and hot-start testing as specified in § 1036.50140 CFR part 86, subpart N.

(3) You may certify your engine family for both tractor and vocational use by submitting CO_2 emission data from both ramped-modalSET and transient cycle testing and specifying FCLs for both.

(4) Some of your engines certified for use in tractors may also be used in vocational vehicles, and some of your engines certified for use in vocational may be used in tractors. However, you may not knowingly circumvent the intent of this part (to reduce in-use emissions of CO_2) by certifying engines designed for tractors or vocational vehicles (and rarely used in the other application) to the wrong cycle. For example, we would generally not allow you to certify all your engines to the ramped-modal cycleSET without certifying any to the transient cycle.

(c) We may perform confirmatory testing by measuring emissions from any of your emission-data engines. If your certification includes powertrain testing as specified in § 40 CFR 1036.630, this paragraph (c) also applies for the powertrain test results.

(1) We may decide to do the testing at your plant or any other facility. If we do this, you must deliver the engine to a test facility we designate. The engine you provide must include appropriate manifolds, aftertreatment devices, electronic control units, and other emission-related components not normally attached directly to the engine block. If we do the testing at your plant, you must schedule it as soon as possible and make available the instruments, personnel, and equipment we need.

(2) If we measure emissions on your engine, the results of that testing become the official emission results for the engine as specified in this paragraph (c). Unless we later invalidate these data, we may decide not to consider your data in determining if your engine family

meets applicable requirements.
(3) Before we test one of your engines, we may set its adjustable parameters to any point within the physically adjustable ranges.
(4) Before we test one of your engines, we may calibrate it within normal production tolerances for anything we do not consider an adjustable parameter. For example, this would apply for an engine parameter that is subject to production variability because it is adjustable during production, but is not considered an adjustable parameter (as defined in § 1036.801) because it is permanently sealed. For parameters that relate to a level of performance that is itself subject to a specified range (such as maximum power output), we will generally perform any calibration under this paragraph (c)(4) in a way that keeps performance within the specified range.
(5) We may use our emission test results for steady-state, idle, cycle-average and powertrain fuel maps defined in § 1036.503(b), as long as we perform at least three valid tests. We will use mean values for each point to specify our fuel maps and may use the resulting fuel maps as the official emission results. We may also consider how the different fuel maps affect GEM emission results as part of our decision. We will not replace individual points from your fuel map, but we may make separate determinations for steady-state, idle, cycle-average and powertrain fuel maps.

(i) We will determine fuel masses, $m_{fuel[cycle]}$, and mean idle fuel mass flow rates, $\bar{\dot{m}}_{fuelidle}$, if applicable, using the method described in § 1036.535(h).

(ii) We will perform this comparison using the weighted results from GEM, using vehicles that are appropriate for the engine under test. For example, we may select vehicles that the engine went into for the previous model year.

(iii6) If you supply cycle-average engine fuel maps for the highway cruise cycles instead of generating a steady-state fuel map for these cycles, we may perform a confirmatory test of your engine fuel maps for the highway cruise cycles by either of the following methods:

(iA) Directly measuring the highway cruise cycle-average fuel maps.

(iiB) Measuring a steady-state fuel map as described in paragraph (c)(5) of this section and using it in GEM to create our own cycle-average engine fuel maps for the highway cruise cycles.

(iv) This section describes how we will replace fuel maps as a result of confirmatory testing.

(A) Weight individual duty cycle results using the vehicle categories determined in paragraph (c)(5)(i) of this section and respective weighting factors in Table 1 of 40 CFR 1037.510 to determine a composite CO_2 emission value for each vehicle configuration; then repeat the process for all the unique vehicle configurations used to generate the manufacturer's fuel maps.

(B) The average percent difference between fuel maps is calculated using the following equation:

$$difference = \left(\frac{\sum_{i=1}^{N} \frac{e_{CO2compEPAi} - e_{CO2compManui}}{e_{CO2compManui}}}{N} \right) \cdot 100\ \%$$

Eq. 1036.235-1

Where:

i = an indexing variable that represents one individual weighted duty cycle result for a vehicle configuration.

N = total number of vehicle configurations.

$e_{CO2compEPA\,i}$ = unrounded composite mass of CO_2 emissions in g/ton-mile for vehicle configuration i for the EPA confirmatory test.

$e_{CO2compManu\,i}$ = unrounded composite mass of CO_2 emissions in g/ton-mile for vehicle configuration i for the manufacturer-declared map.

(C) Where the unrounded average percent difference between our composite weighted fuel map and the manufacturer's is greater than or equal to 0 %, we will not replace the manufacturer's maps, and we will consider an individual engine to have passed the fuel map confirmatory test.

* * * * *

104. Revise § 1036.255 to read as follows:

§ 1036.255 What decisions may EPA make regarding ~~my~~ a certificate of conformity?

(a) If we determine ~~your~~ an application is complete and shows that the engine family meets all the requirements of this part and the Act, we will issue a certificate of conformity for ~~your~~ the engine family for that model year. We may make the approval subject to additional conditions.

(b) We may deny ~~your~~ an application for certification if we determine that ~~your~~ an engine family fails to comply with emission standards or other requirements of this part or the Clean Air Act. We will base our decision on all available information. If we deny ~~your~~ an application, we will explain why in writing.

(c) In addition, we may deny your application or suspend or revoke ~~your~~ a certificate of conformity if you do any of the following:

(1) Refuse to comply with any testing or reporting requirements.

(2) Submit false or incomplete information ~~(paragraph (e) of this section applies if this is fraudulent)~~. This includes doing anything after submitting an application that causes ~~submission of your application to render any of the~~ submitted information to be false or incomplete.

(3) Cause any test data to become inaccurate~~Render inaccurate any test data~~.

(4) Deny us from completing authorized activities (see 40 CFR 1068.20). This includes a failure to provide reasonable assistance.

(5) Produce engines for importation into the United States at a location where local law prohibits us from carrying out authorized activities.

(6) Fail to supply requested information or amend ~~your~~ an application to include all engines being produced.

(7) Take any action that otherwise circumvents the intent of the Act or this part~~, with respect to your an engine family~~.

(d) We may void ~~the~~ a certificate of conformity ~~for an engine family~~ if you fail to keep records, send reports, or give us information as required under this part or the Act. Note that these are also violations of 40 CFR 1068.101(a)(2).

(e) We may void ~~your~~ a certificate of conformity ~~for an engine family~~ if we find that you intentionally submitted false or incomplete information. This includes doing anything after submitting an application that causes~~rendering~~ submitted information to be false or incomplete

after submission.
(f) If we deny ~~your~~ an application or suspend, revoke, or void ~~your~~ a certificate, you may ask for a hearing (see § 1036.820).

Subpart D— Testing Production Engines and Hybrid Powertrains
105. Amend the heading for subpart D as set forth above.

106. Amend § 1036.301 by revising paragraph (b)(2) to read as follows:
§ 1036.301 Measurements related to GEM inputs in a selective enforcement audit.
* * * * *
(b) * * *
(2) Evaluate cycle-average fuel maps by running GEM based on simulated vehicle configurations representing the interpolated center of every group of four test points that define a boundary of cycle work and average engine speed divided by average vehicle speed. These simulated vehicle configurations are defined from the four surrounding points based on averaging values for vehicle mass, drag area (if applicable), tire rolling resistance, tire size, and axle ratio. The regulatory subcategory is defined by the regulatory subcategory of the vehicle configuration with the greatest mass from those four test points. Figure 1 of this section illustrates a determination of vehicle configurations for engines used in tractors and Vocational Heavy-Duty Vehicles (HDV) using a fixed tire size (see § 1036.540(c)(3)(iii)). The vehicle configuration from the upper-left quadrant is defined by values for Tests 1, 2, 4, and 5 from Table 3 of § 1036.540. Calculate vehicle mass as the average of the values from the four tests. Determine the weight reduction needed for GEM to simulate this calculated vehicle mass by comparing the average vehicle mass to the default vehicle mass for the vehicle subcategory from the four points that has the greatest mass, with the understanding that two-thirds of weight reduction for tractors is applied to vehicle weight and one-third is understood to represent increased payload. This is expressed mathematically as $M_{avg} = M_{subcategory} - 2/3 \cdot M_{reduction}$, which can be solved for $M_{reduction}$. For vocational vehicles, half of weight reduction is applied to vehicle weight and half is understood to represent increased payload. Use the following values for default vehicle masses by vehicle subcategory:

Table 1 of § 1036.301—Default Vehicle Mass by Vehicle Subcategory

VEHICLE SUBCATEGORY	DEFAULT VEHICLE MASS (KG)
Vocational Light HDV	7,257
Vocational Medium HDV	11,408
Class 7 Mid-Roof Day Cab	20,910
Class 8 Mid-Roof Day Cab	29,529
Class 8 High-Roof Sleeper Cab	31,978
Heavy-Haul Tractor	53,750

* * * * *

107. Amend § 1036.501 by revising paragraph (g) and adding paragraph (h) to read as follows:
§ 1036.501 How do I run a valid emission test?
* * * * *
(g) The following additional provisions apply for testing to demonstrate compliance with the emission standards in § 1036.108 for model year 2016 through 2020 engines:

(1) Measure CO_2, CH_4, and N_2O emissions using the transient cycle specified in either 40 CFR 86.1333 or appendix II to this part§ 1036.510.
(2) For engines subject to SETRMC testing under § 1036.108(a)(1), measure CO_2 emissions using the ramped-modal cycleSET specified in 40 CFR 86.1362.

(gh) The following additional provisions apply for testing to demonstrate compliance with the emission standards in § 1036.108 for model year 2021 and later engines:

(1) If your engine is intended for installation in a vehicle equipped with stop-start technology, you may use good engineering judgment to turn the engine off during the idle portions of the duty cycle to represent in-use operation, consistent with good engineering judgment. We recommend installing an engine starter motor and allowing the engine's Electronic Control Unit (ECU) to control the engine stop and start events.

(2) Measure CO_2, CH_4, and N_2O emissions using the transient cycle specified in either 40 CFR 86.1333 or appendix II to this part.

(223) For engines subject to SETRMC testing under § 1036.108(a)(1), uUse one of the following methods to measure CO_2 emissions:

(i) Use the ramped-modalSET duty cycle specified in § 1036.505 using either continuous or batch sampling.

(ii) Measure CO_2 emissions over the ramped-modalSET duty cycle specified in 40 CFR 86.1362 using continuous sampling. Integrate the test results by mode to establish separate emission rates for each mode (including the transition following each mode, as applicable). Apply the CO_2 weighting factors specified in 40 CFR 86.1362 to calculate a composite emission result.

(3) Measure CO_2, CH_4, and N_2O emissions over the transient cycle specified in either 40 CFR 86.1333 or § 1036.510.

(34) Measure or calculate emissions of criteria pollutants corresponding to your measurements to demonstrate compliance with CO_2 standards. These test results are not subject to the duty-cycle standards of 40 CFR part 86, subpart A.

108. Add § 1036.503 to read as follows:

§ 1036.503 Engine data and information for vehicle certification.

You must give vehicle manufacturers information as follows so they can certify model year 2021 and later vehicles:

(a) Identify engine make, model, fuel type, combustion type, engine family name, calibration identification, and engine displacement. Also identify which standards the engines meet.

(b) This paragraph (b) describes threefour different methods to generate engine fuel maps. For engines without hybrid components or mild hybrid where you choose not to include hybrid components in the test, you must generate fuel maps using either paragraphs (b)(1) or (2) of this section. For mild hybrid engines where you choose to include the hybrid components in the test and fManufacturers may generally rely on any of the three mapping methods. However, for hybrid engines, manufacturersyou must generate fuel maps using either cycle-average or powertrain testing as described in paragraphs (b)(4) and (3) of this section. For all other hybrids, powertrains,, except mild hybrids, and for vehicles where the transmission is not automatic, automated manual, manual, or dual-clutch followyou must use paragraph (b)(3) of this section. Vehicle manufacturers must use the powertrain method described in paragraph (b)(2) of this section for any vehicle with a transmission that is not automatic, automated manual, manual, or dual-clutch.

(1) Combined steady-state and cycle-average. Determine steady-state engine fuel maps and fuel consumption at idle as described in § 1036.535(b) and (c) respectively, and determine cycle-average engine fuel maps as described in § 1036.540, excluding cycle-average fuel maps for highway cruise cycles.

(2) Cycle-average. Determine fuel consumption at idle as described in § 1036.535(c) and (d), and determine cycle-average engine fuel maps as described in § 1036.540, including cycle-average engine fuel maps for highway cruise cycles. In this case, you do not need to determine steady-state engine fuel maps under § 1036.535(b). Fuel mapping for highway cruise cycles using cycle-average testing is an alternate method, which means that we may do confirmatory testing based on steady-state fuel mapping for highway cruise cycles even if you do not; however, we will use the steady-state fuel maps to create cycle-average fuel maps. In § 1036.540 we define the vehicle configurations for testing; we may add more vehicle configurations to better represent your engine's operation for the range of vehicles in which your engines will be installed (see 40 CFR 1065.10(c)(1)).

(3) Powertrain. Generate a powertrain fuel map as described in 40 CFR 1037.550. In this case, you do not need to perform fuel mapping under § 1036.535 or § 1036.540. The option in 40 CFR 1037.550(b)(2) is only allowed for hybrid powertrain testing.

(4) Hybrid engine. Determine fuel consumption at idle as described in § 1036.535(c) and (d), and determine cycle-average engine fuel maps as described in § 1037.550, including cycle-average engine fuel maps for highway cruise cycles.

(c) Provide the following information if you generate engine fuel maps using either paragraph (b)(1), (2), or (4~~2~~) of this section:

(1) Full-load torque curve for installed engines, and the full-load torque curve of the engine (parent engine) with the highest fueling rate that shares the same engine hardware, including the turbocharger, as described in 40 CFR 1065.510. You may use 40 CFR 1065.510(b)(5)(i) for engines subject to spark-ignition standards. Measure the torque curve for hybrid engines that have an RESS as described in 40 CFR 1065.510(g)(2) with the hybrid system active. For hybrid engines that do not include an RESS follow 40 CFR 1065.510(b)(5)(ii).

(2) Motoring torque map as described in 40 CFR 1065.510(c)(2) and (~~4~~5) for conventional and hybrid engines, respectively. For engines with a low-speed governor, remove data points where the low speed governor is active. If you don't know when the low-speed governor is active, we recommend removing all points below 40 r/min above the low warm idle speed.

(3) Declared engine idle speed. For vehicles with manual transmissions, this is the engine speed with the transmission in neutral. For all other vehicles, this is the engine's idle speed when the transmission is in drive.

(4) The engine idle speed during the transient cycle-average fuel map.

(5) The engine idle torque during the transient cycle-average fuel map.

(d) If you generate powertrain fuel maps using paragraph (b)(3) of this section, determine the system continuous rated power according to § 1036.527.

109. Amend § 1036.505 to read as follows:

§ 1036.505 Supplemental emission test~~Ramped-modal testing procedures~~.

(a) Starting in model year 2021, you must measure CO_2 emissions using the ~~ramped-modal~~SET duty cycle in 40 CFR 86.1362 as described in § 1036.501, or using the ~~ramped-modal~~SET duty cycle in this section.

(b) Perform ~~ramped-modal~~SET testing with one of the following procedures:

(1) For engine testing, the SET~~ramped-modal~~ duty cycle~~s~~ ~~are~~is based on normalized speed and torque values relative to certain maximum values. Denormalize torque as described in 40 CFR 1065.610(d). Denormalize speed as described in 40 CFR 1065.512.

(2) For hybrid powertrain and hybrid engine testing, follow 40 CFR 1037.550 to carry out the test, but do not compensate the duty cycle for the distance driven as described in 40 CFR 1037.550(g)(4), for hybrid engines select the transmission from Table 1 of § 1036.540 substituting "engine" for "vehicle" and "highway cruise cycle" for "SET", and cycles do not follow 40 CFR 1037.550(j). For cycles that begin with a set of contiguous idle points, leave the transmission in neutral or park for the full initial idle segment. Place the transmission into drive within 5 seconds of the first nonzero vehicle speed setpoint. Place the transmission into park or neutral when the cycle reaches SET~~RMC~~ mode 14. Use the following vehicle parameters in place of those in 40 CFR 1037.550 to define the vehicle model in 40 CFR 1037.550(~~b~~a)(3):

(i) Determine the vehicle test mass, *M*, as follows:

$$M = 15.1 \cdot P_{\text{contrated}}^{1.31}$$

Eq. 1036.505-1

Where:

$P_{\text{contrated}}$ = the continuous rated power of the hybrid system determined in § 1036.527.

Example:

$P_{\text{contrated}}$ = 350.1 kW

$M = 15.1 \cdot 350.1^{1.31} = 32499$ kg

(ii) Determine the vehicle frontal area, A_{front}, as follows:

(A) For $M \leq 18050$ kg:

$$A_{\text{front}} = -1.69 \cdot 10^{-8} \cdot M^2 + 6.33 \cdot 10^{-4} \cdot M + 1.67$$

Eq. 1036.505-2

Example:

M = 16499 kg

$$A_{\text{front}} = -1.69 \cdot 10^{-8} \cdot 16499^2 + 6.33 \cdot 10^{-4} \cdot 16499 + 1.67 = 7.51 \text{ m}^2$$

(B) For $M > 18050$ kg, $A_{\text{front}} = 7.59$ m^2

(iii) Determine the vehicle drag area, C_dA, as follows:

$$C_d A = \frac{\left(0.00299 \cdot A_{\text{front}} - 0.000832\right) \cdot 2 \cdot g \cdot 3.6^2}{\rho}$$

Eq. 1036.505-3

Where:

g = gravitational constant = 9.80665~~1~~ m/s^2.

ρ = air density at reference conditions. Use ρ = 1.1845 kg/m^3.

Example:

$$C_d A = \frac{\left(0.00299 \cdot 7.59 - 0.000832\right) \cdot 2 \cdot 9.80665 \cdot 3.6^2}{1.1845} = 3.08 \text{ m}^2$$

Commented [CAL1]: Example updated.

(iv) Determine the coefficient of rolling resistance, C_{rr}, as follows:

$$C_{rr} = 0.00513 + \frac{17.6}{M}$$

Eq. 1036.505-4

Example:

$$C_{rr} = 0.00513 + \frac{17.6}{32499} = 0.0057 \text{ kg/kg}$$

(v) Determine the vehicle curb mass, M_{curb}, as follows:

$$M_{curb} = -0.000007376537 \cdot M^2 + 0.6038432 \cdot M$$

Eq. 1036.505-5

Example:

$$M_{curb} = -0.000007376537 \cdot 32499^2 + 0.6038432 \cdot 32499 = 11833 \text{ kg}$$

(vi) Determine the linear equivalent ~~inertial~~ mass of rotational moment of inertias~~ing~~ ~~components~~, $M_{rotating}$, as follows:

$$M_{rotating} = 0.07 \cdot M_{curb}$$

Eq. 1036.505-6~~5~~

Example:

$$M_{rotating} = 0.07 \cdot 11833 = 828.3 \text{ kg}$$

(vii) Select a drive axle ratio, k_a, that represents the worst-case pair of drive axle ratio and tire size for CO_2 expected for vehicles in which the powertrain will be installed. This is typically the highest numeric axle ratio.

(viii) Select a tire radius, *r*, that represents the worst-case pair of tire size and drive axle ratio for CO_2 expected for vehicles in which the powertrain will be installed. This is typically the smallest tire radius.

(~~viii~~ix) If you are certifying a hybrid powertrain system without the transmission, use a default transmission efficiency of 0.95. If you certify with this configuration, you must use 40 CFR 1037.550(~~b~~a)(3)(ii) to create the vehicle model along with its default transmission shift strategy. Use the transmission parameters defined in Table 1 of § 1036.540 to determine transmission type and gear ratio. For Light and Medium HDVs, u~~U~~se the Light and Medium HDV ~~transient cycle~~ parameters for the FTP and SET. For Tractors and Heavy HDVs, use the Tractor and Heavy HDV transient cycle parameters for the FTP and the Tractor and Heavy HDV highway cruise cycle parameters for the SET~~RMC~~.

(~~i~~x) Select axle efficiency, Eff_{axle}, according to 40 CFR 1037.550.

(c~~b~~) Measure emissions using the ~~ramped-modal~~SET duty cycle shown in ~~the following table~~Table 1 of this section to determine whether engines and hybrid powertrains meet the steady-state compression-ignition standards specified in subpart B of this part~~:~~. Table 1 of this section specifies settings for engine and hybrid powertrain testing, as follows:

(1) The duty cycle for testing engines involves a schedule of normalized engine speed and torque values.

(2) The duty cycle for hybrid powertrain testing involves a schedule of vehicle speeds and road grade.

(i) –Determine road grade at each point based on the continuous rated power of the hybrid powertrain system, $P_{contrated}$, in kW determined in § 1036.527, the vehicle speed (A, B, or C) in mi/hr for a given SET mode, $v_{ref[speed]}$, and the specified road grade coefficients using the

Commented [CAL2]: Equation updated.

following equation:

$$Road\ grade = a \cdot P_{\text{contrated}}^3 + b \cdot P_{\text{contrated}}^2 \cdot v_{\text{ref[speed]}} + c \cdot P_{\text{contrated}}^2 + d \cdot v_{\text{ref[speed]}}^2 + e \cdot P_{\text{contrated}} \cdot v_{\text{ref[speed]}} + f \cdot P_{\text{contrated}} + g \cdot v_{\text{ref[speed]}} + h$$

Eq. 1036.505-7

Example:

This example is for SET mode 3a in Table 1 to § 1036.505.

$P_{\text{contrated}}$ = 345.2 kW

v_{refB} = 59.3 mi/hr

$$Road\ grade = 8.296 \cdot 10^{-9} \cdot 345.2^3 + \left(-4.752 \cdot 10^{-7}\right) \cdot 345.2^2 \cdot 59.3 + 1.291 \cdot 10^{-5} \cdot 345.2^2 + 2.88 \cdot 10^{-4} \cdot 59.3^2 + 4.524 \cdot 10^{-4} \cdot 345.2 \cdot 59.3 + \left(-1.802 \cdot 10^{-2}\right) \cdot 345.2 + \left(-1.83 \cdot 10^{-1}\right) \cdot 59.3 + 8.81 = 0.53\ \%$$

(ii) Use the vehicle C speed determined in § 1036.527 and determine the vehicle A and B speeds as follows:

(A) Determine vehicle A speed using the following equation:

$$v_{\text{refA}} = v_{\text{refC}} \cdot \frac{55.0}{75.0}$$

Eq. 1036.505-8

Example:

V_{refC} = 68.42 mi/hr

$$v_{\text{refA}} = 68.4 \cdot \frac{55.0}{75.0} = 50.2 \text{ mi/hr}$$

(B) Determine vehicle B speed using the following equation:

$$v_{\text{refB}} = v_{\text{refC}} \cdot \frac{65.0}{75.0}$$

Eq. 1036.505-9

Example:

$$v_{\text{refB}} = 68.4 \cdot \frac{65.0}{75.0} = 59.3 \text{ mi/hr}$$

Table 1 ~~of~~ to § 1036.505—Supplemental Emission Test Ramped-modal Duty Cycle

SET~~RMC~~ mode	Engine testing			Hybrid powertrain testing									
	Time in mode (seconds)	Engine speed[~~1~~a,~~2~~b]	Torque (percent)[~~2~~b,c]	Vehicle speed (mi/hr)	Road-grade coefficients								
					a	*b*	*c*	*d*	*e*	*f*	*g*	*h*
1a Steady-state	124	Warm Idle	0	Warm Idle	0	0	0	0	0	0	0	0
1b Transition	20	Linear Transition	Linear Transition	Linear Transition	-1.898E-08	-5.895E-07	3.780E-05	4.706E-03	6.550E-04	-2.679E-02	-1.027E+00	1.542E+01
2a Steady-state	196	A	100	~~5~~v_{refA}~~3.38~~	-1.227E-08	-5.504E-07	3.946E-05	1.212E-03	5.289E-04	-3.116E-02	-3.227E-01	1.619E+01
2b Transition	20	Linear Transition	Linear Transition	Linear Transition	-2.305E-09	-4.873E-07	2.535E-05	8.156E-04	4.730E-04	-2.383E-02	-2.975E-01	1.277E+01
3a Steady-state	220	B	50	v_{refB}~~65.00~~	8.296E-09	-4.752E-07	1.291E-05	2.880E-04	4.524E-04	-1.802E-02	-1.830E-01	8.810E+00
3b Transition	20	B	Linear Transition	v_{refB}~~65.00~~	4.642E-09	-5.143E-07	1.991E-05	3.556E-04	4.873E-04	-2.241E-02	-2.051E-01	1.068E+01
4a Steady-state	220	B	75	v_{refB}~~65.00~~	1.818E-10	-5.229E-07	2.579E-05	5.575E-04	5.006E-04	-2.561E-02	-2.399E-01	1.287E+01
4b Transition	20	Linear Transition	Linear Transition	Linear Transition	5.842E-10	-4.992E-07	2.244E-05	4.700E-04	4.659E-04	-2.203E-02	-1.761E-01	1.072E+01
5a Steady-state	268	A	50	v_{refA}~~53.38~~	3.973E-09	-4.362E-07	1.365E-05	4.846E-04	4.158E-04	-1.606E-02	-1.908E-01	8.206E+00
5b Transition	20	A	Linear Transition	v_{refA}~~53.38~~	-2.788E-10	-4.226E-07	1.812E-05	6.591E-04	4.158E-04	-1.846E-02	-2.201E-01	1.001E+01
6a Steady-state	268	A	75	v_{refA}~~53.38~~	-4.216E-09	-4.891E-07	2.641E-05	8.796E-04	4.692E-04	-2.348E-02	-2.595E-01	1.226E+01
6b Transition	20	A	Linear Transition	v_{refA}~~53.38~~	3.979E-09	-4.392E-07	1.411E-05	2.079E-04	4.203E-04	-1.658E-02	-1.655E-01	7.705E+00
7a Steady-state	268	A	25	v_{refA}~~53.38~~	1.211E-08	-3.772E-07	6.209E-07	1.202E-04	3.578E-04	-8.420E-03	-1.248E-01	4.189E+00
7b Transition	20	Linear Transition	Linear Transition	Linear Transition	1.659E-09	-4.954E-07	2.103E-05	4.849E-04	4.776E-04	-2.194E-02	-2.551E-01	1.075E+01
8a Steady-state	196	B	100	v_{refB}~~65.00~~	-8.232E-09	-5.707E-07	3.900E-05	8.150E-04	5.477E-04	-3.325E-02	-2.956E-01	1.689E+01
8b Transition	20	B	Linear Transition	v_{refB}~~65.00~~	4.286E-09	-5.150E-07	2.070E-05	5.214E-04	4.882E-04	-2.291E-02	-2.271E-01	1.157E+01
9a Steady-state	196	B	25	v_{refB}~~65.00~~	1.662E-08	-4.261E-07	-2.705E-07	2.098E-05	4.046E-04	-1.037E-02	-1.263E-01	4.751E+00

9b Transition	20	Linear Transition	Linear Transition	Linear Transition	7.492E-09	-5.451E-07	1.950E-05	2.243E-04	5.114E-04	-2.331E-02	-2.270E-01	1.062E+01
10a Steady-state	28	C	100	v_{refC}77.80	-1.073E-09	-5.904E-07	3.477E-05	5.069E-04	5.647E-04	-3.354E-02	-2.648E-01	1.651E+01
10b Transition	20	C	Linear Transition	v_{refC}77.80	9.957E-09	-5.477E-07	1.826E-05	2.399E-04	5.196E-04	-2.410E-02	-2.010E-01	1.128E+01
11a Steady-state	4	C	25	v_{refC}77.80	1.916E-08	-5.023E-07	3.715E-06	3.634E-05	4.706E-04	-1.539E-02	-1.485E-01	6.827E+00
11b Transition	20	C	Linear Transition	v_{refC}7	1.474E-08	-5.176E-07	1.027E-05	1.193E-04	4.911E-04	-1.937E-02	-1.713E-01	8.872E+00
12a Steady-state	4	C	75	v_{refC}77.80	6.167E-09	-5.577E-07	2.354E-05	3.524E-04	5.319E-04	-2.708E-02	-2.253E-01	1.313E+01
12b Transition	20	C	Linear Transition	v_{refC}77.80	1.039E-08	-5.451E-07	1.756E-05	2.257E-04	5.165E-04	-2.366E-02	-1.978E-01	1.106E+01
13a Steady-state	4	C	50	v_{refC}77.80	6.209E-09	-5.292E-07	2.126E-05	3.475E-04	5.132E-04	-2.552E-02	-2.212E-01	1.274E+01
13b Transition	20	Linear Transition	Linear Transition	Linear Transition	4.461E-09	-6.452E-07	1.301E-05	1.420E-03	5.779E-04	-1.564E-02	1.949E-01	7.998E+00
14 Steady-state	144	Warm Idle	0	Warm Idle	0	0	0	0	0	0	0	0

[a1]Engine sSpeed terms are defined in 40 CFR part 1065.
[b2]Advance from one mode to the next within a 20 second transition phase. During the transition phase, command a linear progression from the speed or torque settings of the current mode to the speed or torque settings of the next mode.
[c3]The percent torque is relative to maximum torque at the commanded engine speed.

110. Revise § 1036.510 to read as follows:

§1036.510 Transient testing procedures.

(a) Measure emissions by testing the engine or hybrid powertrain on a dynamometer with one of the following transient duty cycles to determine whether it meets the transient emission standards:

(1) For spark-ignition engines, use the transient duty cycle described in paragraph (a) of Appendix II of this part.

(2) For compression-ignition engines, use the transient duty cycle described in paragraph (b) of Appendix II of this part.

(3) For spark-ignition hybrid powertrains, use the transient duty cycle described in paragraph (a) of Appendix II of this part.

(4) For compression-ignition hybrid powertrains, use the transient duty cycle described in paragraph (b) of Appendix II of this part.

(b) Perform the following depending on if you are testing engines or hybrid powertrains:

(1) For engine testing, the transient duty cycles are based on normalized speed and torque values relative to certain maximum values. Denormalize torque as described in 40 CFR 1065.610(d). Denormalize speed as described in 40 CFR 1065.512.

(2) For hybrid powertrain testing, follow § 1036.505(b)(2) to carry out the test except replace $P_{contrated}$ with P_{rated}, the peak rated power determined in § 1036.527, and keep the transmission in drive for all idle segments after the initial idle segment, and for hybrid engines select the transmission from Table 1 of § 1036.540 substituting "engine" for "vehicle". You may request to change the engine commanded torque at idle to better represent CITT.

(c) The transient test sequence consists of an initial run through the transient duty cycle from a cold start, 20 minutes with no engine operation, then a final run through of the same transient duty cycle. Start sampling emissions immediately after you start the engine and continue sampling until the duty cycle is completeEmissions from engine starting is part of the both the cold and hot test intervals. Calculate the total emission mass of each constituent, *m*, and the total work, *W*, over each test interval according to 40 CFR 1065.650. Calculate the official transient emission result from the cold-start and hot-start test intervals using the following equation:

$$Official\ transient\ emission\ result = \frac{cold\ start\ emissions\,(g) + 6 \cdot hot\ start\ emissions\,(g)}{cold\ start\ work\,(hp \cdot hr) + 6 \cdot hot\ start\ work\,(hp \cdot hr)}$$

Eq. 1036.510-1

(d) Calculate cycle statistics and compare with the established criteria as specified in 40 CFR 1065.514 for engines and 40 CFR 1037.550 for hybrid powertrains to confirm that the test is valid.

111. Amend § 1036.525 by revising paragraphs (a), (d) introductory text, and (d)(4) to read as follows:

§ 1036.525 Hybrid engines.

(a) If For model years 2014 through 2020, if your engine system includes features that recover and store energy during engine motoring operation, test the engine as described in paragraph (d) of this section. For purposes of this section, features that recover energy between the engine and transmission are considered related to engine motoring.

* * * * *

(d) Measure emissions using the same procedures that apply for testing non-hybrid engines under this part, except as specified in this part and 40 CFR part 1065. For ~~ramped-modal~~SET testing, deactivate the hybrid features unless we specify otherwise. The following provisions apply for testing hybrid engines:

* * * * *

(4) Limits on braking energy. Calculate brake energy fraction, x_b, as follows:

(i) Calculate x_b as the integrated negative work over the cycle divided by the integrated positive work over the cycle according to Eq. 1036.525-1. Calculate the brake energy limit for the engine, x_{bl}, according to Eq. 1036.525-2. If x_b is less than or equal to x_{bl}, use the integrated positive work for your emission calculations. If x_b is greater than x_{bl} use Eq. 1036.525-3 to calculate an adjusted value for cycle work, W_{cycle}, and use W_{cycle} as the work value for calculating emission results. You may set an instantaneous brake target that will prevent x_b from being larger than x_{bl} to avoid the need to subtract extra brake work from positive work.

$$x_b = \left|\frac{W_{neg}}{W_{pos}}\right|$$

Eq. 1036.525-1

Where:

W_{neg} = the negative work over the cycle.

W_{pos} = the positive work over the cycle.

$$x_{bl} = 4.158 \cdot 10^{-4} \cdot P_{max} + 0.2247$$

Eq. 1036.525-2

Where:

P_{max} = the maximum power of the engine with the hybrid system engaged, in kW.

$$W_{cycle} = W_{pos} - \left(\left|W_{neg}\right| - x_{bl} \cdot W_{pos}\right)$$

Eq. 1036.525-3

Where:

W_{cycle} = cycle work when x_b is greater than x_{bl}.

Example:

W_{neg} = 4.69 kW-hr

W_{pos} = 14.67 kW-hr

P_{max} = 223 kW

$$x_b = \left|\frac{4.69}{14.67}\right| = 0.31970$$

$$x_{bl} = 4.158 \cdot 10^{-4} \cdot 223 + 0.2247 = 0.317423$$

since $x_b > x_{bl}$;

$$W_{cycle} = 14.67 - \left(\left|4.69\right| - 0.317423 \cdot 14.67\right) = 14.6365 \text{ kW-hr}$$

(ii) Convert from g/kW-hr to g/hp-hr as the final step in calculating emission results.

* * * * *

Commented [CAL3]: Example updated.

Commented [CAL4]: Example updated.

Commented [CAL5]: Example updated.

112. Add § 1036.527 to read as follows:

§ 1036.527 Powertrain system rated power determination.

This section describes how to determine the peak and continuous rated power of conventional and hybrid powertrain systems and the vehicle speed for carrying out testing according to § 1036.505, § 1036.510, and 40 CFR 1037.550.

(a) Set up the powertrain according to 40 CFR 1037.550, but use the vehicle parameters in § 1036.505(b)(2), except replace $P_{contrated}$ with the manufacturer declared system peak power and use applicable automatic transmission for the engine. Note that if you repeat the system rated power determination as described in paragraph (fi)(4) of this section, use the measured system peak power in place of $P_{contrated}$.

~~(b) For conventional powertrains follow paragraphs (d), (e), and (h) of this section. For hybrid powertrains, follow paragraphs (c) through (j) of this section.~~

(bc) Prior to the start of each test interval verify the following:

(i1) The state-of-charge of the the rechargeable energy storage system (RESS) is ≥ 90 % of the operating range between the minimum and maximum RESS energy levels specified by the manufacturer.

(ii2) The conditions of all hybrid system components are within their normal operating range as declared by the manufacturer.

(iii3) RESS restrictions (e.g., power limiting, thermal limits, etc.) are not active.

(cd) Carry out the test as follows:

(1) Warm up the powertrain by operating it. We recommend operating the powertrain at any vehicle speed and road grade that achieves approximately 75 % of its expected maximum power. Continue the warm-up until the engine coolant, block, or head absolute temperature is within ±2 % of its mean value for at least 2 min or until the engine thermostat controls engine temperature.

(2) Start the test by keying on the powertrain and letting it sit at 0 mi/hr for 50 seconds.

(3) Set maximum driver demand for a full load acceleration at 06 % road grade starting at an initial vehicle speed of 0 mi/hr.

(4) –268 seconds after the initiation of paragraph (c)(3) of this section, linearly ramp the grade from 6 % to 0 % over 300 seconds. Stop the test ~~300 seconds~~ after the vehicle ~~speed~~speed has stopped increasing above the maximum value observed during the test.

(de) Record the powertrain system angular speed and torque values measured at the dynamometer~~at the wheel hub~~ at 100 Hz and use these in conjunction with the vehicle model to calculate $P_{sys,vehicle}$.

(ef) ~~After completing the test interval described in paragraphs (d) and (e) of this section repeat the steps in paragraphs (c) through (e) of this section for 2 % and 6 % road grades.~~

~~(g) After completing the test intervals described in paragraphs (c) and (e) of this section repeat the steps in paragraphs (c) through (f) of this section for initial vehicle speeds of 20 mi/hr and 40 mi/hr. After completing the test interval on the last road grade and initial vehicle speed point, the rated power determination sequence is complete.(h)~~ Calculate the system ~~peak~~ power, P_{sys}, for each ~~test run~~data point as follows:

(1) For testing with the speed and torque measurements at the transmission input shaft, P_{sys} is equal to the calculated vehicle system peak power, $P_{sys,vehicle}$, determined in paragraphs (c) through (d) of this section.

(2) For testing with the speed and torque measurements at the axle input shaft or the wheel hubs, determine P_{sys} using the following equation:

$$P_{\mathrm{sys}} = \frac{P_{\mathrm{sys,vehicle}}}{\varepsilon_{\mathrm{trans}} \cdot \varepsilon_{\mathrm{axle}}}$$

Eq. 1036.527-1

Where:

$P_{\mathrm{sys,vehicle}}$ = the calculated vehicle system peak power.

$\varepsilon_{\mathrm{trans}}$ = the default transmission efficiency = 0.95.

$\varepsilon_{\mathrm{axle}}$ = the default axle efficiency. Set this value = 1 for speed and torque measurement at the axle input shaft or = 0.955 at the wheel hubs.

Example:

$P_{\mathrm{sys,vehicle}}$ = 317.6 kW

$$P_{\mathrm{sys}} = \frac{317.6}{0.95 \cdot 0.955} = 350.1 \text{ kW}$$

(f~~i~~) The system peak rated power, P_{rated}, is the highest calculated P_{sys} where the coefficient of variation (COV) < 2 %. The COV is determined as follows:

(1) Calculate the standard deviation, $\sigma(t)$.

$$\sigma(t) = \sqrt{\frac{1}{N} \cdot \sum_{i=1}^{N} \left(P_{\mathrm{sys}i} - \bar{P}_{\mu}(t)\right)^2}$$

Eq. 1036.527-2

Where:

N = the number of measurement intervals = 20.

$P_{\mathrm{sys}i}$ = the N samples in the 100 Hz signal previously used to calculate the respective $P_{\mu}(t)$ values at the time step t.

$\bar{P}_{\mu}(t)$ = the power vector from the results of each test run that is determined by a moving averaging of 20 consecutive samples of P_{sys} in the 100 Hz that converts $P_{\mu}(t)$ to a 5 Hz signal.

(2) The resulting 5 Hz power and covariance signals are used to determine system rated power.

(3) The coefficient of variation COV(t) shall be calculated as the ratio of the standard deviation, $\sigma(t)$, to the mean value of power, $\bar{P}_{\mu}(t)$, for each time step t.

$$COV(t) = \frac{\sigma(t)}{\bar{P}_{\mu}(t)}$$

Eq. 1036.527-3

(4) If the determined system peak rated power is not within ±3 % of the system peak rated power as declared by the manufacturer, you must repeat the procedure in paragraphs (a) through (f~~i~~)(3) of this section using the measured system peak rated power determined in paragraph (f~~i~~) of this section instead of the manufacturer declared value. The result from this repeat is the final determined system peak rated power.

(5) If the determined system peak rated power is within ±3 % of the system peak rated power as declared by the manufacturer, the declared system peak rated power shall be used.

(g~~j~~) Determine continuous rated power as follows:

(1) For conventional powertrains, $P_{\mathrm{contrated}}$ equals P_{rated}.

(2) For hybrid powertrains, continuous rated power, $P_{\mathrm{contrated}}$, is the maximum measured power from the data collected in paragraph (c)(3) of this section that meets the requirements in paragraph (f) of this section.

(h) Vehicle C speed, v_{refC}, is determined as follows:
(1) For powertrains where P_{sys} is greater than $0.98 \cdot P_{contrated}$ in top gear at more than one vehicle speed, v_{refC} is the average of the minimum and maximum vehicle speeds from the data collected in paragraph (c)(4) of this section that meets the requirements in paragraph (f) of this section. Determine continuous rated power, $P_{contrated}$, by following paragraphs (i)(1) through (3) of this section using the data that met the requirements of paragraph (i)(4) or (i)(5) of this section, where the system continuous rated power, $P_{contrated}$, is the lowest calculated P_{sys} where the coefficient of variation (COV) < 2 %. Set N = 1000 in Eq. 1036.527-2, which results in a 0.1 Hz signal in paragraph (i)(2) of this section. For this determination, use the data collected in paragraphs (a) through (g) of this section starting with the point 30 seconds after the vehicle speed has stopped increasing above the maximum value observed during the test.
(2) For powertrains where P_{sys} is not greater than $0.98 \cdot P_{contrated}$ in top gear at more than one vehicle speed, v_{refC} is the maximum vehicle speed from the data collected in paragraph (c)(4) of this section that meets the requirements in paragraph (f) of this section where P_{sys} is great than $0.98 \cdot P_{contrated}$.

113. Revise § 1036.530 to read as follows:

§ 1036.530 Calculating greenhouse gas emission rates.

This section describes how to calculate official emission results for CO_2, CH_4, and N_2O.

(a) Calculate brake-specific emission rates for each applicable duty cycle as specified in 40 CFR 1065.650. Apply infrequent regeneration adjustment factors to your CO_2 emission results for each duty cycle cycle-average results as described in 40 CFR 86.004-28 for CO_2 starting in model year 2021. You may optionally apply infrequent regeneration adjustment factors for CH_4 and N_2O.

(b) Adjust CO_2 emission rates calculated under paragraph (a) of this section for measured test fuel properties as specified in this paragraph (b). This adjustment is intended to make official emission results independent of differences in test fuels within a fuel type. Use good engineering judgment to develop and apply testing protocols to minimize the impact of variations in test fuels.

(1) Determine your test fuel's mass-specific net energy content, $E_{mfuelmeas}$, also known as lower heating value, in MJ/kg, expressed to at least three decimal places,. Determine $E_{mfuelmeas}$ as follows:

(i) For liquid fuels, determine $E_{mfuelmeas}$ according to ASTM D4809 (incorporated by reference in § 1036.810). Have the sample analyzed by at least three different labs and determine the final value of use the arithmetic mean of the results as your test fuel's $E_{mfuelmeas}$ as the median all of the lab results you obtained. If you have results from three different labs, we recommend you screen them to determine if additional observations are needed. To perform this screening, determine the absolute value of the difference between each lab result and the average of the other two lab results. If the largest of these three resulting absolute value differences is greater than 0.297 MJ/kg, we recommend you obtain additional results prior to determining the final value of $E_{mfuelmeas}$.

(ii) For gaseous fuels, determine $E_{mfuelmeas}$ according to ASTM D3588 (incorporated by reference in § 1036.810)using good engineering judgment.

(2) Determine your test fuel's carbon mass fraction, w_C, as described in 40 CFR 1065.655(d), expressed to at least three decimal places; however, you must measure fuel properties rather than using the default values specified in Table 1 of 40 CFR 1065.655.

(i) For liquid fuels, ~~–~~h~~H~~ave the sample analyzed by at least three different labs and determine ~~use~~ the final value ~~arithmetic mean~~ of ~~the results as~~ your test fuel's w_C as the median of all of the lab results you obtained. If you have results from three different labs, we recommend you screen them to determine if additional observations are needed. To perform this screening, determine the absolute value of the difference between each lab result and the average of the other two lab results. If the largest of these three resulting absolute value differences is greater than 1.56 percent carbon, we recommend you obtain additional results prior to determining the final value of w_C.

(ii) For gaseous fuels, have the sample analyzed by a single lab and use that result as your test fuel's w_C.

(3) If, over a period of time, you receive multiple fuel deliveries from a single stock batch of test fuel, you may use constant values for mass-specific energy content and carbon mass fraction, consistent with good engineering judgment. To use this provision, you must demonstrate that every subsequent delivery comes from the same stock batch and that the fuel has not been contaminated.

(4) Correct measured CO_2 emission rates as follows:

$$e_{CO2cor} = e_{CO2} \cdot \frac{E_{mfuelmeas}}{E_{mfuelCref} \cdot w_{Cmeas}}$$

Eq. 1036.530-1

Where:

e_{CO2} = the calculated CO_2 emission result.

$E_{mfuelmeas}$ = the mass-specific net energy content of the test fuel as determined in paragraph (b)(1) of this section. Note that dividing this value by w_{Cmeas} (as is done in this equation) equates to a carbon-specific net energy content having the same units as $E_{mfuelCref}$.

$E_{mfuelCref}$ = the reference value of carbon-mass-specific net energy content for the appropriate fuel type, as determined in Table 1 of this section.

w_{Cmeas} = carbon mass fraction of the test fuel (or mixture of test fuels) as determined in paragraph (b)(2) of this section.

Example:

e_{CO2} = 630.0 g/hp·hr

$E_{mfuelmeas}$ = 42.528 MJ/kg

$E_{mfuelCref}$ = 49.3112 MJ/kgC

w_{Cmeas} = 0.870

$$e_{CO2cor} = 630.0 \cdot \frac{42.528}{49.3112 \cdot 0.870}$$

e_{CO2cor} = 624.5 g/hp·hr

Table 1 ~~of~~ to § 1036.530—Reference fuel properties

FUEL T~~T~~YPE[~~1~~A]	REFERENCE FUEL CARBON-MASS-SPECIFIC NET ENERGY CONTENT, $E_{MFUELCREF}$, (MJ/KGC)[~~2~~B]	REFERENCE FUEL CARBON MASS FRACTION, W_{CREF}[B~~2~~]
Diesel fuel	49.3112	0.874
Gasoline	50.4742	0.846
Natural Gas	66.2910	0.750

LPG	56.5218	0.820
Dimethyl Ether	55.3886	0.521
High-level ethanol-gasoline blends	50.3211	0.576

[1 a]For fuels that are not listed, you must ask us to approve reference fuel properties.
[2 b]For multi-fuel streams, such as natural gas with diesel fuel pilot injection, use good engineering judgment to determine blended values for $E_{mfuelCref}$ and w_{Cref} using the values in this table.

(c) Your official emission result for each pollutant equals your calculated brake-specific emission rate multiplied by all applicable adjustment factors, other than the deterioration factor.

114. Revise § 1036.535 to read as follows:

§ 1036.535 Determining steady-state engine fuel maps and fuel consumption at idle.

This section describes how to determine an engine's steady-state fuel map and fuel consumption at idle for model year 2021 and later vehicles. Vehicle manufacturers may need these values to demonstrate compliance with emission standards under 40 CFR part 1037 as described in § 1036.510.

(a) General test provisions. Perform fuel mapping using the procedure described in paragraph (b) of this section to establish measured fuel-consumption rates at a range of engine speed and load settings. Measure fuel consumption at idle using the procedure described in paragraph (c) of this section. If you perform cycle-average mapping for highway cruise cycles as described in § 10367.540, omit mapping under paragraph (b) of the section and instead perform mapping as described in paragraph (c) and (d) of this section. Use these measured fuel-consumption values to declare fuel-consumption rates for certification as described in paragraph (e) of this section.

(1) Map the engine's torque curve and declare engine idle speed as described in § 1036.503510(ac)(12) and (3), and perform emission measurements as described in 40 CFR 1065.501 and 1065.530 for discrete-mode steady-state testing. This section uses engine parameters and variables that are consistent with 40 CFR part 1065.

(2) Measure NO_x emissions for each specified sampling period in g/s. You may perform these measurements using a NO_x emission-measurement system that meets the requirements of 40 CFR part 1065, subpart J. Include these measured NO_x values any time you report to us your fuel consumption values from testing under this section. If a system malfunction prevents you from measuring NO_x emissions during a test under this section but the test otherwise gives valid results, you may consider this a valid test and omit the NO_x emission measurements; however, we may require you to repeat the test if we determine that you inappropriately voided the test with respect to NO_x emission measurement.

(b) Steady-state fuel mapping. Determine fuel-consumption rates for each engine configuration over a series of steady-state engine operating points consisting of pairs of speed and torque points as described in this paragraph (b). You may use shared data across an engine platform to the extent that the fuel-consumption rates remain valid. For example, if you test a high-output configuration and create a different configuration that uses the same fueling strategy but limits the engine operation to be a subset of that from the high-output configuration, you may use the fuel-consumption rates for the reduced number of mapped points for the low-output configuration, as long as the narrower map includes at least 70 points. Perform fuel mapping as follows:

(1) Generate the sequence of steady-state engine operating points as follows:

(i) Determine the required steady-state engine operating points as follows:

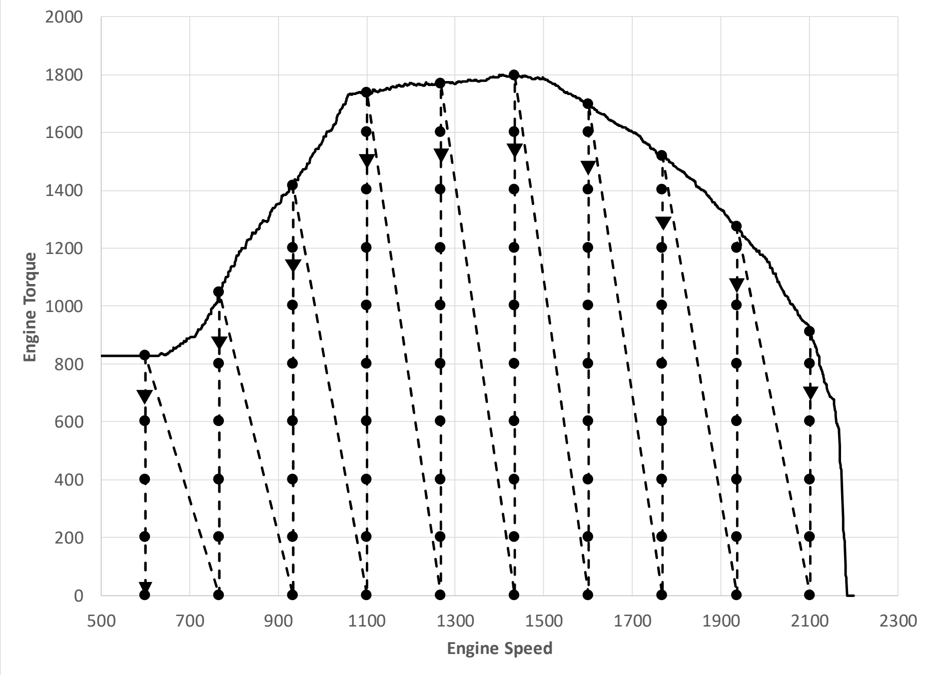
(A) For engines with an adjustable warm idle speed setpoint, sSelect the following ten speed setpoints: that include minimum warm idle speed, $f_{nidlemin}$, the highest speed above maximum power at which 70 % of maximum power occurs, n_{hi}, and eight (or more) equally spaced points between $f_{nidlemin}$ and n_{hi}. Control speed to within ±1 % of n_{hi} (Ssee 40 CFR 1065.610(c)). For engines without an adjustable warm idle speed replace minimum warm idle speed with warm idle speed, f_{nidle}.

(2B) Select the following ten torque setpoints at each of the selected speed setpoints: zero (values, including T = 0), maximum mapped torque, $T_{max\ mapped}$, and eight (or more) equally spaced points between T = 0 and $T_{max\ mapped}$. Replace For each of the selected speed setpoints, replace any torque setpoints that are above the mapped torque at a given the selected speed setpoint, T_{max}, minus 5 percent of $T_{max\ mapped}$, with one test point at T_{max}. Control engine torque to within ±5 % of $T_{max\ mapped}$.

(ii) Select any additional (optional) steady-state engine operating points consistent with good engineering judgment. For example, you may select additional points when linear interpolation between the defined points is not a reasonable assumption for determining fuel consumption from the engine. For each additional speed setpoint, increments between torque setpoints must be no larger than one-ninth of $T_{max,mapped}$ and we recommend including a torque setpoint of T_{max}. If you select a maximum torque setpoint less than T_{max}, use good engineering judgement to select your maximum torque setpoint to avoid unrepresentative data. Note that if the test points were added for the child rating, they should still be reported in the parent fuel map. We will select at least as many points as you.

(iii) Set the run order for all of the steady-state engine operating points (both required and optional) as described in this paragraph (b)(1)(iii). Arrange the list of steady-state engine operating points such that the resulting list of paired speed and torque setpoints begins with the highest speed setpoint and highest torque setpoint followed by decreasing torque setpoints at the highest speed setpoint. This will be followed by the next lowest speed setpoint and the highest torque setpoint at that speed setpoint continuing through all the steady-state engine operating points and ending with the lowest speed ($f_{nidlemin}$) and torque setpoint (T = 0). The following figure provides an example of this array of points and run order.

Figure 1 of § 1036.535—Steady-state engine operation point run order



(iv) The steady-state engine operating points that have the highest torque setpoint for a given speed setpoint are optional reentry points into the steady-state-fuel-mapping sequence, should you need to pause or interrupt the sequence during testing.

(v) The steady-state engine operating points that have the lowest torque setpoint for a given speed setpoint are optional exit points from the steady-state-fuel-mapping sequence, should you need to pause or interrupt the sequence during testing.

(2) If the engine has an adjustable warm idle speed setpoint, set it to its minimum value, $f_{nidlemin}$.

(3) During each test interval, control speed within ±1 % of n_{hi} and engine torque within ±5 % of $T_{max\ mapped}$ except for the following cases where both setpoints cannot be achieved because the steady-state engine operating point is near an engine operating boundary:

(i) For steady-state engine operating points that cannot be achieved and the operator demand stabilizes at minimum; control the dynamometer so it gives priority to follow the torque setpoint and let the engine govern the speed (see 40 CFR 1065.512(b)(1)). In this case, the tolerance on speed control in paragraph (b)(3) of this section does not apply and engine torque is controlled to within ±25 N·m.

(ii) For steady-state engine operating points that cannot be achieved and the operator demand stabilizes at maximum and the speed setpoint is below 90 % of n_{hi}; control the dynamometer so it gives priority to follow the speed setpoint and let the engine govern the torque (see 40 CFR 1065.512(b)(2)). In this case, the tolerance on torque control given in

paragraph (b)(3) of this section does not apply.
(iii) For steady-state engine operating points that cannot be achieved and the operator demand stabilizes at maximum and the speed setpoint is at or above 90 % of n_{hi}; control the dynamometer so it gives priority to follow the torque setpoint and let the engine govern the speed (see 40 CFR 1065.512(b)(1)). In this case, the tolerance on speed control given in paragraph (b)(3) of this section does not apply.
(iv) For the steady-state engine operating points at the minimum speed setpoint and maximum torque setpoint, you may select a dynamometer control mode that gives priority to speed and an engine control mode that gives priority to torque. In this case, if the operator demand stabilizes at minimum or maximum, the tolerance on torque control in paragraph (b)(3) of this section does not apply.You may need to adjust dynamometer settings any time the engine is operating on the low-speed or high-speed governor to maintain stable engine operation. You may change the dynamometer's speed setpoint as needed to avoid activating the engine's governor. You may alternatively set the dynamometer mode to torque-control, in which case speed can fall outside of ±1 % of n_{hi}.
(4) You may select the appropriate dynamometer and engine control modes in real-time or at any time prior based on various factors including the operating setpoint location relative to an engine operating boundary.Precondition Warm-up the engine as described in 40 CFR 1065.510(b)(2).
(556) Within 60 seconds after concluding the warm-uppreconditioning procedure, operate the engine at n_{hi} and T_{max}linearly ramp the speed and torque setpoints over 5 seconds to the first steady-state engine operating point from paragraph (b)(1) of this section.
(667) After Operate the engine operates at the set speed and torquesteady-state engine operating point for 60 (70 ±1) seconds, and then start the test interval and recording measurements using one of the following methods: . You must also measure and report NO_x emissions over each test interval as described in paragraph (a)(2) of this section. If you use redundant systems for the determination of fuel consumption, for example combining measurements of dilute and raw emissions when generating your map, follow the requirements of 40 CFR 1065.201(d).

(i) Carbon mass balanceIndirect measurement of fuel flow. Record speed and torque and measure emissions and other inputs needed to run the chemical balance in 40 CFR 1065.655(c) for a (30 ± 129 to 31) second test intervals; determine the corresponding mean values for the test sampling periodtest interval. We will use carbon mass balance.For dilute sampling of emissions, in addition to the background measurement provisions described in 40 CFR 1065.140 you may do the following:

(A) If you use batch sampling to measure background emissions, you may sample periodically into the bag over the course of multiple test intervals and read them as allowed in paragraph (b)(10)(i) of this section. If you use this provision, you must apply the same background readings to correct emissions from each of the applicable test intervals.

(B) You may determine background emissions by sampling from the dilution air during the non-test interval periods in the test sequence, including pauses allowed in paragraph (b)(10)(i) of this section. If you use this provision, you must allow sufficient time for stabilization of the background measurement; followed by an averaging period of at least 30 seconds. Use the average of the most recent pre-test interval and the next post-test interval background readings to correct each test interval. The most recent pre-test interval background reading must be taken no greater than 30 minutes prior to the start of the first applicable test interval and the next post-test interval background reading must be taken no later than 30 minutes after the end of the last applicable test interval. Background readings must be taken prior to the test interval for each reentry point and after the test interval for each exit point or more frequently.

(ii) Direct measurement of fuel flow. Record speed and torque and measure fuel consumption with a fuel flow meter for a (29 to 30 ±1) second test intervals; determine the corresponding mean values for the sampling periodtest interval.

(778) After completing the sampling periodtest interval described in paragraph (b)(676) of this section, linearly ramp the engine speed and torque setpoints over 15 seconds to the next lowest torque value while holding speed constantsteady-state engine operating point. Perform the measurements described at the new torque setting and repeat this sequence for all remaining torque values down to $T = 0$.

(8) Continue testing to complete fuel mapping as follows:

(i) At $T = 0$, linearly ramp the engine over 15 seconds to operate at the next lowest speed value and increase torque to T_{max}. Perform measurements for all the torque values at the selected speed as described in paragraphs (b)(6) and (7) of this section. Repeat this sequence for all remaining speed values down to f_{nidle} to complete the fuel-mapping procedure. You may interrupt pause the steady-state-fuel-mapping sequence at any of the reentry points (as noted in paragraph (b)(1)(iv) of this section) to calibrate emission-measurement instrumentation; to read and evacuate background bag samples collected over the course of multiple test intervals; or to sample the dilution air for background emissions. This provision allows you to spend more than the 70 seconds noted in paragraph (b)(76) of this section. only during stabilization at T_{max} for a given speed. If you use batch sampling to measure background emissions, you may sample periodically into the bag over the course of multiple test intervals defined by the period between calibrations of emission-measurement instrumentation. The background sample must be applied to correct emissions sampled over the test interval(s) between calibrations.

(ii) If an infrequent regeneration event occurs, interrupt the steady-state-fuel-mapping sequence and allow the regeneration event to finish. You may continue to operate at the steady-state engine operating point where the event began or, using good engineering judgement, you may transition to another operating condition to reduce the regeneration event durationduring fuel mapping, invalidate all the measurements made at that engine speed. You may complete any post-test interval activities to validate test intervals prior to the most recent reentry point. Once Allow the regeneration event to is finished, linearly ramp the speed and torque setpoints over 5 seconds to the most recent reentry point described in paragraph (b)(1)(iv) of this section, andthen restart the steady-state-fuel-mapping sequence by repeating the steps in paragraphs (b)(76) and (87) of this section for all the remaining steady-state engine operating points. Operate at the reentry point for longer than the 70 seconds in paragraph (b)(76), as needed, to bring the aftertreatment to representative thermal conditions. Void all test intervals in the steady-state-fuel-mapping sequence beginning with the reentry point and ending with the steady-state engine operating point where the regeneration event began.engine stabilization at T_{max} at the same engine speed and continue with measurements from that point in the fuel-mapping sequence.

(iii) You may interrupt the steady-state-fuel-mapping sequence after any of the exit points described in paragraph (b)(1)(v) of this section. To restart the steady-state-fuel-mapping sequence; begin with paragraph (b)(~~5~~4) of this section and continue with paragraph (b)(~~6~~5) of this section, except that the steady-state engine operating point is the next reentry point, not the first operating point from paragraph (b)(1) of this section. Follow paragraphs (b)(~~7~~6) and (7~~8~~) of this section until all remaining steady-state engine operating points are tested.

(iv) If the steady-state-fuel-mapping sequence is interrupted due test equipment or engine malfunction, void all test intervals in the steady-state-fuel-mapping sequence beginning with the most recent reentry point as described in paragraph (b)(1)(iv) of this section. ~~You may c~~Complete any post-test interval activities to validate test intervals prior to the most recent reentry point. Correct the malfunction and restart the steady-state-fuel-mapping sequence as described in paragraph (b)(~~10~~7)(iii) of this section.

(v) If any steady-state engine test interval is voided, void all test intervals in the steady-state-fuel-mapping sequence beginning with the most recent reentry point as described in paragraph (b)(1)(iv) of this section and ending with the next exit point as described in paragraph (b)(1)(v) of this section. Rerun that segment of the steady-state-fuel-mapping sequence. If multiple test intervals are voided in multiple speed setpoints, you may exclude the speed setpoints where all of the test intervals were valid from the rerun sequence. Rerun the steady-state-fuel-mapping sequence as described in paragraph (b)(10)(iii) of this section.

(8~~9~~~~11~~) If you determine fuel-consumption rates using emission measurements from the raw or diluted exhaust, calculate the mean fuel mass flow rate, $\bar{\dot{m}}_{\text{fuel}}$, for each point in the fuel map using the following equation:

$$\bar{\dot{m}}_{\text{fuel}} = \frac{M_{\text{C}}}{w_{\text{Cmeas}}} \cdot \left(\bar{\dot{n}}_{\text{exh}} \cdot \frac{\bar{x}_{\text{Ccombdry}}}{1 + \bar{x}_{\text{H2Oexhdry}}} - \frac{\bar{\dot{m}}_{\text{CO2DEF}}}{M_{\text{CO2}}} \right)$$

Eq. 1036.535-1

Where:

$\bar{\dot{m}}_{\text{fuel}}$ = mean fuel mass flow rate for a given fuel map setpoint, expressed to at least the nearest 0.001 g/s.

M_{C} = molar mass of carbon.

w_{Cmeas} = carbon mass fraction of fuel (or mixture of test fuels) as determined in 40 CFR 1065.655(d), except that you may not use the default properties in Table 1 of 40 CFR 1065.655 to determine α, β, and w_{C} for liquid fuels. You may not account for the contribution to α, β, γ, and δ of diesel exhaust fluid or other non-fuel fluids injected into the exhaust.

$\bar{\dot{n}}_{\text{exh}}$ = the mean raw exhaust molar flow rate from which you measured emissions according to 40 CFR 1065.655.

$\bar{x}_{\text{Ccombdry}}$ = the mean concentration of carbon from fuel and any injected fluids in the exhaust per mole of dry exhaust as determined in 40 CFR 1065.655(c).

$\bar{x}_{\text{H2Oexhdry}}$ = the mean concentration of H_2O in exhaust per mole of dry exhaust as determined in 40 CFR 1065.655(c).

$\bar{\dot{m}}_{\text{CO2DEF}}$ = the mean CO_2 mass emission rate resulting from diesel exhaust fluid

decomposition as determined in paragraph (b)(~~10~~129) of this section. If your engine does not use diesel exhaust fluid, or if you choose not to perform this correction, set $\bar{\dot{m}}_{CO2DEF}$ equal to 0.
M_{CO2} = molar mass of carbon dioxide.

Example:
M_C = 12.0107 g/mol
w_{Cmeas} = 0.869
$\bar{\dot{n}}_{exh}$ = 25.534 mol/s
$\bar{x}_{Ccombdry}$ = 0.002805 mol/mol
$\bar{x}_{H2Oexhdry}$ = 0.0353 mol/mol
$\bar{\dot{m}}_{CO2DEF}$ = 0.0726 g/s
M_{CO2} = 44.0095 g/mol

$$\bar{\dot{m}}_{fuel} = \frac{12.0107}{0.869} \cdot \left(25.534 \cdot \frac{0.002805}{1+0.0353} - \frac{0.0726}{44.0095}\right) = 0.933 \text{ g/s}$$

(9~~1~~2~~0~~) If you determine fuel-consumption rates using emission measurements with engines that utilize diesel exhaust fluid for NO_x control, correct for the mean CO_2 mass emissions resulting from diesel exhaust fluid decomposition at each fuel map setpoint using the following equation:

$$\bar{\dot{m}}_{CO2DEF} = \bar{\dot{m}}_{DEF} \cdot \frac{M_{CO2} \cdot w_{CH4N2O}}{M_{CH4N2O}}$$

Eq. 1036.535-2

Where:
$\bar{\dot{m}}_{DEF}$ = the mean mass flow rate of injected urea solution diesel exhaust fluid for a given sampling period, determined directly from the ~~engine~~ electronic control module, or measured separately, consistent with good engineering judgment.
M_{CO2} = molar mass of carbon dioxide.
w_{CH4N2O} = mass fraction of urea in diesel exhaust fluid aqueous solution. Note that the subscript "CH4N2O" refers to urea as a pure compound and the subscript "DEF" refers to the aqueous ~~32.5 %~~ urea diesel exhaust fluid as a solution of urea in water. You may use a default value of 32.5 % or use good engineering judgment to determine this value based on measurement. ~~with a nominal urea concentration of 32.5 %.~~
M_{CH4N2O} = molar mass of urea.

Example:
$\bar{\dot{m}}_{DEF}$ = 0. 304 g/s
M_{CO2} = 44.0095 g/mol
w_{CH4N2O} = 32.5 % = 0.325
M_{CH4N2O} = 60.05526 g/mol

$$\bar{\dot{m}}_{CO2DEF} = 0.304 \cdot \frac{44.0095 \cdot 0.325}{60.05526} = 0.0726 \text{ g/s}$$

Correct the measured or calculated mean fuel mass flow rate, $\bar{\dot{m}}_{\text{fuel}}$ at each engine operating condition to a mass-specific net energy content of a reference fuel using the following equation:

$$\bar{\dot{m}}_{\text{fuelcor}} = \bar{\dot{m}}_{\text{fuel}} \cdot \frac{E_{\text{mfuelmeas}}}{E_{\text{mfuelCref}} \cdot w_{\text{Cref}}}$$

Eq. 1036.535-3

Where:

$E_{\text{mfuelmeas}}$ = the mass-specific net energy content of the test fuel as determined in § 1036.530(b)(1).

$E_{\text{mfuelCref}}$ = the reference value of carbon-mass-specific net energy content for the appropriate fuel. Use the values shown in Table 1 of § 1036.530 for the designated fuel types, or values we approve for other fuel types.

w_{Cref} = the reference value of carbon mass fraction for the test fuel as shown in Table 1 of § 1036.530 for the designated fuels. For other fuels, use the reference carbon mass fraction of diesel fuel for engines subject to compression-ignition standards, and use the reference carbon mass fraction of gasoline for engines subject to spark-ignition standards.

Example:

$\bar{\dot{m}}_{\text{fuel}}$ = 0.933 g/s

$E_{\text{mfuelmeas}}$ = 42.7984 MJ/kgC

$E_{\text{mfuelCref}}$ = 49.3112 MJ/kgC

w_{Cref} = 0.874

$$\bar{\dot{m}}_{\text{fuel}} = 0.933 \cdot \frac{42.7984}{49.3112 \cdot 0.874} = 0.927 \text{ g/s}$$

(c) Fuel consumption at idle. Determine values for fuel-consumption rate at s for engines certified for installation in vocational vehicles for each engine configuration over a series of engine-idle operating points consisting of pairs of speed and torque points for each engine configuration as described in this paragraph (c). You may use shared data across engine configurations, consistent with good engineering judgment. Perform measurements as follows:

(1) Determine the required engine-idle operating points as follows:

(i) Select the following two speed setpoints:

(A) Engines with an adjustable warm idle speed setpoint: minimum warm idle speed, f_{nidlemin}, and the maximum warm idle speed, f_{nidlemax}.

(B) Engines without an adjustable warm idle speed setpoint: warm idle speed (with zero torque on the primary output shaft), f_{nidle}, and 1.15 times f_{nidle}.

(ii) Select the following two torque setpoints at each of the selected speed setpoints: 0 and 100 N·m.

(iii) You may run these four engine-idle operating points in any order.

(2) Control speed and torque as follows:

(i) Engines with an adjustable warm idle speed setpoint. For the warm-up in paragraph (c)(3) and the transition in paragraph (c)(4) of this section control both speed and torque. At any time prior to reaching the next engine-idle operating point, set the engine's adjustable warm idle speed setpoint to the speed setpoint of the next engine-idle operating point in the sequence. This may be done before or during the warm-up or during the transition. Near the end of the transition period control speed and torque as described in paragraph (b)(3)(i) of this section. Once the transition is complete; set the operator demand to minimum to

allow the engine governor to control speed; and control torque with the dynamometer as described in paragraph (b)(3) of this section.
(ii) Engines without an adjustable warm idle speed setpoint. Control speed and torque with operator demand and the dynamometer for the engine-idle operating points at the higher speed setpoint as described in paragraph (b)(3) of this section. Both the speed and torque tolerances apply for these points because they are not near the engine's operating boundary and are achievable. Control speed and torque for the engine-idle operating points at the lower speed setpoint as described in paragraph (c)(2)(i) of this section except for setting the engine's adjustable warm idle speed setpoint.
(13) Warm-up Precondition the engine as described in 40 CFR 1065.510(b)(2).
(24) Within 60 seconds aAfter concluding the preconditioning warm-up procedure, linearly ramp the speed and torque setpoints over 20 seconds to operate the engine at the next engine-idle operating point from paragraph (c)(1) of this section.operate the engine at its minimum declared warm idle speed, $f_{nidlemin}$, as described in 40 CFR 1065.510(b)(3), set zero torque, and start the sampling period. Continue sampling for (595 to 605) seconds. Perform measurements using carbon mass balance. Record speed and torque and measure emissions and other inputs as described in 40 CFR 1065.655(c); determine the corresponding mean values for the sampling period. Calculate the mean fuel mass flow rate, $\bar{\dot{m}}_{fuel}$, during the sampling period as described in paragraph (b)(9) of this section.
Manufacturers may instead measure fuel consumption with a fuel flow meter and determine the corresponding mean values for the sampling period.
(5) Operate the engine at the engine-idle operating point for (180 ±1) seconds, and then start the test interval and record measurements using one of the following methods. You must also measure and report NO_x emissions over each test interval as described in paragraph (a)(2) of this section. If you use redundant systems for the determination of fuel consumption, for example combining measurements of dilute and raw emissions when generating your map, follow the requirements of 40 CFR 1065.201(d).
(3) Repeat the steps in paragraphs (c)(1) and (2) of this section with the engine set to operate at a torque setting of 100 N·m.
(4) Repeat the steps in paragraphs (c)(1) through (3) of this section with the engine operated at its declared maximum warm idle speed, $f_{nidlemax}$.
(5) If an infrequent regeneration event occurs during this procedure, invalidate any measurements made at that idle condition. Allow the regeneration event to finish, then repeat the measurement and continue with the test sequence.
(i) Indirect measurement of fuel flow. Record speed and torque and measure emissions and other inputs needed to run the chemical balance in 40 CFR 1065.655(c) for a (600 ±1) second test interval; determine the corresponding mean values for the test interval. We will use an average of indirect measurement of fuel flow with dilute sampling and direct sampling. For dilute sampling of emissions, measure background according to the provisions described in 40 CFR 1065.140, but read the background as described in paragraph (c)(7)(i) of this section. If you use batch sampling to measure background emissions, you may sample periodically into the bag over the course of multiple test intervals and read them as allowed in paragraph (b)(10)(i) of this section. If you use this provision, you must apply the same background readings to correct emissions from each of the applicable test intervals. Note that the minimum dilution ratio requirements for PM sampling in 40 CFR 1065.140(e)(2) do not apply. We recommend minimizing the CVS

flow rate to minimize errors due to background correction consistent with good engineering judgement and operational constraints such as minimum flow rate for good mixing.

(ii) Direct measurement of fuel flow. Record speed and torque and measure fuel consumption with a fuel flow meter for a (600 ±1) second test interval; determine the corresponding mean values for the test interval.

(6) After completing the test interval described in paragraph (c)(5) of this section, repeat the steps in paragraphs (c)(3) to (5) of this section for all the remaining engine-idle operating points. After completing the test interval on the last engine-idle operating point, the fuel-consumption-at-idle sequence is complete.

(7) The following provisions apply for interruptions in the fuel-consumption-at-idle sequence. These provisions are intended to produce results equivalent to running the sequence without interruption.

(i) You may pause the fuel-consumption-at-idle sequence after each test interval to calibrate emission-measurement instrumentation and to read and evacuate background bag samples collected over the course of a single test interval. This provision allows you to shut-down the engine or to spend more time at the speed/torque idle setpoint after completing the test interval before transitioning to the step in paragraph (c)(3) of this section.

(ii) If an infrequent regeneration event occurs, interrupt the fuel-consumption-at-idle sequence and allow the regeneration event to finish. You may continue to operate at the engine-idle operating point where the event began or, using good engineering judgement, you may transition to another operating condition to reduce the regeneration event duration. If the event occurs during a test interval, void that test interval. Once the regeneration event is finished, restart the fuel-consumption-at-idle sequence by repeating the steps in paragraphs (c)(3) through (5) of this section for all the remaining engine-idle operating points.

(iii) You may interrupt the fuel-consumption-at-idle sequence after any of the test intervals. Restart the fuel-consumption-at-idle sequence by repeating the steps in paragraphs (c)(3) to (5) of this section for all the remaining engine-idle operating points.

(iv) If the fuel-consumption-at-idle sequence is interrupted due to test equipment or engine malfunction, correct the malfunction and restart the fuel-consumption-at-idle sequence by repeating the steps in paragraphs (c)(3) through (5) of this section for all the remaining engine-idle operating points. If the malfunction occurred during a test interval, void that test interval.

(v) If any idle test intervals are voided, repeat the steps in paragraphs (c)(3) through (5) of this section for each of the voided engine-idle operating points.

(68) Correct the measured or calculated mean fuel mass flow rate, $\bar{\dot{m}}_{\text{fuel}}$ at each of the four engine-idle settings operating points to account for mass-specific net energy content as described in paragraph (b)(1113) of this section.

(d) Steady-state fuel maps used for cycle-average fuel mapping of the cruise cycles. Determine fuel-consumption rates for each engine configuration over a series of steady-state engine operating points near idle as described in this paragraph (d). You may use shared data across an engine platform to the extent that the fuel-consumption rates remain valid.

(1) Perform steady-state fuel mapping as described in paragraph (b) of this section with the following exceptions:

(i) All the required steady-state engine operating points as described in paragraph (b)(1)(i) of this section are optional.

(ii) Select speed setpoints to cover the range of idle speeds expected as follows:

(A) The minimum number of speed setpoints is two.

(B) For engines with an adjustable warm idle speed setpoint, the minimum speed setpoint must be equal to the minimum warm idle speed, $f_{nidlemin}$, and the maximum speed setpoint must be equal to or greater than the maximum warm idle speed, $f_{nidlemax}$. The minimum speed setpoint for engines without an adjustable warm idle speed setpoint, must be equal to the warm idle speed (with zero torque on the primary output shaft), f_{nidle}, and the maximum speed setpoint must be equal to or greater than 1.15 times the warm idle speed, f_{nidle}.

(iii) Select torque setpoints at each speed setpoint to cover the range of idle torques expected as follows:

(A) The minimum number of torque setpoints at each speed setpoint is three. Note that you must meet the minimum torque spacing requirements described in paragraph (b)(1)(ii) of this section.

(B) The minimum torque setpoint at each speed setpoint is zero.

(C) The maximum torque setpoint at each speed setpoint must be greater than or equal to the estimated maximum torque at warm idle (in-drive) conditions, $T_{idlemaxest}$. ~~Use the appropriate default steady-state engine fuel map as specified in Appendix I to this part to generate cycle-average fuel maps under § 1036.540, as amended based on the measurements specified in this paragraph (d). Measure fuel consumption at idle at the four specified engine operating conditions. For any values from the default map that lie within the boundaries of the engine speed and torque values represented by these idle-operating points, use the measured values instead of the default values. You may use shared data across engine configurations, consistent with good engineering judgment. Determine values for fuel-consumption rate at idle for each engine configuration as follows:~~

~~(1) Determine idle torque, T_{idle}, at the engine's maximum warm idle speed~~ using the following equation~~:~~. For engines with an adjustable warm idle speed setpoint, evaluate $T_{idlemaxest}$ at the maximum warm idle speed, $f_{nidlemax}$. For engines without an adjustable warm idle speed setpoint, use the warm idle speed (with zero torque on the primary output shaft), f_{nidle}.

$$T_{idlemaxest} = \left(\frac{T_{fnstall} \times f_{nidle}^2}{f_{fnstall}^2} + \frac{P_{acc}}{f_{nidle}} \right) \times 1.1$$

Commented [CAL6]: Equation updated.

Eq. 1036.535-~~4~~3

Where:

$T_{fnstall}$ = the maximum engine torque at f_{nstall}.

f_{nidle}~~[speed]~~ = the applicable engine idle speed as described in this paragraph (d).

f_{nstall} = the stall speed of the torque converter; use f_{ntest} or 2250 r/min~~rpm~~, whichever is lower.

P_{acc} = accessory power for the vehicle class; use 1500 W for Vocational Light HDV, 2500 W for Vocational Medium HDV, and 3500 W for Tractors and Vocational Heavy HDV.

Example:

$T_{fnstall}$ = 1870 N·m

f_{ntest} = 1740.8 r/min = 182.30 rad/s

f_{nstall} = 1740.8 r/min = 182.30 rad/s

f_{nidle}~~max~~ = 700 r/min = 73.30 rad/s

P_{acc} = 1500 W

$$T_{\text{idlemaxest}} = \left(\frac{1870 \times 73.30^2}{182.30^2} + \frac{1500}{73.30}\right) \times 1.1 = 355.07 \text{ N} \times \text{m}$$

(2) Remove the points from the default map that are below 115 % of the maximum speed and 115% of the maximum torque of the boundaries of the points measured in paragraph (d)(1) of this section.

(3) Add the points measured in paragraph (d)(1) of this section.

(2) Precondition the engine as described in 40 CFR 1065.510(b)(2).

(3) Within 60 seconds after concluding the preconditioning procedure, operate the engine at its maximum declared warm idle speed, f_{nidlemax}, as described in 40 CFR 1065.510(b)(3), set torque to the value determined in paragraph (d)(1) of this section, after the engine operates at the set speed and torque for 60 seconds, start the sampling period. Continue sampling for (29 to 31) seconds. Perform measurements using carbon mass balance. Record speed and torque and measure emissions and other inputs as described in 40 CFR 1065.655(c); determine the corresponding mean values for the sampling period. Calculate the mean fuel mass flow rate, $\bar{\dot{m}}_{\text{fuel}}$, during the sampling period as described in paragraph (b)(9) of this section. Manufacturers may instead measure fuel consumption with a fuel flow meter and determine the corresponding mean values for the sampling period.

(4) Repeat the steps in paragraphs (d)(2) and (3) of this section with the engine set to operate at zero torque.

(5) Repeat the steps in paragraphs (d)(1) through (4) of this section with the engine operated at its declared minimum warm idle speed, f_{nidlemin}.

(6) If an infrequent regeneration event occurs during this procedure, invalidate any measurements made at that idle condition. Allow the regeneration event to finish, then repeat the measurement and continue with the test sequence.

(7) Correct the measured or calculated mean fuel mass flow rate, $\bar{\dot{m}}_{\text{fuel}}$ at each of the four idle settings to account for mass-specific net energy content as described in paragraph (b)(11) of this section.

(e) Carbon balance verification. The provisions related to carbon balance verification in § 1036.543 apply to test intervals in this section.

(f) Correction for net energy content. Correct the measured or calculated mean fuel mass flow rate, $\bar{\dot{m}}_{\text{fuel}}$ at each engine operating condition as specified in paragraphs (b), (c), and (d) of this section to a mass-specific net energy content of a reference fuel using the following equation:

$$\bar{\dot{m}}_{\text{fuelcor}} = \bar{\dot{m}}_{\text{fuel}} \cdot \frac{E_{\text{mfuelmeas}}}{E_{\text{mfuelCref}} \cdot w_{\text{Cref}}}$$

Eq. 1036.535-4

Where:

$E_{\text{mfuelmeas}}$ = the mass-specific net energy content of the test fuel as determined in § 1036.530(b)(1).

$E_{\text{mfuelCref}}$ = the reference value of carbon-mass-specific net energy content for the appropriate fuel. Use the values shown in Table 1 of § 1036.530 for the designated fuel types, or values we approve for other fuel types.

w_{Cref} = the reference value of carbon mass fraction for the test fuel as shown in Table 1 of § 1036.530 for the designated fuels. For other fuels, use the reference carbon mass fraction of diesel fuel for engines subject to compression-ignition standards, and use the reference carbon mass fraction of gasoline for engines subject to spark-ignition standards.

Example:

$\bar{\dot{m}}_{fuel}$ = 0.933 g/s

$E_{mfuelmeas}$ = 42.7984 MJ/kgC

$E_{mfuelCref}$ = 49.3112 MJ/kgC

w_{Cref} = 0.874

$$\bar{\dot{m}}_{fuel} = 0.933 \cdot \frac{42.7984}{49.3112 \cdot 0.874} = 0.927 \text{ g/s}$$

(g) Measured vs. declared fuel-consumption rates. Select fuel-consumption rates in g/s to characterize the engine's fuel maps. These declared values may not be lower than any corresponding measured values determined in paragraphs (b) through (d) of this section. This includes if you use multiple measurement methods as allowed in paragraph (b)(7) of this section. You may select any value that is at or above the corresponding measured value. These declared fuel-consumption rates, which serve as emission standards under § 1036.108, are the values that vehicle manufacturers will use for certification under 40 CFR part 1037. Note that production engines are subject to GEM cycle-weighted limits as described in § 1036.301. If you perform the carbon balance error verification in § 1036.543, for each fuel map data point:

(1) If you pass the ϵ_{rC} verification, you must declare fuel-consumption rates no lower than the average of the direct and indirect fuel measurements.

(2) If you pass either the ϵ_{aC} verification or ϵ_{aCrate} verification and fail the ϵ_{rC} verification, you must declare fuel-consumption rates no lower than the indirect fuel measurement.

(3) If you don't pass the ϵ_{rC}, ϵ_{aC}, and ϵ_{aCrate} verifications, you must declare fuel-consumption rates no lower than the highest rate for the direct and indirect fuel measurements.

(h) EPA measured fuel-consumption rates. If we pass the carbon mass relative error for a test interval (ϵ_{rC}) verification, the official fuel-consumption rate result will be the average of the direct and indirect fuel measurements. If we pass either the carbon mass absolute error for a test interval (ϵ_{aC}) verification or carbon mass rate absolute error for a test interval (ϵ_{aCrate}) verification and fail the ϵ_{rC} verification, the official fuel-consumption rate result will be the indirect fuel measurement.

115. Revise § 1036.540 to read as follows:

§ 1036.540 Determining cycle-average engine fuel maps.

(a) Overview. This section describes how to determine an engine's cycle-average fuel maps for model year 2021 and later vehicles with transient cycles. This may also apply for highway cruise cycles as described in § 1036.510. Vehicle manufacturers may need one or both of these to demonstrate compliance with emission standards under 40 CFR part 1037. Generating cycle-average engine fuel maps consists of the following steps:

(1) Determine the engine's torque maps as described in § 1036.510(a).

(2) Determine the engine's steady-state fuel map and fuel consumption at idle as described in § 1036.535.

(3) Simulate several different vehicle configurations using GEM (see 40 CFR 1037.520) to create new engine duty cycles, as described in paragraph (c) of this section. The transient vehicle duty cycles for this simulation are in 40 CFR part 1037, Appendix I; the highway cruise cycles with grade are in 40 CFR part 1037, Appendix IV. Note that GEM simulation relies on vehicle service classes as described in 40 CFR 1037.140.

(4) Test the engines using the new duty cycles to determine fuel consumption, cycle work, and average vehicle speed as described in paragraph (d) of this section and establish GEM inputs for those parameters for further vehicle simulations as described in paragraph (e) of this section.

(b) General test provisions. The following provisions apply for testing under this section:

(1) To perform fuel mapping under this section for hybrid engines, make sure the engine and its hybrid features are appropriately configured to represent the hybrid features in your testing.

(2) Measure NO_x emissions for each specified sampling period in grams. You may perform these measurements using a NO_x emission-measurement system that meets the requirements of 40 CFR part 1065, subpart J. Include these measured NO_x values any time you report to us your fuel consumption values from testing under this section. If a system malfunction prevents you from measuring NO_x emissions during a test under this section but the test otherwise gives valid results, you may consider this a valid test and omit the NO_x emission measurements; however, we may require you to repeat the test if we determine that you inappropriately voided the test with respect to NO_x emission measurement.

(3) This section uses engine parameters and variables that are consistent with 40 CFR part 1065.

(4) For variable-speed gaseous-fueled engines with a single-point fuel injection system, apply all of the following statistical criteria to validate the transient duty cycle in 40 CFR part 1037, Appendix I:

Parameter	Speed	Torque	Power
Slope, a_1	$0.950 \leq a_1 \leq 1.030$	$0.830 \leq a_1 \leq 1.030$	$0.830 \leq a_1 \leq 1.030$
Absolute value of intercept, $\lvert a_0 \rvert$	≤ 10 % of warm idle	≤ 3 % of maximum mapped torque	≤ 2 % of maximum mapped power
Standard error of the estimate, *SEE*	≤ 5 % of maximum test speed	≤ 15 % of maximum mapped torque	≤ 15 % of maximum mapped power
Coefficient of determination, r^2	≥ 0.970	≥ 0.700	≥ 0.750

(c) Create engine duty cycles. Use GEM to simulate several different vehicle configurations to create transient and highway cruise engine duty cycles corresponding to each vehicle configuration, as follows:

(1) Set up GEM to simulate vehicle operation based on your engine's torque maps, steady-state fuel maps, engine minimum warm-idle speed and fuel consumption at idle as described in paragraphs (a)(1) and (2) of this section, as well as 40 CFR 1065.405(b). For engines without an adjustable warm idle speed replace minimum warm idle speed with warm idle speed, f_{nidle}.

(2) Set up GEM with transmission parameters gear ratios for different vehicle service classes and vehicle duty cycles as described in Table 1 of this section. For automatic transmissions set neutral idle to "Y" in the vehicle file. These values are based on automatic or automated manual transmissions, but they apply for all transmission types.

Table 1 of to § 1036.540—Assigned Transmission ParametersGear Ratios

GEAR NUMBER	LIGHT HDV AND MEDIUM HDV	TRACTORS AND HEAVY HDV, TRANSIENT CYCLE	TRACTORS AND HEAVY HDV, HIGHWAY CRUISE CYCLE

Transmission Type	Automatic Transmission		Automatic Transmission		Automated Manual Transmission	
Gear Number	Gear Ratio	Torque Limit (N·m)	Gear Ratio	Torque Limit (N·m)	Gear Ratio	Torque Limit (N·m)
1	3.10	T_{max}	3.51	T_{max}	12.8	T_{max}
2	1.81		1.91		9.25	
3	1.41		1.43		6.76	
4	1.00		1.00		4.90	
5	0.71		0.74		3.58	
6	0.61		0.64		2.61	
7	—				1.89	
8					1.38	
9					1.00	
10					0.73	
Lockup Gear	3				—	

(3) Run GEM for each simulated vehicle configuration as follows:

(i) Use one of the following equations to determine tire size, $\frac{f_{ntire}}{v_{vehicle}}$, and drive axle ratio, k_a, at each of the defined engine speeds in Tables 2 through 4 of this section:

(A) Select a value for $\left[\frac{f_{ntire}}{v_{vehicle}}\right]_{[speed]}$ and solve for $k_{a[speed]}$ using the following equation:

$$k_{a[speed]} = \frac{f_{n[speed]}}{\left[\frac{f_{ntire}}{v_{vehicle}}\right]_{[speed]} \cdot k_{topgear} \cdot v_{ref}}$$

Eq. 1036.540-1

Where:

$f_{n[speed]}$ = engine's angular speed as determined in paragraph (c)(3)(ii) or (iii) of this section.

$k_{topgear}$ = transmission gear ratio in the highest available gear from Table 14 of this section (for powertrain testing use actual top gear ratio).

v_{ref} = reference speed. Use 65 mi/hr for the transient cycle and the 65 mi/hr highway cruise cycle, and use 55 mi/hr for the 55 mi/hr highway cruise cycle.

(B) Select a value for $k_{a[speed]}$ and solve for $\left[\frac{f_{ntire}}{v_{vehicle}}\right]_{[speed]}$ using the following equation:

$$\left[\frac{f_{ntire}}{v_{vehicle}}\right]_{[speed]} = \frac{f_{n[speed]}}{k_{a[speed]} \cdot k_{topgear} \cdot v_{ref}}$$

Eq. 1036.540-2

Example:
This example is for a vocational Light HDV or vocational Medium HDV with a 6-speed automatic transmission at B speed (Test 3 or 4 in Table 2 of this section).
f_{nrefB} = 1870 r/min = 31.17 r/s
k_{aB} = 4.0
k_{topgear} = 0.61
v_{ref} = 65 mi/hr = 29.06 m/s

$$\left[\frac{f_{\text{ntire}}}{v_{\text{vehicle}}}\right]_{\text{B}} = \frac{31.17}{4.0 \cdot 0.61 \cdot 29.06} = 0.4396 \text{ r/m}$$

Commented [CAL7]: Example updated.

(ii) Test at least eight different vehicle configurations for engines that will be installed in vocational Light HDV or vocational Medium HDV using vehicles in Table 2 of this section. If the engine will also be installed in vocational Heavy HDV, use good engineering judgment to select at least nine test configurations that best represent the range of vehicles. For example, if your engines will be installed in vocational Medium HDV and vocational Heavy HDV, you might select Tests 1 through2, 4, 6, and 8 of Table 2 of this section to represent vocational HeavyMedium HDVClass 7 vehicles and Tests 2, 3, 4, 6, and 9 of Table 3 of this section to represent vocational MediumHeavy HDVClass 8 vehicles. You may test your engine using additional vehicle configurations with different k_a and C_{rr} values to represent a wider range of in-use vehicle configurations. For all vehicle configurations set the drive axle configuration to 4×2.Set C_dA to 5.4 for all test configurations. For powertrain testing, set M_{rotating} to 340 kg and Eff_{axle} to 0.955 for all test vehicle configurations. Set the axle ratio, k_a, and tire size, $\frac{f_{\text{ntire}}}{v_{\text{vehicle}}}$, for each test vehicle configuration based on the corresponding designated engine speed (f_{nrefA} A, f_{nrefB}B, f_{nrefC}C, or f_{ntest}) at 65 mi/hr for the transient cycle and the 65 mi/hr highway cruise cycle, and at 55 mi/hr for the 55 mi/hr highway cruise cycle. These vehicle engine speeds apply equally for engines subject to spark-ignition standards. Use the following settings specific to each vehicle configuration:

Table 2 of to § 1036.540—Vehicle Settings Configurations for Testing Vocational Light HDV or Vocational Medium HDV

	VEHICLE CONFIGURATION NUMBER							
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8
C_{rr} (kg/tonne)	6.2	7.7	6.2	7.7	6.2	7.7	6.2	7.7
$\frac{f_{\text{ntire}}}{v_{\text{vehicle}}}$ and k_a for CI engines at engine speed	A	A	B	B	C	C	Maximum test speed	Maximum test speed
$\frac{f_{\text{ntire}}}{v_{\text{vehicle}}}$ and k_a for SI engines at engine speed	Minimum NTE exclusion speed	Minimum NTE exclusion speed	A	A	B	B	C	C
GEM Regulatory Subcategory	LHD	MHD	LHD	MHD	LHD	MHD	LHD	MHD
M (kg)[a]	7,257	11,408	7,257	11,408	7,257	11,408	7,257	11,408

C_dA[a]	3.4	5.4	3.4	5.4	3.4	5.4	3.4	5.4

[a]Note that M and C_dA are applicable for powertrain testing only since GEM contains default M and C_dA values for each vocational regulatory category.

(iii) Test nine different vehicle configurations for engines that will be installed in vocational Heavy HDV and for tractors that are not heavy-haul tractors. Test ~~over~~ six different ~~test~~ vehicle configurations for heavy-haul tractors. You may test your engines for additional configurations with different k_a, C_dA, and C_{rr} values to represent a wider range of in-use vehicle configurations. Set C_{rr} to 6.9 for all nine defined ~~test~~ vehicle configurations. For class 7 and 8 vehicle configurations set the drive axle configuration to 4×2 and 6×4 respectively. For powertrain testing, set Eff_{axle} to 0.955 for all ~~test~~ vehicle configurations. Set the axle ratio, k_a, and tire size, $\frac{f_{ntire}}{v_{vehicle}}$, for each ~~test~~ vehicle configuration based on the corresponding designated engine speed (B, f_{ntest}, or the minimum NTE exclusion speed as determined in 40 CFR 86.1370(b)(1)) at 65 mi/hr for the transient duty cycle and the 65 mi/hr highway cruise duty cycle, and at 55 mi/hr for the 55 mi/hr highway cruise duty cycle. Use the settings specific to each ~~test~~ vehicle configuration as shown in Table 3 or Table 4 of this section, as appropriate. Engines subject to testing under both Table 3 and Table 4 of this section need not repeat overlapping ~~test~~ vehicle configurations, so complete fuel mapping requires testing 12 (not 15) ~~test~~ vehicle configurations for those engines. However, this does not apply if you choose to create two separate maps from the vehicle configurations defined in Table 3 and Table 4 of this section. Note that $M_{rotating}$ is needed for powertrain testing but not for engine testing. Tables 3 and 4 follow:

Table 3 of § 1036.540—Vehicle ~~Settings~~ Configurations for Testing General Purpose Tractors and Vocational Heavy HDV

	VEHICLE CONFIGURATION NUMBER								
	~~Test~~ 1	~~Test~~ 2	~~Test~~ 3	~~Test~~ 4	~~Test~~ 5	~~Test~~ 6	~~Test~~ 7	~~Test~~ 8	~~Test~~ 9
C_dA	5.4	4.7	4.0	5.4	4.7	4.0	5.4	4.7	4.0
$M_{rotating}$ (kg)	1,021	794	794	1,021	794	794	1,021	794	794
$\frac{f_{ntire}}{v_{vehicle}}$ and k_a at engine speed	Minimum NTE exclusion speed	Minimum NTE exclusion speed	Minimum NTE exclusion speed	B	B	B	Maximum test speed	Maximum test speed	Maximum test speed
GEM Regulatory Subcategory	C8_SC_HR	C8_DC_MR	C7_DC_MR	C8_SC_HR	C8_DC_MR	C7_DC_MR	C8_SC_HR	C8_DC_MR	C7_DC_MR
Vehicle Weight Reduction (lbs)[a]	0	13,275	6,147	0	13,275	6,147	0	13,275	6,147
M (kg)[b]	31,978	25,515	19,051	31,978	25,515	19,051	31,978	25,515	19,051

[a]Note that vehicle weight reduction is not applicable for powertrain testing, since M is the total mass that is to be simulated.
[b]Note that M is applicable for powertrain testing only since GEM contains default M values for each vocational regulatory category.

Table 4 of § 1036.540—Vehicle ~~Settings~~ Configurations for Testing Heavy-Haul Tractors

	VEHICLE CONFIGURATION NUMBER					
	~~Test~~ 1	~~Test~~ 2	~~Test~~ 3	~~Test~~ 4	~~Test~~ 5	~~Test~~ 6
C_dA	5.0	5.4	5.0	5.4	5.0	5.4
$M_{rotating}$ (kg)	1,021	1,021	1,021	1,021	1,021	1,021
$\frac{f_{ntire}}{v_{vehicle}}$ and k_a at engine speed	Minimum NTE exclusion speed	Minimum NTE exclusion speed	B	B	Maximum test speed	Maximum test speed
GEM Regulatory Subcategory	C8_HH	C8_SC_HR	C8_HH	C8_SC_HR	C8_HH	C8_SC_HR
M (kg)	53,751	31,978	53,751	31,978	53,751	31,978

(iv) If the engine will be installed in a combination of vehicles defined in paragraphs (ii) and (iii) of this section, use good engineering judgment to select at least nine ~~test~~vehicle configurations from Table 2 and Table 3 of this section that best represent the range of vehicles your engine will be sold in. If there are not nine representative configurations you must add vehicles, that you define, to reach a total of at least nine vehicles. For example, if your engines will be installed in vocational Medium HDV and vocational Heavy HDV, select Tests 2, 4, 6 and 8 of Table 2 of this section to represent Medium HDV and Tests 3, 6, and 9 of Table 3 of this section to represent vocational Heavy HDV and add two more vehicles that you define. You may test your engine using additional vehicle configurations with different k_a and C_{rr} values to represent a wider range of in-use vehicle configurations.

(v) Use the defined values in Tables 1 through 4 of this section to set up GEM with the correct regulatory subcategory and vehicle weight reduction, if applicable, to achieve the target vehicle mass, *M*, for each test.

(4) Use the GEM output of instantaneous engine speed and engine flywheel torque for each of the vehicle configurations to generate a 10 Hz transient duty cycle corresponding to each vehicle configuration operating over each vehicle duty cycle.

(d) Test the engine with GEM cycles. Test the engine over each of the transient engine duty cycles generated in paragraph (c) of this section as follows:

(1) Determine the sequence of engine duty cycles (both required and optional) for the cycle-average-fuel-mapping sequence as follows:

(i) Sort the list of engine duty cycles into three separate groups by vehicle duty cycle; transient vehicle duty cycle, 55 mi/hr highway cruise duty cycle, and the 65 mi/hr highway cruise duty cycle.

(ii) Within each group of engine duty cycles derived from the same vehicle duty cycle, order the duty cycles as follows: Select the engine duty cycle with the highest reference cycle work; followed by the cycle with the lowest cycle work; followed by the cycle with next highest cycle work; followed by the cycle with the next lowest cycle work; until all the cycles are selected.

(iii) For each engine duty cycle, preconditioning cycles will be needed to start the cycle-average-fuel-mapping sequence.

(A) For the first and second cycle in each sequence, the two preconditioning cycles are the first cycle in the sequence, the transient vehicle duty cycle with the highest reference cycle work. This cycle is run twice for preconditioning prior to starting the sequence for either of the first

two cycles.
(B) For all other cycles, the two preconditioning cycles are the previous two cycles in the sequence.
(2) If the engine has an adjustable warm idle speed setpoint, set it to its minimum value, $f_{nidlemin}$.
(3) During each test interval, control speed and torque to meet the cycle validation criteria in 40 CFR 1065.514, except as noted in this paragraph (d)(3). Note that 40 CFR part 1065 does not allow subsampling of the 10 Hz GEM generated reference cycle. If the range of reference speeds is less than 10 percent of the mean reference speed, you only need to meet the standard error of the estimate in Table 2 of 40 CFR 1065.514 for the speed regression.
(4) Warm-up the engine as described in 40 CFR 1065.510(b)(2).
(5) Transition between duty cycles as follows:
(i) For transient duty cycles, start the next cycle within ~~5~~10 seconds after the conclusion of the prece~~e~~ding cycle. Note that this applies to transitioning from both the preconditioning cycles and tests for record.
(ii) For cruise cycles, linearly ramp to the next cycle over 5 seconds and stabilize for 15 seconds prior to starting the next cycle. Note that this applies to transitioning from both the preconditioning cycles and tests for record.
(6) Operate the engine over the engine duty cycle and record measurements using one of the methods described in (d)(6)(i) or (ii) of this section. You must also measure and report NO_x emissions over each test interval as described in paragraph (a)(2) of this section. If you use redundant systems for the determination of fuel consumption, for example combining measurements of dilute and raw emissions when generating your map, follow the requirements of 40 CFR 1065.201(d).
(i) Indirect measurement of fuel flow. Record speed and torque and measure emissions and other inputs needed to run the chemical balance in 40 CFR 1065.655(c) for the test interval defined by the first engine duty cycle; determine the corresponding mean values for the test interval. ~~We will use an average of indirect measurement of fuel flow with dilute sampling and direct sampling.~~ For dilute sampling of emissions, in addition to the background measurement provisions described in 40 CFR 1065.140, you may do the following:
(A) Measure background as described in § 1036.535(b)(7)(i)(A) but read the background as described in paragraph (d)(9)(i) of this section.
(B) Measure background as described in § 1036.535(b)(7)(i)(B) but read the background as described in paragraph (d)(9)(i) of this section.
(ii) Direct measurement of fuel flow. Record speed and torque and measure fuel consumption with a fuel flow meter for the test interval defined by the first engine duty cycle; determine the corresponding mean values for the test interval.
(7) Repeat the steps in paragraph (d)(6) of this section for all the remaining engine duty cycles.
(8) Repeat the steps in paragraphs (d)(4) through (7) of this section for all the applicable groups of duty cycles (e.g., transient vehicle duty cycle, 55 mi/hr highway cruise duty cycle, and the 65 mi/hr highway cruise duty cycle).
(9) The following provisions apply for interruptions in the cycle-average-fuel-mapping sequence. These provisions are intended to produce results equivalent to running the sequence without interruption.
(i) You may pause the cycle-average-fuel-mapping sequence after each test interval to calibrate emission-measurement instrumentation, to read and evacuate background bag samples collected over the course of multiple test intervals, or to sample the dilution air for background emissions.

This provision requires you to shut-down the engine during the pause. If the pause is longer than 30 minutes, restart the engine and restart the cycle-average-fuel-mapping sequence at the step in paragraph (d)(4) of this section. Otherwise, restart the engine and restart the cycle-average-fuel-mapping sequence at the step in paragraph (d)(5) of this section.

(ii) If an infrequent regeneration event occurs, interrupt the cycle-average-fuel-mapping sequence and allow the regeneration event to finish. You may continue to operate the engine over the engine duty cycle where the event began or, using good engineering judgment, you may transition to another operating condition to reduce the regeneration event duration.

(A) Determine which cycles in the sequence to void as follows:

(*1*) If the regeneration event began during a test interval, the cycle associated with that test interval must be voided.

(*2*) If you used dilute sampling to measure emissions and you used batch sampling to measure background emissions that were sampled periodically into the bag over the course of multiple test intervals and you are unable to read the background bag (e.g., sample volume too small), void all cycles associated with that background bag.

(*3*) If you used dilute sampling to measure emissions and you used the option to sample periodically from the dilution air and you did not meet all the requirements for this option as described in paragraph (d)(6)(i)(B) of this section, void all cycles associated with those background readings.

(*4*) If the regeneration event began during a non-test-interval period of the sequence and the provisions in paragraphs (d)(9)(ii)(A)(*2*) and (*3*) of this section do not apply, you do not need to void any cycles.

(B) Determine the cycle to restart the sequence. Identify the cycle associated with the last valid test interval. The next cycle in the sequence is the cycle to be used to restart the sequence.

(C) Once the regeneration event is finished, restart the sequence at the cycle determined in paragraph (d)(9)(ii)(B) of this section instead of the first cycle of the sequence. If the engine is not already warm, restart the sequence at paragraph (d)(4) of this section. Otherwise, restart at paragraph (d)(5) of this section.

(iii) If the cycle-average-fuel-mapping sequence is interrupted due to test equipment or engine malfunction, correct the malfunction and follow the steps in paragraphs (d)(9)(ii)(A) through (C) of this section to restart the sequence. Treat the detection of the malfunction as the beginning of the regeneration event.

(iv) If any test interval in the cycle-average-fuel-mapping sequence is voided, you must rerun that test interval as described in this paragraph (d)(9)(iv). You may rerun the whole sequence or any contiguous part of the sequence. If you end up with multiple valid test intervals for a given cycle, use the last valid test interval for determining the cycle-average fuel map. If the engine has been shut-down for more than 30 minutes or if it is not already warm, restart the sequence at paragraph (d)(4) of this section. Otherwise, restart at paragraph (d)(5) of this section. Repeat the steps in paragraphs (d)(6) and (d)(7) of this section until you complete the whole sequence or part of the sequence. The following examples illustrate possible scenarios for completing only part of the sequence:

(A) If you voided only the test interval associated with the fourth cycle in the sequence, you may restart the sequence using the second and third cycles as the preconditioning cycles and stop after completing the test interval associated with the fourth cycle.

(B) If you voided the test intervals associated with the fourth and sixth cycles, you may restart the sequence using the second and third cycles as the preconditioning cycles and stop after completing the test interval associated with the sixth cycle. If the test interval associated with the fifth cycle in this sequence was valid, it must be used for determining the cycle-average fuel map instead of the original one.

(1~~1~~0) ~~Precondition the engine either as described in 40 CFR 1037.510(a)(2)(i) for the transient duty cycle and 40 CFR 1037.510(a)(2)(ii) for the highway cruise duty cycles using the Test 1 vehicle configuration, and then continue testing the different configurations in the order presented in this section. Measure emissions as described in 40 CFR part 1065; perform cycle validation according to 40 CFR part 1065, subpart F, except as noted in this paragraph (d)(1). If the range of reference speeds is less than 10 percent of the mean reference speed, you need to meet only the standard error of estimate in Table 2 of 40 CFR 1065.514. For purposes of cycle validation, treat points as being at idle if reference speed is at or below declared idle speed.~~ For plug-in hybrid engines, precondition the battery and then complete all back-to-back tests for each ~~test~~ vehicle configuration according to 40 CFR 1066.501 before moving to the next ~~test~~ vehicle configuration.

(11) You may send signals to the engine controller during the test, such as current transmission gear and vehicle speed, if that allows engine operation during the test to better represent in-use operation.

~~(2) If an infrequent regeneration event occurs during a mapping test interval, invalidate that test interval. Continue operating the vehicle to allow the regeneration event to finish, then repeat engine preconditioning and resume testing at the start of the invalidated test cycle.~~

(~~3~~12) ~~For each test, record measurements needed to determine fuel mass using carbon mass balance. Record speed and torque and measure emissions and other inputs as described in 40 CFR 1065.655(c). Manufacturers may instead measure fuel consumption with a fuel flow meter.~~ For hybrid powertrains with no plug-in capability, correct for the net energy change of the energy storage device as described in 40 CFR 1066.501. For plug-in hybrid engines, follow 40 CFR 1066.501 to determine End-of-Test for charge-depleting operation; to do this, you must get our advance approval for a utility factor curve. We will approve your utility factor curve if you can show that you created it from sufficient in-use data of vehicles in the same application as the vehicles in which the PHEV engine will be installed.

(~~4~~13) Calculate the fuel mass flow rate, m_{fuel}, for each duty cycle using one of the following equations:

(i) Determine fuel-consumption rates using emission measurements from the raw or diluted exhaust, calculate the mass of fuel for each duty cycle, $m_{fuel[cycle]}$, as follows:

(A) For calculations that use continuous measurement of emissions and continuous CO_2 from urea, calculate $m_{fuel[cycle]}$ using the following equation:

$$m_{fuel[cycle]} = \frac{M_C}{w_{Cmeas}} \cdot \left(\sum_{i=1}^{N} \left(\dot{n}_{exhi} \cdot \frac{x_{Ccombdryi}}{1 + x_{H2Oexhdryi}} \cdot \Delta t \right) - \frac{1}{M_{CO2}} \sum_{i=1}^{N} \left(\dot{m}_{CO2DEFi} \cdot \Delta t \right) \right)$$

Eq. 1036.540-3

Commented [CAL8]: Equation updated.

Where:

M_C = molar mass of carbon.

w_{Cmeas} = carbon mass fraction of fuel (or mixture of test fuels) as determined in 40 CFR 1065.655(d), except that you may not use the default properties in Table 1 of 40 CFR 1065.655 to determine α, β, and w_C for liquid fuels.

i = an indexing variable that represents one recorded emission value.

N = total number of measurements over the duty cycle.

$\dot{n}_{\text{exh}}$ = exhaust molar flow rate from which you measured emissions.

x_{Ccombdry} = amount of carbon from fuel and any injected fluids in the exhaust per mole of dry exhaust as determined in 40 CFR 1065.655(c).

$x_{\text{H2Oexhdry}}$ = amount of H_2O in exhaust per mole of exhaust as determined in 40 CFR 1065.655(c).

$\Delta t = 1/f_{\text{record}}$

M_{CO2} = molar mass of carbon dioxide.

$\dot{m}_{\text{CO2DEF}i}$ = mass emission rate of CO_2 resulting from diesel exhaust fluid decomposition over the duty cycle as determined from § 1036.535(b)(10). If your engine does not utilize diesel exhaust fluid for emission control, or if you choose not to perform this correction, set $\dot{m}_{\text{CO2DEF}_i}$ equal to 0.

Example:

M_{C} = 12.0107 g/mol

w_{Cmeas} = 0.867

N = 6680

$\dot{n}_{\text{exh1}}$ = 2.876 mol/s

$\dot{n}_{\text{exh2}}$ = 2.224 mol/s

$x_{\text{Ccombdry1}} = 2.61 \cdot 10^{-3}$ mol/mol

$x_{\text{Ccombdry2}} = 1.91 \cdot 10^{-3}$ mol/mol

$x_{\text{H2Oexh1}} = 3.53 \cdot 10^{-2}$ mol/mol

$x_{\text{H2Oexh2}} = 3.13 \cdot 10^{-2}$ mol/mol

f_{record} = 10 Hz

Δt = 1/10 = 0.1 s

M_{CO2} = 44.0095 g/mol

$\dot{m}_{\text{CO2DEF1}}$ = 0.0726 g/s

$\dot{m}_{\text{CO2DEF2}}$ = 0.0751 g/s

$$m_{\text{fueltransientTest1}} = \frac{12.0107}{0.867} \cdot \left(\begin{pmatrix} 2.876 \cdot \dfrac{2.61 \cdot 10^{-3}}{1 + 3.53 \cdot 10^{-2}} \cdot 0.1 + \\ 2.224 \cdot \dfrac{1.91 \cdot 10^{-3}}{1 + 3.13 \cdot 10^{-2}} \cdot 0.1 + \\ \ldots + \dot{n}_{\text{exh6680}} \cdot \dfrac{x_{\text{Ccombdr6680}}}{1 + x_{\text{H2Oexhdry6680}}} \cdot \Delta t_{6680} \end{pmatrix} - \frac{1}{44.0095} \cdot \left(0.0726 \cdot 1.0 + 0.0751 \cdot 1.0 + \ldots + \dot{m}_{\text{CO2DEF6680}} \cdot \Delta t_{6680}\right) \right)$$

$m_{\text{fueltransientTest1}}$ = 1619.6 g

(B) If you measure batch emissions and continuous CO_2 from urea, calculate $m_{\text{fuel[cycle]}}$ using the following equation:

$$m_{\text{fuel[cycle]}} = \frac{M_{\text{C}}}{w_{\text{Cmeas}}} \cdot \left(\frac{\bar{x}_{\text{Ccombdry}}}{1+\bar{x}_{\text{H2Oexhdry}}} \cdot \sum_{i=1}^{N} \left(\dot{n}_{\text{exh}i} \cdot \Delta t \right) - \frac{1}{M_{\text{CO2}}} \sum_{i=1}^{N} \left(\dot{m}_{\text{CO2DEF}i} \cdot \Delta t \right) \right)$$

Eq. 1036.540-4

(C) If you measure continuous emissions and batch CO_2 from urea, calculate $m_{\text{fuel[cycle]}}$ using the following equation:

$$m_{\text{fuel[cycle]}} = \frac{M_{\text{C}}}{w_{\text{Cmeas}}} \cdot \left(\sum_{i=1}^{N} \left(\dot{n}_{\text{exh}i} \cdot \frac{x_{\text{Ccombdry}i}}{1+x_{\text{H2Oexhdry}i}} \cdot \Delta t \right) - \frac{m_{\text{CO2DEF}}}{M_{\text{CO2}}} \right)$$

Eq. 1036.540-5

(D) If you measure batch emissions and batch CO_2 from urea, calculate $m_{\text{fuel[cycle]}}$ using the following equation:

$$m_{\text{fuel[cycle]}} = \frac{M_{\text{C}}}{w_{\text{Cmeas}}} \cdot \left(\frac{\bar{x}_{\text{Ccombdry}}}{1+\bar{x}_{\text{H2Oexhdry}}} \cdot \sum_{i=1}^{N} \left(\dot{n}_{\text{exh}i} \cdot \Delta t \right) - \frac{m_{\text{CO2DEF}}}{M_{\text{CO2}}} \right)$$

Eq. 1036.540-6

(ii) Manufacturers may choose to measure fuel mass flow rate. Calculate the mass of fuel for each duty cycle, $m_{\text{fuel[cycle]}}$, as follows:

$$m_{\text{fuel}} = \sum_{i=1}^{N} \dot{m}_{\text{fuel}i} \cdot \Delta t$$

Eq. 1036.540-7

Where:

i = an indexing variable that represents one recorded value.

N = total number of measurements over the duty cycle. For batch fuel mass measurements, set N = 1.

$\dot{m}_{\text{fuel}i}$ = the fuel mass flow rate, for each point, i, starting from i = 1.

$\Delta t = 1/f_{\text{record}}$

f_{record} = the data recording frequency.

Example:

N = 6680

$\dot{m}_{\text{fuel1}}$ = 1.856 g/s

$\dot{m}_{\text{fuel2}}$ = 1.962 g/s

f_{record} = 10 Hz

Δt = 1/10 = 0.1 s

$m_{\text{fueltransient}} = (1.856 + 1.962 + ... + \dot{m}_{\text{fuel6680}}) \cdot 0.1$

$m_{\text{fueltransient}}$ = 111.95 g

(~~5~~14) The provisions related to carbon balance error verification in § 1036.543 apply to test intervals in this section.

(15) Correct the measured or calculated fuel mass flow rate, m_{fuel}, for each test result to a mass-specific net energy content of a reference fuel as described in § 1036.535(~~b~~e)~~(11)~~, replacing $\bar{\dot{m}}_{\text{fuel}}$ with m_{fuel} in Eq. 1036.535-~~3~~4.

Commented [CAL9]: Equation updated.

Commented [CAL10]: Equation updated.

Commented [CAL11]: Equation updated.

(16) For engines designed for plug-in hybrid electric vehicles, the mass of fuel for each cycle, $m_{\text{fuel[cycle]}}$, is the utility factor-weighted fuel mass. This is done by calculating m_{fuel} for the full charge-depleting and charge-sustaining portions of the test and weighting the results, using the following equation:

$$m_{\text{fuel[cycle],plug-in}} = m_{\text{fuel[cycle],CD}} \cdot UF_{\text{D,CD}} + m_{\text{fuel[cycle],CS}} \cdot \left(1 - UF_{\text{D,CD}}\right)$$

Eq. 1036.540-8

Where:

$m_{\text{fuel[cycle],CD}}$ = total mass of fuel for all the tests in the charge-depleting portion of the test.

$UF_{\text{D,CD}}$ = utility factor fraction at distance D_{CD} as determined by interpolating the approved utility factor curve.

$m_{\text{fuel[cycle],CS}}$ = total mass of fuel for all the tests in the charge-sustaining portion of the test.

$$D_{\text{CD}} = \sum_{i=1}^{N}\left(v_{\text{i}} \cdot \Delta t_{\text{i}}\right)$$

Eq. 1036.540-9

Where:

v = vehicle velocity at each time step. For tests completed under this section, v is the vehicle velocity in the GEM duty-cycle file. For tests under 40 CFR 1037.550, v is the vehicle velocity as determined by Eq. 1037.550-1. Note that this should include complete and incomplete charge-depleting tests.

(e) Determine GEM inputs. Use the results of engine testing in paragraph (d) of this section to determine the GEM inputs for the transient duty cycle and optionally for each of the highway cruise cycles corresponding to each simulated vehicle configuration as follows:

(1) Your declared fuel mass consumption, $m_{\text{fuel[cycle]transient}}$. The dUsing the calculated fuel mass consumption values described in paragraph (d) of this section, declared values using the method described in § 1036.535(g)may be at or above the values calculated in paragraph (d) of this section, as described in § 1036.535(e).

(2) We will determine $m_{\text{fuel[cycle]}}$ values using the method described in § 1036.535(h).

(3) Engine output speed per unit vehicle speed, $\left[\dfrac{\bar{f}_{\text{nengine}}}{\bar{v}_{\text{vehicle}}}\right]_{\text{[cycle]}}$, by taking the average engine speed measured during the engine test while the vehicle is moving and dividing it by the average vehicle speed provided by GEM. Note that the engine cycle created by GEM has a flag to indicate when the vehicle is moving.

(43) Positive work determined accordering to 40 CFR 1065, $W_{\text{[cycle]transient}}$., by using the engine speed and engine torque measured during the engine test while the vehicle is moving. Note that the engine cycle created by GEM has a flag to indicate when the vehicle is moving.

(5) The engine idle speed and torque, by taking the average engine speed and torque measured during the engine test while the vehicle is not moving. Note that the engine cycle created by GEM has a flag to indicate when the vehicle is moving.

(64) The following table illustrates the GEM data inputs corresponding to the different vehicle configurations for a given duty cycle:

Commented [CAL12]: Equation updated.

Commented [CAL13]: Updated.

Table 5 of § 1036.540—Example vehicle configuration test result output matrix for Class 8 vocational vehicles

	VEHICLE CONFIGURATION NUMBER								
	~~Test~~ 1	~~Test~~ 2	~~Test~~ 3	~~Test~~ 4	~~Test~~ 5	~~Test~~ 6	~~Test~~ 7	~~Test~~ 8	~~Test~~ 9
$m_{\text{fuel[cycle]}}$ ~~transient~~									
$\left[\dfrac{\bar{f}_{\text{nengine}}}{\bar{v}_{\text{vehicle}}}\right]_{\text{[cycle]}}$									
$W_{\text{[cycle]}}$ ~~transient~~									
$\bar{f}_{\text{nidle}}$[a]									
$\bar{T}_{\text{idle}}$[a]									

[a]Idle speed and torque apply only for the transient duty cycle.

116. Add § 1036.543 to subpart F to read as follows:

§ 1036.543 Carbon balance error verification.

A carbon balance error verification compares independent assessments of the flow of carbon through the system (engine plus aftertreatment). We will, and you may optionally, verify carbon balance error according to 40 CFR part 1065.543. This applies to all test intervals in § 1036.535 (b), (c), and (d); § 1036.540; and 40 CFR 1037.550.

117. Amend § 1036.620 by revising paragraphs (a) and (b)(1)(iii) to read as follows:

§ 1036.620 Alternate CO_2 standards based on model year 2011 compression-ignition engines.

* * * * *

(a) The standards of this section are determined from the measured emission rate of the test engine of the applicable baseline 2011 engine family or families as described in paragraphs (b) and (c) of this section. Calculate the CO_2 emission rate of the baseline test engine using the same equations used for showing compliance with the otherwise applicable standard. The alternate CO_2 standard for light and medium heavy-duty vocational-certified engines (certified for CO_2 using the transient cycle) is equal to the baseline emission rate multiplied by 0.975. The alternate CO_2 standard for tractor-certified engines (certified for CO_2 using the ~~ramped-modal~~SET duty cycle) and all other heavy heavy-duty engines is equal to the baseline emission rate multiplied by 0.970. The in-use FEL for these engines is equal to the alternate standard multiplied by 1.03.

(b) * * *

(1) * * *

(iii) Calculate separate adjustments for emissions over the ~~ramped-modal~~SET duty cycle and the transient cycle.

* * * * *

118. Amend § 1036.701 by revising paragraphs (i) and (j) to read as follows:

§ 1036.701 General provisions.

* * * * *

(i) Unless the regulations explicitly allow it, you may not calculate Phase 1credits more than once for any emission reduction. For example, if you generate Phase 1 CO_2 emission credits for a hybrid engine under this part for a given vehicle, no one may generate CO_2 emission credits for that same hybrid engine and the associated vehicle under 40 CFR part 1037. However, Phase 1 credits could be generated for identical vehicles using engines that did not generate credits under this part.

(j) Credits you generate with compression-ignition engines in 2020 and earlier model years may be used in model year 2021 and later as follows:

(1) For only if the credit-generating engines were certified to the tractor engine standards in § 1036.108, you may use and credits were calculated relative to the tractor engine standards.

(2) For credit-generating engines certified to the vocational engine standards in § 1036.108, you may optionally carry over adjusted vocational credits from an averaging set, and you may use credits calculated relative to the emission levels in the following table:

Table 1 of §1036.701—Emission lLevels for cCredit cCalculation

Medium Heavy-Duty Engines	Heavy Heavy-Duty Engines
558 g/hp·hr	525 g/hp·hr

You may otherwise use emission credits generated in one model year without adjustment for certifying vehicles in a later model year, even if emission standards are different.

* * * * *

119. Amend § 1036.705 by revising paragraphs (b)(2) and (5) to read as follows:

§ 1036.705 Generating and calculating emission credits.

* * * * *

(b) * * *

(2) For tractor engines:

Emission credits (Mg) = (Std – FCL) · (CF) · (Volume) · (UL) · (10^{-6})

Where:

Std = the emission standard, in g/hp-hr, that applies under subpart B of this part for engines not participating in the ABT program of this subpart (the "otherwise applicable standard").

FCL = the Family Certification Level for the engine family, in g/hp-hr, measured over the ramped-modalSET duty cycle rounded to the same number of decimal places as the emission standard.

CF = a transient cycle conversion factor (hp-hr/mile), calculated by dividing the total (integrated) horsepower-hour over the duty cycle (average of tractor-engine configurations weighted by their production volumes) by 6.3 miles for engines subject to spark-ignition standards and 6.5 miles for engines subject to compression-ignition standards. This represents the average work performed by tractor engines in the family over the mileage represented by operation over the duty cycle. Note that this calculation requires you to use the transient cycle conversion factor even for engines certified to standards based on the ramped-modalSET duty cycle.

Volume = the number of tractor engines eligible to participate in the averaging, banking, and trading program within the given engine family during the model year, as described in paragraph (c) of this section.

UL = the useful life for the given engine family, in miles.

* * * * *

(5) You may generate CO_2 emission credits from a model year 2021 or later medium heavy-

duty engine family subject to spark-ignition standards for exchanging with other engine families only if the engines in the family are gasoline-fueled. You may generate CO_2 credits from non-gasoline these engine families only for the purpose of offsetting CH_4 and/or N_2O emissions within the same engine family as described in paragraph (d) of this section.

* * * * *

120. Amend § 1036.801 by:

a. Revising the definitions for Auxiliary emission control device", "Heavy-duty vehicle", "Hybrid".

b. Adding definitions for "Hybrid engine", "Hybrid powertrain", and "Mild hybrid" in alphabetical order.

c. Revising the definition for "Steady-state".

The new and revised definitions read as follows:

§ 1036.801 Definitions.

* * * * *

Auxiliary emission control device means any element of design that senses temperature, motive speed, engine speed (r/min)rpm, transmission gear, or any other parameter for the purpose of activating, modulating, delaying, or deactivating the operation of any part of the emission control system.

* * * * *

Heavy-duty vehicle means any motor vehicle above 8,500 pounds GVWR. An incomplete vehicle is also a heavy-duty vehicle if it has a or that has a vehicle curb weight above 6,000 pounds or that has a basic vehicle frontal area greater than 45 square feet. *Curb weight* and *Basic vehicle frontal area* have the meaning given in 40 CFR 86.1803.

Hybrid means relating to an engine or powertrain that includes energy storage features other than a conventional battery system or conventional flywheel. Supplemental electrical batteries and hydraulic accumulators are examples of hybrid energy storage systems. Note that certain provisions in this part treat hybrid engines and hybrid powertrains intended for vehicles that include regenerative braking different than those intended for vehicles that do not include regenerative braking.

Hybrid engine means a hybrid system with features for storing and recovering energy that are integral to the engine or are otherwise upstream of the vehicle's transmission other than a conventional battery system or conventional flywheel. Supplemental electrical batteries and hydraulic accumulators are examples of hybrid energy storage systems. Examples of hybrids that could be considered hybrid engines are P0, P1, and P2 hybrids where hHybrid features are connected to the front end of the engine, are known as P0, and at hybrid features connected to the crankshaft, or connected between the clutch and the transmission where the clutch upstream of the hybrid feature is in addition to the transmission clutch(s), respectively are known as P1. Note other examples of systems that qualify as hybrid engines are systems that recover kinetic energy and use it to power an electric heater in the aftertreatment.

Hybrid powertrain means a powertrain that includes energy storage features other than a conventional battery system or conventional flywheel. Supplemental electrical batteries and hydraulic accumulators are examples of hybrid energy storage systems. Note other examples of systems that qualify as hybrid powertrains are systems that recover kinetic energy and use it to power an electric heater in the aftertreatment.

* * * * *

Mild hybrid means a hybrid engine or powertrain with regenerative braking capability where the system recovers less than 20 percent of the total braking energy over the transient cycle defined in Appendix I of 40 CFR part 1037.

* * * * *

Steady-state has the meaning given in 40 CFR 1065.1001. This includes fuel mapping and idle testing where engine speed and load are held at a finite set of nominally constant values.

* * * * *

121. Amend § 1036.805 by revising paragraphs (b) through (f) and adding paragraph (g) to read as follows:

§ 1036.805 Symbols, abbreviations, and acronyms.

* * * * *

(b) Symbols for quantities. This part uses the following symbols and units of measure for various quantities:

SYMBOL	QUANTITY	UNIT	UNIT SYMBOL	UNIT IN TERMS OF SI BASE UNITS
α	atomic hydrogen-to-carbon ratio	mole per mole	mol/mol	1
A	Area	square meter	m^2	m^2
β	atomic oxygen-to-carbon ratio	mole per mole	mol/mol	1
C_dA	drag area	meter squared	m^2	m^2
C_{rr}	coefficient of rolling resistance	kilogram per metric ton	kg/tonne	10^{-3}
D	distance	miles or meters	mi or m	m
ε	efficiency			
ϵ	Difference or error quantity			
e	mass weighted emission result	grams/ton-mile	g/ton-mi	g/kg-km
Eff	efficiency			
E_m	mass-specific net energy content	megajoules/kilogram	MJ/kg	$m^2 \cdot s^{-2}$
f_n	angular speed (shaft)	revolutions per minute	r/min	$\pi \cdot 30 \cdot s^{-1}$
g	gravitational acceleration	meters per second squared	m/s^2	$m \cdot s^{-2}$
i	indexing variable			
k_a	drive axle ratio			1
$k_{topgear}$	highest available transmission gear			
m	Mass	pound mass or kilogram	lbm or kg	kg
M	molar mass	gram per mole	g/mol	$10^{-3} \cdot kg \cdot mol^{-1}$
M	vehicle mass	kilogram	kg	kg
$M_{rotating}$	inertial mass of rotating components	kilogram	kg	kg
N	total number in a series			
P	Power	kilowatt	kW	$10^3 \cdot m^2 \cdot kg \cdot s^{-3}$
ρ	mass density	kilogram per cubic meter	kg/m^3	$m^{-3} \cdot kg$
r	tire radius	meter	m	m

SEE	standard error of the estimate			
σ	standard deviation			
T	torque (moment of force)	newton meter	N·m	$m^2·kg·s^{-2}$
t	Time	second	s	s
Δt	time interval, period, 1/frequency	second	s	s
UF	utility factor			
v	Speed	miles per hour or meters per second	mi/hr or m/s	$m·s^{-1}$
W	Work	kilowatt-hour	kW·hr	$3.6·m^2·kg·s^{-1}$
w_C	carbon mass fraction	gram/gram	g/g	1
w_{CH4N2O}	urea mass fraction	gram/gram	g/g	1
x	amount of substance mole fraction	mole per mole	mol/mol	1
x_b	brake energy fraction			
x_{bl}	brake energy limit			

(c) Superscripts. This part uses the following superscripts ~~to define a~~for modifying quantity symbols:

SUPERSCRIPT	~~QUANTITY~~MEANING
overbar (such as $\bar{y}$)	arithmetic mean
overdot (such as $\dot{y}$)	quantity per unit time

(d) Subscripts. This part uses the following subscripts ~~to define a~~for modifying quantity symbols:

SUBSCRIPT	~~QUANTITY~~MEANING
65	65 miles per hour
A	A speed
A	absolute (e.g., absolute difference or error)
Acc	accessory
App	approved
Axle	axle
B	B speed
C	C speed
C	carbon mass
Ccombdry	carbon from fuel per mole of dry exhaust
CD	charge-depleting
CO2DEF	CO_2 resulting from diesel exhaust fluid decomposition
comb	combustion
comp	composite
Cor	corrected
CS	charge-sustaining
Cycle	test cycle
DEF	diesel exhaust fluid
engine	engine
Exh	raw exhaust
Front	frontal
Fuel	fuel
H2Oexhaustdry	H_2O in exhaust per mole of exhaust
Hi	high

I	an individual of a series
Idle	idle
M	mass
Max	maximum
mapped	mapped
Meas	measured quantity
Neg	negative
Pos	positive
R	relative (e.g., relative difference or error)
Rate	rate (divided by time)
Rated	rated
record	record
Ref	reference quantity
speed	speed
Stall	stall
Test	test
Tire	tire
transient	transient
M	vector
vehicle	vehicle

(e) Other acronyms and abbreviations. This part uses the following additional abbreviations and acronyms:

ABT	AVERAGING, BANKING, AND TRADING
AECD	auxiliary emission control device
ASTM	American Society for Testing and Materials
BTU	British thermal units
CD	charge-depleting
CFR	Code of Federal Regulations
CI	compression ignition
COV	coefficient of variation
CS	charge-sustaining
DEF	diesel exhaust fluid
DF	deterioration factor
DOT	Department of Transportation
E85	gasoline blend including nominally 85 percent denatured ethanol
ECU	Electronic Control Unit
EPA	Environmental Protection Agency
FCL	Family Certification Level
FEL	Family Emission Limit
GEM	Greenhouse gas Emissions Model
g/hp-hr	grams per brake horsepower-hour
GVWR	gross vehicle weight rating
HDV	heavy-duty vehicle
LPG	liquefied petroleum gas
NARA	National Archives and Records Administration
NHTSA	National Highway Traffic Safety Administration
NTE	not-to-exceed
RESS	rechargeable energy storage system
RMC	ramped-modal cycle

Rpm	revolutions per minute
SCR	Selective selective catalytic reduction
SEE	standard error of the estimate
SET	Supplemental Emission Test
SI	spark ignition
U.S.	United States
U.S.C.	United States Code

(f) Constants. This part uses the following constants:

SYMBOL	QUANTITY	VALUE
g	gravitational constant	9.806651 m·s^{-2}

(fg) Prefixes. This part uses the following prefixes to define a quantity:

SYMBOL	QUANTITY	VALUE
μ	micro	10^{-6}
m	milli	10^{-3}
c	centi	10^{-2}
k	kilo	10^{3}
M	mega	10^{6}

122. Revise § 1036.810 to read as follows:

§ 1036.810 Incorporation by reference.

(a) Certain material is incorporated by reference into this part with the approval of the Director of the Federal Register under 5 U.S.C. 552(a) and 1 CFR part 51. To enforce any edition other than that specified in this section, the Environmental Protection Agency must publish a document in the *Federal Register* and the material must be available to the public. All approved material is available for inspection at U.S. EPA, Air and Radiation Docket and Information Center, WJC West Building, Room 3334, 1301 Constitution Ave., NW., Room B102, EPA West Building, Washington, DC 20460, www.epa.gov/dockets, (202) 202-1744, and is available from the sources listed below. It is also available for inspection at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, call 202–741–6030, or go to http://www.archives.gov/federal_-register/code_of_federal_regulationscfr/ibr_-locations.html.

(ab) ASTM InternationalAmerican Society for Testing and Materials, 100 Barr Harbor Drive, P.O. Box C700, West Conshohocken, PA, 19428-2959, (877) 909–2786, http://www.astm.org/.

(1) ASTM D3588-98 (Reapproved 2017)e1, Standard Practice for Calculating Heat Value, Compressibility Factor, and Relative Density of Gaseous Fuels, approved April 1, 2017, (“ASTM D3588”), IBR approved for § 1036.530(b).

(2) ASTM D4809-13, Standard Test Method for Heat of Combustion of Liquid Hydrocarbon Fuels by Bomb Calorimeter (Precision Method), approved May 1, 2013, (“ASTM D4809”), IBR approved for § 1036.530(b).

(2) [Reserved]

(be) National Institute of Standards and Technology, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899-1070, (301) 975-6478, or www.nist.gov.

(1) NIST Special Publication 811, Guide for the Use of the International System of Units (SI), 2008 Edition, March 2008, IBR approved for § 1036.805.

(2) [Reserved]

123. Amend § 1036.825 by revising paragraph (a) to read as follows:

§ 1036.825 Reporting and recordkeeping requirements.

(a) This part includes various requirements to submit and record data or other information. Unless we specify otherwise, store required records in any format and on any media and keep them readily available for eight years after you send an associated application for certification, or eight years after you generate the data if they do not support an application for certification. You are expected to keep your own copy of required records rather than relying on someone else to keep records on your behalf. We may review these records at any time. You must promptly give send us organized, written records in English if we ask for them. We may require you to submit written records in an electronic format.

* * * * *

124. Redesignate appendix I to part 1036 as appendix III to part 1036.

125. Add appendix I to part 1036 to read as follows:

Appendix I to Part 1036—Summary of Previous Emission Standards

The following standards, which EPA originally adopted under 40 CFR part 85 or part 86, apply to compression-ignition engines produced before model year 2007 and to spark-ignition engines produced before model year 2008:

(a) Smoke. Smoke standards applied for compression-ignition engines based on opacity measurement using the test procedures in 40 CFR part 86, subpart I, as follows:

(1) Engines were subject to the following smoke standards for model years 1970 through 1973:

(i) 40 percent during the engine acceleration mode.

(ii) 20 percent during the engine lugging mode.

(2) The smoke standards in 40 CFR 86.11 started to apply in model year 1974.

(b) Idle CO. A standard of 0.5 percent of exhaust gas flow at curb idle applied through model year 2016 to the following engines:

(1) Spark-ignition engines with aftertreatment starting in model year 1987. This standard applied only for gasoline-fueled engines through model year 1997. Starting in model year 1998, the same standard applied for engines fueled by methanol, LPG, and natural gas. The idle CO standard no longer applied for engines certified to meet onboard diagnostic requirements starting in model year 2005.

(2) Methanol-fueled compression-ignition engines starting in model year 1990. This standard also applied for natural gas and LPG engines starting in model year 1997. The idle CO standard no longer applied for engines certified to meet onboard diagnostic requirements starting in model year 2007.

(c) Crankcase emissions. The requirement to design engines to prevent crankcase emissions applied starting with the following engines:

(1) Spark-ignition engines starting in model year 1968. This standard applied only for gasoline-fueled engines through model year 1989, and applied for spark-ignition engines using other fuels starting in model year 1990.

(2) Naturally aspirated diesel-fueled engines starting in model year 1985.

(3) Methanol-fueled compression-ignition engines starting in model year 1990.

(4) Naturally aspirated gaseous-fueled engines starting in model year 1997, and all other gaseous-fueled engines starting in 1998.

(d) Early steady-state standards. The following criteria standards applied to heavy-duty engines based on steady-state measurement procedures:

Table 1 to Appendix I—Early Steady-State Emission Standards for Heavy-Duty Engines

Model Year	Fuel	Pollutant		
		HC	NO_x + HC	CO
1970-1973	gasoline	275 ppm	—	1.5 volume percent
1974-1978	gasoline and diesel	—	16 g/hp·hr	40 g/hp·hr
1979-1984[a]	gasoline and diesel	—	5 g/hp·hr for diesel 5.0 g/hp·hr for gasoline	25 g/hp·hr

[a]An optional NO_x + HC standard of 10 g/hp·hr applied in 1979 through 1984 in conjunction with a separate HC standard of 1.5 g/hp·hr.

(e) Transient emission standards for spark-ignition engines. The following criteria standards applied for spark-ignition engines based on transient measurement using the test procedures in 40 CFR part 86, subpart N. Starting in model year 1991, manufacturers could generate or use emission credits for NO_x and NO_x + NMHC standards. Table 2 follows:

Table 2 to Appendix I—Transient Emission Standards for Spark-Ignition Engines[a,b]

Model Year	Pollutant (g/hp·hr)			
	HC	CO	NO_x	NO_x + NMHC
1985-1987	1.1	14.4	10.6	—
1988-1990	1.1	14.4	6.0	—
1991-1997	1.1	14.4	5.0	—
1998-2004[c]	1.1	14.4	4.0	—
2005-2007	—	14.4	—	1.0[d]

[a]Standards applied only for gasoline-fueled engines through model year 1989. Standards started to apply for methanol in model year 1990, and for LPG and natural gas in model year 1998.

[b]Engines intended for installation only in heavy-duty vehicles above 14,000 pounds GVWR were subject to an HC standard of 1.9 g/hp·hr for model years 1987 through 2004, and a CO standard of 37.1 g/hp·hr for model years 1987 through 2007. In addition, for model years 1987 through 2007, up to 5 percent of a manufacturer's sales of engines intended for installation in heavy-duty vehicles at or below 14,000 pounds GVWR could be certified to the alternative HC and CO standards.

[c]For natural gas engines in model years 1998 through 2004, the NO_x standard was 5.0 g/hp·hr; the HC standards were 1.7 g/hp·hr for engines intended for installation only in vehicles above 14,000 pounds GVWR, and 0.9 g/hp·hr for other engines.

[d]Manufacturers could delay the 1.0 g/hp·hr NO_x + NMHC standard until model year 2008 by meeting an alternate NO_x + NMHC standard of 1.5 g/hp·hr applied for model years 2004 through 2007.

(f) Transient emission standards for compression-ignition engines. The following criteria standards applied for compression-ignition engines based on transient measurement using the test procedures in 40 CFR part 86, subpart N. Starting in model year 1991, manufacturers could generate or use emission credits for NO_x, NO_x + NMHC, and PM standards. Table 3 follows:

Table 3 to Appendix I—Transient Emission Standards for Compression-Ignition Engines[a]

Model Year	Pollutant (g/hp·hr)				
	HC	CO	NO_x	NO_x + NMHC	PM
1985-1987	1.3	15.5	10.7	—	—
1988-1989	1.3	15.5	10.7	—	0.60
1990	1.3	15.5	6.0	—	0.60
1991-1992	1.3	15.5	5.0	—	0.25
1993	1.3	15.5	5.0	—	0.25 truck 0.10 bus
1994-1995	1.3	15.5	5.0	—	0.10 truck 0.07 urban bus
1996-1997	1.3	15.5	5.0	—	0.10 truck 0.05 urban bus[b]
1998-2003	1.3	15.5	4.0	—	0.10 truck 0.05 urban bus[b]
2004-2006	—	15.5	—	2.4[c]	0.10 truck 0.05 urban bus[b]

[a]Standards applied only for diesel-fueled engines through model year 1989. Standards started to apply for methanol in model year 1990, and for LPG and natural gas in model year 1997. An alternate HC standard of 1.2 g/hp·hr applied for natural gas engines for model years 1997 through 2003.

[b]The in-use PM standard for urban bus engines in model years 1996 through 2006 was 0.07 g/hp·hr.

[c]An optional NO_x + NMHC standard of 2.5 g/hp·hr applied in 2004 through 2006 in conjunction with a separate NMHC standard of 0.5 g/hp·hr.

126. Add appendix II to part 1036 to read as follows:

Appendix II to Part 1036—Transient Duty Cycles

(a) This appendix specifies transient duty cycles for the engine and powertrain testing described in § 1036.510, as follows:

(1) The transient duty cycle for testing engines involves a schedule of normalized engine speed and torque values.

(2) The transient duty cycles for powertrain testing involves a schedule of vehicle speeds and road grade. Determine road grade at each point based on the peak rated power of the powertrain system, P_{rated}, determined in § 1036.527 and road grade coefficients using the following equation:

$$Road\ grade = a \cdot P_{rated}^2 + b \cdot P_{rated} + c$$

(b) The following transient duty cycle applies for spark-ignition engines and powertrains:

Record (seconds)	Engine testing		Powertrain testing			
	Normalized revolutions per minute (percent)	Normalized torque (percent)	Vehicle speed (mi/hr)	Road grade coefficients		
				a	*b*	*c*
1	0	0	0	0	0	0
2	0	0	0	0	0	0
3	0	0	0	1.837E-05	-1.876E-02	2.369E+00
4	0	0	0	2.756E-05	-2.814E-02	3.553E+00
5	0	0	0	2.756E-05	-2.814E-02	3.553E+00
6	0	0	0	2.756E-05	-2.814E-02	3.553E+00
7	0	0	0	2.756E-05	-2.814E-02	3.553E+00

8	0	0	0	2.756E-05	-2.814E-02	3.553E+00
9	0	0	0	2.756E-05	-2.814E-02	3.553E+00
10	0	0	0	2.756E-05	-2.814E-02	3.553E+00
11	0	0	0	2.756E-05	-2.814E-02	3.553E+00
12	0	0	0	2.756E-05	-2.814E-02	3.553E+00
13	0	0	0	2.756E-05	-2.814E-02	3.553E+00
14	0	0	0	2.756E-05	-2.814E-02	3.553E+00
15	0	0	0	2.756E-05	-2.814E-02	3.553E+00
16	0	0	0	2.756E-05	-2.814E-02	3.553E+00
17	0	0	0	2.756E-05	-2.814E-02	3.553E+00
18	0	0	0	2.756E-05	-2.814E-02	3.553E+00
19	0	0	0	2.756E-05	-2.814E-02	3.553E+00
20	0	0	0	2.756E-05	-2.814E-02	3.553E+00
21	0	0	0	2.756E-05	-2.814E-02	3.553E+00
22	0	0	0	2.756E-05	-2.814E-02	3.553E+00
23	0	0	0	2.756E-05	-2.814E-02	3.553E+00
24	0	0	0	2.756E-05	-2.814E-02	3.553E+00
25	7.00	44.40	0	2.756E-05	-2.814E-02	3.553E+00
26	16.00	85.40	3.04	2.756E-05	-2.814E-02	3.553E+00
27	27.00	97.80	5.59	2.756E-05	-2.814E-02	3.553E+00
28	38.00	100.00	8.37	2.756E-05	-2.814E-02	3.553E+00
29	45.00	100.00	11.06	2.756E-05	-2.814E-02	3.553E+00
30	51.00	100.00	13.63	2.756E-05	-2.814E-02	3.553E+00
31	54.00	97.50	15.87	2.756E-05	-2.814E-02	3.553E+00
32	53.00	90.00	18.09	2.756E-05	-2.814E-02	3.553E+00
33	49.00	75.20	20.66	2.756E-05	-2.814E-02	3.553E+00
34	45.00	50.00	22.26	9.186E-06	-9.380E-03	1.184E+00
35	40.00	10.00	22.08	-9.186E-06	9.380E-03	-1.184E+00
36	34.00	2.30	20.58	-2.756E-05	2.814E-02	-3.553E+00
37	27.00	0	18.65	-2.756E-05	2.814E-02	-3.553E+00
38	21.00	2.30	16.50	-2.756E-05	2.814E-02	-3.553E+00
39	16.00	12.00	14.19	-2.756E-05	2.814E-02	-3.553E+00
40	12.00	35.30	11.65	-2.756E-05	2.814E-02	-3.553E+00
41	8.50	4.90	9.16	-2.756E-05	2.814E-02	-3.553E+00
42	5.00	([a])	8.01	-2.756E-05	2.814E-02	-3.553E+00
43	3.00	([a])	6.86	-2.756E-05	2.814E-02	-3.553E+00
44	0	0	3.19	-2.756E-05	2.814E-02	-3.553E+00
45	0	0	0	-2.756E-05	2.814E-02	-3.553E+00
46	0	0	0	-2.756E-05	2.814E-02	-3.553E+00
47	0	0	0	-1.587E-05	1.622E-02	-2.202E+00
48	0	0	0	-4.187E-06	4.310E-03	-8.511E-01
49	0	0	0	7.498E-06	-7.604E-03	5.001E-01
50	0	0	0	7.498E-06	-7.604E-03	5.001E-01

51	3.00	10.00	1.05	7.498E-06	-7.604E-03	5.001E-01
52	11.00	40.20	2.13	7.498E-06	-7.604E-03	5.001E-01
53	20.00	53.00	3.26	7.498E-06	-7.604E-03	5.001E-01
54	27.50	64.80	4.31	7.498E-06	-7.604E-03	5.001E-01
55	32.00	78.00	5.35	7.498E-06	-7.604E-03	5.001E-01
56	32.00	78.00	6.38	7.498E-06	-7.604E-03	5.001E-01
57	27.50	56.00	7.42	7.498E-06	-7.604E-03	5.001E-01
58	26.00	24.40	8.45	7.498E-06	-7.604E-03	5.001E-01
59	24.00	([a])	9.43	7.498E-06	-7.604E-03	5.001E-01
60	23.00	([a])	10.18	7.498E-06	-7.604E-03	5.001E-01
61	24.00	([a])	10.71	7.498E-06	-7.604E-03	5.001E-01
62	27.00	([a])	11.10	7.498E-06	-7.604E-03	5.001E-01
63	34.00	([a])	11.62	7.498E-06	-7.604E-03	5.001E-01
64	44.00	28.00	12.44	7.498E-06	-7.604E-03	5.001E-01
65	57.00	74.40	13.55	7.498E-06	-7.604E-03	5.001E-01
66	60.00	74.40	14.69	7.498E-06	-7.604E-03	5.001E-01
67	53.00	33.60	15.42	7.498E-06	-7.604E-03	5.001E-01
68	48.00	([a])	16.06	7.498E-06	-7.604E-03	5.001E-01
69	44.00	([a])	16.64	7.498E-06	-7.604E-03	5.001E-01
70	40.00	([a])	17.36	8.991E-06	-9.177E-03	2.234E+00
71	40.00	7.00	17.86	1.048E-05	-1.075E-02	3.968E+00
72	44.00	22.70	18.05	1.198E-05	-1.232E-02	5.701E+00
73	46.00	30.00	18.09	1.198E-05	-1.232E-02	5.701E+00
74	46.00	32.00	18.19	1.198E-05	-1.232E-02	5.701E+00
75	44.00	25.00	18.55	1.198E-05	-1.232E-02	5.701E+00
76	40.00	18.00	19.04	1.198E-05	-1.232E-02	5.701E+00
77	37.00	14.00	19.58	1.198E-05	-1.232E-02	5.701E+00
78	36.00	10.00	19.90	1.198E-05	-1.232E-02	5.701E+00
79	34.00	0	19.99	1.198E-05	-1.232E-02	5.701E+00
80	34.00	([a])	19.85	1.198E-05	-1.232E-02	5.701E+00
81	32.00	([a])	19.73	1.198E-05	-1.232E-02	5.701E+00
82	31.00	([a])	19.70	1.198E-05	-1.232E-02	5.701E+00
83	36.00	39.90	19.84	1.198E-05	-1.232E-02	5.701E+00
84	42.00	84.70	20.10	1.198E-05	-1.232E-02	5.701E+00
85	48.00	90.00	20.44	1.198E-05	-1.232E-02	5.701E+00
86	50.00	90.00	20.98	1.198E-05	-1.232E-02	5.701E+00
87	50.00	90.00	21.52	1.198E-05	-1.232E-02	5.701E+00
88	47.00	85.00	22.06	1.198E-05	-1.232E-02	5.701E+00
89	43.00	75.00	22.24	1.198E-05	-1.232E-02	5.701E+00
90	38.00	60.00	22.35	1.198E-05	-1.232E-02	5.701E+00
91	36.00	36.00	22.37	3.992E-06	-4.107E-03	1.900E+00
92	36.00	7.50	22.35	-3.992E-06	4.107E-03	-1.900E+00
93	36.30	([a])	22.27	-1.198E-05	1.232E-02	-5.701E+00

94	45.00	64.50	22.05	-1.198E-05	1.232E-02	-5.701E+00
95	53.00	67.00	21.79	-1.198E-05	1.232E-02	-5.701E+00
96	58.00	64.50	21.50	-1.198E-05	1.232E-02	-5.701E+00
97	62.00	60.30	21.20	-1.198E-05	1.232E-02	-5.701E+00
98	63.00	55.50	20.90	-1.198E-05	1.232E-02	-5.701E+00
99	62.00	52.30	20.59	-1.198E-05	1.232E-02	-5.701E+00
100	61.00	47.00	20.42	-1.198E-05	1.232E-02	-5.701E+00
101	55.00	44.00	20.25	-1.198E-05	1.232E-02	-5.701E+00
102	50.00	39.00	20.07	-1.198E-05	1.232E-02	-5.701E+00
103	45.00	36.00	19.75	-1.198E-05	1.232E-02	-5.701E+00
104	40.00	34.00	19.38	-1.198E-05	1.232E-02	-5.701E+00
105	36.00	30.00	19.00	-1.198E-05	1.232E-02	-5.701E+00
106	34.00	25.80	18.61	-1.198E-05	1.232E-02	-5.701E+00
107	32.00	20.00	18.20	-1.198E-05	1.232E-02	-5.701E+00
108	30.00	14.60	17.75	-1.198E-05	1.232E-02	-5.701E+00
109	26.00	10.00	17.27	-1.198E-05	1.232E-02	-5.701E+00
110	23.00	0	16.75	-1.198E-05	1.232E-02	-5.701E+00
111	18.00	([a])	16.20	-1.198E-05	1.232E-02	-5.701E+00
112	16.00	([a])	15.66	-1.198E-05	1.232E-02	-5.701E+00
113	18.00	([a])	15.15	-1.198E-05	1.232E-02	-5.701E+00
114	20.00	27.60	14.65	-1.198E-05	1.232E-02	-5.701E+00
115	17.00	4.00	14.16	-1.198E-05	1.232E-02	-5.701E+00
116	14.00	([a])	13.67	-1.198E-05	1.232E-02	-5.701E+00
117	12.00	([a])	12.59	-1.198E-05	1.232E-02	-5.701E+00
118	9.00	([a])	10.93	-1.198E-05	1.232E-02	-5.701E+00
119	7.00	([a])	9.28	-1.198E-05	1.232E-02	-5.701E+00
120	7.00	([a])	7.62	-1.198E-05	1.232E-02	-5.701E+00
121	5.00	([a])	5.96	-1.198E-05	1.232E-02	-5.701E+00
122	4.00	([a])	4.30	-1.198E-05	1.232E-02	-5.701E+00
123	3.00	([a])	2.64	-1.198E-05	1.232E-02	-5.701E+00
124	2.00	([a])	0.99	-1.198E-05	1.232E-02	-5.701E+00
125	0	0	0.19	-1.198E-05	1.232E-02	-5.701E+00
126	0	0	0	-1.198E-05	1.232E-02	-5.701E+00
127	0	0	0	-1.198E-05	1.232E-02	-5.701E+00
128	0	0	0	5.354E-07	1.492E-03	-6.315E+00
129	0	0	0	1.305E-05	-9.337E-03	-6.929E+00
130	5.00	8.00	3.25	2.556E-05	-2.017E-02	-7.543E+00
131	8.00	16.30	5.47	2.556E-05	-2.017E-02	-7.543E+00
132	10.00	27.50	6.71	2.556E-05	-2.017E-02	-7.543E+00
133	8.00	27.50	6.71	2.556E-05	-2.017E-02	-7.543E+00
134	5.00	9.00	6.71	2.556E-05	-2.017E-02	-7.543E+00
135	2.00	1.80	6.55	8.520E-06	-6.722E-03	-2.514E+00
136	0	0	6.01	-8.520E-06	6.722E-03	2.514E+00

137	0	0	5.15	-2.556E-05	2.017E-02	7.543E+00
138	0	0	3.90	-2.556E-05	2.017E-02	7.543E+00
139	0	0	2.19	-2.556E-05	2.017E-02	7.543E+00
140	0	0	0	-2.556E-05	2.017E-02	7.543E+00
141	0	0	0	-9.124E-06	5.441E-03	6.132E+00
142	0	0	0	7.313E-06	-9.284E-03	4.722E+00
143	0	0	0	2.375E-05	-2.401E-02	3.312E+00
144	0	0	0	2.375E-05	-2.401E-02	3.312E+00
145	0	0	0	2.375E-05	-2.401E-02	3.312E+00
146	0	0	0	2.375E-05	-2.401E-02	3.312E+00
147	0	0	0	2.375E-05	-2.401E-02	3.312E+00
148	0	0	0	2.375E-05	-2.401E-02	3.312E+00
149	2.00	4.80	0	2.375E-05	-2.401E-02	3.312E+00
150	1.00	4.50	0	2.375E-05	-2.401E-02	3.312E+00
151	0	0	0	2.375E-05	-2.401E-02	3.312E+00
152	0	0	0	2.375E-05	-2.401E-02	3.312E+00
153	0	0	0	2.375E-05	-2.401E-02	3.312E+00
154	0	0	0	2.375E-05	-2.401E-02	3.312E+00
155	0	0	0	2.375E-05	-2.401E-02	3.312E+00
156	0	0	0	2.375E-05	-2.401E-02	3.312E+00
157	0	0	0	2.375E-05	-2.401E-02	3.312E+00
158	0	0	0	2.375E-05	-2.401E-02	3.312E+00
159	0	0	0	2.375E-05	-2.401E-02	3.312E+00
160	0	0	0	2.375E-05	-2.401E-02	3.312E+00
161	0	0	0	2.375E-05	-2.401E-02	3.312E+00
162	0	0	0	2.375E-05	-2.401E-02	3.312E+00
163	0	0	0	2.375E-05	-2.401E-02	3.312E+00
164	0	0	0	2.375E-05	-2.401E-02	3.312E+00
165	0	0	0	2.375E-05	-2.401E-02	3.312E+00
166	0	0	0	2.375E-05	-2.401E-02	3.312E+00
167	8.00	27.00	1.95	2.375E-05	-2.401E-02	3.312E+00
168	18.00	65.00	3.70	2.375E-05	-2.401E-02	3.312E+00
169	23.00	82.50	5.53	2.375E-05	-2.401E-02	3.312E+00
170	23.00	88.00	7.22	2.375E-05	-2.401E-02	3.312E+00
171	21.00	88.00	8.64	2.375E-05	-2.401E-02	3.312E+00
172	18.00	81.30	10.33	2.375E-05	-2.401E-02	3.312E+00
173	17.00	32.00	11.18	7.917E-06	-8.003E-03	1.104E+00
174	15.00	([a])	10.57	-7.917E-06	8.003E-03	-1.104E+00
175	13.00	([a])	9.33	-2.375E-05	2.401E-02	-3.312E+00
176	11.00	([a])	7.87	-2.375E-05	2.401E-02	-3.312E+00
177	8.00	([a])	6.27	-2.375E-05	2.401E-02	-3.312E+00
178	6.00	([a])	4.58	-2.375E-05	2.401E-02	-3.312E+00
179	4.00	([a])	3.81	-2.375E-05	2.401E-02	-3.312E+00

180	2.00	([a])	2.35	-2.375E-05	2.401E-02	-3.312E+00
181	0	0	0	-2.375E-05	2.401E-02	-3.312E+00
182	0	0	0	-2.375E-05	2.401E-02	-3.312E+00
183	0	0	0	-1.078E-05	1.103E-02	-1.145E+00
184	0	0	0	2.190E-06	-1.954E-03	1.022E+00
185	0	0	0	1.516E-05	-1.494E-02	3.189E+00
186	0	0	0	1.516E-05	-1.494E-02	3.189E+00
187	0	0	0	1.516E-05	-1.494E-02	3.189E+00
188	0	0	0	1.516E-05	-1.494E-02	3.189E+00
189	0	0	0	1.516E-05	-1.494E-02	3.189E+00
190	0	0	0	1.516E-05	-1.494E-02	3.189E+00
191	0	0	0	1.516E-05	-1.494E-02	3.189E+00
192	0	0	0	1.516E-05	-1.494E-02	3.189E+00
193	0	0	0	1.516E-05	-1.494E-02	3.189E+00
194	0	0	0	1.516E-05	-1.494E-02	3.189E+00
195	0	0	0	1.516E-05	-1.494E-02	3.189E+00
196	0	0	0	1.516E-05	-1.494E-02	3.189E+00
197	0	0	0	1.516E-05	-1.494E-02	3.189E+00
198	0	0	0	1.516E-05	-1.494E-02	3.189E+00
199	0	0	0	1.516E-05	-1.494E-02	3.189E+00
200	0	0	0	1.516E-05	-1.494E-02	3.189E+00
201	0	0	0	1.516E-05	-1.494E-02	3.189E+00
202	0	0	0	1.516E-05	-1.494E-02	3.189E+00
203	0	0	0	1.516E-05	-1.494E-02	3.189E+00
204	0	4.00	0	1.516E-05	-1.494E-02	3.189E+00
205	0.50	7.70	1.60	1.516E-05	-1.494E-02	3.189E+00
206	5.00	14.00	4.24	1.516E-05	-1.494E-02	3.189E+00
207	11.00	24.70	7.50	1.516E-05	-1.494E-02	3.189E+00
208	15.00	42.30	9.18	1.516E-05	-1.494E-02	3.189E+00
209	16.00	70.00	10.11	1.516E-05	-1.494E-02	3.189E+00
210	17.00	70.00	10.34	1.516E-05	-1.494E-02	3.189E+00
211	17.00	50.00	10.46	1.516E-05	-1.494E-02	3.189E+00
212	16.00	26.30	9.93	1.516E-05	-1.494E-02	3.189E+00
213	14.00	5.00	8.70	1.516E-05	-1.494E-02	3.189E+00
214	10.00	([a])	7.43	1.516E-05	-1.494E-02	3.189E+00
215	10.00	([a])	9.14	1.516E-05	-1.494E-02	3.189E+00
216	14.00	73.30	9.72	1.516E-05	-1.494E-02	3.189E+00
217	18.00	83.00	9.84	1.516E-05	-1.494E-02	3.189E+00
218	19.00	84.80	10.02	1.516E-05	-1.494E-02	3.189E+00
219	18.00	84.80	9.92	5.053E-06	-4.979E-03	1.063E+00
220	16.00	82.80	9.14	-5.053E-06	4.979E-03	-1.063E+00
221	11.00	74.00	8.23	-1.516E-05	1.494E-02	-3.189E+00
222	7.00	8.50	6.64	-1.516E-05	1.494E-02	-3.189E+00

223	4.00	0	4.51	-1.516E-05	1.494E-02	-3.189E+00
224	0	0	0	-1.516E-05	1.494E-02	-3.189E+00
225	0	0	0	-1.516E-05	1.494E-02	-3.189E+00
226	0	0	0	-6.857E-06	6.357E-03	-2.057E+00
227	0	0	0	1.446E-06	-2.223E-03	-9.251E-01
228	0	0	0	9.749E-06	-1.080E-02	2.071E-01
229	0	0	0	9.749E-06	-1.080E-02	2.071E-01
230	0	0	0	9.749E-06	-1.080E-02	2.071E-01
231	0	0	0	9.749E-06	-1.080E-02	2.071E-01
232	0	0	0	9.749E-06	-1.080E-02	2.071E-01
233	6.00	17.60	0	9.749E-06	-1.080E-02	2.071E-01
234	6.00	19.60	0	9.749E-06	-1.080E-02	2.071E-01
235	5.00	14.00	0	9.749E-06	-1.080E-02	2.071E-01
236	3.00	9.80	0	9.749E-06	-1.080E-02	2.071E-01
237	1.00	5.50	0	9.749E-06	-1.080E-02	2.071E-01
238	0	3.00	0	9.749E-06	-1.080E-02	2.071E-01
239	0	0	0	9.749E-06	-1.080E-02	2.071E-01
240	0	0	0	9.749E-06	-1.080E-02	2.071E-01
241	0	0	0	9.749E-06	-1.080E-02	2.071E-01
242	0	0	0	9.749E-06	-1.080E-02	2.071E-01
243	0	0	0	9.749E-06	-1.080E-02	2.071E-01
244	0	0	0	9.749E-06	-1.080E-02	2.071E-01
245	0	0	0	9.749E-06	-1.080E-02	2.071E-01
246	0	0	0	9.749E-06	-1.080E-02	2.071E-01
247	0	0	0	9.749E-06	-1.080E-02	2.071E-01
248	0	0	0	9.749E-06	-1.080E-02	2.071E-01
249	0	0	0	9.749E-06	-1.080E-02	2.071E-01
250	0	0	0	9.749E-06	-1.080E-02	2.071E-01
251	0	0	0	9.749E-06	-1.080E-02	2.071E-01
252	0	0	0	9.749E-06	-1.080E-02	2.071E-01
253	0	0	0	9.749E-06	-1.080E-02	2.071E-01
254	0	0	0	9.749E-06	-1.080E-02	2.071E-01
255	0	0	0	9.749E-06	-1.080E-02	2.071E-01
256	0	0	0	9.749E-06	-1.080E-02	2.071E-01
257	0	0	0	9.749E-06	-1.080E-02	2.071E-01
258	0	0	0	9.749E-06	-1.080E-02	2.071E-01
259	0	0	0	9.749E-06	-1.080E-02	2.071E-01
260	0	0	0	9.749E-06	-1.080E-02	2.071E-01
261	0	0	0	9.749E-06	-1.080E-02	2.071E-01
262	0	0	0	9.749E-06	-1.080E-02	2.071E-01
263	0	0	0	9.749E-06	-1.080E-02	2.071E-01
264	0	0	0	9.749E-06	-1.080E-02	2.071E-01
265	0	0	0	9.749E-06	-1.080E-02	2.071E-01

266	0	0	0	9.749E-06	-1.080E-02	2.071E-01
267	0	0	0	9.749E-06	-1.080E-02	2.071E-01
268	0	0	0	9.749E-06	-1.080E-02	2.071E-01
269	0	0	0	9.749E-06	-1.080E-02	2.071E-01
270	0	0	0	9.749E-06	-1.080E-02	2.071E-01
271	0	0	0	9.749E-06	-1.080E-02	2.071E-01
272	0	0	0	9.749E-06	-1.080E-02	2.071E-01
273	0	0	0	9.749E-06	-1.080E-02	2.071E-01
274	0	0	0	9.749E-06	-1.080E-02	2.071E-01
275	0	0	0	9.749E-06	-1.080E-02	2.071E-01
276	0	0	0	9.749E-06	-1.080E-02	2.071E-01
277	0	0	0	9.749E-06	-1.080E-02	2.071E-01
278	0	0	0	9.749E-06	-1.080E-02	2.071E-01
279	0	0	0	9.749E-06	-1.080E-02	2.071E-01
280	0	0	0	9.749E-06	-1.080E-02	2.071E-01
281	0	7.00	0	9.749E-06	-1.080E-02	2.071E-01
282	1.00	10.00	0	9.749E-06	-1.080E-02	2.071E-01
283	2.00	11.50	0	9.749E-06	-1.080E-02	2.071E-01
284	1.00	10.00	0	9.749E-06	-1.080E-02	2.071E-01
285	0	0	0	9.749E-06	-1.080E-02	2.071E-01
286	0	0	0	9.749E-06	-1.080E-02	2.071E-01
287	0	0	0	9.749E-06	-1.080E-02	2.071E-01
288	0	0	0	9.749E-06	-1.080E-02	2.071E-01
289	0	0	0	9.749E-06	-1.080E-02	2.071E-01
290	0	0	0	9.749E-06	-1.080E-02	2.071E-01
291	0	0	0	9.749E-06	-1.080E-02	2.071E-01
292	0	0	0	9.749E-06	-1.080E-02	2.071E-01
293	0	0	0	9.749E-06	-1.080E-02	2.071E-01
294	0	0	0	9.749E-06	-1.080E-02	2.071E-01
295	0	0	0	9.749E-06	-1.080E-02	2.071E-01
296	0	0	0	9.749E-06	-1.080E-02	2.071E-01
297	0	0	0	9.749E-06	-1.080E-02	2.071E-01
298	0	0	0	9.749E-06	-1.080E-02	2.071E-01
299	0	28.00	0	9.749E-06	-1.080E-02	2.071E-01
300	0	30.00	0	9.749E-06	-1.080E-02	2.071E-01
301	2.00	32.00	0.55	9.749E-06	-1.080E-02	2.071E-01
302	6.00	34.00	1.92	9.749E-06	-1.080E-02	2.071E-01
303	14.00	36.00	3.18	9.749E-06	-1.080E-02	2.071E-01
304	19.00	36.00	4.80	9.749E-06	-1.080E-02	2.071E-01
305	24.50	36.00	6.63	9.749E-06	-1.080E-02	2.071E-01
306	24.50	36.00	7.87	9.749E-06	-1.080E-02	2.071E-01
307	24.00	30.00	8.32	9.749E-06	-1.080E-02	2.071E-01
308	19.00	24.00	9.66	9.749E-06	-1.080E-02	2.071E-01

309	13.00	18.00	11.46	9.749E-06	-1.080E-02	2.071E-01
310	9.00	14.00	13.28	9.749E-06	-1.080E-02	2.071E-01
311	7.00	8.00	14.61	9.749E-06	-1.080E-02	2.071E-01
312	6.00	0	14.39	9.749E-06	-1.080E-02	2.071E-01
313	4.00	3.00	13.50	9.749E-06	-1.080E-02	2.071E-01
314	3.00	6.80	12.41	9.749E-06	-1.080E-02	2.071E-01
315	0	0	11.30	9.749E-06	-1.080E-02	2.071E-01
316	0	0	11.25	9.749E-06	-1.080E-02	2.071E-01
317	0	0	12.29	9.749E-06	-1.080E-02	2.071E-01
318	0	0	13.26	9.749E-06	-1.080E-02	2.071E-01
319	0	0	13.66	9.749E-06	-1.080E-02	2.071E-01
320	0	0	14.27	9.749E-06	-1.080E-02	2.071E-01
321	0	0	15.17	9.749E-06	-1.080E-02	2.071E-01
322	0	0	16.05	9.749E-06	-1.080E-02	2.071E-01
323	0	18.00	16.49	9.749E-06	-1.080E-02	2.071E-01
324	3.00	40.00	17.52	9.749E-06	-1.080E-02	2.071E-01
325	8.00	86.00	18.06	9.749E-06	-1.080E-02	2.071E-01
326	18.00	97.00	18.18	9.749E-06	-1.080E-02	2.071E-01
327	38.00	100.00	18.95	9.749E-06	-1.080E-02	2.071E-01
328	45.50	100.00	20.48	9.749E-06	-1.080E-02	2.071E-01
329	45.00	96.00	20.48	3.250E-06	-3.601E-03	6.902E-02
330	44.00	84.40	19.50	-3.250E-06	3.601E-03	-6.902E-02
331	43.00	53.60	18.43	-9.749E-06	1.080E-02	-2.071E-01
332	41.00	5.00	17.44	-9.749E-06	1.080E-02	-2.071E-01
333	43.00	47.60	16.77	-9.749E-06	1.080E-02	-2.071E-01
334	44.00	90.00	16.36	-9.749E-06	1.080E-02	-2.071E-01
335	45.00	90.00	16.34	-9.749E-06	1.080E-02	-2.071E-01
336	44.00	73.00	16.79	-9.749E-06	1.080E-02	-2.071E-01
337	40.00	54.00	16.34	-9.749E-06	1.080E-02	-2.071E-01
338	38.00	34.70	15.13	-9.749E-06	1.080E-02	-2.071E-01
339	36.00	10.00	13.72	-9.749E-06	1.080E-02	-2.071E-01
340	35.00	10.00	12.04	-9.749E-06	1.080E-02	-2.071E-01
341	35.00	10.00	10.44	-9.749E-06	1.080E-02	-2.071E-01
342	35.50	60.00	9.71	-9.749E-06	1.080E-02	-2.071E-01
343	36.00	57.90	9.81	-9.749E-06	1.080E-02	-2.071E-01
344	37.00	53.00	10.65	-9.749E-06	1.080E-02	-2.071E-01
345	39.00	50.00	11.42	-9.749E-06	1.080E-02	-2.071E-01
346	40.50	50.00	10.54	-9.749E-06	1.080E-02	-2.071E-01
347	43.00	50.00	8.87	-9.749E-06	1.080E-02	-2.071E-01
348	45.00	50.00	9.26	-3.250E-06	3.601E-03	-6.902E-02
349	48.00	50.00	10.33	3.250E-06	-3.601E-03	6.902E-02
350	51.00	52.00	10.79	9.749E-06	-1.080E-02	2.071E-01
351	56.00	58.70	11.80	9.749E-06	-1.080E-02	2.071E-01

352	64.00	70.00	14.06	9.749E-06	-1.080E-02	2.071E-01
353	68.00	70.00	16.77	9.749E-06	-1.080E-02	2.071E-01
354	70.00	70.00	18.83	9.749E-06	-1.080E-02	2.071E-01
355	65.50	64.60	22.12	9.749E-06	-1.080E-02	2.071E-01
356	61.00	28.90	24.10	9.749E-06	-1.080E-02	2.071E-01
357	55.00	([a])	25.97	9.749E-06	-1.080E-02	2.071E-01
358	50.00	([a])	27.04	9.749E-06	-1.080E-02	2.071E-01
359	45.00	([a])	27.18	9.749E-06	-1.080E-02	2.071E-01
360	38.00	([a])	28.34	9.749E-06	-1.080E-02	2.071E-01
361	28.00	([a])	29.69	9.749E-06	-1.080E-02	2.071E-01
362	19.00	([a])	29.86	9.749E-06	-1.080E-02	2.071E-01
363	14.00	([a])	29.51	9.749E-06	-1.080E-02	2.071E-01
364	7.00	([a])	29.91	9.749E-06	-1.080E-02	2.071E-01
365	2.00	([a])	30.99	9.749E-06	-1.080E-02	2.071E-01
366	3.00	5.00	32.55	9.749E-06	-1.080E-02	2.071E-01
367	7.00	25.00	33.43	9.749E-06	-1.080E-02	2.071E-01
368	9.00	38.00	33.56	3.250E-06	-3.601E-03	6.902E-02
369	7.00	17.00	33.36	-3.250E-06	3.601E-03	-6.902E-02
370	4.00	2.00	32.65	-9.749E-06	1.080E-02	-2.071E-01
371	3.00	([a])	31.80	-9.749E-06	1.080E-02	-2.071E-01
372	3.00	([a])	30.92	-9.749E-06	1.080E-02	-2.071E-01
373	11.00	70.00	30.42	-9.749E-06	1.080E-02	-2.071E-01
374	15.00	97.60	29.73	-9.749E-06	1.080E-02	-2.071E-01
375	16.00	100.00	28.65	-9.749E-06	1.080E-02	-2.071E-01
376	19.00	100.00	27.50	-9.749E-06	1.080E-02	-2.071E-01
377	26.00	100.00	26.22	-9.749E-06	1.080E-02	-2.071E-01
378	29.00	95.00	24.69	-9.749E-06	1.080E-02	-2.071E-01
379	25.00	63.00	23.13	-9.749E-06	1.080E-02	-2.071E-01
380	19.00	([a])	21.68	-9.749E-06	1.080E-02	-2.071E-01
381	12.00	([a])	20.25	-9.749E-06	1.080E-02	-2.071E-01
382	8.00	([a])	15.73	-9.749E-06	1.080E-02	-2.071E-01
383	5.00	([a])	10.93	-9.749E-06	1.080E-02	-2.071E-01
384	2.00	([a])	6.12	-9.749E-06	1.080E-02	-2.071E-01
385	1.00	([a])	1.31	-9.749E-06	1.080E-02	-2.071E-01
386	0	0	0	-9.749E-06	1.080E-02	-2.071E-01
387	0	0	0	-9.749E-06	1.080E-02	-2.071E-01
388	0	0	0	-9.749E-06	1.080E-02	-2.071E-01
389	0	0	0	-9.749E-06	1.080E-02	-2.071E-01
390	0	0	0	-9.749E-06	1.080E-02	-2.071E-01
391	0	0	0	-9.749E-06	1.080E-02	-2.071E-01
392	0	0	0	-9.749E-06	1.080E-02	-2.071E-01
393	0	0	0	-1.165E-06	1.625E-03	1.971E+00
394	0	0	0	7.420E-06	-7.553E-03	4.149E+00

395	0	0	0	1.600E-05	-1.673E-02	6.327E+00
396	0	0	0	1.600E-05	-1.673E-02	6.327E+00
397	0	0	0	1.600E-05	-1.673E-02	6.327E+00
398	0	0	0	1.600E-05	-1.673E-02	6.327E+00
399	0	0	0	1.600E-05	-1.673E-02	6.327E+00
400	0	0	0	1.600E-05	-1.673E-02	6.327E+00
401	0	0	0	1.600E-05	-1.673E-02	6.327E+00
402	0	0	0	1.600E-05	-1.673E-02	6.327E+00
403	0	0	0	1.600E-05	-1.673E-02	6.327E+00
404	0	0	0	1.600E-05	-1.673E-02	6.327E+00
405	0	0	0	1.600E-05	-1.673E-02	6.327E+00
406	0	0	0	1.600E-05	-1.673E-02	6.327E+00
407	0	0	0	1.600E-05	-1.673E-02	6.327E+00
408	0	0	0	1.600E-05	-1.673E-02	6.327E+00
409	0	0	0	1.600E-05	-1.673E-02	6.327E+00
410	0	0	0	1.600E-05	-1.673E-02	6.327E+00
411	0	0	0	1.600E-05	-1.673E-02	6.327E+00
412	0	0	0	1.600E-05	-1.673E-02	6.327E+00
413	0	0	0	1.600E-05	-1.673E-02	6.327E+00
414	0	0	0	1.600E-05	-1.673E-02	6.327E+00
415	0	0	0	1.600E-05	-1.673E-02	6.327E+00
416	0	0	0	1.600E-05	-1.673E-02	6.327E+00
417	0	0	0	1.600E-05	-1.673E-02	6.327E+00
418	0	0	0	1.600E-05	-1.673E-02	6.327E+00
419	4.00	20.00	0	1.600E-05	-1.673E-02	6.327E+00
420	4.00	20.00	0	1.600E-05	-1.673E-02	6.327E+00
421	0	0	0	1.600E-05	-1.673E-02	6.327E+00
422	0	0	0	1.600E-05	-1.673E-02	6.327E+00
423	0	0	0	1.600E-05	-1.673E-02	6.327E+00
424	0	0	0	1.600E-05	-1.673E-02	6.327E+00
425	0	0	0	1.600E-05	-1.673E-02	6.327E+00
426	0	0	0	1.600E-05	-1.673E-02	6.327E+00
427	0	0	0	1.600E-05	-1.673E-02	6.327E+00
428	0	0	0	1.600E-05	-1.673E-02	6.327E+00
429	0	0	0	1.600E-05	-1.673E-02	6.327E+00
430	2.00	0	1.18	1.600E-05	-1.673E-02	6.327E+00
431	6.00	2.00	2.85	1.600E-05	-1.673E-02	6.327E+00
432	14.00	28.80	4.57	1.600E-05	-1.673E-02	6.327E+00
433	20.00	30.00	7.42	1.600E-05	-1.673E-02	6.327E+00
434	24.40	11.00	10.79	1.600E-05	-1.673E-02	6.327E+00
435	24.00	10.00	13.51	1.600E-05	-1.673E-02	6.327E+00
436	24.00	12.00	15.48	1.600E-05	-1.673E-02	6.327E+00
437	28.00	52.00	16.82	1.600E-05	-1.673E-02	6.327E+00

438	32.00	52.00	17.86	1.600E-05	-1.673E-02	6.327E+00
439	34.00	46.00	18.70	1.600E-05	-1.673E-02	6.327E+00
440	34.00	30.00	19.11	1.600E-05	-1.673E-02	6.327E+00
441	34.50	30.00	19.28	1.600E-05	-1.673E-02	6.327E+00
442	35.00	30.00	19.38	1.600E-05	-1.673E-02	6.327E+00
443	36.00	35.00	19.53	1.600E-05	-1.673E-02	6.327E+00
444	39.00	40.00	19.57	1.600E-05	-1.673E-02	6.327E+00
445	45.00	50.00	19.09	1.600E-05	-1.673E-02	6.327E+00
446	49.00	56.00	18.20	1.600E-05	-1.673E-02	6.327E+00
447	50.00	([a])	17.14	1.600E-05	-1.673E-02	6.327E+00
448	45.00	([a])	15.90	1.600E-05	-1.673E-02	6.327E+00
449	39.00	([a])	14.42	1.600E-05	-1.673E-02	6.327E+00
450	34.00	([a])	13.86	1.600E-05	-1.673E-02	6.327E+00
451	28.00	([a])	15.45	1.600E-05	-1.673E-02	6.327E+00
452	25.00	([a])	17.32	1.600E-05	-1.673E-02	6.327E+00
453	21.00	([a])	18.03	1.600E-05	-1.673E-02	6.327E+00
454	18.00	([a])	18.19	1.600E-05	-1.673E-02	6.327E+00
455	15.00	([a])	18.30	1.600E-05	-1.673E-02	6.327E+00
456	12.00	([a])	18.40	1.600E-05	-1.673E-02	6.327E+00
457	18.00	([a])	18.33	1.600E-05	-1.673E-02	6.327E+00
458	29.00	19.80	18.68	1.600E-05	-1.673E-02	6.327E+00
459	40.00	54.00	19.10	5.335E-06	-5.577E-03	2.109E+00
460	52.00	82.00	18.69	-5.335E-06	5.577E-03	-2.109E+00
461	64.00	95.00	17.89	-1.600E-05	1.673E-02	-6.327E+00
462	71.00	99.00	17.23	-1.600E-05	1.673E-02	-6.327E+00
463	77.00	100.00	16.65	-1.600E-05	1.673E-02	-6.327E+00
464	84.00	100.00	15.76	-1.600E-05	1.673E-02	-6.327E+00
465	85.00	99.00	14.53	-1.600E-05	1.673E-02	-6.327E+00
466	85.00	95.00	13.07	-1.600E-05	1.673E-02	-6.327E+00
467	84.00	90.00	11.26	-1.600E-05	1.673E-02	-6.327E+00
468	82.00	84.60	9.32	-1.600E-05	1.673E-02	-6.327E+00
469	80.00	78.50	8.04	-1.600E-05	1.673E-02	-6.327E+00
470	78.00	78.50	8.15	-7.218E-06	7.554E-03	-2.785E+00
471	77.00	70.00	9.43	1.567E-06	-1.623E-03	7.568E-01
472	76.00	65.50	10.80	1.035E-05	-1.080E-02	4.299E+00
473	74.00	61.50	12.16	1.035E-05	-1.080E-02	4.299E+00
474	72.00	56.00	14.25	1.035E-05	-1.080E-02	4.299E+00
475	70.00	52.00	16.38	1.035E-05	-1.080E-02	4.299E+00
476	68.00	46.00	17.48	1.035E-05	-1.080E-02	4.299E+00
477	66.50	40.00	17.41	1.035E-05	-1.080E-02	4.299E+00
478	65.00	32.00	16.78	1.035E-05	-1.080E-02	4.299E+00
479	63.00	26.00	16.06	1.035E-05	-1.080E-02	4.299E+00
480	61.00	25.60	15.24	1.035E-05	-1.080E-02	4.299E+00

481	61.00	72.00	14.69	1.035E-05	-1.080E-02	4.299E+00
482	61.00	78.00	15.38	1.035E-05	-1.080E-02	4.299E+00
483	58.00	72.00	16.86	1.035E-05	-1.080E-02	4.299E+00
484	50.00	64.00	17.35	1.035E-05	-1.080E-02	4.299E+00
485	44.00	55.00	16.98	1.035E-05	-1.080E-02	4.299E+00
486	35.00	40.00	16.57	1.035E-05	-1.080E-02	4.299E+00
487	26.00	20.00	16.12	1.035E-05	-1.080E-02	4.299E+00
488	21.00	([a])	15.67	1.035E-05	-1.080E-02	4.299E+00
489	18.00	([a])	15.46	1.035E-05	-1.080E-02	4.299E+00
490	16.00	([a])	15.52	1.035E-05	-1.080E-02	4.299E+00
491	19.00	([a])	15.89	1.035E-05	-1.080E-02	4.299E+00
492	24.00	2.00	16.77	1.035E-05	-1.080E-02	4.299E+00
493	32.00	68.50	18.08	1.035E-05	-1.080E-02	4.299E+00
494	45.00	78.00	19.31	1.035E-05	-1.080E-02	4.299E+00
495	51.00	86.00	20.11	1.035E-05	-1.080E-02	4.299E+00
496	58.00	92.00	20.75	1.035E-05	-1.080E-02	4.299E+00
497	64.00	97.00	21.23	1.035E-05	-1.080E-02	4.299E+00
498	71.00	100.00	21.40	1.035E-05	-1.080E-02	4.299E+00
499	73.00	98.00	21.51	1.035E-05	-1.080E-02	4.299E+00
500	73.00	94.00	22.18	1.035E-05	-1.080E-02	4.299E+00
501	73.00	86.00	22.48	1.035E-05	-1.080E-02	4.299E+00
502	73.00	82.00	22.49	1.035E-05	-1.080E-02	4.299E+00
503	76.00	84.00	23.27	1.035E-05	-1.080E-02	4.299E+00
504	80.00	98.00	24.39	1.035E-05	-1.080E-02	4.299E+00
505	84.00	100.00	25.09	1.035E-05	-1.080E-02	4.299E+00
506	85.00	100.00	25.26	1.035E-05	-1.080E-02	4.299E+00
507	84.00	100.00	25.15	1.035E-05	-1.080E-02	4.299E+00
508	81.00	92.00	24.80	1.035E-05	-1.080E-02	4.299E+00
509	75.00	80.00	24.30	1.035E-05	-1.080E-02	4.299E+00
510	73.00	70.00	23.92	1.035E-05	-1.080E-02	4.299E+00
511	70.00	60.00	23.82	1.035E-05	-1.080E-02	4.299E+00
512	67.00	53.00	23.75	1.035E-05	-1.080E-02	4.299E+00
513	65.00	45.00	24.34	1.035E-05	-1.080E-02	4.299E+00
514	63.00	36.50	25.03	1.035E-05	-1.080E-02	4.299E+00
515	62.00	28.00	25.13	1.035E-05	-1.080E-02	4.299E+00
516	61.00	22.50	25.14	1.035E-05	-1.080E-02	4.299E+00
517	60.00	23.00	25.14	1.035E-05	-1.080E-02	4.299E+00
518	60.00	24.00	25.15	1.035E-05	-1.080E-02	4.299E+00
519	60.00	24.00	25.15	1.035E-05	-1.080E-02	4.299E+00
520	60.00	26.00	25.16	1.035E-05	-1.080E-02	4.299E+00
521	61.00	60.00	25.17	1.035E-05	-1.080E-02	4.299E+00
522	62.00	64.00	25.24	1.035E-05	-1.080E-02	4.299E+00
523	63.00	64.00	25.41	1.035E-05	-1.080E-02	4.299E+00

524	64.00	64.00	26.56	1.035E-05	-1.080E-02	4.299E+00
525	62.00	64.00	28.84	1.035E-05	-1.080E-02	4.299E+00
526	56.00	60.00	31.08	1.035E-05	-1.080E-02	4.299E+00
527	53.00	([a])	32.37	1.035E-05	-1.080E-02	4.299E+00
528	49.00	([a])	32.70	1.035E-05	-1.080E-02	4.299E+00
529	47.00	([a])	32.76	1.035E-05	-1.080E-02	4.299E+00
530	46.00	([a])	32.82	6.288E-06	-6.906E-03	2.331E+00
531	45.00	([a])	32.88	2.223E-06	-3.012E-03	3.623E-01
532	45.00	30.00	33.19	-1.842E-06	8.816E-04	-1.606E+00
533	46.00	50.00	33.89	-1.842E-06	8.816E-04	-1.606E+00
534	46.00	50.00	35.07	-1.842E-06	8.816E-04	-1.606E+00
535	47.00	50.00	36.61	-1.842E-06	8.816E-04	-1.606E+00
536	47.00	50.00	37.63	-1.842E-06	8.816E-04	-1.606E+00
537	47.00	30.00	38.05	-1.842E-06	8.816E-04	-1.606E+00
538	46.00	12.00	38.67	-1.842E-06	8.816E-04	-1.606E+00
539	45.00	10.50	39.32	-1.842E-06	8.816E-04	-1.606E+00
540	44.00	10.00	39.54	-1.842E-06	8.816E-04	-1.606E+00
541	41.00	10.00	39.55	-1.842E-06	8.816E-04	-1.606E+00
542	37.00	9.00	39.56	-1.842E-06	8.816E-04	-1.606E+00
543	36.00	2.00	39.58	-1.842E-06	8.816E-04	-1.606E+00
544	35.00	([a])	39.59	-1.842E-06	8.816E-04	-1.606E+00
545	38.00	67.00	39.61	-1.842E-06	8.816E-04	-1.606E+00
546	35.00	([a])	39.60	-1.842E-06	8.816E-04	-1.606E+00
547	31.00	15.00	39.69	-1.842E-06	8.816E-04	-1.606E+00
548	28.00	55.00	39.99	-1.842E-06	8.816E-04	-1.606E+00
549	34.00	44.00	40.39	-1.842E-06	8.816E-04	-1.606E+00
550	35.00	38.50	41.01	-1.842E-06	8.816E-04	-1.606E+00
551	36.00	38.50	41.65	-1.842E-06	8.816E-04	-1.606E+00
552	36.00	38.50	41.69	-1.842E-06	8.816E-04	-1.606E+00
553	37.00	38.50	41.17	-1.842E-06	8.816E-04	-1.606E+00
554	39.00	36.00	40.47	-1.842E-06	8.816E-04	-1.606E+00
555	42.00	27.00	39.83	-1.842E-06	8.816E-04	-1.606E+00
556	45.00	62.00	39.39	-1.842E-06	8.816E-04	-1.606E+00
557	48.00	45.00	39.14	-1.842E-06	8.816E-04	-1.606E+00
558	51.00	15.00	38.99	-1.842E-06	8.816E-04	-1.606E+00
559	51.00	8.00	38.88	-1.842E-06	8.816E-04	-1.606E+00
560	51.00	6.00	38.86	-1.842E-06	8.816E-04	-1.606E+00
561	48.00	10.00	39.17	-1.842E-06	8.816E-04	-1.606E+00
562	46.00	11.00	39.37	-6.139E-07	2.939E-04	-5.353E-01
563	44.00	13.00	38.63	6.139E-07	-2.939E-04	5.353E-01
564	41.00	17.00	36.96	1.842E-06	-8.816E-04	1.606E+00
565	37.00	20.00	34.87	1.842E-06	-8.816E-04	1.606E+00
566	34.00	20.00	32.73	1.842E-06	-8.816E-04	1.606E+00

567	30.00	17.00	30.53	1.842E-06	-8.816E-04	1.606E+00
568	26.00	14.00	28.27	1.842E-06	-8.816E-04	1.606E+00
569	23.00	7.00	26.02	1.842E-06	-8.816E-04	1.606E+00
570	19.00	2.00	23.76	1.842E-06	-8.816E-04	1.606E+00
571	15.00	([a])	21.37	1.842E-06	-8.816E-04	1.606E+00
572	11.00	([a])	18.79	1.842E-06	-8.816E-04	1.606E+00
573	8.00	([a])	16.06	1.842E-06	-8.816E-04	1.606E+00
574	5.00	([a])	13.05	1.842E-06	-8.816E-04	1.606E+00
575	2.00	([a])	9.54	1.842E-06	-8.816E-04	1.606E+00
576	0	0	4.59	1.842E-06	-8.816E-04	1.606E+00
577	0	0	0	1.842E-06	-8.816E-04	1.606E+00
578	0	0	0	1.842E-06	-8.816E-04	1.606E+00
579	0	0	0	1.842E-06	-8.816E-04	1.606E+00
580	0	0	0	1.842E-06	-8.816E-04	1.606E+00
581	0	0	0	8.289E-06	-7.507E-03	1.023E+00
582	0	0	0	1.474E-05	-1.413E-02	4.394E-01
583	4.00	15.00	0	2.118E-05	-2.076E-02	-1.439E-01
584	19.00	31.00	0.78	2.118E-05	-2.076E-02	-1.439E-01
585	30.00	46.00	1.94	2.118E-05	-2.076E-02	-1.439E-01
586	37.00	68.00	3.83	2.118E-05	-2.076E-02	-1.439E-01
587	40.00	76.00	5.98	2.118E-05	-2.076E-02	-1.439E-01
588	41.00	77.00	8.07	2.118E-05	-2.076E-02	-1.439E-01
589	40.50	78.00	10.09	2.118E-05	-2.076E-02	-1.439E-01
590	40.00	77.00	10.29	2.118E-05	-2.076E-02	-1.439E-01
591	40.00	64.00	7.34	2.118E-05	-2.076E-02	-1.439E-01
592	38.00	10.00	3.27	2.118E-05	-2.076E-02	-1.439E-01
593	38.00	25.00	3.24	2.118E-05	-2.076E-02	-1.439E-01
594	40.00	50.00	5.98	2.118E-05	-2.076E-02	-1.439E-01
595	40.00	36.00	8.48	2.118E-05	-2.076E-02	-1.439E-01
596	40.00	31.00	11.00	2.118E-05	-2.076E-02	-1.439E-01
597	40.00	31.00	13.62	2.118E-05	-2.076E-02	-1.439E-01
598	41.00	37.00	16.07	2.118E-05	-2.076E-02	-1.439E-01
599	42.00	97.00	18.51	2.118E-05	-2.076E-02	-1.439E-01
600	43.00	100.00	21.51	1.588E-05	-1.615E-02	-7.554E-01
601	45.00	100.00	24.71	1.058E-05	-1.153E-02	-1.367E+00
602	47.00	100.00	27.57	5.283E-06	-6.920E-03	-1.978E+00
603	48.00	100.00	30.04	5.283E-06	-6.920E-03	-1.978E+00
604	49.00	100.00	32.22	5.283E-06	-6.920E-03	-1.978E+00
605	51.00	97.00	34.28	5.283E-06	-6.920E-03	-1.978E+00
606	52.00	94.00	36.22	5.283E-06	-6.920E-03	-1.978E+00
607	53.00	90.00	38.08	5.283E-06	-6.920E-03	-1.978E+00
608	54.00	87.00	39.83	5.283E-06	-6.920E-03	-1.978E+00
609	56.00	86.00	41.63	5.283E-06	-6.920E-03	-1.978E+00

610	56.00	85.00	43.18	5.283E-06	-6.920E-03	-1.978E+00
611	55.50	85.00	44.33	5.283E-06	-6.920E-03	-1.978E+00
612	55.00	81.00	45.38	5.283E-06	-6.920E-03	-1.978E+00
613	54.00	77.00	46.14	5.283E-06	-6.920E-03	-1.978E+00
614	53.00	72.00	46.39	5.283E-06	-6.920E-03	-1.978E+00
615	52.00	67.00	46.34	5.283E-06	-6.920E-03	-1.978E+00
616	49.00	60.00	46.24	5.283E-06	-6.920E-03	-1.978E+00
617	46.00	45.00	46.14	5.283E-06	-6.920E-03	-1.978E+00
618	45.00	12.00	46.05	5.283E-06	-6.920E-03	-1.978E+00
619	44.00	10.00	46.13	5.283E-06	-6.920E-03	-1.978E+00
620	44.00	10.00	46.49	5.283E-06	-6.920E-03	-1.978E+00
621	45.00	12.00	46.78	5.283E-06	-6.920E-03	-1.978E+00
622	46.00	14.00	46.81	5.283E-06	-6.920E-03	-1.978E+00
623	47.00	24.00	46.95	5.283E-06	-6.920E-03	-1.978E+00
624	49.00	88.00	47.37	5.283E-06	-6.920E-03	-1.978E+00
625	50.00	90.00	47.62	2.349E-06	-3.713E-03	-1.409E+00
626	51.00	90.00	47.58	-5.848E-07	-5.058E-04	-8.401E-01
627	52.00	90.00	48.00	-3.519E-06	2.701E-03	-2.710E-01
628	53.00	90.00	48.46	-3.519E-06	2.701E-03	-2.710E-01
629	54.00	90.00	48.45	-3.519E-06	2.701E-03	-2.710E-01
630	54.00	90.00	48.40	-3.519E-06	2.701E-03	-2.710E-01
631	54.00	87.00	48.59	-3.519E-06	2.701E-03	-2.710E-01
632	54.00	84.00	49.30	-3.519E-06	2.701E-03	-2.710E-01
633	54.00	80.00	50.02	-3.519E-06	2.701E-03	-2.710E-01
634	53.50	77.00	50.27	-3.519E-06	2.701E-03	-2.710E-01
635	53.00	76.00	50.00	-3.519E-06	2.701E-03	-2.710E-01
636	53.00	75.00	49.73	-3.519E-06	2.701E-03	-2.710E-01
637	52.00	73.00	49.57	-3.519E-06	2.701E-03	-2.710E-01
638	51.00	69.00	49.31	-3.519E-06	2.701E-03	-2.710E-01
639	50.00	65.00	49.29	-3.519E-06	2.701E-03	-2.710E-01
640	50.00	60.00	49.71	-3.519E-06	2.701E-03	-2.710E-01
641	49.00	55.00	50.02	-3.519E-06	2.701E-03	-2.710E-01
642	49.00	50.00	50.05	-3.519E-06	2.701E-03	-2.710E-01
643	49.00	50.00	50.07	-3.519E-06	2.701E-03	-2.710E-01
644	49.50	60.00	50.33	-3.519E-06	2.701E-03	-2.710E-01
645	49.50	65.00	50.75	-3.519E-06	2.701E-03	-2.710E-01
646	50.00	70.00	51.03	-3.519E-06	2.701E-03	-2.710E-01
647	50.50	75.00	51.47	-3.519E-06	2.701E-03	-2.710E-01
648	51.00	80.00	51.92	-3.519E-06	2.701E-03	-2.710E-01
649	52.00	85.00	51.93	-3.519E-06	2.701E-03	-2.710E-01
650	53.00	90.00	51.90	-4.549E-06	3.697E-03	-6.366E-01
651	54.00	90.00	51.87	-5.579E-06	4.693E-03	-1.002E+00
652	55.00	90.00	51.85	-6.609E-06	5.688E-03	-1.368E+00

653	55.00	88.00	51.82	-6.609E-06	5.688E-03	-1.368E+00
654	55.00	84.00	51.82	-6.609E-06	5.688E-03	-1.368E+00
655	55.00	79.00	52.54	-6.609E-06	5.688E-03	-1.368E+00
656	55.00	74.00	53.59	-6.609E-06	5.688E-03	-1.368E+00
657	55.00	69.00	54.19	-6.609E-06	5.688E-03	-1.368E+00
658	55.00	64.00	54.26	-6.609E-06	5.688E-03	-1.368E+00
659	55.00	59.00	54.07	-6.609E-06	5.688E-03	-1.368E+00
660	55.00	54.00	53.93	-6.609E-06	5.688E-03	-1.368E+00
661	55.00	49.00	53.92	-6.609E-06	5.688E-03	-1.368E+00
662	55.00	44.50	53.90	-6.609E-06	5.688E-03	-1.368E+00
663	55.00	39.00	53.89	-6.609E-06	5.688E-03	-1.368E+00
664	55.00	34.00	53.88	-6.609E-06	5.688E-03	-1.368E+00
665	55.00	27.00	53.87	-6.609E-06	5.688E-03	-1.368E+00
666	55.00	18.00	53.85	-6.609E-06	5.688E-03	-1.368E+00
667	55.00	8.00	53.81	-6.609E-06	5.688E-03	-1.368E+00
668	55.00	6.00	53.67	-6.609E-06	5.688E-03	-1.368E+00
669	55.00	13.00	53.67	-6.609E-06	5.688E-03	-1.368E+00
670	55.00	27.00	54.32	-6.609E-06	5.688E-03	-1.368E+00
671	55.50	30.00	54.88	-6.609E-06	5.688E-03	-1.368E+00
672	56.00	30.00	54.87	-6.609E-06	5.688E-03	-1.368E+00
673	57.00	30.00	54.86	-6.609E-06	5.688E-03	-1.368E+00
674	58.00	34.00	54.75	-6.609E-06	5.688E-03	-1.368E+00
675	59.00	46.00	54.28	-5.500E-06	4.582E-03	-7.225E-01
676	59.00	89.00	53.84	-4.390E-06	3.477E-03	-7.706E-02
677	59.00	90.00	54.02	-3.280E-06	2.371E-03	5.683E-01
678	59.00	91.00	54.48	-3.280E-06	2.371E-03	5.683E-01
679	59.00	91.00	54.76	-3.280E-06	2.371E-03	5.683E-01
680	60.00	91.00	54.84	-3.280E-06	2.371E-03	5.683E-01
681	60.00	91.00	54.87	-3.280E-06	2.371E-03	5.683E-01
682	60.50	90.00	54.90	-3.280E-06	2.371E-03	5.683E-01
683	61.00	89.00	54.93	-3.280E-06	2.371E-03	5.683E-01
684	61.50	88.00	54.97	-3.280E-06	2.371E-03	5.683E-01
685	62.00	83.00	55.00	-3.280E-06	2.371E-03	5.683E-01
686	63.00	73.00	55.03	-3.280E-06	2.371E-03	5.683E-01
687	65.00	70.00	55.06	-3.280E-06	2.371E-03	5.683E-01
688	66.00	71.00	55.10	-3.280E-06	2.371E-03	5.683E-01
689	67.00	74.00	55.12	-3.280E-06	2.371E-03	5.683E-01
690	67.50	79.00	55.15	-3.280E-06	2.371E-03	5.683E-01
691	68.00	85.00	55.16	-3.280E-06	2.371E-03	5.683E-01
692	68.50	90.00	55.18	-3.280E-06	2.371E-03	5.683E-01
693	69.00	94.00	55.33	-3.280E-06	2.371E-03	5.683E-01
694	69.50	96.00	55.85	-3.280E-06	2.371E-03	5.683E-01
695	70.00	98.00	56.52	-3.280E-06	2.371E-03	5.683E-01

696	70.50	100.00	57.05	-3.280E-06	2.371E-03	5.683E-01
697	71.00	100.00	57.31	-3.280E-06	2.371E-03	5.683E-01
698	72.00	100.00	57.35	-3.280E-06	2.371E-03	5.683E-01
699	72.00	100.00	57.34	-3.280E-06	2.371E-03	5.683E-01
700	72.00	100.00	57.34	-2.967E-06	2.047E-03	8.641E-01
701	72.00	100.00	57.33	-2.653E-06	1.723E-03	1.160E+00
702	72.00	100.00	57.33	-2.340E-06	1.399E-03	1.456E+00
703	72.00	100.00	57.33	-2.340E-06	1.399E-03	1.456E+00
704	72.00	100.00	57.32	-2.340E-06	1.399E-03	1.456E+00
705	72.00	100.00	57.31	-2.340E-06	1.399E-03	1.456E+00
706	72.00	100.00	57.30	-2.340E-06	1.399E-03	1.456E+00
707	72.50	100.00	57.39	-2.340E-06	1.399E-03	1.456E+00
708	73.00	100.00	57.71	-2.340E-06	1.399E-03	1.456E+00
709	73.50	100.00	58.14	-2.340E-06	1.399E-03	1.456E+00
710	74.00	100.00	58.34	-2.340E-06	1.399E-03	1.456E+00
711	74.00	100.00	58.34	-2.340E-06	1.399E-03	1.456E+00
712	74.50	100.00	58.33	-2.340E-06	1.399E-03	1.456E+00
713	75.00	100.00	58.33	-2.340E-06	1.399E-03	1.456E+00
714	75.00	100.00	58.32	-2.340E-06	1.399E-03	1.456E+00
715	75.00	100.00	58.31	-2.340E-06	1.399E-03	1.456E+00
716	75.00	100.00	58.30	-2.340E-06	1.399E-03	1.456E+00
717	75.00	100.00	58.30	-2.340E-06	1.399E-03	1.456E+00
718	75.00	100.00	58.30	-2.340E-06	1.399E-03	1.456E+00
719	75.00	100.00	58.30	-2.340E-06	1.399E-03	1.456E+00
720	75.00	100.00	58.48	-2.340E-06	1.399E-03	1.456E+00
721	75.00	100.00	58.92	-2.340E-06	1.399E-03	1.456E+00
722	75.00	100.00	59.26	-2.340E-06	1.399E-03	1.456E+00
723	75.00	98.00	59.34	-2.340E-06	1.399E-03	1.456E+00
724	75.00	90.00	59.32	-2.340E-06	1.399E-03	1.456E+00
725	75.00	34.00	59.37	-3.622E-06	2.640E-03	9.220E-01
726	74.00	15.00	59.67	-4.905E-06	3.881E-03	3.883E-01
727	72.00	3.00	60.11	-6.187E-06	5.122E-03	-1.455E-01
728	70.00	([a])	60.32	-6.187E-06	5.122E-03	-1.455E-01
729	69.00	([a])	60.30	-6.187E-06	5.122E-03	-1.455E-01
730	68.00	([a])	60.29	-6.187E-06	5.122E-03	-1.455E-01
731	70.50	53.00	60.27	-6.187E-06	5.122E-03	-1.455E-01
732	73.00	80.00	60.26	-6.187E-06	5.122E-03	-1.455E-01
733	75.00	88.00	60.25	-6.187E-06	5.122E-03	-1.455E-01
734	77.00	94.00	60.18	-6.187E-06	5.122E-03	-1.455E-01
735	79.00	97.00	59.83	-6.187E-06	5.122E-03	-1.455E-01
736	82.00	97.00	59.36	-6.187E-06	5.122E-03	-1.455E-01
737	85.00	98.00	59.65	-6.187E-06	5.122E-03	-1.455E-01
738	85.00	98.00	60.12	-6.187E-06	5.122E-03	-1.455E-01

739	87.00	97.00	59.80	-6.187E-06	5.122E-03	-1.455E-01
740	90.00	95.00	59.82	-6.187E-06	5.122E-03	-1.455E-01
741	92.00	90.00	60.18	-6.187E-06	5.122E-03	-1.455E-01
742	93.00	88.00	60.27	-6.187E-06	5.122E-03	-1.455E-01
743	94.00	86.00	60.31	-6.187E-06	5.122E-03	-1.455E-01
744	95.00	83.00	60.35	-6.187E-06	5.122E-03	-1.455E-01
745	96.00	79.00	60.37	-6.187E-06	5.122E-03	-1.455E-01
746	97.00	74.00	60.35	-6.187E-06	5.122E-03	-1.455E-01
747	98.00	68.00	60.33	-6.187E-06	5.122E-03	-1.455E-01
748	99.00	62.00	60.30	-6.187E-06	5.122E-03	-1.455E-01
749	100.00	54.00	60.26	-6.187E-06	5.122E-03	-1.455E-01
750	100.00	30.00	60.45	-7.791E-06	6.722E-03	-9.485E-01
751	100.00	22.00	61.12	-9.395E-06	8.322E-03	-1.752E+00
752	100.00	20.00	61.91	-1.100E-05	9.923E-03	-2.555E+00
753	100.00	22.00	62.23	-1.100E-05	9.923E-03	-2.555E+00
754	100.00	30.00	62.19	-1.100E-05	9.923E-03	-2.555E+00
755	100.00	65.00	62.17	-1.100E-05	9.923E-03	-2.555E+00
756	100.00	76.00	62.19	-1.100E-05	9.923E-03	-2.555E+00
757	100.00	80.00	62.24	-1.100E-05	9.923E-03	-2.555E+00
758	100.00	78.00	62.28	-1.100E-05	9.923E-03	-2.555E+00
759	100.00	72.00	62.30	-1.100E-05	9.923E-03	-2.555E+00
760	100.00	54.00	62.79	-1.100E-05	9.923E-03	-2.555E+00
761	95.00	30.00	63.22	-1.100E-05	9.923E-03	-2.555E+00
762	85.00	12.00	63.11	-1.100E-05	9.923E-03	-2.555E+00
763	68.00	([a])	62.97	-1.100E-05	9.923E-03	-2.555E+00
764	57.00	([a])	62.82	-1.100E-05	9.923E-03	-2.555E+00
765	56.00	([a])	62.67	-1.100E-05	9.923E-03	-2.555E+00
766	57.00	([a])	62.52	-1.100E-05	9.923E-03	-2.555E+00
767	57.00	([a])	62.37	-1.100E-05	9.923E-03	-2.555E+00
768	57.00	22.00	62.32	-1.100E-05	9.923E-03	-2.555E+00
769	58.00	40.00	62.45	-1.100E-05	9.923E-03	-2.555E+00
770	59.00	45.00	62.64	-1.100E-05	9.923E-03	-2.555E+00
771	59.00	46.00	62.69	-1.100E-05	9.923E-03	-2.555E+00
772	59.50	45.00	62.66	-1.100E-05	9.923E-03	-2.555E+00
773	60.00	33.00	62.62	-1.100E-05	9.923E-03	-2.555E+00
774	60.00	0	62.59	-1.100E-05	9.923E-03	-2.555E+00
775	60.00	([a])	62.55	-1.027E-05	9.176E-03	-2.095E+00
776	60.00	([a])	62.51	-9.541E-06	8.429E-03	-1.636E+00
777	60.00	34.00	62.44	-8.813E-06	7.683E-03	-1.177E+00
778	60.00	50.00	62.37	-8.813E-06	7.683E-03	-1.177E+00
779	60.00	60.00	62.29	-8.813E-06	7.683E-03	-1.177E+00
780	60.00	69.00	62.21	-8.813E-06	7.683E-03	-1.177E+00
781	60.00	75.00	62.15	-8.813E-06	7.683E-03	-1.177E+00

782	60.00	79.00	62.46	-8.813E-06	7.683E-03	-1.177E+00
783	61.00	83.00	63.40	-8.813E-06	7.683E-03	-1.177E+00
784	61.00	84.00	63.97	-8.813E-06	7.683E-03	-1.177E+00
785	61.00	85.00	63.98	-8.813E-06	7.683E-03	-1.177E+00
786	62.00	85.00	63.94	-8.813E-06	7.683E-03	-1.177E+00
787	62.00	85.00	63.93	-8.813E-06	7.683E-03	-1.177E+00
788	62.00	85.00	63.92	-8.813E-06	7.683E-03	-1.177E+00
789	63.00	85.00	63.92	-8.813E-06	7.683E-03	-1.177E+00
790	63.00	85.00	63.91	-8.813E-06	7.683E-03	-1.177E+00
791	64.00	85.00	64.21	-8.813E-06	7.683E-03	-1.177E+00
792	64.00	85.00	64.61	-8.813E-06	7.683E-03	-1.177E+00
793	64.00	85.00	64.50	-8.813E-06	7.683E-03	-1.177E+00
794	64.00	85.00	64.05	-8.813E-06	7.683E-03	-1.177E+00
795	64.00	85.00	63.83	-8.813E-06	7.683E-03	-1.177E+00
796	64.00	84.50	63.81	-8.813E-06	7.683E-03	-1.177E+00
797	64.00	84.00	63.79	-8.813E-06	7.683E-03	-1.177E+00
798	64.00	83.00	63.77	-8.813E-06	7.683E-03	-1.177E+00
799	64.00	82.00	63.76	-8.813E-06	7.683E-03	-1.177E+00
800	64.00	81.00	63.75	-8.873E-06	7.725E-03	-1.104E+00
801	64.00	77.00	63.73	-8.933E-06	7.767E-03	-1.032E+00
802	64.00	72.00	63.72	-8.993E-06	7.810E-03	-9.592E-01
803	65.00	67.00	63.70	-8.993E-06	7.810E-03	-9.592E-01
804	66.00	64.00	63.69	-8.993E-06	7.810E-03	-9.592E-01
805	67.00	60.00	63.69	-8.993E-06	7.810E-03	-9.592E-01
806	69.00	62.30	63.68	-8.993E-06	7.810E-03	-9.592E-01
807	72.00	84.00	64.10	-8.993E-06	7.810E-03	-9.592E-01
808	73.00	90.50	64.60	-8.993E-06	7.810E-03	-9.592E-01
809	74.00	91.00	64.73	-8.993E-06	7.810E-03	-9.592E-01
810	74.00	90.00	64.73	-8.993E-06	7.810E-03	-9.592E-01
811	74.00	84.50	64.73	-8.993E-06	7.810E-03	-9.592E-01
812	73.00	74.00	64.72	-8.993E-06	7.810E-03	-9.592E-01
813	72.00	66.00	64.71	-8.993E-06	7.810E-03	-9.592E-01
814	71.00	60.00	64.71	-8.993E-06	7.810E-03	-9.592E-01
815	70.00	54.00	64.70	-8.993E-06	7.810E-03	-9.592E-01
816	69.00	50.00	64.69	-8.993E-06	7.810E-03	-9.592E-01
817	68.00	49.00	64.68	-8.993E-06	7.810E-03	-9.592E-01
818	68.00	48.00	64.82	-8.993E-06	7.810E-03	-9.592E-01
819	68.00	48.00	65.27	-8.993E-06	7.810E-03	-9.592E-01
820	68.00	48.50	65.65	-8.993E-06	7.810E-03	-9.592E-01
821	68.00	49.00	65.71	-8.993E-06	7.810E-03	-9.592E-01
822	68.00	51.00	65.72	-8.993E-06	7.810E-03	-9.592E-01
823	68.00	53.50	65.72	-8.993E-06	7.810E-03	-9.592E-01
824	68.00	55.00	65.72	-8.993E-06	7.810E-03	-9.592E-01

825	68.00	58.00	65.71	-8.993E-06	7.810E-03	-9.592E-01
826	68.00	60.00	65.70	-8.993E-06	7.810E-03	-9.592E-01
827	68.00	62.00	65.69	-8.993E-06	7.810E-03	-9.592E-01
828	68.00	64.00	65.67	-8.993E-06	7.810E-03	-9.592E-01
829	68.00	67.00	65.27	-8.993E-06	7.810E-03	-9.592E-01
830	69.00	68.50	64.33	-8.993E-06	7.810E-03	-9.592E-01
831	70.00	70.00	63.65	-8.993E-06	7.810E-03	-9.592E-01
832	70.00	70.00	63.50	-8.993E-06	7.810E-03	-9.592E-01
833	70.00	70.00	63.49	-8.993E-06	7.810E-03	-9.592E-01
834	70.00	70.00	63.49	-8.993E-06	7.810E-03	-9.592E-01
835	70.00	70.00	63.37	-8.993E-06	7.810E-03	-9.592E-01
836	70.00	70.00	63.01	-8.993E-06	7.810E-03	-9.592E-01
837	71.00	66.00	62.60	-8.993E-06	7.810E-03	-9.592E-01
838	73.00	64.00	62.44	-8.993E-06	7.810E-03	-9.592E-01
839	75.00	64.00	62.45	-8.993E-06	7.810E-03	-9.592E-01
840	77.00	98.00	62.47	-5.933E-06	4.759E-03	5.464E-01
841	79.00	100.00	62.50	-2.873E-06	1.709E-03	2.052E+00
842	81.00	100.00	62.52	1.865E-07	-1.342E-03	3.558E+00
843	82.00	100.00	62.54	1.865E-07	-1.342E-03	3.558E+00
844	83.00	100.00	62.57	1.865E-07	-1.342E-03	3.558E+00
845	84.00	98.00	62.70	1.865E-07	-1.342E-03	3.558E+00
846	84.00	94.00	62.90	1.865E-07	-1.342E-03	3.558E+00
847	85.00	93.00	63.11	1.865E-07	-1.342E-03	3.558E+00
848	86.00	94.00	63.32	1.865E-07	-1.342E-03	3.558E+00
849	87.00	98.00	63.53	1.865E-07	-1.342E-03	3.558E+00
850	89.00	100.00	63.74	1.865E-07	-1.342E-03	3.558E+00
851	92.00	100.00	62.20	1.865E-07	-1.342E-03	3.558E+00
852	95.00	100.00	62.67	1.865E-07	-1.342E-03	3.558E+00
853	97.50	100.00	63.19	1.865E-07	-1.342E-03	3.558E+00
854	100.00	100.00	63.62	1.865E-07	-1.342E-03	3.558E+00
855	100.00	100.00	64.06	1.865E-07	-1.342E-03	3.558E+00
856	100.00	100.00	64.19	6.218E-08	-4.474E-04	1.186E+00
857	100.00	100.00	63.87	-6.218E-08	4.474E-04	-1.186E+00
858	100.00	97.00	63.38	-1.865E-07	1.342E-03	-3.558E+00
859	96.00	([a])	62.62	-1.865E-07	1.342E-03	-3.558E+00
860	94.00	([a])	61.32	-1.865E-07	1.342E-03	-3.558E+00
861	91.00	([a])	59.72	-1.865E-07	1.342E-03	-3.558E+00
862	88.00	([a])	58.30	-1.865E-07	1.342E-03	-3.558E+00
863	86.00	([a])	57.08	-1.865E-07	1.342E-03	-3.558E+00
864	84.00	([a])	55.85	-1.865E-07	1.342E-03	-3.558E+00
865	82.00	([a])	54.61	-1.865E-07	1.342E-03	-3.558E+00
866	79.00	([a])	53.36	-1.865E-07	1.342E-03	-3.558E+00
867	77.00	([a])	52.10	-1.865E-07	1.342E-03	-3.558E+00

868	75.00	([a])	50.74	-1.865E-07	1.342E-03	-3.558E+00
869	73.00	([a])	49.34	-1.865E-07	1.342E-03	-3.558E+00
870	72.00	([a])	48.05	-1.865E-07	1.342E-03	-3.558E+00
871	72.00	([a])	46.82	-1.865E-07	1.342E-03	-3.558E+00
872	72.00	([a])	45.61	-1.865E-07	1.342E-03	-3.558E+00
873	71.00	8.00	44.37	-1.865E-07	1.342E-03	-3.558E+00
874	68.00	9.00	43.06	-1.865E-07	1.342E-03	-3.558E+00
875	64.00	([a])	41.65	-1.865E-07	1.342E-03	-3.558E+00
876	58.00	([a])	40.32	-1.865E-07	1.342E-03	-3.558E+00
877	56.00	53.00	39.28	-1.865E-07	1.342E-03	-3.558E+00
878	56.00	67.00	38.40	-1.865E-07	1.342E-03	-3.558E+00
879	56.00	70.00	37.30	-1.865E-07	1.342E-03	-3.558E+00
880	56.00	67.00	35.79	-1.865E-07	1.342E-03	-3.558E+00
881	55.00	60.00	34.14	-1.865E-07	1.342E-03	-3.558E+00
882	54.00	60.00	32.69	-1.865E-07	1.342E-03	-3.558E+00
883	49.00	75.00	31.38	-1.865E-07	1.342E-03	-3.558E+00
884	38.00	80.00	29.63	-1.865E-07	1.342E-03	-3.558E+00
885	30.00	78.00	27.22	-1.865E-07	1.342E-03	-3.558E+00
886	25.00	53.00	25.01	-1.865E-07	1.342E-03	-3.558E+00
887	18.00	32.00	23.09	-1.865E-07	1.342E-03	-3.558E+00
888	14.00	16.00	20.23	-1.865E-07	1.342E-03	-3.558E+00
889	9.00	3.00	17.20	-1.865E-07	1.342E-03	-3.558E+00
890	5.00	([a])	12.61	-1.865E-07	1.342E-03	-3.558E+00
891	1.00	([a])	7.43	-1.865E-07	1.342E-03	-3.558E+00
892	0	0	2.81	-1.865E-07	1.342E-03	-3.558E+00
893	0	0	0	-1.865E-07	1.342E-03	-3.558E+00
894	0	0	0	-1.865E-07	1.342E-03	-3.558E+00
895	0	0	0	-1.865E-07	1.342E-03	-3.558E+00
896	0	0	0	-1.865E-07	1.342E-03	-3.558E+00
987	0	0	0	-1.865E-07	1.342E-03	-3.558E+00
898	0	0	0	-1.865E-07	1.342E-03	-3.558E+00
899	0	0	0	-1.865E-07	1.342E-03	-3.558E+00
900	0	0	0	-1.865E-07	1.342E-03	-3.558E+00
901	0	0	0	8.801E-06	-7.855E-03	-7.493E-01
902	0	0	0	1.779E-05	-1.705E-02	2.059E+00
903	0	0	0	2.678E-05	-2.625E-02	4.867E+00
904	0	0	0	2.678E-05	-2.625E-02	4.867E+00
905	0	0	0	2.678E-05	-2.625E-02	4.867E+00
906	0	0	0	2.678E-05	-2.625E-02	4.867E+00
907	0	0	0	2.678E-05	-2.625E-02	4.867E+00
908	0	0	0	2.678E-05	-2.625E-02	4.867E+00
909	0	0	0	2.678E-05	-2.625E-02	4.867E+00
910	0	0	0	2.678E-05	-2.625E-02	4.867E+00

911	0	0	0	2.678E-05	-2.625E-02	4.867E+00
912	0	0	0	2.678E-05	-2.625E-02	4.867E+00
913	0	0	0	2.678E-05	-2.625E-02	4.867E+00
914	0	0	0	2.678E-05	-2.625E-02	4.867E+00
915	0	0	0	2.678E-05	-2.625E-02	4.867E+00
916	0	0	0	2.678E-05	-2.625E-02	4.867E+00
917	0	0	0	2.678E-05	-2.625E-02	4.867E+00
918	0	0	0	2.678E-05	-2.625E-02	4.867E+00
919	0	0	0	2.678E-05	-2.625E-02	4.867E+00
920	4.50	47.00	2.63	2.678E-05	-2.625E-02	4.867E+00
921	12.00	85.00	4.93	2.678E-05	-2.625E-02	4.867E+00
922	30.00	97.00	7.24	2.678E-05	-2.625E-02	4.867E+00
923	42.00	100.00	9.73	2.678E-05	-2.625E-02	4.867E+00
924	51.00	100.00	11.91	2.678E-05	-2.625E-02	4.867E+00
925	54.00	100.00	14.16	2.678E-05	-2.625E-02	4.867E+00
926	54.00	97.00	16.04	2.678E-05	-2.625E-02	4.867E+00
927	52.00	90.00	17.98	2.678E-05	-2.625E-02	4.867E+00
928	48.00	75.00	20.21	2.678E-05	-2.625E-02	4.867E+00
929	44.00	57.00	22.03	2.678E-05	-2.625E-02	4.867E+00
930	37.00	47.00	22.35	8.925E-06	-8.749E-03	1.622E+00
931	29.00	40.00	21.52	-8.925E-06	8.749E-03	-1.622E+00
932	24.00	34.00	20.04	-2.678E-05	2.625E-02	-4.867E+00
933	21.00	27.00	18.29	-2.678E-05	2.625E-02	-4.867E+00
934	22.00	24.00	16.40	-2.678E-05	2.625E-02	-4.867E+00
935	22.50	22.00	14.40	-2.678E-05	2.625E-02	-4.867E+00
936	20.00	16.00	12.23	-2.678E-05	2.625E-02	-4.867E+00
937	15.00	7.00	9.84	-2.678E-05	2.625E-02	-4.867E+00
938	10.00	0	8.55	-2.678E-05	2.625E-02	-4.867E+00
939	5.00	([a])	7.56	-2.678E-05	2.625E-02	-4.867E+00
940	2.00	([a])	6.14	-2.678E-05	2.625E-02	-4.867E+00
941	1.00	([a])	2.60	-2.678E-05	2.625E-02	-4.867E+00
942	0	0	0	-2.678E-05	2.625E-02	-4.867E+00
943	0	0	0	-2.678E-05	2.625E-02	-4.867E+00
944	0	0	0	-1.658E-05	1.607E-02	-3.386E+00
945	1.00	0	1.06	-6.376E-06	5.889E-03	-1.905E+00
946	5.00	20.00	2.16	3.823E-06	-4.291E-03	-4.241E-01
947	15.00	43.00	3.30	3.823E-06	-4.291E-03	-4.241E-01
948	28.00	52.00	4.37	3.823E-06	-4.291E-03	-4.241E-01
949	34.00	64.00	5.42	3.823E-06	-4.291E-03	-4.241E-01
950	37.00	74.00	6.47	3.823E-06	-4.291E-03	-4.241E-01
951	37.50	90.00	7.51	3.823E-06	-4.291E-03	-4.241E-01
952	37.00	56.00	8.55	3.823E-06	-4.291E-03	-4.241E-01
953	36.00	27.00	9.55	3.823E-06	-4.291E-03	-4.241E-01

954	35.00	([a])	10.25	3.823E-06	-4.291E-03	-4.241E-01
955	33.00	([a])	10.78	3.823E-06	-4.291E-03	-4.241E-01
956	29.00	([a])	11.16	3.823E-06	-4.291E-03	-4.241E-01
957	29.00	([a])	11.76	3.823E-06	-4.291E-03	-4.241E-01
958	29.00	([a])	12.59	3.823E-06	-4.291E-03	-4.241E-01
959	34.00	30.00	13.80	3.823E-06	-4.291E-03	-4.241E-01
960	38.00	75.00	14.85	3.823E-06	-4.291E-03	-4.241E-01
961	34.00	70.00	15.59	3.823E-06	-4.291E-03	-4.241E-01
962	31.00	25.00	16.20	3.823E-06	-4.291E-03	-4.241E-01
963	28.00	([a])	16.82	3.823E-06	-4.291E-03	-4.241E-01
964	26.00	([a])	17.55	3.823E-06	-4.291E-03	-4.241E-01
965	24.00	([a])	17.91	3.823E-06	-4.291E-03	-4.241E-01
966	23.00	4.00	18.08	3.823E-06	-4.291E-03	-4.241E-01
967	23.00	22.00	18.10	3.823E-06	-4.291E-03	-4.241E-01
968	24.00	30.00	18.31	3.823E-06	-4.291E-03	-4.241E-01
969	23.00	32.00	18.67	3.823E-06	-4.291E-03	-4.241E-01
970	22.00	25.00	19.23	7.198E-06	-7.629E-03	2.015E+00
971	18.00	18.00	19.69	1.057E-05	-1.097E-02	4.453E+00
972	16.00	14.00	20.02	1.395E-05	-1.430E-02	6.892E+00
973	15.00	10.00	19.94	1.395E-05	-1.430E-02	6.892E+00
974	15.00	0.0	19.80	1.395E-05	-1.430E-02	6.892E+00
975	15.00	([a])	19.69	1.395E-05	-1.430E-02	6.892E+00
976	15.00	([a])	19.76	1.395E-05	-1.430E-02	6.892E+00
977	18.00	([a])	19.93	1.395E-05	-1.430E-02	6.892E+00
978	25.00	40.00	20.24	1.395E-05	-1.430E-02	6.892E+00
979	37.00	90.00	20.69	1.395E-05	-1.430E-02	6.892E+00
980	46.00	90.00	21.23	1.395E-05	-1.430E-02	6.892E+00
981	49.00	90.00	21.78	1.395E-05	-1.430E-02	6.892E+00
982	49.00	90.00	22.15	1.395E-05	-1.430E-02	6.892E+00
983	49.00	85.00	22.33	1.395E-05	-1.430E-02	6.892E+00
984	47.00	77.00	22.36	1.395E-05	-1.430E-02	6.892E+00
985	44.00	59.00	22.36	4.650E-06	-4.768E-03	2.297E+00
986	43.00	36.00	22.33	-4.650E-06	4.768E-03	-2.297E+00
987	42.00	13.00	22.15	-1.395E-05	1.430E-02	-6.892E+00
988	40.00	([a])	21.91	-1.395E-05	1.430E-02	-6.892E+00
989	41.00	65.00	21.62	-1.395E-05	1.430E-02	-6.892E+00
990	44.00	65.00	21.32	-1.395E-05	1.430E-02	-6.892E+00
991	45.00	65.00	21.01	-1.395E-05	1.430E-02	-6.892E+00
992	45.00	62.00	20.70	-1.395E-05	1.430E-02	-6.892E+00
993	44.00	56.00	20.48	-1.395E-05	1.430E-02	-6.892E+00
994	42.00	46.00	20.31	-1.395E-05	1.430E-02	-6.892E+00
995	41.00	36.00	20.13	-1.395E-05	1.430E-02	-6.892E+00
996	39.00	20.00	19.86	-1.395E-05	1.430E-02	-6.892E+00

997	38.00	4.00	19.49	-1.395E-05	1.430E-02	-6.892E+00
998	37.00	33.00	19.11	-1.395E-05	1.430E-02	-6.892E+00
999	38.00	39.00	18.71	-1.395E-05	1.430E-02	-6.892E+00
1,000	36.00	40.00	18.30	-1.395E-05	1.430E-02	-6.892E+00
1,001	35.00	40.00	17.86	-1.395E-05	1.430E-02	-6.892E+00
1,002	33.00	39.00	17.39	-1.395E-05	1.430E-02	-6.892E+00
1,003	30.00	36.00	16.86	-1.395E-05	1.430E-02	-6.892E+00
1,004	27.00	33.00	16.31	-1.395E-05	1.430E-02	-6.892E+00
1,005	22.00	24.00	15.75	-1.395E-05	1.430E-02	-6.892E+00
1,006	21.00	([a])	15.24	-1.395E-05	1.430E-02	-6.892E+00
1,007	20.00	([a])	14.73	-1.395E-05	1.430E-02	-6.892E+00
1,008	18.00	([a])	14.23	-1.395E-05	1.430E-02	-6.892E+00
1,009	17.00	28.00	13.73	-1.395E-05	1.430E-02	-6.892E+00
1,010	16.00	5.00	12.79	-1.395E-05	1.430E-02	-6.892E+00
1,011	14.00	([a])	11.11	-1.395E-05	1.430E-02	-6.892E+00
1,012	12.00	([a])	9.43	-1.395E-05	1.430E-02	-6.892E+00
1,013	9.00	([a])	7.75	-1.395E-05	1.430E-02	-6.892E+00
1,014	7.00	([a])	6.07	-1.395E-05	1.430E-02	-6.892E+00
1,015	5.00	([a])	4.39	-4.650E-06	4.768E-03	-2.297E+00
1,016	4.00	([a])	2.71	4.650E-06	-4.768E-03	2.297E+00
1,017	3.00	([a])	1.03	1.395E-05	-1.430E-02	6.892E+00
1,018	2.00	([a])	0.19	1.395E-05	-1.430E-02	6.892E+00
1,019	0	0	0	1.395E-05	-1.430E-02	6.892E+00
1,020	0	0	0	1.395E-05	-1.430E-02	6.892E+00
1,021	0	0	0	1.458E-05	-1.532E-02	5.630E+00
1,022	0	0	0	1.520E-05	-1.634E-02	4.368E+00
1,023	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,024	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,025	2.00	7.00	3.25	1.583E-05	-1.736E-02	3.105E+00
1,026	6.00	15.00	5.47	1.583E-05	-1.736E-02	3.105E+00
1,027	10.00	28.00	6.71	1.583E-05	-1.736E-02	3.105E+00
1,028	11.00	26.00	6.71	1.583E-05	-1.736E-02	3.105E+00
1,029	10.00	10.00	6.71	5.277E-06	-5.787E-03	1.035E+00
1,030	8.00	3.00	6.55	-5.277E-06	5.787E-03	-1.035E+00
1,031	5.00	0	6.01	-1.583E-05	1.736E-02	-3.105E+00
1,032	2.00	0	5.15	-1.583E-05	1.736E-02	-3.105E+00
1,033	0	0	3.90	-1.583E-05	1.736E-02	-3.105E+00
1,034	0	0	2.19	-1.583E-05	1.736E-02	-3.105E+00
1,035	0	0	0	-5.277E-06	5.787E-03	-1.035E+00
1,036	0	0	0	5.277E-06	-5.787E-03	1.035E+00
1,037	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,038	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,039	0	0	0	1.583E-05	-1.736E-02	3.105E+00

1,040	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,041	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,042	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,043	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,044	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,045	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,046	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,047	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,048	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,049	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,050	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,051	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,052	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,053	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,054	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,055	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,056	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,057	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,058	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,059	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,060	0	0	0	1.583E-05	-1.736E-02	3.105E+00
1,061	4.00	5.00	1.95	1.583E-05	-1.736E-02	3.105E+00
1,062	11.00	35.00	3.70	1.583E-05	-1.736E-02	3.105E+00
1,063	21.00	73.00	5.53	1.583E-05	-1.736E-02	3.105E+00
1,064	25.00	86.00	7.22	1.583E-05	-1.736E-02	3.105E+00
1,065	26.00	90.00	8.64	1.583E-05	-1.736E-02	3.105E+00
1,066	25.00	90.00	10.33	1.583E-05	-1.736E-02	3.105E+00
1,067	23.00	83.00	11.18	5.277E-06	-5.787E-03	1.035E+00
1,068	20.00	32.00	10.57	-5.277E-06	5.787E-03	-1.035E+00
1,069	16.00	([a])	9.33	-1.583E-05	1.736E-02	-3.105E+00
1,070	14.00	([a])	7.87	-1.583E-05	1.736E-02	-3.105E+00
1,071	10.00	([a])	6.27	-1.583E-05	1.736E-02	-3.105E+00
1,072	7.00	([a])	4.58	-1.583E-05	1.736E-02	-3.105E+00
1,073	3.00	([a])	3.81	-1.583E-05	1.736E-02	-3.105E+00
1,074	1.00	([a])	2.35	-1.583E-05	1.736E-02	-3.105E+00
1,075	0	0	0	-1.583E-05	1.736E-02	-3.105E+00
1,076	0	0	0	-6.540E-06	7.597E-03	-2.563E+00
1,077	0	0	0	2.749E-06	-2.167E-03	-2.021E+00
1,078	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,079	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,080	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,081	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,082	0	0	0	1.204E-05	-1.193E-02	-1.480E+00

1,083	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,084	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,085	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,086	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,087	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,088	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,089	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,090	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,091	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,092	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,093	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,094	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,095	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,096	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,097	0	0	0	1.204E-05	-1.193E-02	-1.480E+00
1,098	1.00	3.00	1.35	1.204E-05	-1.193E-02	-1.480E+00
1,099	3.00	6.00	3.37	1.204E-05	-1.193E-02	-1.480E+00
1,100	6.00	13.00	6.40	1.204E-05	-1.193E-02	-1.480E+00
1,101	9.00	14.00	8.47	1.204E-05	-1.193E-02	-1.480E+00
1,102	12.00	16.00	9.57	1.204E-05	-1.193E-02	-1.480E+00
1,103	15.00	28.00	10.19	1.204E-05	-1.193E-02	-1.480E+00
1,104	18.00	60.00	10.35	1.204E-05	-1.193E-02	-1.480E+00
1,105	20.00	47.00	10.46	1.204E-05	-1.193E-02	-1.480E+00
1,106	21.00	31.00	10.11	1.204E-05	-1.193E-02	-1.480E+00
1,107	21.00	15.00	9.12	1.204E-05	-1.193E-02	-1.480E+00
1,108	20.00	([a])	7.81	1.133E-05	-1.140E-02	1.667E-01
1,109	20.00	([a])	7.87	1.062E-05	-1.087E-02	1.813E+00
1,110	20.00	([a])	9.57	9.917E-06	-1.035E-02	3.459E+00
1,111	20.00	70.00	9.75	9.917E-06	-1.035E-02	3.459E+00
1,112	21.00	83.00	9.84	9.917E-06	-1.035E-02	3.459E+00
1,113	22.00	84.00	9.96	9.917E-06	-1.035E-02	3.459E+00
1,114	22.00	83.00	10.13	3.306E-06	-3.449E-03	1.153E+00
1,115	18.00	78.00	9.36	-3.306E-06	3.449E-03	-1.153E+00
1,116	14.00	68.00	8.80	-9.917E-06	1.035E-02	-3.459E+00
1,117	8.00	10.00	7.67	-9.917E-06	1.035E-02	-3.459E+00
1,118	4.00	4.00	6.08	-9.917E-06	1.035E-02	-3.459E+00
1,119	1.00	0.0	4.03	-9.917E-06	1.035E-02	-3.459E+00
1,120	0	0	0	-3.306E-06	3.449E-03	-1.153E+00
1,121	0	0	0	3.306E-06	-3.449E-03	1.153E+00
1,122	0	0	0	9.917E-06	-1.035E-02	3.459E+00
1,123	0	0	0	9.917E-06	-1.035E-02	3.459E+00
1,124	0	0	0	9.917E-06	-1.035E-02	3.459E+00
1,125	0	1.00	0	9.917E-06	-1.035E-02	3.459E+00

1,126	1.00	5.00	3.25	9.917E-06	-1.035E-02	3.459E+00
1,127	5.00	18.00	5.47	9.917E-06	-1.035E-02	3.459E+00
1,128	9.00	19.00	6.71	9.917E-06	-1.035E-02	3.459E+00
1,129	12.00	18.00	6.71	9.917E-06	-1.035E-02	3.459E+00
1,130	12.00	15.00	6.71	9.917E-06	-1.035E-02	3.459E+00
1,131	9.00	10.00	6.55	9.917E-06	-1.035E-02	3.459E+00
1,132	5.00	5.00	6.01	9.917E-06	-1.035E-02	3.459E+00
1,133	2.00	2.00	5.15	9.917E-06	-1.035E-02	3.459E+00
1,134	0	0	3.90	9.917E-06	-1.035E-02	3.459E+00
1,135	0	0	2.19	9.917E-06	-1.035E-02	3.459E+00
1,136	0	0	0	6.611E-06	-6.897E-03	2.306E+00
1,137	0	0	0	3.306E-06	-3.449E-03	1.153E+00
1,138	0	0	0	0	0	0
1,139	0	0	0	0	0	0
1,140	0	0	0	0	0	0
1,141	0	0	0	0	0	0
1,142	0	0	0	0	0	0
1,143	0	0	0	0	0	0
1,144	0	0	0	0	0	0
1,145	0	0	0	0	0	0
1,146	0	0	0	0	0	0
1,147	0	0	0	0	0	0
1,148	0	0	0	0	0	0
1,149	0	0	0	0	0	0
1,150	0	0	0	0	0	0
1,151	0	0	0	0	0	0
1,152	0	0	0	0	0	0
1,153	0	0	0	0	0	0
1,154	0	0	0	0	0	0
1,155	0	0	0	0	0	0
1,156	0	0	0	0	0	0
1,157	0	0	0	0	0	0
1,158	0	0	0	0	0	0
1,159	0	0	0	0	0	0
1,160	0	0	0	0	0	0
1,161	0	0	0	0	0	0
1,162	0	0	0	0	0	0
1,163	0	0	0	0	0	0
1,164	0	0	0	0	0	0
1,165	0	0	0	0	0	0
1,166	0	0	0	0	0	0
1,167	0	0	0	0	0	0

[a]Closed throttle motoring.

(c) The following transient duty cycle applies for compression-ignition engines and powertrains:

Record (seconds)	Engine testing		Powertrain testing			
	Normalized revolutions per minute (percent)	Normalized torque (percent)	Vehicle speed (mi/hr)	Road grade coefficients		
				a	*b*	*c*
1	0	0	0	0	0	0
2	0	0	0	1.248E-05	-1.073E-02	1.064E+00
3	0	0	0	1.872E-05	-1.609E-02	1.596E+00
4	0	0	0	1.872E-05	-1.609E-02	1.596E+00
5	0	0	0	1.872E-05	-1.609E-02	1.596E+00
6	0	0	0	1.872E-05	-1.609E-02	1.596E+00
7	0	0	0	1.872E-05	-1.609E-02	1.596E+00
8	0	0	0	1.872E-05	-1.609E-02	1.596E+00
9	0	0	0	1.872E-05	-1.609E-02	1.596E+00
10	0	0	0	1.872E-05	-1.609E-02	1.596E+00
11	0	0	0	1.872E-05	-1.609E-02	1.596E+00
12	0	0	0	1.872E-05	-1.609E-02	1.596E+00
13	0	0	0	1.872E-05	-1.609E-02	1.596E+00
14	0	0	0	1.872E-05	-1.609E-02	1.596E+00
15	0	0	0	1.872E-05	-1.609E-02	1.596E+00
16	0	0	0	1.872E-05	-1.609E-02	1.596E+00
17	0	0	0	1.872E-05	-1.609E-02	1.596E+00
18	0	0	0	1.872E-05	-1.609E-02	1.596E+00
19	0	0	0	1.872E-05	-1.609E-02	1.596E+00
20	0	0	0	1.872E-05	-1.609E-02	1.596E+00
21	0	0	0	1.872E-05	-1.609E-02	1.596E+00
22	0	0	0	1.872E-05	-1.609E-02	1.596E+00
23	0	0	0	1.872E-05	-1.609E-02	1.596E+00
24	0	0	0	1.872E-05	-1.609E-02	1.596E+00
25	0	3.67	0	1.872E-05	-1.609E-02	1.596E+00
26	0	47.69	0	1.872E-05	-1.609E-02	1.596E+00
27	2.78	59.41	0.33	1.872E-05	-1.609E-02	1.596E+00
28	8.12	84.54	1.67	1.872E-05	-1.609E-02	1.596E+00
29	13.95	80.00	2.83	1.872E-05	-1.609E-02	1.596E+00
30	29.90	80.00	4.02	1.872E-05	-1.609E-02	1.596E+00
31	33.87	79.29	5.64	1.872E-05	-1.609E-02	1.596E+00
32	27.86	38.25	7.39	1.872E-05	-1.609E-02	1.596E+00
33	19.63	26.67	8.83	1.872E-05	-1.609E-02	1.596E+00
34	26.79	15.10	9.15	1.872E-05	-1.609E-02	1.596E+00
35	19.85	16.47	9.70	1.872E-05	-1.609E-02	1.596E+00
36	17.51	28.05	11.37	1.872E-05	-1.609E-02	1.596E+00
37	17.86	20.38	13.04	1.872E-05	-1.609E-02	1.596E+00

38	16.37	([a])	14.74	1.872E-05	-1.609E-02	1.596E+00
39	5.85	([a])	16.41	2.033E-05	-1.775E-02	3.890E+00
40	14.13	([a])	16.85	2.194E-05	-1.941E-02	6.184E+00
41	21.10	([a])	16.09	2.356E-05	-2.107E-02	8.477E+00
42	15.63	([a])	15.23	2.356E-05	-2.107E-02	8.477E+00
43	12.67	62.52	14.22	2.356E-05	-2.107E-02	8.477E+00
44	14.86	69.36	13.02	2.356E-05	-2.107E-02	8.477E+00
45	24.79	60.00	12.47	2.356E-05	-2.107E-02	8.477E+00
46	33.06	63.79	13.05	2.356E-05	-2.107E-02	8.477E+00
47	42.29	75.36	14.26	2.356E-05	-2.107E-02	8.477E+00
48	48.90	80.00	15.09	2.356E-05	-2.107E-02	8.477E+00
49	51.52	80.00	15.42	2.356E-05	-2.107E-02	8.477E+00
50	48.24	79.92	15.96	2.356E-05	-2.107E-02	8.477E+00
51	51.79	65.03	16.58	2.356E-05	-2.107E-02	8.477E+00
52	52.37	43.23	17.61	2.356E-05	-2.107E-02	8.477E+00
53	56.14	50.00	18.33	2.356E-05	-2.107E-02	8.477E+00
54	62.35	50.00	18.65	2.356E-05	-2.107E-02	8.477E+00
55	64.29	42.05	19.67	2.356E-05	-2.107E-02	8.477E+00
56	67.69	40.00	20.47	2.356E-05	-2.107E-02	8.477E+00
57	75.20	42.20	20.57	2.356E-05	-2.107E-02	8.477E+00
58	74.88	41.28	20.68	2.356E-05	-2.107E-02	8.477E+00
59	71.92	([a])	21.56	2.356E-05	-2.107E-02	8.477E+00
60	71.88	([a])	23.19	2.356E-05	-2.107E-02	8.477E+00
61	69.64	([a])	23.64	7.852E-06	-7.024E-03	2.826E+00
62	71.24	([a])	22.75	-7.852E-06	7.024E-03	-2.826E+00
63	71.72	30.54	21.81	-2.356E-05	2.107E-02	-8.477E+00
64	76.41	42.12	20.79	-2.356E-05	2.107E-02	-8.477E+00
65	73.02	50.00	19.86	-2.356E-05	2.107E-02	-8.477E+00
66	69.64	50.00	19.18	-2.356E-05	2.107E-02	-8.477E+00
67	72.09	43.16	18.75	-2.356E-05	2.107E-02	-8.477E+00
68	82.23	73.65	18.43	-2.356E-05	2.107E-02	-8.477E+00
69	78.58	([a])	18.61	-2.356E-05	2.107E-02	-8.477E+00
70	75.00	([a])	19.11	-2.356E-05	2.107E-02	-8.477E+00
71	75.00	([a])	18.76	-2.356E-05	2.107E-02	-8.477E+00
72	72.47	([a])	17.68	-2.356E-05	2.107E-02	-8.477E+00
73	62.91	([a])	16.46	-2.356E-05	2.107E-02	-8.477E+00
74	58.93	13.57	15.06	-2.356E-05	2.107E-02	-8.477E+00
75	55.56	29.43	13.41	-2.356E-05	2.107E-02	-8.477E+00
76	57.14	20.00	11.91	-2.356E-05	2.107E-02	-8.477E+00
77	56.68	17.42	11.09	-2.356E-05	2.107E-02	-8.477E+00
78	53.88	10.00	10.90	-2.356E-05	2.107E-02	-8.477E+00
79	50.76	10.00	11.40	-2.356E-05	2.107E-02	-8.477E+00
80	50.00	([a])	12.38	-2.356E-05	2.107E-02	-8.477E+00

81	46.83	([a])	13.02	-2.356E-05	2.107E-02	-8.477E+00
82	35.63	10.00	12.30	-2.356E-05	2.107E-02	-8.477E+00
83	32.48	10.00	10.32	-2.356E-05	2.107E-02	-8.477E+00
84	26.79	10.00	9.70	-2.356E-05	2.107E-02	-8.477E+00
85	24.94	10.00	11.05	-2.356E-05	2.107E-02	-8.477E+00
86	23.21	16.74	11.88	-2.356E-05	2.107E-02	-8.477E+00
87	24.70	3.36	12.21	-2.356E-05	2.107E-02	-8.477E+00
88	25.00	([a])	13.29	-2.356E-05	2.107E-02	-8.477E+00
89	24.47	([a])	13.73	-2.356E-05	2.107E-02	-8.477E+00
90	18.71	([a])	12.77	-2.356E-05	2.107E-02	-8.477E+00
91	10.85	([a])	11.46	-2.356E-05	2.107E-02	-8.477E+00
92	3.40	([a])	9.84	-2.356E-05	2.107E-02	-8.477E+00
93	0	0	7.62	-2.356E-05	2.107E-02	-8.477E+00
94	0	0	3.57	-2.356E-05	2.107E-02	-8.477E+00
95	0	0.91	1.33	-2.356E-05	2.107E-02	-8.477E+00
96	0	7.52	0	-2.356E-05	2.107E-02	-8.477E+00
97	0	0	0	-2.356E-05	2.107E-02	-8.477E+00
98	0	0	0	-2.356E-05	2.107E-02	-8.477E+00
99	0	0	0	-2.356E-05	2.107E-02	-8.477E+00
100	0	0	0	-9.275E-06	8.450E-03	-4.643E+00
101	0	0	0	5.004E-06	-4.171E-03	-8.092E-01
102	0	0	0	1.928E-05	-1.679E-02	3.025E+00
103	0	0	0	1.928E-05	-1.679E-02	3.025E+00
104	0	0	0	1.928E-05	-1.679E-02	3.025E+00
105	0	0	0	1.928E-05	-1.679E-02	3.025E+00
106	0	0	0	1.928E-05	-1.679E-02	3.025E+00
107	0	0	0	1.928E-05	-1.679E-02	3.025E+00
108	0	0	0	1.928E-05	-1.679E-02	3.025E+00
109	0	0	0	1.928E-05	-1.679E-02	3.025E+00
110	0	0	0	1.928E-05	-1.679E-02	3.025E+00
111	0	0	0	1.928E-05	-1.679E-02	3.025E+00
112	0	0	0	1.928E-05	-1.679E-02	3.025E+00
113	0	0	0	1.928E-05	-1.679E-02	3.025E+00
114	0	0	0	1.928E-05	-1.679E-02	3.025E+00
115	0	0	0	1.928E-05	-1.679E-02	3.025E+00
116	0	0	0	1.928E-05	-1.679E-02	3.025E+00
117	0	0	0	1.928E-05	-1.679E-02	3.025E+00
118	0	0	0	1.928E-05	-1.679E-02	3.025E+00
119	0	0	0	1.928E-05	-1.679E-02	3.025E+00
120	0	0	0	1.928E-05	-1.679E-02	3.025E+00
121	0	0	0	1.928E-05	-1.679E-02	3.025E+00
122	0	0	0	1.928E-05	-1.679E-02	3.025E+00
123	0	0	0	1.928E-05	-1.679E-02	3.025E+00

124	0	0	0	1.928E-05	-1.679E-02	3.025E+00
125	0	0	0	1.928E-05	-1.679E-02	3.025E+00
126	0	0	0	1.928E-05	-1.679E-02	3.025E+00
127	0	0	0	1.928E-05	-1.679E-02	3.025E+00
128	0	0	0	1.928E-05	-1.679E-02	3.025E+00
129	1.58	([a])	0	1.928E-05	-1.679E-02	3.025E+00
130	1.43	([a])	0	1.928E-05	-1.679E-02	3.025E+00
131	0	0	0	1.928E-05	-1.679E-02	3.025E+00
132	0	0	0	1.928E-05	-1.679E-02	3.025E+00
133	1.91	9.28	0	1.928E-05	-1.679E-02	3.025E+00
134	2.75	0	0	1.928E-05	-1.679E-02	3.025E+00
135	0	0	0	1.928E-05	-1.679E-02	3.025E+00
136	0	0	0	1.928E-05	-1.679E-02	3.025E+00
137	0	0	0	1.928E-05	-1.679E-02	3.025E+00
138	0	0	0	1.928E-05	-1.679E-02	3.025E+00
139	0	0	0	1.928E-05	-1.679E-02	3.025E+00
140	0	0	0	1.928E-05	-1.679E-02	3.025E+00
141	0	0	0	1.928E-05	-1.679E-02	3.025E+00
142	0	0	0	1.928E-05	-1.679E-02	3.025E+00
143	0	0	0	1.928E-05	-1.679E-02	3.025E+00
144	0	0	0	1.928E-05	-1.679E-02	3.025E+00
145	0	0	0	1.928E-05	-1.679E-02	3.025E+00
146	0	0	0	1.928E-05	-1.679E-02	3.025E+00
147	0	5.51	0	1.928E-05	-1.679E-02	3.025E+00
148	0	11.34	0	1.928E-05	-1.679E-02	3.025E+00
149	0	0	0	1.928E-05	-1.679E-02	3.025E+00
150	0	0	0	1.928E-05	-1.679E-02	3.025E+00
151	0	0	0	1.928E-05	-1.679E-02	3.025E+00
152	0	0	0	1.928E-05	-1.679E-02	3.025E+00
153	0	0	0	1.928E-05	-1.679E-02	3.025E+00
154	0	0	0	1.928E-05	-1.679E-02	3.025E+00
155	0	0	0	1.928E-05	-1.679E-02	3.025E+00
156	0	0	0	1.928E-05	-1.679E-02	3.025E+00
157	0	0	0	1.928E-05	-1.679E-02	3.025E+00
158	0	0.21	0	1.928E-05	-1.679E-02	3.025E+00
159	0	30.00	0	1.928E-05	-1.679E-02	3.025E+00
160	0	26.78	0	1.928E-05	-1.679E-02	3.025E+00
161	0	20.00	0	1.928E-05	-1.679E-02	3.025E+00
162	0	20.00	0	1.928E-05	-1.679E-02	3.025E+00
163	0	4.12	0	1.928E-05	-1.679E-02	3.025E+00
164	0	0	0	1.928E-05	-1.679E-02	3.025E+00
165	0	0	0	1.928E-05	-1.679E-02	3.025E+00
166	0	0	0	1.928E-05	-1.679E-02	3.025E+00

167	0	0	0	1.928E-05	-1.679E-02	3.025E+00
168	0	0	0	1.928E-05	-1.679E-02	3.025E+00
169	0	0	0	1.928E-05	-1.679E-02	3.025E+00
170	0	0	0	1.928E-05	-1.679E-02	3.025E+00
171	0	0	0	1.928E-05	-1.679E-02	3.025E+00
172	0	0	0	1.928E-05	-1.679E-02	3.025E+00
173	0	0	0	1.928E-05	-1.679E-02	3.025E+00
174	0	0	0	1.928E-05	-1.679E-02	3.025E+00
175	0	0	0	1.928E-05	-1.679E-02	3.025E+00
176	0	0	0	1.928E-05	-1.679E-02	3.025E+00
177	0	0	0	1.928E-05	-1.679E-02	3.025E+00
178	0	0	0	1.928E-05	-1.679E-02	3.025E+00
179	0	0	0	1.928E-05	-1.679E-02	3.025E+00
180	0	0	0	1.928E-05	-1.679E-02	3.025E+00
181	0	0	0	1.928E-05	-1.679E-02	3.025E+00
182	0	0	0	1.928E-05	-1.679E-02	3.025E+00
183	0	0	0	1.928E-05	-1.679E-02	3.025E+00
184	0	20.00	0	1.928E-05	-1.679E-02	3.025E+00
185	0	20.00	0	1.928E-05	-1.679E-02	3.025E+00
186	0	11.73	0	1.928E-05	-1.679E-02	3.025E+00
187	0	0	0	1.928E-05	-1.679E-02	3.025E+00
188	0	0	0	1.928E-05	-1.679E-02	3.025E+00
189	0	0	0	1.928E-05	-1.679E-02	3.025E+00
190	0	0	0	1.928E-05	-1.679E-02	3.025E+00
191	0	0	0	1.928E-05	-1.679E-02	3.025E+00
192	0	0	0	1.928E-05	-1.679E-02	3.025E+00
193	0	0	0	1.928E-05	-1.679E-02	3.025E+00
194	0	0	0	1.928E-05	-1.679E-02	3.025E+00
195	0	0	0	1.928E-05	-1.679E-02	3.025E+00
196	0	0	0	1.928E-05	-1.679E-02	3.025E+00
197	0	0	0	1.928E-05	-1.679E-02	3.025E+00
198	0	0	0	1.928E-05	-1.679E-02	3.025E+00
199	0	0	0	1.928E-05	-1.679E-02	3.025E+00
200	0	0	0	1.928E-05	-1.679E-02	3.025E+00
201	0	0	0	1.928E-05	-1.679E-02	3.025E+00
202	0	0	0	1.928E-05	-1.679E-02	3.025E+00
203	0	0	0	1.928E-05	-1.679E-02	3.025E+00
204	0	0	0	1.928E-05	-1.679E-02	3.025E+00
205	0	0	0	1.928E-05	-1.679E-02	3.025E+00
206	0	0	0	1.928E-05	-1.679E-02	3.025E+00
207	0	0	0	1.928E-05	-1.679E-02	3.025E+00
208	0	0	0	1.928E-05	-1.679E-02	3.025E+00
209	0	0	0	1.928E-05	-1.679E-02	3.025E+00

210	0	0	0	1.928E-05	-1.679E-02	3.025E+00
211	0	0	0	1.928E-05	-1.679E-02	3.025E+00
212	0	0	0	1.928E-05	-1.679E-02	3.025E+00
213	0	0	0	1.928E-05	-1.679E-02	3.025E+00
214	0	73.41	0	1.928E-05	-1.679E-02	3.025E+00
215	0	90.00	0	1.928E-05	-1.679E-02	3.025E+00
216	27.95	81.30	0	1.928E-05	-1.679E-02	3.025E+00
217	36.74	90.00	2.80	1.928E-05	-1.679E-02	3.025E+00
218	39.29	90.00	5.59	1.928E-05	-1.679E-02	3.025E+00
219	41.44	90.00	8.39	1.928E-05	-1.679E-02	3.025E+00
220	45.57	82.41	11.19	1.928E-05	-1.679E-02	3.025E+00
221	59.52	80.00	14.30	1.928E-05	-1.679E-02	3.025E+00
222	66.99	90.00	16.03	1.928E-05	-1.679E-02	3.025E+00
223	80.22	90.00	17.30	1.928E-05	-1.679E-02	3.025E+00
224	86.41	93.88	19.72	1.928E-05	-1.679E-02	3.025E+00
225	86.53	50.94	23.18	1.928E-05	-1.679E-02	3.025E+00
226	84.46	17.02	25.27	1.928E-05	-1.679E-02	3.025E+00
227	88.54	28.60	26.91	1.928E-05	-1.679E-02	3.025E+00
228	89.29	39.83	28.89	1.928E-05	-1.679E-02	3.025E+00
229	89.29	30.00	29.43	1.928E-05	-1.679E-02	3.025E+00
230	89.29	26.69	29.50	1.928E-05	-1.679E-02	3.025E+00
231	90.16	20.00	30.49	1.928E-05	-1.679E-02	3.025E+00
232	89.92	20.00	32.02	1.928E-05	-1.679E-02	3.025E+00
233	89.29	36.06	32.91	1.928E-05	-1.679E-02	3.025E+00
234	85.86	40.00	32.55	1.928E-05	-1.679E-02	3.025E+00
235	85.51	30.00	32.26	1.928E-05	-1.679E-02	3.025E+00
236	84.42	32.75	32.65	1.928E-05	-1.679E-02	3.025E+00
237	86.48	35.68	33.50	1.928E-05	-1.679E-02	3.025E+00
238	88.55	30.00	34.96	1.928E-05	-1.679E-02	3.025E+00
239	89.29	44.93	36.44	1.928E-05	-1.679E-02	3.025E+00
240	90.90	50.00	36.95	6.428E-06	-5.597E-03	1.008E+00
241	77.27	([a])	37.02	-6.428E-06	5.597E-03	-1.008E+00
242	56.75	([a])	36.97	-1.928E-05	1.679E-02	-3.025E+00
243	50.00	([a])	36.37	-1.928E-05	1.679E-02	-3.025E+00
244	41.07	([a])	35.56	-1.928E-05	1.679E-02	-3.025E+00
245	37.38	45.18	34.72	-1.928E-05	1.679E-02	-3.025E+00
246	34.21	78.47	33.84	-1.928E-05	1.679E-02	-3.025E+00
247	32.13	80.00	33.40	-1.928E-05	1.679E-02	-3.025E+00
248	27.71	80.00	32.93	-1.928E-05	1.679E-02	-3.025E+00
249	22.64	80.00	31.98	-1.928E-05	1.679E-02	-3.025E+00
250	20.58	60.97	30.98	-1.928E-05	1.679E-02	-3.025E+00
251	16.25	27.34	29.91	-1.928E-05	1.679E-02	-3.025E+00
252	11.46	43.71	28.73	-1.928E-05	1.679E-02	-3.025E+00

253	9.02	68.95	27.34	-1.928E-05	1.679E-02	-3.025E+00
254	3.38	68.95	25.85	-1.928E-05	1.679E-02	-3.025E+00
255	1.32	44.28	24.49	-1.928E-05	1.679E-02	-3.025E+00
256	0	0	23.19	-1.928E-05	1.679E-02	-3.025E+00
257	0	0	21.87	-1.928E-05	1.679E-02	-3.025E+00
258	0	0	17.39	-1.928E-05	1.679E-02	-3.025E+00
259	0	0	12.92	-1.928E-05	1.679E-02	-3.025E+00
260	0	0	8.45	-1.928E-05	1.679E-02	-3.025E+00
261	0	0	3.97	-1.928E-05	1.679E-02	-3.025E+00
262	0	0	0	-1.928E-05	1.679E-02	-3.025E+00
263	0	24.97	0	-1.928E-05	1.679E-02	-3.025E+00
264	0	17.16	0	-1.928E-05	1.679E-02	-3.025E+00
265	0	6.20	0	-6.926E-06	5.240E-03	8.504E-01
266	0	10.00	0	5.431E-06	-6.313E-03	4.726E+00
267	0	10.00	0	1.779E-05	-1.787E-02	8.601E+00
268	0	0	0	1.779E-05	-1.787E-02	8.601E+00
269	0	0	0	1.779E-05	-1.787E-02	8.601E+00
270	0	0	0	1.779E-05	-1.787E-02	8.601E+00
271	0	0	0	1.779E-05	-1.787E-02	8.601E+00
272	0	0	0	1.779E-05	-1.787E-02	8.601E+00
273	0	0	0	1.779E-05	-1.787E-02	8.601E+00
274	0	0	0	1.779E-05	-1.787E-02	8.601E+00
275	0	0	0	1.779E-05	-1.787E-02	8.601E+00
276	0	0	0	1.779E-05	-1.787E-02	8.601E+00
277	0	0	0	1.779E-05	-1.787E-02	8.601E+00
278	0	0	0	1.779E-05	-1.787E-02	8.601E+00
279	0	0	0	1.779E-05	-1.787E-02	8.601E+00
280	0	0	0	1.779E-05	-1.787E-02	8.601E+00
281	0	0	0	1.779E-05	-1.787E-02	8.601E+00
282	0	0	0	1.779E-05	-1.787E-02	8.601E+00
283	0	0	0	1.779E-05	-1.787E-02	8.601E+00
284	0	0	0	1.779E-05	-1.787E-02	8.601E+00
285	0	0	0	1.779E-05	-1.787E-02	8.601E+00
286	0	0	0	1.779E-05	-1.787E-02	8.601E+00
287	0	0	0	1.779E-05	-1.787E-02	8.601E+00
288	0	0	0	1.779E-05	-1.787E-02	8.601E+00
289	0	0	0	1.779E-05	-1.787E-02	8.601E+00
290	0	0	0	1.779E-05	-1.787E-02	8.601E+00
291	0	0	0	1.779E-05	-1.787E-02	8.601E+00
292	0	0	0	1.779E-05	-1.787E-02	8.601E+00
293	0	0	0	1.779E-05	-1.787E-02	8.601E+00
294	0	0	0	1.779E-05	-1.787E-02	8.601E+00
295	0	0	0	1.779E-05	-1.787E-02	8.601E+00

296	0	0	0	1.779E-05	-1.787E-02	8.601E+00
297	0	0	0	1.779E-05	-1.787E-02	8.601E+00
298	0	0	0	1.779E-05	-1.787E-02	8.601E+00
299	0	0	0	1.779E-05	-1.787E-02	8.601E+00
300	0	0	0	1.779E-05	-1.787E-02	8.601E+00
301	0	0	0	1.779E-05	-1.787E-02	8.601E+00
302	0	0	0	1.779E-05	-1.787E-02	8.601E+00
303	0	0	0	1.779E-05	-1.787E-02	8.601E+00
304	0	0	0	1.779E-05	-1.787E-02	8.601E+00
305	0	0	0	1.779E-05	-1.787E-02	8.601E+00
306	0	0	0	1.779E-05	-1.787E-02	8.601E+00
307	0	0	0	1.779E-05	-1.787E-02	8.601E+00
308	0	0	0	1.779E-05	-1.787E-02	8.601E+00
309	0	0	0	1.779E-05	-1.787E-02	8.601E+00
310	0	0	0	1.779E-05	-1.787E-02	8.601E+00
311	0	0	0	1.779E-05	-1.787E-02	8.601E+00
312	0	0	0	1.779E-05	-1.787E-02	8.601E+00
313	0	0	0	1.779E-05	-1.787E-02	8.601E+00
314	0	0	0	1.779E-05	-1.787E-02	8.601E+00
315	0	0	0	1.779E-05	-1.787E-02	8.601E+00
316	0	0	0	1.779E-05	-1.787E-02	8.601E+00
317	0	0	0	1.779E-05	-1.787E-02	8.601E+00
318	0	0	0	1.779E-05	-1.787E-02	8.601E+00
319	0	0	0	1.779E-05	-1.787E-02	8.601E+00
320	0	0	0	1.779E-05	-1.787E-02	8.601E+00
321	0	15.55	0	1.779E-05	-1.787E-02	8.601E+00
322	0	20.00	0	1.779E-05	-1.787E-02	8.601E+00
323	21.59	19.08	1.20	1.779E-05	-1.787E-02	8.601E+00
324	20.54	10.00	2.18	1.779E-05	-1.787E-02	8.601E+00
325	10.32	1.86	2.88	1.779E-05	-1.787E-02	8.601E+00
326	6.13	([a])	3.00	1.779E-05	-1.787E-02	8.601E+00
327	5.36	([a])	2.28	1.779E-05	-1.787E-02	8.601E+00
328	0.64	([a])	0	1.779E-05	-1.787E-02	8.601E+00
329	0	0	0	1.779E-05	-1.787E-02	8.601E+00
330	0	0	0	1.779E-05	-1.787E-02	8.601E+00
331	0	0	0	1.779E-05	-1.787E-02	8.601E+00
332	0	0	0	1.779E-05	-1.787E-02	8.601E+00
333	0	0	0	1.779E-05	-1.787E-02	8.601E+00
334	0	0	0	1.779E-05	-1.787E-02	8.601E+00
335	0	0	0	1.779E-05	-1.787E-02	8.601E+00
336	0	0	0	1.779E-05	-1.787E-02	8.601E+00
337	0	0	0	1.779E-05	-1.787E-02	8.601E+00
338	0	0	0	1.779E-05	-1.787E-02	8.601E+00

339	0	0	0	1.779E-05	-1.787E-02	8.601E+00
340	0	0	0	1.779E-05	-1.787E-02	8.601E+00
341	0	0	0	1.779E-05	-1.787E-02	8.601E+00
342	0	0	0	1.779E-05	-1.787E-02	8.601E+00
343	0	0	0	1.779E-05	-1.787E-02	8.601E+00
344	0	0	0	1.779E-05	-1.787E-02	8.601E+00
345	0	0	0	1.779E-05	-1.787E-02	8.601E+00
346	0	0	0	1.779E-05	-1.787E-02	8.601E+00
347	0	0	0	1.779E-05	-1.787E-02	8.601E+00
348	0	0	0	1.779E-05	-1.787E-02	8.601E+00
349	0	0	0	1.779E-05	-1.787E-02	8.601E+00
350	0	0	0	1.779E-05	-1.787E-02	8.601E+00
351	0	0	0	1.779E-05	-1.787E-02	8.601E+00
352	0	0	0	1.779E-05	-1.787E-02	8.601E+00
353	0	0	0	1.779E-05	-1.787E-02	8.601E+00
354	0	0	0	1.779E-05	-1.787E-02	8.601E+00
355	0	0	0	1.779E-05	-1.787E-02	8.601E+00
356	0	0	0	1.779E-05	-1.787E-02	8.601E+00
357	0	0	0	1.779E-05	-1.787E-02	8.601E+00
358	0	0	0	1.779E-05	-1.787E-02	8.601E+00
359	0	0	0	1.779E-05	-1.787E-02	8.601E+00
360	0	0	0	1.779E-05	-1.787E-02	8.601E+00
361	0	0	0	1.779E-05	-1.787E-02	8.601E+00
362	0	0	0	1.779E-05	-1.787E-02	8.601E+00
363	0	0	0	1.779E-05	-1.787E-02	8.601E+00
364	0	0	0	1.779E-05	-1.787E-02	8.601E+00
365	0	0	0	1.779E-05	-1.787E-02	8.601E+00
366	0	0	0	1.779E-05	-1.787E-02	8.601E+00
367	0	0	0	1.779E-05	-1.787E-02	8.601E+00
368	0	0	0	1.779E-05	-1.787E-02	8.601E+00
369	0	0	0	1.779E-05	-1.787E-02	8.601E+00
370	0	0	0	1.779E-05	-1.787E-02	8.601E+00
371	0	0	0	1.779E-05	-1.787E-02	8.601E+00
372	0	0	0	1.779E-05	-1.787E-02	8.601E+00
373	0	0	0	1.779E-05	-1.787E-02	8.601E+00
374	0	0	0	1.779E-05	-1.787E-02	8.601E+00
375	0	0	0	2.077E-05	-1.947E-02	7.751E+00
376	0	0	0	2.376E-05	-2.108E-02	6.900E+00
377	0	29.59	0	2.674E-05	-2.269E-02	6.050E+00
378	-1.34	87.46	0	2.674E-05	-2.269E-02	6.050E+00
379	7.93	100.00	1.15	2.674E-05	-2.269E-02	6.050E+00
380	41.11	100.00	3.82	2.674E-05	-2.269E-02	6.050E+00
381	68.65	100.00	6.11	2.674E-05	-2.269E-02	6.050E+00

382	71.43	100.00	10.00	2.674E-05	-2.269E-02	6.050E+00
383	73.34	94.64	14.52	2.674E-05	-2.269E-02	6.050E+00
384	76.24	83.07	18.09	2.674E-05	-2.269E-02	6.050E+00
385	78.30	88.51	20.64	2.674E-05	-2.269E-02	6.050E+00
386	82.14	79.83	22.36	2.674E-05	-2.269E-02	6.050E+00
387	82.14	61.66	23.70	2.674E-05	-2.269E-02	6.050E+00
388	84.45	66.77	24.80	2.674E-05	-2.269E-02	6.050E+00
389	91.86	60.00	25.26	2.674E-05	-2.269E-02	6.050E+00
390	94.64	72.76	25.44	2.674E-05	-2.269E-02	6.050E+00
391	97.48	8.43	25.57	2.674E-05	-2.269E-02	6.050E+00
392	99.92	([a])	25.79	2.674E-05	-2.269E-02	6.050E+00
393	73.21	([a])	25.80	2.674E-05	-2.269E-02	6.050E+00
394	70.83	([a])	24.98	2.674E-05	-2.269E-02	6.050E+00
395	63.53	([a])	23.70	2.674E-05	-2.269E-02	6.050E+00
396	61.46	([a])	22.23	2.674E-05	-2.269E-02	6.050E+00
397	69.96	49.17	20.51	2.674E-05	-2.269E-02	6.050E+00
398	73.21	70.00	18.44	2.674E-05	-2.269E-02	6.050E+00
399	72.01	69.46	18.19	2.674E-05	-2.269E-02	6.050E+00
400	82.90	60.00	21.27	2.674E-05	-2.269E-02	6.050E+00
401	87.04	60.00	23.53	2.674E-05	-2.269E-02	6.050E+00
402	88.35	60.00	23.88	2.674E-05	-2.269E-02	6.050E+00
403	89.95	60.00	24.03	2.674E-05	-2.269E-02	6.050E+00
404	92.57	43.17	24.17	2.228E-05	-1.969E-02	5.457E+00
405	92.86	10.04	24.30	1.781E-05	-1.670E-02	4.864E+00
406	71.98	20.00	24.09	1.335E-05	-1.370E-02	4.271E+00
407	74.44	20.00	24.97	1.335E-05	-1.370E-02	4.271E+00
408	72.38	15.29	25.32	4.449E-06	-4.566E-03	1.424E+00
409	71.43	10.00	24.15	-4.449E-06	4.566E-03	-1.424E+00
410	68.63	([a])	23.14	-1.335E-05	1.370E-02	-4.271E+00
411	66.17	([a])	22.38	-1.335E-05	1.370E-02	-4.271E+00
412	63.93	([a])	21.58	-1.335E-05	1.370E-02	-4.271E+00
413	63.02	([a])	20.06	-1.335E-05	1.370E-02	-4.271E+00
414	69.64	([a])	18.29	-1.335E-05	1.370E-02	-4.271E+00
415	71.69	1.45	16.16	-1.335E-05	1.370E-02	-4.271E+00
416	71.91	17.30	13.44	-1.335E-05	1.370E-02	-4.271E+00
417	69.85	11.13	11.00	-1.335E-05	1.370E-02	-4.271E+00
418	70.04	19.55	10.13	-7.827E-06	7.759E-03	-3.711E+00
419	75.32	24.16	11.50	-2.306E-06	1.819E-03	-3.150E+00
420	64.43	80.00	13.65	3.214E-06	-4.121E-03	-2.590E+00
421	70.63	74.83	15.03	3.214E-06	-4.121E-03	-2.590E+00
422	80.44	16.04	17.50	3.214E-06	-4.121E-03	-2.590E+00
423	66.11	([a])	20.79	3.214E-06	-4.121E-03	-2.590E+00
424	60.73	([a])	22.92	3.214E-06	-4.121E-03	-2.590E+00

425	61.19	([a])	23.23	3.214E-06	-4.121E-03	-2.590E+00
426	53.03	([a])	22.42	3.214E-06	-4.121E-03	-2.590E+00
427	56.73	([a])	21.51	3.214E-06	-4.121E-03	-2.590E+00
428	62.50	2.38	20.46	3.214E-06	-4.121E-03	-2.590E+00
429	65.27	17.76	19.25	3.214E-06	-4.121E-03	-2.590E+00
430	64.40	([a])	19.61	3.214E-06	-4.121E-03	-2.590E+00
431	60.06	([a])	21.94	3.214E-06	-4.121E-03	-2.590E+00
432	32.17	([a])	22.99	3.214E-06	-4.121E-03	-2.590E+00
433	18.53	([a])	22.51	3.214E-06	-4.121E-03	-2.590E+00
434	10.26	([a])	21.98	3.214E-06	-4.121E-03	-2.590E+00
435	-1.87	0.0	21.39	3.214E-06	-4.121E-03	-2.590E+00
436	-0.65	0.0	20.73	3.214E-06	-4.121E-03	-2.590E+00
437	7.65	60.00	20.38	3.214E-06	-4.121E-03	-2.590E+00
438	27.28	61.93	20.38	3.214E-06	-4.121E-03	-2.590E+00
439	59.91	63.00	20.78	3.214E-06	-4.121E-03	-2.590E+00
440	76.81	39.85	21.84	3.214E-06	-4.121E-03	-2.590E+00
441	79.76	30.00	23.60	3.214E-06	-4.121E-03	-2.590E+00
442	81.82	30.00	25.31	3.214E-06	-4.121E-03	-2.590E+00
443	87.39	10.40	26.41	3.214E-06	-4.121E-03	-2.590E+00
444	87.26	1.37	27.29	3.214E-06	-4.121E-03	-2.590E+00
445	85.71	10.00	27.97	3.214E-06	-4.121E-03	-2.590E+00
446	85.71	0.96	28.20	3.214E-06	-4.121E-03	-2.590E+00
447	85.71	([a])	28.31	3.214E-06	-4.121E-03	-2.590E+00
448	76.13	28.34	29.22	3.214E-06	-4.121E-03	-2.590E+00
449	78.16	30.76	29.63	3.214E-06	-4.121E-03	-2.590E+00
450	76.93	29.18	29.64	3.214E-06	-4.121E-03	-2.590E+00
451	78.57	20.00	30.67	3.214E-06	-4.121E-03	-2.590E+00
452	77.87	20.00	32.17	3.214E-06	-4.121E-03	-2.590E+00
453	76.79	20.00	33.10	3.214E-06	-4.121E-03	-2.590E+00
454	78.05	20.00	33.30	3.214E-06	-4.121E-03	-2.590E+00
455	78.57	11.32	33.15	3.214E-06	-4.121E-03	-2.590E+00
456	69.50	([a])	32.66	3.214E-06	-4.121E-03	-2.590E+00
457	64.29	([a])	31.98	3.214E-06	-4.121E-03	-2.590E+00
458	63.68	([a])	31.48	3.214E-06	-4.121E-03	-2.590E+00
459	62.50	0.04	31.39	3.214E-06	-4.121E-03	-2.590E+00
460	62.50	([a])	31.30	3.214E-06	-4.121E-03	-2.590E+00
461	66.86	([a])	32.20	3.214E-06	-4.121E-03	-2.590E+00
462	66.13	([a])	33.13	3.214E-06	-4.121E-03	-2.590E+00
463	60.48	([a])	33.13	3.214E-06	-4.121E-03	-2.590E+00
464	58.93	([a])	33.14	3.214E-06	-4.121E-03	-2.590E+00
465	57.35	([a])	33.14	3.214E-06	-4.121E-03	-2.590E+00
466	55.36	([a])	33.15	3.214E-06	-4.121E-03	-2.590E+00
467	49.95	([a])	33.16	3.214E-06	-4.121E-03	-2.590E+00

468	48.21	[a]	33.16	3.214E-06	-4.121E-03	-2.590E+00
469	59.31	[a]	33.17	2.308E-06	-3.167E-03	-2.524E+00
470	67.15	70.00	33.30	1.401E-06	-2.214E-03	-2.458E+00
471	76.79	54.53	33.56	4.942E-07	-1.260E-03	-2.391E+00
472	76.79	24.56	35.59	4.942E-07	-1.260E-03	-2.391E+00
473	79.29	[a]	39.04	4.942E-07	-1.260E-03	-2.391E+00
474	80.36	[a]	41.83	4.942E-07	-1.260E-03	-2.391E+00
475	94.18	[a]	43.06	4.942E-07	-1.260E-03	-2.391E+00
476	66.07	[a]	43.13	4.942E-07	-1.260E-03	-2.391E+00
477	65.48	[a]	43.21	4.942E-07	-1.260E-03	-2.391E+00
478	63.41	10.00	43.29	4.942E-07	-1.260E-03	-2.391E+00
479	68.27	29.38	43.37	4.942E-07	-1.260E-03	-2.391E+00
480	72.87	40.00	44.00	4.942E-07	-1.260E-03	-2.391E+00
481	69.79	30.39	45.13	4.942E-07	-1.260E-03	-2.391E+00
482	66.19	26.46	47.02	4.942E-07	-1.260E-03	-2.391E+00
483	80.36	0.0	49.20	4.942E-07	-1.260E-03	-2.391E+00
484	81.13	0.0	49.92	4.942E-07	-1.260E-03	-2.391E+00
485	82.14	[a]	50.36	4.942E-07	-1.260E-03	-2.391E+00
486	83.48	[a]	51.52	4.942E-07	-1.260E-03	-2.391E+00
487	83.93	[a]	52.11	4.942E-07	-1.260E-03	-2.391E+00
488	84.04	[a]	52.12	4.942E-07	-1.260E-03	-2.391E+00
489	79.43	[a]	52.14	4.942E-07	-1.260E-03	-2.391E+00
490	56.47	[a]	52.16	4.942E-07	-1.260E-03	-2.391E+00
491	55.36	[a]	52.18	4.942E-07	-1.260E-03	-2.391E+00
492	44.23	45.37	52.20	4.942E-07	-1.260E-03	-2.391E+00
493	46.87	86.99	52.22	4.942E-07	-1.260E-03	-2.391E+00
494	57.14	90.00	52.16	4.942E-07	-1.260E-03	-2.391E+00
495	58.03	90.00	52.53	4.942E-07	-1.260E-03	-2.391E+00
496	64.22	93.22	52.98	4.942E-07	-1.260E-03	-2.391E+00
497	70.42	95.21	53.65	4.942E-07	-1.260E-03	-2.391E+00
498	73.21	83.64	54.77	4.942E-07	-1.260E-03	-2.391E+00
499	77.46	80.00	55.14	4.942E-07	-1.260E-03	-2.391E+00
500	83.67	80.00	54.57	4.942E-07	-1.260E-03	-2.391E+00
501	84.71	80.00	53.63	4.942E-07	-1.260E-03	-2.391E+00
502	92.50	80.00	52.70	4.942E-07	-1.260E-03	-2.391E+00
503	90.38	41.89	52.03	4.942E-07	-1.260E-03	-2.391E+00
504	85.25	24.85	51.66	4.942E-07	-1.260E-03	-2.391E+00
505	87.50	50.00	51.42	4.942E-07	-1.260E-03	-2.391E+00
506	89.10	50.00	51.28	4.942E-07	-1.260E-03	-2.391E+00
507	94.83	46.82	51.13	4.942E-07	-1.260E-03	-2.391E+00
508	98.96	[a]	51.53	4.942E-07	-1.260E-03	-2.391E+00
509	87.99	[a]	52.04	1.647E-07	-4.200E-04	-7.972E-01
510	63.35	[a]	51.32	-1.647E-07	4.200E-04	7.972E-01

511	60.06	([a])	49.20	-4.942E-07	1.260E-03	2.391E+00
512	54.43	([a])	46.43	-4.942E-07	1.260E-03	2.391E+00
513	42.88	([a])	43.58	-4.942E-07	1.260E-03	2.391E+00
514	46.71	([a])	40.65	-4.942E-07	1.260E-03	2.391E+00
515	48.21	([a])	37.62	-4.942E-07	1.260E-03	2.391E+00
516	58.28	([a])	34.62	-4.942E-07	1.260E-03	2.391E+00
517	69.64	([a])	31.62	-4.942E-07	1.260E-03	2.391E+00
518	51.44	([a])	28.44	-4.942E-07	1.260E-03	2.391E+00
519	38.02	([a])	25.01	-4.942E-07	1.260E-03	2.391E+00
520	34.65	([a])	21.38	-4.942E-07	1.260E-03	2.391E+00
521	19.97	([a])	17.39	-4.942E-07	1.260E-03	2.391E+00
522	3.14	([a])	12.76	-4.942E-07	1.260E-03	2.391E+00
523	0	0	6.14	-4.942E-07	1.260E-03	2.391E+00
524	-1.30	36.39	0	-4.942E-07	1.260E-03	2.391E+00
525	-0.21	5.75	0	-4.942E-07	1.260E-03	2.391E+00
526	0	0	0	-4.942E-07	1.260E-03	2.391E+00
527	0	0	0	-4.942E-07	1.260E-03	2.391E+00
528	0	0	0	-4.942E-07	1.260E-03	2.391E+00
529	0	0	0	-4.942E-07	1.260E-03	2.391E+00
530	0	0	0	7.439E-06	-5.768E-03	1.455E+00
531	0	0	0	1.537E-05	-1.280E-02	5.195E-01
532	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
533	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
534	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
535	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
536	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
537	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
538	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
539	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
540	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
541	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
542	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
543	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
544	0	([a])	0	2.331E-05	-1.982E-02	-4.165E-01
545	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
546	-0.67	0	0	2.331E-05	-1.982E-02	-4.165E-01
547	-0.50	0	0	2.331E-05	-1.982E-02	-4.165E-01
548	3.57	([a])	0	2.331E-05	-1.982E-02	-4.165E-01
549	0.61	([a])	0	2.331E-05	-1.982E-02	-4.165E-01
550	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
551	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
552	0	2.60	0	2.331E-05	-1.982E-02	-4.165E-01
553	0	20.00	0	2.331E-05	-1.982E-02	-4.165E-01

554	0	20.00	0	2.331E-05	-1.982E-02	-4.165E-01
555	0	7.96	0	2.331E-05	-1.982E-02	-4.165E-01
556	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
557	0	0	0	2.331E-05	-1.982E-02	-4.165E-01
558	0	78.53	0	2.331E-05	-1.982E-02	-4.165E-01
559	1.65	60.00	0	2.331E-05	-1.982E-02	-4.165E-01
560	9.91	63.88	2.80	2.331E-05	-1.982E-02	-4.165E-01
561	14.29	70.00	6.02	2.331E-05	-1.982E-02	-4.165E-01
562	26.83	70.00	8.57	2.331E-05	-1.982E-02	-4.165E-01
563	38.29	70.00	11.07	2.331E-05	-1.982E-02	-4.165E-01
564	50.09	70.00	13.68	2.331E-05	-1.982E-02	-4.165E-01
565	56.60	66.52	16.52	2.331E-05	-1.982E-02	-4.165E-01
566	63.09	59.94	19.38	2.331E-05	-1.982E-02	-4.165E-01
567	65.16	80.00	21.91	2.331E-05	-1.982E-02	-4.165E-01
568	69.53	86.46	24.34	2.331E-05	-1.982E-02	-4.165E-01
569	78.60	90.00	27.02	2.331E-05	-1.982E-02	-4.165E-01
570	80.36	90.00	29.41	2.331E-05	-1.982E-02	-4.165E-01
571	82.35	100.00	31.57	2.331E-05	-1.982E-02	-4.165E-01
572	83.93	100.00	33.52	2.331E-05	-1.982E-02	-4.165E-01
573	84.70	100.00	35.75	2.331E-05	-1.982E-02	-4.165E-01
574	85.71	100.00	38.34	2.331E-05	-1.982E-02	-4.165E-01
575	87.04	100.00	40.83	2.331E-05	-1.982E-02	-4.165E-01
576	97.18	100.00	43.37	2.331E-05	-1.982E-02	-4.165E-01
577	98.21	83.92	44.90	2.331E-05	-1.982E-02	-4.165E-01
578	93.54	([a])	45.32	7.769E-06	-6.608E-03	-1.388E-01
579	78.13	([a])	45.25	-7.769E-06	6.608E-03	1.388E-01
580	80.36	0	44.24	-2.331E-05	1.982E-02	4.165E-01
581	81.59	([a])	42.61	-2.331E-05	1.982E-02	4.165E-01
582	73.07	([a])	40.93	-2.331E-05	1.982E-02	4.165E-01
583	58.92	([a])	39.03	-2.331E-05	1.982E-02	4.165E-01
584	56.86	([a])	36.96	-2.331E-05	1.982E-02	4.165E-01
585	54.22	([a])	34.84	-2.331E-05	1.982E-02	4.165E-01
586	50.94	([a])	32.66	-2.331E-05	1.982E-02	4.165E-01
587	47.74	([a])	30.40	-2.331E-05	1.982E-02	4.165E-01
588	45.02	([a])	28.04	-2.331E-05	1.982E-02	4.165E-01
589	39.56	([a])	25.57	-2.331E-05	1.982E-02	4.165E-01
590	33.55	37.91	22.94	-2.331E-05	1.982E-02	4.165E-01
591	29.89	20.00	20.11	-2.331E-05	1.982E-02	4.165E-01
592	27.82	20.00	18.17	-2.331E-05	1.982E-02	4.165E-01
593	25.76	20.00	17.20	-2.331E-05	1.982E-02	4.165E-01
594	19.76	20.00	16.06	-2.331E-05	1.982E-02	4.165E-01
595	8.31	([a])	14.93	-2.331E-05	1.982E-02	4.165E-01
596	0	0	13.78	-2.331E-05	1.982E-02	4.165E-01

597	0	0	10.72	-2.331E-05	1.982E-02	4.165E-01
598	0	0	6.24	-2.331E-05	1.982E-02	4.165E-01
599	0	0	1.77	-2.331E-05	1.982E-02	4.165E-01
600	0	0	0	-2.331E-05	1.982E-02	4.165E-01
601	0	0	0	-2.331E-05	1.982E-02	4.165E-01
602	0	0	0	-2.331E-05	1.982E-02	4.165E-01
603	0	0	0	-2.331E-05	1.982E-02	4.165E-01
604	0	0	0	-2.331E-05	1.982E-02	4.165E-01
605	0	0	0	-2.331E-05	1.982E-02	4.165E-01
606	2.25	6.30	0	-2.331E-05	1.982E-02	4.165E-01
607	9.20	17.87	0	-1.029E-05	8.762E-03	1.296E+00
608	12.40	20.00	0.75	2.727E-06	-2.302E-03	2.176E+00
609	18.04	20.00	1.90	1.574E-05	-1.337E-02	3.055E+00
610	21.49	22.59	3.81	1.574E-05	-1.337E-02	3.055E+00
611	29.76	17.50	5.91	1.574E-05	-1.337E-02	3.055E+00
612	35.98	([a])	7.92	1.574E-05	-1.337E-02	3.055E+00
613	42.72	([a])	9.86	1.574E-05	-1.337E-02	3.055E+00
614	58.93	7.78	9.37	1.574E-05	-1.337E-02	3.055E+00
615	60.71	10.93	5.32	1.574E-05	-1.337E-02	3.055E+00
616	60.35	32.04	1.45	1.574E-05	-1.337E-02	3.055E+00
617	58.93	40.00	4.28	1.574E-05	-1.337E-02	3.055E+00
618	59.86	40.00	6.78	1.574E-05	-1.337E-02	3.055E+00
619	60.71	40.00	9.12	1.574E-05	-1.337E-02	3.055E+00
620	60.71	48.33	11.69	1.574E-05	-1.337E-02	3.055E+00
621	67.79	99.53	14.17	1.574E-05	-1.337E-02	3.055E+00
622	69.64	100.00	16.35	1.574E-05	-1.337E-02	3.055E+00
623	69.64	100.00	19.18	1.574E-05	-1.337E-02	3.055E+00
624	68.81	100.00	22.35	1.574E-05	-1.337E-02	3.055E+00
625	67.86	100.00	25.17	1.574E-05	-1.337E-02	3.055E+00
626	67.86	100.00	27.60	1.574E-05	-1.337E-02	3.055E+00
627	67.86	100.00	29.72	1.574E-05	-1.337E-02	3.055E+00
628	67.53	100.00	31.71	1.574E-05	-1.337E-02	3.055E+00
629	65.18	97.50	33.60	1.574E-05	-1.337E-02	3.055E+00
630	68.58	90.00	35.39	1.574E-05	-1.337E-02	3.055E+00
631	71.66	90.00	37.08	1.574E-05	-1.337E-02	3.055E+00
632	74.50	90.00	38.83	1.574E-05	-1.337E-02	3.055E+00
633	75.00	98.79	40.28	1.574E-05	-1.337E-02	3.055E+00
634	75.00	100.00	41.29	1.574E-05	-1.337E-02	3.055E+00
635	74.65	100.00	42.31	1.574E-05	-1.337E-02	3.055E+00
636	73.21	100.00	42.90	1.574E-05	-1.337E-02	3.055E+00
637	74.13	94.91	42.94	1.574E-05	-1.337E-02	3.055E+00
638	77.38	90.00	42.83	1.574E-05	-1.337E-02	3.055E+00
639	80.04	90.00	42.74	1.574E-05	-1.337E-02	3.055E+00

640	80.36	99.81	42.65	1.574E-05	-1.337E-02	3.055E+00
641	79.87	100.00	42.56	1.574E-05	-1.337E-02	3.055E+00
642	76.79	100.00	42.88	1.574E-05	-1.337E-02	3.055E+00
643	76.79	95.47	43.29	1.574E-05	-1.337E-02	3.055E+00
644	77.88	90.00	43.30	1.574E-05	-1.337E-02	3.055E+00
645	78.57	90.00	43.37	1.574E-05	-1.337E-02	3.055E+00
646	78.57	80.74	43.79	1.574E-05	-1.337E-02	3.055E+00
647	78.57	79.17	44.07	1.574E-05	-1.337E-02	3.055E+00
648	78.57	77.21	44.01	1.574E-05	-1.337E-02	3.055E+00
649	78.57	100.00	44.41	1.046E-05	-8.994E-03	2.433E+00
650	78.57	94.45	44.85	5.183E-06	-4.623E-03	1.811E+00
651	78.57	90.00	44.83	-9.733E-08	-2.513E-04	1.190E+00
652	78.57	90.00	44.78	-9.733E-08	-2.513E-04	1.190E+00
653	80.36	90.00	45.00	-9.733E-08	-2.513E-04	1.190E+00
654	80.03	90.00	45.80	-9.733E-08	-2.513E-04	1.190E+00
655	79.18	90.00	46.46	-9.733E-08	-2.513E-04	1.190E+00
656	80.36	90.00	46.54	-9.733E-08	-2.513E-04	1.190E+00
657	80.36	90.00	46.12	-9.733E-08	-2.513E-04	1.190E+00
658	81.81	81.86	45.94	-9.733E-08	-2.513E-04	1.190E+00
659	82.14	80.00	45.81	-9.733E-08	-2.513E-04	1.190E+00
660	80.36	81.29	45.45	-9.733E-08	-2.513E-04	1.190E+00
661	79.85	92.86	45.81	-9.733E-08	-2.513E-04	1.190E+00
662	77.78	100.00	46.26	-9.733E-08	-2.513E-04	1.190E+00
663	76.79	100.00	46.32	-9.733E-08	-2.513E-04	1.190E+00
664	76.79	100.00	46.28	-9.733E-08	-2.513E-04	1.190E+00
665	80.05	100.00	46.46	-9.733E-08	-2.513E-04	1.190E+00
666	80.36	99.27	46.92	-9.733E-08	-2.513E-04	1.190E+00
667	80.77	90.00	47.16	-9.733E-08	-2.513E-04	1.190E+00
668	82.84	90.00	47.58	-9.733E-08	-2.513E-04	1.190E+00
669	84.90	90.00	48.04	-9.733E-08	-2.513E-04	1.190E+00
670	89.48	82.97	48.05	-9.733E-08	-2.513E-04	1.190E+00
671	91.07	80.00	48.02	-9.733E-08	-2.513E-04	1.190E+00
672	91.07	70.18	48.00	-9.733E-08	-2.513E-04	1.190E+00
673	91.07	80.00	47.97	-9.733E-08	-2.513E-04	1.190E+00
674	86.91	50.07	47.95	-9.733E-08	-2.513E-04	1.190E+00
675	77.70	([a])	47.95	-9.733E-08	-2.513E-04	1.190E+00
676	76.79	([a])	48.86	-9.733E-08	-2.513E-04	1.190E+00
677	65.29	22.19	49.92	-9.733E-08	-2.513E-04	1.190E+00
678	67.65	39.62	50.26	-9.733E-08	-2.513E-04	1.190E+00
679	67.64	48.80	50.18	-9.733E-08	-2.513E-04	1.190E+00
680	67.06	37.23	49.91	-9.733E-08	-2.513E-04	1.190E+00
681	69.64	34.34	49.90	-9.733E-08	-2.513E-04	1.190E+00
682	71.76	40.00	49.88	-9.733E-08	-2.513E-04	1.190E+00

683	69.21	47.49	49.87	-9.733E-08	-2.513E-04	1.190E+00
684	72.71	50.00	49.86	-9.733E-08	-2.513E-04	1.190E+00
685	73.33	39.36	49.85	-9.733E-08	-2.513E-04	1.190E+00
686	75.00	27.79	49.83	-9.733E-08	-2.513E-04	1.190E+00
687	75.00	16.21	49.82	-9.733E-08	-2.513E-04	1.190E+00
688	75.00	15.36	49.67	-9.733E-08	-2.513E-04	1.190E+00
689	76.24	26.93	49.60	-9.733E-08	-2.513E-04	1.190E+00
690	76.79	30.00	50.23	-9.733E-08	-2.513E-04	1.190E+00
691	76.79	30.08	50.78	-9.733E-08	-2.513E-04	1.190E+00
692	76.49	40.00	50.77	-9.733E-08	-2.513E-04	1.190E+00
693	75.58	40.00	50.76	-9.733E-08	-2.513E-04	1.190E+00
694	76.79	35.20	50.64	-9.733E-08	-2.513E-04	1.190E+00
695	77.93	30.00	50.14	-9.733E-08	-2.513E-04	1.190E+00
696	78.57	22.05	49.74	-9.733E-08	-2.513E-04	1.190E+00
697	76.87	([a])	50.07	-9.733E-08	-2.513E-04	1.190E+00
698	74.80	([a])	50.56	-9.733E-08	-2.513E-04	1.190E+00
699	72.74	([a])	50.73	-2.744E-06	1.973E-03	3.071E-01
700	72.95	([a])	50.76	-5.391E-06	4.198E-03	-5.755E-01
701	76.04	([a])	50.79	-8.038E-06	6.423E-03	-1.458E+00
702	75.46	([a])	50.82	-8.038E-06	6.423E-03	-1.458E+00
703	73.40	([a])	50.85	-8.038E-06	6.423E-03	-1.458E+00
704	71.33	([a])	50.88	-8.038E-06	6.423E-03	-1.458E+00
705	69.27	([a])	50.91	-8.038E-06	6.423E-03	-1.458E+00
706	67.86	6.31	50.94	-8.038E-06	6.423E-03	-1.458E+00
707	70.68	0	50.98	-8.038E-06	6.423E-03	-1.458E+00
708	67.11	27.36	51.00	-8.038E-06	6.423E-03	-1.458E+00
709	64.29	40.00	51.03	-8.038E-06	6.423E-03	-1.458E+00
710	64.29	40.00	51.04	-8.038E-06	6.423E-03	-1.458E+00
711	66.07	38.44	51.05	-8.038E-06	6.423E-03	-1.458E+00
712	66.07	30.00	51.19	-8.038E-06	6.423E-03	-1.458E+00
713	66.07	30.00	51.69	-8.038E-06	6.423E-03	-1.458E+00
714	66.07	36.28	52.35	-8.038E-06	6.423E-03	-1.458E+00
715	64.67	47.86	52.85	-8.038E-06	6.423E-03	-1.458E+00
716	60.92	59.43	53.06	-8.038E-06	6.423E-03	-1.458E+00
717	65.89	50.00	53.07	-8.038E-06	6.423E-03	-1.458E+00
718	64.75	50.00	53.06	-8.038E-06	6.423E-03	-1.458E+00
719	66.07	45.85	53.06	-8.038E-06	6.423E-03	-1.458E+00
720	65.04	57.18	53.05	-8.038E-06	6.423E-03	-1.458E+00
721	68.20	62.70	53.05	-8.038E-06	6.423E-03	-1.458E+00
722	72.81	60.00	53.05	-8.038E-06	6.423E-03	-1.458E+00
723	71.59	60.00	53.04	-8.038E-06	6.423E-03	-1.458E+00
724	74.64	60.00	53.03	-6.308E-06	4.994E-03	-7.637E-01
725	74.50	56.40	53.02	-4.577E-06	3.565E-03	-6.931E-02

726	76.79	50.00	53.24	-2.847E-06	2.136E-03	6.251E-01
727	77.99	50.00	53.73	-2.847E-06	2.136E-03	6.251E-01
728	77.09	50.00	53.98	-2.847E-06	2.136E-03	6.251E-01
729	76.79	40.11	53.98	-2.847E-06	2.136E-03	6.251E-01
730	78.83	61.47	53.98	-2.847E-06	2.136E-03	6.251E-01
731	79.27	63.92	53.98	-2.847E-06	2.136E-03	6.251E-01
732	77.61	50.00	53.97	-2.847E-06	2.136E-03	6.251E-01
733	77.46	50.00	53.95	-2.847E-06	2.136E-03	6.251E-01
734	78.17	42.24	53.95	-2.847E-06	2.136E-03	6.251E-01
735	78.57	49.34	53.94	-2.847E-06	2.136E-03	6.251E-01
736	76.79	50.91	53.94	-2.847E-06	2.136E-03	6.251E-01
737	76.79	67.45	53.94	-2.847E-06	2.136E-03	6.251E-01
738	76.79	81.88	54.15	-2.847E-06	2.136E-03	6.251E-01
739	77.79	70.00	54.65	-2.847E-06	2.136E-03	6.251E-01
740	79.86	77.21	54.92	-2.847E-06	2.136E-03	6.251E-01
741	81.93	88.78	54.90	-2.847E-06	2.136E-03	6.251E-01
742	80.42	89.65	54.89	-2.847E-06	2.136E-03	6.251E-01
743	82.14	80.00	54.97	-2.847E-06	2.136E-03	6.251E-01
744	82.77	80.00	55.44	-2.847E-06	2.136E-03	6.251E-01
745	83.93	80.00	55.82	-2.847E-06	2.136E-03	6.251E-01
746	83.93	80.00	55.80	-2.847E-06	2.136E-03	6.251E-01
747	83.93	80.00	55.79	-2.847E-06	2.136E-03	6.251E-01
748	83.93	80.00	55.78	-2.847E-06	2.136E-03	6.251E-01
749	83.93	81.37	55.76	-5.174E-06	4.059E-03	-2.026E-01
750	84.46	87.05	55.75	-7.501E-06	5.983E-03	-1.030E+00
751	85.71	57.40	55.74	-9.827E-06	7.906E-03	-1.858E+00
752	85.71	42.19	55.42	-9.827E-06	7.906E-03	-1.858E+00
753	85.71	42.33	54.91	-9.827E-06	7.906E-03	-1.858E+00
754	85.71	40.00	55.19	-9.827E-06	7.906E-03	-1.858E+00
755	85.71	38.37	55.64	-9.827E-06	7.906E-03	-1.858E+00
756	85.71	12.83	55.31	-9.827E-06	7.906E-03	-1.858E+00
757	85.71	(a)	55.36	-9.827E-06	7.906E-03	-1.858E+00
758	85.71	(a)	55.75	-9.827E-06	7.906E-03	-1.858E+00
759	85.71	(a)	55.78	-9.827E-06	7.906E-03	-1.858E+00
760	87.27	7.37	55.81	-9.827E-06	7.906E-03	-1.858E+00
761	89.33	19.74	55.85	-9.827E-06	7.906E-03	-1.858E+00
762	91.07	11.83	55.86	-9.827E-06	7.906E-03	-1.858E+00
763	91.07	26.81	55.84	-9.827E-06	7.906E-03	-1.858E+00
764	91.96	49.96	55.81	-9.827E-06	7.906E-03	-1.858E+00
765	92.86	60.00	55.78	-9.827E-06	7.906E-03	-1.858E+00
766	91.40	60.00	55.74	-9.827E-06	7.906E-03	-1.858E+00
767	92.80	60.00	56.19	-9.827E-06	7.906E-03	-1.858E+00
768	92.86	40.00	57.13	-9.827E-06	7.906E-03	-1.858E+00

769	92.86	25.75	57.59	-9.827E-06	7.906E-03	-1.858E+00
770	92.07	([a])	57.55	-9.827E-06	7.906E-03	-1.858E+00
771	90.00	([a])	57.52	-9.827E-06	7.906E-03	-1.858E+00
772	89.29	([a])	57.53	-9.827E-06	7.906E-03	-1.858E+00
773	90.92	44.88	57.58	-9.827E-06	7.906E-03	-1.858E+00
774	91.07	36.40	57.63	-1.014E-05	8.189E-03	-1.873E+00
775	91.07	([a])	57.64	-1.045E-05	8.472E-03	-1.887E+00
776	91.07	([a])	58.11	-1.077E-05	8.756E-03	-1.902E+00
777	90.10	([a])	58.52	-1.077E-05	8.756E-03	-1.902E+00
778	90.54	([a])	58.38	-1.077E-05	8.756E-03	-1.902E+00
779	89.54	([a])	58.24	-1.077E-05	8.756E-03	-1.902E+00
780	87.47	([a])	58.10	-1.077E-05	8.756E-03	-1.902E+00
781	85.71	([a])	57.96	-1.077E-05	8.756E-03	-1.902E+00
782	85.71	10.00	57.81	-1.077E-05	8.756E-03	-1.902E+00
783	85.71	0.23	57.67	-1.077E-05	8.756E-03	-1.902E+00
784	85.71	([a])	57.66	-1.077E-05	8.756E-03	-1.902E+00
785	85.71	([a])	57.89	-1.077E-05	8.756E-03	-1.902E+00
786	84.00	([a])	58.03	-1.077E-05	8.756E-03	-1.902E+00
787	69.64	([a])	57.99	-1.077E-05	8.756E-03	-1.902E+00
788	69.15	([a])	57.96	-1.077E-05	8.756E-03	-1.902E+00
789	63.99	28.96	57.93	-1.077E-05	8.756E-03	-1.902E+00
790	59.98	80.00	57.89	-1.077E-05	8.756E-03	-1.902E+00
791	59.38	87.48	57.85	-1.077E-05	8.756E-03	-1.902E+00
792	63.78	90.00	57.80	-1.077E-05	8.756E-03	-1.902E+00
793	66.19	90.00	57.72	-1.077E-05	8.756E-03	-1.902E+00
794	67.46	92.20	57.65	-1.077E-05	8.756E-03	-1.902E+00
795	66.74	100.00	57.57	-1.077E-05	8.756E-03	-1.902E+00
796	68.81	94.65	57.50	-1.077E-05	8.756E-03	-1.902E+00
797	70.88	83.08	57.80	-1.077E-05	8.756E-03	-1.902E+00
798	71.43	71.51	58.72	-1.077E-05	8.756E-03	-1.902E+00
799	71.44	69.93	59.25	-8.819E-06	7.137E-03	-1.079E+00
800	73.51	58.36	59.19	-6.873E-06	5.518E-03	-2.559E-01
801	75.00	50.00	59.16	-4.927E-06	3.899E-03	5.670E-01
802	75.00	59.58	59.15	-4.927E-06	3.899E-03	5.670E-01
803	75.00	76.36	59.15	-4.927E-06	3.899E-03	5.670E-01
804	75.00	80.00	59.14	-4.927E-06	3.899E-03	5.670E-01
805	75.00	70.49	59.14	-4.927E-06	3.899E-03	5.670E-01
806	73.21	80.00	59.62	-4.927E-06	3.899E-03	5.670E-01
807	72.74	82.66	59.93	-4.927E-06	3.899E-03	5.670E-01
808	71.43	90.00	59.42	-4.927E-06	3.899E-03	5.670E-01
809	69.36	90.00	59.07	-4.927E-06	3.899E-03	5.670E-01
810	66.54	75.24	59.05	-4.927E-06	3.899E-03	5.670E-01
811	69.27	78.96	59.03	-4.927E-06	3.899E-03	5.670E-01

812	73.12	80.00	59.02	-4.927E-06	3.899E-03	5.670E-01
813	71.80	80.00	59.00	-4.927E-06	3.899E-03	5.670E-01
814	73.21	83.68	58.99	-4.927E-06	3.899E-03	5.670E-01
815	74.15	79.50	58.97	-4.927E-06	3.899E-03	5.670E-01
816	75.00	70.00	58.96	-4.927E-06	3.899E-03	5.670E-01
817	75.00	61.60	58.95	-4.927E-06	3.899E-03	5.670E-01
818	75.00	50.03	58.94	-4.927E-06	3.899E-03	5.670E-01
819	76.79	60.00	58.93	-4.927E-06	3.899E-03	5.670E-01
820	76.79	60.00	58.93	-4.927E-06	3.899E-03	5.670E-01
821	76.79	69.39	59.38	-4.927E-06	3.899E-03	5.670E-01
822	79.03	73.73	59.87	-4.927E-06	3.899E-03	5.670E-01
823	78.96	70.00	59.91	-4.927E-06	3.899E-03	5.670E-01
824	78.57	70.00	59.90	-4.927E-06	3.899E-03	5.670E-01
825	83.93	70.99	59.89	-4.927E-06	3.899E-03	5.670E-01
826	84.38	80.00	59.88	-4.927E-06	3.899E-03	5.670E-01
827	84.97	80.00	59.88	-4.927E-06	3.899E-03	5.670E-01
828	84.95	80.00	59.87	-4.927E-06	3.899E-03	5.670E-01
829	84.41	80.00	59.86	-5.382E-06	4.139E-03	6.372E-01
830	83.93	80.00	59.85	-5.838E-06	4.378E-03	7.074E-01
831	83.93	77.89	59.84	-6.294E-06	4.618E-03	7.776E-01
832	83.93	31.99	60.25	-6.294E-06	4.618E-03	7.776E-01
833	83.93	43.57	60.73	-6.294E-06	4.618E-03	7.776E-01
834	83.93	60.28	60.80	-6.294E-06	4.618E-03	7.776E-01
835	83.93	63.29	60.81	-6.294E-06	4.618E-03	7.776E-01
836	83.93	76.57	60.81	-6.294E-06	4.618E-03	7.776E-01
837	83.93	89.86	60.81	-6.294E-06	4.618E-03	7.776E-01
838	84.19	90.00	60.80	-6.294E-06	4.618E-03	7.776E-01
839	87.32	87.00	60.79	-6.294E-06	4.618E-03	7.776E-01
840	91.88	80.00	60.78	-6.294E-06	4.618E-03	7.776E-01
841	92.86	73.85	60.77	-6.294E-06	4.618E-03	7.776E-01
842	92.86	62.28	60.34	-6.294E-06	4.618E-03	7.776E-01
843	92.86	69.29	59.34	-6.294E-06	4.618E-03	7.776E-01
844	94.64	70.00	58.76	-6.294E-06	4.618E-03	7.776E-01
845	94.64	62.70	58.76	-6.294E-06	4.618E-03	7.776E-01
846	94.64	40.00	58.75	-6.294E-06	4.618E-03	7.776E-01
847	93.64	40.00	58.75	-6.294E-06	4.618E-03	7.776E-01
848	92.86	32.85	58.57	-6.294E-06	4.618E-03	7.776E-01
849	92.86	30.00	58.08	-7.448E-06	5.557E-03	8.947E-02
850	92.86	0.30	57.77	-8.602E-06	6.495E-03	-5.987E-01
851	92.53	11.87	57.78	-9.756E-06	7.434E-03	-1.287E+00
852	89.84	13.12	57.80	-9.756E-06	7.434E-03	-1.287E+00
853	87.50	5.01	57.82	-9.756E-06	7.434E-03	-1.287E+00
854	86.32	10.00	57.84	-9.756E-06	7.434E-03	-1.287E+00

855	85.71	([a])	57.86	-9.756E-06	7.434E-03	-1.287E+00
856	85.71	([a])	57.88	-9.756E-06	7.434E-03	-1.287E+00
857	85.71	([a])	57.99	-9.756E-06	7.434E-03	-1.287E+00
858	85.21	([a])	58.19	-9.756E-06	7.434E-03	-1.287E+00
859	83.93	([a])	58.39	-9.756E-06	7.434E-03	-1.287E+00
860	83.93	([a])	58.59	-9.756E-06	7.434E-03	-1.287E+00
861	85.29	5.18	58.79	-9.756E-06	7.434E-03	-1.287E+00
862	87.35	([a])	59.00	-9.756E-06	7.434E-03	-1.287E+00
863	87.50	([a])	57.32	-9.756E-06	7.434E-03	-1.287E+00
864	87.50	([a])	58.15	-9.756E-06	7.434E-03	-1.287E+00
865	86.80	([a])	58.57	-9.756E-06	7.434E-03	-1.287E+00
866	85.71	6.35	58.99	-9.756E-06	7.434E-03	-1.287E+00
867	85.71	12.98	59.41	-3.252E-06	2.478E-03	-4.290E-01
868	85.71	10.00	59.38	3.252E-06	-2.478E-03	4.290E-01
869	85.65	10.00	58.90	9.756E-06	-7.434E-03	1.287E+00
870	82.14	10.00	58.42	9.756E-06	-7.434E-03	1.287E+00
871	82.14	10.00	57.46	9.756E-06	-7.434E-03	1.287E+00
872	83.02	14.89	55.85	9.756E-06	-7.434E-03	1.287E+00
873	83.93	13.54	54.38	9.756E-06	-7.434E-03	1.287E+00
874	81.06	42.12	53.19	9.756E-06	-7.434E-03	1.287E+00
875	78.64	40.40	52.00	9.756E-06	-7.434E-03	1.287E+00
876	76.99	30.00	50.80	9.756E-06	-7.434E-03	1.287E+00
877	78.57	32.75	49.59	9.756E-06	-7.434E-03	1.287E+00
878	77.80	44.32	48.39	9.756E-06	-7.434E-03	1.287E+00
879	75.73	50.00	47.07	9.756E-06	-7.434E-03	1.287E+00
880	73.67	50.00	45.71	9.756E-06	-7.434E-03	1.287E+00
881	73.21	50.00	44.46	9.756E-06	-7.434E-03	1.287E+00
882	73.32	40.00	43.27	9.756E-06	-7.434E-03	1.287E+00
883	74.22	35.64	42.10	9.756E-06	-7.434E-03	1.287E+00
884	71.43	20.00	40.89	9.756E-06	-7.434E-03	1.287E+00
885	75.23	51.95	39.61	9.756E-06	-7.434E-03	1.287E+00
886	77.34	66.21	38.22	9.756E-06	-7.434E-03	1.287E+00
887	75.28	60.00	36.96	9.756E-06	-7.434E-03	1.287E+00
888	73.21	9.96	36.06	9.756E-06	-7.434E-03	1.287E+00
889	70.85	1.61	35.23	9.756E-06	-7.434E-03	1.287E+00
890	67.29	19.56	34.02	9.756E-06	-7.434E-03	1.287E+00
891	65.22	40.00	32.37	9.756E-06	-7.434E-03	1.287E+00
892	63.15	8.35	30.81	9.756E-06	-7.434E-03	1.287E+00
893	61.09	([a])	29.57	9.756E-06	-7.434E-03	1.287E+00
894	42.10	8.95	28.26	9.756E-06	-7.434E-03	1.287E+00
895	31.96	10.00	25.94	9.756E-06	-7.434E-03	1.287E+00
896	29.42	7.38	23.56	9.756E-06	-7.434E-03	1.287E+00
897	26.04	([a])	22.00	9.756E-06	-7.434E-03	1.287E+00

898	14.71	([a])	19.21	9.756E-06	-7.434E-03	1.287E+00
899	1.90	([a])	16.51	9.756E-06	-7.434E-03	1.287E+00
900	0	0	12.12	9.756E-06	-7.434E-03	1.287E+00
901	0	0	7.07	9.756E-06	-7.434E-03	1.287E+00
902	0	0	2.60	9.756E-06	-7.434E-03	1.287E+00
903	0	0	0	9.756E-06	-7.434E-03	1.287E+00
904	0	0	0	1.390E-05	-1.206E-02	3.180E+00
905	0	0	0	1.805E-05	-1.669E-02	5.073E+00
906	0	0	0	2.219E-05	-2.131E-02	6.967E+00
907	0	0	0	2.219E-05	-2.131E-02	6.967E+00
908	0	0	0	2.219E-05	-2.131E-02	6.967E+00
909	0	0	0	2.219E-05	-2.131E-02	6.967E+00
910	0	0	0	2.219E-05	-2.131E-02	6.967E+00
911	0	0	0	2.219E-05	-2.131E-02	6.967E+00
912	0	0	0	2.219E-05	-2.131E-02	6.967E+00
913	0	0	0	2.219E-05	-2.131E-02	6.967E+00
914	0	0	0	2.219E-05	-2.131E-02	6.967E+00
915	0	0	0	2.219E-05	-2.131E-02	6.967E+00
916	0	0	0	2.219E-05	-2.131E-02	6.967E+00
917	0	0	0	2.219E-05	-2.131E-02	6.967E+00
918	0	0	0	2.219E-05	-2.131E-02	6.967E+00
919	0	0	0	2.219E-05	-2.131E-02	6.967E+00
920	0	0	0	2.219E-05	-2.131E-02	6.967E+00
921	0	0	0	2.219E-05	-2.131E-02	6.967E+00
922	0	0	0	2.219E-05	-2.131E-02	6.967E+00
923	0	0	0	2.219E-05	-2.131E-02	6.967E+00
924	0	0	0	2.219E-05	-2.131E-02	6.967E+00
925	0	0	0	2.219E-05	-2.131E-02	6.967E+00
926	0	0	0	2.219E-05	-2.131E-02	6.967E+00
927	0	3.67	0	2.219E-05	-2.131E-02	6.967E+00
928	0	47.69	0	2.219E-05	-2.131E-02	6.967E+00
929	2.78	59.41	0.33	2.219E-05	-2.131E-02	6.967E+00
930	8.12	84.54	1.67	2.219E-05	-2.131E-02	6.967E+00
931	13.95	80.00	2.83	2.219E-05	-2.131E-02	6.967E+00
932	29.90	80.00	4.02	2.219E-05	-2.131E-02	6.967E+00
933	33.87	79.29	5.64	2.219E-05	-2.131E-02	6.967E+00
934	27.86	38.25	7.39	2.219E-05	-2.131E-02	6.967E+00
935	19.63	26.67	8.83	2.219E-05	-2.131E-02	6.967E+00
936	26.79	15.10	9.15	2.219E-05	-2.131E-02	6.967E+00
937	19.85	16.47	9.70	2.219E-05	-2.131E-02	6.967E+00
938	17.51	28.05	11.37	2.219E-05	-2.131E-02	6.967E+00
939	17.86	20.38	13.04	2.219E-05	-2.131E-02	6.967E+00
940	16.37	([a])	14.74	2.219E-05	-2.131E-02	6.967E+00

941	5.85	([a])	16.41	2.219E-05	-2.131E-02	6.967E+00
942	14.13	([a])	16.85	2.219E-05	-2.131E-02	6.967E+00
943	21.10	([a])	16.09	2.219E-05	-2.131E-02	6.967E+00
944	15.63	([a])	15.23	2.219E-05	-2.131E-02	6.967E+00
945	12.67	62.52	14.22	2.219E-05	-2.131E-02	6.967E+00
946	14.86	69.36	13.02	2.219E-05	-2.131E-02	6.967E+00
947	24.79	60.00	12.47	2.219E-05	-2.131E-02	6.967E+00
948	33.06	63.79	13.05	2.219E-05	-2.131E-02	6.967E+00
949	42.29	75.36	14.26	2.219E-05	-2.131E-02	6.967E+00
950	48.90	80.00	15.09	2.219E-05	-2.131E-02	6.967E+00
951	51.52	80.00	15.42	2.219E-05	-2.131E-02	6.967E+00
952	48.24	79.92	15.96	2.219E-05	-2.131E-02	6.967E+00
953	51.79	65.03	16.58	2.219E-05	-2.131E-02	6.967E+00
954	52.37	43.23	17.61	2.219E-05	-2.131E-02	6.967E+00
955	56.14	50.00	18.33	2.219E-05	-2.131E-02	6.967E+00
956	62.35	50.00	18.65	2.219E-05	-2.131E-02	6.967E+00
957	64.29	42.05	19.67	2.219E-05	-2.131E-02	6.967E+00
958	67.69	40.00	20.47	2.219E-05	-2.131E-02	6.967E+00
959	75.20	42.20	20.57	2.219E-05	-2.131E-02	6.967E+00
960	74.88	41.28	20.68	2.219E-05	-2.131E-02	6.967E+00
961	71.92	([a])	21.56	2.219E-05	-2.131E-02	6.967E+00
962	71.88	([a])	23.19	2.219E-05	-2.131E-02	6.967E+00
963	69.64	([a])	23.64	7.398E-06	-7.105E-03	2.322E+00
964	71.24	([a])	22.75	-7.398E-06	7.105E-03	-2.322E+00
965	71.72	30.54	21.81	-2.219E-05	2.131E-02	-6.967E+00
966	76.41	42.12	20.79	-2.219E-05	2.131E-02	-6.967E+00
967	73.02	50.00	19.86	-2.219E-05	2.131E-02	-6.967E+00
968	69.64	50.00	19.18	-2.219E-05	2.131E-02	-6.967E+00
969	72.09	43.16	18.75	-2.219E-05	2.131E-02	-6.967E+00
970	82.23	73.65	18.43	-2.219E-05	2.131E-02	-6.967E+00
971	78.58	([a])	18.61	-2.219E-05	2.131E-02	-6.967E+00
972	75.00	([a])	19.11	-2.219E-05	2.131E-02	-6.967E+00
973	75.00	([a])	18.76	-2.219E-05	2.131E-02	-6.967E+00
974	72.47	([a])	17.68	-2.219E-05	2.131E-02	-6.967E+00
975	62.91	([a])	16.46	-2.219E-05	2.131E-02	-6.967E+00
976	58.93	13.57	15.06	-2.219E-05	2.131E-02	-6.967E+00
977	55.56	29.43	13.41	-2.219E-05	2.131E-02	-6.967E+00
978	57.14	20.00	11.91	-2.219E-05	2.131E-02	-6.967E+00
979	56.68	17.42	11.09	-2.219E-05	2.131E-02	-6.967E+00
980	53.88	10.00	10.90	-2.219E-05	2.131E-02	-6.967E+00
981	50.76	10.00	11.40	-2.219E-05	2.131E-02	-6.967E+00
982	50.00	([a])	12.38	-2.219E-05	2.131E-02	-6.967E+00
983	46.83	([a])	13.02	-2.219E-05	2.131E-02	-6.967E+00

984	35.63	10.00	12.30	-2.219E-05	2.131E-02	-6.967E+00
985	32.48	10.00	10.32	-2.219E-05	2.131E-02	-6.967E+00
986	26.79	10.00	9.70	-2.219E-05	2.131E-02	-6.967E+00
987	24.94	10.00	11.05	-2.219E-05	2.131E-02	-6.967E+00
988	23.21	16.74	11.88	-2.219E-05	2.131E-02	-6.967E+00
989	24.70	3.36	12.21	-2.219E-05	2.131E-02	-6.967E+00
990	25.00	([a])	13.29	-2.219E-05	2.131E-02	-6.967E+00
991	24.47	([a])	13.73	-2.219E-05	2.131E-02	-6.967E+00
992	18.71	([a])	12.77	-2.219E-05	2.131E-02	-6.967E+00
993	10.85	([a])	11.46	-2.219E-05	2.131E-02	-6.967E+00
994	3.40	([a])	9.84	-2.219E-05	2.131E-02	-6.967E+00
995	0	0	7.62	-2.219E-05	2.131E-02	-6.967E+00
996	0	0	3.57	-2.219E-05	2.131E-02	-6.967E+00
997	0	0.91	1.33	-2.219E-05	2.131E-02	-6.967E+00
998	0	7.52	0	-2.219E-05	2.131E-02	-6.967E+00
999	0	0	0	-2.219E-05	2.131E-02	-6.967E+00
1,000	0	0	0	-4.577E-06	5.686E-03	-3.784E+00
1,001	0	0	0	1.304E-05	-9.944E-03	-6.018E-01
1,002	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,003	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,004	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,005	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,006	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,007	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,008	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,009	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,010	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,011	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,012	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,013	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,014	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,015	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,016	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,017	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,018	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,019	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,020	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,021	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,022	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,023	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,024	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,025	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,026	0	0	0	3.066E-05	-2.557E-02	2.581E+00

1,027	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,028	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,029	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,030	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,031	1.58	([a])	0	3.066E-05	-2.557E-02	2.581E+00
1,032	1.43	([a])	0	3.066E-05	-2.557E-02	2.581E+00
1,033	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,034	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,035	1.91	9.28	0	3.066E-05	-2.557E-02	2.581E+00
1,036	2.75	0	0	3.066E-05	-2.557E-02	2.581E+00
1,037	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,038	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,039	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,040	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,041	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,042	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,043	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,044	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,045	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,046	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,047	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,048	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,049	0	5.51	0	3.066E-05	-2.557E-02	2.581E+00
1,050	0	11.34	0	3.066E-05	-2.557E-02	2.581E+00
1,051	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,052	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,053	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,054	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,055	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,056	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,057	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,058	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,059	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,060	0	0.21	0	3.066E-05	-2.557E-02	2.581E+00
1,061	0	30.00	0	3.066E-05	-2.557E-02	2.581E+00
1,062	0	26.78	0	3.066E-05	-2.557E-02	2.581E+00
1,063	0	20.00	0	3.066E-05	-2.557E-02	2.581E+00
1,064	0	20.00	0	3.066E-05	-2.557E-02	2.581E+00
1,065	0	4.12	0	3.066E-05	-2.557E-02	2.581E+00
1,066	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,067	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,068	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,069	0	0	0	3.066E-05	-2.557E-02	2.581E+00

1,070	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,071	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,072	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,073	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,074	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,075	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,076	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,077	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,078	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,079	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,080	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,081	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,082	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,083	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,084	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,085	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,086	0	20.00	0	3.066E-05	-2.557E-02	2.581E+00
1,087	0	20.00	0	3.066E-05	-2.557E-02	2.581E+00
1,088	0	11.73	0	3.066E-05	-2.557E-02	2.581E+00
1,089	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,090	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,091	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,092	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,093	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,094	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,095	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,096	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,097	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,098	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,099	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,100	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,101	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,102	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,103	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,104	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,105	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,106	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,107	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,108	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,109	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,110	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,111	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,112	0	0	0	3.066E-05	-2.557E-02	2.581E+00

1,113	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,114	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,115	0	0	0	3.066E-05	-2.557E-02	2.581E+00
1,116	0	73.41	0	3.066E-05	-2.557E-02	2.581E+00
1,117	0	90.00	0	3.066E-05	-2.557E-02	2.581E+00
1,118	27.95	81.30	2.83	3.066E-05	-2.557E-02	2.581E+00
1,119	36.74	90.00	5.87	3.066E-05	-2.557E-02	2.581E+00
1,120	39.29	90.00	8.67	3.066E-05	-2.557E-02	2.581E+00
1,121	41.44	90.00	11.47	3.066E-05	-2.557E-02	2.581E+00
1,122	45.57	82.41	14.26	3.066E-05	-2.557E-02	2.581E+00
1,123	59.52	80.00	16.91	3.066E-05	-2.557E-02	2.581E+00
1,124	66.99	90.00	18.33	3.066E-05	-2.557E-02	2.581E+00
1,125	80.22	90.00	19.35	3.066E-05	-2.557E-02	2.581E+00
1,126	86.41	93.88	21.55	3.066E-05	-2.557E-02	2.581E+00
1,127	86.53	50.94	24.84	3.066E-05	-2.557E-02	2.581E+00
1,128	84.46	17.02	26.81	3.066E-05	-2.557E-02	2.581E+00
1,129	88.54	28.60	28.36	2.397E-05	-2.025E-02	2.539E+00
1,130	89.29	39.83	30.31	1.729E-05	-1.494E-02	2.498E+00
1,131	89.29	30.00	30.82	1.060E-05	-9.616E-03	2.457E+00
1,132	89.29	26.69	30.86	1.060E-05	-9.616E-03	2.457E+00
1,133	90.16	20.00	31.82	1.060E-05	-9.616E-03	2.457E+00
1,134	89.92	20.00	33.33	1.060E-05	-9.616E-03	2.457E+00
1,135	89.29	36.06	34.20	1.060E-05	-9.616E-03	2.457E+00
1,136	85.86	40.00	33.82	1.060E-05	-9.616E-03	2.457E+00
1,137	85.51	30.00	33.51	1.060E-05	-9.616E-03	2.457E+00
1,138	84.42	32.75	33.87	1.060E-05	-9.616E-03	2.457E+00
1,139	86.48	35.68	34.70	1.060E-05	-9.616E-03	2.457E+00
1,140	88.55	30.00	36.14	1.060E-05	-9.616E-03	2.457E+00
1,141	89.29	44.93	37.60	1.060E-05	-9.616E-03	2.457E+00
1,142	90.90	50.00	38.09	1.060E-05	-9.616E-03	2.457E+00
1,143	77.27	([a])	38.13	3.535E-06	-3.205E-03	8.188E-01
1,144	56.75	([a])	38.05	-3.535E-06	3.205E-03	-8.188E-01
1,145	50.00	([a])	37.47	-1.060E-05	9.616E-03	-2.457E+00
1,146	41.07	([a])	36.69	-1.060E-05	9.616E-03	-2.457E+00
1,147	37.38	45.18	35.89	-1.060E-05	9.616E-03	-2.457E+00
1,148	34.21	78.47	35.06	-1.060E-05	9.616E-03	-2.457E+00
1,149	32.13	80.00	34.63	-1.060E-05	9.616E-03	-2.457E+00
1,150	27.71	80.00	34.13	-1.060E-05	9.616E-03	-2.457E+00
1,151	22.64	80.00	33.15	-1.060E-05	9.616E-03	-2.457E+00
1,152	20.58	60.97	32.12	-1.060E-05	9.616E-03	-2.457E+00
1,153	16.25	27.34	31.02	-1.060E-05	9.616E-03	-2.457E+00
1,154	11.46	43.71	29.82	-1.060E-05	9.616E-03	-2.457E+00
1,155	9.02	68.95	28.41	-1.060E-05	9.616E-03	-2.457E+00

1,156	3.38	68.95	26.91	-1.060E-05	9.616E-03	-2.457E+00
1,157	1.32	44.28	25.53	-1.060E-05	9.616E-03	-2.457E+00
1,158	0	0	24.21	-1.060E-05	9.616E-03	-2.457E+00
1,159	0	0	22.88	-1.060E-05	9.616E-03	-2.457E+00
1,160	0	0	18.40	-1.060E-05	9.616E-03	-2.457E+00
1,161	0	0	13.93	-1.060E-05	9.616E-03	-2.457E+00
1,162	0	0	9.45	-1.060E-05	9.616E-03	-2.457E+00
1,163	0	0	4.98	-1.060E-05	9.616E-03	-2.457E+00
1,164	0	0	0.50	-7.069E-06	6.411E-03	-1.638E+00
1,165	0	24.97	0	-3.535E-06	3.205E-03	-8.188E-01
1,166	0	17.16	0	0	0	0
1,167	0	6.20	0	0	0	0
1,168	0	10.00	0	0	0	0
1,169	0	10.00	0	0	0	0
1,170	0	0	0	0	0	0
1,171	0	0	0	0	0	0
1,172	0	0	0	0	0	0
1,173	0	0	0	0	0	0
1,174	0	0	0	0	0	0
1,175	0	0	0	0	0	0
1,176	0	0	0	0	0	0
1,177	0	0	0	0	0	0
1,178	0	0	0	0	0	0
1,179	0	0	0	0	0	0
1,180	0	0	0	0	0	0
1,181	0	0	0	0	0	0
1,182	0	0	0	0	0	0
1,183	0	0	0	0	0	0
1,184	0	0	0	0	0	0
1,185	0	0	0	0	0	0
1,186	0	0	0	0	0	0
1,187	0	0	0	0	0	0
1,188	0	0	0	0	0	0
1,189	0	0	0	0	0	0
1,190	0	0	0	0	0	0
1,191	0	0	0	0	0	0
1,192	0	0	0	0	0	0
1,193	0	0	0	0	0	0
1,194	0	0	0	0	0	0
1,195	0	0	0	0	0	0
1,196	0	0	0	0	0	0
1,197	0	0	0	0	0	0
1,198	0	0	0	0	0	0

1,199	0	0	0	0	0	0

[a]Closed throttle motoring.

PART 1037—CONTROL OF EMISSIONS FROM NEW HEAVY-DUTY MOTOR VEHICLES

127. The authority citation for part 1037 continues to read as follows:
Authority: 42 U.S.C. 7401 - 7671q.

128. Amend § 1037.103 by revising paragraph (c) to read as follows:

§ 1037.103 Evaporative and refueling emission standards.

*   *   *   *   *

(c) Compliance demonstration. You may provide a statement in the application for certification that vehicles above 14,000 pounds GVWR comply with evaporative and refueling emission standards instead of submitting test data if you include an engineering analysis describing how vehicles include design parameters, equipment, operating controls, or other elements of design that adequately demonstrate that vehicles comply with the standards throughout the useful life. We would expect emission control components and systems to exhibit a comparable degree of control relative to vehicles that comply based on testing. For example, vehicles that comply under this paragraph (c) should rely on comparable material specifications to limit fuel permeation, and components should be sized and calibrated to correspond with the appropriate fuel capacities, fuel flow rates, purge strategies, and other vehicle operating characteristics. You may alternatively show that design parameters are comparable to those for vehicles at or below 14,000 pounds GVWR certified under 40 CFR part 86, subpart S.

*   *   *   *   *

129. Amend § 1037.105 by revising paragraph (h)(1) to read as follows:

§ 1037.105 CO_2 emission standards for vocational vehicles.

*   *   *   *   *

(h) *   *   *

(1) The following alternative emission standards apply by vehicle type and model year as follows:

Table 5 of § 1037.105—Phase 2 Custom Chassis Standards (g/ton-mile)

VEHICLE TYPE[1][A]	ASSIGNED VEHICLE SERVICE CLASS	MY 2021-2026	MY 2027+
School bus	Medium HDV	291	271
Motor home	Medium HDV	228	226
Coach bus	Heavy HDV	210	205
Other bus	Heavy HDV	300	286
Refuse hauler	Heavy HDV	313	298
Concrete mixer	Heavy HDV	319	316
Mixed-use vehicle	Heavy HDV	319	316
Emergency vehicle	Heavy HDV	324	319

[1][a]Vehicle types are generally defined in § 1037.801. “Other bus” includes any bus that is not a school bus or a coach bus. A “mixed-use vehicle” is one that meets at least one of the criteria specified in § 1037.631(a)(1) and at least one of the criteria in § 1037.631(a)(2), but not both.

*   *   *   *   *

130. Amend § 1037.106 by revising paragraphs (b) and (f)(2)(i) to read as follows:

§ 1037.106 Exhaust emission standards for tractors above 26,000 pounds GVWR.

*   *   *   *   *

(b) The CO_2 standards for tractors above 26,000 pounds GVWR in Table 1 of this section apply based on modeling and testing as described in subpart F of this part. The provisions of § 1037.241 specify how to comply with these standards.

Table 1 of § 1037.106—CO_2 Standards for
Class 7 and Class 8 Tractors by Model Year (g/ton-mile)

SUBCATEGORY[1A]	PHASE 1 STANDARDS FOR MODEL YEARS 2014-2016	PHASE 1 STANDARDS FOR MODEL YEARS 2017-2020	PHASE 2 STANDARDS FOR MODEL YEARS 2021-2023	PHASE 2 STANDARDS FOR MODEL YEARS 2024-2026	PHASE 2 STANDARDS FOR MODEL YEAR 2027 AND LATER
Class 7 Low-Roof (all cab styles)	107	104	105.5	99.8	96.2
Class 7 Mid-Roof (all cab styles)	119	115	113.2	107.1	103.4
Class 7 High-Roof (all cab styles)	124	120	113.5	106.6	100.0
Class 8 Low-Roof Day Cab	81	80	80.5	76.2	73.4
Class 8 Low-Roof Sleeper Cab	68	66	72.3	68.0	64.1
Class 8 Mid-Roof Day Cab	88	86	85.4	80.9	78.0
Class 8 Mid-Roof Sleeper Cab	76	73	78.0	73.5	69.6
Class 8 High-Roof Day Cab	92	89	85.6	80.4	75.7
Class 8 High-Roof Sleeper Cab	75	72	75.7	70.7	64.3
Heavy-Haul Tractors	—	—	52.4	50.2	48.3

[a1]Sub-category terms are defined in § 1037.801.

*   *   *   *   *

(f) *   *   *

(2) *   *   *

(i) If you certify all your Class 7 tractors to Class 8 standards, you may use these Heavy HDV credits without restriction. This applies equally for hybrid and electric vehicles.

*   *   *   *   *

131. Amend § 1037.115 by revising paragraph (e) to read as follows:

§ 1037.115 Other requirements.

*   *   *   *   *

(e) Air conditioning leakage. Loss of refrigerant from your air conditioning systems may not exceed a total leakage rate of 11.0 grams per year or a percent leakage rate of 1.50 percent per year, whichever is greater. This applies for all refrigerants. Calculate the total leakage rate in g/year as specified in 40 CFR 86.1867-12(a). Calculate the percent leakage rate as: [total leakage rate (g/yr)] ÷ [total refrigerant capacity (g)] × 100. Round your percent leakage rate to the nearest one-hundredth of a percent.

(1) This paragraph (e) is intended to address air conditioning systems for which the primary purpose is to cool the driver compartment. This would generally include all cab-complete

pickups and vans. This paragraph (e) does not apply for refrigeration units on trailers.; similarlySimilarly, it this paragraph (e) does not apply for self-contained air conditioning used to cool passengers or refrigeration units used to cool cargo on vocational vehicles even if . Air conditioning and refrigeration units may be considered self-contained whether or not they draw electrical power from engines used to propel the vehicles. For purposes of this paragraph (e), a self-contained system is an enclosed unit with its own evaporator and condenser even if it draws power from the engine.

(2) For purposes of this requirement, "refrigerant capacity" is the total mass of refrigerant recommended by the vehicle manufacturer as representing a full charge. Where full charge is specified as a pressure, use good engineering judgment to convert the pressure and system volume to a mass.

(3) If air conditioning systems with capacity above 3000 grams of refrigerant are designed such that a compliance demonstration under 40 CFR 86.1867-12(a) is impossible or impractical, you may ask to use alternative means to demonstrate that your air conditioning system achieves an equivalent level of control.

132. Amend § 1037.120 by revising paragraph (b)(1)(i) and (ii) to read as follows:

§ 1037.120 Emission-related warranty requirements.

* * * * *

(b)(1) * * *

(i) 5 years or 50,000 miles for Light HDV (except tires).

(ii) 5 years or 100,000 miles for Medium HDV and Heavy HDV (except tires).

* * * * *

§ 1037.135—[Revised]

133. Amend § 1037.135 by removing and reserving paragraph (c)(4).

134. Amend § 1037.140 by revising paragraphs (g) and (h) to read as follows:

§ 1037.140 Classifying vehicles and determining vehicle parameters.

* * * * *

(g) The standards and other provisions of this part apply to specific vehicle service classes for tractors and vocational vehicles as follows:

(1) Phase 1 and Phase 2 tractors are divided based on GVWR into Class 7 tractors and Class 8 tractors. Where provisions apply to both tractors and vocational vehicles, Class 7 tractors are considered "Medium HDV" and Class 8 tractors are considered "Heavy HDV". This applies for bothelectric, hybrid, and non-hybrid vehicles.

(2) Phase 1 vocational vehicles are divided based on GVWR. "Light HDV" includes Class 2b through Class 5 vehicles; "Medium HDV includes Class 6 and Class 7 vehicles; and "Heavy HDV includes Class 8 vehicles.

(3) or Phase 2 vocational vehicles propelled by engines subject to the with spark-ignition standards of 40 CFR part 1036. For these vehicles, engines are divided based on GVWR. "Light HDV" includes Class 2b through Class 5 vehicles, and "Medium HDV" includes Class 6 through Class 8 vehicles.

(4) This paragraph (g)(34) applies for Phase 2 vocational vehicles propelled by engines subject to the Phase 2 vocational vehicles with compression-ignition standards in or 40 CFR part 1036.engines are divided as follows:

(i) Class 2b through Class 5 vehicles are considered “Light HDV”.
(ii) Class 6 through 8 vehicles are considered “Heavy HDV” if the installed engine’s primary intended service class is heavy heavy-duty (see 40 CFR 1036.140).
(iii) Class 8 hybrid and electric vehicles are considered “Heavy HDV”, regardless of the engine’s primary intended service class.
(iv) All other Class 6 through Class 8 vehicles are considered “Medium HDV”.

(5) In certain circumstances, you may certify vehicles to standards that apply for a different vehicle service class. For example, see §§ 1037.105(g) and 1037.106(f). If you optionally certify vehicles to different standards, those vehicles are subject to all the regulatory requirements as if the standards were mandatory.

(h) Use good engineering judgment to identify the intended regulatory subcategory duty cycle (Urban, Multi-Purpose, or Regional) for each of your vocational vehicle configurations based on the expected use of the vehicles.

135. Amend § 1037.150 by revising paragraphs (c), (q)(2), (s), (u), (x) introductory text, (y), (z), and (aa) to read as follows:

§ 1037.150 Interim provisions.

* * * * *

(c) Provisions for sSmall manufacturers. The following provisions apply for small manufacturers:Standards apply on a delayed schedule for manufacturers meeting the small business criteria specified in 13 CFR 121.201. Apply the small business criteria for NAICS code 336120 for vocational vehicles and tractors and 336212 for trailers; the employee limits apply to the total number employees together for affiliated companies.

(1) Small manufacturers are not subject to the greenhouse gas standards of § 1037.107 for trailers with a date of manufacture before January 1, 2019.

(2) TQualifying small manufacturers are not subject to the greenhouse gas standards of §§ 1037.105 and 1037.106 are optional for small manufacturers producing vehicles with a date of manufacture before January 1, 2022. Similarly, qualifying small manufacturers are not subject to the greenhouse gas standards of § 1037.107 for trailers with a date of manufacture before January 1, 2019. In addition, qualifying small manufacturers producing vehicles that run on any fuel other than gasoline, E85, or diesel fuel may delay complying with every later standard under this part by one model year.

(3) Qualifying manufacturers must notify the Designated Compliance Officer each model year before introducing these excluded vehicles into U.S. commerce. This notification must include a description of the manufacturer’s qualification as a small business under 13 CFR 121.201. You Manufacturers must label your excluded vehicles with the following statement: “THIS VEHICLE IS EXCLUDED UNDER 40 CFR 1037.150(c).”Small manufacturers may certify their vehicles under this part 1037 before standards start to apply; however, they may generate emission credits only if they certify their entire U.S. directed production volume within the applicable averaging set for that model year

(4) Small manufacturers may meet Phase 1 standards instead of Phase 2 standards in the first year Phase 2 standards apply to them if they voluntarily comply with the Phase 1 standards for the full preceding year. Specifically, small manufacturers may certify their model year 2022 vehicles to the Phase 1 greenhouse gas standards of §§ 1037.105 and 1037.106 if they certify all the vehicles from their annual U.S.-directed production volume to the Phase 1

standards starting on or before January 1, 2021.

(5) See paragraphs (r), (t), (y), and (aa) of this section for additional allowances for small manufacturers.

* * * * *

(q) * * *

(2) For vocational vehicles and tractors subject to Phase 2 standards, create separate vehicle subfamilies if there is a credit multiplier for advanced technology; group those vehicles together in a vehicle subfamily if they use the same multiplier.

* * * * *

(s) Confirmatory testing for $F_{alt-aero}$. If we conduct coastdown testing to verify your $F_{alt-aero}$ value for Phase 2 tractors, we will make our determination using ~~a statistical analysis consistent with~~ the principles of SEA testing in § 1037.305. We will ~~calculate confidence intervals~~ not replace your $F_{alt-aero}$ value if the tractor passes. If your tractor fails, we will generate a replacement value of $F_{alt-aero}$ based on at least one C_dA value and corresponding effective yaw angle, ψ_{eff}, from a minimum of 100 valid runs using the procedures of § 1037.528(h). ~~the same SEA equations and will not replace your test results with ours if your result falls within our confidence interval or is greater than our test result.~~ Note that we intend to minimize the differences between our test conditions and those of the manufacturer by testing at similar times of the year where possible and the same location where possible and when appropriate.

* * * * *

(u) Streamlined preliminary approval for trailer devices. Before January 1, 2018, manufacturers of aerodynamic devices for trailers may ask for preliminary EPA approval of compliance data for their devices based on qualifying for designation under the SmartWay program based on measured C_dA values, whether or not that involves testing or other methods specified in § 1037.526. Trailer manufacturers may certify based on ΔC_dA values established under this paragraph (u) through model year 2020. Manufacturers must perform testing as specified in subpart F of this part for any vehicles or aerodynamic devices not qualifying for approval under this paragraph (u).

* * * * *

(x) Aerodynamic testing for trailers. Section 1037.526 generally requires you to adjust ΔC_dA values from alternate test methods to be equivalent to measurements with the primary test method. This paragraph (x) describes approximations that we believe are consistent with good engineering judgment; however, you may not use these approximations where we determine that clear and convincing evidence shows that they would significantly overestimate actual improvements in aerodynamic performance.

* * * * *

(y) Transition to Phase 2 standards. The following provisions allow for enhanced generation and use of emission credits from Phase 1 tractors and vocational vehicles for meeting the Phase 2 standards:

(1) For vocational Light HDV and vocational Medium HDV, emission credits you generate in model years 2018 through 2021 may be used through model year 2027, instead of being limited to a five-year credit life as specified in § 1037.740(c). For Class 8 vocational vehicles with medium heavy-duty engines, we will approve your request to generate these credits in and use these credits for the Medium HDV averaging set if you show that these vehicles would qualify as Medium HDV under the Phase 2 program as described in § 1037.140(g)(4).

Commented [CAL14]: Note that eCFR has the "A" incorrectly subscripted in both uses of C_dA in this paragraph.

Commented [CAL15]: Note that eCFR has the "A" incorrectly subscripted.

(2) You may use the off-cycle provisions of § 1037.610 to apply technologies to Phase 1 vehicles as follows:

(i) You may apply an improvement factor of 0.988 for tractors and vocational vehicles with automatic tire inflation systems on all axles.

(ii) For vocational vehicles with automatic engine shutdown systems that conform with § 1037.660, you may apply an improvement factor of 0.95.

(iii) For vocational vehicles with stop-start systems that conform with § 1037.660, you may apply an improvement factor of 0.92.

(iv) For vocational vehicles with neutral-idle systems conforming with § 1037.660, you may apply an improvement factor of 0.98. You may adjust this improvement factor if we approve a partial reduction under § 1037.660(a)(2); for example, if your design reduces fuel consumption by half as much as shifting to neutral, you may apply an improvement factor of 0.99.

(3) Small manufacturers may generate emission credits for natural gas-fueled vocational vehicles as follows:

(i) Small manufacturers may certify their vehicles instead of relying on the exemption of paragraph (c) of this section. The provisions of this part apply for such vehicles, except as specified in this paragraph (y)(3).

(ii) Use Phase 1 GEM version 2.0.1 to determine a CO_2 emission level for your vehicle, then multiply this value by the engine's FCL for CO_2 and divide by the engine's applicable CO_2 emission standard.

(4) Phase 1 vocational vehicle credits that small manufacturers generate may be used through model year 2027.Small manufacturers that certify their entire U.S.-directed production volume to the Phase 1 standards for calendar year 2021 may certify to the Phase 1 standards for model year 2022 (instead of the otherwise applicable Phase 2 standards). Vocational vehicle manufacturers that certify their vehicles in calendar year 2021 as specified in paragraph (c) may apply Phase 1 vehicle credits they generate from model years 2018 through 2022 vocational vehicles may be used through model year 2027 (instead of being subject to the five-year credit life).

(z) Constraints for vocational regulatory subcategoriesduty cycles. The following provisions apply to determinations of vocational regulatory subcategories duty cycles as described in § 1037.140:

(1) Select theThe Regional regulatory subcategory duty cycle applies if you certify the engine was certified based on testing only with the Supplemental Emission Testramped-modal cycle.

(2) The Select the Regional regulatory subcategory duty cycle applies for coach buses and motor homes you certify under § 1037.105(b).

(3) You may not select the Urban regulatory subcategoryduty cycle for any vehicle with a manual or single-clutch automated manual transmission.

(4) Starting in model year 2024, you must select the Regional regulatory subcategoryduty cycle for any vehicle with a manual transmission.

(5) You may select the Multi-purpose regulatory subcategory for any vocational vehicle, except as specified in paragraphs (z)(1) through (3) of this section.

(6) You may not select the Urban regulatory subcategory for any vehicle with a manual or single-clutch automated manual transmission.

(75) You may select the Urban regulatory subcategoryduty cycle for a hybrid vehicle

equipped with regenerative braking, unless it is equipped with a manual transmission.

(86) You may select the Urban regulatory subcategory duty cycle for any vehicle with a hydrokinetic torque converter paired with an automatic transmission, or a continuously variable automatic transmission, or a dual-clutch transmission with no more than two consecutive forward gears between which it is normal for both clutches to be momentarily disengaged.

(aa) Custom-chassis standards. The following provisions apply uniquely to small manufacturers under the custom-chassis standards of § 1037.105(h):

(1) You may use emission credits generated under § 1037.105(d), including banked or traded credits from any averaging set. Such credits remain subject to other limitations that apply under subpart H of this part.

(2) You may produce up to 200 drayage tractors in a given model year to the standards described in § 1037.105(h) for "other buses". This limit applies with respect to vehicles produced by you and your affiliated companies. Treat these drayage tractors as being in their own averaging set.

~~(bb) Applying good engineering judgment in selecting vocational duty cycles. Except as specified in paragraph (z) of this section, compliance with the following criteria is deemed to be consistent with good engineering judgment. Note that the paragraph (bb) does address whether other selection criteria are or are not consistent with good engineering judgment.~~

~~(1) Any vocational vehicle may be classified as Multi-purpose.~~

~~(2) Your vocational vehicles not classified as Multi-purpose must be classified and Regional and Urban as specified in this paragraph (bb)(2). We are proposing a quantitative measure of that evaluates the ratio Regional vehicles to Urban vehicles within an averaging set. Specifically, ratio of Regional vehicles to Urban vehicles in each averaging set must be between 1:5 and 5:1. An equivalent way of saying this is that the number of Regional vehicles divided by the number of Urban vehicles would need to be between 0.20 and 5.0.~~

136. Amend § 1037.201 by revising paragraph (h) to read as follows:

§ 1037.201 General requirements for obtaining a certificate of conformity.

* * * * *

(h) The certification and testing provisions of 40 CFR part 86, subpart S, apply instead of the provisions of this subpart relative to the evaporative and refueling emission standards specified in § 1037.103, except that § 1037.243245 describes how to demonstrate compliance with evaporative emission standards. For vehicles that do not use an evaporative canister for controlling diurnal emissions, you may certify with respect to exhaust emissions and use the provisions of § 1037.622 to let a different company certify with respect to evaporative emissions.

* * * * *

137. Amend § 1037.205 by revising paragraphs (e) amd (f) to read as follows:

§ 1037.205 What must I include in my application?

* * * * *

(e) Describe any test equipment and procedures that you used, including any special or alternate test procedures you used (see § 1037.501). Include information describing the procedures you used to determine C_dA values as specified in §§ 1037.525 through 1037.527. Describe which type of data you are using for engine fuel maps (see 40 CFR 1036.510503). If your trailer certification relies on approved data from device manufacturers, identify the device and device manufacturer.

(f) Describe how you operated any emission-data vehicle before testing, including the duty cycle and the number of vehicle operating miles used to stabilize emission-related performance. Explain why you selected the method of service accumulation. Describe any scheduled maintenance you did, and any practices or specifications that should apply for our testing.

* * * * *

138. Amend § 1037.225 by revising paragraph (e) to read as follows:

§ 1037.225 Amending applications for certification.

* * * * *

(e) The amended application applies starting with the date you submit the amended application, as follows:

(1) For vehicle families already covered by a certificate of conformity, you may start producing ~~the~~ a new or modified vehicle configuration any time after you send us your amended application and before we make a decision under paragraph (d) of this section. However, if we determine that the affected vehicles do not meet applicable requirements, we will notify you to cease production of the vehicles and may require you to recall the vehicles at no expense to the owner. Choosing to produce vehicles under this paragraph (e) is deemed to be consent to recall all vehicles that we determine do not meet applicable emission standards or other requirements and to remedy the nonconformity at no expense to the owner. If you do not provide information required under paragraph (c) of this section within 30 days after we request it, you must stop producing the new or modified vehicles.

(2) [Reserved]

* * * * *

139. Amend § 1037.230 by revising paragraph (a)(2) to read as follows:

§ 1037.230 Vehicle families, sub-families, and configurations.

(a) * * *

(2) Apply subcategories for tractors (other than vocational tractors) as shown in Table 2 of this section.

(i) For vehicles certified to the optional tractor standards in § 1037.670, assign the subcategories as described in § 1037.670.

(ii) For vehicles intended for export to Canada, you may assign the subcategories as specified in the Canadian regulations.

(iii) Table 2 follows:

Table 2 of § 1037.230— Tractor Subcategories

CLASS 7	CLASS 8	
Low-roof tractors	Low-roof day cabs	Low-roof sleeper cabs
Mid-roof tractors	Mid-roof day cabs	Mid-roof sleeper cabs
High-roof tractors	High-roof day cabs	High-roof sleeper cabs
—	Heavy-haul tractors (starting with Phase 2)	

* * * * *

140. Amend § 1037.231 by revising paragraph (b)(7) to read as follows:

§ 1037.231 Powertrain families.

* * * * *

(b) * * *

(7) Number of available forward gears, and transmission gear ratio for each available forward gear, if applicable. Count forward gears as being available only if the vehicle has the hardware and software to allow operation in those gears.

* * * * *

141. Amend § 1037.235 by revising paragraphs (a), (c)(2), and (h) to read as follows:

§ 1037.235 Testing requirements for certification.

* * * * *

(a) Select emission-data vehicles that represent production vehicles and components for the vehicle family consistent with the specifications in §§ 1037.205(o), 1037.515, and 1037.520. Where the test results will represent multiple vehicles or components with different emission performance, use good engineering judgment to select worst-case emission data vehicles or components. In the case of powertrain testing under § 1037.550, select a test engine, test hybrid components, test axle and test transmission as applicable, by considering the whole range of vehicle models covered by the powertrain family and the mix of duty cycles specified in § 1037.510. If the powertrain has more than one transmission calibration, for example economy vs. performance, you may weight the results from the powertrain testing in § 1037.550 by the percentage of vehicles in the family by prior model year for each configuration. This can be done, for example, through the use of survey data or based on the previous model year's sales volume. Weight the results of $M_{\text{fuel[cycle]}}$, $\frac{f_{\text{npowertrain}}}{v_{\text{powertrain}}}$, and $W_{\text{[cycle]}}$ from Table 2 of § 1037.550 according to the percentage of vehicles in the family that use each transmission calibration.

* * * * *

(c) * * *

(2) If we measure emissions (or other parameters, as applicable) from your vehicle or component, the results of that testing become the official emission results for the vehicle or component. Note that changing the official emission result does not necessarily require a change in the declared modeling input value. These results will only affect your vehicle FEL if the results of our confirmatory testing result in a GEM vehicle emission value that is higher than the vehicle FEL declared by the manufacturer. Unless we later invalidate these data, we may decide not to consider your data in determining if your vehicle family meets applicable requirements.

* * * * *

(h) You may ask us to use analytically derived GEM inputs for untested configurations (such as untested axle ratios within an axle family) as identified in subpart F of this part based on interpolation of all relevant measured values for related configurations, consistent with good engineering judgment. We may establish specific approval criteria based on prevailing industry practice. If we allow this, we may test any configuration~~s~~. We may also require you to test any configuration~~s~~ as part of a selective enforcement audit.

142. Amend § 1037.243 by revising paragraph (c) to read as follows:

§ 1037.243 Demonstrating compliance with evaporative emission standards.

* * * * *

(c) A~~To compare emission levels with emission standards, a~~pply deterioration factors to ~~the~~ measured emission levels for comparing to the emission standard. Establish an additive deterioration factor based on an engineering analysis that takes into account the expected aging from in-use vehicles.

*   *   *   *   *

143. Revise § 1037.255 to read as follows:

§ 1037.255 What decisions may EPA make regarding my certificate of conformity?

(a) If we determine ~~your~~ an application is complete and shows that the vehicle family meets all the requirements of this part and the Act, we will issue a certificate of conformity for ~~your~~ the vehicle family for that model year. We may make the approval subject to additional conditions.

(b) We may deny ~~your~~ an application for certification if we determine that ~~your~~ a vehicle family fails to comply with emission standards or other requirements of this part or the Clean Air Act. We will base our decision on all available information. If we deny ~~your~~ an application, we will explain why in writing.

(c) In addition, we may deny ~~your~~ an application or suspend or revoke ~~your~~ a certificate of conformity if you do any of the following:

(1) Refuse to comply with any testing or reporting requirements.

(2) Submit false or incomplete information ~~(paragraph (e) of this section applies if this is fraudulent)~~. This includes doing anything after submitting an application that causes ~~submission of your application to render any of the~~ submitted information to be false or incomplete.

(3) Cause any test data to become inaccurate~~Render any test data inaccurate~~.

(4) Deny us from completing authorized activities (see 40 CFR 1068.20). This includes a failure to provide reasonable assistance.

(5) Produce vehicles for importation into the United States at a location where local law prohibits us from carrying out authorized activities.

(6) Fail to supply requested information or amend ~~your~~ an application to include all vehicles being produced.

(7) Take any action that otherwise circumvents the intent of the Act or this part~~, with respect to your a vehicle family~~.

(d) We may void ~~the~~ a certificate of conformity ~~for a vehicle family~~ if you fail to keep records, send reports, or give us information as required under this part or the Act. Note that these are also violations of 40 CFR 1068.101(a)(2).

(e) We may void ~~your~~ a certificate of conformity ~~for a vehicle family~~ if we find that you intentionally submitted false or incomplete information. This includes doing anything after submitting an application that causes ~~rendering~~ submitted information to be false or incomplete after submission.

(f) If we deny ~~your~~ an application or suspend, revoke, or void ~~your~~ a certificate, you may ask for a hearing (see § 1037.820).

144. Amend § 1037.301 by revising paragraph (b) to read as follows:

§ 1037.301 Overview of measurements related to GEM inputs in a selective enforcement audit.

*   *   *   *   *

(b) A selective enforcement audit for this part 1037 consists of performing measurements with production vehicles relative to one or more declared values for GEM inputs, and using those measured values in place of your declared values to run GEM. Except as specified in this subpart, the vehicle is considered passing if the new modeled emission result is at or below the modeled emission result corresponding to the declared GEM inputs. If you report an FEL for the vehicle configuration before the audit, we will instead consider the vehicle passing if the new cycle-weighted emission result matches or exceeds the efficiency improvement is at or below the FEL.

* * * * *

145. Amend § 1037.305 by revising the introductory text and paragraph (a) to read as follows:

§ 1037.305 Audit procedures for tractors—aerodynamic testing.

To perform a selective enforcement audit with respect to drag area for tractors, use the reference method specified in § 1037.525; we may instead require you to use the same method you used for certification. The following provisions apply instead of 40 CFR 1068.420 415 through 1068.425 for a selective enforcement audit with respect to drag area:

(a) Determine whether or not a tractor fails to meets standards as follows:

(1) We will select a vehicle configuration for testing. Perform a coastdown measurement according to § 1037.528 with the vehicle in its production configuration according to §1037.528. If the production configuration cannot be connected to a standard trailer, you may ask us to approve trailer specifications different than § 1037.501(g)(1) based on good engineering judgment. Instead of the process described in § 1037.528(h)(12), determine your test result as described in this paragraph (a). You must have an equal number of runs in each direction.

(2) Measure a yaw curve for your test vehicle using your alternate method according to § 1037.525(b)(3). You do not need to test at the coastdown effective yaw angle. You may use a previously established yaw curve from your certification testing if it is available.

(3) Using this the yaw curve, perform a regression using values of drag area, C_dA_{alt}, and yaw angle, ψ_{alt}, to determine the air-direction correction coefficients, a_0, a_1, a_2, a_3, and a_4, for the following equation:

$$C_dA_{alt}(\psi) = a_0 + a_1 \cdot \psi_{alt} + a_2 \cdot \psi_{alt}^2 + a_3 \cdot \psi_{alt}^3 + a_4 \cdot \psi_{alt}^4$$

Eq. 1037.305-1

(4) Adjust the drag area value from each coastdown run, C_dA_{run}, from the yaw angle of each run, ψ_{run}, to ±4.5° to represent a wind-averaged drag area value, C_dA_{wa} by applying Eq. 1037.305-1 as follows:

$$C_dA_{wa\text{-}run} = C_dA_{run} \cdot \left[\frac{C_dA_{alt,4.5°} + C_dA_{alt,-4.5°}}{C_dA_{alt,\psi run} + C_dA_{alt,-\psi run}} \right]$$

Eq. 1037.305-2

(5) Perform additional coastdown measurements until you reach a pass or fail decision under this paragraph (a). The minimum number of runs to pass is 24. The minimum number of runs to fail is 100.

(6) Calculate statistical values to characterize cumulative test results at least once per day based on an equal number of coastdown runs in each direction. Determine the wind-averaged drag area value for the test C_dA_{wa} by averaging all $C_dA_{wa\text{-}run}$ values for all days of testing. Determine the upper and lower bounds of the drag area value, $C_dA_{wa\text{-}bounded}$, expressed to two decimal places, using a confidence interval as follows:

$$C_d A_{\text{wa-bounded}} = C_d A_{\text{wa}} \pm \left(\frac{1.5 \cdot \sigma}{\sqrt{n}} + 0.03 \right)$$

Eq. 1037.305-3

Where:

$C_dA_{\text{wa-boundeded}}$ = the upper bound, $C_dA_{\text{wa-upper}}$, and lower bound, $C_dA_{\text{wa-lower}}$, of the drag area value, where $C_dA_{\text{wa-upper}}$ is the larger number.

C_dA_{wa} = the average of all $C_dA_{\text{wa-run}}$ values.

σ = the standard deviation of all C_dA_{run} values (see 40 CFR 1065.602(c)).

n = the total number of coastdown runs.

(7) Compliance is determined Determine compliance based on the values of $C_dA_{\text{wa-upper}}$ and $C_dA_{\text{wa-lower}}$ relative to the adjusted bin boundary. For purposes of this section, the upper limit of a bin is expressed as the specified value plus 0.05 to account for rounding. For example, for a bin including values of 5.5-5.9 m^2, being above the upper limit means exceeding 5.95 m^2. The vehicle reaches a passes or fails decision relative to the adjusted bin boundary based on one of the following criteria:

(i) The vehicle passes if $C_dA_{\text{wa-upper}}$ is less than or equal to the upper limit of the bin to which you certified the vehicle.

(ii) The vehicle fails if $C_dA_{\text{wa-lower}}$ is greater than the upper limit of the bin to which you certified the vehicle.

(iii) The vehicle passes if you perform 100 coastdown runs and $C_dA_{\text{wa-upper}}$ is greater than and $C_dA_{\text{wa-lower}}$ is lower than the upper limit of the bin to which you certified the vehicle.

(iv) The vehicle fails if you choose to stop testing before reaching a final determination under this paragraph (a)(7).

(v) ManufacturersYou may continue testing beyond the stopping point specified in this paragraph (a)(7). We may consider the additional data in making pass/fail determinations.

* * * * *

146. Revise § 1037.320 to read as follows:

§ 1037.320 Audit procedures for axles and transmissions.

Selective enforcement audit provisions apply for axles and transmissions relative to the efficiency demonstrations of §§ 1037.560 and 1037.565 as specified in this section. The following provisions apply instead of 40 CFR 1068.415 through 1068.445 for the selective enforcement audit.follows:

(a) A selective enforcement audit for axles or transmissions would consist of performing measurements with a production axle or transmission to determine mean power loss values as declared for GEM simulations, and running GEM over one or more applicable duty cycles based on those measured values. The axle or transmission engine is considered passing for a given configuration if the new modeled emission result for every applicable duty cycle is at or below the modeled emission result corresponding to the declared GEM inputs.

(b) Run GEM for each applicable vehicle configuration identified in 40 CFR 1036.540 using the applicable default engine map defined in Appendix III of 40 CFR part 1036, and the default torque curve given in Table 1 of this section for the vehicle class as defined in § 1037.140(g). For axle testing, this may require omitting several vehicle configurations based on selecting axle ratios that correspond to the tested axle. For transmission testing, use the test transmission's gear ratios in place of the gear ratios defined in 40 CFR 1036.540. The GEM result for each vehicle configuration counts as a separate test for determining whether the family passes or fails the audit.

-(c) If the initial axle or transmission passes, the family passes and no further testing is required. If the initial axle or transmission does not pass, sSelect two additional production axles or transmissions, as applicable, to perform additional tests as needed. Note that these could be different axle and transmission configurations within the family. These become official test results for the family. Use good engineering judgment to combineuse the results of these three tests into a single maptests to update the declared maps for the axle or transmission family. For example, if you fail the audit test for any of the axles or transmissions tested, the audit result becomes the declared map. This may also require revising any analytically derived maps. This becomes the official test result for the family.

Table 1 to § 1037.320—Default Torque Curves for Vehicle Class

Light HDV		**Medium HDV**		**Heavy HDV**		**Light HDV and Medium HDV Spark Ignition**	
Engine Speed (r/min)	Engine Torque (N·m)	Engine Speed (r/min)	Engine Torque (N·m)	Engine Speed (r/min)	Engine Torque (N·m)	Engine Speed (r/min)	Engine Torque (N·m)
750	470	600	850	600	1200	600	433
907	579	750	890	750	1320	700	436
1055	721	850	1000	850	1490	800	445
1208	850	950	1200	950	1700	900	473
1358	876	1050	1440	1050	1950	1000	492
1507	866	1100	1520	1100	2090	1100	515
1660	870	1150	1570	1200	2100	1200	526
1809	868	1250	1590	1250	2100	1300	541
1954	869	1300	1590	1300	2093	1400	542
2105	878	1450	1590	1400	2092	1500	542
2258	850	1500	1590	1500	2085	1600	542
2405	800	1600	1540	1520	2075	1700	547
2556	734	1700	1470	1600	2010	1800	550
2600	0	1800	1385	1700	1910	1900	551
		1900	1300	1800	1801	2000	554
		2000	1220	1900	1640	2100	553
		2100	1040	2000	1350	2200	558
		2250	590	2100	910	2300	558
		2400	0	2250	0	2400	566
						2500	571
						2600	572
						2700	581
						2800	586
						2900	587
						3000	590
						3100	591
						3200	589

						3300	585
						3400	584
						3500	582
						3600	573
						3700	562
						3800	555
						3900	544
						4000	534
						4100	517
						4200	473
						4291	442
						4500	150

147. Amend § 1037.501 by adding paragraph (i) to read as follows:

§ 1037.501 General testing and modeling provisions.

* * * * *

(i) Note that declared GEM inputs for fuel maps and aerodynamic drag area ~~will~~ typically includes compliance margins to account for testing variability; for other measured GEM inputs, the declared values are ~~will~~ typically ~~be~~ the measured values without adjustment.

148. Amend § 1037.510 by revising paragraphs (a)(2), (c)(3), (d), and (e) to read as follows:

§ 1037.510 Duty-cycle exhaust testing.

* * * * *

(a) * * *

(2) ~~For~~ Perform cycle-average engine fuel mapping ~~under~~ as described in 40 CFR 1036.540. For powertrain testing under §§ 1037.550 or 1037.555, perform testing as described in this paragraph (a)(2) to generate GEM inputs for each simulated vehicle configuration, and ~~for each of the four~~ test runs representing different idle ~~speed settings~~conditions. ~~You may perform any number of these test runs directly in succession once the engine or powertrain is warmed up. If you interrupt the test sequence with a break of up to 30 minutes, such as to perform analyzer calibration, repeat operation over the previous duty cycle to precondition the vehicle before restarting the test sequence.~~ Perform testing as follows:

(i) Transient cycle. The transient cycle is specified in Appendix I of this part. ~~Initially warm up the engine or powertrain by operating over one transient cycle. Within 60 seconds after concluding the warm up cycle, start emission sampling while the vehicle operates over the duty cycle.~~

(ii) Highway cruise cycles. The grade portion of the route corresponding to the 55 mi/hr and 65 mi/hr highway cruise cycles is specified in Appendix IV of this part. ~~Initially warm up the engine or powertrain by operating it over the duty cycle. Within 60 seconds after concluding the preconditioning cycle, start emission sampling while the vehicle operates over the duty cycle, m~~Maintain~~ing~~ vehicle speed between –1.0 mi/hr and 3.0 mi/hr of the speed setpoint; this speed tolerance applies instead of the approach specified in 40 CFR 1066.425(b)(1) and (2).

(iii) Drive idle. Perform testing at a loaded idle condition for Phase 2 vocational vehicles. For engines with an adjustable warm idle speed setpoint, test at the minimum warm idle speed and the maximum warm idle speed; otherwise simply test at the engine's warm idle speed. Warm up the powertrain using the vehicle settings for the Test 1 vehicle configuration as defined in Table 2 or Table 3 of 40 CFR 1036.540 by operating it at 65 mi/hr for 600 seconds. Linearly ramp the powertrain down to zero vehicle speed in 20 seconds. Within 10 seconds after concluding the preconditioning cycle, sSet the engine to operate at idle speed for 90 seconds, with the brake applied and the transmission in drive (or clutch depressed for manual transmission), and sample emissions to determine mean emission values (in g/s) over the last 30 seconds of idling.

(iv) Parked idle. Perform testing at an unloaded idle condition for Phase 2 vocational vehicles. For engines with an adjustable warm idle speed setpoint, test at the minimum warm idle speed and the maximum warm idle speed; otherwise simply test at the engine's warm idle speed. Warm up the powertrain using the vehicle settings for the Test 1 vehicle configuration by operating it at 65 mi/hr for 600 seconds. Linearly ramp the powertrain down to zero vehicle speed in 20 seconds. Within 60 seconds after concluding the preconditioning cycle, sSet the engine to operate at idle speed for 600 780 seconds, with the transmission in park (or the transmission in neutral with the parking brake applied for manual transmissions), and sample emissions to determine mean emission values (in g/s) over the full last 600 seconds of idling.

* * * * *

(c) * * *

(3) Table 1 follows.

Table 1 of § 1037.510—Weighting Factors for Duty Cycles

	DISTANCE-WEIGHTED			TIME-WEIGHTED[1A]			AVERAGE SPEED DURING NON-IDLE CYCLES (MI/HR)[2B]
	Transient	55 mi/hr Cruise	65 mi/hr Cruise	Drive Idle	Parked Idle	Non-idle	
Day Cabs	19 %	17 %	64 %	—	—	—	—
Sleeper Cabs	5 %	9 %	86 %	—	—	—	—
Heavy-haul tractors	19 %	17 %	64 %	—	—	—	—
Vocational—Regional	20 %	24 %	56 %	0 %	25 %	75 %	38.41
Vocational—Multi-Purpose (2b-7)	54 %	29 %	17 %	17 %	25 %	58 %	23.18
Vocational—Multi-Purpose (8)	54 %	23 %	23 %	17 %	25 %	58 %	23.27
Vocational—Urban (2b-7)	92 %	8 %	0 %	15 %	25 %	60 %	16.25
Vocational—Urban (8)	90 %	10 %	0 %	15 %	25 %	60 %	16.51
Vocational with conventional powertrain (Phase 1 only)	42 %	21 %	37 %	—	—	—	—
Vocational Hybrid Vehicles (Phase 1 only)	75 %	9 %	16 %	—	—	—	—

[1-a] Note that these drive idle and non-idle weighting factors do not reflect additional drive idle that occurs during the transient cycle. The transient cycle does not include any parked idle.
[2-b] These values apply even for vehicles not following the specified speed traces.

(d) For transient testing, compare actual second-by-second vehicle speed with the speed specified in the test cycle and ensure any differences are consistent with the criteria as specified in 40 CFR 1066.425(b) and (c). If the speeds do not conform to these criteria, the test is not valid and must be repeated.
(e) Run test cycles as specified in 40 CFR part 1066. For testing vehicles equipped with cruise control over the highway cruise cycles, you may use the vehicle's cruise control to control the vehicle speed. For vehicles equipped with adjustable vehicle speed limiters, test the vehicle with the vehicle speed limiter at its highest setting.
* * * * *

149. Amend § 1037.515 by revising paragraphs (c) and (d)(2) to read as follows:
§ 1037.515 Determining CO_2 emissions to show compliance for trailers.
* * * * *
(c) Drag area. You may use ΔC_dA values approved under § 1037.211 for device manufacturers if your trailers are properly equipped with those devices. Determine ΔC_dA values for other trailers based on testing. Measure C_dA and determine ΔC_dA values as described in § 1037.526(a). You may use ΔC_dA values from one trailer configuration to represent any number of additional trailers based on worst-case testing. This means that you may apply ΔC_dA values from your measurements to any trailer models of the same category with drag area at or below that of the tested configuration. For trailers in the short dry box vans and short refrigerated box vans that are not 28 feet long, apply the ΔC_dA value established for a comparable 28-foot trailer model; you may use the same devices designed for 28-foot trailers or you may adapt those devices as appropriate for the different trailer length, consistent with good engineering judgment. For example, 48-foot trailers may use longer side skirts than the skirts that were tested with a 28-foot trailer. Trailer and device manufacturers may seek preliminary approval for these adaptations. Determine bin levels based on ΔC_dA test results as described in the following table:

Table 2 of § 1037.515—Bin Determinations for Trailers Based on Aerodynamic Test Results (ΔC_dA in m^2)

IF A TRAILER'S MEASURED ΔC_DA IS …	DESIGNATE THE TRAILER AS …	AND USE THE FOLLOWING VALUE FOR ΔC_DA
≤ 0.09	Bin I	0.0
0.10 – 0.39	Bin II	0.1
0.40 – 0.69	Bin III	0.4
0.70 – 0.99	Bin IV	0.7
1.00 – 1.39	Bin V	1.0
1.40 – 1.79	Bin VI	1.4
≥> 1.80	Bin VII	1.8

(d) * * *
(2) Apply weight reductions for other components made with light-weight materials as shown in the following table:

Table 3 of § 1037.515—Weight Reductions for Trailers (pounds)

COMPONENT	MATERIAL	WEIGHT REDUCTION (POUNDS)
Structure for Suspension Assembly[~~1~~a]	Aluminum	280
Hub and Drum (per axle)	Aluminum	80
Floor[~~2~~b]	Aluminum	375
Floor[~~2~~b]	Composite (wood and plastic)	245
Floor Crossmembers[~~2~~b]	Aluminum	250
Landing Gear	Aluminum	50
Rear Door	Aluminum	187
Rear Door Surround	Aluminum	150
Roof Bows	Aluminum	100
Side Posts	Aluminum	300
Slider Box	Aluminum	150
Upper Coupler Assembly	Aluminum	430

[~~1~~ a]For tandem-axle suspension sub-frames made of aluminum, apply a weight reduction of 280 pounds. Use good engineering judgment to estimate a weight reduction for using aluminum sub-frames with other axle configurations.

[~~2~~ b]Calculate a smaller weight reduction for short trailers by multiplying the indicated values by 0.528 (28/53).

* * * * *

150. Revise § 1037.520 to read as follows:

§ 1037.520 Modeling CO_2 emissions to show compliance for vocational vehicles and tractors.

This section describes how to use the Greenhouse gas Emissions Model (GEM) (incorporated by reference in § 1037.810) to show compliance with the CO_2 standards of §§ 1037.105 and 1037.106 for vocational vehicles and tractors. Use GEM version 2.0.1 to demonstrate compliance with Phase 1 standards; use GEM Phase 2, Version 3.~~0~~ 5.1 to demonstrate compliance with Phase 2 standards. Use good engineering judgment when demonstrating compliance using GEM. See § 1037.515 for calculation procedures for demonstrating compliance with trailer standards.

(a) General modeling provisions. To run GEM, enter all applicable inputs as specified by the model.

(1) GEM inputs apply for Phase 1 standards as follows:

(i) Model year and regulatory subcategory (see § 1037.230).

(ii) Coefficient of aerodynamic drag or drag area, as described in paragraph (b) of this section (tractors only).

(iii) Steer and drive tire rolling resistance, as described in paragraph (c) of this section.

(iv) Vehicle speed limit, as described in paragraph (d) of this section (tractors only).

(v) Vehicle weight reduction, as described in paragraph (e) of this section (tractors only for Phase 1).

(vi) Automatic engine shutdown systems, as described in § 1037.660 (only for Class 8 sleeper cabs). Enter a GEM input value of 5.0 g/ton-mile, or an adjusted value as specified in § 1037.660.

(2) For Phase 2 vehicles, the GEM inputs described in paragraphs (a)(1)(i) through (v) of this section continue to apply. Note that the provisions related to vehicle speed limiters and automatic engine shutdown systems are available for vocational vehicles in Phase 2. The rest of this section describes additional GEM inputs for demonstrating compliance with Phase 2 standards. Simplified versions of GEM apply for limited circumstances as follows:

(i) You may use default engine fuel maps for glider kits as described in § 1037.635.

(ii) If you certify vehicles to the custom-chassis standards specified in § 1037.105(h), run GEM by identifying the vehicle type and entering "NA" instead of what would otherwise apply for, tire revolutions per mile, engine information, transmission information, drive axle ratio, axle efficiency, and aerodynamic improvement as specified in paragraphs (c)(1), (f), (g)(1), (g)(3), (i), and (m) of this section, respectively. Incorporate other GEM inputs as specified in this section.

(b) Coefficient of aerodynamic drag and drag area for tractors. Determine the appropriate drag area, C_dA, for tractors as described in this paragraph (b). Use the recommended method or an alternate method to establish a value for C_dA, expressed in m^2 to one decimal place, as specified in § 1037.525. Where we allow you to group multiple configurations together, measure C_dA of the worst-case configuration.

(1) Except as specified in paragraph (b)(2) of this section, determine the Phase 1 bin level for your vehicle based on measured C_dA values as shown in the following tables:

Table 1 ~~of~~ to § 1037.520(b)(1)— C_d inputs for Phase 1 High-Roof Tractors

TRACTOR TYPE	BIN LEVEL	IF YOUR MEASURED C_DA (M^2) IS . . .	THEN YOUR C_D INPUT IS . . .
High-Roof Day Cabs	Bin I	≥ 8.0	0.79
	Bin II	7.1-7.9	0.72
	Bin III	6.2-7.0	0.63
	Bin IV	5.6-6.1	0.56
	Bin V	≤ 5.5	0.51
High-Roof Sleeper Cabs	Bin I	≥ 7.6	0.75
	Bin II	6.8-7.5	0.68
	Bin III	6.3-6.7	0.60
	Bin IV	5.6-6.2	0.52
	Bin V	≤5.5	0.47

Table 2 to~~of~~ § 1037.520(b)(1)— C_d inputs for Phase 1 Low-Roof and Mid-Roof Tractors

TRACTOR TYPE	BIN LEVEL	IF YOUR MEASURED C_DA (M^2) IS . . .	THEN YOUR C_D INPUT IS . . .
Low-Roof Day and Sleeper Cabs	Bin I	≥ 5.1	0.77
	Bin II	≤ 5.0	0.71
Mid-Roof Day and Sleeper Cabs	Bin I	≥ 5.6	0.87
	Bin II	≤ 5.5	0.82

(2) For Phase 1 low- and mid-roof tractors, you may instead determine your drag area bin based on the drag area bin of an equivalent high-roof tractor. If the high-roof tractor is in Bin I or Bin II, then you may assume your equivalent low- and mid-roof tractors are in Bin I. If

the high-roof tractor is in Bin III, Bin IV, or Bin V, then you may assume your equivalent low- and mid-roof tractors are in Bin II.

(3) For Phase 2 tractors other than heavy-haul tractors, determine bin levels and C_dA inputs as follows:

(i) Determine bin levels for high-roof tractors based on aerodynamic test results as specified in § 1037.525 and summarizeddescribed in the following table:

Table 3 toof § 1037.520(b)(3)(i)—Bin determinations for Phase 2 High-Roof Tractors Based on Aerodynamic Test Results (C_dA in m^2)

TRACTOR TYPE	BIN I	BIN II	BIN III	BIN IV	BIN V	BIN VI	BIN VII
Day Cabs	≥ 7.2	6.6-7.1	6.0-6.5	5.5-5.9	5.0-5.4	4.5-4.9	≤ 4.4
Sleeper Cabs	≥ 6.9	6.3-6.8	5.7-6.2	5.2-5.6	4.7-5.1	4.2-4.6	≤ 4.1

(ii) For low- and mid-roof tractors, you may either use the same bin level that applies for an equivalent high-roof tractor as shown in Table 3 of this section, or you may determine your bin level based on aerodynamic test results as described in Table 4 of this section.

Table 4 toof § 1037.520(b)(3)(ii)—Bin determinations for Phase 2 Low-Roof and Mid-Roof Tractors Based on Aerodynamic Test Results (C_dA in m^2)

TRACTOR TYPE	BIN I	BIN II	BIN III	BIN IV	BIN V	BIN VI	BIN VII
Low-Roof Cabs	≥ 5.4	4.9-5.3	44.5-4.8	4.1-4.4	3.8-4.0	3.5-3.7	≤ 3.4
Mid-Roof Cabs	≥ 5.9	5.5-5.8	5.1-5.4	4.7-5.0	4.4-4.6	4.1-4.3	≤ 4.0

(iii) Determine the C_dA input according to the tractor's bin level as described in the following table:

Table 5 toof § 1037.520(b)(3)(iii)—Phase 2 C_dA Tractor Inputs Based on Bin Level

TRACTOR TYPE	BIN I	BIN II	BIN III	BIN IV	BIN V	BIN VI	BIN VII
High-Roof Day Cabs	7.45	6.85	6.25	5.70	5.20	4.70	4.20
High-Roof Sleeper Cabs	7.15	6.55	5.95	5.40	4.90	4.40	3.90
Low-Roof Cabs	6.00	5.60	5.15	4.75	4.40	4.10	3.80
Mid-Roof Cabs	7.00	6.65	6.25	5.85	5.50	5.20	4.90

(4) Note that, starting in model year 2027, GEM internally reduces C_dA for high-roof tractors by 0.3 m^2 to simulate adding a rear fairing to the standard trailer.

(c) Tire revolutions per mile and rolling resistance. You must have a tire revolutions per mile (TRPM) and a tire rolling resistance level (TRRL) for each tire configuration. For purposes of this section, you may consider tires with the same SKU number to be the same configuration. Determine TRRL input values separately for drive and steer tires; determine TRPM only for drive tires.

(1) Use good engineering judgment to determine a tire's revolutions per mile to the nearest whole number as specified in SAE J1025 (incorporated by reference in § 1037.810). Note that for tire sizes that you do not test, we will treat your analytically derived revolutions per mile the same as test results, and we may perform our own testing to verify your values. We may require you to test a sample of additional tire sizes that we select.

(2) Measure tire rolling resistance in kg per metric ton as specified in ISO 28580 (incorporated by reference in § 1037.810), except as specified in this paragraph (c). Use good engineering judgment to ensure that your test results are not biased low. You may ask

us to identify a reference test laboratory to which you may correlate your test results. Prior to beginning the test procedure in Section 7 of ISO 28580 for a new bias-ply tire, perform a break-in procedure by running the tire at the specified test speed, load, and pressure for 60±2 minutes.

(3) For each tire design tested, measure rolling resistance of at least three different tires of that specific design and size. Perform the test at least once for each tire. Calculate the arithmetic mean of these results to the nearest 0.1 kg/tonne and use this value or any higher value as your GEM input for TRRL. You must test at least one tire size for each tire model, and may use engineering analysis to determine the rolling resistance of other tire sizes of that model. Note that for tire sizes that you do not test, we will treat your analytically derived rolling resistances the same as test results, and we may perform our own testing to verify your values. We may require you to test a small sub-sample of untested tire sizes that we select.

(4) If you obtain your test results from the tire manufacturer or another third party, you must obtain a signed statement from the party supplying those test results to verify that tests were conducted according to the requirements of this part. Such statements are deemed to be submissions to EPA.

(5) For tires marketed as light truck tires that have load ranges C, D, or E, use as the GEM input TRRL multiplied by 0.87.

(6) For vehicles with at least three drive axles or for vehicles with more than three axles total, use good engineering judgment to combine tire rolling resistance into three values (steer, drive 1, and drive 2) for use in GEM. This may require performing a weighted average of tire rolling resistance from multiple axles based on the typical load on each axle. For liftable axles, calculate load- and time-weighted values to represent the load and the amount of time these tires are in contact with the ground during typical in-use operation.

(7) For vehicles with a single rear axle, enter “NA” as the TRRL value for drive axle 2.

(d) Vehicle speed limit. If the vehicles will be equipped with a vehicle speed limiter, input the maximum vehicle speed to which the vehicle will be limited (in miles per hour rounded to the nearest 0.1 mile per hour) as specified in § 1037.640. Use good engineering judgment to ensure the limiter is tamper resistant. We may require you to obtain preliminary approval for your designs.

(e) Vehicle weight reduction. Develop a weight-reduction as a GEM input as described in this paragraph (e). Enter the sum of weight reductions as described in this paragraph (e), or enter zero if there is no weight reduction. For purposes of this paragraph (e), high-strength steel is steel with tensile strength at or above 350 MPa.

(1) Vehicle weight reduction inputs for wheels are specified relative to dual-wide tires with conventional steel wheels. For purposes of this paragraph (e)(1), an aluminum alloy qualifies as light-weight if a dual-wide drive wheel made from this material weighs at least 21 pounds less than a comparable conventional steel wheel. The inputs are listed in Table 6 of this section. For example, a tractor or vocational vehicle with aluminum steer wheels and eight (4×2) dual-wide aluminum drive wheels would have an input of 210 pounds (2×21 + 8×21).

Table 6 to~~of~~ § 1037.520(e)(1)—Wheel-Related Weight Reductions

WEIGHT-REDUCTION TECHNOLOGY		WEIGHT REDUCTION—PHASE 1 (LB PER WHEEL)	WEIGHT REDUCTION—PHASE 2 (LB PER WHEEL)
	Steel Wheel	84	84

Wide-Base Single Drive Tire with . . .[~~1~~a]	Aluminum Wheel	139	147
	Light-Weight Aluminum Alloy Wheel	147	147
Wide-Base Single Trailer Tire with . . .[~~1~~a]	Steel Wheel	—	84
	Aluminum or Aluminum Alloy Wheel	—	131
Steer Tire, Dual-wide Drive Tire, or Dual-wide Trailer Tire with . . .	High-Strength Steel Wheel	8	8
	Aluminum Wheel	21	25
	Light-Weight Aluminum Alloy Wheel	30	25

[~~1~~ a]The weight reduction for wide-base tires accounts for reduced tire weight relative to dual-wide tires.

(2) Weight reduction inputs for tractor components other than wheels are specified in the following table:

Table 7 to~~of~~ § 1037.520(e)(2)—Nonwheel-Related Weight Reductions f~~F~~rom Alternative Materials for Tractors (pounds)

WEIGHT REDUCTION TECHNOLOGIES	ALUMINUM	HIGH-STRENGTH STEEL	THERMOPLASTIC
Door	20	6	
Roof	60	18	
Cab rear wall	49	16	
Cab floor	56	18	
Hood Support Structure System	15	3	
Hood and Front Fender			65
Day Cab Roof Fairing			18
Sleeper Cab Roof Fairing	75	20	40
Aerodynamic Side Extender			10
Fairing Support Structure System	35	6	
Instrument Panel Support Structure	5	1	
Brake Drums – Drive (set of 4)	140	74	
Brake Drums – Non Drive (set of 2)	60	42	
Frame Rails	440	87	
Crossmember – Cab	15	5	
Crossmember – Suspension	25	6	
Crossmember – Non Suspension (set of 3)	15	5	
Fifth Wheel	100	25	
Radiator Support	20	6	
Fuel Tank Support Structure	40	12	
Steps	35	6	
Bumper	33	10	
Shackles	10	3	
Front Axle	60	15	
Suspension Brackets, Hangers	100	30	
Transmission Case	50	12	
Clutch Housing	40	10	
Fairing Support Structure System	35	6	
Drive Axle Hubs (set of 4)	80	20	
Non Drive Hubs (2)	40	5	
Two-piece driveshaft	20	5	

Transmission/Clutch Shift Levers	20	4	

(3) Weight-reduction inputs for vocational-vehicle components other than wheels are specified in the following table:

Table 8 to~~of~~ § 1037.520(e)(3)—Nonwheel-Related Weight Reductions from Alternative Materials for Phase 2 Vocational Vehicles (pounds)[a]

COMPONENT	MATERIAL	VEHICLE TYPE		
		Light HDV	Medium HDV[b]	Heavy HDV
Axle Hubs - Non-Drive	Aluminum	40		40
Axle Hubs - Non-Drive	High Strength Steel	5		5
Axle - Non-Drive	Aluminum	60		60
Axle - Non-Drive	High Strength Steel	15		15
Brake Drums - Non-Drive	Aluminum	60		60
Brake Drums - Non-Drive	High Strength Steel	42		42
Axle Hubs – Drive	Aluminum	40		80
Axle Hubs – Drive	High Strength Steel	10		20
Brake Drums - Drive	Aluminum	70		140
Brake Drums - Drive	High Strength Steel	37		74
Suspension Brackets, Hangers	Aluminum	67		100
Suspension Brackets, Hangers	High Strength Steel	20		30
Crossmember – Cab	Aluminum	10	15	15
Crossmember – Cab	High Strength Steel	2	5	5
Crossmember - Non-Suspension	Aluminum	15	15	15
Crossmember - Non-Suspension	High Strength Steel	5	5	5
Crossmember -Suspension	Aluminum	15	25	25
Crossmember -Suspension	High Strength Steel	6	6	6
Driveshaft	Aluminum	12	40	50
Driveshaft	High Strength Steel	5	10	12
Frame Rails	Aluminum	120	300	440
Frame Rails	High Strength Steel	40	40	87

[a]Weight~~-~~-reduction values apply per vehicle unless otherwise noted.
[b]For ~~m~~Medium HDV ~~vehicles~~ with 6×~~x~~4 or 6×~~x~~2 axle configurations, use the values for Heavy HDVs.

(4) Apply vehicle weight inputs for changing technology configurations as follows:

(i) For Class 8 tractors or for Class 8 vocational vehicles with a permanent 6×2 axle configuration, apply a weight reduction input of 300 pounds. This does not apply for coach buses certified to custom-chassis standards under § 1037.105(h).

(ii) For Class 8 tractors with 4×2 axle configuration, apply a weight reduction input of 400 pounds.

(iii) For tractors with installed engines with displacement below 14.0 liters, apply a weight reduction of 300 pounds.

(iv) For tractors with single-piece driveshafts with a total length greater than 86 inches, apply a weight reduction of 43 pounds for steel driveshafts and 63 pounds for aluminum driveshafts.

(5) You may ask to apply the off-cycle technology provisions of § 1037.610 for weight reductions not covered by this paragraph (e).

(f) Engine characteristics. Enter information from the engine manufacturer to describe the installed engine and its operating parameters as described in 40 CFR 1036.~~510~~503. The fuel-mapping information must apply for the vehicle's GVWR; for example, if you install a medium heavy-duty engine in a Class 8 vehicle, the engine must have additional fuel-mapping information for the heavier vehicle. Note that you do not need fuel consumption at idle for tractors.

(g) Vehicle characteristics. Enter the following information to describe ~~and~~ the vehicle and its operating parameters:

(1) Transmission make, model, and type. Also identify the gear ratio for every available forward gear to two decimal places, the input torque limit for each of the forward gears, and, if applicable, ~~identify~~ the lowest gear involving a locked torque converter~~, if applicable~~. Count forward gears as being available only if the vehicle has the hardware and software to allow operation in those gears. For vehicles with a manual transmission, GEM applies a 2 % emission increase relative to automated manual transmissions. If your vehicle has a dual-clutch transmission, use good engineering judgment to determine if it can be accurately represented in GEM as an automated manual transmission. We may require you to perform a powertrain test with dual-clutch transmissions to show that they can be properly simulated as an automated manual transmission.

(2) Drive axle make, model, and configuration~~ type~~. Select a drive axle configuration to represent your vehicle for modeling.

(i) 4×2: One drive axle and one non-drive axle. This includes vehicles with two drive axles where one of the drive axles is disconnectable and that disconnectable drive axle is designed to be connected only when the vehicle is driven off-road or in slippery conditions if at least one of the following is true:

(A) The input and output of the disconnectable axle is mechanically disconnected from the drive shaft and the wheels when the axle is in 4×2 configuration.

(B) You provide power loss data generated according to § 1037.560 for the combination of both drive axles, where the disconnectable drive axle is in the disconnected configuration.

(ii) 6×2: One drive axle and two non-drive axles.

(iii) 6×4: Two or more drive axles, or more than three total axles. Note that this includes, for example, a vehicle with two drive axles out of four total axles (otherwise known as an 8×4 configuration).

(iv) 6×4D: One non-drive axle and two drive axles~~, including~~where ~~An axle~~one of the two drive axles is automatically disconnectable ~~drive axle. The axle configuration~~ ~~that can automatically~~such that the axle can switch between 6×2 and 6×4 configurations. You may select this configuration only if at least one of the following is true:

(A) ~~When the axle is in the 6×2 configuration t~~The input and output of the disconnectable axle ~~must be~~is mechanically disconnected from the drive shaft and the wheels when the axle is in the 6×2 configuration.~~to qualify.~~

(B) You provide power loss data generated according to § 1037.560 for the combination of both drive axles, where the disconnectable drive axle is in the disconnected configuration.

(3) Drive axle ratio, k_a. If a vehicle is designed with two or more user-selectable axle ratios, use the drive axle ratio that is expected to be engaged for the greatest driving distance. If the vehicle does not have a drive axle, such as a hybrid vehicle with direct electric drive, let $k_a = 1$.

(4) GEM inputs associated with powertrain testing include powertrain family, transmission calibration identifier, test data from § 1037.550, and the powertrain test configuration (dynamometer connected to transmission output or wheel hub). You do not need to identify or provide inputs for transmission gear ratios, fuel map data, or engine torque curves, which would otherwise be required under paragraph (f) of this section.

(h) Idle speed and idle~~-~~-reduction technologies. The following provisions apply for engine idling:

(1) For engines with no adjustable warm idle speed, input vehicle idle speed as the manufacturer's declared warm idle speed. For engines with adjustable warm idle speed, i~~I~~nput your vehicle idle speed as follows:

If your vehicle is a...	**And your engine is subject to...**	**Your default vehicle idle speed is...**[a]
(i) Heavy HDV	compression-ignition or spark-ignition standards	600 r/min.
(ii) Medium HDV tractor	compression-ignition standards	700 r/min.
(iii) Light HDV or Medium HDV vocational vehicle	compression-ignition standards	750 r/min.
(iv) Light HDV or Medium HDV	spark-ignition standards	600 r/min.

[a]If the default idle speed is above or below the engine manufacturer's whole range of declared warm idle speeds, use the manufacturer's maximum or minimum declared warm idle speed, respectively, instead of the default value.

~~(i) For heavy heavy-duty vehicles, input your vehicle's maximum adjustable idle speed or 600 rpm, whichever is lower.~~

~~(ii) For light heavy-duty and mMedium heavy-duty vehicles input your vehicle's maximum adjustable idle speed or 750 rpm, whichever is lower.~~

~~(iii) For spark-ignition vehicles input your vehicle's maximum adjustable idle speed or 600 rpm, whichever is lower.~~

(2) Identify whether your vehicle has qualifying idle-reduction technologies, subject to the qualifying criteria in § 1037.660, as follows:

(i~~1~~) Stop-start technology and automatic engine shutdown systems apply for vocational vehicles. See paragraph (j) of this section for automatic engine shutdown systems for tractors.

(ii~~2~~) Neutral idle applies for tractors and vocational vehicles.

(i) Axle, ~~and~~ transmission, and torque converter ~~efficiency~~characterization. You may characterize the axle, transmission, and torque converter ~~and use~~ using axle efficiency maps as described in § 1037.560, and transmission efficiency maps as described in § 1037.565, and torque converter capacity factors and torque ratios as described in § 1037.570 to replace the default values in GEM. If you obtain your test results from the axle manufacturer, transmission manufacturer, torque converter manufacturer or another third party, you must obtain a signed statement from the party supplying those test results to verify that tests were conducted according to the requirements of this part. Such statements are deemed to be submissions to EPA.

(j) Additional reduction technologies. Enter input values in GEM as follows to characterize the percentage CO_2 emission reduction corresponding to certain technologies and vehicle configurations, or enter 0:

(1) Intelligent controls. Enter 2 for tractors with predictive cruise control. This includes any cruise control system that incorporates satellite-based global-positioning data for controlling operator demand. For other vehiclestractors, enter 1.5 if they have neutral coasting, unless good engineering judgment indicates that a lower percentage should apply.

(2) Accessory load. Enter the following values related to accessory loads; if more than one item applies, enter the sum of those values:

(i) If vocational vehicles have electrically powered pumps for steering, enter 0.5 for vocational vehicles certified with the Regional duty cycle, and enter 1 for tractors and other vocational vehicles.

(ii) If tractors have electrically powered pumps for both steering and engine cooling, enter 1.

(iii) If vehicles have a high-efficiency air conditioning compressor, enter 0.5 for tractors and vocational Heavy HDV, and enter 1 for other vocational vehicles. This includes mechanically powered compressors meeting the specifications described in 40 CFR 86.1868-12(h)(5), and all electrically powered compressors.all electrically powered compressors. It also include mechanically powered compressors if the coefficient of performance improves by 10 percent or greater over the baseline design, consistent with the provisions for improved evaporators and condensers in 40 CFR 86.1868-12(h)(5).

(3) Tire-pressure systems. Enter 1.2 for vehicles with automatic tire inflation systems on all axles (1.1 for Multi-Purpose and Urban vocational vehicles). Enter 1.0 for vehicles with tire pressure monitoring systems on all axles (0.9 for Multi-Purpose and Urban vocational vehicles). If vehicles use a mix of the two systems, treat them as having only tire pressure monitoring systems.

(4) Extended-idle reduction. Enter values as shown in the following table for sleeper cabs equipped with idle-reduction technology meeting the requirements of § 1037.660 that are designed to automatically shut off the main engine after 300 seconds or less:

Table 9 toof § 1037.520(j)(4)—GEM Input Values For AES Systems

Technology	GEM Input Values	
	Adjustable	Tamper-resistant
Standard AES system	1	4
With diesel APU	3	4
With battery APU	5	6
With automatic stop-start	3	3
With Fuelfuel-operated heater (FOH)	2	3
With diesel APU and FOH	4	5
With battery APU and FOH	5	6
With stop-start and FOH	4	5

(5) Other. Additional GEM inputs may apply as follows:

(i) Enter 0.9 1.7 and 1.70.9, respectively, for school buses and coach buses that have at least seven available forward gears.

(ii) If we approve off-cycle technology under § 1037.610 in the form of an improvement factor, enter the improvement factor expressed as a percentage reduction in CO_2 emissions. (Note: In the case of approved off-cycle technologies whose benefit is quantified as a g/ton-mile credit, apply the credit to the GEM result, not as a GEM input value.)

(k) Vehicles with hybrid power take-off. For vocational vehicles, determine the delta PTO emission result of your engine and hybrid power take-off system as described in § 1037.540.

(l) [Reserved]

(m) Aerodynamic improvements for vocational vehicles. For vocational vehicles certified using the Regional duty cycle, enter ΔC_dA values to account for using aerodynamic devices as follows:

(1) Enter 0.2 for vocational vehicles with an installed rear fairing if the vehicle is at least 7 m long with a minimum frontal area of 8 m^2.

(2) For vehicles at least 11 m long with a minimum frontal area of 9 m^2, enter 0.5 if the vehicle has both skirts and a front fairing, and enter 0.3 if it has only one of those devices.

(3) You may determine input values for these or other technologies based on aerodynamic measurements as described in § 1037.527.

(n) Alternate fuels. For fuels other than those identified in GEM, perform the simulation by identifying the vehicle as being diesel-fueled if the engine is subject to the compression-ignition standard, or as being gasoline-fueled if the engine is subject to the spark-ignition standards. Correct the engine or powertrain fuel map for mass-specific net energy content as described in 40 CFR 1036.535(b).

151. Revise § 1037.525 to read as follows:

§ 1037.525 Aerodynamic measurements for tractors.

This section describes a methodology for quantifying aerodynamic drag for use in determining input values for tractors as described in § 1037.520. This coastdown testing is the reference method for aerodynamic measurements.

(a) General provisions. The GEM input for a tractor's aerodynamic performance is a C_d value for Phase 1 and a C_dA value for Phase 2. The input value is measured or calculated for a tractor in a specific test configuration with a trailer, such as a high-roof tractor with a box van meeting the requirements for the standard trailer.

(1) Aerodynamic measurements may involve any of several different procedures. Measuring with different procedures introduces variability, so we identify the coastdown method in § 1037.528 as the primary (or reference) procedure. You may use other procedures with our advance approval as described in paragraph (d) of this section, but we require that you adjust your test results from other test methods to correlate with coastdown test results. All adjustments must be consistent with good engineering judgment. Submit information describing how you quantify aerodynamic drag from coastdown testing, whether or not you use an alternate method.

(2) Test high-roof tractors with a standard trailer as described in § 1037.501(g)(1). Note that the standard trailer for Phase 1 tractors is different from that of later model years. Note also that GEM may model a different configuration than the test configuration, but accounts for this internally. Test low-roof and mid-roof tractors without a trailer; however, you may test low-roof and mid-roof tractors with a trailer to evaluate off-cycle technologies.

(b) Adjustments to correlate with coastdown testing. Adjust aerodynamic drag values from alternate methods to be equivalent to the corresponding values from coastdown measurements as follows:

(1) Determine the functional relationship between your alternate method and coastdown testing. Specify this functional relationship as $F_{alt\text{-}aero}$ for a given alternate drag measurement method. The effective yaw angle, ψ_{eff}, is assumed to be zero degrees for Phase 1. For Phase 2, determine ψ_{eff} from coastdown test results using the following equation:

$$F_{alt\text{-}aero} = \frac{C_d A_{coastdown}(\psi_{eff})}{C_d A_{alt}(\psi_{eff})}$$

Eq. 1037.525-1

Where:

$C_dA_{coastdown}(\psi_{eff})$ = the average drag area measured during coastdown at an effective yaw angle, ψ_{eff}.

$C_dA_{alt}(\psi_{eff})$ = the average drag area calculated from an alternate drag measurement method at an effective yaw angle, ψ_{eff}.

(2) Unless good engineering judgment dictates otherwise, assume that coastdown drag is proportional to drag measured using alternate methods. This means you may and apply a constant adjustment factor, $F_{alt\text{-}aero}$, for a given alternate drag measurement method of similar vehicles.using the following equation, where the effective yaw angle, ψ_{eff}, is assumed to be zero degrees for Phase 1 and is determined from coastdown test results for Phase 2:

$$F_{alt\text{-}aero} = \frac{C_d A_{effective\text{-}yaw\text{-}coastdown}}{C_d A_{effective\text{-}yaw\text{-}alt}}$$

Eq. 1037.525-1

(23) Determine $F_{alt\text{-}aero}$ by performing coastdown testing and applying your alternate method on the same vehicles. Consider all applicable test data including data collected during selective enforcement audits. Where you have test results from multiple vehicles expected to have the same $F_{alt\text{-}aero}$, you may either average the $F_{alt\text{-}aero}$ values or select any greater value. Unless we approve another vehicle, one vehicle must be a Class 8 high-roof sleeper cab with a full aerodynamics package pulling a standard trailer. Where you have more than one tractor model meeting these criteria, use the tractor model with the highest projected sales. If you do not have such a tractor model, you may use your most comparable tractor model with our prior approval. In the case of alternate methods other than those specified in this subpart,

good engineering judgment may require you to determine your adjustment factor based on results from more than the specified minimum number of vehicles.

(34) Measure the drag area using your alternate method for a Phase 2 tractor used to determine $F_{alt\text{-}aero}$ with testing at yaw angles of 0°, ±1°, ±3°, ±4.5°, ±6°, and ±9° (you may include additional angles), using direction conventions described in Figure 2 of SAE J1252 (incorporated by reference in § 1037.810). Also, determine the drag area at the coastdown effective yaw angle, $C_dA_{alt(\psi_{eff})}$effective yaw alt, by taking the average drag area at ψ_{eff} and $-\psi_{eff}$ for your vehicle using the same alternate method.

(45) For Phase 2 testing, determine separate values of $F_{alt\text{-}aero}$ for a minimum of at least one high-roof day cab and one high-roof sleeper cab for model year 2021, for at least two high-roof day cabs and two high-roof sleeper cabs for model year 2024, and for at least three high-roof day cabs and three high-roof sleeper cabs for model year 2027. These test requirements are cumulative; for example, you may meet these requirements by testing two vehicles to support model year 2021 certification and four additional vehicles to support model year 2023 certification. for 2021, 2024, and 2027 model years based on testing as described in paragraph (b)(2) of this section (six tests total). Alternatively, you may test earlier model years than specified here. For any untested tractor models, apply the value of $F_{alt\text{-}aero}$ from the tested tractor model that best represents the aerodynamic characteristics of the untested tractor model, consistent with good engineering judgment. Testing under this paragraph (b)(45) continues to be valid for later model years until you change the tractor model in a way that causes the test results to no longer represent production vehicles. You must also determine unique values of $F_{alt\text{-}aero}$ for low-roof and mid-roof tractors if you determine C_dA values based on low or mid-roof tractor testing as shown in Table 4 of § 1037.520. For Phase 1 testing, if good engineering judgment allows it, you may calculate a single, constant value of $F_{alt\text{-}aero}$ for your whole product line by dividing the coastdown drag area, $C_dA_{coastdown}$, by drag area from your alternate method, C_dA_{alt}.

(56) Determine $F_{alt\text{-}aero}$ to at least three decimal places. For example, if your coastdown testing results in a drag area of 6.430, but your wind tunnel method results in a drag area of 6.200, $F_{alt\text{-}aero}$ would be 1.037 (or a higher value you declare).

(67) If a tractor and trailer cannot be configured to meet the gap requirements specified in § 1037.501(g)(1)(ii), test with the trailer positioned as close as possible to the specified gap dimension and use good engineering judgment to correct the results to be equivalent to a test configuration meeting the specified gap dimension. For example, we may allow you to correct your test output using an approved alternate method or substitute a test vehicle that is capable of meeting the required specifications and is otherwise aerodynamically equivalent. This allowance applies for certification, confirmatory testing, SEA, and all other testing to demonstrate compliance with standards.for all testing, including confirmatory and SEA testing.

(8) You may ask us for preliminary approval of your Manufacturers are encouraged to coordinate $F_{alt\text{-}aero}$ coastdown testing with EPA before testing under § 1037.210. We may witness the testing.

(c) Yaw sweep corrections. Aerodynamic features can have a different effectiveness for reducing wind-averaged drag than is predicted by zero-yaw drag. The following procedures describe how to determine a tractor's C_dA values to account for wind-averaged drag as specified in § 1037.520and differences from coastdown testing:

(1) Apply the following method for all For Phase 2 testing with an alternate method, apply

the following method using your alternate method for aerodynamic testing:

(i) For all testing, cCalculate the wind-averaged drag area from the alternate method, $C_dA_{wa\text{-}alt}$, using an average of measurements at –4.5 and +4.5 degrees.

(ii) Determine your wind-averaged drag area, C_dA_{wa}, rounded to one decimal place, using the following equation:

$$C_dA_{wa} = C_dA_{wa\text{-}alt} \cdot F_{alt\text{-}aero}$$

Eq. 1037.525-2

(2) Apply the following method fFor Phase 2 coastdown testing other than coastdown testing used to establish $F_{alt\text{-}aero}$test results, apply the following method:

(i) For all coastdown testing, dDetermine your drag area at the effective yaw angle from coastdown, $C_dA_{effective\ yaw\ coastdown}(\psi_{eff})$.

(ii) Use an alternate method to calculate the ratio of the wind-averaged drag area-, $C_dA_{wa\text{-}alt}$ (using an average of measurements at –4.5 and +4.5 degrees, $C_dA_{wa\text{-}alt}$) to the drag area at the effective yaw angle, $C_dA_{alt(\psi_{eff})effective\ yaw}$.

(iii) Determine your wind-averaged drag area, C_dA_{wa}, rounded to one decimal place, using the following equation:

$$C_dA_{wa} = C_dA_{coastdown}(\psi_{eff}) \cdot \frac{C_dA_{wa\text{-}alt}}{C_dA_{alt}(\psi_{eff})}$$

Eq. 1037.525-3

(3) Different approximations apply for Phase 1. For Phase 1 testing, you may correct your zero-yaw drag area as follows if the ratio of the zero-yaw drag area divided by yaw-sweep drag area for your vehicle is greater than 0.8065 (which represents the ratio expected for a typical Class 8 high-roof sleeper cab):

(i) Determine the zero-yaw drag area, $C_dA_{zero\text{-}yaw}$, and the yaw-sweep drag area for your vehicle using the same alternate method as specified in this subpart. Measure the drag area for 0°, –6°, and +6°. Use the arithmetic mean of the –6° and +6° drag areas as the ±6° drag area, $C_dA_{\pm 6}$.

(ii) Calculate your yaw-sweep correction factor, CF_{ys}, using the following equation:

$$CF_{ys} = \frac{C_dA_{\pm 6} \cdot 0.8065}{C_dA_{zero\text{-}yaw}}$$

Eq. 1037.525-4

(iii) Calculate your corrected drag area for determining the aerodynamic bin by multiplying the measured zero-yaw drag area by CF_{ys}, as determined using Eq. 1037.525-4, as applicable. You may apply the correction factor to drag areas measured using other procedures. For example, apply CF_{ys} to drag areas measured using the coastdown method. If you use an alternate method, apply an alternate correction, $F_{alt\text{-}aero}$, and calculate the final drag area using the following equation:

$$C_dA = F_{alt\text{-}aero} \cdot CF_{ys} \cdot C_dA_{zero\text{-}alt}$$

Eq. 1037.525-5

(iv) You may ask us to apply CF_{ys} to similar vehicles incorporating the same design features.

(v) As an alternative, you may calculate the wind-averaged drag area according to SAE J1252 (incorporated by reference in § 1037.810) and substitute this value into Eq. 1037.525-4 for the ±6° drag area.

(d) Approval of alternate methods. You must obtain preliminary approval before using any

Commented [CAL16]: Equation updated.

method other than coastdown testing to quantify aerodynamic drag. We will approve your request if you show that your procedures produce data that are the same as or better than coastdown testing with respect to repeatability and unbiased correlation. Note that the correlation is not considered to be biased if there is a bias before correction, but you remove the bias using $F_{alt\text{-}aero}$. Send your request for approval to the Designated Compliance Officer. Keep records of the information specified in this paragraph (d). Unless we specify otherwise, include this information with your request. You must provide any information we require to evaluate whether you may apply the provisions of this section. Include additional information related to your alternate method as described in §§ 1037.530 through 1037.534. If you use a method other than those specified in this subpart, include all the following information, as applicable:

(1) Official name/title of the procedure.

(2) Description of the procedure.

(3) Cited sources for any standardized procedures that the method is based on.

(4) Description and rationale for any modifications/deviations from the standardized procedures.

(5) Data comparing the procedure to the coastdown reference procedure.

(6) Additional information specified for the alternate methods described in §§ 1037.530 through 1037.534 as applicable to this method (*e.g.*, source location/address, background/history).

152. Amend § 1037.528 by revising the introductory text and paragraphs (a), (c) introductory text, (e) introductory text, (g)(3) introductory text, (h)(3)(i), (h)(6), and (h)(12)(v) to read as follows:

§ 1037.528 Coastdown procedures for calculating drag area (C_dA).

The coastdown procedures in this section describe how to calculate drag area, C_dA, for Phase 2 tractors, trailers, and vocational vehicles, subject to the provisions of §§ 1037.525 through 1037.527. These procedures are considered the reference methodprimary procedures for tractors, but an alternate procedures method for trailers. Follow the provisions of Sections 1 through 9 of SAE J2263 (incorporated by reference in § 1037.810), with the clarifications and exceptions described in this section. Several of these exceptions are from SAE J1263 (incorporated by reference in § 1037.810). The coastdown procedures in 40 CFR 1066.310 apply instead of the provisions of this section for Phase 1 tractors.

(a) The terms and variables identified in this section have the meaning given in SAE J1263 (incorporated by reference in § 1037.810) and SAE J2263 unless specified otherwise.

* * * * *

(c) The test condition specifications described in Sections 7.1 through 7.4 of SAE J1263 apply, with certain the following exceptions and additional provisions: as described in this paragraph (c). These conditions apply to each run separately.

* * * * *

(e) Measure wind speed, wind direction, air temperature, and air pressure at a recording frequency of 10 Hz, in conjunction with time-of-day data. Use at least one stationary electro-mechanical anemometer and suitable data loggers meeting SAE J1263 specifications, subject to the following additional specifications for the anemometer placed along the test surface:

* * * * *

(g) * * *

(3) Correct measured air direction from all the high-speed segments using the wind speed and

wind direction measurements described in paragraph (e) of this section as follows:

* * * * *

(h) * * *

(3) * * *

(i) Calculate the mean vehicle speed to represent the start point of each speed range as the arithmetic average of measured speeds throughout the continuous time speed interval that begins when measured defined asvehicle speed is less than 2.00 mi/hr above the nominal starting speed point to and ends when measured vehicle speed reaches 2.00 mi/hr below the nominal starting speed point, expressed to at least two decimal places. CalculateDetermine the timestamp corresponding to the starting point of each speed range as the time midpointthe ±2.00 mi/hr spaverage timestamp of the interval.

* * * * *

(6) For tractor testing, calculate the tire rolling resistance force at high and low speeds for steer, drive, and trailer axle positions, $F_{\text{TRR[speed,axle]}}$, and determine ΔF_{TRR}, the rolling resistance difference between 65 mi/hr and 15 mi/hr, for each tire as follows:

(i) Conduct a stepwise coastdown tire rolling resistance test with three tires for each tire model installed on the vehicle using SAE J2452 (incorporated by reference in § 1037.810) for the following test points (which replace the test points in Table 3 of SAE J2452):

Table 1 of § 1037.528—Stepwise Coastdown Test Points for Determining Tire Rolling Resistance as a Function of Speed

Step #	Load (% of Max)	Inflation pressure (% of max)
1	20	100
2	55	70
3	85	120
4	85	100
5	100	95

(ii) Calculate $F_{\text{TRR[speed,axle]}}$ using the following equation:

$$F_{\text{TRR[speed,axle]}} = n_{\text{t,[axle]}} \cdot p_{\text{[axle]}}^{\alpha} \cdot \left(\frac{L_{\text{[axle]}}}{n_{\text{t,[axle]}}}\right)^{\beta_{\text{[axle]}}} \cdot \left(a_{\text{[axle]}} + b_{\text{[axle]}} \cdot \bar{v}_{\text{seg[speed]}} + c_{\text{[axle]}} \cdot \bar{v}_{\text{seg[speed]}}^{2}\right)$$

Eq. 1037.528-11

Commented [CAL17]: Equation updated.

Where:

$n_{\text{t,[axle]}}$ = number of tires at the axle position.

pP$_{\text{[axle]}}$ = the inflation pressure set and measured on the tires at the axle position at the beginning of the coastdown test.

$L_{\text{[axle]}}$ = the load over the axle at the axle position on the coastdown test vehicle.

$\alpha_{\text{[axle]}}$, $\beta_{\text{[axle]}}$, $a_{\text{[axle]}}$, $b_{\text{[axle]}}$, and $c_{\text{[axle]}}$ = regression coefficients from SAE J2452 that are specific to axle position.

Example:

$n_{\text{t,steer}} = 2$

pP$_{\text{steer}}$ = 758.4 kPa

L_{steer} = 51421.2 N

α_{steer} = –0.2435

β_{steer} = 0.9576

a_{steer} = 0.0434

$b_{steer} = 5.4 \cdot 10^{-5}$

$c_{steer} = 5.53 \cdot 10^{-7}$

$n_{t,drive}$ = 8

p~~P~~$_{drive}$ = 689.5 kPa

L_{drive} = 55958.4 N

α_{drive} = –0.3146

β_{drive} = 0.9914

a_{drive} = 0.0504

$b_{drive} = 1.11 \cdot 10^{-4}$

$c_{drive} = 2.86 \cdot 10^{-7}$

$n_{t,trailer}$ = 8

p~~P~~$_{trailer}$ = 689.5 kPa

$L_{trailer}$ = 45727.5 N

$\alpha_{trailer}$ = –0.3982

$\beta_{trailer}$ = 0.9756

$a_{trailer}$ = 0.0656

$b_{trailer} = 1.51 \cdot 10^{-4}$

$c_{trailer} = 2.94 \cdot 10^{-7}$

$\overline{v}_{seghi}$ = 28.86 m/s = 103.896 km/hr

$\overline{v}_{seglo}$ = 5.84 m/s = 21.024 km/hr

$$F_{TRRhi,steer} = 2 \cdot 758.4^{-0.2435} \cdot \left(\frac{51421.2}{2}\right)^{0.9576} \cdot \left(0.0434 + 5.4 \cdot 10^{5} \cdot 103.896 + 5.53 \cdot 10^{-7} \cdot 103.896^{2}\right)$$

$F_{TRRhi,steer}$ = 365.6 N

$F_{TRRhi,drive}$ = 431.4 N

$F_{TRRhi,trailer}$ = 231.7 N

$F_{TRRlo,steer}$ = 297.8 N

$F_{TRRlo,drive}$ = 350.7 N

$F_{TRRlo,trailer}$ = 189.0 N

(iii) Calculate $F_{TRR[speed]}$ by summing the tire rolling resistance calculations at a given speed for each axle position~~ and determine ΔF_{TRR} as follows~~:

$$F_{TRR[speed]} = F_{TRR,[speed]steer} + F_{TRR,[speed]drive} + F_{TRR,[speed]trailer}$$

Eq. 1037.528-12

Example:

F_{TRRhi} = 365.6 + 431.4 + 231.7 = 1028.7 N

F_{TRRlo} = 297.8 + 350.7 + 189.0 = 837.5 N

(iv) Adjust $F_{TRR[speed]}$ to the ambient temperature during the coastdown segment as follows:

$$F_{\mathrm{TRRadj[speed]}} = F_{\mathrm{TRR,[speed]}} \left[1 + 0.006 \cdot (24 - \overline{T}_{seg[speed]})\right]$$

Eq. 1037.528-13

Where:

$\overline{T}_{\mathrm{seg[speed]}}$ = the average ambient temperature during the ~~low or high speed~~ coastdown segment, in °C~~s~~.

Example:

F_{TRRhi} = 1028.7 N

F_{TRRlo} = 837.5 N

$\overline{T}_{\mathrm{seghi}}$ = 25.5 °C

$\overline{T}_{\mathrm{seglo}}$ = 25.1 °C

$$F_{\mathrm{TRRhi,adj}} = 1028.7 \cdot \left[1 + 0.006 \cdot (24 - 25.5)\right] = 1019.4 \text{ N}$$

$$F_{\mathrm{TRRlo,adj}} = 837.5 \cdot \left[1 + 0.006 \cdot (24 - 25.1)\right] = 832.0 \text{ N}$$

(v) Determine the difference in rolling resistance between 65 mph and 15 mph, ΔF_{TRR}, for each tire. Use good engineering judgment to consider the multiple results. For example, you may ignore the test results for the tires with the highest and lowest differences and use the result from the remaining tire. Determine ΔF_{TRR} as follows:

$$\Delta F_{\mathrm{TRR}} = F_{\mathrm{TRRhi,adj}} - F_{\mathrm{TRRlo,adj}}$$

Eq. 1037.528-14

Commented [CAL18]: Equation updated.

Example:

ΔF_{TRR} = 1019.4 – 832.0 = 187.4 N

~~Determine the rolling resistance difference between 65 mph and 15 mph for each tire. Use good engineering judgment to consider the multiple results. For example, you may ignore the test results for the tires with the highest and lowest differences and use the result from the remaining tire.~~

* * * * *

(12) * * *

(v) For the same set of points, recalculate the mean C_dA. This is the final result of the coastdown test, C_dA~~effective yaw~~ coastdown(ψ_{eff}).

* * * * *

153. Amend § 1037.530 by revising paragraph (d)(7) to read as follows:

§ 1037.530 Wind-tunnel procedures for calculating drag area (C_dA).

* * * * *

(d) * * *

(7) Fan section description: fan type, diameter, power, maximum ~~rotational~~ angular speed, maximum speed, support type, mechanical drive, and sectional total weight.

* * * * *

154. Amend § 1037.532 by revising paragraph (a) to read as follows:

§ 1037.532 Using computational fluid dynamics to calculate drag area (C_dA).

* * * * *

(a) For Phase 2 vehicles, use SAE J2966 (incorporated by reference in § 1037.810), with the following clarifications and exceptions:

(1) Vehicles are subject to the requirement to meet standards based on the average of testing at yaw angles of +4.5° ~~or~~ and –4.5°; however, you may submit your application for certification with CFD results based on only one of those yaw angles.

(2) For CFD code with a Navier-Stokes based solver, follow the additional steps in paragraph (d) of this section. For Lattice-Boltzmann based CFD code, follow the additional steps in paragraph (e) of this section.

(3) Simulate a Reynolds number of 5.1 million (based on a 102-inch trailer width) and an air speed of 65 mi/hr.

(4) Perform an open-road simulation ~~the General On-Road Simulation~~ (not the Wind Tunnel Simulation).

(5) Use a free stream turbulence intensity of 0.0 %.

(6) Choose time steps that can accurately resolve intrinsic flow instabilities, consistent with good engineering judgment.

(7) The result must be drag area (C_dA), not drag coefficient (C_d), based on an air speed of 65 mi/hr.

(8) Submit information as described in paragraph (g) of this section.

* * * * *

155. Amend § 1037.534 by revising paragraph (c)(1), (c)(2), (d)(4)(i), and (f)(4)(iv) to read as follows:

§ 1037.534 Constant-speed procedure for calculating drag area (C_dA).

* * * * *

(c) * * *

(1) Measure torque at each of the drive wheels using a hub torque meter or a rim torque meter. If testing a tractor with two drive axles, you may disconnect one of the drive axles from receiving torque from the driveshaft, in which case you would measure torque at only the wheels that receive torque from the driveshaft. Set up instruments to read engine ~~rpm~~ speed for calculating angular ~~rotational~~ speed at the point of the torque measurements, or install instruments for measuring the angular ~~rotational~~ speed of the wheels directly.

(2) Install instrumentation to measure vehicle speed at 10 Hz, with an accuracy and resolution of 0.1 mi/hr. Also install instrumentation for reading engine ~~rpm~~ speed from the engine's onboard computer.

* * * * *

(d) * * *

(4) * * *

(i) Measure the angular ~~rotational~~ speed of the driveshaft, axle, or wheel where the torque is measured, or calculate it from engine ~~rpm~~ speed in conjunction with gear and axle ratios, as applicable.

* * * * *

(f) * * *

(4) * * *

(iv) Calculate C_dA for each 10 second increment from the 50 mi/hr and 70 mi/hr test segments using the following equation:

$$C_d A_{i[\text{speed}]} = \left[\frac{2 \cdot \overline{F}_{\text{aero[speed]}}}{\overline{v}^2_{\text{air[speed]}}} \cdot \frac{R \cdot \overline{T}}{\overline{p}_{\text{act}}} \right]_i$$

Eq. 1037.534-6

Where:

$C_dA_{i[\text{speed}]}$ = the mean drag area for each 10 second increment, *i*.

$\overline{F}_{\text{aero[speed]}}$ = mean aerodynamic force over a given 10 second increment = $\overline{F}_{\text{RL[speed]}} - \overline{F}_{\text{RL10,test}}$.

$\overline{v}_{\text{air[speed]}}$ = mean aerodynamic force over a given 10 second increment.

R = specific gas constant = 287.058 J/(kg·K).

$\overline{T}$ = mean air temperature.

$\overline{p}_{\text{act}}$ = mean absolute air pressure.

Example:

$\overline{F}_{\text{RL70}}$ = 4310.6 N

$\overline{F}_{\text{RL10,test}}$ = 900.1 N

$\overline{F}_{\text{aero70}}$ = 4310.6 – 900.1 = 3410.5 N

$\overline{v}^2_{\text{air70}}$ = 1089.5 m²/s²

R = 287.058 J/(kg·K)

$\overline{T}$ = 293.68 K

$\overline{p}_{\text{act}}$ = 101300 Pa

$$C_d A_{i70} = \left[\frac{2 \cdot 3410.5}{1089.5} \cdot \frac{287.058 \cdot 293.68}{101300} \right]_i$$

C_dA_{i70} = 5.210 m²

* * * * *

156. Amend § 1037.540 by revising paragraphs (b)(3), (b)(8), (d)(2), (e)(2), and (f) to read as follows:

§ 1037.540 Special procedures for testing vehicles with hybrid power take-off.

* * * * *

(b) * * *

(3) Denormalize the PTO duty cycle in Appendix II of this part using the following equation:

$$p_{\text{ref}i} = p_i \cdot \left(\overline{p}_{\text{max}} - \overline{p}_{\text{min}} \right) + \overline{p}_{\text{min}}$$

Eq. 1037.540-1

Where:

$p_{\text{ref}i}$ = the reference pressure at each point *i* in the PTO cycle.

p_i = the normalized pressure at each point *i* in the PTO cycle (relative to $\overline{p}_{\text{max}}$).

$\overline{p}_{\text{max}}$ = the mean maximum pressure measured in paragraph (b)(2) of this section.

Commented [CAL19]: Equation updated.

Commented [CAL20]: Updated.

Commented [CAL21]: Equation updated.

Commented [CAL22]: Updated.

Commented [CAL23]: Equation updated.

Commented [CAL24]: Updated.

Commented [CAL25]: Updated.

$\bar{p}_{min}$ = the mean minimum pressure measured in paragraph (b)(2) of this section.

* * * * *

(8) Measured pressures must meet the cycle-validation specifications in the following table for each test run over the duty cycle:

Table 1 of § 1037.540 – Statistical criteria for validating each test run over the duty cycle

PARAMETER~~[1]~~[A]	PRESSURE
Slope, a_1	$0.950 \le a_1 \le 1.030$
Absolute value of intercept, $\|a_0\|$	≤ 2.0 % of maximum mapped pressure
Standard error of the estimate, *SEE*	≤ 10 % of maximum mapped pressure
Coefficient of determination, r^2	≥ 0.970

~~[1]~~ [a] Determine values for specified parameters as described in 40 CFR 1065.514(e) by comparing measured values to denormalized pressure values from the duty cycle in Appendix II of this part.

* * * * *

(d) * * *

(2) For fractions of a test, use the following equation to calculate the time:

$$t_{\text{test-partial}} = \frac{\sum_{i=1}^{N} \left(p_{\text{circuit-1},i} + p_{\text{circuit-2},i} \right) \cdot \Delta t}{\bar{p}_{\text{circuit-1}} + \bar{p}_{\text{circuit-2}}}$$

Eq. 1037.540-2

Where:

i = an indexing variable that represents one recorded value.

N = number of measurement intervals.

$p_{\text{circuit-1},i}$ = normalized pressure command from circuit 1 of the PTO cycle for each point, i, starting from i = 1.

$p_{\text{circuit-2},i}$ = normalized pressure command from circuit 2 of the PTO cycle for each point, i, starting from i = 1. Let $p_{\text{circuit-2}}$ = 0 if there is only one circuit.

$\bar{p}_{\text{circuit-1}}$ = the mean normalized pressure command from circuit 1 over the entire PTO cycle.

$\bar{p}_{\text{circuit-2}}$ = the mean normalized pressure command from circuit 2 over the entire PTO cycle. Let $\bar{p}_{\text{circuit-2}}$ = 0 if there is only one circuit.

Δt = the time interval between measurements. For example, at 100 Hz, Δt = 0.0100 seconds.

* * * * *

(e) * * *

(2) Divide the CO_2 mass from the PTO cycle by the distance determined in paragraph (d)(4) of this section and the standard payload as defined in § 1037.801 to get the CO_2 emission rate in g/ton-mile. For plug-in hybrid electric vehicles follow paragraph (f)(3) of this section to calculate utility factor weighted CO_2 emissions in g/ton-mile.

* * * * *

(f) For Phase 2, calculate the delta PTO fuel results for input into GEM during vehicle certification as follows:

Commented [CAL26]: Equation updated.

Commented [CAL27]: Updated.

Commented [CAL28]: Updated.

(1) Calculate fuel consumption in grams per test, $m_{fuelPTO}$, without rounding, as described in 40 CFR 1036.540(d)(4) ~~and (5)~~ for both the conventional vehicle and the charge-sustaining and charge-depleting portions of the test for the hybrid vehicle as applicable.

(2) Divide the fuel mass by the applicable distance determined in paragraph (d)(4) of this section and the appropriate standard payload as defined in § 1037.801 to determine the fuel rate in g/ton-mile.

(3) For plug-in hybrid electric vehicles calculate the utility factor weighted fuel consumption in g/ton-mile, as follows:

(i) Determine the utility factor fraction for the PTO system from the table in Appendix V of this part using interpolation based on the total time of the charge-depleting portion of the test as determined in paragraphs (c)(6) and (d)(3) of this section.

(ii) Weight the emissions from the charge-sustaining and charge-depleting portions of the test using the following equation:

$$m_{\text{fuelPTO,plug-in}} = m_{\text{PTO,CD}} \cdot UF_{\text{t,CD}} + m_{\text{PTO,CS}} \cdot \left(1 - UF_{\text{t,CD}}\right)$$

Eq. 1037.540-3

Where:

$m_{PTO,CD}$ = mass of fuel per ton-mile while in charge-depleting mode.

$UF_{t,CD}$ = utility factor fraction at time t_{CD} as determined in paragraph (f)(3)(i) of this section.

$m_{PTO,CS}$ = mass of fuel per ton-mile while in charge-sustaining mode.

(4) Calculate the difference between the conventional PTO emissions result and the hybrid PTO emissions result for input into GEM.

* * * * *

Commented [CAL29]: Equation updated.

Commented [CAL30]: Updated.

157. Revise § 1037.550 to read as follows:

§ 1037.550 Powertrain testing.

~~(a)~~ This section describes the procedure ~~how~~ to measure fuel consumption and create ~~determine~~ engine fuel maps ~~using a measurement procedure that involves~~by testing a powertrain that includes an engine coupled with a transmission, drive axle, and hybrid components or any assembly with one or more of those hardware elements~~a powertrain to simulate vehicle operation~~. Engine fuel maps are part of demonstrating compliance with Phase 2 vehicle standards under this part 1037; the powertrain test procedure in this section is one option for generating this fuel-mapping information ~~may come from different types of testing~~ as described in 40 CFR 1036.~~510~~503. Additionally, this powertrain test procedure is one option for certifying hybrids to the engine standards in 40 CFR part 1036.108.

(a~~b~~) General provisions. The following provisions apply broadly for testing under this section:~~Perform powertrain testing to establish measured fuel-consumption rates over applicable duty cycles for several different vehicle configurations. The following general provisions apply:~~

(1) Measure NO_x emissions as described in paragraph (k) of this section~~for each sampling period in grams. You may perform these measurements using a NO_x emission-measurement system that meets the requirements of 40 CFR part 1065, subpart J~~. Include these measured NO_x values any time you report to us your greenhouse gas emissions or fuel consumption values from testing under this section.~~ If a system malfunction prevents you from measuring NO_x emissions during a test under this section but the test otherwise gives valid results, you may consider this a valid test and omit the NO_x emission measurements; however, we may require you to repeat the test if we determine that you inappropriately voided the test with~~

respect to NO_x emission measurement.

(2) The procedures of 40 CFR part 1065 apply for testing in this section except as specified. This section uses engine parameters and variables that are consistent with 40 CFR part 1065.

(3) Powertrain testing depends on models to calculate certain parameters. You can uUse one of the following options to create the vehicle model:

(i) Use the detailed equations in this section .

to create your own models, or use the GEM HIL model (ii) Use a While this section includes the detailed equations, you need to develop your own driver model and vehicle model; we recommend that you use the MATLAB/Simulink code in GEM to create the vehicle model (incorporated by reference in § 1037.810) provided at to simulate vehicle hardware elements as follows:.

If you use this option(i) Create driveline and vehicle models that calculate the angular speed setpoint for the test cell dynamometer, $f_{nref,dyno}$, based on the torque measurement location. Use the detailed equations in paragraph (f) of this section, the GEM HIL model's driveline and vehicle submodels, or a combination of the equations and the submodels. You may use the GEM HIL model's transmission submodel in paragraph (f) of this section to simulate a transmission only if testing hybrid engines.

(ii) Create a driver model or use the GEM HIL model's driver submodel to simulate a human driver modulating the throttle and brake pedals to follow the test cycle as closely as possible.

(iii) Create a cycle-interpolation model or use the GEM HIL model's cycle submodel to interpolate the duty-cycles and feed the driver model the duty-cycle reference vehicle speed for each point in the duty-cycle.

(4) The powertrain test procedure in this section is designed to simulate operation of different vehicle configurations over specific duty cycles. See paragraphs (h) and (j) of this section.

(5) For each test run, record engine speed and torque as defined in 40 CFR 1065.915(d)(5) with a minimum sampling frequency of 1 Hz. These engine speed and torque values represent a duty cycle that can be used for separate testing with an engine mounted on an engine dynamometer under § 1037.551, such as for a selective enforcement audit as described in § 1037.301.

(6) For hybrid powertrains with no plug-in capability, correct for the net energy change of the energy storage device as described in 40 CFR 1066.501. For PHEV powertrains, follow 40 CFR 1066.501 to determine End-of-Test for charge-depleting operation. You must get our approval in advance for your utility factor curve; we will approve it if you can show that you created it from sufficient in-use data of vehicles in the same application as the vehicles in which the PHEV powertrain will be installed.

, set the accessory load in GEM to zero. This option is required if you are testing a hybrid powertrain system where the transmission is not part of the test, but is required when installed in the vehicle.

(cb) Test configuration. Select an engine and powertrain for testing as described in § 1037.235 or 40 CFR 1036.235 as applicable1.

(d) Set up the engine according to 40 CFR 1065.110 and 40 CFR 1065.405(b). Set the engine's idle speed to the minimum warm-idle speed. If warm idle speed is not adjustable, simply let the engine operate at its warm idle speed.

(1) The default test configuration consists of a powertrain with all components upstream of the axle. This involves connecting the powertrain's transmission output shaft directly to the

dynamometer or to a gear box with a fixed gear ratio and measuring torque at the axle input shaft ~~for use in the vehicle model~~. You may instead set up the dynamometer to connect at the wheel hubs and measure torque at that location. This may apply if your powertrain configuration requires it, such as for hybrid powertrains~~,~~ or if you want to represent the axle performance with powertrain test results. ~~If you measure torque connect at the wheel hubs for use in the vehicle model, input your test results into GEM to reflect this.~~

(2) For testing hybrid~~s~~ engines, connect the engine's crankshaft directly to the dynamometer and measure torque at that location.~~that do not include the transmission or axle, connect the powertrain's output shaft that would connect to the transmission directly to the dynamometer.~~

(~~e~~c) Powertrain temperatures during testing. Cool the powertrain during testing so temperatures for ~~intake air,~~ oil, coolant, block, head, transmission, battery, and power electronics are within the~~ir~~ manufacturer's expected ranges for normal operation. You may use electronic control module outputs ~~ECM measurements~~ to comply with this requirement. You may use auxiliary coolers and fans.

(d~~f~~) Engine break in. Break in the engine according to 40 CFR 1065.405, the axle assembly according to § 1037.560, and the transmission according to § 1037.565. You may instead break in the powertrain as a complete system ~~by following~~using the engine break in procedure ~~according to~~in 40 CFR 1065.405.

(~~f~~ge) Dynamometer setup. Set the dynamometer to operate in speed-control mode (or torque-control mode for hybrid engine testing at idle, including idle portions of transient duty cycles). Record data as described in 40 CFR 1065.202. Command and control the dynamometer speed at a minimum of 5 Hz, or 10 Hz for testing engine hybrids. Run the vehicle model to calculate the dynamometer setpoints at a rate of at least 100 Hz. If the dynamometer's command frequency is less than the vehicle model dynamometer setpoint frequency~~If you choose to command the dynamometer at a slower rate than the calculated dynamometer speed setpoint~~, ~~use good engineering judgment to~~ subsample the calculated setpoints for ~~use in~~ commanding the dynamome~~m~~ter ~~speed~~ setpoints.

(f) Driveline and vehicle model. Use the GEM HIL model's driveline and vehicle submodels or the equations in this paragraph (f) of this section to~~Design a vehicle model to use the measured torque and~~ calculate the dynamometer speed setpoint~~,~~, $f_{nref,dyno}$, based on the torque measurement location. Note that the GEM HIL model is configured to set the accessory load to zero and it comes configured with the tire slip model disabled.

~~at a rate of at least 100 Hz, as follows:~~

(1) Driveline model with a transmission in hardware. For testing with ~~the speed~~ torque measurement at the axle input shaft or wheel hubs, c~~C~~alculate ~~the dynamometer's angular speed target~~, $f_{nref,dyno}$, using the GEM HIL model's driveline submodel or the following equation~~based on the simulated linear speed of the tires~~:

$$f_{nrefi,dyno} = \frac{k_{a[speed]} \cdot v_{refi}}{2 \cdot \pi \cdot r_{[speed]}}$$

Eq. 1037.550-1

Where:

$k_{a[speed]}$ = drive axle ratio as determined in paragraph (~~h~~ih) of this section. Set $k_{a[speed]}$ equal to 1.0 if torque is measured at the wheel hubs.

v_{refi} = simulated vehicle reference speed as calculated in paragraph (f)(3) of this section. ~~Use the unrounded result for calculating $f_{nrefi,dyno}$.~~

Commented [CAL31]: Equation updated.

$r_{[speed]}$ = tire radius as determined in paragraph (~~h~~ih) of this section.

(2) Driveline model with a simulated transmission. For testing with the torque measurement at the engine's crankshaft, $f_{nref,dyno}$ is the dynamometer target speed from the GEM HIL model's transmission submodel. You may request our approval to change the transmission submodel, as long as the changes do not affect the gear selection logic. Before testing, initialize the transmission model with the engine's measured torque curve and the applicable steady-state fuel map from the GEM HIL model. You may request our approval to input your own steady-state fuel map. Configure the torque converter to simulate neutral idle when using this procedure to generate engine fuel maps in 40 CFR 1036.503 or to perform SET testing under 40 CFR 1036.505. You may change engine commanded torque at idle to better represent CITT for transient testing under 40 CFR 1036.510. You may change the simulated engine inertia to match the inertia of the engine under test. We will evaluate your requests under this paragraph (f)(3) based on your demonstration that that the adjusted testing better represents in-use operation.

(i) The transmission submodel needs the following model inputs:

(A) Torque measured at the engine's crankshaft.

(B) Engine estimated torque determined from the electronic control module or by converting the instantaneous operator demand to an instantaneous torque in N·m.

(C) Dynamometer mode when idling (speed-control or torque-control).

(D) Measured engine speed when idling.

(E) Transmission output angular speed, $f_{ni,transmission}$, calculated as follows:

$$f_{ni,\text{transmission}} = \frac{k_{a[\text{speed}]} \cdot v_{\text{ref}i}}{2 \cdot \pi \cdot r_{[\text{speed}]}}$$

Eq. 1037.550-2

Where:

$k_{a[speed]}$ = drive axle ratio as determined in paragraph (h) of this section.

v_{refi} = simulated vehicle reference speed as calculated in paragraph (f)(3) of this section.

$r_{[speed]}$ = tire radius as determined in paragraph (h) of this section.

(ii) The transmission submodel generates the following model outputs:

(A) Dynamometer target speed.

(B) Dynamometer idle load.

(C) Transmission engine load limit.

(D) Engine speed target.

(3) Vehicle model. Calculate the simulated vehicle reference speed, v_{refi}, using the GEM HIL model's vehicle submodel or the equations in this paragraph (f)(3):

$$v_{\text{ref}i} = \left(\frac{k_{\text{a}} \cdot T_{i\text{-}1}}{r} \cdot \left(Eff_{\text{axle}}\right) - \left(M \cdot g \cdot C_{\text{rr}} \cdot \cos\left(\operatorname{atan}\left(G_{i\text{-}1}\right)\right) + \frac{\rho \cdot C_{\text{d}} A}{2} \cdot v_{\text{ref},i\text{-}1}^{2} \right) - F_{\text{brake},i\text{-}1} - F_{\text{grade},i\text{-}1} \right) \cdot \frac{\Delta t_{i\text{-}1}}{M + M_{\text{rotating}}} + v_{\text{ref},i\text{-}1}$$

Eq. 1037.550-3~~2~~

Where:

i = a time-based counter corresponding to each measurement during the sampling period. Let v_{ref1} = 0; start calculations at i = 2. A 10-minute sampling period will generally involve 60,000 measurements.

Commented [CAL32]: Equation updated.

T = instantaneous measured torque at the axle input, measured at the wheel hubs, or simulated by the GEM HIL model's transmission submodel.

Eff_{axle} = axle efficiency. Use Eff_{axle} = 0.955 for $T \geq >$ 0, and use Eff_{axle} = 1/0.955 for $T < 0$. Use Eff_{axle} = 1.0 if torque is measured at the wheel hubs. To calculate $f_{nrefi,dyno}$ for a dynamometer connected at the wheel hubs, as described in paragraph (f)(2) of this section, use Eff_{axle} = 1.0.

M = vehicle mass for a vehicle class as determined in paragraph (hih) of this section.

g = gravitational constant = 9.806651 m/s^2.

C_{rr} = coefficient of rolling resistance for a vehicle class as determined in paragraph (hih) of this section.

G_{i-1} = the percent grade interpolated at distance, D_{i-1}, from the duty cycle in Appendix IV corresponding to measurement (i–1).

$$D_{i\text{-}1} = \sum_{i=1}^{N} \left(v_{\text{ref},i\text{-}1} \cdot \Delta t_{i\text{-}1} \right)$$

Eq. 1037.550-43

ρ = air density at reference conditions. Use ρ = 1.184520 kg/m^3.

C_dA = drag area for a vehicle class as determined in paragraph (hih) of this section.

$F_{brake,i-1}$ = instantaneous braking force applied by the driver model.

$$F_{\text{grade},i\text{-}1} = M \cdot g \cdot \sin\left(\text{atan}\left(G_{i\text{-}1}\right)\right)$$

Eq. 1037.550-54

Δt = the time interval between measurements. For example, at 100 Hz, Δt = 0.0100 seconds.

$M_{rotating}$ = inertial mass of rotating components. Let $M_{rotating}$ = 340 kg for vocational Light HDV or vocational Medium HDV. See paragraph (hih) of this section for tractors and for vocational Heavy HDV.

(4) Example. The following example illustrates a calculation of $f_{nref,dyno}$ using paragraph (f)(1) of this section where torque is measured at the axle input shaft.

Example:

This example is for a vocational Light HDV or vocational Medium HDV with 6 speed automatic transmission at B speed (Test 4 in Table 2 of 40 CFR 1036.540).

k_{aB} = 4.0

r_B = 0.399 m

$T_{9991000-1}$ = 500.0 N·m

C_{rr} = 67.79 kg/tonne = 76.79·10^{-3} kg/kg

M = 11408 kg

C_dA = 5.4 m^2

$G_{9991000-1}$ = 10.390 % = 0.0180039

$$D_{999} = \sum_{i=0}^{998} \left(19.99 \cdot 0.01 + 20.0 \cdot 0.01 + ... + v_{\text{ref},998} \cdot \Delta t_{998} \right) = 1792 \text{ m}$$

$F_{brake,999}$ = 0 N

$vV_{ref,999}$ = 20.0 m/s

$$F_{\text{grade},999} = 11408 \cdot 9.81 \cdot \sin\left(\text{atan}\left(0.0039\right)\right) = 436.5 \text{ N}$$

Δt = 0.0100 s

$M_{rotating}$ = 340 kg

Commented [CAL33]: Updated.

Commented [CAL34]: Updated.

Commented [CAL35]: Equation updated.

Commented [CAL36]: Equation updated.

$$v_{\text{ref1000}} = \left(\frac{4.0\cdot 500.0}{0.399}\cdot(0.955) - \left(11408\cdot 9.80665\cdot 7.7\cdot 10^{-3}\cdot\cos\left(\text{atan}\left(0.0039\right)\right) + \frac{1.1845\cdot 5.4}{2}\cdot 20.0^{2}\right) - 0 - 436.5\right)\cdot\frac{0.0100}{11408+340} + 20.0$$

v_{ref1000} = 20.00129 00189 m/s

$$f_{\text{nref1000,dyno}} = \frac{4.0\cdot 20.00189}{2\cdot 3.14\cdot 0.399} = 31.93 \text{ r/s} = 1915.8 \text{ r/min}$$

(2) For testing with the speed measurementdynamometer connected at the wheel hubs, calculate $f_{\text{nref,dyno}}$ using the following Eq.equation 1037.550-1, setting $k_{\text{a[speed]}}$ equal to 1.:

$$f_{\text{nrefi,dyno}} = \frac{v_{\text{refi}}}{2\cdot\pi\cdot r}$$

$$f_{ni,\text{transmission}} = \frac{k_{\text{a[speed]}}\cdot v_{\text{ref}i}}{2\cdot\pi\cdot r_{\text{[speed]}}}$$ Eq. 1037.550-5

(ghg) Driver model. Use the GEM HIL model's driver submodel or dDesign a driver model to simulate a human driver modulating the throttle and brake pedals. In either case, tune the model to follow the test cycle as closely as possible meeting the following specifications.:

(1) The driver model must meet the speed requirements for operation over the highway cruise cycles as described in § 1037.510 and for operation over the transient cycle as described in 40 CFR 1066.425(b). The exceptions in 40 CFR 1066.425(b)(4) apply to the transient cycle and the highway cruise cycles. Design the driver model to meet the following specifications:

(12) Send a brake signal when throttle positionoperator demand is zero and vehicle speed is greater than the reference vehicle speed from the test cycle. Include a delay before changing the brake signal to prevent dithering, consistent with good engineering judgment.

(23) Allow braking only if throttle positionoperator demand is zero.

(34) Compensate for the distance driven over the duty cycle over the course of the test. Use the following equation to perform the compensation in real time to determine your time in the cycle:

$$t_{\text{cycle}i} = \sum_{i=1}^{N}\left(\left(\frac{v_{\text{vehicle},i-1}}{v_{\text{cycle},i-1}}\right)\cdot\Delta t_{i-1}\right)$$

Eq. 1037.550-66

Where:

v_{vehicle} = measured vehicle speed.

v_{cycle} = reference speed from the test cycle. If $v_{\text{cycle},i-1} < 1.0$ m/s, set $v_{\text{cycle},i-1} = v_{\text{vehicle},i-1}$.

(hih) Vehicle configurations to evaluate for generating fuel maps as defined in 40 CFR 1036.503. Configure the driveline and vehicle models from paragraph (f) of this section in the test cell to test the powertrain. Simulate multiple vehicle configurations that represent the range of intended vehicle applications. Useusing at least three equally spaced axle ratios or tire sizes and three different road loads (nine configurations), or at least four equally spaced axle ratios or tire sizes and two different road loads (eight configurations) to cover the range of intended vehicle applications. Select axle ratios to represent the full range of expected vehicle installations.

(1) Determine the vehicle model inputs for Mvehicle mass, M_{rotating}, C_dA, and C_{rr} for a set of vehicle configurations as described in 40 CFR 1036.540(c)(3). You may instead test to simulate eight or nine vehicle configurations from different vehicle categories if you limit

Commented [CAL37]: Example updated.

Commented [CAL38]: Example updated.

Commented [CAL39]: Example updated.

Commented [CAL40]: Equation updated.

Commented [CAL41]: Updated.

your powertrains to a certain range of vehicles. For example, if your powertrain will be installed only in vocational Medium HDV and vocational Heavy HDV, you may perform testing to represent eight or nine vehicle configurations using vehicle masses for Medium HDV and Heavy HDV, the predefined C_dA for those vehicles, and the lowest and highest C_{rr} of the tires that will be installed on those vehicles. Also, iInstead of selecting specific axle ratios and tire sizes based on the range of intended vehicle applications as described in this paragraph (hih), you may select equally spaced axle ratios and tire sizes such that the ratio of engine speed overto vehicle speed that covers the range of ratios of minimum and maximum engine speed over to vehicle speed when the transmission is in top gear for the vehicles in which the powertrain will be installed in. Note that you do not have to use the same axle ratios and tire sizes for each GEM regulatory subcategory.

(2) For hybrid powertrain systems where the transmission will be part of the vehicle modelsimulated, use the transmission parameters defined in Table 1 of 40 CFR 1036.540 to determine transmission type and gear ratio. and Use a fixed transmission efficiency of 0.95. The GEM HIL transmission model uses a transmission parameter file for each test that includes the transmission type, gear ratios, lockup gear, torque limit per gear from Table 1 of 40 CFR 1036.540, and the values from 40 CFR 1036.503(b)(4) and (c).

(i) [Reserved]

(ij) Duty cycles to evaluate. Operate the powertrain over each of the duty cycles specified in § 1037.510(a)(2), and for each applicable test vehicle configuration from paragraph (h) of this sectionidentified in 40 CFR 1036.540(c). Determine cycle-average powertrain fuel maps by testing the powertrain using the procedures in Test the powertrain according to 40 CFR 1036.540(d), understanding "engine" to mean "powertrain", with the following exceptions:

(1) Understand "engine" to mean "powertrain".

(2) If the preceding duty cycle does not end at 0 mi/hr, transition between duty cycles by decelerating at a rate of 2 mi/hr/s at 0 % grade until the vehicle reaches zero speed. Shut off the powertrain. Prepare the powertrain and test cell for the next duty-cycle. Start the next duty-cycle within 60 to 180 seconds after shutting off the powertrain. Do not run the powertrain or change its physical state before starting the next duty cycle. If the next duty cycle begins at 0 mi/hr vehicle speed, key on the vehicle and start the duty-cycle after 10 seconds, otherwise key on the vehicle and transition to the next duty cycle by accelerating at a rate of 1 mi/hr/s at 0 % grade for vehicle configurations given in Table 2 of 40 CFR 1036.540 or 2 mi/hr/s at 0 % grade for vehicle configurations given in Table 3 and Table 4 of 40 CFR 1036.540, then stabilize for 10 seconds at the initial duty cycle conditions.Add a 20-second transition period between adjacent duty cycles. If you are transitioning from an engine stop situation, transition to the next cycle within 60 seconds. For cruise cycles, add a 40-second stabilization period after the transition period before starting the next cycle.

(23) You may useCalculate cycle work using GEM or the speed and torque from the driveline and vehicle models from paragraph (f) of this section to determine the sequence of duty cyclesyour own vehicle model to calculate cycle work for determining cycle run order.

(34) Calculate the mass of fuel consumed for the idle duty cycles as described in paragraph (n) of this section.For each duty cycle, precondition the powertrain using the Test 1 vehicle configuration and test the different configurations in numerical order starting with Test 1. If an infrequent regeneration event occurs during testing, void the test, but continue operating the vehicle to allow the regeneration event to finish, then precondition the engine to the same condition as would apply for normal testing and restart testing at the start of the same duty

cycle for that test configuration. For PHEV powertrains, precondition the battery and then complete all back to back tests for each test configuration according to 40 CFR 1066.501 before moving to the next test configuration. You may send signals to the engine controller during the test, such as cycle road grade and vehicle speed, if that allows powertrain operation during the test to better represent real-world operation.

(5) Warm up the powertrain as described in 40 CFR 1036.527(c)(1).

(jk) Measuring NO_x emissions. Measure NO_x emissions for each sampling period in grams. You may perform these measurements using a NO_x emission-measurement system that meets the requirements of 40 CFR part 1065, subpart J. If a system malfunction prevents you from measuring NO_x emissions during a test under this section but the test otherwise gives valid results, you may consider this a valid test and omit the NO_x emission measurements; however, we may require you to repeat the test if we determine that you inappropriately voided the test with respect to NO_x emission measurement.Collect and measure emissions as described in 40 CFR part 1065. For hybrid powertrains with no plug-in capability, correct for the net energy change of the energy storage device as described in 40 CFR 1066.501. For PHEV powertrains, follow 40 CFR 1066.501 to determine End-of-Test for charge-depleting operation. You must get our approval in advance for your utility factor curve; we will approve it if you can show that you created it from sufficient in-use data of vehicles in the same application as the vehicles in which the PHEV powertrain will be installed.

(l) [Reserved]

(mk) Measured output speed validation. For each test point, validate the measured output speed with the corresponding reference values. If the range of reference speed is less than 10 percent of the mean reference speed, you need to meet only the standard error of the estimate in Table 1 of this section. You may delete points when the vehicle is stopped. If your speed measurement is not at the location of $f_{n,ref}$, you may correct your measured speed byusing the constant speed ratio between the two locations. Apply cycle-validation criteria for each separate transient or highway cruise cycle based on the following parameters:

Table 1 of § 1037.550 – Statistical criteria for validating duty cycles

PARAMETER[1A]	SPEED CONTROL
Slope, a_1	$0.990 \leq a_1 \leq 1.010$
Absolute value of intercept, $\lvert a_0 \rvert$	≤ 2.0 % of maximum test f_{nvref} speed
Standard error of the estimate, *SEE*	≤ 2.0 % of maximum f_{nvref} test speed
Coefficient of determination, r^2	≥ 0.990

[1 a]Determine values for specified parameters as described in 40 CFR 1065.514(e) by comparing measured and reference values for $f_{nref,dyno}$.

[Reserved]

(m) Calculate mass of fuel consumed for all duty cycles except idle as described in 40 CFR 1036.540(d)(4).

(n) Fuel consumption at idle. Determine the mass of fuel consumed at idle for the applicable duty cycles described in § 1037.510(a)(2) as follows:

(1) Measure fuel consumption with a fuel flow meter and report the mean idle fuel mass flow

rate for each duty cycle as applicable, $\bar{\dot{m}}_{fuelidle}$.

(2) If you do not ~~For measurements that do not involve~~ measure~~d~~ fuel mass flow rate, calculate the idle fuel mass flow rate for each duty cycle, $\bar{\dot{m}}_{fuelidle}$, for each set of vehicle settings, as follows:

$$\bar{\dot{m}}_{fuelidle} = \frac{M_C}{w_{Cmeas}} \cdot \left(\bar{\dot{n}}_{exh} \cdot \frac{\bar{x}_{Ccombdry}}{1 + \bar{x}_{H2Oexhdry}} - \frac{\bar{\dot{m}}_{CO2DEF}}{M_{CO2}} \right)$$

Eq. 1037.550-7~~7~~

Where:

M_C = molar mass of carbon.

w_{Cmeas} = carbon mass fraction of fuel (or mixture of test fuels) as determined ~~by~~ in 40 CFR 1065.655(d), except that you may not use the default properties in Table 1 of 40 CFR 1065.655 to determine α, β, and w_C for liquid fuels.

$\bar{\dot{n}}_{exh}$ = the mean raw exhaust molar flow rate from which you measured emissions according to 40 CFR 1065.655.

$\bar{x}_{Ccombdry}$ = the mean concentration of carbon from fuel and any injected fluids in the exhaust per mole of dry exhaust.

$\bar{x}_{H2Oexhdry}$ = the mean concentration of H_2O in exhaust per mole of dry exhaust.

$\bar{\dot{m}}_{CO2DEF}$ = the mean CO_2 mass emission rate resulting from diesel exhaust fluid decomposition over the duty cycle as determined in 40 CFR 1036.535(b)(10). If your engine does not use diesel exhaust fluid, or if you choose not to perform this correction, set $\bar{\dot{m}}_{CO2DEF}$ equal to 0.

M_{CO2} = molar mass of carbon dioxide.

Example:

M_C = 12.0107 g/mol

w_{Cmeas} = 0.867

$\bar{\dot{n}}_{exh}$ = 25.534 mol/s

$\bar{x}_{Ccombdry}$ = $2.805 \cdot 10^{-3}$ mol/mol

$\bar{x}_{H2Oexhdry}$ = $3.53 \cdot 10^{-2}$ mol/mol

$\bar{\dot{m}}_{CO2DEF}$ = 0.0726 g/s

M_{CO2} = 44.0095

$$\bar{\dot{m}}_{fuelidle} = \frac{12.0107}{0.867} \cdot \left(25.534 \cdot \frac{2.805 \cdot 10^{-3}}{1 + 3.53 \cdot 10^{-2}} - \frac{0.0726}{44.0095} \right)$$

$\bar{\dot{m}}_{fuelidle}$ = 0.405 g/s = 1458.6 g/hr

(o) Create GEM inputs. Use the results of powertrain testing to determine GEM inputs for the different simulated vehicle configurations as follows:

(1) Correct the measured or calculated fuel masses, $m_{fuel[cycle]}$, and mean idle fuel mass flow rates, $\bar{\dot{m}}_{fuelidle}$, if applicable, for each test result to a mass-specific net energy content of a reference fuel as described in 40 CFR~~§~~ 1036.535(~~b~~f)~~(11)~~, replacing $\bar{\dot{m}}_{fuel}$ with $m_{fuel[cycle]}$ where applicable in Eq. 1036.535-~~3~~4.

(2) Select Declare fuel consumption rates masses, $m_{\text{fuel[cycle]}}$, in g/cycle. In addition, declare mean a fuel mass consumption flow rate for each applicable idle duty cycle, $\bar{m}_{\text{fuelidle}}$. These declared values may not be lower than any corresponding measured values determined in this section. If you use multiple measurement methods as allowed in 40 CFR 1036.540(d), follow 40 CFR 1036.535(g) regarding the use of direct and indirect fuel measurements and the carbon balance error verification. You may select any value that is at or above the corresponding measured value. These declared fuel consumption ratesvalues, which serve as emission standards, represent collectively as represent the certified powertrain fuel map for certification.

(23) Calculate pPowertrain output speed per unit of vehicle speed, $\left[\frac{\bar{f}_{\text{npowertrain}}}{\bar{v}_{\text{powertrain}}}\right]_{\text{[cycle]}}$, using one of the following methods:.

(i) For testing with torque measurement at the axle input shaft:

$$\left[\frac{\bar{f}_{\text{npowertrain}}}{\bar{v}_{\text{powertrain}}}\right]_{\text{[cycle]}} = \frac{k_{\text{a}}}{2 \cdot \pi \cdot r_{\text{[speed]}}}$$

Eq. 1037.550-8

Example:

$k_{\text{a}} = 4.0$

$r_{\text{B}} = 0.399$ m

$$\left[\frac{\bar{f}_{\text{npowertrain}}}{\bar{v}_{\text{powertrain}}}\right]_{\text{transienttest4}} = \frac{4.0}{2 \cdot 3.14 \cdot 0.399} = 1.596 \text{ r/m}$$

(ii) For testing with If the test is done with the torque measurementdynamometer connected at the wheel hubs, use Eq. 1037.550-8 setting k_{a} to the axle ratio of the rear axle that was used in the test. If the vehicle does not have a drive axle, such as hybrid vehicles with direct electric drive, let k_{a} equal to= 1.

$$\frac{f_{\text{npowertrain}}}{v_{\text{powertrain}}} = \frac{k_{\text{a}}}{2 \cdot \pi \cdot r_{\text{[speed]}}}$$

Eq. 1037.

(iii) For testing with torque measurement at the engine's crankshaft:

$$\left[\frac{\bar{f}_{\text{npowertrain}}}{\bar{v}_{\text{powertrain}}}\right]_{\text{[cycle]}} = \frac{\bar{f}_{\text{nengine}}}{\bar{v}_{\text{ref}}}$$

Eq. 1037.550-9

Where:

$\bar{f}_{\text{nengine}}$ = average engine speed when vehicle speed is at or above 0.100 m/s.

$\bar{v}_{\text{ref}}$ = average simulated vehicle speed at or above 0.100 m/s.

Example:

$\bar{f}_{\text{nengine}}$ = 1870 r/min = 31.17 r/s

$\bar{v}_{\text{ref}}$ = 19.06 m/s

$$\left[\frac{\bar{f}_{\text{npowertrain}}}{\bar{v}_{\text{powertrain}}}\right]_{\text{transienttest4}} = \frac{31.17}{19.06} = 1.635 \text{ r/m}$$

(43) Positive Calculate positive work, $W_{[\text{cycle}]}$, as the work over the duty cycle at the transmission outputaxle input shaft, or wheel hubs, or the powertrain's output shaft that would connect to the transmission from the powertrain testengine's crankshaft, as applicable, when vehicle speed is at or above 0.100 m/s.

(55) TheCalculate engine idle speed, by taking the average engine speed measured during the transient cycle engine test while the vehicle speed is not moving. Note that GEM has a flag to indicate when the vehicle is movingbelow 0.100 m/s.

(p) Correct the measured or calculated fuel mass, m_{fuel}, and idle fuel mass flow rate, $\bar{\dot{m}}_{\text{fuelidle}}$ if applicable, for each test result to a mass-specific net energy content of a reference fuel as described in 40 CFR§ 1036.535(bf)(11), replacing $\bar{\dot{m}}_{\text{fuel}}$ with m_{fuel} where applicable in Eq. 1036.535-34.

(q) For each test run, record the engine speed and torque as defined in 40 CFR 1065.915(d)(5) with a minimum sampling frequency of 1 Hz. These engine speed and torque values represent a duty cycle that can be used for separate testing with an engine mounted on an engine dynamometer under § 1037.551, such as for a selective enforcement audit as described in § 1037.301.

(64) The following table illustrates the GEM data inputs corresponding to the different vehicle configurations for a given duty cycle:

Table 2 of § 1037.550 – Example vehicle configuration test result output matrix for Heavy HDV

	VEHICLE CONFIGURATION NUMBER								
	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Test 7	Test 8	Test 9
$mM_{\text{fuel[cycle]}}$									
$\left[\frac{\bar{f}_{\text{npowertrain}}}{\bar{v}_{\text{powertrain}}}\right]_{[\text{cycle}]}$									
$W_{[\text{cycle}]}$									
$\bar{f}_{\text{nidle}}$[a]									

[a]Idle speed applies only for the transient duty cycle.

158. Amend § 1037.551 by revising paragraph (b) to read as follows:

§ 1037.551 Engine-based simulation of powertrain testing.

* * * * *

(b) Operate the engine over the applicable engine duty cycles corresponding to the vehicle cycles specified in § 1037.510(a)(2) for powertrain testing over the applicable vehicle simulations described in § 1037.550(hi). Warm up the engine to prepare for the transient test or one of the highway cruise cycles by operating it one time over one of the simulations of the corresponding duty cycle. Warm up the engine to prepare for the idle test by operating it over a simulation of the 65-mi/hr highway cruise cycle for 600 seconds. Within 60 seconds after concluding the warm up cycle, start emission sampling while the engine operates over the duty cycle. You may perform any number of test runs directly in succession once the engine is warmed up. Perform cycle validation as described in 40 CFR 1065.514 for engine speed, torque, and power.

* * * * *

159. Amend § 1037.555 by revising paragraphs (d), (e), and (f) to read as follows:

§ 1037.555 Special procedures for testing Phase 1 hybrid systems.

* * * * *

(d) Calculate the transmission output shaft's angular speed target for the driver model, $f_{\text{nref,driver}}$, from the linear speed associated with the vehicle cycle using the following equation:

$$f_{\text{nref}i\text{,driver}} = \frac{v_{\text{cycle}i} \cdot k_{\text{a}}}{2 \cdot \pi \cdot r}$$

Eq. 1037.555-1

Commented [CAL42]: Updated.

Where:

$v_{\text{cycle}i}$ = vehicle speed of the test cycle for each point, i, starting from i = 1.

k_{a} = drive axle ratio, as declared by the manufacturer.

r = radius of the loaded tires, as declared by the manufacturer.

(e) Use speed control with a loop rate of at least 100 Hz to program the dynamometer to follow the test cycle, as follows:

(1) Calculate the transmission output shaft's angular speed target for the dynamometer, $f_{\text{nref,dyno}}$, from the measured linear speed at the dynamometer rolls using the following equation:

$$f_{\text{nref}_{\text{i,dyno}}} = \frac{v_{\text{ref}_{\text{i}}} \cdot k_{\text{a}}}{2 \cdot \pi \cdot r}$$

Eq. 1037.555-2

Where:

$$v_{\text{ref}i} = \left(\frac{k_{\text{a}} \cdot T_{i-1}}{r} - \left(A + B \cdot v_{\text{ref},i-1} + C \cdot v_{\text{ref},i-1}^{2} \right) - F_{\text{brake},i-1} \right) \cdot \frac{t_{\text{i}} - t_{i-1}}{M} + v_{\text{ref},i-1}$$

Eq. 1037.555-3

Commented [CAL43]: Updated.

T = instantaneous measured torque at the transmission output shaft.

F_{brake} = instantaneous brake force applied by the driver model to add force to slow down the vehicle.

t = elapsed time in the driving schedule as measured by the dynamometer, in seconds.

(2) For each test, validate the measured transmission output shaft's speed with the corresponding reference values according to 40 CFR 1065.514(e). You may delete points when the vehicle is stopped. Perform the validation based on speed values at the transmission output shaft. For steady-state tests (55 mi/hr and 65 mi/hr cruise), apply cycle-validation criteria by treating the sampling periods from the two tests as a continuous sampling period. Perform this validation based on the following parameters:

Table 1 of § 1037.555 – Statistical criteria for validating duty cycles

PARAMETER	SPEED CONTROL
Slope, a_1	$0.950 \leq a_1 \leq 1.030$
Absolute value of intercept, $\lvert a_0 \rvert$	$\leq$ 2.0 % of maximum test speed
Standard error of the estimate, *SEE*	$\leq$ 5 % of maximum test speed
Coefficient of determination, r^2	≥ 0.970

(f) Send a brake signal when throttle positionoperator demand is equal to zero and vehicle speed is greater than the reference vehicle speed from the test cycle. Set a delay before changing the brake state to prevent the brake signal from dithering, consistent with good engineering judgment.

* * * * *

160. Revise § 1037.560 to read as follows:

§ 1037.560 Axle efficiency test.

This section describes a procedure for mapping axle efficiency through a determination of axle power loss.

(a) You may establish axle power loss maps based on testing any number of axle configurations within an axle family as specified in § 1037.232. You may share data across a family of axle configurations, as long as you test the axle configuration with the lowest efficiency from the axle family; this will generally involve testing the axle with the highest axle ratio. For vehicles with tandem drive axles, always test each drive axle separately. For tandem axles that can be disconnected, test both single-drive and tandem axle configurations. This includes 4×4 axles where one of the axles is disconnectable. Alternatively, you may ask us to approve power loss maps for untested configurations that are analytically derived power loss maps for untested configurations within the same axle family as defineddescribed in paragraph (h) of this sectionfrom tested configurations within the same family (see § 1037.235(h)).

(b) Prepare an axle assembly for testing as follows:

(1) Select an axle assembly with less than 500 hours of operation before testing. Assemble the axle in its housing, along with wheel ends and bearings.

(2) If you have a family of axle assemblies with different axle ratios, you may test multiple configurations using a common axle housing, wheel ends, and bearings.

(3) Install the axle assembly on the dynamometer with an input shaft angle perpendicular to the axle.

(i) For axle assemblies with or without a locking main differential, test the axle assembly using one of the following methods:

(A) Lock the main differential and test it with one electric motor on the input shaft and a second electric motor on the output side of the output shaft that has the speed-reduction gear attached to it.

(B) Test with the main differential unlocked and with one electric motor on the input shaft and electric motors on the output sides of each of the output shafts.

(ii) For drive-through tandem-axle setups, lock the longitudinal and inter-wheel differentials.

(4) Add gear oil according to the axle manufacturer's instructions. If the axle manufacturer specifies multiple gear oils, select the one with the highest viscosity at operating temperature. You may use a lower-viscosity gear oil if we approve that as critical emission-related maintenance under § 1037.125. Fill the gear oil to a level that represents in-use operation. You may use an external gear oil conditioning system, as long as it does not affect measured values.

(5) Install equipment for measuring the bulk temperature of the gear oil in the oil sump or a similar location. Report temperature to the nearest 0.1 °C.

(6) Break in the axle assembly using good engineering judgment. Maintain gear oil

temperature at or below 100 °C throughout the break-in period.

(7) You may drain~~Drain~~ the gear oil following the break-in procedure and repeat the filling procedure described in paragraph (b)(~~3~~4) of this section. We will follow your ~~protocol~~practice for our testing.

(c) Measure input and output speed and torque as described in 40 CFR 1065.210(b)~~, except that y~~. You ~~may use a magnetic or optical shaft-position detector with only one count per revolution. U~~must use a speed-measurement system that meets an accuracy of ±0.05 % of point. Use torque transducers that meet an accuracy requirement of ±1.0 N·m for unloaded test points and ±0.2 % of the maximum tested axle input torque or output torque, respectively, ~~tested~~ for loaded test points~~, and ±1.0 N·m for unloaded test points~~. Calibrate and verify measurement instruments according to 40 CFR part 1065, subpart ~~C~~D. Command speed and torque at a minimum of 10 Hz, and record all data, including bulk oil temperature, as 1 Hz mean values.

(d) The test matrix consists of test points representing output torque and wheel speed values meeting the following specifications:

(1) Output torque includes both loaded and unloaded operation. For measurement involving unloaded output torque, also called spin loss testing, the wheel end is not connected to the dynamometer and is left to rotate freely; in this condition the input torque (to maintain constant wheel speed) equals the power loss. Test axles at a range of output torque values, as follows:

(i) 0, 500, 1000, 2000, 3000, and 4000 N·m for single drive axle applications for tractors and for vocational Heavy HDV with a single drive axle.

(ii) 0, 250, 500, 1000, 1500, and 2000 N·m for tractors, for vocational Heavy HDV with tandem drive axles, and for all vocational Light HDV or vocational Medium HDV.

(iii) You may exclude values that exceed your axle's maximum torque rating.

(2) Determine maximum wheel speed corresponding to a vehicle speed of 65 mi/hr based on the smallest tire (as determined using § 1037.520(c)(1)) that will be used with the axle. If you do not know the smallest tire size, you may use a default size of 650 r/mi. Use wheel angular ~~rotational~~ speeds for testing that include 50 r/min and speeds in 100 r/min increments that encompass the maximum wheel speed (150, 250, etc.).

(3) You may test the axle assembly at additional speed and torque setpoints.

(e) Determine axle efficiency using the following procedure:

(1) Maintain ambient temperature between (15 and 35) °C throughout testing. Measure ambient temperature within 1.0 m of the axle assembly. Verify that critical axle settings (such as bearing preload, backlash, and oil sump level) are within specifications before and after testing.

(2) Maintain gear oil temperature at (81 to 83) °C. You may alternatively specify a lower range by shifting both temperatures down by the same amount.~~specify an alternative range with lower temperatures; if you measure temperature to the nearest 0.1 °C, the maximum allowable range is 3.0 °C.~~ We will test your axle assembly using the same temperature range you ~~used~~specify for your testing.~~ Measure gear oil temperature at the drain of the sump.~~ You may use an external gear oil conditioning system, as long as it does not affect measured values.

(3) Use good engineering judgment to warm up the axle assembly by operating it until the gear oil is within the specified temperature range.

(4) Stabilize operation at each point in the test matrix for at least 10 seconds, then measure the input torque, output torque, and wheel angular speed for at least 10 seconds~~, r~~. Record~~ing~~

~~the~~ arithmetic mean values for all three parameters over the measurement period. Calculate power loss as described in paragraph (f) of this section based on ~~torque and speed~~these values for mean input torque, $\bar{T}_{\text{in}}$, mean output torque, $\bar{T}_{\text{out}}$, and mean wheel angular speed, $\bar{f}_{\text{nwheel}}$, at each test point.

(5) Perform the map sequence described in paragraph (e)(4) of this section three times. Remove torque from the input shaft and allow the axle to come to a full stop before each repeat measurement.

(6) You may need to perform additional testing at a given test point based on a calculation of a confidence interval to represent repeatability at a 95 % confidence level for that test point. ~~Make a separate repeatability calculation for the three data points at each operating condition in the test matrix.~~ If the confidence limit is greater than 0.10 % for loaded tests or greater than 0.05 % for unloaded tests, perform another repeat of measurements at that ~~operating condition~~test point~~the axle power loss map~~ and recalculate the repeatability for the whole set of test results. Continue testing until the ~~repeatability~~ confidence interval is at or below the specified values for all ~~operating conditions~~test points. Calculate a confidence ~~limit~~ interval representing the repeatability in establishing a 95 % confidence level using the following equation:

$$Confidence\ Interval = \frac{1.96 \cdot \sigma_{\text{Ploss}}}{\sqrt{N} \cdot P_{\text{max}}} \cdot 100\ \%$$

Eq. 1037.560-1

Where:

σ_{Ploss} = standard deviation of power loss values at a given torque-speed setting (see 40 CFR 1065.602(c)).

N = number of repeat tests.

P_{max} = maximum output torque setting from the test matrix.

Example:

σ_{Ploss} = 0.165~~.~~0 kW

N = 3

P_{max} = 314.20000 kW

$$Confidence\ Interval = \frac{1.96 \cdot 0.1650}{\sqrt{3} \cdot 314.2000} \cdot 100\ \%$$

Confidence ~~Limit~~ Interval = 0.0594 %

~~(7) Calculate mean input torque, $\bar{T}_{\text{in}}$, mean output torque, $\bar{T}_{\text{out}}$, and mean wheel rotational speed, $\bar{f}_{\text{nwheel}}$, for each point in the test matrix using the results from all~~for each ~~the repeat tests.~~

(f) Calculate the mean power loss, $\bar{\bar{P}}_{\text{loss}}$, at each ~~operating condition in the test matrix~~test point as follows:

(1) ~~$\bar{\bar{P}}_{\text{loss}}$ is the mean power loss, of all~~for each ~~the tests, at each operating condition.~~

~~(2) For each test c~~Calculate ~~the mean power loss,~~ $\bar{P}_{\text{loss}}$ for each measurement at each test point~~,~~ as follows:

$$\bar{P}_{\text{loss}} = \bar{T}_{\text{in}} \cdot \bar{f}_{\text{nwheel}} \cdot k_{\text{a}} - \bar{T}_{\text{out}} \cdot \bar{f}_{\text{nwheel}}$$

Commented [CAL44]: Example updated.

Commented [CAL45]: Updated.

Eq. 1037.560-2

Where:

$\overline{T}_{\text{in}}$ = mean input torque from paragraph (e)(4) of this section.

$\overline{f}_{\text{nwheel}}$ = mean wheel angularrotational speed from paragraph (e)(4) of this section in rad/s.

k_a = drive axle ratio, expressed to at least the nearest 0.001.

$\overline{T}_{\text{out}}$ = mean output torque from paragraph (e)(4) of this section. Let $\overline{T}_{\text{out}}$ = 0 for all unloaded tests.

(2) Calculate $\overline{\overline{P}}_{\text{loss}}$ as the mean power loss from all measurements at a given test point.

(3) The following example illustrates a calculation of $\overline{\overline{P}}_{\text{loss}}$:

Example:

$\overline{T}_{\text{in,1}}$ = 845.10 N·m

$\overline{f}_{\text{nwheel,1}}$ = 100.0 r/min = 10.472 rad/s

k_a = 3.731

$\overline{T}_{\text{out,1}}$ = 3000.00 N·m

$\overline{P}_{\text{loss,1}} = 845.10 \cdot 10.472 \cdot 3.731 - 3000.00 \cdot 10.472$

$\overline{P}_{\text{loss,1}}$ = 1602.9 W = 1.6029 kW

$\overline{P}_{\text{loss,2}}$ = 1601.9 W = 1.6019 kW

$\overline{P}_{\text{loss,3}}$ = 1603.9 W = 1.6039 kW

$$\overline{\overline{P}}_{\text{loss}} = \frac{1.6029 + 1.6019 + 1.6039}{3} = 1.6029 \text{ kW}$$

Commented [CAL46]: Updated.

(g) Create a table showing with the mean power loss, $\overline{\overline{P}}_{\text{loss}}$, corresponding to each mean output torque and mean wheel speedtest point for input into GEM. Express wheel angular speed in r/min to one decimal place; express output torque in N·m to two decimal places; express power loss in kW to four decimal places.

(1) Record $\overline{\overline{P}}_{\text{loss}}$, $\overline{\overline{T}}_{\text{out}}$, and $\overline{\overline{f}}_{\text{nin}}$ for each test point. Calculate $\overline{\overline{T}}_{\text{out}}$ and $\overline{\overline{f}}_{\text{nin}}$ for each test point by calculating the arithmetic average of $\overline{T}_{\text{out}}$ and $\overline{f}_{\text{nin}}$ for all the repeat tests at that test point.

(2) Record declared Select mean power loss values at or above the corresponding value calculated in paragraph (f) of this section. Use good engineering judgment to select values that will be at or above the mean power loss values for your production axles. Vehicle manufacturers will use these declared mean power loss values for certification. For vehicles with tandem drive axles, the GEM input is the sum of the power losses and output torques of from the individual axles when creating your table. For vehicles with a disconnectable axle, GEM uses separate inputs for tandem axles with a disconnect, input a separate table into GEM for the single and tandem drive axle configurations. Vehicle manufacturers will use these declared mean power loss values for certification.

(h) You may analytically derive axle power loss maps for untested configurations within the

~~same~~an axle family as follows:

(1) Test ~~a minimum of three numeric ratios~~at least three axle assemblies within the same family representing at least the smallest axle ratio, the largest axle ratio, and an axle ratio closest to the arithmetic mean from the two other tested axle assemblies~~according to this section~~. Test each ~~of these~~ axle assembl~~s~~y as described in this section at the same speed and torque set~~test~~ points.~~ Test the smallest and largest numeric axle ratios within the family and an axle ratio with a value that is near the arithmetic mean of the smallest and largest axle ratios.~~

(2) Perform a second~~-~~-order least-squares regression ~~of the~~between declared power loss ~~values versus the~~and axle ratio ~~for~~using each speed and torque set~~test~~ point described in paragraph (d) of this section for your tested axle assemblies~~in the power loss map~~. Use the declared power loss values from paragraph (g) of this section; however, for purposes of analytically deriving power loss maps under this paragraph (h), you must select declared values for the largest and smallest axle ratios in the axle family that are adjusted relative to the calculated values for mean power loss by the same multiplier.

~~(i) If the coefficient of the second order term is positive, then proceed to paragraph (c) of this section.~~

~~(ii)~~ If the coefficent of the second-order term is negative, include testing from additional axle ratios, or ~~either retest the axle(s) or~~ increase ~~the~~your declared power loss ~~of~~for the largest and smallest axle ratios ~~test points~~ by the same multiplier as needed for the second-order term to become positive~~until the second order term of the least-squares regression is positive~~.

(3) Determine $\bar{\bar{P}}_{\text{loss}}$ of untested axles for each speed and torque setpoint based on a linear relationship between your declared power loss and axle ratio as follows:

(i) Determine the slope of the correlation line by connecting the declared power loss values for the smallest and largest axle ratios.

(ii) Fix the intercept for the correlation line by shifting it upward as needed so all the declared power loss values are on the correlation line or below it. Note that for cases involving three tested axle assemblies, the correlation line will always include the declared power loss for the smallest and largest axle ratio.

(4) Select declared values of $\bar{\bar{P}}_{\text{loss}}$ for untested configurations that are at or above the values you determined in paragraph (h)(3) of this section.~~Use linear interpolation, between the smallest and largest axle ratios, for each speed and torque test point in the power loss mapto determine power loss of untested axles for each test point.~~

161. Revise § 1037.565 to read as follows:

§ 1037.565 Transmission efficiency test.

This section describes a procedure for mapping transmission efficiency through a determination of transmission power loss.

(a) You may establish transmission power loss maps based on testing any number of transmission configurations within a transmission family as specified in § 1037.232. You may share data across any configurations within the family, as long as you test the transmission configuration with the lowest efficiency from the ~~emission~~ transmission family. Alternatively, you may ask us to approve analytically derived power loss maps for untested configurations ~~that are analytically derived from tested configurations~~ within the same transmission family (see § 1037.235(h)).

(b) Prepare a transmission for testing as follows:

(1) Select a transmission with less than 500 hours of operation before testing.

(2) Mount the transmission to the dynamometer such that the geared shaft in the transmission is aligned with the input shaft from the dynamometer.

(3) Add transmission oil according to the transmission manufacturer's instructions. If the transmission manufacturer specifies multiple transmission oils, select the one with the highest viscosity at operating temperature. You may use a lower-viscosity transmission oil if we approve ~~that~~ it as critical emission-related maintenance under § 1037.125. Fill the transmission oil to a level that represents in-use operation. You may use an external transmission oil conditioning system, as long as it does not affect measured values.

(4) Include any internal and external pumps for hydraulic fluid and lubricating oil in the test. Determine the work required to drive an external pump according to 40 CFR 1065.210.

(5) Install equipment for measuring the bulk temperature of the transmission oil in the oil sump or a similar location.

(6) If the transmission is equipped with a torque converter, lock it for all testing performed in this section.

(7) Break in the transmission using good engineering judgment. Maintain transmission oil temperature at (87 to 93) °C for automatic transmissions and transmissions having more than two friction clutches, and at (77 to 83) °C for all other transmissions. You may ask us to approve a different range of transmission oil temperatures if you have data showing that it better represents in-use operation.

(c) Measure input and output shaft speed and torque as described in 40 CFR 1065.210(b)~~, except that y~~. You ~~may use a magnetic or optical shaft-position detector with only one count per revolution. U~~must use a~~-~~ speed measurement system that meets an accuracy of ±0.05 % of point. Accuracy requirements for torque transducers depend on the highest loaded transmission input and output torque as described in paragraph (d)(2) of this section. Use torque transducers for torque input measurements that meet an accuracy requirement of ±0.2 % of the ~~transmission's~~ highest loaded transmission ~~maximum rated~~ input ~~torque or output torque for the selected gear ratio,~~ for loaded test points~~,~~ and ±0.1 % of the highest loaded transmission ~~transmission's maximum rated~~ input torque for unloaded test points. For torque output measurements, torque transducers must meet an accuracy requirement of ±0.2 % of the highest loaded transmission output torque for each gear ratio. Calibrate and verify measurement instruments according to 40 CFR part 1065, subpart ~~C~~D. Command speed and torque at a minimum of 10 Hz, and record all data, including bulk oil temperature, at a minimum of 1 Hz mean values.

(d) Test the transmission at input shaft speeds and torque setpoints as described in this paragraph (d). You may exclude lower gears from testing; however, you must test all the gears above the highest excluded gear. GEM will use default values for any untested gears. The test matrix consists of test points representing transmission input shaft speeds and torque setpoints meeting the following specifications for each tested gear ~~tested~~:

(1) ~~Include~~ Test at the following transmission input shaft speeds:

~~at the maximum rated input shaft speed,~~(i) 600.0 r/min or transmission input shaft speed when paired with the engine operating at idle~~, and three equally spaced intermediate speeds~~.

(ii) The transmission's maximum rated input shaft speed. You may alternatively select a value representing the highest expected in-use transmission input shaft speed.

(iii) Three equally spaced intermediate speeds. The intermediate speed points may be adjusted to the nearest 50 or 100 r/min. You may test any number of additional speed setpoints to improve accuracyincrease the number of speed test points to improve the accuracy of the transmission power loss map, consistent with good engineering judgment.

(2) Test at certain transmission input torque setpoints as follows:

(i) Include one unloaded (zero-torque) setpoint.

(ii) Include one loaded torque setpoint between 75 % and 105 % of the transmission's maximum rated transmission input shaft torque and one unloaded (zero-torque) setpoint. However, you may use a lower torque setpoint as needed to avoid exceeding dynamometer torque limits, as long as testing accurately represents in-use performance. If your loaded torque setpoint is below 75 % of the transmission's maximum rated input shaft torque, you must demonstrate that the sum of time for all gears where demanded engine torque is between your maximum torque setpoint and 75 % of the transmission's maximum rated input shaft torque is no more than 10 % of the time for each vehicle drive cycle specified in subpart F of this part. This demonstration must be made available upon request.

(iii) You may test at any number of additional torque setpoints to improve accuracy.

(iv) Note that GEM calculates power loss between tested or default values by linear interpolation, except that GEM may extrapolate outside of measured values to account for testing at torque setpoints below 75 % as specified in paragraph (d)(2)(ii) of this section.

(3) In the case of transmissions that automatically go into neutral when the vehicle is stopped, also perform tests at 600 r/min and 800 r/min with the transmission in neutral and the transmission output fixed at zero speed.

(4) Test all the gears at the transmission input shaft speeds and torque setpoints as described in this paragraph (d). You may exclude the lower gears from testing; however, you must test all the gears above the highest excluded gear. If you choose this option, GEM will use default values for any gears not tested.

(e) Determine transmission torque lossefficiency using the following procedure:

(1) Maintain ambient temperature between (15 and 35) °C throughout testing. Measure ambient temperature within 1.0 m of the transmission.

(2) Maintain transmission oil temperature as described in paragraph (b)(7) of this section. You may use an external transmission oil conditioning system, as long as it does not affect measured values.

(3) Use good engineering judgment to warm up the transmission according to the transmission manufacturer's specifications.

(4) Perform unloaded transmission tests by disconnecting the transmission output shaft from the dynamometer and letting it rotate freely. If the transmission adjusts pump pressure based on whether the vehicle is moving or stopped, set up the transmission for unloaded tests to operate as if the vehicle is moving.

(5) For transmissions that have multiple configurations for a given gear ratio, such as dual-clutch transmissions that can pre-select an upshift or downshift, set the transmission to operate in the configuration with the greatest power loss. Alternatively, test in each configuration and use good engineering judgment to calculate a weighted power loss for each test point under this section based on field data that characterizes the degree of in-use operation in each configuration.

(6) ~~Operate~~ For a selected gear, operate the transmission ~~in the top~~at a selected ~~gear at a selected~~and ~~torque setpoint with the input shaft speed at one of the speed setpoints~~at one of the test points from paragraph (d) of this section for at least 10 seconds~~, then m~~. Measure the speed and torque of the input and output shafts for at least 10 seconds. You may omit measurement of output shaft speeds if your transmission is configured ~~is~~ ~~in a way that does~~to not allow slip. Calculate arithmetic mean values for mean input shaft torque, $\bar{T}_{in}$, mean output shaft torque, $\bar{T}_{out}$, mean input shaft speed, $\bar{f}_{nin}$, and mean output shaft speed, $\bar{f}_{nout}$, for each point in the test matrix for each test~~all speed and torque values over each measurement period~~. Repeat this stabilization, measurement, and calculation for the other speed and torque setpoints from the test matrix for the selected gear in any sequence. Calculate power loss as described in paragraph (f) of this section based on mean speed and torque ~~and speed~~ values at each test point.

(7) Repeat the procedure described in paragraph (e)(6) of this section for all gears, or for all gears down to a selected gear. This section refers to an “operating condition” to represent operation at a test point in a specific gear. ~~GEM will use default values for any gears not tested.~~

(8) Perform the test sequence described in paragraphs (~~d~~e)(6) and (7) of this section three times. You may do this repeat testing at any given test point before you perform measurements for the whole test matrix. Remove torque from the transmission input shaft and bring the transmission to a complete stop before each repeat measurement.

(9) You may need to perform additional testing at a given operating condition based on a calculation of a confidence interval to represent repeatability at a 95 % confidence level at that operating condition. ~~Make a separate repeatability calculation for the three data points at each operating condition in the test matrix.~~ If the confidence ~~limit~~ interval is greater than 0.10 % for loaded tests or greater than 0.05 % for unloaded tests, perform another ~~repeat of~~ measurement~~s~~ at that operating condition and recalculate the repeatability for the whole set of test results. Continue testing until the ~~repeatability~~ confidence interval is at or below the specified values for all operating conditions. As an alternative, for any operating condition that does not meet this repeatability criterion, you may determine a maximum power loss instead of calculating a mean power loss as described in paragraph (g) of this section.

Calculate a confidence ~~limit~~ interval representing the repeatability in establishing a 95 % confidence level using the following equation:

$$Confidence\ Interval = \frac{1.96 \cdot \sigma_{Ploss}}{\sqrt{N} \cdot P_{rated}} \cdot 100\ \%$$

Eq. 1037.565-1

Where:

σ_{Ploss} = standard deviation of power loss values at a given ~~test point~~operating condition (see 40 CFR 1065.602(c)).

N = number of repeat tests for an operating condition.

P_{rated} = the transmission’s rated input power for a given gear. For testing in neutral, use the value of P_{rated} for the top gear.

Example:

σ_{Ploss} = 0.120~~.~~0 kW

N = 3

P_{rated} = 314.2000 kW

$$Confidence\ Interval = \frac{1.96 \cdot 0.1650}{\sqrt{3} \cdot 314.2000} \cdot 100\ \%$$

Confidence Limit Interval = 0.0432 %

(10) Calculate mean input shaft torque, $\overline{T}_{in}$, mean output shaft torque, $\overline{T}_{out}$, mean input shaft speed, $\overline{f}_{nin}$, and mean output shaft speed, $\overline{f}_{nout}$, for each point in the test matrix using the results from allfor each the repeat tests. $\overline{\overline{T}}_{in}$ $\overline{\overline{f}}_{nin}$ $\overline{T}_{in}$ $\overline{f}_{nin}$

(f) Calculate the mean power loss, $\overline{\overline{P}}_{loss}$, at each operating condition in the test matrix as follows:

Commented [CAL47]: Updated.

(1) Calculate $\overline{P}_{loss}$ is the mean power loss, of all for eachthe tests,measurement at each operating condition.

(2) For each test calculate the mean power loss, $\overline{P}_{loss}$, as follows:

$$\overline{P}_{loss} = \overline{T}_{in} \cdot \overline{f}_{nin} - \overline{T}_{out} \cdot \overline{f}_{nout}$$

Eq. 1037.565-2

Where:

$\overline{T}_{in}$ = mean input shaft torque from paragraph (e)(6) of this section.

$\overline{f}_{nin}$ = mean input shaft speed from paragraph (e)(6) of this section in rad/s.

$\overline{T}_{out}$ = mean output shaft torque from paragraph (e)(6) of this section. Let $\overline{T}_{out}$ = 0 for all unloaded tests.

$\overline{f}_{nout}$ = mean output shaft speed from paragraph (e)(6) of this section in rad/s. Let $\overline{f}_{nout}$ = 0 for all tests with the transmission in neutral. See paragraph (f)(32) of this section for calculating $\overline{f}_{nout}$ as a function of $\overline{f}_{nin}$ instead of measuring $f_{nout}$for certain transmission configurations.

Example:

$\overline{T}_{in}$ = 1000.0 N·m

$\overline{f}_{nin}$ = 1000 r/min = 104.72 rad/sec

$\overline{T}_{out}$ = 2654.5 N·m

$\overline{f}_{nout}$ = 361.27 r/min = 37.832 rad/s

$\overline{P}_{loss} = 1000.0 \cdot 104.72 - 2654.5 \cdot 37.832$

$\overline{P}_{loss,1}$ = 4295 W = 4.295 kW

$\overline{P}_{loss,2}$ = 4285 W = 4.285 kW

$\overline{P}_{loss,3}$ = 4292 W = 4.292 kW

$$\overline{\overline{P}}_{loss} = \frac{4.295 + 4.285 + 4.292}{3} = 4.291\ \text{kW}$$

(32) For transmissions that are configured in a way that doesto not allow slip, you may calculate $\overline{f}_{nout}$ based on the gear ratio using the following equation:

$$\bar{f}_{nout} = \frac{\bar{f}_{nin}}{k_g}$$

Eq. 1037.565-3

Where:

k_g = transmission gear ratio, expressed to at least the nearest 0.001.

(3) Calculate $\bar{\bar{P}}_{loss}$ as the mean power loss from all measurements at a given operating condition.

(4) The following example illustrates a calculation of $\bar{\bar{P}}_{loss}$:

Example:

$\bar{T}_{in,1}$ = 1000.0 N·m

$\bar{f}_{nin,1}$ = 1000 r/min = 104.72 rad/sec

$\bar{T}_{out,1}$ = 2654.5 N·m

$\bar{f}_{nout,1}$ = 361.27 r/min = 37.832 rad/s

$\bar{P}_{loss,1} = 1000.0 \cdot 104.72 - 2654.5 \cdot 37.832$

$\bar{P}_{loss,1}$ = 4295 W = 4.295 kW

$\bar{P}_{loss,2}$ = 4285 W = 4.285 kW

$\bar{P}_{loss,3}$ = 4292 W = 4.292 kW

$$\bar{\bar{P}}_{loss} = \frac{4.295 + 4.285 + 4.292}{3} = 4.291 \text{ kW}$$

(g) Create a table showing with the mean mean power loss, $\bar{\bar{P}}_{loss}$, $\bar{\bar{P}}_{loss}$, corresponding to each operating condition mean transmission input speed and mean input torque for input into GEM. Also include mean power loss in neutral for each tested engine's speed, if applicable. Express transmission input speed in r/min to one decimal place; express input torque in N·m to two decimal places; express power loss in kW to four decimal places. Record the following values:

(1) Recored $\bar{\bar{P}}_{loss}$, $\bar{\bar{T}}_{in}$, and $\bar{\bar{f}}_{nin}$ for each operating condition meeting the repeatability criterion in in paragraph (e)(9) of this section. Calculate $\bar{\bar{T}}_{in}$ and $\bar{\bar{f}}_{nin}$ for each operating condition by calculating the arithmetic average of $\bar{T}_{in}$ and $\bar{f}_{nin}$ for all the repeat tests at that operating condition.

(2) For any operating condition not meeting the repeatability criterion in paragraph (e)(9) of this section, record the maximum value of $\bar{P}_{loss}$ for that operating condition along with the corresponding values of $\bar{T}_{in}$ and $\bar{f}_{nin}$. $\bar{\bar{P}}_{loss}$ $\bar{\bar{T}}_{in}$ $\bar{\bar{f}}_{nin}$ $\bar{P}_{loss}$ $\bar{T}_{in}$ $\bar{f}_{nin}$.

(h) Select meanRecord declared power loss values at or above the corresponding value calculated in paragraph (f) of this section. Use good engineering judgment to select values that will be at or above the mean power loss values for your production axlestransmissions. Vehicle manufacturers will use these declared mean power loss values for certification.

162. Add § 1037.570 to subpart F to read as follows:

§ 1037.570 ~~Determinatoin of~~ Procedures to characterize torque converters ~~capacity factors~~.

GEM includes input values related to torque converters. This section describes a procedure for mapping a torque converter's capacity factors and torque ratios over a range of operating conditions~~through a determination of torque converter input and output speeds and torques~~. You may ask us to approve analytically derived input values based on this testing for additional untested configurations as described in § 1037.235(h).

(a) ~~You may establish torque converter capacity factors based on testing any torque converter. Alternatively, you may ask us to approve torque converter capacity factors for untested configurations that are analytically derived from tested configurations (see § 1037.235(h)).~~
~~(b)~~ Prepare a torque converter for testing as follows:

(1) Select a torque converter with less than 500 hours of operation before the start of testing.

(2) If the torque converter ~~is equipped with~~has a locking feature, unlock it for all testing performed ~~in~~under this section. If ~~equipped with~~the torque convertuer has a slipping lockup clutch, ~~technology~~ you may ask us to approve a different strategy ~~if you have~~based on data showing that it represents better in-use operation.

(3) Mount the torque converter with a transmission to the dynamometer in series ~~either a serial~~ or parallel arrangement or mount the torque converter without a transmission to represent a series configuration.~~ If you choose a serial arrangement, you may test without the transmission.~~

(4~~3~~) Add transmission oil according to the torque converter manufacturer's instructions, with the following additional specifications:

(i)~~.~~ If the torque converter manufacturer specifies multiple transmission oils, select the one with the highest viscosity at operating temperature. You may use a lower-viscosity transmission oil if we approve that as critical emission-related maintenance under § 1037.125.

(ii) -Fill the transmission oil to a level that represents in-use operation. If you are testing the torque converter ~~only~~without the transmission, ~~the input torque converter transmission oil flow rate and~~ keep output pressure ~~must be kept~~ and the flow rate of transmission oil into the torque converter within the torque converter manufacturer's limits~~ for the transmission type and maximum input speed~~.

(iii)- You may use an external transmission oil conditioning system, as long as it does not affect measured values.

(~~4~~5) Install equipment for measuring the bulk temperature of the transmission oil in the oil sump or a similar location and at the torque converter inlet. If the torque converter is tested without ~~the~~a transmission, measure the oil temperature ~~prior to where it enters~~at the torque converter inlet.

~~(5)~~(6) Break in the torque converter and transmission (if applicable) using good engineering judgment. Maintain transmission oil temperature at (87 to 93) °C. You may ask us to approve a different range of transmission oil temperatures if you have data showing that it better represents in-use operation.

(~~c~~b) Measure pump and ~~output shaft~~turbine shaft speed and torque as described in 40 CFR 1065.210(b)~~, except that y~~. You must use a speed measurement system that meets an accuracy of ±0.1 % of point or ±1 r/min, whichever is greater. Use torque transducers that meet an accuracy ~~requirement~~ of ±1.0 % of the torque converter's maximum rated input ~~torque or~~and output torque~~ for loaded and unloaded test points~~, respectively. Calibrate and verify measurement instruments according to 40 CFR part 1065, subpart ~~C~~D. Command speed and torque at a minimum of 10 Hz~~, and r~~. Record all speed and torque data~~, including bulk oil temperature,~~ at a minimum of 1 Hz mean values. Note that this section relies on the convention of describing the input shaft as the pump and the output shaft as the turbine shaft.

(~~d~~c) Determine torque converter characteristics based on a test matrix using either constant input speed or constant input torque as follows:~~The test matrix consists of torque converter constant input shaft speeds or input shaft torque setpoints depending on the measurement option that you choose.~~

(1) Constant input speed. Test at ~~To determine torque converter characteristics at~~ constant input speed as follows:

(i) Select a ~~n input rotational~~fixed pump speed, f_{npum}, ~~fixed to a constant speed~~ between (1000 and 2000) r/min.

(ii) Test the torque converter at multiple speed ratios, *v*, in the range of v = 0.00 to v = 0.95. Use a step width of 0.10 for the range of v = 0.00 to 0.60 and 0.05 for the range of v = 0.60 to 0.95. Calculate speed ratio, *v*, as turbine shaft speed divided by pump speed.

(2) Constant input torque. Test ~~To determine torque converter characteristics~~ at constant input torque as follows:

(i) Set the ~~input~~ pump torque, T_{pum}, to a fixed positive ~~level~~value at f_{npum} = 1000 r/min with the ~~output shaft of the~~ torque converter's turbine shaft locked in a non-rotating state (i.e., ~~output rotational~~ turbine's ~~-~~speed, n_{tur}, = 0 r/min).

(ii) Test the torque converter at multiple speed ratios, *v*, in the range of v = 0.00 up to a ~~usable~~ value of f_{ntur} that covers the usable range of *v* ~~with at least seven evenly distributed points~~. Use a step width of 0.10 for the range of v = 0.00 to 0.60 and 0.05 for the range of v = 0.60 to 0.95.

(3) You may limit the maximum speed ratio to a value below 0.95 if you have data showing this better represents in-use operation. You must use the step widths defined in paragraph (c)(1) or (2) of this section and include the upper limit as a test point. If you choose a value less than 0.60, you must test at least seven evenly distributed points between v = 0 and your new upper speed ratio.

(~~e~~d) Characterize the torque converter using the following procedure:

(1) Maintain ambient temperature between (15 and 35) °C throughout testing. Measure ambient temperature within 1.0 m of the torque converter.

(2) Maintain transmission oil temperature as described in paragraph (~~b~~a)(6) of this section. You may use an external transmission oil conditioning system, as long as it does not affect measured values.

(3) Use good engineering judgment to warm up the torque converter according to the torque converter manufacturer's specifications.

(4) Test the torque converter at constant input speed or constant input torque as described in paragraph (c) of this section. ~~Operate the torque converter as follows:~~

~~(i) For testing at constant input speed, set the input rotational pump speed to the value chosen in paragraph (d)(1)(i) of this section.~~

~~(ii) For testing at constant input torque, set the input pump torque and pump speed to the values chosen in paragraph (d)(2)(i) of this section.~~

~~(5)~~ Operate the torque converter at v = 0.00 for (5 to 60) seconds, then measure pump torque, turbine shaft torque, angular pump speed, angular turbine shaft speed, and the transmission oil temperature at the torque converter inlet measure input pump torque, T_{pum}, output turbine torque, T_{tur}, input rotational pump speed, f_{npum}, output rotational turbine speed, f_{ntur}, and the torque converter inlet oil temperature, T_{TCin}, for (5 to 15) seconds. Calculate arithmetic mean values for pump torque, all speed and torque values $\bar{T}_{pum}$, turbine shaft torque, $\bar{T}_{tur}$, angular pump speed, $\bar{f}_{npum}$, and angular turbine shaft speed, $\bar{f}_{ntur}$, over eachthe measurement period. Repeat this stabilization, measurement, and calculation for the other speed ratios from the test matrix in order of increasing speed ratio. Adjust the speed ratio by increasing the output angularrotational turbine shaft speed. You may limit the upper speed ratio to a value below 0.95 if you have data that shows this better represents in-use operation. If you choose a lower this limit you must test at least seven evenly distributed points between v = 0 and your new upper speed ratio.

(65) PComplete a test run by performing the test sequence described in paragraph (ed)(54) of this section two times.

(7) Calculate mean input pump torque, $\bar{T}_{pum}$, mean output turbine torque, $\bar{T}_{tur}$, mean input rotational pump speed, $\bar{f}_{npum}$, and mean output rotational turbine speed, $\bar{f}_{ntur}$, for each point in the test matrix for each of the repeat tests.

(68) Invalidate the test run if the difference between the pair of mean torque values for the repeat tests at any test point differ by more than ±1 N·m or by more than ±5 % of the average of those two values. This applies separately for mean pump torque and mean turbine shaft torque at each test point.The deviation between the mean of the two torque measurement sets cannot exceed ± 5 % of the average or ± 1 N·m (whichever is greater) or the test mest be repeated.

(79) Invalidate the test run if any calculated value for mean angular pump speed does not stay within ±5 r/min of the speed setpoint or if any calculated value for mean pump torque does not stay within ±5 N·m of the torque setpoint. The deviation for the complete speed ratio series between the measured and averaged speed and torque values at the input shaft may not exceed ± 5 rpm and ± 5 N·m of the speed and torque set points for each measured operating point. If any of these ranges are exceed, the test must be repeated.

(fe) Calculate the mean torque ratio, $\bar{\bar{\mu}}$, at each operating condition in the test matrixtested speed ratio, v, as follows:

(1) $\bar{\mu}$ is the mean torque ratio, for each of the tests, at each operating condition.

(2) For each test cCalculate the mean torque ratio, $\bar{\mu}$ at each tested speed ratio, as follows:

$$\bar{\mu} = \frac{\bar{T}_{tur}}{\bar{T}_{pum}}$$

Eq. 1037.570-1

Where:

$\bar{T}_{tur}$ = mean output turbine shaft torque from paragraph (d)(4) of this section.

$\bar{T}_{pum}$ = mean input pump torque from paragraph (d)(4) of this section.

(2) Calculate $\bar{\bar{\mu}}$ as the average of the two values of $\bar{\mu}$ at each tested speed ratio.

(3) The following example illustrates a calculation of $\bar{\bar{\mu}}$:Example:

$\bar{T}_{tur,v=0,1}$ = 332.4 N·m

$\bar{T}_{pum,v=0,1}$ = 150.8 N·m

$\bar{T}_{tur,v=0,2}$ = 333.6 N·m

$\bar{T}_{pum,v=0,2}$ = 150.3 N·m

$$\bar{\mu}_{v=0,1} = \frac{332.4}{150.8} = 2.20$$

$$\bar{\mu}_{v=0,2} = \frac{333.6}{150.3} = 2.22 = 2.22$$

$$\bar{\bar{\mu}}_{v=0} = \frac{2.20 + 2.22}{2} = 2.21$$

(gf) Calculate the mean capacity factor, $\bar{\bar{K}}$, at each operating condition in the test matrixtested speed ratio, *v*, as follows:

(1) Calculate $\bar{K}$ is the mean capacity factor, for each of the tests, at each operating condition.

(2) For each test calculate the mean capacity factor, $\bar{K}$,at each tested speed ratio as follows:

$$\bar{K} = \frac{\bar{f}_{npum}}{\sqrt{\bar{T}_{pum}}}$$

Eq. 1037.570-2

Where:

$\bar{f}_{npum}$ = mean input angularrotational pump speed from paragraph (d)(4) of this section.

$\bar{T}_{pum}$ = mean input pump torque from paragraph (d)(4) of this section.

(2) Calculate $\bar{\bar{K}}$ as the average of the two values of $\bar{K}$ at each tested speed ratio.

(3) The following example illustrates a calculation of $\bar{\bar{K}}$:

$\bar{f}_{npum,v=0,1} = \bar{f}_{npum,v=0,2}$ = 1000.0 r/min

$\bar{T}_{pum,v=0,1}$ = 150.8 N·m

$$\bar{K}_{v=0,1} = \frac{1000.0}{\sqrt{150.8}} = 81.43\ \text{r/(min}\cdot\text{(N}\cdot\text{m)}^{0.5})$$

$\bar{T}_{pum,v=0,2}$ = 150.4 N·m

$$\bar{K}_{v=0,2} = \frac{1000.0}{\sqrt{150.4}} = 81.54\ \text{r/(min}\cdot\text{(N}\cdot\text{m)}^{0.5})$$

$$\bar{\bar{K}}_{v=0} = \frac{81.43 + 81.54}{2} = 81.49\ \text{r/(min}\cdot\text{(N}\cdot\text{m)}^{0.5})$$

(hg) Create a table of GEM inputs showing the mean torque ratio, $\bar{\bar{\mu}}$, and mean capacity factor,

$\bar{\bar{K}}$, at each of correspondingtested speed ratios, v, that were tested, for input into GEM. Express $\bar{\bar{\mu}}$ to two decimal places; express $\bar{\bar{K}}$ mean capacity factor in r/(min·(N·m)$^{0.5}$) to one decimal place; express v speed ratio to two decimal places.

163. Amend § 1037.601 by revising paragraph (a)(2) to read as follows:

§ 1037.601 General compliance provisions.

(a) * * *

(2) The provisions of 40 CFR 1068.105(a) apply for vehicle manufacturers installing engines certified under 40 CFR part 1036 as further limited by this paragraph (a)(2). If new engine emission standards apply in a given model year, you may install normal inventories of engines from the preceding model year under the provisions of 40 CFR 1068.105(a) through March 31 of that year without our approval; you may not install such engines after March 31 of that year unless we approve it in advance. Installing such engines after March 31 without our prior approval is considered to be prohibited stockpiling of engines. In a written request for our approval, you must describe how your circumstances led you and your engine supplier to have normal inventories of engines that were not used up in the specified time frame. We will approve your request for up to three additional months to install up to 50 engines under this paragraph (a)(2) if we determine that the excess inventory is a result of unforeseeable circumstances and should not be considered circumvention of emission standards. We will limit this approval to a certain number of engines consistent with your normal production and inventory practices. Note that 40 CFR 1068.105(a) allows vehicle manufacturers to use up only normal inventories of engines meeting less stringent standards; if, for example, a vehicle manufacturer's normal practice is to receive a shipment of engines every two weeks, it will deplete its potential to install previous-tier engines under this paragraph (a)(2) well before March 31 in the year that new standards apply.

* * * * *

164. Amend § 1037.615 by revising paragraph (f) to read as follows:

§ 1037.615 Advanced technologies.

* * * * *

(f) For electric vehicles and for fuel cells powered by hydrogen, calculate CO_2 credits using an FEL of 0 g/ton-mile.

* * * * *

165. Amend § 1037.621 by revising paragraph (g) introductory text to read as follows:

§ 1037.621 Delegated assembly.

* * * * *

(g) We may allow certifying vehicle manufacturers to authorize dealers or distributors to reconfigure/recalibrate vehicles after the vehicles have been introduced into commerce if they have not yet been delivered to the ultimate purchaser as follows:

* * * * *

166. Amend § 1037.635 by revising paragraph (c)(1) introductory text to read as follows:

§ 1037.635 Glider kits and glider vehicles.

* * * * *

(c) * * *

(1) The allowance in this paragraph (c) applies only for the following engines:

* * * * *

167. Amend § 1037.660 by revising paragraphs (a)(2) and (b) to read as follows:

§ 1037.660 Idle-reduction technologies.

* * * * *

(a) * * *

(2) Neutral idle. Phase 2 vehicles with hydrokinetic torque converters paired with automatic transmissions qualify for neutral-idle credit in GEM modeling if the transmission reduces torque equivalent to shifting into neutral throughout the interval during which the vehicle's brake pedal is depressed and the vehicle is at a zero-speed condition (beginning within ~~two~~five seconds of the vehicle reaching zero speed with the brake depressed). If a vehicle reduces torque partially but not enough to be equivalent to shifting to neutral, you may use the provisions of § 1037.610(g) to apply for an appropriate partial emission reduction; this may involve A to B testing with the powertrain test procedure in § 1037.550 or the spin-loss portion of the transmission efficiency test in § 1037.565.

* * * * *

(b) Override conditions. The system may limit activation of the idle-reduction technology while any of the conditions of this paragraph (b) apply. These conditions allow the system to delay engine shutdown, adjust engine restarting, or delay disengaging transmissions, but do not allow for resetting timers. Engines may restart and transmissions may re-engage during override conditions if the vehicle is set up to do this automatically. We may approve additional override criteria as needed to protect the engine and vehicle from damage and to ensure safe vehicle operation.

(1) For AES systems on tractors, the system may delay shutdown—

(i) When ~~While~~ an exhaust emission control device is regenerating. The period considered to be regeneration for purposes of this allowance must be consistent with good engineering judgment and may differ in length from the period considered to be regeneration for other purposes. For example, in some cases it may be appropriate to include a cool down period for this purpose but not for infrequent regeneration adjustment factors.

(ii) ~~If necessary while servicing the vehicle, provided the deactivation of the AES system is accomplished using a diagnostic scan tool. The system must be automatically reactivated when the engine is shut down for more than 60 minutes.~~

~~(iii) If~~ When the vehicle's main battery state-of-charge is not sufficient to allow the main engine to be restarted.

(iii~~v~~) ~~If~~ When the vehicle's transmission, fuel, oil, or engine coolant temperature is too low or too high according to the manufacturer's specifications for protecting against system damage. This allows the engine to continue operating until it is in a predefined temperature range, within which the shutdown sequence of paragraph (a) of this section would resume.

(iv) ~~While~~ When the vehicle's main engine is operating in power take-off (PTO) mode. For purposes of this paragraph (b), an engine is considered to be in PTO mode when a switch or setting designating PTO mode is enabled.

(v~~i~~) ~~If~~ When external ambient conditions prevent managing cabin temperatures for the

driver's safety.
(vi) When necessary while servicing the vehicle, provided the deactivation of the AES system is accomplished using a diagnostic scan tool. The system must be automatically reactivated when the engine is shut down for more than 60 minutes.

(2) For AES systems on vocational vehicles, the system may limit activation—

(i) If When any condition specified in paragraphs (b)(1)(i) through (vi) of this section applies.

(ii) When the engine compartment is openIf internal cab temperatures are too hot or too cold for the driver's safety.

(3) For neutral idle, the system may delay shifting the transmission to neutral—

(i) When the system meets For the PTO conditions specified in paragraph (b)(1)(iv) of this section.

(ii) When the transmission is in reverse gear.[Reserved]

(iii) When the vehicle is ascending or descending a road with grade at or above 6.0 %.

(4) For stop-start, the system may limit activation—

(i) When For any of the conditions specified in paragraphs (b)(2) or (b)(3)(ii) or (iii) of this section applies.

(ii) When air brake pressure is too low according to the manufacturer's specifications for maintaining vehicle-braking capability.

(iii) When an automatic transmission is in "park" or "neutral" and the parking brake is engagedWhen the transmission is in reverse gear.

(iv) When recent vehicle speeds indicate an abnormally high shutdown and restart frequency, such as with congested driving. For example, a vehicle not exceeding 10 mi/hr for the previous 300 seconds or since the most recent engine start would be a proper basis for overriding engine shutdown. You may also design this override to protect against system damage or malfunction of safety systems.

(v) When the vehicle detects that a system or component is worn or malfunctioning in a way that could reasonably prevent the engine from restarting, such as low battery voltage.

(vi) When the steering angle is at or near the limit of travel.

(vii) When flow of diesel exhaust fluid is limited due to freezing.

(viii) When a sensor failure could prevent the anti-lock braking system from properly detecting vehicle speed.

(ix) When a protection mode designed to prevent component failure is active.

(x) When a fault on a system component needed for starting the engine is active.

* * * * *

168. Amend § 1037.665 by revising paragraph (c) to read as follows:

§ 1037.665 Production and in-use tractor testing.

* * * * *

(c) We may approve your request to perform alternative testing that will provide equivalent or better information compared to the specified testing. For example, we may allow you to provide CO_2 data from in-use operation or from manufacturer-run on-road testing as long as it allows for reasonable year-to-year comparisons and includes testing from non-prototypeproduction vehicles. We may also direct you to do less testing than we specify in this section.

* * * * *

169. Amend § 1037.670 by revising paragraphs (a) and (b) to read as follows:

§ 1037.670 Optional CO_2 emission standards for tractors at or above 120,000 pounds GCWR.

(a) You may certify tractors at or above 120,000 pounds GCWR to the following CO_2 standards instead of the Phase 2 CO_2 standards of § 1037.106:

Table 1 of § 1037.670—Optional Phase 2 CO_2 Standards
for Tractors above 120,000 Pounds GCWR by Model Year (g/ton-mile)[a]

SUBCATEGORY	PHASE 2 STANDARDS FOR MODEL YEARS 2021 AND LATER 2023	MODEL YEARS 2024 -2026	MODEL YEARS 2026 AND LATER
Heavy Class 8 Low-Roof Day Cab	53.551.8	50.8	48.9
Heavy Class 8 Low-Roof Sleeper Cab	47.145.3	44.5	42.4
Heavy Class 8 Mid-Roof Day Cab	55.654.1	52.8	50.8
Heavy Class 8 Mid-Roof Sleeper Cab	49.647.9	46.9	44.7
Heavy Class 8 High-Roof Day Cab	54.554.1	51.4	48.6
Heavy Class 8 High-Roof Sleeper Cab	47.146.9	44.2	41.0

[a]Note that these standards are not directly comparable to the standards for Heavy-Haul Tractors in § 1037.106 because GEM handles aerodynamic performance differently for the two sets of standards.

(b) Determine subcategories as described in § 1037.230 for tractors that are not heavy-haul tractors. For example, the subcategory for tractors that would otherwise be considered Class 8 low-roof day cabs would be Heavy Class 8 Low-Roof Day Cabs and would be identified as HC8_DC_LR for the GEM run.

* * * * *

170. Amend § 1037.701 by revising paragraphs (h) and (i) to read as follows:

§ 1037.701 General provisions.

* * * * *

(h) See § 1037.740 for special credit provisions that apply for credits generated under 40 CFR 86.1819-14 (k)(7), 40 CFR 1036.615, or § 1037.615.

(i) Unless the regulations explicitly allow it, you may not calculate Phase 1 credits more than once for any emission reduction. For example, if you generate Phase 1 CO_2 emission credits for a given hybrid vehicle under this part, no one may generate CO_2 emission credits for the associated hybrid engine under 40 CFR part 1036. However, Phase 1 credits could be generated for identical engines used in vehicles that did not generate credits under this part.

* * * * *

171. Amend § 1037.705 by revising paragraph (c)(2) to read as follows:

§ 1037.705 Generating and calculating emission credits.

* * * * *

(c) * * *

(2) Exported vehicles. This exclusion applies even for exported vehicles that are certified under this part and labeled accordingly.

* * * * *

172. Amend § 1037.740 by revising paragraph (b)(1) to read as follows:

§ 1037.740 Restrictions for using emission credits.

* * * * *

(b) * * *

(1) The maximum amount of credits you may bring into the following service class groups is 60,000 Mg per model year:

(i) Spark-ignition engines, light heavy-duty compression-ignition engines, and ~~light~~ Light HDV~~heavy-duty vehicles~~. This group comprises the averaging set listed in paragraphs (a)(1) of this section and the averaging set listed in 40 CFR 1036.740(a)(1) and (2).

(ii) Medium heavy-duty compression-ignition engines and ~~medium~~ Medium HDV~~heavy-duty vehicles~~. This group comprises the averaging sets listed in paragraph (a)(2) of this section and 40 CFR 1036.740(a)(3).

(iii) Heavy heavy-duty compression-ignition engines and ~~heavy~~ Heavy HDV~~heavy-duty vehicles~~. This group comprises the averaging sets listed in paragraph (a)(3) of this section and 40 CFR 1036.740(a)(4).

* * * * *

173. Amend § 1037.801 by–

a. Revising the definitions for "Auxiliary emission control device", "Compression-ignition", and "Electric vehicle".

b. Adding a definition for "Electronic control module" in alphabetical order.

c. Revising the definitions for "Gear ratio or Transmission gear ratio, k_g" and "Heavy-duty vehicle".

d. Adding a definition for "High-strength steel" in alphabetical order.

e. Revising the definitions for "Hybrid engine or hybrid powertrain", "Hybrid vehicle", "Light-duty truck", "Low rolling resistance tire", "Model year", and "Small manufacturer".

f. Adding a definition for "Tonne" in alphabetical order.

The new and revised definitions read as follows:

§ 1037.801 Definitions.

* * * * *

Auxiliary emission control device means any element of design that senses temperature, motive speed, engine speed (r/min)~~rpm~~, transmission gear, or any other parameter for the purpose of activating, modulating, delaying, or deactivating the operation of any part of the emission control system.

* * * * *

Compression-ignition has the meaning given in § 1037.101.

* * * * *

Electric vehicle means a motor vehicle that does not include an engine, and is powered solely by an external source of electricity and/or solar power. Note that this does not include hybrid electric vehicles or fuel-cell vehicles that use a chemical fuel such as gasoline, diesel fuel, or hydrogen. Electric vehicles may also be referred to as all-electric vehicles to distinguish them from hybrid vehicles.

~~Engine~~Electronic control module has the meaning given in 40 CFR 1065.1001.

* * * * *

Gear ratio or Transmission gear ratio, $k_{g,}$ means the dimensionless number representing the

angular ~~velocity~~ speed of the transmission's input shaft divided by the angular ~~velocity~~ speed of the transmission's output shaft when the transmission is operating in a specific gear.
* * * * *

Heavy-duty vehicle means any trailer and any other motor vehicle that has a GVWR above 8,500 pounds. An incomplete vehicle is also a heavy-duty vehicle if it has~~,~~ a curb weight above 6,000 pounds~~,~~ or a basic vehicle frontal area greater than 45 square feet.
* * * * *

High-strength steel has the meaning given in § 1037.520.

Hybrid engine or hybrid powertrain means an engine or powertrain that includes energy storage features other than a conventional battery system or conventional flywheel. Supplemental electrical batteries and hydraulic accumulators are examples of hybrid energy storage systems. Note other examples of systems that qualify as hybrid engines or powertrains are systems that recover kinetic energy and use it to power an electric heater in the aftertreatment. Note that certain provisions in this part treat hybrid engines and hybrid powertrains intended for vehicles that include regenerative braking different than those intended for vehicles that do not include regenerative braking.

Hybrid vehicle means a vehicle that includes energy storage features (other than a conventional battery system or conventional flywheel) in addition to an internal combustion engine or other engine using consumable chemical fuel. Supplemental electrical batteries and hydraulic accumulators are examples of hybrid energy storage systems. Note other examples of systems that qualify as hybrid engines or powertrains are systems that recover kinetic energy and use it to power an electric heater in the aftertreatment. Note that certain provisions in this part treat hybrid vehicles that include regenerative braking different than those that do not include regenerative braking.
* * * * *

Light-duty truck means any motor vehicle that is not a heavy-duty vehicle, but ~~rated at or below 8,500 pounds GVWR with a curb weight at or below 6,000 pounds and basic vehicle frontal area at or below 45 square feet, which~~ is:

(1) Designed primarily for purposes of transportation of property or is a derivation of such a vehicle; or

(2) Designed primarily for transportation of persons and has a capacity of more than 12 persons; or

(3) Available with special features enabling off-street or off-highway operation and use.
* * * * *

Low rolling resistance tire means a tire on a vocational vehicle with a TRRL at or below of 7.7 kg/tonne, a steer tire on a tractor with a TRRL at or below 7.7 kg/tonne, a drive tire on a tractor with a TRRL at or below 8.1 kg/tonne, a tire on a non-box trailer with a TRRL at or below of 6.5 kg/tonne, or a tire on a box van with a TRRL at or below of 6.0 kg/tonne~~,~~.
* * * * *

Model year means one of the following for compliance with this part 1037. Note that manufacturers may have other model year designations for the same vehicle for compliance with other requirements or for other purposes:

(1) For tractors and vocational vehicles with a date of manufacture on or after January 1, 2021, ~~the vehicle's~~ *model year* means the manufacturer's annual new model production period based on the vehicle's date of manufacture, where the model year is the calendar year corresponding to the date of manufacture, except as follows:~~; however, t~~

(i) The vehicle's model year may be designated asto be the year before the calendar year corresponding to the date of manufacture if the engine's model year is also from an earlier year. You may ask us to extend your prior model year certificate to include such vehicles. Note that § 1037.601(a)(2) limits the extent to which vehicle manufacturers may install engines built in earlier calendar years.

(ii) The vehicle's model year may be designated to beas the year after the calendar year corresponding to the vehicle's date of manufacture. For example, a manufacturer may produce a new vehicle by installing the engine in December 2023 and designating it to beas a model year 2024 vehicle.

(2) For trailers and for Phase 1 tractors and vocational vehicles with a date of manufacture before January 1, 2021, *model year* means the manufacturer's annual new model production period, except as restricted under this definition and 40 CFR part 85, subpart X. It must include January 1 of the calendar year for which the model year is named, may not begin before January 2 of the previous calendar year, and it must end by December 31 of the named calendar year. The model year may be set to match the calendar year corresponding to the date of manufacture.

(i) The manufacturer who holds the certificate of conformity for the vehicle must assign the model year based on the date when its manufacturing operations are completed relative to its annual model year period. In unusual circumstances where completion of your assembly is delayed, we may allow you to assign a model year one year earlier, provided it does not affect which regulatory requirements will apply.

(ii) Unless a vehicle is being shipped to a secondary vehicle manufacturer that will hold the certificate of conformity, the model year must be assigned prior to introduction of the vehicle into U.S. commerce. The certifying manufacturer must redesignate the model year if it does not complete its manufacturing operations within the originally identified model year. A vehicle introduced into U.S. commerce without a model year is deemed to have a model year equal to the calendar year of its introduction into U.S. commerce unless the certifying manufacturer assigns a later date.

* * * * *

Small manufacturer means a manufacturer meeting the criteria specified in 13 CFR 121.201. Apply the small business criteria for NAICS code 336120 for vocational vehicles and tractors and 336212 for trailers. The employee and revenue limits apply to the total number employees and total revenue together for affiliated companies.

* * * * *

Tonne means metric ton, which is exactly 1000 kg.

* * * * *

174. Amend § 1037.805 by revising paragraphs (b), (c), (d), (e), and (f) to read as follows:

§ 1037.805 Symbols, abbreviations, and acronyms.

* * * * *

(b) Symbols for quantities. This part 1037 uses the following symbols and units of measure for various quantities:

SYMBOL	QUANTITY	UNIT	UNIT SYMBOL	UNIT IN TERMS OF SI BASE UNITS
A	vehicle frictional load	pound force or newton	lbf or N	$kg \cdot m \cdot s^{-2}$
a	axle position regression coefficient			

α	atomic hydrogen-to-carbon ratio	mole per mole	mol/mol	1
α	axle position regression coefficient			
α_0	intercept of air speed correction			
α_1	slope of air speed correction			
a_g	acceleration of Earth's gravity	meters per second squared	m/s^2	$m \cdot s^{-2}$
a_0	intercept of least squares regression			
a_1	slope of least squares regression			
B	vehicle load from drag and rolling resistance	pound force per mile per hour or newton second per meter	lbf/(mi/hr) or N·s/m	$kg \cdot s^{-1}$
b	axle position regression coefficient			
β	atomic oxygen-to-carbon ratio	mole per mole	mol/mol	1
β	axle position regression coefficient			
β_0	intercept of air direction correction			
β_1	slope of air direction correction			
C	vehicle-specific aerodynamic effects	pound force per mile per hour squared or newton-second squared per meter squared	lbf/mph^2 or $N \cdot s^2/m^2$	$kg \cdot m^{-1}$
c	axle position regression coefficient			
c_i	axle test regression coefficients			
C_i	constant			
ΔC_dA	differential drag area	meter squared	m^2	m^2
C_dA	drag area	meter squared	m^2	m^2
C_d	drag coefficient			
CF	correction factor			
C_{rr}	coefficient of rolling resistance	kilogram per metric ton	kg/tonne	10^{-3}
D	distance	miles or meters	mi or m	m
e	mass-weighted emission result	grams/ton-mile	g/ton-mi	g/kg-km
Eff	efficiency			
F	adjustment factor			
F	force	pound force or newton	lbf or N	$kg \cdot m \cdot s^{-2}$
f_n	angular speed (shaft)	revolutions per minute	r/min	$\pi \cdot 30 \cdot s^{-1}$
G	road grade	percent	%	10^{-2}
g	gravitational acceleration	meters per second squared	m/s^2	$m \cdot s^{-2}$
h	elevation or height	meters	m	m
i	indexing variable			

k_a	drive axle ratio			1
k_d	transmission gear ratio			
$k_{topgear}$	highest available transmission gear			
L	load over axle	pound force or newton	lbf or N	kg·m·s^{-2}
m	mass	pound mass or kilogram	lbm or kg	kg
M	molar mass	gram per mole	g/mol	10^{-3}·kg·mol^{-1}
M	vehicle mass	kilogram	kg	kg
M_e	vehicle effective mass	kilogram	kg	kg
$M_{rotating}$	inertial mass of rotating components	kilogram	kg	kg
N	total number in series			
n	number of tires			
$\dot{n}$	amount of substance rate	mole per second	mol/s	mol·s^{-1}
P	power	kilowatt	kW	10^3·m^2·kg·s^{-3}
~~P~~	~~tire inflation pressure~~	~~pascal~~	~~Pa~~	~~kg·m^{-1}·s^{-2}~~
p	pressure	pascal	Pa	kg·m^{-1}·s^{-2}
ρ	mass density	kilogram per cubic meter	kg/m^3	kg·m^{-3}
PL	payload	tons	ton	kg
ϕ	direction	degrees	°	°
ψ	direction	degrees	°	°
r	tire radius	meter	m	m
r^2	coefficient of determination			
$Re^\#$	Reynolds number			
SEE	standard error of the estimate ~~of error~~			
σ	standard deviation			
$TRPM$	tire revolutions per mile	revolutions per mile	r/mi	
$TRRL$	tire rolling resistance level	kilogram per metric ton	kg/tonne	10^{-3}
T	absolute temperature	kelvin	K	K
T	Celsius temperature	degree Celsius	°C	K – 273.15
T	torque (moment of force)	newton meter	N·m	m^2·kg·s^{-2}
t	time	hour or second	hr or s	s
Δt	time interval, period, 1/frequency	second	s	s
UF	utility factor			
v	speed	miles per hour or meters per second	mi/hr or m/s	m·s^{-1}
w	weighting factor			
w	wind speed	miles per hour	mi/hr	m·s^{-1}
W	work	kilowatt-hour	kW·hr	3.6·m^2·kg·s^{-1}
w_C	carbon mass fraction	gram/gram	g/g	1
WR	weight reduction	pound mass	lbm	kg
x	amount of substance mole fraction	mole per mole	mol/mol	1

(c) Superscripts. This part uses the following superscripts ~~to define a~~for modifying quantity symbols:

SUPERSCRIPT	~~QUANTITY~~MEANING

overbar (such as $\bar{y}$)	arithmetic mean
Double overbar (such as $\bar{\bar{y}}$)	arithmetic mean of arithmetic mean
overdot (such as $\dot{y}$)	quantity per unit time

(d) Subscripts. This part uses the following subscripts ~~to define a~~for modifying quantity symbols:

SUBSCRIPT	~~QUANTITY~~MEANING
±6	±6° yaw angle sweep
A	A speed
air	air
aero	aerodynamic
alt	alternative
act	actual or measured condition
air	air
axle	axle
B	B speed
brake	brake
C	C speed
Ccombdry	carbon from fuel per mole of dry exhaust
CD	charge-depleting
circuit	circuit
CO2DEF	CO_2 resulting from diesel exhaust fluid decomposition
CO2PTO	CO_2 emissions for PTO cycle
coastdown	coastdown
comp	composite
CS	charge-sustaining
cycle	test cycle
drive	drive axle
drive-idle	idle with the transmission in drive
driver	driver
dyno	dynamometer
effective	effective
end	end
eng	engine
event	event
fuel	fuel
full	full
grade	grade
H2Oexhaustdry	H_2O in exhaust per mole of exhaust
hi	high
i	an individual of a series
idle	idle
in	inlet
inc	increment
lo	low
loss	loss
max	maximum
meas	measured quantity
med	median

min	minimum
moving	moving
out	outlet
P	power
pair	pair of speed segments
parked-idle	idle with the transmission in park
partial	partial
ploss	power loss
plug-in	plug-in hybrid electric vehicle
powertrain	powertrain
PTO	power take-off
rated	rated speed
record	record
ref	reference quantity
RL	road load
rotating	rotating
seg	segment
speed	speed
spin	axle spin loss
start	start
steer	steer axle
t	tire
test	test
th	theoretical
total	total
trac	traction
trac10	traction force at 10 mi/hr
trailer	trailer axle
transient	transient
TRR	tire rolling resistance
urea	urea
veh	vehicle
w	wind
wa	wind average
yaw	yaw angle
ys	yaw sweep
zero	zero quantity

(e) Other acronyms and abbreviations. This part uses the following additional abbreviations and acronyms:

ABT	AVERAGING, BANKING, AND TRADING
AECD	auxiliary emission control device
AES	automatic engine shutdown
APU	auxiliary power unit
CD	charge-depleting
CFD	computational fluid dynamics
CFR	Code of Federal Regulations
CITT	curb idle transmission torque
CS	charge-sustaining
DOT	Department of Transportation
ECM	~~engine~~electronic control module
EPA	Environmental Protection Agency

FE	fuel economy
FEL	Family Emission Limit
GAWR	gross axle weight rating
GCWR	gross combination weight rating
GEM	greenhouse gas emission model
GVWR	gross vehicle weight rating
Heavy HDV	Heavy heavy-duty vehicle (see § 1037.140)
HVAC	heating, ventilating, and air conditioning
ISO	International Organization for Standardization
Light HDV	Light heavy-duty vehicle (see § 1037.140)
Medium HDV	Medium heavy-duty vehicle (see § 1037.140)
NARA	National Archives and Records Administration
NHTSA	National Highway Transportation Safety Administration
PHEV	plug-in hybrid electric vehicle
PTO	power take-off
RESS	rechargeable energy storage system
rpm	revolutions per minute
SAE	Society of Automotive Engineers
SEE	standard error of the estimate
SKU	stock-keeping unit
TRPM	tire revolutions per mile
TRRL	tire rolling resistance level
U.S.C.	United States Code
VSL	vehicle speed limiter

(f) Constants. This part uses the following constants:

SYMBOL	QUANTITY	VALUE
g	gravitational constant	9.8066511 m·s^{-2}
R	specific gas constant	287.058 J/(kg·K)

* * * * *

175. Revise § 1037.810 to read as follows:

§ 1037.810 Incorporation by reference.

(a) Certain material is incorporated by reference into this part with the approval of the Director of the Federal Register under 5 U.S.C. 552(a) and 1 CFR part 51. To enforce any edition other than that specified in this section, the Environmental Protection Agency must publish a notice of the changedocument in the Federal Register and the material must be available to the public. All approved material is available for inspection at EPA Docket Center, WJC West Building, Room 3334, 1301 Constitution Avenue, N.W., Washington, DC 20004, www.epa.gov/docketsU.S. EPA, Air and Radiation Docket and Information Center, 1301 Constitution Ave., NW., Room B102, EPA West Building, Washington, DC 20460, (202) 202-1744, and is available from the sources listed below. It is also available for inspection at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, email fedreg.legal@nara.gov, call 202-741-6030, or go to *http://www.archives.gov/federal-‑register/code_of_federal_regulationscfr/ibr-‑locations.html.*

(b) International Organization for Standardization, Case Postale 56, CH-1211 Geneva 20, Switzerland, (41) 22749 0111, www.iso.org, or central@iso.org.

(1) ISO 28580:2009(E) “Passenger car, truck and bus tyres – Methods of measuring rolling

resistance – Single point test and correlation of measurement results", First Edition, July 1, 2009, ("ISO 28580"), IBR approved for § 1037.520(c).

(2) [Reserved]

(c) U.S. EPA, Office of Air and Radiation, 2565 Plymouth Road, Ann Arbor, MI 48105, www.epa.gov.

(1) Greenhouse gas Emissions Model (GEM), Version 2.0.1, September 2012 ("GEM version 2.0.1"), IBR approved for § 1037.520. The computer code for this model is available as noted in paragraph (a) of this section. A working version of this software is also available for download at http://www.epa.gov/otaq/climate/gem.htm.

(2) Greenhouse gas Emissions Model (GEM) Phase 2, Version 3.5.1, November 2020 ("GEM Phase 2, Version 3.5.1")3.0, July 2016; IBR approved for §§ 1037.520 and 1037.550(b). The computer code for this model is available as noted in paragraph (a) of this section. A working version of this software is also available for download at https://www.epa.gov/regulations-emissions-vehicles-and-engines/greenhouse-gas-emissions-model-gem-medium-and-heavy-duty.http://www.epa.gov/otaq/climate/gem.htm.

(3) GEM's MATLAB/Simulink Hardware-in-Loop model, Version 3.8, December 2020 ("GEM HIL model"); IBR approved for § 1037.550(a).

Note 1 to paragraph (c): The computer code for these models is available as noted in paragraph (a) of this section. A working version of the software is also available for download at https://www.epa.gov/regulations-emissions-vehicles-and-engines/greenhouse-gas-emissions-model-gem-medium-and-heavy-duty.

(d) National Institute of Standards and Technology, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899-1070, (301) 975-6478, or www.nist.gov.

(1) NIST Special Publication 811, Guide for the Use of the International System of Units (SI), 2008 Edition, March 2008, IBR approved for § 1037.805.

(2) [Reserved]

(e) SAE International, 400 Commonwealth Dr., Warrendale, PA 15096–0001, (877) 606-7323 (U.S. and Canada) or (724) 776–4970 (outside the U.S. and Canada), http://www.sae.org.

(1) SAE J1025, Test Procedures for Measuring Truck Tire Revolutions Per Kilometer/Mile, Stabilized August 2012, ("SAE J1025"), IBR approved for § 1037.520(c).

(2) SAE J1252, SAE Wind Tunnel Test Procedure for Trucks and Buses, Revised July 2012, ("SAE J1252"), IBR approved for §§ 1037.525(b) and 1037.530(a).

(3) SAE J1263, Road Load Measurement and Dynamometer Simulation Using Coastdown Techniques, revised March 2010, ("SAE J1263"), IBR approved for §§ 1037.528 introductory text, (a), (b), (c), (e), and (h) and 1037.665(a).

(4) SAE J1594, Vehicle Aerodynamics Terminology, Revised July 2010, ("SAE J1594"), IBR approved for § 1037.530(d).

(5) SAE J2071, Aerodynamic Testing of Road Vehicles - Open Throat Wind Tunnel Adjustment, Revised June 1994, ("SAE J2071"), IBR approved for § 1037.530(b).

(6) SAE J2263, Road Load Measurement Using Onboard Anemometry and Coastdown Techniques, Revised December 2008, ("SAE J2263"), IBR approved for §§ 1037.528 introductory text, (a), (b), (d), and (f) and 1037.665(a).

(7) SAE J2343, Recommended Practice for LNG Medium and Heavy-Duty Powered Vehicles, Revised July 2008, ("SAE J2343"), IBR approved for § 1037.103(e).

(8) SAE J2452, Stepwise Coastdown Methodology for Measuring Tire Rolling Resistance, Revised June 1999, ("SAE J2452"), IBR approved for § 1037.528(h).

(9) SAE J2966, Guidelines for Aerodynamic Assessment of Medium and Heavy Commercial Ground Vehicles Using Computational Fluid Dynamics, Issued September 2013, ("SAE J2966"), IBR approved for § 1037.532(a).

176. Amend § 1037.825 by revising paragraph (a) to read as follows:

§ 1037.825 Reporting and recordkeeping requirements.

(a) This part includes various requirements to submit and record data or other information. Unless we specify otherwise, store required records in any format and on any media and keep them readily available for eight years after you send an associated application for certification, or eight years after you generate the data if they do not support an application for certification. ~~You may not rely on anyone else to meet recordkeeping requirements on your behalf unless we specifically authorize it.~~ We may review these records at any time. You must promptly ~~send~~ give us organized, written records in English if we ask for them. We may require you to submit written records in an electronic format.

* * * * *

177. Revise appendix III to part 1037 to read as follows:

Appendix III to Part 1037 — Emission Control Identifiers

This appendix identifies abbreviations for emission control information labels, as required under § 1037.135.

Vehicle Speed Limiters

-VSL – Vehicle speed limiter
-VSLS – "Soft-top" vehicle speed limiter
-VSLE – Expiring vehicle speed limiter
-VSLD – Vehicle speed limiter with both "soft-top" and expiration

Idle Reduction Technology

-IRT5 – Engine shutoff after 5 minutes or less of idling
-IRTE – Expiring engine shutoff

Tires

-LRRA – Low rolling resistance tires (all, including trailers)
-LRRD – Low rolling resistance tires (drive)
-LRRS – Low rolling resistance tires (steer)

Aerodynamic Components

-ATS – Aerodynamic side skirt and/or fuel tank fairing
-ARF – Aerodynamic roof fairing
-ARFR – Adjustable height aerodynamic roof fairing
-TGR – Gap reducing tractor fairing (tractor to trailer gap)
-TGRT – Gap reducing trailer fairing (tractor to trailer gap)
-TATS – Trailer aerodynamic side skirt
-TARF – Trailer aerodynamic rear fairing
-TAUD – Trailer aerodynamic underbody device

Other Components

-ADVH – Vehicle includes advanced hybrid technology components
-ADVO – Vehicle includes other advanced-technology components (i.e., non-hybrid system)
-INV – Vehicle includes innovative (off-cycle) technology components
-ATI – Automatic tire inflation system

-TPMS – Tire pressure monitoring system
-WRTW – Weight-reducing trailer wheels
-WRTC – Weight-reducing trailer upper coupler plate
-WRTS – Weight-reducing trailer axle sub-frames
-WBSW – Wide-base single trailer tires with steel wheel
-WBAW – Wide-base single trailer tires with aluminum wheel
-WBLW – Wide-base single trailer tires with light-weight aluminum alloy wheel
-DWSW – Dual-wide trailer tires with high-strength steel wheel
-DWAW – Dual-wide trailer tires with aluminum wheel
-DWLW – Dual-wide trailer tires with light-weight aluminum alloy wheel

178. Revise appendix IV to part 1037 to read as follows:

Appendix IV to Part 1037 — Heavy-duty Grade Profile for Phase 2 Steady-State Test Cycles

The following table identifies a grade profile for operating vehicles over the highway cruise cycles specified in subpart F of this part. Determine intermediate values by linear interpolation.

Distance (m)	Grade (%)
0	0
402	0
804	0.5
1206	0
1210	0
1222	-0.1
1234	0
1244	0
1294	0.36
1344	0
1354	0
1408	-0.28
1504	-1.04
1600	-0.28
1654	0
1666	0
1792	0.39
1860	0.66
1936	1.15
2098	2.44
2260	1.15
2336	0.66
2404	0.39
2530	0
2548	0
2732	-0.46
2800	-0.69
2880	-1.08
2948	-1.53
3100	-2.75
3252	-1.53
3320	-1.08
3400	-0.69
3468	-0.46
3652	0
3666	0
3742	0.35
3818	0.9
3904	1.59
3990	0.9
4066	0.35
4142	0
4158	0
4224	-0.1
4496	-0.69
4578	-0.97
4664	-1.36
4732	-1.78
4916	-3.23
5100	-1.78
5168	-1.36
5254	-0.97
5336	-0.69
5608	-0.1
5674	0
5724	0
5808	0.1
5900	0.17
6122	0.38
6314	0.58
6454	0.77
6628	1.09
6714	1.29
6838	1.66
6964	2.14
7040	2.57
7112	3
7164	3.27
7202	3.69
7292	5.01
7382	3.69
7420	3.27
7472	3
7544	2.57
7620	2.14
7746	1.66
7870	1.29
7956	1.09
8130	0.77
8270	0.58
8462	0.38
8684	0.17
8776	0.1
8860	0
8904	0
9010	-0.38
9070	-0.69
9254	-2.13
9438	-0.69
9498	-0.38
9604	0
9616	0
9664	0.26
9718	0.7
9772	0.26
9820	0
9830	0
9898	-0.34
10024	-1.33
10150	-0.34
10218	0
10228	0
10316	0.37
10370	0.7
10514	1.85
10658	0.7
10712	0.37
10800	0
10812	0
10900	-0.37
10954	-0.7
11098	-1.85
11242	-0.7
11296	-0.37
11384	0
11394	0
11462	0.34
11588	1.33
11714	0.34
11782	0
11792	0
11840	-0.26
11894	-0.7
11948	-0.26
11996	0
12008	0
12114	0.38
12174	0.69

12358	2.13
12542	0.69
12602	0.38
12708	0
12752	0
12836	-0.1
12928	-0.17
13150	-0.38
13342	-0.58
13482	-0.77
13656	-1.09
13742	-1.29
13866	-1.66
13992	-2.14
14068	-2.57
14140	-3
14192	-3.27
14230	-3.69

14320	-5.01
14410	-3.69
14448	-3.27
14500	-3
14572	-2.57
14648	-2.14
14774	-1.66
14898	-1.29
14984	-1.09
15158	-0.77
15298	-0.58
15490	-0.38
15712	-0.17
15804	-0.1
15888	0
15938	0
16004	0.1
16276	0.69

16358	0.97
16444	1.36
16512	1.78
16696	3.23
16880	1.78
16948	1.36
17034	0.97
17116	0.69
17388	0.1
17454	0
17470	0
17546	-0.35
17622	-0.9
17708	-1.59
17794	-0.9
17870	-0.35
17946	0
17960	0

18144	0.46
18212	0.69
18292	1.08
18360	1.53
18512	2.75
18664	1.53
18732	1.08
18812	0.69
18880	0.46
19064	0
19082	0
19208	-0.39
19276	-0.66
19352	-1.15
19514	-2.44
19676	-1.15
19752	-0.66
19820	-0.39

19946	0
19958	0
20012	0.28
20108	1.04
20204	0.28
20258	0
20268	0
20318	-0.36
20368	0
20378	0
20390	0.1
20402	0
20406	0
20808	-0.5
21210	0
21612	0

Distance (m)	Grade (%)
0	0
808	0
820	-0.1
832	0
842	0
892	0.36
942	0
952	0
1006	-0.28
1102	-1.04
1198	-0.28
1252	0
1264	0
1390	0.39
1458	0.66
1534	1.15
1696	2.44
1858	1.15
1934	0.66
2002	0.39
2128	0

2146	0
2330	-0.46
2398	-0.69
2478	-1.08
2546	-1.53
2698	-2.75
2850	-1.53
2918	-1.08
2998	-0.69
3066	-0.46
3250	0
3264	0
3340	0.35
3416	0.9
3502	1.59
3588	0.9
3664	0.35
3740	0
3756	0
3822	-0.1
4094	-0.69
4176	-0.97
4262	-1.36

4330	-1.78
4514	-3.23
4698	-1.78
4766	-1.36
4852	-0.97
4934	-0.69
5206	-0.1
5272	0
5322	0
5406	0.1
5498	0.17
5720	0.38
5912	0.58
6052	0.77
6226	1.09
6312	1.29
6436	1.66
6562	2.14
6638	2.57
6710	3
6762	3.27
6800	3.69
6890	5.01

6980	3.69
7018	3.27
7070	3
7142	2.57
7218	2.14
7344	1.66
7468	1.29
7554	1.09
7728	0.77
7868	0.58
8060	0.38
8282	0.17
8374	0.1
8458	0
8502	0
8608	-0.38
8668	-0.69
8852	-2.13
9036	-0.69
9096	-0.38
9202	0
9214	0
9262	0.26

9316	0.7
9370	0.26
9418	0
9428	0
9496	-0.34
9622	-1.33
9748	-0.34
9816	0
9826	0
9914	0.37
9968	0.7
10112	1.85
10256	0.7
10310	0.37
10398	0
10410	0
10498	-0.37
10552	-0.7
10696	-1.85
10840	-0.7
10894	-0.37
10982	0
10992	0

11060	0.34
11186	1.33
11312	0.34
11380	0
11390	0
11438	-0.26
11492	-0.7
11546	-0.26
11594	0
11606	0
11712	0.38
11772	0.69
11956	2.13
12140	0.69
12200	0.38
12306	0
12350	0
12434	-0.1
12526	-0.17
12748	-0.38

12940	-0.58
13080	-0.77
13254	-1.09
13340	-1.29
13464	-1.66
13590	-2.14
13666	-2.57
13738	-3
13790	-3.27
13828	-3.69
13918	-5.01
14008	-3.69
14046	-3.27
14098	-3
14170	-2.57
14246	-2.14
14372	-1.66
14496	-1.29
14582	-1.09
14756	-0.77

14896	-0.58
15088	-0.38
15310	-0.17
15402	-0.1
15486	0
15536	0
15602	0.1
15874	0.69
15956	0.97
16042	1.36
16110	1.78
16294	3.23
16478	1.78
16546	1.36
16632	0.97
16714	0.69
16986	0.1
17052	0
17068	0
17144	-0.35

17220	-0.9
17306	-1.59
17392	-0.9
17468	-0.35
17544	0
17558	0
17742	0.46
17810	0.69
17890	1.08
17958	1.53
18110	2.75
18262	1.53
18330	1.08
18410	0.69
18478	0.46
18662	0
18680	0
18806	-0.39
18874	-0.66
18950	-1.15

19112	-2.44
19274	-1.15
19350	-0.66
19418	-0.39
19544	0
19556	0
19610	0.28
19706	1.04
19802	0.28
19856	0
19866	0
19916	-0.36
19966	0
19976	0
19988	0.1
20000	0
20808	0

PART 1065—ENGINE-TESTING PROCEDURES

314. The authority citation for part 1065 continues to read as follows:
Authority: 42 U.S.C. 7401 - 7671q.

315. Amend § 1065.1 by revising paragraph (g) to read as follows:

§ 1065.1 Applicability.

* * * * *

(g) For additional information regarding these test procedures, visit our Web site at www.epa.gov, and in particular https://www.epa.gov/vehicle-and-fuel-emissions-testing/engine-testing-regulations~~http://www.epa.gov/nvfel/testing/regulations.htm~~.

* * * * *

316. Amend § 1065.2 by revising paragraph (c) to read as follows:

§ 1065.2 Submitting information to EPA under this part.

* * * * *

(c) We may void any certificates or approvals associated with a submission of information if we find that you intentionally submitted false, incomplete, or misleading information. For example, if we find that you intentionally submitted incomplete information to mislead EPA when requesting approval to use alternate test procedures, we may void the certificates for all engine~~s~~ families certified based on emission data collected using the alternate procedures. This would also apply if you ignore data from incomplete tests or from repeat tests with higher emission results.

* * * * *

317. Amend § 1065.130 by revising paragraph (e) to read as follows:

§ 1065.130 Engine exhaust.

* * * * *

(e) Leaks. Minimize leaks sufficiently to ensure your ability to demonstrate compliance with the applicable standards. We recommend performing ~~a chemical balance of fuel, intake air, and exhaust according to § 1065.655~~carbon balance error verification as described in § 1065.543 to verify exhaust system integrity.

* * * * *

318. Amend § 1065.140 by revising paragraphs (c)(6)(i) and (e)(2) to read as follows:

§ 1065.140 Dilution for gaseous and PM constituents.

* * * * *

(c) * * *

(6) * * *

(i) Preventing aqueous condensation. To prevent condensation, you must keep the temperature of internal surfaces, excluding any sample probes, above the dew~~-~~point of the dilute exhaust passing through the CVS tunnel. Use good engineering judgment to monitor temperatures in the CVS. For the purposes of this paragraph (c)(6), assume that aqueous condensation is pure water condensate only, even though the definition of “aqueous condensation” in § 1065.1001 includes condensation of any constituents that contain water. No specific verification check is required under this paragraph (c)(6)(i), but we may ask you to show how you comply with this requirement. You may use engineering analysis, CVS tunnel design, alarm systems, measurements of wall temperatures, and calculation of water dew-point to demonstrate compliance with this requirement. For optional CVS heat exchangers, you may use the lowest water temperature at the inlet(s) and outlet(s) to determine the minimum internal surface temperature.

* * * * *

(e) * * *

(2) For any PM dilution system (i.e., CVS or PFD), add dilution air to the raw exhaust such that the minimum overall ratio of diluted exhaust to raw exhaust is within the range of (5:1 to 7:1) and is at least 2:1 for any primary dilution stage. Base this minimum value on the maximum engine exhaust flow rate during a given duty cycle for discrete-mode testing and on the maximum engine exhaust flow rate during ~~for~~ a given test interval for other testing. ~~For discrete mode testing, base the minimum value on the maximum engine exhaust flow rate for a given duty cycle.~~ Either measure the maximum exhaust flow during a practice run of the test interval or estimate it based on good engineering judgment (for example, you might rely on manufacturer-published literature).

* * * * *

319. Amend § 1065.145 by revising paragraph (e)(3)(i) to read as follows:

§ 1065.145 Gaseous and PM probes, transfer lines, and sampling system components.

* * * * *

(e) * * *

(3) * * *

(i) If you use a NO_x sample pump upstream of either an NO_2-to-NO converter that meets § 1065.378 or a chiller that meets § 1065.376, ~~it must be heated~~design the sampling system to prevent aqueous condensation.

* * * * *

320. Amend § 1065.170 by revising the introductory text and paragraph (a)(1) to read as follows:

§ 1065.170 Batch sampling for gaseous and PM constituents.

Batch sampling involves collecting and storing emissions for later analysis. Examples of batch sampling include collecting and storing gaseous emissions in a bag or collecting and storing PM on a filter. You may use batch sampling to store emissions that have been diluted at least once in some way, such as with CVS, PFD, or BMD. You may use batch-~~ ~~sampling to store undiluted emissions. You may stop emission sampling anytime the engine is turned off, consistent with good engineering judgment. This is intended to allow for higher concentrations of dilute exhaust gases and more accurate measurements. Account for exhaust transport delay in the sampling system and ~~be sure to~~ integrate over the actual sampling duration when determining n_{dexh}. Use good engineering judgement to add ~~additional~~ dilution air~~, as needed,~~ to fill bags up to minimum read volumes, as needed.

(a) * * *

(1) Verify proportional sampling after an emission test as described in § 1065.545. You ~~may~~must exclude from the proportional sampling verification ~~segments~~any portion of the test where you are not sampling emissions because the engine is turned off ~~where~~and the ~~bag is~~batch samplers are not sampling, accounting for exhaust transport delay in the sampling system~~ not being filled from the proportional sampling verification.~~ Use good engineering judgment to select storage media that will not significantly change measured emission levels (either up or

down). For example, do not use sample bags for storing emissions if the bags are permeable with respect to emissions or if they off gas emissions to the extent that it affects your ability to demonstrate compliance with the applicable gaseous emission standards. As another example, do not use PM filters that irreversibly absorb or adsorb gases to the extent that it affects your ability to demonstrate compliance with the applicable PM emission standard.

* * * * *

321. Revise § 1065.205 to read as follows:

§ 1065.205 Performance specifications for measurement instruments.

Your test system as a whole must meet all the calibrations, verifications, and test-validation criteria specified outside this section for laboratory testing or field testing, as applicable. We recommend that your instruments meet the specifications in ~~Table 1 of~~ this section for all ranges you use for testing. We also recommend that you keep any documentation you receive from instrument manufacturers showing that your instruments meet the specifications in ~~Table 1 of this section.~~the following table:

TABLE 1 OF § 1065.205–RECOMMENDED PERFORMANCE SPECIFICATIONS FOR MEASUREMENT INSTRUMENTS

Measurement Instrument	Measured quantity symbol	Complete System Rise time ($t_{10\text{-}90}$) and Fall time ($t_{90\text{-}10}$)[a]	Recording update frequency	Accuracy[b]	Repeatability[b]	Noise[b]
Engine speed transducer	f_n	1 s	1 Hz means	2 % of pt. or 0.5 % of max.	1 % of pt. or 0.25 % of max.	0.05 % of max
Engine torque transducer	T	1 s	1 Hz means	2 % of pt. or 1 % of max.	1 % of pt. or 0.5 % of max	0.05 % of max.
Electrical work (active-power meter)	W	1 s	1 Hz means	2 % of pt. or 0.5 % of max.	1 % of pt. or 0.25 % of max.	0.05 % of max
General pressure transducer (not a part of another instrument)	p	5 s	1 Hz	2 % of pt. or 1 % of max.	1 % of pt. or 0.5 % of max.	0.1 % of max
Atmospheric pressure meter for PM-stabilization and balance environments	p_{atmos}	50 s	5 times per hour	50 Pa	25 Pa	5 Pa
General purpose atmospheric pressure meter	p_{atmos}	50 s	5 times per hour	250 Pa	100Pa	50 Pa
Temperature sensor for PM-stabilization and balance environments	T	50 s	0.1 Hz	0.25 K	0.1 K	0.1 K
Other temperature sensor (not a part of another instrument)	T	10 s	0.5 Hz	0.4 % of pt. K or 0.2 % of max. K	0.2 % of pt. K or 0.1 % of max. K	0.1 % of max.
Dewpoint sensor for intake air, PM-stabilization and balance environments	T_{dew}	50 s	0.1 Hz	0.25 K	0.1 K	0.02 K
Other dewpoint sensor	T_{dew}	50 s	0.1 Hz	1 K	0.5 K	0.1 K
Fuel mass flow rate meter[c] ~~(Fuel totalizer)~~	$\dot{m}$	5 s ~~(—)~~	1 Hz ~~(—)~~	2 % of pt. or 1.5 % of max.	1 % of pt. or 0.75 % of max.	0.5 % of max.
DEF mass flow rate meter[c]	$\dot{m}$	5 s	1 Hz	5 % of pt. or 4 % of max.	2.5 % of pt. or 2 % of max.	1.25 % of max.
Fuel mass scale[d]	m	5 s	1 Hz	$0.36\ \% \cdot m_{max}$ + $0.25\ \% \cdot$ pt.	$1.13\ \% \cdot m_{max}$	$4.4\ \% \cdot m_{max}$
DEF mass scale[d]	m	5 s	1 Hz	$0.36\ \% \cdot m_{max}$ + $0.25\ \% \cdot$ pt.	$1.13\ \% \cdot m_{max}$	$4.4\ \% \cdot m_{max}$
Total diluted exhaust meter (CVS)[c] (With heat exchanger before meter)	$\dot{n}$	1 s (5 s)	1 Hz means (1 Hz)	2 % of pt. or 1.5 % of max.	1 % of pt. or 0.75 % of max.	1 % of max.
Dilution air, inlet air, exhaust, and sample flow meters[c]	$\dot{n}$	1 s	1 Hz means of 5 Hz samples	2.5 % of pt. or 1.5 % of max.	1.25 % of pt. or 0.75 % of max.	1 % of max.
Continuous gas analyzer	x	5 s	1 Hz	2 % of pt. or 2 % of meas.	1 % of pt. or 1 % of meas.	1 % of max.
Batch gas analyzer	x	—	—	2 % of pt. or 2 % of meas.	1 % of pt. or 1 % of meas.	1 % of max.
Gravimetric PM balance	m_{PM}	—	—	See § 1065.790	0.5 µg	—
Inertial PM balance	m_{PM}	5 s	1 Hz	2 % of pt. or 2 % of meas.	1 % of pt. or 1 % of meas.	0.2 % of max.

[a]The performance specifications identified in the table apply separately for rise time and fall time.
[b]Accuracy, repeatability, and noise are all determined with the same collected data, as described in § 1065.305, and based on absolute values. "pt." refers to the overall flow-weighted mean value expected at the standard; "max." refers to the peak value expected at the standard over any test interval, not the maximum of the instrument's range; "meas" refers to the actual flow-weighted mean measured over any test interval.
[c]The procedure for accuracy, repeatability, and noise measurement described in § 1065.305 may be modified for flow meters to allow noise to be measured at the lowest calibrated value instead of zero flow rate.

[d]For these quantities, the values that are to be used for the limit requirements are Base performance specifications for mass scales on differential mass over the test interval as described in paragraphs §1065.307(e)(9).

322. Amend § 1065.220 by revising paragraph (a) introductory text to read as follows:

§ 1065.220 Fuel flow meter.

(a) Application. You may use fuel flow meters in combination with a chemical balance of fuel, DEF, ~~inlet~~ intake air, and raw exhaust to calculate raw exhaust flow as described in § 1065.655(f). ~~, as follows:~~ You may also use fuel flow meters ~~and~~ to determine the mass flow rate of carbon-carrying fuel streams ~~input to the~~ for performing carbon balance error verification in § 1065.543 and to calculate the mass of those fuel streams as described in § 1065.643. The following provisions apply for using fuel flow meters:

(1) Use the actual value of calculated raw exhaust flow rate in the following cases:

(i) For multiplying raw exhaust flow rate with continuously sampled concentrations.

(ii) For multiplying total raw exhaust flow with batch-sampled concentrations.

(iii) For calculating the dilution air flow for background correction as described in § 1065.667.

(2) In the following cases, you may use a fuel flow meter signal that does not give the actual value of raw exhaust, as long as it is linearly proportional to the exhaust molar flow rate's actual calculated value:

(i) For feedback control of a proportional sampling system, such as a partial-flow dilution system.

(ii) For multiplying with continuously sampled gas concentrations, if the same signal is used in a chemical-balance calculation to determine work from brake-specific fuel consumption and fuel consumed.

~~(3) You may use fuel flow meters to calculate the mass of carbon-carrying fuel streams as described in § 1065.643.~~

* * * * *

323. Amend § 1065.225 by revising paragraph (a) introductory text to read as follows:

§ 1065.225 Intake-air flow meter.

(a) Application. You may use ~~an~~ intake-air flow meters in combination with a chemical balance of fuel, DEF, ~~inlet~~ intake air, and raw exhaust to calculate raw exhaust flow as described in § 1065.655(f) and (g). ~~, as follows:~~ You may also use intake-air flow meters ~~and~~ to determine the ~~measured~~ amount of intake air input for performing ~~to the~~ carbon balance error verification ~~described~~ in § 1065.543 and to calculate the measured amount of intake air, n_{int}, as described in § 1065.643. The following provisions apply for using intake air flow meters:

(1) Use the actual value of calculated raw exhaust in the following cases:

(i) For multiplying raw exhaust flow rate with continuously sampled concentrations.

(ii) For multiplying total raw exhaust flow with batch-sampled concentrations.

(iii) For verifying minimum dilution ratio for PM batch sampling as described in § 1065.546.

(iv) For calculating the dilution air flow for background correction as described in § 1065.667.

(2) In the following cases, you may use an intake-air flow meter signal that does not give the actual value of raw exhaust, as long as it is linearly proportional to the exhaust flow rate's actual calculated value:

(i) For feedback control of a proportional sampling system, such as a partial-flow dilution system.

(ii) For multiplying with continuously sampled gas concentrations, if the same signal is used in a chemical-balance calculation to determine work from brake-specific fuel consumption and fuel consumed.

(3) You may use intake-air flow meters to calculate n_{int}, the measured amount of intake air as described in § 1065.643.
* * * * *

324. Revise § 1065.247 to read as follows:

§ 1065.247 Diesel exhaust fluid flow rate.

(a) Application. Determine diesel exhaust fluid (DEF) flow rate over a test interval for batch or continuous emission sampling using one of the three methods described in this section.

(b) ECM. Use the ECM signal directly to determine DEFdiesel exhaust fluid flow rate. You may combine this with a gravimetric scale if that improves measurement quality. Prior to testing, you may characterize the ECM signal using a laboratory measurement and adjust the ECM signal, consistent with good engineering judgment.

(c) Flow meter. Measure DEFdiesel exhaust fluid flow rate with a flow meter. We recommend that the flow meter that meets the specifications in Table 1 of § 1065.205. Note that your overall system for measuring DEFdiesel exhaust fluid flow must meet the linearity verification in § 1065.307. Measure using the following procedure:

(1) Condition the flow of DEFdiesel exhaust fluid as needed to prevent wakes, eddies, circulating flows, or flow pulsations from affecting the accuracy or repeatability of the meter. You may accomplish this by using a sufficient length of straight tubing (such as a length equal to at least 10 pipe diameters) or by using specially designed tubing bends, straightening fins, or pneumatic pulsation dampeners to establish a steady and predictable velocity profile upstream of the meter. Condition the flow as needed to prevent any gas bubbles in the fluid from affecting the flow meter.

(2) Account for any fluid that bypasses the engine DEFdiesel exhaust fluid dosing unit or returns from the engine dosing unit to the fluid storage tank.

(d) Gravimetric scale. Use a gravimetric scale to determine the mass of DEFdiesel exhaust fluid the engine uses over a discrete-mode test interval and divide by the time of the test interval.

325. Amend § 1065.260 by revising paragraph (e) to read as follows:

§ 1065.260 Flame-ionization detector.

* * * * *

(e) NMHC and NMOG. For demonstrating compliance with NMHC standards, you may either measure THC and determine NMHC mass as described in § 1065.660(b)(1), or you may measure THC and CH_4 and determine NMHC as described in § 1065.660(b)(2) or (3). For gaseous-fueled engines, yYou may also use the additive method in § 1065.660(b)(4) for natural gas-fueled engines as described in § 1065.266. See 40 CFR 1066.635 for methods to demonstrate compliance with NMOG standards for vehicle testing.

* * * * *

326. Amend § 1065.266 by revising paragraphs (a) and (b) to read as follows:

§ 1065.266 Fourier transform infrared analyzer.

(a) Application. For engines that run only on natural gas, you may use a Fourier transform infrared (FTIR) analyzer to measure nonmethane hydrocarbon (NMHC) and nonmethane-nonethane hydrocarbon (NMNEHC) for continuous sampling. You may use an FTIR analyzer with any gaseous-fueled engine, including dual-fuel and flexible-fuel engines, to measure CH_4 and C_2H_6, for either batch or continuous sampling (for subtraction from THC).

(b) Component requirements. We recommend that you use an FTIR analyzer that meets the specifications in Table 1 of § 1065.205. Note that your FTIR-based system must meet the linearity verification in § 1065.307. Use appropriate analytical procedures for interpretation of infrared spectra. For example, EPA Test Method 320 (see https://www.epa.gov/emc/method-320-vapor-phase-organic-and-inorganic-emissions-extractive-ftirhttps://www3.epa.gov/ttn/emc/promgate/m-320.pdf) and ASTM D6348 (incorporated by reference in § 1065.1010) are considered valid methods for spectral interpretation. You must use heated FTIR analyzers that maintain all surfaces that are exposed to emissions at a temperature of (110 to 202) °C.

* * * * *

327. Amend § 1065.275 by revising paragraph (b)(2) to read as follows:

§ 1065.275 N_2O measurement devices.

* * * * *

(b) * * *

(2) Fourier transform infrared (FTIR) analyzer. Use appropriate analytical procedures for interpretation of infrared spectra. For example, EPA Test Method 320 (see § 1065.266(b)https://www3.epa.gov/ttn/emc/promgate/m-320.pdf) and ASTM D6348 (incorporated by reference in § 1065.1010) are considered valid methods for spectral interpretation.

* * * * *

328. Amend § 1065.280 by revising paragraph (a) to read as follows:

§ 1065.280 Paramagnetic and magnetopneumatic O_2 detection analyzers.

(a) Application. You may use a paramagnetic detection (PMD) or magnetopneumatic detection (MPD) analyzer to measure O_2 concentration in raw or diluted exhaust for batch or continuous sampling. You may use good engineering judgment to develop calculations that use O_2 measurements with a chemical balance of fuel, DEF, inlet intake air, and exhaust intake air or fuel flow measurements to calculate exhaust flow rate according to § 1065.650.

* * * * *

329. Revise § 1065.303 to read as follows:

§ 1065.303 Summary of required calibration and verifications.

The following table summarizes the required and recommended calibrations and verifications described in this subpart and indicates when these have to be performed:

TABLE 1 OF § 1065.303–SUMMARY OF REQUIRED CALIBRATION AND VERIFICATIONS

Type of calibration or verification	Minimum frequency[a1]
§ 1065.305: Accuracy, repeatability and noise	Accuracy: Not required, but recommended for initial installation. Repeatability: Not required, but recommended for initial installation. Noise: Not required, but recommended for initial installation.

Formatted: Underline

Formatted: Underline

§ 1065.307: Linearity verification	Speed: Upon initial installation, within 370 days before testing and after major maintenance. Torque: Upon initial installation, within 370 days before testing and after major maintenance. Electrical power, current, and voltage: Upon initial installation, within 370 days before testing and after major maintenance.~~[a]~~[b] Fuel mass flow rate ~~rate~~: Upon initial installation, within 370 days before testing, and after major maintenance. Fuel mass scale: Upon initial installation, within 370 days before testing, and after major maintenance. DEF mass flow rate: Upon initial installation, within 370 days before testing, and after major maintenance.[c] DEF mass scale: Upon initial installation, within 370 days before testing, and after major maintenance. Intake-air, dilution air, diluted exhaust, and batch sampler flow rates: Upon initial installation, within 370 days before testing and after major maintenance~~, unless flow is verified by propane check or by carbon or oxygen balance~~.[d] Raw exhaust flow rate: Upon initial installation, within 185 days before testing and after major maintenance~~, unless flow is verified by propane check or by carbon or oxygen balance~~.[d] Gas dividers: Upon initial installation, within 370 days before testing, and after major maintenance. Gas analyzers (unless otherwise noted): Upon initial installation, within 35 days before testing and after major maintenance. FTIR and photoacoustic analyzers: Upon initial installation, within 370 days before testing and after major maintenance. GC-ECD: Upon initial installation and after major maintenance. PM balance: Upon initial installation, within 370 days before testing and after major maintenance. Pressure, temperature, and dewpoint: Upon initial installation, within 370 days before testing and after major maintenance.
§ 1065.308: Continuous gas analyzer system response and updating-recording verification—for gas analyzers not continuously compensated for other gas species	Upon initial installation or after system modification that would affect response.
§ 1065.309: Continuous gas analyzer system-response and updating-recording verification—for gas analyzers continuously compensated for other gas species	Upon initial installation or after system modification that would affect response.
§ 1065.310: Torque	Upon initial installation and after major maintenance.
§ 1065.315: Pressure, temperature, dewpoint	pon initial installation and after major maintenance.
§ 1065.320: Fuel flow	Upon initial installation and after major maintenance.
§ 1065.325: Intake flow	Upon initial installation and after major maintenance.
§ 1065.330: Exhaust flow	Upon initial installation and after major maintenance.
§ 1065.340: Diluted exhaust flow (CVS) U	Upon initial installation and after major maintenance.
§ 1065.341: CVS and PFD flow ~~and batch sampler~~ verification (propane check)[a]	~~CVS and PFD used for sampling gaseous emissions:~~ Upon initial installation, within 35 days before testing, and after major maintenance.[e]
§ 1065.342 Sample dryer verification	For thermal chillers: upon installation and after major maintenance. For osmotic membranes; upon installation, within 35 days of testing, and after major maintenance.
§ 1065.345: Vacuum leak	For laboratory testing: upon initial installation of the sampling system, within 8 hours before the start of the first test interval of each duty-cycle sequence, and after maintenance such as pre-filter changes. For field testing: after each installation of the sampling system on the vehicle, prior to the start of the field test, and after maintenance such as pre-filter changes.
§ 1065.350: CO_2 NDIR H_2O interference	Upon initial installation and after major maintenance.
§ 1065.355: CO NDIR CO_2 and H_2O interference	Upon initial installation and after major maintenance.

Formatted: Underline
Formatted: Underline
Formatted: Underline
Formatted: Underline
Formatted: Underline
Formatted: Underline
Formatted: Underline
Formatted: Underline
Formatted: Underline
Formatted: Underline
Formatted: Underline
Formatted: Underline
Formatted: Underline
Formatted: Underline
Formatted: Underline
Formatted: Underline

§ 1065.360: FID calibration THC FID optimization, and THC FID verification	Calibrate all FID analyzers: upon initial installation and after major maintenance. Optimize and determine CH_4 response for THC FID analyzers: upon initial installation and after major maintenance. Verify CH_4 response for THC FID analyzers: upon initial installation, within 185 days before testing, and after major maintenance. Verify C_2H_6 response for THC FID analyzers if used for NMNEHC determination: upon initial installation, within 185 days before testing, and after major maintenance.
§ 1065.362: Raw exhaust FID O_2 interference	For all FID analyzers: upon initial installation, and after major maintenance. For THC FID analyzers: upon initial installation, after major maintenance, and after FID optimization according to § 1065.360.
§ 1065.365: Nonmethane cutter penetration	Upon initial installation, within 185 days before testing, and after major maintenance.
§ 1065.366: Interference verification for FTIR analyzers	Upon initial installation and after major maintenance.
§ 1065.369: H_2O, CO, and CO_2 interference verification for ethanol photoacoustic analyzers	Upon initial installation and after major maintenance.
§ 1065.370: CLD CO_2 and H_2O quench	Upon initial installation and after major maintenance.
§ 1065.372: NDUV HC and H_2O interference	Upon initial installation and after major maintenance.
§ 1065.375: N_2O analyzer interference	Upon initial installation and after major maintenance.
§ 1065.376: Chiller NO_2 penetration	Upon initial installation and after major maintenance.
§ 1065.378: NO_2-to-NO converter conversion	Upon initial installation, within 35 days before testing, and after major maintenance.
§ 1065.390: PM balance and weighing	Independent verification: upon initial installation, within 370 days before testing, and after major maintenance. Zero, span, and reference sample verifications: within 12 hours of weighing, and after major maintenance.
§ 1065.395: Inertial PM balance and weighing	Independent verification: upon initial installation, within 370 days before testing, and after major maintenance. Other verifications: upon initial installation and after major maintenance.

[a] ~~[1]~~ Perform calibrations and verifications more frequently than we specify, according to measurement system manufacturer instructions and good engineering judgment.

[b] ~~[2]~~ Perform linearity verification either for electrical power or for current and voltage.

[c] Linearity verification is not required if DEF flow rate comes directly from the ECM signal ~~is used~~ as described in § 1065.247(b).

[d] ~~The l~~Linearity verification is not required if the flow signal’s accuracy ~~of the flow signal~~ is verified by carbon balance error verification as described in § 1065.307(e)(5) or a propane check as described in § 1065.341 ~~or by a carbon balance error verification as described in § 1065.307(e)(5)~~.

[e] ~~[3]~~ ~~The~~ CVS and PFD flow verification (propane check) ~~described in § 1065.341~~ is not required for measurement systems ~~that are~~ verified by linearity verification as described in § 1065.307 or ~~a~~ carbon balance error verification as described in § 1065.341(h). ~~agree within ±2 % based on a chemical balance of carbon or oxygen of the intake air, fuel, and diluted exhaust.~~

330. Amend § 1065.307 by–

a. Revising paragraphs (c)(13), (d)(4), (d)(6)(i), (d)(7), (d)(9), (e)(3), and (e)(5).

b. Adding paragraphs (e)(7)(i)(F) and (G), (f), and (g).

The added and revised paragraphs read as follows:

§ 1065.307 Linearity verification.

* * * * *

(c) * * * *

(13) Use the arithmetic means, $\bar{y}_i$, and reference values, y_{refi}, to calculate least-squares linear regression parameters and statistical values to compare to the minimum performance criteria specified in Table 1 of this section. Use the calculations for a floating intercept described in

§ 1065.602. Using good engineering judgment, you may weight the results of individual data pairs (i.e., (y_{refi}, $\bar{y}_i$)), in the linear regression calculations.

(d) * * *

(4) Fuel ~~or~~ and DEF mass flow rate. ~~Operate the engine at a series of constant fuel-flow rates or re-circulate fuel back to a tank through the fuel flow meter at different flow rates.~~ Use a gravimetric reference measurement (such as a scale, balance, or mass comparator) ~~at the inlet to the fuel-measurement system~~and a container. Use a stopwatch or timer to measure the time intervals over which reference masses of ~~fuel~~ fluid pass through the mass flow rate meter. Use good engineering judgement to correct the reference mass ~~that~~ flow~~ed~~ing through the mass flow rate meter for buoyancy effects from ~~including~~ any tubes, temperature probes, or objects submerged in the fluid in the container that are ~~and~~ not attached to the container. If the container has any tubes or wires connected to the container, recalibrate the gravimetric reference measurement device with them connected and at normal operating pressure using calibration weights that meet the requirements in § 1065.790~~are introduced to the fuel measurement system~~. The corrected reference ~~fuel~~ mass that flowed through the mass flow rate meter during a time interval divided by the duration of the time interval is the average reference ~~fuel~~ mass flow rate. For meters that report a different quantity (such as actual volume, standard volume, or moles), convert the reported quantity to mass. For meters that report a cumulative ~~mass (or other~~ quantity~~),~~ calculate the average measured mass flow rate as the difference in the reported cumulative mass during ~~from the beginning to the end of~~ the time interval divided by the duration of the time interval. For measuring flow rate of gaseous fuel~~ flow meters,~~ prevent condensation on the fuel container and any attached tubes, fittings, or regulators~~ attached to the fuel container~~.

* * * * *

(6) * * *

(i) At the outlet of the gas-division system, connect a gas analyzer that meets the linearity verification described in this section and has not been linearized with the gas divider being verified. For example, verify the linearity of an analyzer using a series of reference analytical gases directly from compressed gas cylinders that meet the specifications of § 1065.750. We recommend using a FID analyzer or a PMD or MPD O_2 analyzer because of their inherent linearity. Operate this analyzer consistent with how you would operate it during an emission test. Connect a span gas containing only a single constituent of interest with balance of purified air or ~~nitrogen~~purified N_2 to the gas-divider inlet. Use the gas-division system to divide the span gas with purified air or nitrogen. Select gas divisions that you typically use. Use a selected gas division as the measured value. Use the analyzer response divided by the span gas concentration as the reference gas-division value. Because the instrument response is not absolutely constant, sample and record values of x_{refi} for 30 seconds and use the arithmetic mean of the values, $\bar{x}_{ref}$, as the reference value. Refer to § 1065.602 for an example of calculating arithmetic mean.

* * * * *

(7) Continuous constituent concentration. For reference values, use a series of gas cylinders of known gas concentration containing only a single constituent of interest with balance of purified air or ~~nitrogen~~purified N_2 or use a gas-division system that is known to be linear with a span gas. Gas cylinders, gas-division systems, and span gases that you use for reference values must meet the specifications of § 1065.750.

* * * * *

(9) Mass. For linearity verification for gravimetric PM balances, fuel mass scales, and DEF mass scales, use external calibration weights that meet the requirements in § 1065.790. Perform the linearity verification for fuel mass scales and DEF mass scales with the in-use container, installing and all objects that interface with the container installed. For example, this iIncludes all tubes, temperature probes, and objects submerged in the fluid in the container; it also includes and all tubes, fittings, regulators, and wires, and any other objectsetc. attached to the container. If the container is vented to ambient, fill the container and tubes with fluid above the minimum level used to trigger a fill operation; drain the fluid down to the minimum level; tare the scale; and perform the linearity verification. If the container is rigid and not vented, drain the fluid down to the minimum level; fill all tubes attached to the container to normal operating pressure; tare the scale; and perform the linearity verification. We recommend that you use good engineering judgement to develop and apply appropriate buoyancy corrections for the configuration of your mass scale during normal testing, consistent with good engineering judgment. Account for During the linearity verification, configure this buoyancy correction to account for the fact that the scale is weighing a calibration weight instead of fluid if you calculate buoyancy corrections. You may also correct develop corrections in your mass scales for the effect of natural convection currents from generated by temperature differences between the fluid container and ambient air. Prepare for linearity verification by taking the following steps for vented and unvented containers:

(i) If the container is vented to ambient, fill the container and tubes with fluid above the minimum level used to trigger a fill operation; drain the fluid down to the minimum level; tare the scale; and perform the linearity verification.

(ii) If the container is rigid and not vented, drain the fluid down to the minimum level; fill all tubes attached to the container to normal operating pressure; tare the scale; and perform the linearity verification.

(e) * * *

(3) The expression "max" generally refers to the absolute value of the reference value used during linearity verification that is furthest from zero. This is the value used to scale the first and third tolerances in Table 1 of this section using a_0 and *SEE*. For example, if the reference values chosen to validate a pressure transducer vary from –10 to –1 kPa, then p_{max} is +10 kPa. If the reference values used to validate a temperature device vary from 290 to 390 K, then T_{max} is 390 K. For gas dividers where "max" is expressed as, x_{max}/x_{span}; x_{max} is the maximum gas concentration used during the verification, x_{span} is the undivided, undiluted, span gas concentration, and the resulting ratio is the maximum divider point reference value used during the verification (typically 1). The following are special cases where "max" refers to a different value:

(i) For linearity verification with of a PM balance, m_{max} refers tois the typical mass of a PM filter.

(ii) For linearity verification of a torque on measurement system used with to determine the engine's primary output shaft, T_{max} refers tois the manufacturer's specified engine torque peak value torque of the lowest torque engine to be testedexpected during testing.

(iii) For linearity verification of a fuel mass scale, m_{max} is determined based on the range of engines and test interval durations expected during testing. It is the minimum, over all engines expected during testing, of the fuel consumption expected over the minimum test interval duration at the engine's maximum fuel rate. If the minimum test interval duration used during testing does not change with engine power or if the minimum test interval duration used during testing increases with engine power, m_{max} is given by Eq. 1065.307-1. Calculate m_{max} using the following equation:

$$m_{\text{max,fuel scale}} = \dot{m}_{\text{max,fuel}} \cdot t_{\text{min}}$$

Eq. 1065.307-1

Where:

$\dot{m}_{\text{max,fuel}}$ = the manufacturer's specified maximum fuel rate on the lowest~~-~~-power engine expected during testing.

t_{min} = the minimum test interval duration expected during testing. If the minimum test interval duration ~~used during testing~~ decreases with engine power, evaluate Eq. 1065.307-1 for the range of engines expected during testing and use the minimum calculated value of $m_{\text{max,fuel scale}}$.

(iv) For linearity verification of a DEF mass scale, m_{max} is 10 % of ~~m_{max}~~the value determined for a fuel mass scale~~, as determined~~ in paragraph (e)(3)(iii) of this section. ~~For purposes of determining~~ You may determine m_{max} for a DEF mass scale by evaluating ~~, you may evaluate~~ m_{max} for a fuel mass scale based only on the DEF-using engines expected during testing.

(v) For linearity verification of a fuel flow rate meter, $\dot{m}_{max}$ is the manufacturer's specified maximum fuel rate of the lowest~~-~~-power engine expected during testing.

(vi) For linearity verification of a DEF flow rate meter, $\dot{m}_{max}$ is 10 % of the manufacturer's specified maximum fuel rate of the lowest~~-~~-power~~,~~ DEF-using~~,~~ engine expected during testing.

(vii) For linearity verification of an intake-air flow rate meter, $\dot{n}_{max}$ is the manufacturer's specified maximum intake-air flow rate (converted to molar flow rate) of the lowest~~-~~-power engine expected during testing.

(viii) For linearity verification of a raw exhaust flow rate meter, $\dot{n}_{max}$ is the manufacturer's specified maximum exhaust flow rate (converted to molar flow rate) of the lowest~~-~~-power engine expected during testing.

(ix) For linearity verification of an electrical~~-~~-power measurement system used to determine the engine's primary output shaft torque, P_{max} is the manufacturer's specified maximum power of the lowest~~-~~-power engine expected during testing.

(x) For linearity verification of an electrical~~-~~-current measurement system used to determine the engine's primary output shaft torque, I_{max} is the maximum current expected on the lowest~~-~~-power engine expected during testing.

(xi) For linearity verification of an electrical~~-~~-voltage measurement system used to determine the engine's primary output shaft torque, V_{max} is the minimum peak voltage expected on the range of engines expected during testing.

*   *   *   *   *

(5) Table 2 of this section describes optional verification procedures you may perform instead of linearity verification for certain~~lists~~ ~~the flow measurement~~ systems~~ that have optional verifications to the linearity verification~~. The following provisions apply for the alternative verification procedures:

(i) ~~If you substitute~~ Perform the propane check verification described in § 1065.341 ~~, it must be performed~~ at the frequency specified in Table 1 of § 1065.303.

~~If you substitute~~ (ii) Perform the carbon balance error verification described in § 1065.543 ~~, it must be performed~~ on all test sequences that use the corresponding system. ~~and i~~It must also meet the restrictions listed in Table 2 of this section. You may evaluate the carbon balance error verification multiple ways with different inputs to validate multiple flow~~-~~-measurement systemsLinearity verification is optional for systems that pass the flow-rate verification for diluted exhaust as described in § 1065.341 (the propane check) or for systems that agree within ±2 % based on a chemical balance of carbon or oxygen of the intake air, fuel, and exhaust..

* * * * *

(7) * * *

(i) * * *

(F) Transmission oil.

(G) Axle gear oil.

* * * * *

(f) Table 1 follows:

TABLE 1 OF § 1065.307–MEASUREMENT SYSTEMS THAT REQUIRE LINEARITY VERIFICATION

Measurement system	Quantity	Linearity criteria			
		$\lvert x_{min}(a_1-1)+a_0 \rvert$	a_1	*SEE*	r^2
Speed	f_n	$\leq 0.05\ \% \cdot f_{nmax}$	0.98-1.02	$\leq 2\ \% \cdot f_{nmax}$	≥ 0.990
Torque	T	$\leq 1\ \% \cdot T_{max}$	0.98-1.02	$\leq 2\ \% \cdot T_{max}$	≥ 0.990
Electrical power	P	$\leq 1\ \% \cdot P_{max}$	0.98-1.02	$\leq 2\ \% \cdot P_{max}$	≥ 0.990
Current	I	$\leq 1\ \% \cdot I_{max}$	0.98-1.02	$\leq 2\ \% \cdot I_{max}$	≥ 0.990
Voltage	U	$\leq 1\ \% \cdot U_{max}$	0.98-1.02	$\leq 2\ \% \cdot U_{max}$	≥ 0.990
Fuel flow rate	$\dot{m}$	$\leq 1\ \% \cdot \dot{m}_{max}$	0.98-1.02	$\leq 2\ \% \cdot \dot{m}_{max}$	≥ 0.990
Fuel mass scale	m	$\leq 0.3\ \% \cdot m_{max}$	0.996-1.004	$\leq 0.4\ \% \cdot m_{max}$	≥ 0.999
DEF flow rate	$\dot{m}$	$\leq 1\ \% \cdot \dot{m}_{max}$	0.98-1.02	$\leq 2\ \% \cdot \dot{m}_{max}$	≥ 0.990
DEF mass scale	m	$\leq 0.3\ \% \cdot m_{max}$	0.996-1.004	$\leq 0.4\ \% \cdot m_{max}$	≥ 0.999
Intake-air flow rate[a]	$\dot{n}$	$\leq 1\ \% \cdot \dot{n}_{max}$	0.98-1.02	$\leq 2\ \% \cdot \dot{n}_{max}$	≥ 0.990
Dilution air flow rate[a]	$\dot{n}$	$\leq 1\ \% \cdot \dot{n}_{max}$	0.98-1.02	$\leq 2\ \% \cdot \dot{n}_{max}$	≥ 0.990
Diluted exhaust flow rate[a]	$\dot{n}$	$\leq 1\ \% \cdot \dot{n}_{max}$	0.98-1.02	$\leq 2\ \% \cdot \dot{n}_{max}$	≥ 0.990
Raw exhaust flow rate[a]	$\dot{n}$	$\leq 1\ \% \cdot \dot{n}_{max}$	0.98-1.02	$\leq 2\ \% \cdot \dot{n}_{max}$	≥ 0.990
Batch sampler flow rates[a]	$\dot{n}$	$\leq 1\ \% \cdot \dot{n}_{max}$	0.98-1.02	$\leq 2\ \% \cdot \dot{n}_{max}$	≥ 0.990
Gas dividers	x/x_{span}	$\leq 0.5\ \% \cdot x_{max}/x_{span}$	0.98-1.02	$\leq 2\ \% \cdot x_{max}/x_{span}$	≥ 0.990
Gas analyzers for laboratory testing	x	$\leq 0.5\ \% \cdot x_{max}$	0.99-1.01	$\leq 1\ \% \cdot x_{max}$	≥ 0.998
Gas analyzers for field testing	x	$\leq 1\ \% \cdot x_{max}$	0.99-1.01	$\leq 1\ \% \cdot x_{max}$	≥ 0.998
PM balance	m	$\leq 1\ \% \cdot m_{max}$	0.99-1.01	$\leq 1\ \% \cdot m_{max}$	≥ 0.998
Pressures	p	$\leq 1\ \% \cdot p_{max}$	0.99-1.01	$\leq 1\ \% \cdot p_{max}$	≥ 0.998
Dewpoint for intake air, PM-stabilization and balance environments	T_{dew}	$\leq 0.5\ \% \cdot T_{dewmax}$	0.99-1.01	$\leq 0.5\ \% \cdot T_{dewmax}$	≥ 0.998
Other dewpoint measurements	T_{dew}	$\leq 1\ \% \cdot T_{dewmax}$	0.99-1.01	$\leq 1\ \% \cdot T_{dewmax}$	≥ 0.998
Analog-to-digital conversion of temperature signals	T	$\leq 1\ \% \cdot T_{max}$	0.99-1.01	$\leq 1\ \% \cdot T_{max}$	≥ 0.998

[a][1]For flow meters that determine volumetric flow rate, $\dot{V}_{std}$, you may substitute $\dot{V}_{std}$ for $\dot{n}$ as the quantity and substitute $\dot{V}_{stdmax}$ for $\dot{n}_{max}$.

(g) Table 2 follows:

TABLE 2 OF § 1065.307–OPTIONAL VERIFICATION TO LINEARITY VERIFICATION

Measurement system	**§ 1065.341**	**§ 1065.543**	**Restrictions for § 1065.543**
Intake-air flow rate	**Yes**	**Yes**	**Determine raw exhaust flow rate using the i~~I~~ntake-air flow rate signal ~~must be used to compute raw exhaust flow rate~~as an input into Eq. 1065.655-24 and d~~. M~~etermine mass of CO_2 over each test interval input into Eq. 1065.643-6 ~~must be determined fro~~using samples taken from the raw exhaust (continuous or bag, and with or without a PFD).**
Dilution air flow rate for CVS	**Yes**	**No**	**Not allowed.**
Diluted exhaust flow rate for CVS	**Yes**	**Yes**	**~~M~~Determine mass of CO_2 over each test interval input into Eq. 1065.643-6 ~~must be determined from~~ using samples taken from the CVS (continuous or bag, and with or without a PFD).**
Raw exhaust flow rate for exhaust stack	**Yes**	**Yes**	**~~M~~Determine mass of CO_2 over each test interval input into Eq. 1065.643-6 ~~must be determined from~~ using samples taken from the raw exhaust (continuous or bag, and with or without a PFD).**
Flow measurements in a PFD (usually dilution air and diluted exhaust streams) used to determine the dilution ratio in the PFD	**Yes**	**Yes**	**~~M~~Determine mass of CO_2 over each test interval input into Eq. 1065.643-6 ~~must be determined from~~ using samples taken from the PFD (continuous or bag).**
Batch sampler flow rates	**Yes**	**No**	**Not allowed.**
Fuel mass flow rate	**No**	**Yes**	**~~M~~Determine mass of ~~one of the~~a carbon-carrying fluid streams used as an input into Eq. 1065.643-1 ~~must be determined from~~ using the fuel mass flow rate meter.**
Fuel mass scale	**No**	**Yes**	**~~M~~Determine mass of ~~one of the~~a carbon-carrying fluid streams used as an input into Eq. 1065.643-1 ~~must be determined from~~ using the fuel mass scale.**

331. Amend § 1065.309 by revising paragraph (d)(2) to read as follows:

§ 1065.309 Continuous gas analyzer system-response and updating-recording verification—for gas analyzers continuously compensated for other gas species.

* * * * *

(d) * * *

(2) Equipment setup. We recommend using minimal lengths of gas transfer lines between all connections and fast-acting three-way valves (2 inlets, 1 outlet) to control the flow of zero and blended span gases to the sample system's probe inlet or a tee near the outlet of the probe. If you inject the gas at a tee near the outlet of the probe, you may correct the transformation time, t_{50}, for an estimate of the transport time from the probe inlet to the tee. Normally the gas flow rate is higher than the sample flow rate and the excess is overflowed out the inlet of the probe. If the gas flow rate is lower than the sample flow rate, the gas concentrations must be adjusted to account for the dilution from ambient air drawn into the probe. We recommend you use the final, stabilized analyzer reading as the final gas concentration. Select span gases for the species being continuously combined, other than H_2O. Select concentrations of compensating species that will yield concentrations of these species at the analyzer inlet that covers the range of concentrations expected during testing. You may use binary or multi-gas span gases. You may use a gas blending or mixing device to blend span gases. A gas blending or mixing device is recommended when blending span gases diluted in N_2 with span gases diluted in air. You may use a multi-gas span gas, such as NO-CO-CO_2-C_3H_8-CH_4, to verify multiple analyzers at the same time. In designing your experimental setup, avoid pressure pulsations due to stopping the

flow through the gas blending device. The change in gas concentration must be at least 20 % of the analyzer's range. If H_2O correction is applicable, then span gases must be humidified before entering the analyzer; however, you may not humidify NO_2 span gas by passing it through a sealed humidification vessel that contains H_2O~~water~~. You must humidify NO_2 span gas with another moist gas stream. We recommend humidifying your NO-CO-CO_2-C_3H_8-CH_4, balance N_2, blended gas by ~~flowing~~ bubbling the gas mixture that meets the specifications in § 1065.750 through distilled H_2O in a sealed vessel ~~that humidifies the gas by bubbling it through distilled water~~ and then mixing the gas with dry NO_2 gas, balance purified air, or by using a device that ~~injects~~introduces distilled H_2O ~~water~~ as vapor into a controlled span gas flow. If ~~your system does not use~~the sample does not pass through a ~~sample~~ dryer ~~to remove water from the sample gas~~during emission testing, ~~you must~~ humidify your span gas to ~~the highest sample~~an H_2O level at or above the maximum expected ~~content that you estimate~~ during emission ~~sampling~~testing. If ~~your system uses a~~the sample passes through a dryer during emission testing, it must pass the sample dryer verification check in § 1065.342, and you must humidify your span gas to an H_2O ~~content~~ level, at or above ~~greater than or equal to~~ the level determined in § 1065.145(e)(2) for that dryer. If you are humidifying span gases without NO_2, use good engineering judgment to ensure that the wall temperatures in the transfer lines, fittings, and valves from the humidifying system to the probe are above the dewpoint required for the target H_2O content. If you are humidifying span gases with NO_2, use good engineering judgment to ensure that there is no condensation in the transfer lines, fittings, or valves from the point where humidified gas is mixed with NO_2 span gas to the probe. We recommend that you design your setup so that the wall temperatures in the transfer lines, fittings, and valves from the humidifying system to the probe are at least 5 ºC above the local sample gas dewpoint. Operate the measurement and sample handling system as you do for emission testing. Make no modifications to the sample handling system to reduce the risk of condensation. Flow humidified gas through the sampling system before this check to allow stabilization of the measurement system's sampling handling system to occur, as it would for an emission test.

* * * * *

§ 1065.320—[Revised]

332. Amend § 1065.320 by removing and reserving paragraph (b).

333. Revise § 1065.341 to read as follows:

§ 1065.341 CVS~~,~~ and PFD ~~, and batch sampler~~flow verification (propane check).

This section describes two optional methods, using propane as a tracer gas, to verify CVS and PFD flow streams. You may use good engineering judgment and safe practices to use other tracer gases, such as CO_2 or CO. The first method, described in paragraphs (a) through (e) of this section, ~~is written~~ applies for the CVS diluted exhaust flow measurement system. It may also apply for ~~be applied to~~ other single-flow measurement systems as described in Table 2 of § 1065.307. Paragraph (g) of this section describes a second method you may use ~~may be used~~ to verify ~~the~~ flow measurements in a PFD for determining ~~that are used to determine~~ the PFD dilution ratio~~ in the PFD (usually dilution air and diluted exhaust streams), as it is difficult to scale this method down to the flow rates in a typical PFD using pure propane. You may use good engineering judgment and safe practices to use other tracer gases, such as CO_2 or CO.~~

~~(a) A propane check serves as a CVS verification to determine if there is a discrepancy in measured values of diluted exhaust flow. You may use the same procedure to verify PFDs and~~

Formatted: Font: 12 pt

Formatted: Font: 12 pt, Font color: Auto

batch samplers. For purposes of PFD and batch sampler verification, read the term CVS to mean PFD or batch sampler as appropriate. A propane check also serves as a batch-sampler verification to determine if there is a discrepancy in a batch sampling system that extracts a sample from a CVS, as described in paragraph (g) of this section. Using good engineering judgment and safe practices, this check may be performed using a gas other than propane, such as CO_2 or CO. A failed propane check might indicate one or more problems that may require corrective action, as follows:
(1) Incorrect analyzer calibration. Re-calibrate, repair, or replace the FID analyzer.
(2) Leaks. Inspect CVS tunnel, connections, fasteners, and HC sampling system, and repair or replace components.
(3) Poor mixing. Perform the verification as described in this section while traversing a sampling probe across the tunnel's diameter, vertically and horizontally. If the analyzer response indicates any deviation exceeding ±2 % of the mean measured concentration, consider operating the CVS at a higher flow rate or installing a mixing plate or orifice to improve mixing.
(4) Hydrocarbon contamination in the sample system. Perform the hydrocarbon-contamination verification as described in § 1065.520.
(5) Change in CVS calibration. Perform a calibration of the CVS flow meter as described in § 1065.340.
(6) Flow meter entrance effects. Inspect the CVS tunnel to determine whether the entrance effects from the piping configuration upstream of the flow meter adversely affect the flow measurement.
(7) Other problems with the CVS or sampling verification hardware or software. Inspect the CVS system, CVS verification hardware, and software for discrepancies.
(ba) A propane check uses either a reference mass or a reference flow rate of C_3H_8 as a tracer gas in a CVS. Note that if you use a reference flow rate, account for any non-ideal gas behavior of C_3H_8 in the reference flow meter. Refer to § 1065.640 and § 1065.642, which describe how to calibrate and use certain flow meters. Do not use any ideal gas assumptions in § 1065.640 and § 1065.642. The propane check compares the calculated mass of injected C_3H_8 using HC measurements and CVS flow rate measurements with the reference value.
(cb) Prepare for the propane check as follows:
(1) If you use a reference mass of C_3H_8 instead of a reference flow rate, obtain a cylinder charged with C_3H_8. Determine the reference cylinder's mass of C_3H_8 within ±0.5 % of the amount of C_3H_8 that you expect to use. You may substitute a C_3H_8 analytical gas mixture (i.e., a prediluted tracer gas) for pure C_3H_8. This would be most appropriate for lower flow rates. The analytical gas mixture must meet the specifications in § 1065.750(a)(3).
(2) Select appropriate flow rates for the CVS and C_3H_8.
(3) Select a C_3H_8 injection port in the CVS. Select the port location to be as close as practical to the location where you introduce engine exhaust into the CVS, or at some point in the laboratory exhaust tubing upstream of this location. Connect the C_3H_8 cylinder to the injection system.
(4) Operate and stabilize the CVS.
(5) Preheat or pre-cool any heat exchangers in the sampling system.
(6) Allow heated and cooled components such as sample lines, filters, chillers, and pumps to stabilize at operating temperature.
(7) You may purge the HC sampling system during stabilization.
(8) If applicable, perform a vacuum side leak verification of the HC sampling system as described in § 1065.345.

(9) You may also conduct any other calibrations or verifications on equipment or analyzers.
(~~d~~c) If you performed the vacuum-side leak verification of the HC sampling system as described in paragraph (~~c~~b)(8) of this section, you may use the HC contamination procedure in § 1065.520(f) to verify HC contamination. Otherwise, zero, span, and verify contamination of the HC sampling system, as follows:
(1) Select the lowest HC analyzer range that can measure the C_3H_8 concentration expected for the CVS and C_3H_8 flow rates.
(2) Zero the HC analyzer using zero air introduced at the analyzer port.
(3) Span the HC analyzer using C_3H_8 span gas introduced at the analyzer port.
(4) Overflow zero air at the HC probe inlet or into a tee near the outlet of the probe.
(5) Measure the stable HC concentration of the HC sampling system as overflow zero air flows. For batch HC measurement, fill the batch container (such as a bag) and measure the HC overflow concentration.
(6) If the overflow HC concentration exceeds 2 µmol/mol, do not proceed until contamination is eliminated. Determine the source of the contamination and take corrective action, such as cleaning the system or replacing contaminated portions.
(7) When the overflow HC concentration does not exceed 2 µmol/mol, record this value as $x_{THCinit}$ and use it to correct for HC contamination as described in § 1065.660.
(~~e~~d) Perform the propane check as follows:
(1) For batch HC sampling, connect clean storage media, such as evacuated bags.
(2) Operate HC measurement instruments according to the instrument manufacturer's instructions.
(3) If you will correct for dilution air background concentrations of HC, measure and record background HC in the dilution air.
(4) Zero any integrating devices.
(5) Begin sampling, and start any flow integrators.
(6) Release the contents of the C_3H_8 reference cylinder at the rate you selected. If you use a reference flow rate of C_3H_8, start integrating this flow rate.
(7) Continue to release the cylinder's contents until at least enough C_3H_8 has been released to ensure accurate quantification of the reference C_3H_8 and the measured C_3H_8.
(8) Shut off the C_3H_8 reference cylinder and continue sampling until you have accounted for time delays due to sample transport and analyzer response.
(9) Stop sampling and stop any integrators.
(e~~f~~) Perform post-test procedure as follows:
(1) If you used batch sampling, analyze batch samples as soon as practical.
(2) After analyzing HC, correct for contamination and background.
(3) Calculate total C_3H_8 mass based on your CVS and HC data as described in § 1065.650 (40 CFR 1066.605 for vehicle testing) and § 1065.660, using the molar mass of C_3H_8, M_{C3H8}, instead the effective molar mass of HC, M_{HC}.
(4) If you use a reference mass, determine the cylinder's propane mass within ±0.5 % and determine the C_3H_8 reference mass by subtracting the empty cylinder propane mass from the full cylinder propane mass.
(5) Subtract the reference C_3H_8 mass from the calculated mass. If this difference is within ±2 % of the reference mass, the CVS passes this verification. If not, take corrective action as described in paragraph (~~a~~f) of this section.

(f) A failed propane check might indicate one or more problems requiring corrective action, as follows:

Problem	Recommended Corrective Action
Incorrect analyzer calibration	Recalibrate, repair, or replace the FID analyzer.
Leaks	Inspect CVS tunnel, connections, fasteners, and HC sampling system. Repair or replace components.
Poor mixing	Perform the verification as described in this section while traversing a sampling probe across the tunnel's diameter, vertically and horizontally. If the analyzer response indicates any deviation exceeding ±2 % of the mean measured concentration, consider operating the CVS at a higher flow rate or installing a mixing plate or orifice to improve mixing.
Hydrocarbon contamination in the sample system	Perform the hydrocarbon-contamination verification as described in § 1065.520.
Change in CVS calibration	Perform a calibration of the CVS flow meter as described in § 1065.340.
Flow meter entrance effects	Inspect the CVS tunnel to determine whether the entrance effects from the piping configuration upstream of the flow meter adversely affect the flow measurement.
Other problems with the CVS or sampling verification hardware or software	Inspect the CVS system and related verification hardware, and software for discrepancies.

(g) You may verify ~~the~~ flow measurements in a PFD (usually dilution air and diluted exhaust streams) ~~used to determine~~ for determining the dilution ratio in the PFD using the following method:~~repeat the propane check to verify a batch sampler, such as a PM secondary dilution system.~~

(1) Configure the HC sampling system to extract a sample from the PFD's diluted exhaust stream ~~of the PFD~~~~near the location of the batch sampler's storage media~~ (such as near ~~the location of~~ a PM filter). If the absolute pressure at this location is too low to extract an HC sample, you may sample HC from the ~~batch sampler~~PFD's~~ system's~~ pump~~'s~~ exhaust. Use caution when sampling from pump exhaust because an otherwise acceptable pump leak downstream of a ~~batch sampler~~PFD diluted exhaust flow meter will cause a false failure of the propane check.

(2) ~~Repeat~~ Perform the propane check described in paragraphs (~~c~~b), (~~d~~c), and (~~e~~d) of this section, but sample HC from the PFD's diluted exhaust stream~~ of the PFD~~. Inject the propane in the same exhaust stream that the PFD is sampling from (either CVS or raw exhaust stack)~~batch sampler~~.

(3) Calculate C_3H_8 mass, taking into account ~~any secondary~~the dilution from the ~~batch sampler~~PFD.

(4) Subtract the reference C_3H_8 mass from the calculated mass. If this difference is within ±~~5~~ 2 % of the reference mass, ~~the the~~ all PFD flow measurements ~~in a PFD (usually dilution air and diluted exhaust streams) used to determine the~~ for determining PFD dilution ratio ~~in the PFD all~~

~~batch sampler~~ pass~~es~~ this verification. If not, take corrective action as described in paragraph (~~a~~f) of this section. For PFDs sampling only for PM ~~only~~, the allowed difference is ±5 %.

(h) Table 2 of § 1065.307 describes optional verification procedures you may perform instead of linearity verification for certain ~~lists the~~ flow--measurement systems ~~that have optional verifications to the linearity verification~~. ~~The allowances for substituting the~~ Performing carbon balance error verification also replaces ~~for the linearity verification may also be used to substitute for~~ any required propane checks.

334. Amend § 1065.342 by revising paragraph (d)(2) to read as follows:

§ 1065.342 Sample dryer verification.

*   *   *   *   *

(d)   *   *   *

(2) Humidify room air, purified N_2, or purified air by bubbling it through distilled ~~water~~ H_2O in a sealed vessel or use a device that injects distilled H_2O ~~water~~ as vapor into a controlled gas flow ~~that~~ to humidif~~yies~~ the gas to the highest sample H_2O ~~water~~ content that you estimate during emission sampling.

*   *   *   *   *

335. Amend § 1065.350 by revising paragraph (d)(2) to read as follows:

§ 1065.350 H_2O interference verification for CO_2 NDIR analyzers.

*   *   *   *   *

(d)   *   *   *

(2) Create a humidified test gas by bubbling zero gas that meets the specifications in § 1065.750 through distilled H_2O in a sealed vessel or use a device that ~~injects~~introduces distilled H_2O~~water~~ as vapor into a controlled gas flow. If the sample ~~is~~ does not pass~~ed~~ through a dryer during emission testing, ~~control the vessel temperature to generate~~humidify your test gas to an H_2O level at or above ~~at least as high as~~ the maximum expected during emission testing. If the sample ~~is~~ passe~~s~~d through a dryer during emission testing, you must humidify your test gas to an H_2O level at or above ~~control the vessel temperature to generate an H_2O level at least as high as~~ the level determined in § 1065.145(e)(2) for that dryer.

*   *   *   *   *

336. Amend § 1065.355 by revising paragraph (d)(2) to read as follows:

§ 1065.355 H_2O and CO_2 interference verification for CO NDIR analyzers.

*   *   *   *   *

(d)   *   *   *

(2) Create a humidified CO_2 test gas by bubbling a CO_2 span gas that meets the specifications in § 1065.750 through distilled H_2O in a sealed vessel or use a device that ~~injects~~introduces distilled H_2O~~water~~ as vapor into a controlled gas flow. If the sample ~~is~~ does not pass~~ed~~ through a dryer during emission testing, humidify your test gas to ~~control the vessel temperature to generate~~ an H_2O level at or above ~~at least as high as~~ the maximum expected during emission testing. If the sample ~~is~~ passe~~s~~d through a dryer during emission testing, you must humidify your test gas to~~control the vessel temperature to generate~~ an H_2O at or above ~~level at least as high as~~ the level determined in § 1065.145(e)(2) for that dryer. Use a CO_2 span gas concentration at least as high as the maximum expected during testing.

*   *   *   *   *

337. Amend § 1065.360 by adding paragraphs (a)(4) and (d)(12) to read as follows:

§ 1065.360 FID optimization and verification.

(a) * * *

(4) For any gaseous-fueled engine, including dual-fuel and flexible-fuel engines, you may determine the methane (CH_4) and ethane (C_2H_6) response factors as a function of the molar water concentration in the raw or diluted exhaust. If you choose this option, Ggenerate and verify the humidity level (or fraction) as described in § 1065.365(d)(112).

* * * * *

(d) * * *

(12) Determine the response factor as a function of exhaust molar water concentration, and use this response factor to account for the CH_4 response for NMHC determination described in §1065.660(b)(2)(iii). Humidify the CH_4 span gas as described in § 1065.365(d)(11) and repeat the steps in paragraphs (d)(7) through (9) of this section until measurements are complete for each setpoint in the selected range. For each measurement, divide the Divide each mean measured CH_4 concentration by the recorded span concentration of the CH_4 calibration gas, adjusted for water content, to determine . The result is the FID analyzer's CH_4 response factor for CH_4, $RF_{CH4[THC-FID]}$. Use thesе CH_4 response factors at the different setpoints to create a functional relationship between to determine the response factor based on theand exhaust molar water concentration, downstream of the last sample dryer if any sample dryers are present. Use, this functional relationship to determine the response factor during thean emission test and use this response factor to account for the CH_4 response for NMHC determination described in §1065.660(b)(2)(iii).

* * * * *

338. Amend § 1065.365 by revising paragraphs (a), (d), (f)(9), and (f)(14) to read as follows:

§ 1065.365 Nonmethane cutter penetration fractions.

(a) Scope and frequency. If you use a FID analyzer and a nonmethane cutter (NMC) to measure methane (CH_4), determine the nonmethane cutter's penetration fractions of CH_4methane, PF_{CH4}, and ethane, PF_{C2H6}. As detailed in this section, these penetration fractions may be determined as a combination of NMC penetration fractions and FID analyzer response factors, depending on your particular NMC and FID analyzer configuration. Perform this verification after installing the nonmethane cutter. Repeat this verification within 185 days of testing to verify that the catalytic activity of the cutter has not deteriorated. Note that because nonmethane cutters can deteriorate rapidly and without warning if they are operated outside of certain ranges of gas concentrations and outside of certain temperature ranges, good engineering judgment may dictate that you determine a nonmethane cutter's penetration fractions more frequently.

* * * * *

(d) Procedure for a FID calibrated with the NMC. The method described in this paragraph (d) is recommended over the procedures specified in paragraphs (e) and (f) of this section and required for any gaseous-fueled engine, including dual-fuel and flexible-fuel engines. If your FID arrangement is such that a FID is always calibrated to measure CH_4 with the NMC, then span that FID with the NMC using a CH_4 span gas, set the product of that FID's CH_4 response factor and CH_4 penetration fraction, $RFPF_{CH4[NMC-FID]}$, equal to 1.0 for all emission calculations, and determine its combined ethane (C_2H_6) response factor and C_2H_6 penetration fraction, $RFPF_{C2H6[NMC-FID]}$, as follows:. For any gaseous-fueled engine, including dual-fuel and flexible-fuel engines, you must determine the CH_4 penetration fraction, $PF_{CH4[NMC-FID]}$, and C_2H_6 response factor and C_2H_6 penetration fraction, $RFPF_{C2H6[NMC-FID]}$, as a function of the molar water concentration in the raw or diluted exhaust as described in paragraphs (d)(10) and (12) of this section. Generate and verify the humidity generation as described in § 1065.365(d)(121). When using this option, note that the FID's CH_4 penetration fraction, $PF_{CH4[NMC-FID]}$, is set equal to 1.0 only for 0 % molar water concentration. You are not required to meet the recommended lower limit for PF_{CH4} of greater than 0.85 for any of the penetration fractions generated as a function of molar water concentration.

(1) Select CH_4 and C_2H_6 analytical gas mixtures and ensure that both mixtures meet the specifications of § 1065.750. Select a CH_4 concentration that you would use for spanning the FID during emission testing and select a C_2H_6 concentration that is typical of the peak NMHC concentration expected at the hydrocarbon standard or equal to the THC analyzer's span value. For CH_4 analyzers with multiple ranges, perform this procedure on the highest range used for emission testing.

(2) Start, operate, and optimize the nonmethane cutter according to the manufacturer's instructions, including any temperature optimization.

(3) Confirm that the FID analyzer meets all the specifications of § 1065.360.

(4) Start and operate the FID analyzer according to the manufacturer's instructions.

(5) Zero and span the FID with the nonmethane cutter as you would during emission testing. Span the FID through the cutter by using CH_4 span gas.

(6) Introduce the C_2H_6 analytical gas mixture upstream of the nonmethane cutter. Use good engineering judgment to address the effect of hydrocarbon contamination if your point of introduction is vastly different from the point of zero/span gas introduction.

(7) Allow time for the analyzer response to stabilize. Stabilization time may include time to purge the nonmethane cutter and to account for the analyzer's response.

(8) While the analyzer measures a stable concentration, record 30 seconds of sampled data. Calculate the arithmetic mean of these data points.

(9) Divide the mean C_2H_6 concentration by the reference concentration of C_2H_6, converted to a C_1 basis. The result is the C_2H_6 combined response factor and penetration fraction, $RFPF_{C2H6[NMC-FID]}$. Use this combined C_2H_6 response factor and C_2H_6 penetration fraction and the product of the CH_4 response factor and CH_4 penetration fraction, $RFPF_{CH4[NMC-FID]}$, set to 1.0 in emission calculations according to § 1065.660(b)(2)(i), § 1065.660(d)(1)(i), or § 1065.665, as applicable.

(10) To dDetermine the combined C_2H_6 response factor and C_2H_6 penetration fraction as a function of exhaust molar water concentration and use it to account for C_2H_6 response factor and C_2H_6 penetration fraction for NMHC determination as described in §1065.660(b)(2)(iii) and for CH_4 determination in § 1065.660(d)(1)(iii)., Hhumidify the C_2H_6 analytical gas mixture as described in paragraph (d)(112) of this section. Repeat the steps in paragraphs (d)(6) through (8) of this section until measurements are complete for each setpoint in the selected range. For each measurement, dDivide theeach mean measured C_2H_6 concentration by the reference concentration of C_2H_6, converted to a C_1-basis and adjusted for water content. The result is to determine the FID analyzer's combined C_2H_6 response factor and C_2H_6 penetration fraction, $RFPF_{C2H6[NMC-FID]}$. Use $RFPF_{C2H6[NMC-FID]}$ these combined C_2H_6 response factors and C_2H_6 penetration fractions at the different setpoints to create a functional relationship between the combined response factor and penetration fraction and to determine the combined response factor and penetration fraction based on the exhaust molar water concentration, downstream of

the last sample dryer if any sample dryers are present~~,~~. Use this functional relationship to determine the combined response factor and penetration fraction during the emission test~~ and use this combined response factor and penetration fraction to account for C_2H_6 response factor and penetration fraction for NMHC and CH_4 determination as described in §1065.660(b)(2)(iii) and (d)(1)(iii)~~.

(1~~2~~1) Create a humidified test gas by bubbling the analytical gas mixture that meets the specifications in § 1065.750 through distilled H_2O in a sealed vessel or use a device that introduces distilled H_2O as vapor into a controlled gas flow. If the sample does not pass through a dryer during emission testing~~For wet methane analyzers~~, generate at least five different ~~water~~H_2O concentrations that cover the range from less than the minimum expected ~~water concentration~~ to greater than the maximum expected water concentration during testing. Use good engineering judgement to determine the target concentrations. ~~Dry gas can be one of these points.~~ For ~~dry methane~~ analyzers ~~, determine the methane penetration fraction by humidifying~~ where the sample passes through a dryer during emission testing, humidify your test gas to an H_2O level at or above the level determined in § 1065.145(e)(2) for that dryer ~~the sample to a level higher than the sample dryer outlet humidity~~ and ~~measure~~determine a single wet ~~penetration fraction~~ analyzer response to~~of~~ the dehumidified sample. Heat all transfer lines from the water generation system to a temperature at least 5 °C higher than the highest dewpoint generated. ~~Use at least 30 second averages of measured~~Determine H_2O~~water~~ concentration as an average value over intervals of at least 30 seconds~~in paragraphs (d)(12)(i) and (ii)(B) of this section to determine the water content of the sample stream at the same time you determine the response factor and penetration fraction~~. Monitor the humidified sample stream with a dewpoint analyzer, relative humidity sensor, FTIR, NDIR, or other water analyzer during each test or, if the humidity generator achieves humidity levels with controlled flow rates, validate the instrument within 370 days before testing and after major maintenance ~~Validate the water generation system~~ using one of the following methods~~.~~:

~~(i) Monitor humidified sample stream with a dewpoint analyzer, relative humidity sensor, FTIR, NDIR, or other water analyzer during the test.~~

~~(ii) If the humidity generator utilizes controlled flow rates of gas and/or liquids to generate the humidity levels, validate the instrument within 370 days before testing and after major maintenance by using one of the following options:~~

(i~~A~~) Determine the linearity of each flow metering device. Use one or more reference flow meters to measure the humidity generator's flow rates ~~of the gas divider~~ and verify the H_2O level ~~gas-division~~ value based on the humidity generator manufacturer's recommendations and good engineering judgment. ~~This method should~~We recommend that you utilize at least 10 flow rates for each flow-~~-~~metering device.

(~~B~~ii) Perform validation testing based on m~~M~~onitoring the humidified stream with a dewpoint analyzer, relative humidity sensor, FTIR, NDIR, or other water analyzer as described in this paragraph (d)(11). ~~Generate at least five different water concentrations that cover the range from minimum expected water concentration to greater than the maximum expected water during testing.~~ Compare the measured humidity to the humidity generator's value~~versus the calculated generated humidity~~. Verify overall linearity performance for the generated humidity as described in ~~by following~~ § 1065.307 using the criteria for other dewpoint measurements or confirm all measured values are within ± 2 % of the ~~generated~~ target mole fraction. In the case of dry gas, the measured value may not exceed 0.002 mole fraction.~~If dry gas is used it must be measured within 0.002 mole fraction.~~

(iiiC) Follow the performance requirements in § 1065.307(b) if the humidity generator does not meet validation criteria.
(12) To dDetermine the CH_4 penetration fraction as a function of exhaust molar water concentration and use this penetration fraction for NMHC determination in § 1065.660(b)(2)(iii) and for CH_4 determination in § 1065.660(d)(1)(iii)., rRepeat the steps in paragraphs (d)(6) through (101) of this section, but with the CH_4 analytical gas mixture instead of C_2H_6. Use this functional relationship to determine the penetration fraction during the emission test.The result will be the CH_4 penetration fraction, $PF_{CH4[NMC\text{-}FID]}$ based on the exhaust molar water concentration during the emission test. Use this penetration fraction for NMHC and CH_4 determination as described in § 1065.660(b)(2)(iii) and (d)(1)(iii).

* * * * *

(f) * * *

(9) Divide the mean C_2H_6 concentration by the reference concentration of C_2H_6, converted to a C_1 basis. The result is the C_2H_6 combined C_2H_6 response factor and C_2H_6 penetration fraction, $RFPF_{C2H6[NMC\text{-}FID]}$. Use this combined C_2H_6 response factor and C_2H_6 penetration fraction according to § 1065.660(b)(2)(iii), § 1065.660(d)(1)(iii), or § 1065.665, as applicable.

* * * * *

(14) Divide the mean CH_4 concentration measured through the nonmethane cutter by the mean CH_4 concentration measured after bypassing the nonmethane cutter. The result is the CH_4 penetration fraction, $PF_{CH4[NMC\text{-}FID]}$. Use this CH_4 penetration fraction according to § 1065.660(b)(2)(iii), § 1065.660(d)(1)(iii), or § 1065.665, as applicable.

339. Amend § 1065.370 by revising paragraph (e)(5) to read as follows:

§ 1065.370 CLD CO_2 and H_2O quench verification.

* * * * *

(e) * * *

(5) Create a Humidify humidified the NO span gas by bubbling a NO gas that meets the specifications in § 1065.750it through distilled H_2O in a sealed vessel or use a device that introduces distilled H_2O as vapor into a controlled gas flow. If the humidified NO span gas sample does does not pass through a sample dryer for this verification testduring emission testing, humidify your test gas to control the vessel temperature to generate an H_2O level approximately equal to the maximum mole fraction of H_2O expected during emission testing. If the humidified NO span gas sample does not pass through a sample dryer, the quench verification calculations in § 1065.675 scale the measured H_2O quench to the highest mole fraction of H_2O expected during emission testing. If the humidified NO span gas sample passespasses through a dryer for this verification testduring emission testing, you must humidify your test gas to control the vessel temperature to generate an H_2O level at or above at least as high as the level determined in § 1065.145(e)(2) for that dryer. For this case, the quench verification calculations in § 1065.675 do not scale the measured H_2O quench.

* * * * *

340. Amend § 1065.375 by revising paragraph (d)(2) to read as follows:

§ 1065.375 Interference verification for N_2O analyzers.

* * * * *

(d) * * *

(2) Create a humidified test gas by bubbling a multi component span gas that incorporates the target interference species and meets the specifications in § 1065.750 through distilled H_2O in a sealed vessel or use a device that injectsintroduces distilled H_2O water as vapor into a controlled gas flow. If the sample doesis not passed through a dryer during emission testing, humidify your test gas to control the vessel temperature to generate an H_2O level at least as high asat or above the maximum expected during emission testing. If the sample is passesd through a dryer during emission testing, you must humidify your test gas tocontrol the vessel temperature to generate an H_2O level at or above at least as high as the level determined in § 1065.145(e)(2) for that dryer. Use interference span gas concentrations that are at least as high as the maximum expected during testing.

* * * * *

341. Amend § 1065.410 by revising paragraphs (c) and (d) to read as follows:

§ 1065.410 Maintenance limits for stabilized test engines.

* * * * *

(c) If you inspect an engine, keep a record of the inspection and update your application for certification to document any changes that result. You may use any kind of equipment, instrument, or tool that is available at dealerships and other service outlets to identify bad enginemalfunctioning components or perform maintenance if it is available at dealerships and other service outlets.

(d) You may repair a test engine as needed for defective parts from a test engine if they that are unrelated to emission control. You must ask us to approve repairs that might affect the engine's emission controls. If we determine that a part failure, system malfunction, or associated repairs have mademakes the engine's emission controls unrepresentative of production engines, you may not longer use it as an emission-data engine. Also, if your test engine has a major mechanical failure that requires you to take it apart, you may no longer use it as an emission-data engine.

342. Amend § 1065.510 by–

a. Revising paragraphs (a) introductory text and (b)(5)(i).

b. Adding paragraph (c)(5).

c. Revising paragraph (f)(4)(i)

The revisions and addition read as follows:

§ 1065.510 Engine mapping.

(a) Applicability, scope, and frequency. An engine map is a data set that consists of a series of paired data points that represent the maximum brake torque versus engine speed, measured at the engine's primary output shaft. Map your engine if the standard-setting part requires engine mapping to generate a duty cycle for your engine configuration. Map your engine while it is connected to a dynamometer or other device that can absorb work output from the engine's primary output shaft according to § 1065.110. To establish speed and torque values for mapping, we generally recommend that you stabilize an engine for at least 15 seconds at each setpoint and record the mean feedback speed and torque of the last (4 to 6) seconds. Configure any auxiliary work inputs and outputs such as hybrid, turbo-compounding, or thermoelectric systems to represent their in-use configurations, and use the same configuration for emission testing. See Figure 1 of § 1065.210. This may involve configuring initial states of charge and rates and times of auxiliary-work inputs and outputs. We recommend that you contact the Designated

Compliance Officer before testing to determine how you should configure any auxiliary-work inputs and outputs. Use the most recent engine map to transform a normalized duty cycle from the standard-setting part to a reference duty cycle specific to your engine. Normalized duty cycles are specified in the standard-setting part. You may update an engine map at any time by repeating the engine-mapping procedure. You must map or re-map an engine before a test if any of the following apply:

* * * * *

(b) * * *

(5) * * *

(i) For any engine subject only to steady-state duty cycles, you may perform an engine map by using discrete speeds. Select at least 20 evenly spaced setpoints from 95 % of warm idle speed to the highest speed above maximum power at which 50 % of maximum power occurs. We refer to this 50 % speed as the check point speed as described in paragraph (b)(5)(iii) of this section. At each setpoint, stabilize speed and allow torque to stabilize. We recommend that you stabilize an engine for at least 15 seconds at each setpoint and record the mean feedback speed and torque of the last (4 to 6) seconds. Record the mean speed and torque at each setpoint. Use linear interpolation to determine intermediate speeds and torques. Use this series of speeds and torques to generate the power map as described in paragraph (e) of this section.

* * * * *

(c) * * *

(5) For engines with an electric hybrid system, map the negative torque required to motor the engine by repeating paragraph (b) of this section with minimum operator demand and a fully charged RESS or with the hybrid system disabled, such that it doesn't affect the motoring torque. You may start the negative torque map at either the minimum or maximum speed from paragraph (b) of this section.

* * * * *

(f) * *

(4) * * *

(i) For variable-speed engines, declare a warm idle torque that is representative of in-use operation. For example, if your engine is typically connected to an automatic transmission or a hydrostatic transmission, declare the torque that occurs at the idle speed at which your engine operates when the transmission is engaged. Use this value for cycle generation. You may use multiple warm idle torques and associated idle speeds in cycle generation for representative testing. For example, for cycles that start the engine and begin with idle, you may start a cycle in idle with the transmission in neutral with zero torque and later switch to a different idle with the transmission in drive with the Curb-Idle Transmission Torque (CITT). For variable-speed engines intended primarily for propulsion of a vehicle with an automatic transmission where that engine is subject to a transient duty cycle with idle operation, you must declare a CITT. We recommend that you specify CITT as a function of idle speed for engines with ~~in cases where you have an~~ adjustable warm idle or enhanced~~-~~idle. You ~~must~~ may specify a CITT based on typical applications at the mean of the range of idle speeds you specify at stabilized temperature conditions.

* * * * *

343. Amend § 1065.512 by revising paragraphs (b)(1) and (2) to read as follows:

§ 1065.512 Duty cycle generation.

*   *   *   *   *

(b)   *   *   *

(1) Engine speed for variable-speed engines. For variable-speed engines, normalized speed may be expressed as a percentage between warm idle speed, f_{nidle}, and maximum test speed, f_{ntest}, or speed may be expressed by referring to a defined speed by name, such as "warm idle," "intermediate speed," or "A," "B," or "C" speed. Section 1065.610 describes how to transform these normalized values into a sequence of reference speeds, f_{nref}. Running duty cycles with negative or small normalized speed values near warm idle speed may cause low-speed idle governors to activate and the engine torque to exceed the reference torque even though the operator demand is at a minimum. In such cases, we recommend controlling the dynamometer so it gives priority to follow the reference torque instead of the reference speed and let the engine govern the speed. Note that the cycle-validation criteria in § 1065.514 allow an engine to govern itself. This allowance permits you to test engines with enhanced-idle devices and to simulate the effects of transmissions such as automatic transmissions. For example, an enhanced-idle device might be an idle speed value that is normally commanded only under cold-start conditions to quickly warm up the engine and aftertreatment devices. In this case, negative and very low normalized speeds will generate reference speeds below this higher enhanced enhanced-idle speed. You may do either of the following with wWhen using enhanced-idle devices you may do one of the following:

(i) Control and we recommend controlling the dynamometer so it gives priority to follow the reference torque, controlling the operator demand so it gives priority to follow reference speed and let the engine govern the speed when the operator demand is at minimum.

(ii) While running an engine thatwhere the electronic control module broadcasts an enhanced-idle speed that is above the denormalized speed, use that the broadcast speed as the reference speed whenever the denormalized speed is below that broadcast value. Use these new reference points for duty-cycle validation. Note the special This does not affect how you determine denormalized reference torque denormalization in paragraph (b)(2) of this section. When performing duty-cycle validation, use these new reference points.

(2) Engine torque for variable-speed engines. For variable-speed engines, normalized torque is expressed as a percentage of the mapped torque at the corresponding reference speed. Section 1065.610 describes how to transform normalized torques into a sequence of reference torques, T_{ref}. Section 1065.610 also describes special requirements for modifying transient duty cycles for variable-speed engines intended primarily for propulsion of a vehicle with an automatic transmission. Section 1065.610 also describes under what conditions you may command T_{ref} greater than the reference torque you calculated from a normalized duty cycle. This provision permits you to command T_{ref} values that are limited by a declared minimum torque. For any negative torque commands, command minimum operator demand and use the dynamometer to control engine speed to the reference speed, but if reference speed is so low that the idle governor activates, we recommend using the dynamometer to control torque to zero, CITT, or a declared minimum torque as appropriate. Note that you may omit power and torque points during motoring from the cycle-validation criteria in § 1065.514. Also, use the maximum mapped torque at the minimum mapped speed as the maximum torque for any reference speed at or below the minimum mapped speed. If you use the provision in paragraph (b)(1)(ii) of this section do not alter the denormalized reference torque.

*   *   *   *   *

344. Amend § 1065.514 by revising paragraphs (e) introductory text, (e)(3), and (f)(3) to read as follows:

§ 1065.514 Cycle-validation criteria for operation over specified duty cycles.

* * * * *

(e) Statistical parameters. Use the remaining points to calculate regression statistics for a floating intercept as described in § 1065.602. Round calculated regression statistics to the same number of significant digits as the criteria to which they are compared. Refer to Table 2 of § 1065.514 for the default criteria and refer to the standard-setting part to determine if there are other criteria for your engine. Calculate the following regression statistics:

* * * * *

(3) Standard error of the estimates of error for feedback speed, SEE_{fn}, feedback torque, SEE_T, and feedback power SEE_P.

* * * * *

(f) * * *

(3) For discrete-mode steady-state testing, apply cycle-validation criteria by treating the sampling periods from the series of test modes as a continuous sampling period, analogous to ramped-modal testing and apply statistical criteria as described in paragraph (f)(1) or (f)(2) of this section. Note that if the gaseous and particulate test intervals are different periods of time, separate validations are required for the gaseous and particulate test intervals. Table 2 follows:

TABLE 2 OF § 1065.514—DEFAULT STATISTICAL CRITERIA FOR VALIDATING DUTY CYCLES

Parameter	Speed	Torque	Power
Slope, a_1	$0.950 \leq a_1 \leq 1.030$	$0.830 \leq a_1 \leq 1.030$	$0.830 \leq a_1 \leq 1.030$
Absolute value of intercept, $\lvert a_0 \rvert$	≤ 10 % of warm idle	≤ 2 % of maximum mapped torque	≤ 2 % of maximum mapped power
Standard error of the estimate, *SEE*	≤ 5 % of maximum test speed	≤ 10 % of maximum mapped torque	≤ 10 % of maximum mapped power
Coefficient of determination, r^2	≥ 0.970	≥ 0.850	≥ 0.910

345. Amend § 1065.530 by revising paragraphs (a)(2)(iii) and (g)(5) to read as follows:

§ 1065.530 Emission test sequence.

(a) * * *

(2) * * *

(iii) For testing that involves hot-stabilized emission measurements, bring the engine either to warm idle or the first operating point of the duty cycle. Start the test within 10 min of achieving temperature stability. Determine temperature stability as the point at which the engine thermostat controls engine temperature or as the point at which based on measured operating temperature has stayed staying within ±2 % of the mean value for at least 2 min based on the following parameters:

(A) Engine coolant or block or head absolute temperatures for water-cooled engines. You may also determine temperature stability as the point at which the engine thermostat controls engine temperature.

(B) Oil sump absolute temperature for air-cooled engines with an oil sump.

(C) Cylinder head absolute temperature or exhaust gas temperature for air-cooled engines with no oil sump.either as the point at which the engine coolant, block, or head absolute temperature is within ±2 % of its mean value for at least 2 min, or as the point at which the engine thermostat controls engine temperature.

* * * * *

(g) * * *

(5) If you perform carbon balance error verification is required or if you choose to perform the verification, verify carbon balance error as required by specified in the standard-setting part and as described in § 1065.543. For all test intervals, cCalculate and report the three test-interval carbon balance error quantities for each test interval; carbon mass absolute error for a test interval (ϵ_{aC}), carbon mass rate absolute error for a test interval (ϵ_{aCrate}), and carbon mass relative error for a test interval (ϵ_{rC}). For multi-test-interval duty cycles with multiple test intervals, you may instead calculate and report the composite carbon mass relative error, ϵ_{rCcomp}, for the whole duty cycleinstead of the test-interval carbon balance error quantities. If you report ϵ_{rCcomp}choose to use the multi-test-interval option, you must still calculate and report ϵ_{aC}, ϵ_{aCrate}, and ϵ_{rC} for each test intervalthe results for the three test-interval options.

* * * * *

346. Add § 1065.543 to read as follows:

§ 1065.543 Carbon balance error verification.

(a) A cCarbon balance error verification compares independently calculated quantities of carbon flowing into and out of an engine system. The engine system includes aftertreatment devices as applicable. Calculating carbon intake considers carbon-carrying streams flowing into the system, including intake air, fuel, and optionally DEF or other fluids. Cassessments of the flow of carbon through the system (engine plus aftertreatment). The carbon flow out of the system , as determined by thecomes from exhaust emissions calculations., is compared to the carbon flow of all the streams flowing into the system (fuels, fluids (e.g., DEF), and intake-air). Note that this verification is not valid whenif you calculate exhaust molar flow rate is calculated using fuel rate and chemical balance as described in § 1065.655(f)(3) because the flows of carbon flows into and out of the system are not independent. Use good engineering judgment to ensure that carbon mass in and carbon mass out data signals align. The following is a partial list of possible causes for failing a carbon balance error verification and recommended corrective actions:

(1) Problems with the gas analyzer system:

(i) Incorrect analyzer calibration. Perform a calibration of the NDIR and/or THC analyzers.

(ii) Incorrect time alignment between flow and concentration data. Determine transformation time, t_{50}, for continuous gas analyzers and time-align flow and concentration data as described in § 1065.650(c)(2)(i).

(iii) Problems with the sample system. Inspect the sample system components such as sample lines, filters, chillers, and pumps for leaks, operating temperature, and contamination.

(2) Problems with fuel flow measurement:

(i) Zero shift of fuel flow rate meter. Perform an in-situ zero adjustment.

(ii) Change in fuel flow meter calibration. Perform a calibration of the fuel flow meter as described in § 1065.320.

(iii) Incorrect time alignment of fuel flow data. Time align fuel flow data to ensure that fuel flow data from transitions between test intervals is not included when integrating the fuel mass over a test interval.

(iv) Short sampling periods. For test intervals that are allowed to vary in duration, such as discrete-mode steady-state duty cycles, extend the test interval duration to improve accuracy when measuring low fuel flow rates.
(v) Fluctuations in the fuel conditioning system. Improve the stability of the fuel temperature and pressure conditioning system to improve accuracy when measuring low fuel flows.
(3) Dilute testing using a CVS system:
(i) Leaks. Inspect exhaust system and CVS tunnel, connections, and fasteners and repair or replace components. A leak in the exhaust transfer tube to the CVS will drive your carbon balance error negative.
(ii) Poor mixing. Perform the verification described in § 1065.341(a)(3) to look for and correct poor mixing.
(iii) Change in CVS calibration. Perform a calibration of the CVS flow meter as described in § 1065.340.
(iv) Flow meter entrance effects. Inspect the CVS tunnel to determine whether the entrance effects from the piping configuration upstream of the flow meter adversely affect the flow measurement.
(v) Other problems with the CVS or sampling verification hardware or software. Inspect the CVS system, CVS verification hardware, and software for discrepancies.
(4) Raw testing using intake air flow measurement or direct exhaust flow measurement:
(i) Leaks. Inspect the intake air system and exhaust system, connections, fasteners, and repair or replace components.
(ii) Zero shift of intake air flow rate meter. Perform an in-situ zero adjustment.
(iii) Change in intake air flow meter calibration. Perform a calibration of the intake air flow meter as described in § 1065.325.
(iv) Zero shift of exhaust flow rate meter. Perform an in-situ zero adjustment.
(v) Change in exhaust flow meter calibration. Perform a calibration of the exhaust flow meter as described in § 1065.330.
(vi) Flow meter entrance effects. Inspect the intake air system and the exhaust system to determine whether the entrance effects from the piping configuration upstream and downstream of the intake air flow meter or the exhaust flow meter adversely affect the flow measurement.
(v) Other problems with the intake air flow and exhaust flow measurement hardware or software. Inspect the intake air flow and exhaust flow measurement hardware or software for discrepancies.
(b) Perform the carbon balance error verification as follows:
(1) Carbon balance error verification takes place during the postafter emission sampling is complete for a portion of the emission test sequenceinterval or duty cycle as described in § 1065.530(g). Testing must include measured values as needed to determine intake air, fuel flow, and carbon-related gaseous exhaust emissions. Your test must include measurements of the following to verify carbon balance error: fuel flow, flow of all other carbon-carrying fluids into the system, flows required to determine intake air flow, and the amount of carbon containing gaseous emissions.You may optionally account for the flow of carbon-carrying fluids other than intake air and fuel into the system.
Perform carbon balance error verification as follows:
(21) Calculate carbon balance error quantities as The calculations for determining carbon balance error are described in § 1065.643. The three quantities for individual test intervals areThere are four different carbon balance error quantities: carbon mass absolute error, for a test interval (ϵ_{aC}),

carbon mass rate absolute error for a test interval, (ϵ_{aCrate}), and carbon mass relative error, for a test interval (ϵ_{rC})., Determine ϵ_{aC}, ϵ_{aCrate}, and ϵ_{rC} for all test intervals. You may determine cand ccomposite carbon mass relative error, for multiple-test-interval duty cycles (ϵ_{rCcomp}, as a fourth quantity that optionally applies for duty cycles with multiple test intervals). If you choose to verify carbon balance error, verify as follows:

(i) For all test intervals, determine ϵ_{aC}, ϵ_{aCrate}, and ϵ_{rC}.

(ii) For all duty cycles, verify using one of the following two methods:

(A) For all test intervals, verify that at least one of the three carbon balance error quantities for test intervals (ϵ_{aC}, ϵ_{aCrate}, or ϵ_{rC}) meets its applicable limit specified in paragraph (b)(3) of this section.

(B) For multiple-test-interval duty cycles, you may instead verify that ϵ_{rCcomp} is within (0.000 ± 0.020).

(32) You meet verification criteria for an individual test interval if the absolute values of carbon balance error quantities are at or below the following limit values:The following are the limits for the three carbon balance error quantities for test intervals:

(i) ϵ_{aC} must be within (0.000 ± $L_{\epsilon aC}$) g, whereCalculate the carbon mass absolute error limit, $L_{\epsilon aC}$, is determined using Eq. 1065.543-1, in units of grams and expressed to at least fourthree decimal places for comparision to the absolute value of ϵ_{aC}, using the following equation:.

$$L_{\epsilon aC} = c \cdot P_{max}$$

Eq. 1065.543-1

Where:

c = power-specific carbon mass absolute error coefficient = 0.007 g/kW.

P_{max} = maximum power from the engine map generated according to § 1065.510. If a measured P_{max} is not available, use a manufacturer-declared value for P_{max}.

Example:

c = 0.007 g/kW

P_{max} = 230.0 kW

$$L_{\epsilon aC} = 0.007 \cdot 230.0 = 1.610 \text{ g}$$

(ii) ϵ_{aCrate} must be within (0.000 ± $L_{\epsilon aCrate}$) g/hr, whereCalculate the carbon mass rate absolute error limit, $L_{\epsilon aCrate}$, is determined using Eq. 1065.543-2, in units of grams per hour and expressed to at least three decimal places for comparison to the absolute value of ϵ_{aCrate}, using the following equation:.

$$L_{\epsilon aCrate} = d \cdot P_{max}$$

Eq. 1065.543-2

Where:

d = power-specific carbon mass rate absolute error coefficient = 0.31 g/(kW·hr).

P_{max} = maximum power from the engine map generated according to § 1065.510. If a measured P_{max} is not available, use a manufacturer-declared value for P_{max}.

Example:

d = 0.31 g/(kW·hr)

P_{max} = 230.0 kW

$$L_{\epsilon aCrate} = 0.31 \cdot 230.0 = 71.300 \text{ g/hr}$$

(iii) The ~~ϵ_{rC}~~ carbon mass relative error limit, $L_{\epsilon rC}$, is 0.020 for comparision to the absolute value of ϵ_{rC}, and optionally the absolute value of ϵ_{rCcomp}~~must be within (0.000 ± 0.020)~~.

(c) A failed carbon balance error verification might indicate one or more problems requiring corrective action, as follows:

Area of Concern	**Problem**	**Recommended Corrective Action**
~~Problems with the g~~Gas analyzer system	Incorrect analyzer calibration	~~Perform a calibration of the~~ Calibrate NDIR and~~/or~~ THC analyzers.
	Incorrect time ~~-~~alignment between flow and concentration data	Determine transformation time, t_{50}, for continuous gas analyzers and time-align flow and concentration data as described in § 1065.650(c)(2)(i).
	Problems with the sample system	Inspect ~~the~~ sample system components such as sample lines, filters, chillers, and pumps for leaks, operating temperature, and contamination.
~~Problems with f~~Fuel flow measurement	Zero shift of fuel flow rate meter	Perform an in-situ zero adjustment.
	Change in fuel flow meter calibration	~~Perform a calibration of~~ Calibrate the fuel flow meter as described in § 1065.320.
	Incorrect time ~~-~~alignment of fuel flow data	~~Time align fuel flow data to ensure that fuel flow data from transitions between test intervals is not included when integrating the fuel mass over a test interval.~~Verify alignment of carbon mass in and carbon mass out data streams.
	Short sampling periods	For test intervals ~~that are allowed to vary in~~ with varying duration, such as discrete-mode steady-state duty cycles, make the test intervals longer ~~extend the test interval duration~~ to improve accuracy when measuring low fuel flow rates.
	Fluctuations in the fuel conditioning system	Improve ~~the~~ stability of the fuel temperature and pressure conditioning system to improve accuracy when measuring low fuel flow rates.
Dilute testing using a CVS system	Leaks	Inspect exhaust system and CVS tunnel, connections, and fasteners. ~~and r~~Repair or replace components as needed. A leak in the exhaust transfer tube to the CVS may result in negative values for ~~will drive your~~ carbon balance error ~~negative~~.
	Poor mixing	Perform the verification related to mixing ~~described~~ in § 1065.341(f)~~(a)(3) to look for and correct poor mixing~~.
	Change in CVS calibration	~~Perform a calibration of~~ Calibrate the CVS flow meter as described in § 1065.340.
	Flow meter entrance effects	Inspect the CVS tunnel to determine whether ~~the~~ entrance effects from the piping configuration upstream of the flow meter adversely affect ~~the~~ flow measurement.
	Other problems with the CVS or sampling verification hardware or software	Inspect hardware and software for the CVS system~~,~~ and CVS verification ~~hardware, and software~~system for discrepancies.
Raw testing using intake air flow measurement or direct exhaust	Leaks	Inspect ~~the~~ intake air ~~system~~ and exhaust systems, connections, fasteners. R~~, and~~epair or replace components as needed.
	Zero shift of intake air flow rate meter	Perform an in-situ zero adjustment.

flow measurement	Change in intake air flow meter calibration	~~Perform a calibration of~~ Calibrate the intake air flow meter as described in § 1065.325.
	Zero shift of exhaust flow rate meter	Perform an in-situ zero adjustment.
	Change in exhaust flow meter calibration	~~Perform a calibration of~~ Calibrate the exhaust flow meter as described in § 1065.330.
	Flow meter entrance effects	Inspect ~~the~~ intake air ~~system~~ and ~~the~~ exhaust systems to determine whether ~~the~~ entrance effects from the piping configuration upstream and downstream of the intake air flow meter or the exhaust flow meter adversely affect ~~the~~ flow measurement.
	Other problems with the intake air flow and exhaust flow measurement hardware or software	~~Inspect the intake air flow and exhaust flow measurement~~ Look for discrepancies in the hardware ~~or~~ and software for measuring intake air flow and exhaust flow~~discrepancies~~.
	Poor mixing	Ensure that all streams are well mixed.
Accuracy of fluid properties	Inaccurate fluid properties	If defaults are used, use measured values. If measured values are used, verify fluid property determination.

347. Amend § 1065.545 by revising paragraphs (a) and (b) introductory text to read as follows:

§ 1065.545 Verification of proportional flow control for batch sampling.

* * * * *

(a) For any pair of flow rates, use recorded sample and total flow rates. Total flow rate means the raw exhaust flow rate for raw exhaust sampling and the dilute exhaust flow rate for CVS sampling, or their 1 Hz means with the statistical calculations in § 1065.602 forcing the intercept through zero. Determine the standard error of the estimate, *SEE*, of the sample flow rate versus the total flow rate. For each test interval, demonstrate that *SEE* was less than or equal to 3.5 % of the mean sample flow rate.

(b) For any pair of flow rates, use recorded sample and total flow rates~~, where t~~. Total flow rate means the raw exhaust flow rate for raw exhaust sampling and the dilute exhaust flow rate for CVS sampling, or their 1 Hz means to demonstrate that each flow rate was constant within ±2.5 % of its respective mean or target flow rate. You may use the following options instead of recording the respective flow rate of each type of meter:

* * * * *

348. Revise § 1065.602 to read as follows:

§ 1065.602 Statistics.

(a) Overview. This section contains equations and example calculations for statistics that are specified in this part. In this section we use the letter "y" to denote a generic measured quantity, the superscript over-bar "‾" to denote an arithmetic mean, and the subscript "ref" to denote the reference quantity being measured.

(b) Arithmetic mean. Calculate an arithmetic mean, $\bar{y}$, as follows:

$$\bar{y} = \frac{\sum_{i=1}^{N} y_i}{N}$$

Eq. 1065.602-1

Commented [CAL48]: Equation updated.

Example:

$N = 3$
$y_1 = 10.60$
$y_2 = 11.91$
$y_N = y_3 = 11.09$

$$\bar{y} = \frac{10.60 + 11.91 + 11.09}{3}$$

$\bar{y} = 11.20$

(c) Standard deviation. Calculate the standard deviation for a non-biased (e.g., N–1) sample, σ, as follows:

$$\sigma_y = \sqrt{\frac{\sum_{i=1}^{N}(y_i - \bar{y})^2}{(N-1)}}$$

Eq. 1065.602-2

Commented [CAL49]: Equation updated.

Example:
$N = 3$
$y_1 = 10.60$
$y_2 = 11.91$
$y_N = y_3 = 11.09$
$\bar{y} = 11.20$

$$\sigma_y = \sqrt{\frac{(10.60 - 11.2)^2 + (11.91 - 11.2)^2 + (11.09 - 11.2)^2}{2}}$$

$\sigma_y = 0.6619$

(d) Root mean square. Calculate a root mean square, rms_y, as follows:

$$rms_y = \sqrt{\frac{1}{N}\sum_{i=1}^{N} y_i^2}$$

Eq. 1065.602-3

Commented [CAL50]: Equation updated.

Example:
$N = 3$
$y_1 = 10.60$
$y_2 = 11.91$
$y_N = y_3 = 11.09$

$$rms_y = \sqrt{\frac{10.60^2 + 11.91^2 + 11.09^2}{3}}$$

$rms_y = 11.21$

(e) Accuracy. Determine accuracy as described in this paragraph (e).. Make multiple measurements of a standard quantity to create a set of observed values, y_i, and compare each observed value to the known value of the standard quantity. The standard quantity may have a single known value, such as a gas standard, or a set of known values of negligible range, such as a known applied pressure produced by a calibration device during repeated applications. The known value of the standard quantity is represented by $y_{\text{ref}i}$. If you use a standard quantity with a single value, y_{ref_i} would be constant. Calculate an accuracy value as follows:

$$accuracy = \left| \frac{1}{N} \sum_{i=1}^{N} \left(y_i - y_{\text{ref}i} \right) \right|$$

Eq. 1065.602-4

Commented [CAL51]: Equation updated.

Example:

$y_{\text{ref}} = 1800.0$

$N = 3$

$y_1 = 1806.4$

$y_2 = 1803.1$

$y_3 = 1798.9$

$$accuracy = \left| \frac{1}{3} \left((1806.4 - 1800.0) + (1803.1 - 1800.0) + (1798.9 - 1800.0) \right) \right|$$

$$accuracy = \left| \frac{1}{3} \left((6.4) + (3.1) + (-1.1) \right) \right|$$

$accuracy = 2.8$

(f) t-test. Determine if your data passes a *t*-test by using the following equations and tables:

(1) For an unpaired *t*-test, calculate the *t* statistic and its number of degrees of freedom, *v*, as follows:

$$t = \frac{\left| \bar{y}_{\text{ref}} - \bar{y} \right|}{\sqrt{\frac{\sigma_{\text{ref}}^2}{N_{\text{ref}}} + \frac{\sigma_{\text{y}}^2}{N}}}$$

Eq. 1065.602-5

$$v = \frac{\left(\frac{\sigma_{\text{ref}}^2}{N_{\text{ref}}} + \frac{\sigma_{\text{y}}^2}{N} \right)^2}{\frac{\left(\frac{\sigma_{\text{ref}}^2}{N_{\text{ref}}} \right)^2}{N_{\text{ref}} - 1} + \frac{\left(\frac{\sigma_{\text{y}}^2}{N} \right)^2}{N - 1}}$$

Eq. 1065.602-6

Example:

$\bar{y}_{\text{ref}} = 1205.3$

$\bar{y} = 1123.8$

$\sigma_{\text{ref}} = 9.399$

$\sigma_{\text{y}} = 10.583$

$N_{\text{ref}} = 11$

$N = 7$

$$t = \frac{|1205.3 - 1123.8|}{\sqrt{\frac{9.399^2}{11} + \frac{10.583^2}{7}}}$$

t = 16.63

σ_{ref} = 9.399
σ_y = 10.583
N_{ref} = 11
N = 7

$$v = \frac{\left(\frac{9.399^2}{11} + \frac{10.583^2}{7}\right)^2}{\frac{\left(\frac{9.399^2}{11}\right)^2}{11-1} + \frac{\left(\frac{10.583^2}{7}\right)^2}{7-1}}$$

v = 11.76

(2) For a paired t-test, calculate the t statistic and its number of degrees of freedom, v, as follows, noting that the ε_i are the errors (e.g., differences) between each pair of y_{refi} and y_i:

$$t = \frac{|\bar{\varepsilon}| \cdot \sqrt{N}}{\sigma_\varepsilon}$$

Eq. 1065.602-7

Example:
$\bar{\varepsilon}$ = –0.12580
N = 16
σ_ε = 0.04837

$$t = \frac{|-0.12580| \cdot \sqrt{16}}{0.04837}$$

t = 10.403
$v = N - 1$
Example:
N = 16
v = 16 – 1
v = 15

(3) Use Table 1 of this section to compare t to the t_{crit} values tabulated versus the number of degrees of freedom. If t is less than t_{crit}, then t passes the t-test. The Microsoft Excel software has a TINV function that returns results equivalent results and may be used in place of Table 1, which follows:

TABLE 1 OF § 1065.602–
CRITICAL *t* VALUES VERSUS NUMBER OF DEGREES OF FREEDOM, *v*[a1]

v	Confidence	
	90 %	95 %
1	6.314	12.706
2	2.920	4.303
3	2.353	3.182
4	2.132	2.776
5	2.015	2.571
6	1.943	2.447
7	1.895	2.365
8	1.860	2.306
9	1.833	2.262
10	1.812	2.228
11	1.796	2.201
12	1.782	2.179
13	1.771	2.160
14	1.761	2.145
15	1.753	2.131
16	1.746	2.120
18	1.734	2.101
20	1.725	2.086
22	1.717	2.074
24	1.711	2.064
26	1.706	2.056
28	1.701	2.048
30	1.697	2.042
35	1.690	2.030
40	1.684	2.021
50	1.676	2.009
70	1.667	1.994
100	1.660	1.984
1000+	1.645	1.960

[1 a]Use linear interpolation to establish values not shown here.

(g) F-test. Calculate the *F* statistic as follows:

$$F_{y} = \frac{\sigma_{y}^{2}}{\sigma_{ref}^{2}}$$

Eq. 1065.602-8

Example:

$$\sigma_y = \sqrt{\frac{\sum_{i=1}^{N}(y_i - \bar{y})^2}{(N-1)}} = 10.583$$

$$\sigma_{ref} = \sqrt{\frac{\sum_{i=1}^{N_{ref}}(y_{refi} - \bar{y}_{ref})^2}{(N_{ref}-1)}} = 9.399$$

$$F = \frac{10.583^2}{9.399^2}$$

$F = 1.268$

(1) For a 90 % confidence F-test, use ~~Table 2 of this section~~the following table to compare F to the F_{crit90} values tabulated versus (N–1) and (N_{ref} –1). If F is less than F_{crit90}, then F passes the F-test at 90 % confidence.

TABLE 2 OF § 1065.602–CRITICAL *F* VALUES, F_{crit90}, VERSUS *N*–1 AND N_{ref}–1 AT 90 % CONFIDENCE

N–1	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	1000+
N_{ref}–1																			
1	39.86	49.50	53.59	55.83	57.24	58.20	58.90	59.43	59.85	60.19	60.70	61.22	61.74	62.00	62.26	62.52	62.79	63.06	63.32
2	8.526	9.000	9.162	9.243	9.293	9.326	9.349	9.367	9.381	9.392	9.408	9.425	9.441	9.450	9.458	9.466	9.475	9.483	9.491
3	5.538	5.462	5.391	5.343	5.309	5.285	5.266	5.252	5.240	5.230	5.216	5.200	5.184	5.176	5.168	5.160	5.151	5.143	5.134
4	4.545	4.325	4.191	4.107	4.051	4.010	3.979	3.955	3.936	3.920	3.896	3.870	3.844	3.831	3.817	3.804	3.790	3.775	3.761
5	4.060	3.780	3.619	3.520	3.453	3.405	3.368	3.339	3.316	3.297	3.268	3.238	3.207	3.191	3.174	3.157	3.140	3.123	3.105
6	3.776	3.463	3.289	3.181	3.108	3.055	3.014	2.983	2.958	2.937	2.905	2.871	2.836	2.818	2.800	2.781	2.762	2.742	2.722
7	3.589	3.257	3.074	2.961	2.883	2.827	2.785	2.752	2.725	2.703	2.668	2.632	2.595	2.575	2.555	2.535	2.514	2.493	2.471
8	3.458	3.113	2.924	2.806	2.726	2.668	2.624	2.589	2.561	2.538	2.502	2.464	2.425	2.404	2.383	2.361	2.339	2.316	2.293
9	3.360	3.006	2.813	2.693	2.611	2.551	2.505	2.469	2.440	2.416	2.379	2.340	2.298	2.277	2.255	2.232	2.208	2.184	2.159
10	3.285	2.924	2.728	2.605	2.522	2.461	2.414	2.377	2.347	2.323	2.284	2.244	2.201	2.178	2.155	2.132	2.107	2.082	2.055
11	3.225	2.860	2.660	2.536	2.451	2.389	2.342	2.304	2.274	2.248	2.209	2.167	2.123	2.100	2.076	2.052	2.026	2.000	1.972
12	3.177	2.807	2.606	2.480	2.394	2.331	2.283	2.245	2.214	2.188	2.147	2.105	2.060	2.036	2.011	1.986	1.960	1.932	1.904
13	3.136	2.763	2.560	2.434	2.347	2.283	2.234	2.195	2.164	2.138	2.097	2.053	2.007	1.983	1.958	1.931	1.904	1.876	1.846
14	3.102	2.726	2.522	2.395	2.307	2.243	2.193	2.154	2.122	2.095	2.054	2.010	1.962	1.938	1.912	1.885	1.857	1.828	1.797
15	3.073	2.695	2.490	2.361	2.273	2.208	2.158	2.119	2.086	2.059	2.017	1.972	1.924	1.899	1.873	1.845	1.817	1.787	1.755
16	3.048	2.668	2.462	2.333	2.244	2.178	2.128	2.088	2.055	2.028	1.985	1.940	1.891	1.866	1.839	1.811	1.782	1.751	1.718
17	3.026	2.645	2.437	2.308	2.218	2.152	2.102	2.061	2.028	2.001	1.958	1.912	1.862	1.836	1.809	1.781	1.751	1.719	1.686
18	3.007	2.624	2.416	2.286	2.196	2.130	2.079	2.038	2.005	1.977	1.933	1.887	1.837	1.810	1.783	1.754	1.723	1.691	1.657
19	2.990	2.606	2.397	2.266	2.176	2.109	2.058	2.017	1.984	1.956	1.912	1.865	1.814	1.787	1.759	1.730	1.699	1.666	1.631
20	2.975	2.589	2.380	2.249	2.158	2.091	2.040	1.999	1.965	1.937	1.892	1.845	1.794	1.767	1.738	1.708	1.677	1.643	1.607
21	2.961	2.575	2.365	2.233	2.142	2.075	2.023	1.982	1.948	1.920	1.875	1.827	1.776	1.748	1.719	1.689	1.657	1.623	1.586
22~~0~~	2.949	2.561	2.351	2.219	2.128	2.061	2.008	1.967	1.933	1.904	1.859	1.811	1.759	1.731	1.702	1.671	1.639	1.604	1.567
23	2.937	2.549	2.339	2.207	2.115	2.047	1.995	1.953	1.919	1.890	1.845	1.796	1.744	1.716	1.686	1.655	1.622	1.587	1.549
24	2.927	2.538	2.327	2.195	2.103	2.035	1.983	1.941	1.906	1.877	1.832	1.783	1.730	1.702	1.672	1.641	1.607	1.571	1.533
25	2.918	2.528	2.317	2.184	2.092	2.024	1.971	1.929	1.895	1.866	1.820	1.771	1.718	1.689	1.659	1.627	1.593	1.557	1.518
26	2.909	2.519	2.307	2.174	2.082	2.014	1.961	1.919	1.884	1.855	1.809	1.760	1.706	1.677	1.647	1.615	1.581	1.544	1.504
27	2.901	2.511	2.299	2.165	2.073	2.005	1.952	1.909	1.874	1.845	1.799	1.749	1.695	1.666	1.636	1.603	1.569	1.531	1.491
28	2.894	2.503	2.291	2.157	2.064	1.996	1.943	1.900	1.865	1.836	1.790	1.740	1.685	1.656	1.625	1.593	1.558	1.520	1.478
29	2.887	2.495	2.283	2.149	2.057	1.988	1.935	1.892	1.857	1.827	1.781	1.731	1.676	1.647	1.616	1.583	1.547	1.509	1.467
30	2.881	2.489	2.276	2.142	2.049	1.980	1.927	1.884	1.849	1.819	1.773	1.722	1.667	1.638	1.606	1.573	1.538	1.499	1.456
40	2.835	2.440	2.226	2.091	1.997	1.927	1.873	1.829	1.793	1.763	1.715	1.662	1.605	1.574	1.541	1.506	1.467	1.425	1.377
60	2.791	2.393	2.177	2.041	1.946	1.875	1.819	1.775	1.738	1.707	1.657	1.603	1.543	1.511	1.476	1.437	1.395	1.348	1.291
120	2.748	2.347	2.130	1.992	1.896	1.824	1.767	1.722	1.684	1.652	1.601	1.545	1.482	1.447	1.409	1.368	1.320	1.265	1.193
1000+	2.706	2.303	2.084	1.945	1.847	1.774	1.717	1.670	1.632	1.599	1.546	1.487	1.421	1.383	1.342	1.295	1.240	1.169	1.000

(2) For a 95 % confidence F-test, use ~~Table 3 of this section~~the following table to compare F to the F_{crit95} values tabulated versus (N–1) and (N_{ref} –1). If F is less than F_{crit95}, then F passes the F-test at 95 % confidence.

TABLE 3 OF § 1065.602–CRITICAL *F* VALUES, F_{crit95}, VERSUS *N*–1 AND N_{ref}–1 AT 95 % CONFIDENCE

N–1	1	2	3	4	5	6	7	8	9	10	12	15	20	24	30	40	60	120	1000+
N_{ref}–1																			
1	161.4	199.5	215.7	224.5	230.1	233.9	236.7	238.8	240.5	241.8	243.9	245.9	248.0	249.0	250.1	251.1	252.2	253.2	254.3
2	18.51	19.00	19.16	19.24	19.29	19.33	19.35	19.37	19.38	19.39	19.41	19.42	19.44	19.45	19.46	19.47	19.47	19.48	19.49
3	10.12	9.552	9.277	9.117	9.014	8.941	8.887	8.845	8.812	8.786	8.745	8.703	8.660	8.639	8.617	8.594	8.572	8.549	8.526
4	7.709	6.944	6.591	6.388	6.256	6.163	6.094	6.041	5.999	5.964	5.912	5.858	5.803	5.774	5.746	5.717	5.688	5.658	5.628
5	6.608	5.786	5.410	5.192	5.050	4.950	4.876	4.818	4.773	4.735	4.678	4.619	4.558	4.527	4.496	4.464	4.431	4.399	4.365
6	5.987	5.143	4.757	4.534	4.387	4.284	4.207	4.147	4.099	4.060	4.000	3.938	3.874	3.842	3.808	3.774	3.740	3.705	3.669
7	5.591	4.737	4.347	4.120	3.972	3.866	3.787	3.726	3.677	3.637	3.575	3.511	3.445	3.411	3.376	3.340	3.304	3.267	3.230
8	5.318	4.459	4.066	3.838	3.688	3.581	3.501	3.438	3.388	3.347	3.284	3.218	3.150	3.115	3.079	3.043	3.005	2.967	2.928
9	5.117	4.257	3.863	3.633	3.482	3.374	3.293	3.230	3.179	3.137	3.073	3.006	2.937	2.901	2.864	2.826	2.787	2.748	2.707
10	4.965	4.103	3.708	3.478	3.326	3.217	3.136	3.072	3.020	2.978	2.913	2.845	2.774	2.737	2.700	2.661	2.621	2.580	2.538
11	4.844	3.982	3.587	3.357	3.204	3.095	3.012	2.948	2.896	2.854	2.788	2.719	2.646	2.609	2.571	2.531	2.490	2.448	2.405
12	4.747	3.885	3.490	3.259	3.106	2.996	2.913	2.849	2.796	2.753	2.687	2.617	2.544	2.506	2.466	2.426	2.384	2.341	2.296
13	4.667	3.806	3.411	3.179	3.025	2.915	2.832	2.767	2.714	2.671	2.604	2.533	2.459	2.420	2.380	2.339	2.297	2.252	2.206
14	4.600	3.739	3.344	3.112	2.958	2.848	2.764	2.699	2.646	2.602	2.534	2.463	2.388	2.349	2.308	2.266	2.223	2.178	2.131
15	4.543	3.682	3.287	3.056	2.901	2.791	2.707	2.641	2.588	2.544	2.475	2.403	2.328	2.288	2.247	2.204	2.160	2.114	2.066
16	4.494	3.634	3.239	3.007	2.852	2.741	2.657	2.591	2.538	2.494	2.425	2.352	2.276	2.235	2.194	2.151	2.106	2.059	2.010
17	4.451	3.592	3.197	2.965	2.810	2.699	2.614	2.548	2.494	2.450	2.381	2.308	2.230	2.190	2.148	2.104	2.058	2.011	1.960
18	4.414	3.555	3.160	2.928	2.773	2.661	2.577	2.510	2.456	2.412	2.342	2.269	2.191	2.150	2.107	2.063	2.017	1.968	1.917
19	4.381	3.522	3.127	2.895	2.740	2.628	2.544	2.477	2.423	2.378	2.308	2.234	2.156	2.114	2.071	2.026	1.980	1.930	1.878
20	4.351	3.493	3.098	2.866	2.711	2.599	2.514	2.447	2.393	2.348	2.278	2.203	2.124	2.083	2.039	1.994	1.946	1.896	1.843
21	4.325	3.467	3.073	2.840	2.685	2.573	2.488	2.421	2.366	2.321	2.250	2.176	2.096	2.054	2.010	1.965	1.917	1.866	1.812
22	4.301	3.443	3.049	2.817	2.661	2.549	2.464	2.397	2.342	2.297	2.226	2.151	2.071	2.028	1.984	1.938	1.889	1.838	1.783
23	4.279	3.422	3.028	2.796	2.640	2.528	2.442	2.375	2.320	2.275	2.204	2.128	2.048	2.005	1.961	1.914	1.865	1.813	1.757
24	4.260	3.403	3.009	2.776	2.621	2.508	2.423	2.355	2.300	2.255	2.183	2.108	2.027	1.984	1.939	1.892	1.842	1.790	1.733
25	4.242	3.385	2.991	2.759	2.603	2.490	2.405	2.337	2.282	2.237	2.165	2.089	2.008	1.964	1.919	1.872	1.822	1.768	1.711
26	4.225	3.369	2.975	2.743	2.587	2.474	2.388	2.321	2.266	2.220	2.148	2.072	1.990	1.946	1.901	1.853	1.803	1.749	1.691
27	4.210	3.354	2.960	2.728	2.572	2.459	2.373	2.305	2.250	2.204	2.132	2.056	1.974	1.930	1.884	1.836	1.785	1.731	1.672
28	4.196	3.340	2.947	2.714	2.558	2.445	2.359	2.291	2.236	2.190	2.118	2.041	1.959	1.915	1.869	1.820	1.769	1.714	1.654
29	4.183	3.328	2.934	2.701	2.545	2.432	2.346	2.278	2.223	2.177	2.105	2.028	1.945	1.901	1.854	1.806	1.754	1.698	1.638
30	4.171	3.316	2.922	2.690	2.534	2.421	2.334	2.266	2.211	2.165	2.092	2.015	1.932	1.887	1.841	1.792	1.740	1.684	1.622
40	4.085	3.232	2.839	2.606	2.450	2.336	2.249	2.180	2.124	2.077	2.004	1.925	1.839	1.793	1.744	1.693	1.637	1.577	1.509
60	4.001	3.150	2.758	2.525	2.368	2.254	2.167	2.097	2.040	1.993	1.917	1.836	1.748	1.700	1.649	1.594	1.534	1.467	1.389
120	3.920	3.072	2.680	2.447	2.290	2.175	2.087	2.016	1.959	1.911	1.834	1.751	1.659	1.608	1.554	1.495	1.429	1.352	1.254
1000+	3.842	2.996	2.605	2.372	2.214	2.099	2.010	1.938	1.880	1.831	1.752	1.666	1.571	1.517	1.459	1.394	1.318	1.221	1.000

(h) Slope. Calculate a least-squares regression slope, a_{1y}, using one of the following two methodsas follows:

(1) If the intercept floats, i.e., is not forced through zero:

$$a_{1y} = \frac{\sum_{i=1}^{N}(y_i - \bar{y})\cdot(y_{\text{ref}i} - \bar{y}_{\text{ref}})}{\sum_{i=1}^{N}(y_{\text{ref}i} - \bar{y}_{\text{ref}})^2}$$

Eq. 1065.602-9

Commented [CAL54]: Equation updated.

Example:

$N = 6000$

$y_1 = 2045.8$

$\bar{y} = 1050.1$

$y_{\text{ref}1} = 2045.0$

$\bar{y}_{\text{ref}} = 1055.3$

$$a_{1y} = \frac{(2045.8 - 1050.1)\cdot(2045.0 - 1055.3) + ... + (y_{6000} - 1050.1)\cdot(y_{\text{ref}6000} - 1055.3)}{(2045.0 - 1055.3)^2 + ... + (y_{\text{ref}6000} - 1055.3)^2}$$

$a_{1y} = 1.0110$

(2) If the intercept is forced through zero, such as e.g., for verifying proportional sampling:

$$a_{1y} = \frac{\sum_{i=1}^{N} y_i \cdot y_{\text{ref}i}}{\sum_{i=1}^{N} y_{\text{ref}i}^2}$$

Eq. 1065.602-10

Example:

$N = 6000$

$y_1 = 2045.8$

$y_{\text{ref}1} = 2045.0$

$$a_{1y} = \frac{2045.8 \cdot 2045.0 + ... + y_{6000} \cdot y_{\text{ref}\,6000}}{2045.0^2 + ... + y_{\text{ref}\,6000}^2}$$

$a_{1y} = 1.0110$

(i) Intercept. For a floating interceptIf the intercept floats, i.e., is not forced through zero, cCalculate a least-squares regression intercept, a_{0y}, as follows:

$$a_{0y} = \bar{y} - (a_{1y} \cdot \bar{y}_{\text{ref}})$$

Eq. 1065.602-110

Example:

$\bar{y} = 1050.1$

$a_{1y} = 1.0110$

$\bar{y}_{\text{ref}} = 1055.3$

a_{0y} = 1050.1 – (1.0110 · 1055.3)
a_{0y} = –16.8083

(j) Standard error of the estimate~~ of error~~. Calculate a standard error of the estimate~~ of error~~, *SEE*, using one of the following two methods~~as follows~~:

(1) For a floating intercept~~If the intercept floats, i.e., is not forced through zero~~:

$$SEE_{\mathrm{y}} = \sqrt{\frac{\sum_{i=1}^{N}\left(y_i - a_{0\mathrm{y}} - (a_{1\mathrm{y}} \cdot y_{\mathrm{ref}i})\right)^2}{N-2}}$$

Eq. 1065.602-12~~1~~

Example:
N = 6000
y_1 = 2045.8
a_{0y} = –16.8083
a_{1y} = 1.0110
y_{ref1} = 2045.0

$$SEE_{\mathrm{y}} = \sqrt{\frac{(2045.8-(-16.8083)-(1.0110\cdot 2045.0))^2+...\left(y_{6000}-(-16.8083)-(1.0110\cdot y_{\mathrm{ref}\,6000})\right)^2}{6000-2}}$$

SEE_y = 5.348

(2) If the intercept is forced through zero, ~~e.g.,~~such as for verifying proportional sampling:

$$SEE_{\mathrm{y}} = \sqrt{\frac{\sum_{i=1}^{N}\left(y_i - a_{1\mathrm{y}} \cdot y_{\mathrm{ref}i}\right)^2}{N-1}}$$

Eq. 1065.602-13

Example:
N = 6000
y_1 = 2045.8
a_{1y} = 1.0110
y_{ref1} = 2045.0

$$SEE_{\mathrm{y}} = \sqrt{\frac{(2045.8-1.0110\cdot 2045.0)^2+...+\left(y_{6000}-1.0110\cdot y_{\mathrm{ref}\,6000}\right)^2}{6000-1}}$$

SEE_y = 5.347

(k) Coefficient of determination. Calculate a coefficient of determination, r_{y}^2, as follows:

$$r_{\mathrm{y}}^2 = 1 - \frac{\sum_{i=1}^{N}\left(y_i - a_{0\mathrm{y}} - (a_{1\mathrm{y}} \cdot y_{\mathrm{ref}i})\right)^2}{\sum_{i=1}^{N}\left(y_i - \bar{y}\right)^2}$$

Eq. 1065.602-14~~2~~

Example:
N = 6000
y_1 = 2045.8
a_{0y} = –16.8083
a_{1y} = 1.0110

Commented [CAL57]: Updated.

Commented [CAL58]: Equation updated.

$y_{ref1} =$ 2045.0

$\bar{y} = 1480.5$

$$r_y^2 = 1 - \frac{\left(2045.8 - (-16.8083) - (1.0110 \times 2045.0)\right)^2 + ...\left(y_{6000} - (-16.8083) - (1.0110 \cdot y_{ref6000})\right)^2}{\left(2045.8 - 1480.5\right)^2 + ...\left(y_{6000} - 1480.5\right)^2}$$

$r_y^2 = 0.9859$

Commented [CAL59]: Example updated.

(l) Flow-weighted mean concentration. In some sections of this part, you may need to calculate a flow-weighted mean concentration to determine the applicability of certain provisions. A flow-weighted mean is the mean of a quantity after it is weighted proportional to a corresponding flow rate. For example, if a gas concentration is measured continuously from the raw exhaust of an engine, its flow-weighted mean concentration is the sum of the products of each recorded concentration times its respective exhaust molar flow rate, divided by the sum of the recorded flow rate values. As another example, the bag concentration from a CVS system is the same as the flow-weighted mean concentration because the CVS system itself flow-weights the bag concentration. You might already expect a certain flow-weighted mean concentration of an emission at its standard based on previous testing with similar engines or testing with similar equipment and instruments. If you need to estimate your expected flow-weighted mean concentration of an emission at its standard, we recommend using the following examples as a guide for how to estimate the flow-weighted mean concentration expected at the standard. Note that these examples are not exact and that they contain assumptions that are not always valid. Use good engineering judgment to determine if you can use similar assumptions.

(1) To estimate the flow-weighted mean raw exhaust NO_x concentration from a turbocharged heavy-duty compression-ignition engine at a NO_x standard of 2.5 g/(kW·hr), you may do the following:

(i) Based on your engine design, approximate a map of maximum torque versus speed and use it with the applicable normalized duty cycle in the standard-setting part to generate a reference duty cycle as described in § 1065.610. Calculate the total reference work, W_{ref}, as described in § 1065.650. Divide the reference work by the duty cycle's time interval, $\Delta t_{dutycycle}$, to determine mean reference power, $\bar{P}_{ref}$.

(ii) Based on your engine design, estimate maximum power, P_{max}, the design speed at maximum power, f_{nmax}, the design maximum intake manifold boost pressure, p_{inmax}, and temperature, T_{inmax}. Also, estimate a mean fraction of power that is lost due to friction and pumping, $\bar{P}_{frict}$. Use this information along with the engine displacement volume, V_{disp}, an approximate volumetric efficiency, η_V, and the number of engine strokes per power stroke (two-stroke or four-stroke), N_{stroke}, to estimate the maximum raw exhaust molar flow rate, $\dot{n}_{exhmax}$.

(iii) Use your estimated values as described in the following example calculation:

$$\bar{x}_{exp} = \frac{e_{std} \cdot W_{ref}}{M \cdot \dot{n}_{exhmax} \cdot \Delta t_{duty\ cycle} \cdot \left(\frac{\bar{P}_{ref} + \left(\bar{P}_{frict} \cdot P_{max}\right)}{P_{max}}\right)}$$

Eq. 1065.602-153

$$\dot{n}_{exhmax} = \frac{p_{max} \cdot V_{disp} \cdot f_{nmax} \cdot \frac{2}{N_{stroke}} \cdot \eta_V}{R \cdot T_{max}}$$

Eq. 1065.602-164

Example:

e_{NOx} = 2.5 g/(kW·hr)
W_{ref} = 11.883 kW·hr
M_{NOx} = 46.0055 g/mol = 46.0055·10^{-6} g/μmol
$\Delta t_{dutycycle}$ = 20 min = 1200 s
$\bar{P}_{ref}$ = 35.65 kW
$\bar{P}_{frict}$ = 15 %
P_{max} = 125 kW
p_{max} = 300 kPa = 300000 Pa
V_{disp} = 3.0 l = 0.0030 m^3/r
f_{nmax} = 2800 r/min = 46.67 r/s
N_{stroke} = 4
η_V = 0.9
R = 8.314472 J/(mol·K)
T_{max} = 348.15 K

$$\dot{n}_{exhmax} = \frac{300000 \cdot 0.0030 \cdot 46.67 \cdot \frac{2}{4} \cdot 0.9}{8.314472 \cdot 348.15}$$

$\dot{n}_{exhmax}$ = 6.53 mol/s

$$\bar{x}_{exp} = \frac{2.5 \cdot 11.883}{46.0055 \cdot 10^{-6} \cdot 6.53 \cdot 1200 \cdot \left(\frac{35.65 + (0.15 \cdot 125)}{125}\right)}$$

$\bar{x}_{exp}$ = 189.4 μmol/mol

(2) To estimate the flow-weighted mean NMHC concentration in a CVS from a naturally aspirated nonroad spark-ignition engine at an NMHC standard of 0.5 g/(kW·hr), you may do the following:

(i) Based on your engine design, approximate a map of maximum torque versus speed and use it with the applicable normalized duty cycle in the standard-setting part to generate a reference duty cycle as described in § 1065.610. Calculate the total reference work, W_{ref}, as described in § 1065.650.

(ii) Multiply your CVS total molar flow rate by the time interval of the duty cycle, $\Delta t_{dutycycle}$. The result is the total diluted exhaust flow of the n_{dexh}.

(iii) Use your estimated values as described in the following example calculation:

$$\bar{x}_{NMHC} = \frac{e_{std} \cdot W_{ref}}{M \cdot \dot{n}_{dexh} \cdot \Delta t_{duty\ cycle}}$$

Eq. 1065.602-175

Example:

e_{NMHC} = 1.5 g/(kW·hr)
W_{ref} = 5.389 kW·hr
M_{NMHC} = 13.875389 g/mol = 13.875389·10^{-6} g/µmol
$\dot{n}_{dexh}$ = 6.021 mol/s
$\Delta t_{dutycycle}$= 30 min = 1800 s

$$\bar{x}_{NMHC} = \frac{1.5 \cdot 5.389}{13.875389 \cdot 10^{-6} \cdot 6.021 \cdot 1800}$$

$\bar{x}_{NMHC}$= 53.8 µmol/mol

349. Amend § 1065.610 by revising paragraphs (a)(1)(iv), (a)(2) introductory text, and (d)(3) introductory text to read as follows:

§ 1065.610 Duty cycle generation.

* * * * *

(a) * * *

(1) * * *

(iv) Transform the map into a normalized power-versus-speed map by dividing power terms by P_{max} and dividing speed terms by f_{nPmax}. Use the following equation to calculate a quantity representing the sum of squares from the normalized map:

$$\text{Sum of squares} = f_{nnormi}^2 + P_{normi}^2$$

Eq. 1065.610-1

Commented [CAL60]: Equation updated.

Where:
i = an indexing variable that represents one recorded value of an engine map.
f_{nnormi} = an engine speed normalized by dividing it by f_{nPmax}.
P_{normi} = an engine power normalized by dividing it by P_{max}.

* * * * *

(2) For engines with a high-speed governor that will be subject to a reference duty cycle that specifies normalized speeds greater than 100 %, calculate an alternate maximum test speed, $f_{ntest,alt}$, as specified in this paragraph (a)(2). If $f_{ntest,alt}$ is less than the measured maximum test speed, f_{ntest}, determined in paragraph (a)(1) of this section, replace f_{ntest} with $f_{ntest,alt}$. In this case, $f_{ntest,alt}$ becomes the "maximum test speed" for that engine for all duty- cycles. Note that § 1065.510 allows you to apply an optional declared maximum test speed to the final measured maximum test speed determined as an outcome of the comparison between f_{ntest}, and $f_{ntest,alt}$ in this paragraph (a)(2). Determine $f_{ntest,alt}$ as follows:

* * * * *

(d) * * *

(3) Required deviations. We require the following deviations for variable-speed engines intended primarily for propulsion of a vehicle with an automatic transmission where that engine is subject to a transient duty cycle with idle operation. These deviations are intended to produce a more representative transient duty cycle for these applications. For steady-state duty cycles or transient duty cycles with no idle operation, these requirements do not apply. Idle points for steady--state duty cycles of such engines are to be run at conditions simulating neutral or park on the transmission. You may develop ~~an alternate~~ different procedures for adjusting CITT as a function of speed, consistent with good engineering judgment.

*   *   *   *   *

350. Amend § 1065.640 by revising paragraph (a), (b)(3), (d)(1), and (d)(3) to read as follows:

§ 1065.640 Flow meter calibration calculations.

*   *   *   *   *

(a) Reference meter conversions. The calibration equations in this section use molar flow rate, $\dot{n}_{\text{ref}}$, as a reference quantity. If your reference meter outputs a flow rate in a different quantity, such as standard volume rate, $\dot{V}_{\text{stdref}}$, actual volume rate, $\dot{V}_{\text{actref}}$, or mass rate, $\dot{m}_{\text{ref}}$, convert your reference meter output to a molar flow rate using the following equations, noting that while values for volume rate, mass rate, pressure, temperature, and molar mass may change during an emission test, you should ensure that they are as constant as practical for each individual set point during a flow meter calibration:

$$\dot{n}_{\text{ref}} = \frac{\dot{V}_{\text{stdref}} \cdot p_{\text{std}}}{T_{\text{std}} \cdot R} = \frac{\dot{V}_{\text{actref}} \cdot p_{\text{act}}}{T_{\text{act}} \cdot R} = \frac{\dot{m}_{\text{ref}}}{M_{\text{mix}}}$$

Eq. 1065.640-1

Where:

$\dot{n}_{\text{ref}}$ = reference molar flow rate.

$\dot{V}_{\text{stdref}}$ = reference volume flow rate, corrected to a standard pressure and a standard temperature.

$\dot{V}_{\text{actref}}$ = reference volume flow rate at the actual pressure and temperature of the flow rate.

$\dot{m}_{\text{ref}}$ = reference mass flow.

p_{std} = standard pressure.

p_{act} = actual pressure of the flow rate.

T_{std} = standard temperature.

T_{act} = actual temperature of the flow rate.

R = molar gas constant.

M_{mix} = molar mass of the flow rate.

Example 1:

$\dot{V}_{\text{stdref}}$ = 1000.00 ft^3/min = 0.471948 m^3/s

p_{std} = 29.9213 in Hg @ 32 °F = 101.325 kPa = 101325 Pa = 101325 kg/(m·s^2)

T_{std} = 68.0 °F = 293.15 K

R = 8.314472 J/(mol·K) = 8.314472 (m^2·kg)/(s^2·mol·K)

$$\dot{n}_{\text{ref}} = \frac{0.471948 \cdot 101325}{293.15 \cdot 8.314472}$$

$\dot{n}_{\text{ref}}$ = 19.619 mol/s

Example 2:

$\dot{m}_{\text{ref}}$ = 17.2683 kg/min = 287.805 g/s

M_{mix} = 28.7805 g/mol

$$\dot{n}_{\text{ref}} = \frac{287.805}{28.7805}$$

$\dot{n}_{ref}$ = 10.0000 mol/s

(b) * *

(3) Perform a least-squares regression of V_{rev}, versus K_s, by calculating slope, a_1, and intercept, a_0, as described for a floating intercept in § 1065.602.

* * * * *

(d) * * *

(1) Calculate the Reynolds number, $Re^{\#}$, for each reference molar flow rate, $\dot{n}_{ref}$, using the throat diameter of the venturi, d_t. Because the dynamic viscosity, μ, is needed to compute $Re^{\#}$, you may use your own fluid viscosity model to determine μ for your calibration gas (usually air), using good engineering judgment. Alternatively, you may use the Sutherland three-coefficient viscosity model to approximate μ, as shown in the following sample calculation for $Re^{\#}$:

$$Re^{\#} = \frac{4 \cdot M_{mix} \cdot \dot{n}_{ref}}{\pi \cdot d_t \cdot \mu}$$

Eq. 1065.640-10

Where, using the Sutherland three-coefficient viscosity model as captured in Table 4 of this section:

$$\mu = \mu_0 \cdot \left(\frac{T_{in}}{T_0}\right)^{\frac{3}{2}} \cdot \left(\frac{T_0 + S}{T_{in} + S}\right)$$

Eq. 1065.640-11

Where:

μ_0 = Sutherland reference viscosity.

T_0 = Sutherland reference temperature.

S = Sutherland constant.

TABLE 4 OF § 1065.640–

SUTHERLAND THREE-COEFFICIENT VISCOSITY MODEL PARAMETERS

Gas[a]	μ_0	T_0	S	Temperature range within ±2 % error[b]	Pressure limit[b]
	kg/(m·s)	K	K	K	kPa
Air	$1.716 \cdot 10^{-5}$	273	111	170 to 1900	≤ 1800
CO_2	$1.370 \cdot 10^{-5}$	273	222	190 to 1700	≤ 3600
H_2O	$1.12 \cdot 10^{-5}$	350	1064	360 to 1500	≤ 10000
O_2	$1.919 \cdot 10^{-5}$	273	139	190 to 2000	≤ 2500
N_2	$1.663 \cdot 10^{-5}$	273	107	100 to 1500	≤ 1600

[a]Use tabulated parameters only for the pure gases, as listed. Do not combine parameters in calculations to calculate viscosities of gas mixtures.

[b]The model results are valid only for ambient conditions in the specified ranges.

Example:

$\mu_0 = 1.716 \cdot 10^{-5}$ kg/(m·s)

T_0 = 273 K

S = 111 K

$$\mu = 1.716\cdot10^{-5}\cdot\left(\frac{298.15}{273}\right)^{\frac{3}{2}}\cdot\left(\frac{273+111}{298.15+111}\right)$$

μ = 1.838·10^{-5} kg/(m·s)

M_{mix} = 28.7805 g/mol = 0.0287805 kg/mol

$\dot{n}_{ref}$ = 57.625 mol/s

d_t = 152.4 mm = 0.1524 m

T_{in} = 298.15 K

$$Re^{\#} = \frac{4\cdot0.0287805\cdot57.625}{3.14159\cdot0.1524\cdot1.838\cdot10^{-5}}$$

$Re^{\#}$ = 7.538·10^{58}

Commented [CAL61]: Example updated.

* * * * *

(3) Perform a least-squares regression analysis to determine the best-fit coefficients for the equation and calculate *SEE* as described in § 1065.602. When using Eq. 1065.640-12the example equation above, treat C_d as y and the radical term as y_{ref} and use Eq. 1065.602-12 to calculate *SEE*. When using another mathematical expression, use the same approach to substitute that expression into the numerator of Eq. 1065.602-12 and replace the 2 in the denominator with the number of coefficients in the mathematical expression.

* * * * *

351. Amend § 1065.642 by revising paragraphs (b) and (c)(1) to read as follows:

§ 1065.642 PDP, SSV, and CFV molar flow rate calculations.

* * * * *

(b) SSV molar flow rate. Calculate SSV molar flow rate, $\dot{n}$, as follows:

$$\dot{n} = C_d\cdot C_f\cdot\frac{A_t\cdot p_{in}}{\sqrt{Z\cdot M_{mix}\cdot R\cdot T_{in}}}$$

Eq. 1065.642-3

Where:

C_d = discharge coefficient, as determined based on the C_d versus $Re^{\#}$ equation in § 1065.640(d)(2).

C_f = flow coefficient, as determined in § 1065.640(c)(32)(ii).

A_t = venturi throat cross-sectional area.

p_{in} = static absolute pressure at the venturi inlet.

Z = compressibility factor.

M_{mix} = molar mass of gas mixture.

R = molar gas constant.

T_{in} = absolute temperature at the venturi inlet.

Example:

A_t = 0.01824 m^2

p_{in} = 99.132 kPa = 99132 Pa = 99132 kg/(m·s^2)

Z = 1

M_{mix} = 28.7805 g/mol = 0.0287805 kg/mol
R = 8.314472 J/(mol·K) = 8.314472 (m²·kg)/(s²·mol·K)
T_{in} = 298.15 K
$Re^{\#} = 7.232 \cdot 10^5$
γ = 1.399
β = 0.8
Δp = 2.312 kPa

Using Eq. 1065.640-7,
r_{ssv} = 0.997

Using Eq. 1065.640-6,
C_f = 0.274

Using Eq. 1065.640-5,
C_d = 0.990

$$\dot{n} = 0.990 \cdot 0.274 \cdot \frac{0.01824 \cdot 99132}{\sqrt{1 \cdot 0.0287805 \cdot 8.314472 \cdot 298.15}}$$

$\dot{n}$ = 58.173 mol/s

(c) * * *

(1) To calculate $\dot{n}$ through one venturi or one combination of venturis, use its respective mean C_d and other constants you determined according to § 1065.640 and calculate $\dot{n}$ as follows:

$$\dot{n} = C_d \cdot C_f \cdot \frac{A_t \cdot p_{in}}{\sqrt{Z \cdot M_{mix} \cdot R \cdot T_{in}}}$$

Eq. 1065.642-4

Where:
C_f = flow coefficient, as determined in § 1065.640(c)(3).

Example:
C_d = 0.985
C_f = 0.7219
A_t = 0.00456 m²
p_{in} = 98.836 kPa = 98836 Pa = 98836 kg/(m·s²)
Z = 1
M_{mix} = 28.7805 g/mol = 0.0287805 kg/mol
R = 8.314472 J/(mol·K) = 8.314472 (m²·kg)/(s²·mol·K)
T_{in} = 378.15 K

$$\dot{n} = 0.985 \cdot 0.7219 \cdot \frac{0.00456 \cdot 98836}{\sqrt{1 \cdot 0.0287805 \cdot 8.314472 \cdot 378.15}}$$

$\dot{n}$ = 33.690 mol/s

* * * * *

352. Add § 1065.643 to read as follows:

§ 1065.643 Carbon balance error verification calculations.

This section describes ~~the equations for calculating carbon balance error~~how to calculate quantities used in the carbon balance error verification described in § 1065.543. Paragraphs (a) through (c) of this section describe how to c~~C~~alculate the mass of carbon for a test interval from ~~in all of the~~ carbon-carrying fluid streams, intake air into the system, and exhaust emissions~~,~~, respectively~~over the test interval~~. Paragraph (d) of this section describes how to use these carbon masses to calculate four different quantities for evaluating carbon balance error. ~~You may u~~Use rectangular or trapezoidal integration methods to calculate masses and amounts over a test interval from continuously measured or calculated mass and molar flow rates.~~You may use ECM broadcast signals for DEF flow rate to calculate the mass of carbon into the stream from the DEF system. You may use ECM broadcast fuel flow rate for field testing to calculate the mass of carbon in the fuel stream into the system.~~

(a) Fuel and other fluids. Determine the mass~~es~~ of fuel, DEF, and other ~~of all the~~ carbon-carrying fluid streams, other than intake air, ~~(fuel and other (e.g., DEF))~~flowing into the system ~~over each test interval~~, $m_{\text{fluid}j}$, for each test interval~~where *j* is an indexing variable that represents one carbon-carrying fluid stream~~. Note that §1065.543 allows you to omit all flows other than fuel. You may determine the mass of DEF based on ECM signals for DEF flow rate. You may determine fuel mass during field testing based on ECM signals for fuel flow rate. C

~~(b) For each test interval c~~alculate the mass of carbon ~~in all of the~~from the combined carbon-carrying fluid streams flowing into the system as follows:

$$m_{\text{Cfluid}} = \sum_{j=1}^{N}\left(w_{\text{C}j} \cdot m_{\text{fluid}j}\right)$$

Eq. 1065.643-1

Where:

j = an indexing variable that represents one carbon-carrying fluid stream.

N = total number of carbon-carrying fluid streams into the system over the test interval.

w_{C} = carbon mass fraction of the carbon-carrying fluid stream as determined in § 1065.655(d).

m_{fluid} = the mass of the carbon-carrying fluid stream determined over the test interval.

~~*j* = an indexing variable that represents one carbon-carrying fluid stream.~~

~~*M* = total number of carbon-carrying fluid streams into the system over the test interval.~~

Example:

N = 2

w_{Cfuel} = 0.869

w_{CDEF} = 0.065

m_{fuel} = 1119.6 g

m_{DEF} = 36.8 g

~~*M* = 2~~

$$m_{\text{Cfluid}} = 0.869 \cdot 1119.6 + 0.065 \cdot 36.8 = 975.3 \text{ g}$$

(~~c~~b) Intake air. Calculate the mass of carbon in the intake air~~ that flowed into the system~~, m_{Cair}, for each test interval~~,~~ using one of the methods in this paragraph (b). The methods are listed ~~below~~ in order of preference. Use the first method where all the inputs are available for your test configuration. For methods that calculate m_{Cair} based on the amount of CO_2 per mole of intake air, we recommend measuring intake air concentration, but you may calculate x_{CO2int} using Eq. 1065.655-10 and letting $x_{\text{CO2intdry}}$ = 375 µmol/mol.

(1) Calculate m_{Cair}, using the following equation if you measure intake air flow~~When the amount of intake air is measured over the test interval~~:

$$m_{Cair} = M_C \cdot n_{int} \cdot x_{CO2int}$$

Eq. 1065.643-2

Where:

M_C = molar mass of carbon.

n_{int} = ~~the~~ measured amount of intake air over the test interval.

x_{CO2int} = ~~the~~ amount of intake air CO_2 per mole of intake air. ~~You may calculate x_{CO2int} using Eq. 1065.655-10 and $x_{CO2intdry}$ = 375 µmol/mol, but we recommend measuring the actual concentration in the intake air.~~

Example:

M_C = 12.0107 g/mol

n_{int} = 62862 mol

x_{CO2int} = 369 µmol/mol = 0.000369 mol/mol

$$m_{Cair} = 12.0107 \cdot 62862 \cdot 0.000369 = 278.6 \text{ g}$$

(2) Calculate m_{Cair}, using the following equation if you measure or calculate ~~When the amount of~~ raw exhaust flow and you calculate~~is measured or calculated, and~~ chemical balance terms ~~are calculated for the raw exhaust~~:

$$m_{Cair} = M_C \cdot n_{exh} \cdot (1 - x_{H2Oexh}) \cdot x_{CO2int} \cdot (x_{dil/exhdry} + x_{int/exhdry})$$

Eq. 1065.643-3

Where:

M_C = molar mass of carbon.

n_{exh} = ~~the~~ calculated or measured amount of ~~amount of~~ raw exhaust over the test interval.

x_{H2Oexh} = amount of H_2O in exhaust per mole of exhaust.

x_{CO2int} = ~~the~~ amount of intake air CO_2 per mole of intake air. ~~You may calculate x_{CO2int} using Eq. 1065.655-10 and $x_{CO2intdry}$ = 375 µmol/mol, but we recommend measuring the actual concentration in the intake air.~~

$x_{dil/exhdry}$ = amount of excess air per mole of dry exhaust. Note that excess air and intake air have the same composition~~for the chemical balance calculation from raw exhaust~~, so $x_{CO2dil} = x_{CO2int}$ and $x_{H2Odil} = x_{H2Oint}$ for the chemical balance calculation for raw exhaust.~~, as excess air and intake air have the same composition.~~

$x_{int/exhdry}$ = amount of intake air required to produce actual combustion products per mole of dry exhaust.

Example:

M_C = 12.0107 g/mol

n_{exh} = 62862 mol

x_{H2Oexh} = 0.034 mol/mol

x_{CO2int} = 369 µmol/mol = 0.000369 mol/mol

$x_{dil/exhdry}$ = 0.570 mol/mol

$x_{int/exhdry}$ = 0.465 mol/mol

$$m_{Cair} = 12.0107 \cdot 62862 \cdot (1 - 0.034) \cdot 0.000369 \cdot (0.570 + 0.465) = 278.6 \text{ g}$$

(3) Calculate m_{Cair}, using the following equation if you measure ~~When the amount of~~ raw exhaust flow ~~is measured~~:

$$m_{Cair} = M_C \cdot n_{exh} \cdot x_{CO2int}$$

Eq. 1065.643-4

Where:

M_C = molar mass of carbon.

n_{exh} = ~~the~~ measured amount of raw exhaust over the test interval.

x_{CO2int} = ~~the~~ amount of intake air CO_2 per mole of intake air. ~~You may calculate x_{CO2int} using Eq. 1065.655-10 and $x_{CO2intdry}$ = 375 µmol/mol, but we recommend measuring the actual concentration in the intake air.~~

Example:

M_C = 12.0107 g/mol

n_{exh} = 62862 mol

x_{CO2int} = 369 µmol/mol = 0.000369 mol/mol

$$m_{Cair} = 12.0107 \cdot 62862 \cdot 0.000369 = 278.6 \text{ g}$$

(4) Calculate m_{Cair}, using the following equation if you measure ~~When the amount of~~ diluted exhaust flow and dilution air flow ~~are measured~~:

$$m_{Cair} = M_C \cdot \left(n_{dexh} - n_{dil}\right) \cdot x_{CO2int}$$

Eq. 1065.643-5

Where:

M_C = molar mass of carbon.

n_{dexh} = ~~the~~ measured amount of diluted exhaust over the test interval as determined in § 1065.642.

n_{dil} = ~~the~~ measured amount of dilution air over the test interval as determined in § 1065.667(b).

x_{CO2int} = ~~the~~ amount of intake air CO_2 per mole of intake air. ~~You may calculate x_{CO2int} using Eq. 1065.655-10 and $x_{CO2intdry}$ = 375 µmol/mol, but we recommend measuring the actual concentration in the intake air.~~

Example:

M_C = 12.0107 g/mol

n_{dexh} = 942930 mol

n_{dil} = 880068 mol

x_{CO2int} = 369 µmol/mol = 0.000369 mol/mol

$$m_{Cair} = 12.0107 \cdot \left(942930 - 880068\right) \cdot 0.000369 = 278.6 \text{ g}$$

(5) ~~When the amount of intake air can be d~~Determined ~~from recorded ECM broadcast signals, use ECM broadcast intake air to determine~~ m_{Cair} based on ECM signals for intake air flow as described in paragraph (~~c~~b)(1) of this section.

(6) If you measure ~~When~~ diluted exhaust ~~is measured~~, determine m_{Cair} as described in paragraph (b)(4) of this section using~~use~~ a calculated amount of dilution air over the test interval as determined in § 1065.667(d) instead of the measured amount of dilution air ~~to determine m_{Cair} as described in paragraph (c)(4) of this section~~.

(~~d~~c) Exhaust emissions. Calculate the mass of carbon in exhaust emissions, m_{Cexh}, for each test interval as follows:

$$m_{\text{Cexh}} = M_{\text{C}} \cdot \left(\frac{m_{\text{CO2}}}{M_{\text{CO2}}} + \frac{m_{\text{CO}}}{M_{\text{CO}}} + \frac{m_{\text{THC}}}{M_{\text{THC}}} \right)$$

Eq. 1065.643-6

Where:

M_C = molar mass of carbon.

m_{CO2} = mass of CO_2 over the test interval as determined in § 1065.650(c).

M_{CO2} = molar mass of carbon dioxide.

m_{CO} = mass of CO over the test interval as determined in § 1065.650(c).

M_{CO} = molar mass of carbon monoxide.

m_{THC} = mass of THC over the test interval as determined in § 1065.650(c).

M_{THC} = effective C_1 molar mass of total hydrocarbon as defined in § 1065.1005(f)(2).

m_{CO2} = is the mass of CO_2 over the test interval as determined in § 1065.650(c).

m_{CO} = is the mass of CO over the test interval as determined in § 1065.650(c).

m_{THC} = is the mass of THC over the test interval as determined in § 1065.650(c).

Example:

M_C = 12.0107 g/mol

m_{CO2} = 4567 g

M_{CO2} = 44.0095 g/mol

m_{CO} = 0.803 g

M_{CO} = 28.0101 g/mol

m_{THC} = 0.537 g

M_{THC} = 13.875389 g/mol

m_{CO2} = 4567 g

m_{CO} = 0.803 g

m_{THC} = 0.537 g

$$m_{\text{Cexh}} = 12.0107 \cdot \left(\frac{4567}{44.0095} + \frac{0.803}{28.0101} + \frac{0.537}{13.875389} \right) = 1247.2 \text{ g}$$

(ed) Carbon balance error quantities. Calculate carbon balance error quantities as follows:

(1) Calculate carbon mass absolute error, ϵ_{aC}, for a test interval as follows:

$$\epsilon_{\text{aC}} = m_{\text{Cexh}} - m_{\text{Cfluid}} - m_{\text{Cair}}$$

Eq. 1065.643-7

Where:

m_{Cexh} = mass of carbon in exhaust emissions over the test interval as determined in paragraph (d) of this section.

m_{Cfluid} = mass of carbon in all of the carbon-carrying fluid streams that flowedflowing into the system over the test interval as determined in paragraph (ba) of this section.

m_{Cair} = mass of carbon in the intake air that flowedflowing into the system over the test interval as determined in paragraph (cb) of this section.

Example:

m_{Cexh} = 1247.2 g

m_{Cfluid} = 975.3 g

m_{Cair} = 278.6 g

$$\epsilon_{aC} = 1247.2 - 975.3 - 278.6 = -6.7 \text{ g}$$

(2) Calculate carbon mass rate absolute error, ϵ_{aCrate}, for a test interval as follows:

$$\epsilon_{aCrate} = \frac{\epsilon_{aC}}{t}$$

Eq. 1065.643-8

Where:

t = duration of the test interval.

Example:

ϵ_{aC} = –6.7 g

t = 1202.2 s = 0.3339 hr

$$\epsilon_{aCrate} = \frac{-6.7}{0.3339} = -20.065 \text{ g/hr}$$

(3) Calculate carbon mass relative error, ϵ_{rC}, for a test interval as follows:

$$\epsilon_{rC} = \frac{\epsilon_{aC}}{m_{Cfluid} + m_{Cair}}$$

Eq. 1065.643-9

Example:

ϵ_{aC} = –6.7 g

m_{Cfliud} = 975.3 g

m_{Cair} = 278.6 g

$$\epsilon_{rC} = \frac{-6.7}{975.3 + 278.6} = -0.0053$$

(4) Calculate composite carbon mass relative error, ϵ_{rCcomp}, for a duty cycle with multiple test intervals as follows:

(i) ~~Use the following equation to c~~Calculate~~,~~ ϵ_{rCcomp}~~,~~ using the following equation~~for duty cycles with multiple test intervals of a prescribed duration, such as cold-start and hot-start transient cycles~~:

$$\epsilon_{rCcomp} = \frac{\sum_{i=1}^{N} WF_i \cdot \frac{\left(m_{Cexhi} - m_{Cfluidi} - m_{Cairi}\right)}{t_i}}{\sum_{i=1}^{N} WF_i \cdot \frac{\left(m_{Cfluidi} + m_{Cairi}\right)}{t_i}}$$

Eq. 1065.643-10

Where:

i = an indexing variable that represents one test interval~~ number~~.

N = number of test intervals.

WF = weighting factor for the test interval as defined in the standard-setting part.

m_{Cexh} = mass of carbon in exhaust emissions over the test interval as determined in paragraph (~~d~~c) of this section.

m_{Cfluid} = mass of carbon in all ~~of~~ the carbon-carrying fluid streams that flowed into the system over the test interval as determined in paragraph (~~b~~a) of this section.

m_{Cair} = mass of carbon in the intake air that flowed into the system over the test interval as determined in paragraph (~~c~~b) of this section.

t = duration of the test interval. For duty cycles with multiple test intervals of a prescribed duration, such as cold-start and hot-start transient cycles, set t = 1 for all test intervals. For discrete-mode steady-state duty cycles with multiple test intervals of varying duration, set t equal to the actual duration of each test interval.

(ii) The following example illustrates calculation of ϵ_{rCcomp}, for cold-start and hot-start transient cycles:

Example:

$N = 2$

$WF_1 = 1/7$

$WF_2 = 6/7$

$m_{\text{Cexh1}} = 1255.3$ g

$m_{\text{Cexh2}} = 1247.2$ g

$m_{\text{Cfluid1}} = 977.8$ g

$m_{\text{Cfluid2}} = 975.3$ g

$m_{\text{Cair1}} = 280.2$ g

$m_{\text{Cair2}} = 278.6$ g

$$\epsilon_{\text{rCcomp}} = \frac{\frac{1}{7}\cdot\frac{(1255.3-977.8-280.2)}{1}+\frac{6}{7}\cdot\frac{(1247.2-975.3-278.6)}{1}}{\frac{1}{7}\cdot\frac{(977.8+280.2)}{1}+\frac{6}{7}\cdot\frac{(975.3+278.6)}{1}} = -0.0049$$

(iii) The following example illustrates calculation ofUse the following equation to calculate, ϵ_{rCcomp}, for duty cycles with multiple test intervals that allow use ofwith varying duration, such as discrete-mode steady-state duty cycles:

$$\epsilon_{\text{rCcomp}} = \frac{\sum_{i=1}^{N} WF_i \cdot \frac{(m_{\text{Cexh}i} - m_{\text{Cfluid}i} - m_{\text{Cair}i})}{t_i}}{\sum_{i=1}^{N} WF_i \cdot \frac{(m_{\text{Cfluid}i} + m_{\text{Cair}i})}{t_i}}$$

Eq. 1065.643-11

Where:

t = duration of the test interval.

Example:

$N = 2$

$WF_1 = 0.85$

$WF_2 = 0.15$

$m_{\text{Cexh1}} = 2.873$ g

$m_{\text{Cexh2}} = 0.125$ g

$m_{\text{Cfluid1}} = 2.864$ g

$m_{\text{Cfluid2}} = 0.095$ g

$m_{\text{Cair1}} = 0.023$ g

$m_{\text{Cair2}} = 0.024$ g

$t_1 = 123$ s

$t_2 = 306$ s

$$\grave{o}_{\mathrm{rCcomp}} = \frac{0.85 \cdot \left(\frac{2.873 - 2.864 - 0.023}{123}\right) + 0.15 \cdot \left(\frac{0.125 - 0.095 - 0.024}{306}\right)}{0.85 \cdot \left(\frac{2.864 + 0.023}{123}\right) + 0.15 \cdot \left(\frac{0.095 + 0.024}{306}\right)} = -0.0047$$

353. Amend § 1065.650 by revising paragraphs (b)(3) introductory text, (c)(1), (c)(2)(i) introductory text, (c)(3), (d) introductory text, (d)(7), (f)(2) introductory text, and (g) to read as follows:

§ 1065.650 Emission calculations.

* * * * *

(b) * * *

(3) For field testing, you may calculate the ratio of total mass to total work, where these individual values are determined as described in paragraph (f) of this section. You may also use this approach for laboratory testing, consistent with good engineering judgment. Good engineering judgment dictates that this method not be used if there are any work flow paths described in § 1065.210 that cross the system boundary, other than the primary output shaft (crankshaft). This is a special case in which you use a signal linearly proportional to raw exhaust molar flow rate to determine a value proportional to total emissions. You then use the same linearly proportional signal to determine total work using a chemical balance of fuel, DEF, intake air, and exhaust as described in § 1065.655, plus information about your engine's brake-specific fuel consumption. Under this method, flow meters need not meet accuracy specifications, but they must meet the applicable linearity and repeatability specifications in subpart D or subpart J of this part. The result is a brake-specific emission value calculated as follows:

* * * * *

(c) * * *

(1) Concentration corrections. Perform the following sequence of preliminary calculations on recorded concentrations:

(i) Use good engineering judgment to time-align flow and concentration data to match transformation time, t_{50}, to within ±1 s.

(ii) Correct all gaseous emission analyzer concentration readings, including continuous readings, sample bag readings, and dilution air background readings, for drift as described in § 1065.672. Note that you must omit this step where brake-specific emissions are calculated without the drift correction for performing the drift validation according to § 1065.550(b). When applying the initial THC and CH_4 contamination readings according to § 1065.520(f), use the same values for both sets of calculations. You may also use as-measured values in the initial set of calculations and corrected values in the drift-corrected set of calculations as described in § 1065.520(f)(7).

(iii) Correct all THC and CH_4 concentrations for initial contamination as described in § 1065.660(a), including continuous readings, sample bags readings, and dilution air background readings.

(~~iii~~iv) Correct all concentrations measured on a "dry" basis to a "wet" basis, including dilution air background concentrations, as described in § 1065.659.

(~~i~~v) Calculate all NMHC and CH_4 concentrations, including dilution air background concentrations, as described in § 1065.660.

(vi) For emission testing with an oxygenated fuel, calculate any HC concentrations, including dilution air background concentrations, as described in § 1065.665. See subpart I of this part for testing with oxygenated fuels.

(vii) Correct all the NO_x concentrations, including dilution air background concentrations, for intake-air humidity as described in § 1065.670.

(2) * * *

(i) Varying flow rate. If you continuously sample from a changing exhaust flow rate, time align and then multiply concentration measurements by the flow rate from which you extracted it. ~~Use good engineering judgment to time-align flow and concentration data to match transformation time, t_{50}, to within ±1 s.~~ We consider the following to be examples of changing flows that require a continuous multiplication of concentration times molar flow rate: raw exhaust, exhaust diluted with a constant flow rate of dilution air, and CVS dilution with a CVS flow meter that does not have an upstream heat exchanger or electronic flow control. This multiplication results in the flow rate of the emission itself. Integrate the emission flow rate over a test interval to determine the total emission. If the total emission is a molar quantity, convert this quantity to a mass by multiplying it by its molar mass, *M*. The result is the mass of the emission, *m*. Calculate *m* for continuous sampling with variable flow using the following equations:

* * * * *

(3) Batch sampling. For batch sampling, the concentration is a single value from a proportionally extracted batch sample (such as a bag, filter, impinger, or cartridge). In this case, multiply the mean concentration of the batch sample by the total flow from which the sample was extracted. You may calculate total flow by integrating a changing flow rate or by determining the mean of a constant flow rate, as follows:

(i) Varying flow rate. If you collect a batch sample from a changing exhaust flow rate, extract a sample proportional to the changing exhaust flow rate. We consider the following to be examples of changing flows that require proportional sampling: raw exhaust, exhaust diluted with a constant flow rate of dilution air, and CVS dilution with a CVS flow meter that does not have an upstream heat exchanger or electronic flow control. Integrate the flow rate over a test interval to determine the total flow from which you extracted the proportional sample. Multiply the mean concentration of the batch sample by the total flow from which the sample was extracted. If the total emission is a molar quantity, convert this quantity to a mass by multiplying it by its molar mass, *M*. The result is the mass of the emission, *m*. In the case of PM emissions, where the mean PM concentration is already in units of mass per mole of sample, $\bar{M}_{PM}$, simply multiply it by the total flow. The result is the total mass of PM, m_{PM}. Calculate *m* for batch sampling with variable flow using the following equation:

$$m = M \cdot \bar{x} \cdot \sum_{i=1}^{N} \dot{n}_i \cdot \Delta t$$

Eq. 1065.650-6

Commented [CAL62]: Equation updated.

Example:

M_{NOx} = 46.0055 g/mol

N = 9000

$\bar{x}_{NOx}$ = 85.6 µmol/mol = 85.6·10^{-6} mol/mol

$\dot{n}_{dexh1}$ = 25.534 mol/s

$\dot{n}_{dexh2}$ = 26.950 mol/s

f_{record} = 5 Hz

Using Eq. 1065.650-5,
Δt = 1/5 = 0.2
$m_{\mathrm{NOx}} = 46.0055 \cdot 85.6 \cdot 10^{-6} \cdot (25.534 + 26.950 + ... + \dot{n}_{\mathrm{exh9000}}) \cdot 0.2$
m_{NOx} = 4.201 g

(ii) Constant flow rate. If you batch sample from a constant exhaust flow rate, extract a sample at a proportional or constant flow rate. We consider the following to be examples of constant exhaust flows: CVS diluted exhaust with a CVS flow meter that has either an upstream heat exchanger, electronic flow control, or both. Determine the mean molar flow rate from which you extracted the constant flow rate sample. Multiply the mean concentration of the batch sample by the mean molar flow rate of the exhaust from which the sample was extracted, and multiply the result by the time of the test interval. If the total emission is a molar quantity, convert this quantity to a mass by multiplying it by its molar mass, *M*. The result is the mass of the emission, *m*. In the case of PM emissions, where the mean PM concentration is already in units of mass per mole of sample, $\bar{M}_{\mathrm{PM}}$, simply multiply it by the total flow, and the result is the total mass of PM, m_{PM}, —.Calculate *m* for sampling with constant flow using the following equations:

$$m = M \cdot \bar{x} \cdot \bar{\dot{n}} \cdot \Delta t$$

Eq. 1065.650-7

$\bar{M}$ and for PM or any other analysis of a batch sample that yields a mass per mole of sample,

$$\bar{M} = M \cdot \bar{x}$$

Eq. 1065.650-8

Example:
$\bar{M}_{\mathrm{PM}}$ = 144.0 µg/mol = 144.0·10^{-6} g/mol
$\bar{\dot{n}}_{\mathrm{dexh}}$ = 57.692 mol/s
Δt = 1200 s
m_{PM} = 144.0·10^{-6}·57.692·1200
m_{PM} = 9.9692 g

*   *   *   *   *

(d) Total work over a test interval. To calculate the total work from the engine over a test interval, add the total work from all the work paths described in § 1065.210 that cross the system boundary including electrical energy/work, mechanical shaft work, and fluid pumping work. For all work paths, except the engine's primary output shaft (crankshaft), the total work for the path over the test interval is the integration of the net work flow rate (power) out of the system boundary. When energy/work flows into the system boundary, this work flow rate signal becomes negative; in this case, include these negative work rate values in the integration to calculate total work from that work path. Some work paths may result in a negative total work. Include negative total work values from any work path in the calculated total work from the engine rather than setting the values to zero. The rest of this paragraph (d) describes how to calculate total work from the engine's primary output shaft over a test interval. Before integrating power on the engine's primary output shaft, adjust the speed and torque data for the time alignment used in § 1065.514(c). Any advance or delay used on the feedback signals for cycle validation must also be used for calculating work. Account for work of accessories according to § 1065.110. Exclude any work during cranking and starting. Exclude work during actual motoring operation (negative feedback torques), unless the engine was connected to one or more energy storage devices. Examples of such energy storage devices include hybrid powertrain batteries and hydraulic accumulators, like the ones illustrated in Figure 1 of

§ 1065.210. Exclude any work during reference zero-load idle periods (0 % speed or idle speed with 0 N·m reference torque). Note, that there must be two consecutive reference zero load idle points to establish a period where this applies. Include work during idle points with simulated minimum torque such as Curb Idle Transmissions Torque (CITT) for automatic transmissions in “drive”. The work calculation method described in paragraphs (~~b~~d)(1) though (7) of this section meets these requirements using rectangular integration. You may use other logic that gives equivalent results. For example, you may use a trapezoidal integration method as described in paragraph (~~b~~d)(8) of this section.

* * * * *

(7) Integrate the resulting values for power over the test interval. Calculate total work as follows:

$$W = \sum_{i=1}^{N} P_i \cdot \Delta t$$

Eq. 1065.650-10

Commented [CAL63]: Equation updated.

Where:

W = total work from the primary output shaft

P_i = instantaneous power from the primary output shaft over an interval i.

$$P_i = f_{ni} \cdot T_i$$

Eq. 1065.650-11

Example:

N = 9000

f_{n1} = 1800.2 r/min

f_{n2} = 1805.8 r/min

T_1 = 177.23 N·m

T_2 = 175.00 N·m

C_{rev} = 2·π rad/r

C_{t1} = 60 s/min

C_p = 1000 (N·m·rad/s)/kW

f_{record} = 5 Hz

C_{t2} = 3600 s/hr

$$P_1 = \frac{1800.2 \cdot 177.23 \cdot 2 \cdot 3.14159}{60 \cdot 1000}$$

P_1 = 33.41 kW

P_2 = 33.09 kW

Using Eq. 1065.650-5,

Δt = 1/5 = 0.2 s

$$W = \frac{(33.41 + 33.09 + ... + P_{9000}) \cdot 0.2}{3600}$$

W = 16.875 kW·hr

* * * * *

(f) * * *

(2) <u>Total work</u>. To calculate a value proportional to total work over a test interval, integrate a value that is proportional to power. Use information about the brake-specific fuel consumption of your engine, e_{fuel}, to convert a signal proportional to fuel flow rate to a signal proportional to

power. To determine a signal proportional to fuel flow rate, divide a signal that is proportional to the mass rate of carbon products by the fraction of carbon in your fuel, w_C.. You may use a measured w_C or you may use default values for a given fuel as described in § 1065.655(e). Calculate the mass rate of carbon from the amount of carbon and water in the exhaust, which you determine with a chemical balance of fuel, DEF, intake air, and exhaust as described in § 1065.655. In the chemical balance, you must use concentrations from the flow that generated the signal proportional to molar flow rate, $\tilde{n}$, in paragraph (e)(1) of this section. Calculate a value proportional to total work as follows:

*   *   *   *   *

(g) Brake-specific emissions over a duty cycle with multiple test intervals. The standard-setting part may specify a duty cycle with multiple test intervals, such as with discrete-mode steady-state testing. Unless we specify otherwise, calculate composite brake-specific emissions over the duty cycle as described in this paragraph (g). If a measured mass (or mass rate) is negative, set it to zero for calculating composite brake-specific emissions, but leave it unchanged for drift validation. In the case of calculating composite brake-specific emissions relative to a combined emission standard (such as a NO_x + NMHC standard), change any negative mass (or mass rate) values to zero for a particular pollutant before combining the values for the different pollutants.

(1) Use the following equation to calculate composite brake-specific emissions for duty cycles with multiple test intervals all with prescribed durations, such as cold-start and hot-start transient cycles:

$$e_{\text{comp}} = \frac{\sum_{i=1}^{N} WF_i \cdot m_i}{\sum_{i=1}^{N} WF_i \cdot W_i}$$

Eq. 1065.650-17

Commented [CAL64]: Equation updated.

Where

i = test interval number.

N = number of test intervals.

WF = weighting factor for the test interval as defined in the standard-setting part.

m = mass of emissions over the test interval as determined in paragraph (c) of this section.

W = total work from the engine over the test interval as determined in paragraph (d) of this section.

Example:

N = 2

WF_1 = 0.1428

WF_2 = 0.8572

m_1 = 70.125 g

m_2 = 64.975 g

W_1 = 25.783 kW·hr

W_2 = 25.783 kW·hr

$$e_{NO_x\text{comp}} = \frac{(0.1428 \cdot 70.125) + (0.8572 \cdot 64.975)}{(0.1428 \cdot 25.783) + (0.8572 \cdot 25.783)}$$

e_{NOxcomp}~~osite~~ = 2.548 g/kW·hr

Commented [CAL65]: Example updated.

(2) Calculate composite brake-specific emissions for duty cycles with multiple test intervals that allow use of varying duration, such as discrete-mode steady-state duty cycles, as follows:
(i) Use the following equation if you calculate brake-specific emissions over test intervals based on total mass and total work as described in paragraph (b)(1) of this section:

$$e_{\text{comp}} = \frac{\sum_{i=1}^{N} WF_i \cdot \frac{m_i}{t_i}}{\sum_{i=1}^{N} WF_i \cdot \frac{W_i}{t_i}}$$

Eq. 1065.650-18

Commented [CAL66]: Equation updated.

Where
i = test interval number.
N = number of test intervals.
WF = weighting factor for the test interval as defined in the standard-setting part.
m = mass of emissions over the test interval as determined in paragraph (c) of this section.
W = total work from the engine over the test interval as determined in paragraph (d) of this section.
t = duration of the test interval.

Example:
$N = 2$
$WF_1 = 0.85$
$WF_2 = 0.15$
$m_1 = 1.3753$ g
$m_2 = 0.4135$ g
$t_1 = 120$ s
$t_2 = 200$ s
$W_1 = 2.8375$ kW·hr
$W_2 = 0.0$ kW·hr

$$e_{\text{NO}_x\text{comp}} = \frac{\left(0.85 \cdot \frac{1.3753}{120}\right) + \left(0.15 \cdot \frac{0.4135}{200}\right)}{\left(0.85 \cdot \frac{2.8375}{120}\right) + \left(0.15 \cdot \frac{0.0}{200}\right)}$$

Commented [CAL67]: Example updated.

e_{NOxcomp}~~osite~~ = 0.5001 g/kW·hr
(ii) Use the following equation if you calculate brake-specific emissions over test intervals based on the ratio of mass rate to power as described in paragraph (b)(2) of this section:

$$e_{\text{comp}} = \frac{\sum_{i=1}^{N} WF_i \cdot \bar{\dot{m}}_i}{\sum_{i=1}^{N} WF_i \cdot \bar{P}_i}$$

Eq. 1065.650-19

Commented [CAL68]: Equation updated.

Where
i = test interval number.

N = number of test intervals.
WF = weighting factor for the test interval as defined in the standard-setting part.
$\bar{m}$ = mean steady-state mass rate of emissions over the test interval as determined in paragraph (e) of this section.
$\bar{P}$ = mean steady-state power over the test interval as described in paragraph (e) of this section.

Example:
$N = 2$
$WF_1 = 0.85$
$WF_2 = 0.15$
$\bar{m}_1 = 2.25842$ g/hr
$\bar{m}_2 = 0.063443$ g/hr
$\bar{P}_1 = 4.5383$ kW
$\bar{P}_2 = 0.0$ kW

$$e_{\mathrm{NO}_x\mathrm{comp}} = \frac{(0.85 \cdot 2.25842) + (0.15 \cdot 0.063443)}{(0.85 \cdot 4.5383) + (0.15 \cdot 0.0)}$$

e_{NOxcomp}~~osite~~ = 0.5001 g/kW·hr
* * * * *

354. Amend § 1065.655 by revising the section heading and paragraphs (a), (c) introductory text, (c)(3), (d) introductory text, (e), and (f)(3) to read as follows:

§ 1065.655 Chemical balances of fuel, DEF, intake air, and exhaust.

(a) General. Chemical balances of fuel, intake air, and exhaust may be used to calculate flows, the amount of water in their flows, and the wet concentration of constituents in their flows. With one flow rate of either fuel, intake air, or exhaust, you may use chemical balances to determine the flows of the other two. For example, you may use chemical balances along with either intake air or fuel flow to determine raw exhaust flow. Note that chemical balance calculations ~~require~~ allow measured values for the flow rate of diesel exhaust fluid for engines with urea-based selective catalytic reduction~~, if applicable~~.
* * * * *

(c) Chemical balance procedure. The calculations for a chemical balance involve a system of equations that require iteration. We recommend using a computer to solve this system of equations. You must guess the initial values of up to three quantities: the amount of water in the measured flow, x_{H2Oexh}, fraction of dilution air in diluted exhaust, $x_{\mathrm{dil/exh}}$, and the amount of products on a C_1 basis per dry mole of dry measured flow, x_{Ccombdry}. You may use time-weighted mean values of combustion air humidity and dilution air humidity in the chemical balance; as long as your combustion air and dilution air humidities remain within tolerances of ±0.0025 mol/mol of their respective mean values over the test interval. For each emission concentration, x, and amount of water, x_{H2Oexh}, you must determine their completely dry concentrations, x_{dry} and $x_{\mathrm{H2Oexhdry}}$. You must also use your fuel mixture's atomic hydrogen-to-carbon ratio, α, oxygen-to-carbon ratio, β, sulfur-to-carbon ratio, γ, and nitrogen-to-carbon ratio, δ; you may optionally account for diesel exhaust fluid (or other fluids injected into the exhaust), if applicable. You may calculate α, β, γ, and δ based on measured fuel composition or based on measured fuel and diesel exhaust fluid (or other fluids injected into the exhaust) composition together, as described

Commented [CAL69]: Example updated.

in paragraph (e) of this section. ~~or y~~You may alternatively use any combination of default values and measured values as described in paragraph (e) of this section. Use the following steps to complete a chemical balance:

* * * * *

(3) Use the following symbols and subscripts in the equations for performing the chemical balance calculations in this paragraph (c):

$x_{dil/exh}$ = amount of dilution gas or excess air per mole of exhaust.

x_{H2Oexh} = amount of H_2O in exhaust per mole of exhaust.

$x_{Ccombdry}$ = amount of carbon from fuel and any injected fluids in the exhaust per mole of dry exhaust.

x_{H2dry} = amount of H_2 in exhaust per amount of dry exhaust.

K_{H2Ogas} = water-gas reaction equilibrium coefficient. You may use 3.5 or calculate your own value using good engineering judgment.

$x_{H2Oexhdry}$ = amount of H_2O in exhaust per dry mole of dry exhaust.

$x_{prod/intdry}$ = amount of dry stoichiometric products per dry mole of intake air.

$x_{dil/exhdry}$ = amount of dilution gas and/or excess air per mole of dry exhaust.

$x_{int/exhdry}$ = amount of intake air required to produce actual combustion products per mole of dry (raw or diluted) exhaust.

$x_{raw/exhdry}$ = amount of undiluted exhaust, without excess air, per mole of dry (raw or diluted) exhaust.

x_{O2int} = amount of intake air O_2 per mole of intake air.

$x_{CO2intdry}$ = amount of intake air CO_2 per mole of dry intake air. You may use $x_{CO2intdry}$ = 375 µmol/mol, but we recommend measuring the actual concentration in the intake air.

$x_{H2Ointdry}$ = amount of intake air H_2O per mole of dry intake air.

x_{CO2int} = amount of intake air CO_2 per mole of intake air.

x_{CO2dil} = amount of dilution gas CO_2 per mole of dilution gas.

$x_{CO2dildry}$ = amount of dilution gas CO_2 per mole of dry dilution gas. If you use air as diluent, you may use $x_{CO2dildry}$ = 375 µmol/mol, but we recommend measuring the actual concentration in the intake air.

$x_{H2Odildry}$ = amount of dilution gas H_2O per mole of dry dilution gas.

x_{H2Odil} = amount of dilution gas H_2O per mole of dilution gas.

$x_{[emission]meas}$ = amount of measured emission in the sample at the respective gas analyzer.

$x_{[emission]dry}$ = amount of emission per dry mole of dry sample.

$x_{H2O[emission]meas}$ = amount of H_2O in sample at emission-detection location. Measure or estimate these values according to § 1065.145(e)(2).

x_{H2Oint} = amount of H_2O in the intake air, based on a humidity measurement of intake air.

α = atomic hydrogen-to-carbon ratio of the fuel (or mixture of test fuels) and any injected fluids.

β = atomic oxygen-to-carbon ratio of the fuel (or mixture of test fuels) and any injected fluids.

γ~~δ~~ = atomic sulfur-to-carbon ratio of the fuel (or mixture of test fuels) and any injected fluids.

δ ~~γ~~ = atomic nitrogen-to-carbon ratio of the fuel (or mixture of test fuels) and any injected fluids.

* * * * *

(d) Carbon mass fraction of fuel. Determine carbon mass fraction of fuel, w_C, based on the fuel properties as determined in paragraph (e) of this section, optionally accounting for diesel exhaust fluid's contribution to α, β, γ, and δ, or other fluids injected into the exhaust, if applicable (for example, the engine is equipped with an emission control system that utilizes DEF). Calculate w_C using the following equation:

* * * * *

(e) Fuel and diesel exhaust fluid composition. Determine fuel and diesel exhaust fluid composition represented by α, β, γ, and δ as described in this paragraph (e). When using measured fuel or diesel exhaust fluid properties, you must determine values for α and β in all cases. If you determine compositions based on measured values and the default value listed in Table 1 of this section is zero, you may set γ and δ to zero; otherwise determine γ and δ (along with α and β) based on measured values. Determine elemental mass fractions and values for α, β, γ, and δ as follows:

(1) For liquid fuels, use the default values for α, β, γ, and δ in Table 1 of this section or determine mass fractions of liquid fuels for calculation of α, β, γ, and δ as follows:

(i) Determine the carbon and hydrogen mass fractions according to ASTM D5291 (incorporated by reference in § 1065.1010). When using ASTM D5291 to determine carbon and hydrogen mass fractions of gasoline (with or without blended ethanol), use good engineering judgment to adapt the method as appropriate. This may include consulting with the instrument manufacturer on how to test high-volatility fuels. Allow the weight of volatile fuel samples to stabilize for 20 minutes before starting the analysis; if the weight still drifts after 20 minutes, prepare a new sample). Retest the sample if the carbon, hydrogen, ~~and~~ oxygen, sulfur, and nitrogen mass fractions do not add up to a total mass of 100 ±0.5 %; if you do not measure oxygen, you may assume it has a zero concentration for this specification. You may also assume that sulfur and nitrogen have a zero concentration for all fuels except residual fuel blends.

(ii) Determine oxygen mass fraction of gasoline (with or without blended ethanol) according to ASTM D5599 (incorporated by reference in § 1065.1010). For all other liquid fuels, determine the oxygen mass fraction using good engineering judgment.

(iii) Determine the nitrogen mass fraction according to ASTM D4629 or ASTM D5762 (incorporated by reference in § 1065.1010) for all liquid fuels. Select the correct method based on the expected nitrogen content.

(iv) Determine the sulfur mass fraction according to subpart H of this part.

(2) For gaseous fuels and diesel exhaust fluid, use the default values for α, β, γ, and δ in Table 1 of this section, or use good engineering judgment to determine those values based on measurement.

(3) For nonconstant fuel mixtures, you must account for the varying proportions of the different fuels. This generally applies for dual-fuel and flexible-fuel engines, but it also applies if diesel exhaust fluid is injected in a way that is not strictly proportional to fuel flow. Account for these varying concentrations either with a batch measurement that provides averaged values to represent the test interval, or by analyzing data from continuous mass rate measurements. Application of average values from a batch measurement generally applies to situations where one fluid is a minor component of the total fuel mixture, for example dual-fuel and flexible-fuel engines with diesel pilot injection, where the diesel pilot fuel mass is less than 5 % of the total fuel mass and diesel exhaust fluid injection; consistent with good engineering judgment.

(4) Calculate α, β, γ, and δ using the following equations:

$$\alpha = \frac{M_{\mathrm{C}}}{M_{\mathrm{H}}} \cdot \frac{\sum_{j=1}^{N} \dot{m}_j \cdot w_{\mathrm{H}j}}{\sum_{j=1}^{N} \dot{m}_j \cdot w_{\mathrm{C}j}}$$

Eq. 1065.655-20

Commented [CAL70]: Equation updated.

$$\beta = \frac{M_{C}}{M_{O}} \cdot \frac{\sum_{j=1}^{N} \dot{m}_{j} \cdot w_{Oj}}{\sum_{j=1}^{N} \dot{m}_{j} \cdot w_{Cj}}$$

Eq. 1065.655-21

Eq. 1065.655-22

$$\delta = \frac{M_{C}}{M_{N}} \cdot \frac{\sum_{j=1}^{N} \dot{m}_{j} \cdot w_{Nj}}{\sum_{j=1}^{N} \dot{m}_{j} \cdot w_{Cj}}$$

Eq. 1065.655-23

Where:

N = total number of fuels and injected fluids over the duty cycle.

j = an indexing variable that represents one fuel or injected fluid, starting with j = 1.

$\dot{m}_j$ = the mass flow rate of the fuel or any injected fluid j. For applications using a single fuel and no DEF fluid, set this value to 1. For batch measurements, divide the total mass of fuel over the test interval duration to determine a mass rate.

w_{Hj} = hydrogen mass fraction of fuel or any injected fluid j.

w_{Cj} = carbon mass fraction of fuel or any injected fluid j.

w_{Oj} = oxygen mass fraction of fuel or any injected fluid j.

w_{Sj} = sulfur mass fraction of fuel or any injected fluid j.

w_{Nj} = nitrogen mass fraction of fuel or any injected fluid j.

Example:

$N = 1$

$j = 1$

$\dot{m}_1 = 1$

Commented [CAL74]: Updated.

$w_{H1} = 0.1239$

$w_{C1} = 0.8206$

$w_{O1} = 0.0547$

$w_{S1} = 0.00066$

$w_{N1} = 0.000095$

$M_C = 12.0107$

$M_H = 1.00794$

$M_O = 15.9994$

$M_S = 32.065$

$M_N = 14.0067$

$$\alpha = \frac{12.0107 \cdot 1 \cdot 0.1239}{1.00794 \cdot 1 \cdot 0.8206}$$

$$\beta = \frac{12.0107 \cdot 1 \cdot 0.0547}{15.9994 \cdot 1 \cdot 0.8206}$$
$$\gamma = \frac{12.0107 \cdot 1 \cdot 0.00066}{32.065 \cdot 1 \cdot 0.8206}$$
$$\delta = \frac{12.0107 \cdot 1 \cdot 0.000095}{14.0067 \cdot 1 \cdot 0.8206}$$

$\alpha = 1.799$
$\beta = 0.05004$
$\gamma = 0.0003012$
$\delta = 0.0001003$

(5) Table 1 follows:

TABLE 1 OF § 1065.655–DEFAULT VALUES OF α, β, γ, δ, AND w_C

Fuel or injected fluid	Atomic hydrogen, oxygen, sulfur, and nitrogen-to-carbon ratios $CH_{\alpha}O_{\beta}S_{\gamma}N_{\delta}$	Carbon mass fraction, w_C g/g
Gasoline	$CH_{1.85}O_0S_0N_0$	0.866
E10 Gasoline	$CH_{1.92}O_{0.03}S_0N_0$	0.833
E15 Gasoline	$CH_{1.95}O_{0.05}S_0N_0$	0.817
E85 Gasoline	$CH_{2.73}O_{0.38}S_0N_0$	0.576
E100 Ethanol	$CH_3O_{0.5}S_0N_0$	0.521
M100 Methanol	$CH_4O_1S_0N_0$	0.375
#1 Diesel	$CH_{1.93}O_0S_0N_0$	0.861
#2 Diesel	$CH_{1.80}O_0S_0N_0$	0.869
Liquefied petroleum gas	$CH_{2.64}O_0S_0N_0$	0.819
Natural gas	$CH_{3.78}O_{0.016}S_0N_0$	0.747
Residual fuel blends	Must be determined by measured fuel properties as described in paragraph (~~d~~e)(1) of this section.	
Diesel exhaust fluid	$CH_{17.85}O_{7.92}S_0N_2$	0.065

(f) * * *

(3) Fluid mass flow rate calculation. This calculation may be used only for steady-state laboratory testing. You may not use this calculation if the standard-setting part requires carbon balance error verification as described in § 1065.543. See § 1065.915(d)(5)(iv) for application to field testing. Calculate $\dot{n}_{exh}$ based on $\dot{m}_j$ using the following equation:

$$\dot{n}_{exh} = \sum_{j=1}^{N} \dot{m}_j \cdot \frac{w_{C_j} \cdot \left(1 + x_{H2Oexhdry\,j}\right)}{M_C \cdot x_{Ccombdry_j}}$$

Eq. 1065.655-25

Where:

$\dot{n}_{exh}$ = raw exhaust molar flow rate from which you measured emissions.

j = an indexing variable that represents one fuel or injected fluid, starting with j = 1.

Commented [CAL75]: Equation updated.

N = total number of fuels and injected fluids over the duty cycle.
~~j = an indexing variable that represents one fuel or injected fluid, starting with j = 1.~~
$\dot{m}_j$ = the mass flow rate of the fuel or any injected fluid j.
w_{Cj} = carbon mass fraction of the fuel and any injected fluid j.

Example:
N = 1
j = 1
$\dot{m}_1$ = 7.559 g/s
w_{C1} = 0.869 g/g
M_C = 12.0107 g/mol
$x_{Ccombdry1}$ = 99.87 mmol/mol = 0.09987 mol/mol
$x_{H20exhdry1}$ = 107.64 mmol/mol = 0.10764 mol/mol

$$\dot{n}_{exh} = 7.559 \cdot \frac{0.869 \cdot (1 + 0.10764)}{12.0107 \cdot 0.09987}$$

$\dot{n}_{exh}$ = 6.066 mol/s

* * * **

Commented [CAL76]: Updated.

355. Amend § 1065.659 by revising paragraph (c)(2) and (3) to read as follows:

§ 1065.659 Removed water correction.

* * * * *

(c) * * *

(2) If the measurement comes from raw exhaust, you may determine the amount of water based on intake-air humidity, plus a chemical balance of fuel, DEF, intake air, and exhaust as described in § 1065.655.

(3) If the measurement comes from diluted exhaust, you may determine the amount of water based on intake-air humidity, dilution air humidity, and a chemical balance of fuel, DEF, intake air, and exhaust as described in § 1065.655.

* * * * *

356. Amend § 1065.660 by adding paragraphs (a)(5) and (6) and revising paragraphs (b)(2) introductory text, (b)(2)(ii) introductory text, (b)(2)(iii) introductory text, (b)(3) introductory text, (b)(4), (c)(2), and (d) introductory text, (d)(1) introductory text, (d)(1)(ii) introductory text, (d)(1)(iii) introductory text, (d)(2), and (e) to read as follows:

§ 1065.660 THC, NMHC, NMNEHC, CH_4, and C_2H_6 determination.

(a) * * *

(5) You may calculate THC as the sum of NMHC and CH_4 if you determine CH_4 with an FTIR as described in § 1065.660(d)(2) and NMHC with an FTIR using the additive method from § 1065.660(b)(4).

(6) You may calculate THC as the sum of NMNEHC, C_2H_6, and CH_4 if you determine CH_4 with an FTIR as described in § 1065.660(d)(2), C_2H_6 with an FTIR as described in § 1065.660(e), and NMNEHC with an FTIR using the additive method from $ 1065.660(c)(3).

(b) * * *

(2) For nonmethane cutters, calculate x_{NMHC} using the nonmethane cutter's methane penetration

fraction, ~~(~~$PF_{CH4[NMC-FID]}$,~~)~~ ~~of CH4~~ and the ethane response factor penetration fraction, ~~(~~$RFPF_{C2H6[NMC-FID]}$,~~) of C2H6~~ from § 1065.365, the THC FID's methane response factor, ~~(~~$RF_{CH4[THC-FID]}$~~)~~, ~~of the THC FID to CH4~~ from § 1065.360, the initial THC contamination and dry-to-wet corrected THC concentration, $x_{THC[THC-FID]cor}$, as determined in paragraph (a) of this section, and the dry-to-wet corrected ~~CH4~~ methane concentration, $x_{THC[NMC-FID]cor}$, optionally corrected for initial THC contamination as determined in paragraph (a) of this section.

* * * * *

(ii) Use the following equation f~~F~~or penetration fractions determined using an NMC configuration as outlined in ~~section~~ § 1065.365(e)~~, use the following equation~~:

* * * * *

(iii) Use the following equation f~~F~~or penetration fractions determined using an NMC configuration as outlined in ~~section~~ § 1065.365(f) or for penetration fractions determined as a function of molar water concentration using an NMC configuration as outlined in § 1065.365(d)~~, use the following equation~~:

* * * * *

(3) For a GC-FID or FTIR, calculate x_{NMHC} using the THC analyzer's methane response factor, ~~(~~RF,~~) for~~ $_{CH4[THC-FID]}$, from § 1065.360, and the initial THC contamination and dry-to-wet corrected THC concentration, $x_{THC[THC-FID]cor}$, as determined in paragraph (a) of this section as follows:

* * * * *

(4) For an FTIR, calculate x_{NMHC} by summing the hydrocarbon species listed in § 1065.266(c) as follows:

$$x_{NMHC} = \sum_{i=1}^{N}\left(x_{HCi} - x_{HCi\text{-}init}\right)$$

Eq. 1065.660-6

Where:

x_{NMHC} = concentration of NMHC.

x_{HCi} = the C_1-equivalent concentration of hydrocarbon species *i* as measured by the FTIR, not corrected for initial contamination.

$x_{HCi\text{-}init}$ = the C_1-equivalent concentration of the initial system contamination (optional) of hydrocarbon species *i*, dry-to-wet corrected, as measured by the FTIR.

Example:

x_{C2H6} = 4.9 µmol/mol
x_{C2H4} = 0.9 µmol/mol
x_{C2H2} = 0.8 µmol/mol
x_{C3H8} = 0.4 µmol/mol
x_{C3H6} = 0.5 µmol/mol
x_{C4H10} = 0.3 µmol/mol
x_{CH2O} = 0.8 µmol/mol
x_{C2H4O} = 0.3 µmol/mol
x_{C2H2O2} = 0.1 µmol/mol
x_{CH4O} = 0.1 µmol/mol
x_{NMHC} = 4.9 + 0.9 + 0.8 + 0.4 + 0.5 + 0.3 + 0.8 + 0.3 + 0.1 + 0.1
x_{NMHC} = 9.1 µmol/mol

(c) * * *

(2) For a GC-FID, NMC FID, or FTIR, calculate x_{NMNEHC} using the THC analyzer's methane response factor,~~s~~ ~~(~~RF,~~) for~~ $_{CH4[THC-FID]}$, and ethane response factor, $RF_{C2H6[THC-FID]}$, from §

Formatted: Subscript

Formatted: Subscript

Formatted: Subscript

Formatted: Subscript

Formatted: Subscript

1065.360, ~~and~~ the initial contamination and dry-to-wet corrected THC concentration, $x_{THC[THC-FID]cor}$, as determined in paragraph (a) of this section, the dry-to-wet corrected methane concentration, x_{CH4}, as determined in paragraph (d) of this section, and the dry-to-wet corrected ethane concentration, x_{C2H6}, as determined in paragraph (e) of this section as follows:

$$x_{NMNEHC} = x_{THC[THC\text{-}FID]cor} - RF_{CH4[THC\text{-}FID]} \cdot x_{CH4} - RF_{C2H6[THC\text{-}FID]} \cdot x_{C2H6}$$

Eq. 1065.660-7

Where:

x_{NMNEHC} = concentration of NMNEHC.

$x_{THC[THC-FID]cor}$ = concentration of THC, initial THC contamination and dry-to-wet corrected, as measured by the THC FID.

$RF_{CH4[THC-FID]}$ = response factor of THC-FID to CH_4.

x_{CH4} = concentration of CH_4, dry-to-wet corrected, as measured by the GC-FID, NMC FID, or FTIR.

$RF_{C2H6[THC-FID]}$ = response factor of THC-FID to C_2H_6.

x_{C2H6} = the C_1-equivalent concentration of C_2H_6, dry-to-wet corrected, as measured by the GC-FID or FTIR.

Example:

$x_{THC[THC-FID]cor}$ = 145.6 µmol/mol

$RF_{CH4[THC-FID]}$ = 0.970

x_{CH4} = 18.9 µmol/mol

$RF_{C2H6[THC-FID]}$ = 1.02

x_{C2H6} = 10.6 µmol/mol

x_{NMNEHC} = 145.6 – 0.970 · 18.9 – 1.02 · 10.6

x_{NMNEHC} = 116.5 µmol/mol

*   *   *   *   *

(d) CH_4 determination. Use one of the following methods to determine ~~CH_4~~ methane concentration, x_{CH4}:

(1) For nonmethane cutters, calculate x_{CH4} using the nonmethane cutter's methane penetration fraction, ~~(~~PF~~) of~~ $_{CH4[NMC-FID]}$, and the ethane response factor penetration fraction, ~~(~~$RFPF$~~) of~~ $_{C2H6[NMC-FID]}$, from § 1065.365, the THC FID's methane response factor, ~~(~~RF~~)~~ $_{CH4[THC-FID]}$, ~~of the THC FID to CH_4~~ from § 1065.360, the initial THC contamination and dry-to-wet corrected THC concentration, $x_{THC[THC-FID]cor}$, as determined in paragraph (a) of this section, and the dry-to-wet corrected ~~CH_4~~ methane concentration, $x_{THC[NMC-FID]cor}$, optionally corrected for initial THC contamination as determined in paragraph (a) of this section.

*   *   *   *   *

(ii) ~~For~~ Use the following equation for penetration fractions determined using an NMC configuration as outlined in § 1065.365(e)~~, use the following equation~~:

*   *   *   *   *

(iii) Use the following equation f~~F~~or penetration fractions determined using an NMC configuration as outlined in § 1065.365(f) or for penetration fractions determined as a function of molar water concentration using an NMC configuration as outlined in § 1065.365(d)~~, use the following equation~~:

*   *   *   *   *

(2) For a GC-FID or FTIR, x_{CH4} is the actual dry-to-wet corrected ~~CH_4~~ methane concentration as measured by the analyzer.

(e) C_2H_6 determination. For a GC-FID or FTIR, x_{C2H6} is the C_1-equivalent, dry-to-wet corrected

Formatted: Subscript

Formatted: Subscript

Formatted: Subscript

Formatted: Subscript

~~C_2H_6~~ ethane concentration as measured by the analyzer.

357. Amend § 1065.665 by revising paragraph (a) to read as follows:

§ 1065.665 THCE and NMHCE determination.

(a) If you measured an oxygenated hydrocarbon's mass concentration, first calculate its molar concentration in the exhaust sample stream from which the sample was taken (raw or diluted exhaust), and convert this into a C_1-equivalent molar concentration. Add these C_1-equivalent molar concentrations to the molar concentration of non-oxygenated total hydrocarbon (NOTHC). The result is the molar concentration of total hydrocarbon equivalent (THCE). Calculate THCE concentration using the following equations, noting that Eq. 1065.665-3 is required only if you need to convert your oxygenated hydrocarbon (OHC) concentration from mass to moles:

$$x_{\mathrm{THCE}} = x_{\mathrm{NOTHC}} + \sum_{i=1}^{N}\left(x_{\mathrm{OHC}i} - x_{\mathrm{OHC}i\text{-init}}\right)$$

Eq. 1065.665-1

$$x_{\mathrm{NOTHC}} = x_{\mathrm{THC[THC\text{-}FID]cor}} - \sum_{i=1}^{N}\left(\left(x_{\mathrm{OHC}i} - x_{\mathrm{OHC}i\text{-init}}\right)\cdot RF_{\mathrm{OHC}i\mathrm{[THC\text{-}FID]}}\right)$$

Eq. 1065.665-2

$$x_{\mathrm{OHC}i} = \frac{\dfrac{m_{\mathrm{dexhOHC}i}}{M_{\mathrm{OHC}i}}}{\dfrac{m_{\mathrm{dexh}}}{M_{\mathrm{dexh}}}} = \frac{n_{\mathrm{dexhOHC}i}}{n_{\mathrm{dexh}}}$$

Eq. 1065.665-3

Where:

x_{THCE} = the sum of the C_1-equivalent concentrations of non-oxygenated hydrocarbon, alcohols, and aldehydes.

x_{NOTHC} = the sum of the C_1-equivalent concentrations of NOTHC.

$x_{\mathrm{OHC}i}$ = the C_1-equivalent concentration of oxygenated species *i* in diluted exhaust, not corrected for initial contamination.

$x_{\mathrm{OHC}i\text{-init}}$ = the C_1-equivalent concentration of the initial system contamination (optional) of oxygenated species *i*, dry-to-wet corrected.

$x_{\mathrm{THC[THC\text{-}FID]cor}}$ = the C_1-equivalent response to NOTHC and all OHC in diluted exhaust, HC contamination and dry-to-wet corrected, as measured by the THC-FID.

$RF_{\mathrm{OHC}i\mathrm{[THC\text{-}FID]}}$ = the response factor of the FID to species *i* relative to propane on a C_1-equivalent basis.

~~$C_{\#}$ = the mean number of carbon atoms in the particular compound.~~

M_{dexh} = the molar mass of diluted exhaust as determine in § 1065.340.

$m_{\mathrm{dexhOHC}i}$ = the mass of oxygenated species *i* in dilute exhaust.

$M_{\mathrm{OHC}i}$ = the C_1-equivalent molecular weight of oxygenated species *i*.

m_{dexh} = the mass of diluted exhaust

$n_{\mathrm{dexhOHC}i}$ = the number of moles of oxygenated species *i* in total diluted exhaust flow.

n_{dexh} = the total diluted exhaust flow.

* * * * *

358. Amend § 1065.667 by revising paragraph (d) to read as follows:

§ 1065.667 Dilution air background emission correction.

* * * * *

(d) You may determine the total flow of dilution air from the measured dilute exhaust flow and a chemical balance of the fuel, DEF, intake air, and dilute exhaust as described in § 1065.655. For this option, the molar flow of dilution air is calculated by multiplying the dilute exhaust flow by the mole fraction of dilution gas to dilute exhaust, $x_{dil/exh}$, from the dilute chemical balance. This may be done by totaling continuous calculations or by using batch results. For example, to use batch results, the total flow of dilution air is calculated by multiplying the total flow of diluted exhaust, n_{dexh}, by the flow-weighted mean mole fraction of dilution air in diluted exhaust, $\bar{x}_{dil/exh}$. Calculate $\bar{x}_{dil/exh}$ using flow-weighted mean concentrations of emissions in the chemical balance, as described in § 1065.655. The chemical balance in § 1065.655 assumes that your engine operates stoichiometrically, even if it is a lean-burn engine, such as a compression-ignition engine. Note that for lean-burn engines this assumption could result in an error in emission calculations. This error could occur because the chemical balance in § 1065.655 treats excess air passing through a lean-burn engine as if it was dilution air. If an emission concentration expected at the standard is about 100 times its dilution air background concentration, this error is negligible. However, if an emission concentration expected at the standard is similar to its background concentration, this error could be significant. If this error might affect your ability to show that your engines comply with applicable standards, we recommend that you either determine the total flow of dilution air using one of the more accurate methods in paragraph (b) or (c) of this section, or remove background emissions from dilution air by HEPA filtration, chemical adsorption, or catalytic scrubbing. You might also consider using a partial-flow dilution technique such as a bag mini-diluter, which uses purified air as the dilution air.

* * * * *

359. Amend § 1065.675 by revising paragraph (d) to read as follows:

§ 1065.675 CLD quench verification calculations.

* * * * *

(d) Calculate quench as follows:

$$quench = \left(\left(\frac{\frac{x_{NOwet}}{1 - x_{H2Omeas}}}{x_{NOdry}} - 1 \right) \cdot \frac{x_{H2Oexp}}{x_{H2Omeas}} + \left(\frac{x_{NOmeas}}{x_{NOact}} - 1 \right) \cdot \frac{x_{CO2exp}}{x_{CO2act}} \right) \cdot 100\ \%$$

Eq. 1065.675-1

Where:

quench = amount of CLD quench.

x_{NOdry} = concentration of NO upstream of a ~~bubbler~~humidity generator, according to § 1065.370(e)(4).

x_{NOwet} = measured concentration of NO downstream of a humidity generator~~bubbler~~, according to § 1065.370(e)(9).

x_{H2Oexp} = maximum expected mole fraction of water during emission testing, according to paragraph (b) of this section.

$x_{H2Omeas}$ = measured mole fraction of water during the quench verification, according to § 1065.370(e)(7).
x_{NOmeas} = measured concentration of NO when NO span gas is blended with CO_2 span gas, according to § 1065.370(d)(10).
x_{NOact} = actual concentration of NO when NO span gas is blended with CO_2 span gas, according to § 1065.370(d)(11) and calculated according to Eq. 1065.675-2.
x_{CO2exp} = maximum expected concentration of CO_2 during emission testing, according to paragraph (c) of this section.
x_{CO2act} = actual concentration of CO_2 when NO span gas is blended with CO_2 span gas, according to § 1065.370(d)(9).

$$x_{NOact} = \left(1 - \frac{x_{CO2act}}{x_{CO2span}}\right) \cdot x_{NOspan}$$

Eq. 1065.675-2

Where:
x_{NOspan} = the NO span gas concentration input to the gas divider, according to § 1065.370(d)(5).
$x_{CO2span}$ = the CO_2 span gas concentration input to the gas divider, according to § 1065.370(d)(4).

Example:
x_{NOdry} = 1800.0 µmol/mol
x_{NOwet} = 1739.6 µmol/mol
x_{H2Oexp} = 0.030 mol/mol
$x_{H2Omeas}$ = 0.030 mol/mol
x_{NOmeas} = 1515.2 µmol/mol
x_{NOspan} = 3001.6 µmol/mol
x_{CO2exp} = 3.2 %
$x_{CO2span}$ = 6.1 %
x_{CO2act} = 2.98 %

$$x_{NOact} = \left(1 - \frac{2.98}{6.1}\right) \cdot 3001.6 = 1535.24459 \text{ µmol/mol}$$

$$quench = \left(\left(\frac{\frac{1739.6}{1-0.030}}{1800.0} - 1\right) \cdot \frac{0.030}{0.030} + \left(\frac{1515.2}{1535.24459} - 1\right) \cdot \frac{3.2}{2.98}\right) \cdot 100\ \%$$

quench = (–0.0036655 – 0.014020171) ·100 % = –1.7685671 %

360. Amend § 1065.695 by adding paragraph (c)(8)(v) to read as follows:
§ 1065.695 Data requirements.
* * * * *
(c) * *
(8) * * *
(v) Carbon balance error verification, if performed.
* * * * *

361. Amend § 1065.701 by revising paragarphs (b) and (f) to read as follows:

§ 1065.701 General requirements for test fuels.

* * * * *

(b) Fuels meeting alternate specifications. We may allow you to use a different test fuel (such as California LEV ~~Phase 2~~ III gasoline) if it does not affect your ability to show that your engines would comply with all applicable emission standards using the specified test fuel ~~specified in this subpart~~.

* * * * *

(f) Service accumulation and field testing fuels. If we do not specify a service-accumulation or field-testing fuel in the standard-setting part, use an appropriate commercially available fuel such as those meeting minimum specifications from the following table:

TABLE 1 OF § 1065.701–EXAMPLES OF SERVICE-ACCUMULATION AND FIELD-TESTING FUELS

Fuel category	Subcategory	Reference procedure[a1]
Diesel	Light distillate and light blends with residual	ASTM D975
	Middle distillate	ASTM D6985
	Biodiesel (B100)	ASTM D6751
Intermediate and residual fuel	All	See § 1065.705
Gasoline	Automotive gasoline	ASTM D4814
	Automotive gasoline with ethanol concentration up to 10 volume %.	ASTM D4814
Alcohol	Ethanol (E51-83)	ASTM D5798
	Methanol (M70-M85)	ASTM D5797
Aviation fuel	Aviation gasoline	ASTM D910
	Gas turbine	ASTM D1655
	Jet B wide cut	ASTM D6615
Gas turbine fuel	General	ASTM D2880

[a1] ~~ASTM specifications are i~~Incorporated by reference; ~~see~~in § 1065.1010.

362. Amend § 1065.703 by revising paragraph (b) to read as follows:

§ 1065.703 Distillate diesel fuel.

* * * * *

(b) There are three grades of #2 diesel fuel specified for use as a test fuel. See the standard-setting part to determine which grade to use. If the standard-setting part does not specify which grade to use, use good engineering judgment to select the grade that represents the fuel on which the engines will operate in use. The three grades are specified in Table 1 of this section.

TABLE 1 OF § 1065.703–TEST FUEL SPECIFICATIONS FOR DISTILLATE DIESEL FUEL

Property	Unit	Ultra Low Sulfur	Low Sulfur	High Sulfur	Reference Procedure[a1]
Cetane Number	—	40-50	40-50	40-50	ASTM D613
Distillation range: Initial boiling point 10 pct. point 50 pct. point 90 pct. point Endpoint	°C	 171-204 204-238 243-282 293-332 321-366	 171-204 204-238 243-282 293-332 321-366	 171-204 204-238 243-282 293-332 321-366	 ASTM D86
Gravity	°API	32-37	32-37	32-37	ASTM D4052
Total sulfur	mg/kg	7-15	300-500	800-2500	ASTM D2622, ASTM D5453, or ASTM D7039
Aromatics, min. (Remainder shall be paraffins, naphthenes, and olefins)	g/kg	100	100	100	ASTM D5186
Flashpoint, min.	°C	54	54	54	ASTM D93
Kinematic Viscosity	mm^2/scSt	2.0-3.2	2.0-3.2	2.0-3.2	ASTM D445

[a1]ASTM procedures are iIncorporated by reference, see in § 1065.1010. See § 1065.701(d) for other allowed procedures.

*   *   *   *   *

363. Amend § 1065.705 by revising paragraph (c) to read as follows:

§ 1065.705 Residual and intermediate residual fuel.

*   *   *   *   *

(c) The fuel must meet the specifications for one of the categories in the following table:

TABLE 1 OF § 1065.705–SERVICE ACCUMULATION AND TEST FUEL SPECIFICATIONS FOR RESIDUAL FUEL

Property	Unit	Category ISO-F-										Reference Procedure~~[1]~~[a]
		RMA 30	RMB 30	RMD 80	RME 180	RMF 180	RMG 380	RMH 380	RMK 380	RMH 700	RMK 700	
Density at 15 °C, max.	kg/m^3	960.0	975.0	980.0	991.0		991.0		1010.0	991.0	1010.0	ISO 3675 or ISO 12185 (see also ISO 8217)
Kinematic viscosity at 50 °C, max.	mm^2/s~~cSt~~	30.0		80.0	180.0		380.0		700.0			ISO 3104
Flash point, min.	°C	60		60	60		60		60			ISO 2719 (see also ISO 8217)
Pour point (upper) Winter quality, max. Summer quality, max.	°C	0 6	24 24	30 30	30 30		30 30		30 30			ISO 3016
Carbon residue, max.	(kg/kg) %	10		14	15	20	18	22	22			ISO 10370
Ash, max.	(kg/kg) %	0.10		0.10	0.10	0.15	0.15		0.15			ISO 6245
Water, max.	(m^3/m^3) %	0.5		0.5	0.5		0.5		0.5			ISO 3733
Sulfur, max.	(kg/kg) %	3.50		4.00	4.50		4.50		4.50			ISO 8754 or ISO 14596 (see also ISO 8217)
Vanadium, max.	mg/kg	150		350	200	500	300	600	600			ISO 14597 or IP~~–~~-501 or IP-470 (see also ISO 8217)
Total sediment potential, max.	(kg/kg) %	0.10		0.10	0.10		0.10		0.10			ISO 10307-2 (see also ISO 8217)
Aluminium plus silicon, max.	mg/kg	80		80	80		80		80			ISO 10478 or IP 501 or IP 470 (see also ISO 8217~~:2012~~)

[a]~~[1]~~I~~SO procedures are i~~ncorporated by reference; see~~in~~ § 1065.1010. See § 1065.701(d) for other allowed procedures.

364. Amend § 1065.710 by revising paragraphs (b)(2) and (c) to read as follows:

§ 1065.710 Gasoline.

* * * * *

(b) * * *

(2) Table 1 of this section identifies limit values consistent with the units in the reference procedure for each fuel property. These values are generally specified in international units. Values presented in parentheses are for information only. Table 1 follows:

TABLE 1 OF § 1065.710–TEST FUEL SPECIFICATIONS FOR A LOW-LEVEL ETHANOL-GASOLINE BLEND

Property	Unit	SPECIFICATION General Testing	SPECIFICATION Low-Temperature Testing	SPECIFICATION High Altitude Testing	Reference Procedure[a1]
Antiknock Index (R+M)/2	-	87.0-88.4[b2]		Minimum, 87.0 ~~Minimum~~	ASTM D2699 and ASTM D2700
Sensitivity (R-M)	-	Minimum, 7.5 ~~Minimum~~			ASTM D2699 and ASTM D2700
Dry Vapor Pressure Equivalent (*DVPE*)[3c,4d]	kPa (psi)	60.0-63.4 (8.7-9.2)	77.2-81.4 (11.2-11.8)	52.4-55.2 (7.6-8.0)	ASTM D5191
Distillation[d] 10 % evaporated	°C (°F)	49-60 (120-140)	43-54 (110-130)	49-60 (120-140)	ASTM D86
50 % evaporated	°C (°F)	88-99 (190-210)			
90 % evaporated	°C (°F)	157-168 (315-335)			
Evaporated final boiling point	°C (°F)	193-216 (380-420)			
Residue	milliliter	Maximum, 2.0 ~~Maximum~~			
Total Aromatic Hydrocarbons	volume %	21.0-25.0			ASTM D5769
C6 Aromatics (benzene)	volume %	0.5-0.7			
C7 Aromatics (toluene)	volume %	5.2-6.4			
C8 Aromatics	volume %	5.2-6.4			
C9 Aromatics	volume %	5.2-6.4			
C10+ Aromatics	volume %	4.4-5.6			
Olefins[e5]	~~mass~~ volume %	4.0-10.0			ASTM D6550
Ethanol blended	volume %	9.6-10.0			See paragraph (b)(3) of this section.
Ethanol confirmatory[f6]	volume %	9.4-10.2			ASTM D4815 or ASTM D5599
Total Content of Oxygenates Other than Ethanol[f]	volume %	Maximum, 0.1 ~~Maximum~~			ASTM D4815 or ASTM D5599
Sulfur	mg/kg	8.0-11.0			ASTM D2622, ASTM D5453 or ASTM D7039
Lead	g/liter	Maximum, 0.0026 ~~Maximum~~			ASTM D3237
Phosphorus	g/liter	Maximum, 0.0013 ~~Maximum~~			ASTM D3231
Copper Corrosion	-	Maximum, No. 1 ~~Maximum~~			ASTM D130
Solvent-Washed Gum Content	mg/100 milliliter	Maximum, 3.0 ~~Maximum~~			ASTM D381
Oxidation Stability	minute	Minimum, 1000 ~~Minimum~~			ASTM D525

[a1] ~~ASTM procedures are i~~Incorporated by reference; see~~in~~ § 1065.1010. See § 1065.701(d) for other allowed procedures.
[b2] Octane specifications apply only for testing related to exhaust emissions. For engines or vehicles that require the use of premium fuel, as described in paragraph (d) of this section, the adjusted specification for antiknock index is a minimum value of 91.0; no maximum value applies. All other specifications apply for this high-octane fuel.
[c3] Calculate dry vapor pressure equivalent, *DVPE*, based on the measured total vapor pressure, p_T, using the following equation: $DVPE$ (kPa) = $0.956 \cdot p_T - 2.39$ or $DVPE$ (psi) = $0.956 \cdot p_T - 0.347$. *DVPE* is intended to be equivalent to Reid Vapor Pressure using a different test method.
[d4] Parenthetical values are shown for informational purposes only.
[5e] ~~The reference procedure~~ASTM D6550 prescribes measurement of olefin concentration in mass %. Multiply this result by 0.857 and round to the first decimal place to determine the olefin concentration in volume %.
[f6] ASTM D5599 prescribes concentration measurements for ethanol and other oxygenates in mass %. Convert results to volume % as specified in Section 14.3 of ASTM D4815.

*   *   *   *   *

(c) The specifications of this paragraph (c) apply for testing with neat gasoline. This is sometimes called indolene or E0 test fuel. Gasoline for testing must have octane values that represent commercially available fuels for the appropriate application. Test fuel specifications apply as follows:

TABLE 2 OF § 1065.710–TEST FUEL SPECIFICATIONS FOR NEAT (E0) GASOLINE

Property	Unit	SPECIFICATION		Reference Procedure[a]~~[1]~~
		General Testing	Low-Temperature Testing	
Distillation Range:				ASTM D86
Evaporated initial boiling point	°C	24-35[b]~~[2]~~	24-36	
10 % evaporated	°C	49-57	37-48	
50 % evaporated	°C	93-110	82-101	
90 % evaporated	°C	149-163	158-174	
Evaporated final boiling point	°C	Maximum, 213	Maximum, 212	
Total Aromatic Hydrocarbons ~~composition:~~ ~~Olefins~~ ~~Aromatics~~ ~~Saturates~~	volume %	~~Maximum, 10~~ Maximum, 35 ~~Remainder~~	~~Maximum, 17.5~~ Maximum, 30.4 ~~Remainder~~	ASTM D1319 or ASTM D5769
Olefins[c]	volume %	Maximum, 10	Maximum, 17.5	ASTM D1319 or ASTM D6550
Lead	g/liter	Maximum, 0.013	Maximum, 0.013	ASTM D3237
Phosphorous	g/liter	Maximum, 0.0013	Maximum, 0.005	ASTM D3231
Total sulfur	mg/kg	Maximum, 80	Maximum, 80	ASTM D2622
Dry vapor pressure equivalent~~[3]~~[d]	kPa	60.0-63.4~~[2]~~[b],~~[4]~~[e]	77.2-81.4	ASTM D5191

[a]~~[1]ASTM procedures are i~~Incorporated by reference; see~~in~~ § 1065.1010. See § 1065.701(d) for other allowed procedures.

[b]~~[2]~~For testing at altitudes above 1219 m, the specified initial boiling point range is (23.9 to 40.6) °C and the specified volatility range is (52.0 to 55.2) kPa.

[c]ASTM D6550 prescribes measurement of olefin concentration in mass %. Multiply this result by 0.857 and round to the first decimal place to determine the olefin concentration in volume %.

~~[3]~~[d]Calculate dry vapor pressure equivalent, *DVPE*, based on the measured total vapor pressure, p_T, in kPa using the following equation: $DVPE$ (kPa) = 0.956·p_T – 2.39 or $DVPE$ (psi) = 0.956·p_T – 0.347. *DVPE* is intended to be equivalent to Reid Vapor Pressure using a different test method.

~~[4]~~[e]For testing unrelated to evaporative emissions, the specified range is (55.2 to 63.4) kPa.

*   *   *   *   *

365. Amend § 1065.715 by revising paragraph (a) to read as follows:

§ 1065.715 Natural gas.

(a) Except as specified in paragraph (b) of this section, natural gas for testing must meet the specifications in the following table:

TABLE 1 OF § 1065.715–TEST FUEL SPECIFICATIONS FOR NATURAL GAS

Property	Value[a1]
Methane, CH_4	Minimum, 0.87 mol/mol
Ethane, C_2H_6	Maximum, 0.055 mol/mol
Propane, C_3H_8	Maximum, 0.012 mol/mol
Butane, C_4H_{10}	Maximum, 0.0035 mol/mol
Pentane, C_5H_{12}	Maximum, 0.0013 mol/mol
C_6 and higher	Maximum, 0.001 mol/mol
Oxygen	Maximum, 0.001 mol/mol
Inert gases (sum of CO_2 and N_2)	Maximum, 0.051 mol/mol

[1 a]Demonstrate compliance with fuel specifications based on the reference procedures in ASTM D1945 (incorporated by reference in § 1065.1010), or on other measurement procedures using good engineering judgment. See § 1065.701(d) for other allowed procedures.

* * * * *

366. Amend § 1065.720 by revising paragraph (a) to read as follows:

§ 1065.720 Liquefied petroleum gas.

(a) Except as specified in paragraph (b) of this section, liquefied petroleum gas for testing must meet the specifications in the following table:

TABLE 1 OF § 1065.720(a)–TEST FUEL SPECIFICATIONS FOR LIQUEFIED PETROLEUM GAS

Property	Value	Reference Procedure[a1]
Propane, C_3H_8	Minimum, 0.85 m^3/m^3	ASTM D2163
Vapor pressure at 38 °C	Maximum, 1400 kPa	ASTM D1267 or ASTM D2598[b2]
Volatility residue (evaporated temperature, 35 °C)	Maximum, –38 °C	ASTM D1837
Butanes	Maximum, 0.05 m^3/m^3	ASTM D2163
Butenes	Maximum, 0.02 m^3/m^3	ASTM D2163
Pentenes and heavier	Maximum, 0.005 m^3/m^3	ASTM D2163
Propene	Maximum, 0.1 m^3/m^3	ASTM D2163
Residual matter (residue on evaporation of 100 ml oil stain observation)	Maximum, 0.05 ml pass[c3]	ASTM D2158
Corrosion, copper strip	Maximum, No. 1	ASTM D1838
Sulfur	Maximum, 80 mg/kg	ASTM D2784D6667
Moisture content	pass	ASTM D2713

[a1]ASTM procedures are iIncorporated by reference; seein § 1065.1010. See § 1065.701(d) for other allowed procedures.

[b2]If these two test methods yield different results, use the results from ASTM D1267.

[c3]The test fuel must not yield a persistent oil ring when you add 0.3 ml of solvent residue mixture to a filter paper in 0.1 ml increments and examine it in daylight after two minutes.

* * * * *

367. Amend § 1065.750 by revising paragraph (a)(1)(ii) to read as follows:

§ 1065.750 Analytical gases.

(a) * * *

(1) * * *

(ii) Contamination as specified in the following table:

TABLE 1 OF § 1065.750–GENERAL SPECIFICATIONS FOR PURIFIED GASES[a1]

Constituent	Purified Air	Purified N_2
THC (C_1-equivalent)	≤ 0.05 µmol/mol	≤ 0.05 µmol/mol
CO	≤ 1 µmol/mol	≤ 1 µmol/mol
CO_2	≤ 10 µmol/mol	≤ 10 µmol/mol
O_2	0.205 to 0.215 mol/mol	≤ 2 µmol/mol
NO_x	≤ 0.02 µmol/mol	≤ 0.02 µmol/mol
N_2O[b2]	≤ 0.02 µmol/mol	≤ 0.02 µmol/mol

[a1]We do not require these levels of purity to be NIST-traceable.

[b2]The N_2O limit applies only if the standard-setting part requires you to report N_2O or certify to an N_2O standard.

*   *   *   *   *

368. Amend § 1065.790 by revising paragraph (b) to read as follows:

§ 1065.790 Mass standards.

*   *   *   *   *

(b) Dynamometer, fuel mass scale, and DEF mass scale calibration weights. Use dynamometer and mass scale calibration weights that are certified as NIST-traceable within 0.1 % uncertainty. Calibration weights may be certified by any calibration lab that maintains NIST-traceability.[Reserved]

369. Amend § 1065.905 by revising paragraph (f) to read as follows:

§ 1065.905 General provisions.

*   *   *   *   *

(f) Summary. The following table summarizes the requirements of paragraphs (d) and (e) of this section:

TABLE 1 OF § 1065.905–SUMMARY OF TESTING REQUIREMENTS SPECIFIED OUTSIDE OF THIS SUBPART J

Subpart	Applicability for field testing[a]	Applicability for laboratory or similar testing with PEMS without restriction[a]	Applicability for laboratory or similar testing with PEMS with restrictions[a]
A: Applicability and general provisions	Use all.	Use all.	Use all.
B: Equipment for testing	Use § 1065.101 and § 1065.140 through the end of subpart B, except § 1065.140(e)(1) and (4), § 1065.170(c)(1)(vi), and § 1065.195(c). § 1065.910 specifies equipment specific to field testing.	Use all.	Use all. § 1065.910 specifies equipment specific to laboratory testing with PEMS.
C: Measurement instruments	Use all. § 1065.915 allows deviations.	Use all except § 1065.295(c).	Use all except § 1065.295(c). § 1065.915 allows deviations.
D: Calibrations and verifications	Use all except § 1065.308 and § 1065.309. § 1065.920 allows deviations, but also has additional specifications.	Use all.	Use all. § 1065.920 allows deviations, but also has additional specifications.
E: Test engine selection, maintenance, and durability	Do not use. Use standard-setting part.	Use all.	Use all.
F: Running an emission test in the laboratory	Use §§ 1065.590 and 1065.595 for PM § 1065.930 and § 1065.935 to start and run a field test.	Use all.	Use all.
G: Calculations and data requirements	Use all. § 1065.940 has additional calculation instructions	Use all.	Use all. § 1065.940 has additional calculation instructions
H: Fuels, engine fluids, analytical gases, and other calibration materials	Use all.	Use all.	Use all.
I: Testing with oxygenated fuels	Use all.	Use all.	Use all.
K: Definitions and reference materials	Use all.	Use all.	Use all.

[a] Refer to paragraphs (d) and (e) of this section for complete specifications.

370. Amend § 1065.910 by revising paragraph (a)(2) to read as follows:

§ 1065.910 PEMS auxiliary equipment for field testing.

* * * * *

(a) * * *

(2) Tubing. ~~Use~~ We recommend using rigid 300 series stainless steel tubing to connect between flexible connectors. Tubing may be straight or bent to accommodate vehicle geometry. You may use "T" or "Y" fittings ~~made of 300 series stainless steel tubing~~ to join multiple connections, or you may cap or plug redundant flow paths if the engine manufacturer recommends it.

* * * * *

371. Amend § 1065.915 by revising paragraph (a) to read as follows:

§ 1065.915 PEMS instruments.

(a) Instrument specifications. We recommend that you use PEMS that meet the specifications of subpart C of this part. For unrestricted use of PEMS in a laboratory or similar environment, use a PEMS that meets the same specifications as each lab instrument it replaces. For field testing or for testing with PEMS in a laboratory or similar environment, under the provisions of § 1065.905(b), the specifications in the following table apply instead of the specifications in Table 1 of § 1065.205:~~.~~

TABLE 1 OF § 1065.915–RECOMMENDED MINIMUM PEMS MEASUREMENT INSTRUMENT PERFORMANCE

Measurement	Measured quantity symbol	Rise time, $t_{10\text{-}90}$, and Fall time, $t_{90\text{-}10}$	Recording update frequency	Accuracy[a]	Repeatability[a]	Noise[a]
Engine speed transducer	f_n	1 s	1 Hz means	5 % of pt. or 1 % of max.	2 % of pt. or 1 % of max.	0.5 % of max
Engine torque estimator, BSFC (This is a signal from an engine's ECM)	T or BSFC	1 s	1 Hz means	8 % of pt. or 5 % of max.	2 % of pt. or 1 % of max.	1 % of max.
General pressure transducer (not a part of another instrument)	p	5 s	1 Hz	5 % of pt. or 5 % of max.	2 % of pt. or 0.5 % of max.	1 % of max
Atmospheric pressure meter	p_{atmos}	50 s	0.1 Hz	250 Pa	200 Pa	100 Pa
General temperature sensor (not a part of another instrument)	T	5 s	1 Hz	1 % of pt. K or 5 K	0.5 % of pt. K or 2 K	0.5 % of max 0.5 K
General dewpoint sensor	T_{dew}	50 s	0.1 Hz	3 K	1 K	1 K
Exhaust flow meter	$\dot{n}$	1 s	1 Hz means	5 % of pt. or 3 % of max.	2 % of pt.	2 % of max.
Dilution air, inlet air, exhaust, and sample flow meters	$\dot{n}$	1 s	1 Hz means	2.5 % of pt. or 1.5 % of max.	1.25 % of pt. or 0.75 % of max.	1 % of max.
Continuous gas analyzer	x	5 s	1 Hz	4 % of pt. or 4 % of meas.	2 % of pt. or 2 % of meas.	1 % of max.
Gravimetric PM balance	m_{PM}	—	—	See § 1065.790	0.5 µg	—
Inertial PM balance	m_{PM}	—	—	4 % of pt. or 4 % of meas.	2 % of pt. or 2 % of meas.	1 % of max

[a]Accuracy, repeatability, and noise are all determined with the same collected data, as described in § 1065.305, and based on absolute values. "pt." refers to the overall flow-weighted mean value expected at the standard; "max." refers to the peak value expected at the standard over any test interval, not the maximum of the instrument's range; "meas" refers to the actual flow-weighted mean measured over any test interval.

*   *   *   *   *

372. Amend § 1065.1001 by adding a definition for "Enhanced-idle" in alphabetical order and revising the definition for "Test interval" to read as follows:

§ 1065.1001 Definitions.

*   *   *   *   *

Enhanced-idle means a mode of engine idle operation where idle speed is elevated above warm idle speed as determined by the electronic control module, for example during engine warm-up or to increase exhaust temperature.

*   *   *   *   *

Test interval means a duration of time over which you determine mass of brake-specificemissions. For example, the standard-setting part may specify a complete laboratory duty cycle as a cold-start test interval, plus a hot-start test interval. As another example, a standard-setting part may specify a field-test interval, such as a "not-to-exceed" (NTE) event, as a duration of time over which an engine operates within a certain range of speed and torque. In cases where multiple test intervals occur over a duty cycle, the standard-setting part may specify additional calculations that weight and combine results to arrive at composite values for comparison against the applicable standards.

*   *   *   *   *

373. Amend § 1065.1005 by revising paragraphs (a), (c), (d), (e), (f)(2), and (g) to read as follows:

§ 1065.1005 Symbols, abbreviations, acronyms, and units of measure.

*   *   *   *   *

(a) Symbols for quantities. This part uses the following symbols and units of measure for various quantities:

Symbol	Quantity	Unit	Unit symbol	Units in terms of SI base units
α	atomic hydrogen-to-carbon ratio	mole per mole	mol/mol	1
A	area	square meter	m^2	m^2
a_0	intercept of least squares regression			
a_1	slope of least squares regression			
a_g	acceleration of Earth's gravity	meter per square second	m/s^2	$m\cdot s^{-2}$
β	ratio of diameters	meter per meter	m/m	1
β	atomic oxygen-to-carbon ratio	mole per mole	mol/mol	1
$C_\#$	number of carbon atoms in a molecule			
c	power-specific carbon mass error coefficient	gram per kilowatt--hour	g/(kW·hr)	$3.6^{-1}\cdot 10^{-9}\cdot m^{-2}\cdot s^2$
C_d	discharge coefficient			
C_f	flow coefficient			
δ	atomic nitrogen-to-carbon ratio	mole per mole	mol/mol	1
d	Diameterdiameter	meter	m	m
d	power-specific carbon mass rate absolute error coefficent	gram per kilowatt--hour	g/(kW·hr)	$3.6^{-1}\cdot 10^{-9}\cdot m^{-2}\cdot s^2$
DR	dilution ratio	mole per mole	mol/mol	1
ε	error between a quantity and its reference			
ϵ	difference or error quantity			
e	brake-specific emission or fuel consumption	gram per kilowatt hour	g/(kW·hr)	$g\cdot 3.6^{-1}\cdot 10^{-69}\cdot m^{-2}\cdot kg^{-1}\cdot s^2$
F	F-test statistic			
f	frequency	hertz	Hz	s^{-1}

f_n	angular speed (shaft)	revolutions per minute	r/min	$\pi\cdot 30^{-1}\cdot s^{-1}$
γ	ratio of specific heats	(joule per kilogram kelvin) per (joule per kilogram kelvin)	(J/(kg·K))/(J/(kg·K))	1
γ	atomic sulfur-to-carbon ratio	mole per mole	mol/mol	1
K	correction factor			1
K_v	calibration coefficient		$m^4\cdot s\cdot K^{0.5}/kg$	$m^4\cdot kg^{-1}\cdot s\cdot K^{0.5}$
l	length	meter	m	m
L	limit			
μ	viscosity, dynamic	pascal second	Pa·s	$m^{-1}\cdot kg\cdot s^{-1}$
M	molar mass[a] ~~[1]~~	gram per mole	g/mol	$10^{-3}\cdot kg\cdot mol^{-1}$
m	mass	kilogram	kg	kg
$\dot{m}$	mass rate	kilogram per second	kg/s	$kg\cdot s^{-1}$
ν	viscosity, kinematic	meter squared per second	m^2/s	$m^2\cdot s^{-1}$
N	total number in series			
n	amount of substance	mole	mol	mol
$\dot{n}$	amount of substance rate	mole per second	mol/s	$mol\cdot s^{-1}$
P	power	kilowatt	kW	$10^3\cdot m^2\cdot kg\cdot s^{-3}$
PF	penetration fraction			
p	pressure	pascal	Pa	$m^{-1}\cdot kg\cdot s^{-2}$
ρ	mass density	kilogram per cubic meter	kg/m^3	$m^{-3}\cdot kg$
Δp	differential static pressure	pascal	Pa	$m^{-1}\cdot kg\cdot s^{-2}$
r	ratio of pressures	pascal per pascal	Pa/Pa	1
r^2	coefficient of determination			
Ra	average surface roughness	micrometer	µm	$10^{-6}\cdot m$
$Re^{\#}$	Reynolds number			
RF	response factor			
RH	relative humidity			
σ	non-biased standard deviation			
S	Sutherland constant	kelvin	K	K
SEE	standard error of the estimate ~~of error~~			
T	absolute temperature	kelvin	K	K
T	Celsius temperature	degree Celsius	°C	K – 273.15
T	torque (moment of force)	newton meter	N·m	$m^2\cdot kg\cdot s^{-2}$
Θ	plane angle	degrees	°	rad
t	time	second	s	s
Δt	time interval, period, 1/frequency	second	s	s
V	volume	cubic meter	m^3	m^3
$\dot{V}$	volume rate	cubic meter per second	m^3/s	$m^3\cdot s^{-1}$
W	work	kilowatt-hour	kW·hr	3.6~~·1~~ $\cdot 10^6\cdot m^2\cdot kg\cdot s^{-2}$
w_C	carbon mass fraction	gram per gram	g/g	1
x	amount of substance mole fraction[b] ~~[2]~~	mole per mole	mol/mol	1
$\bar{x}$	flow-weighted mean concentration	mole per mole	mol/mol	1
y	generic variable			
Z	compressibility factor			

[a] ~~[1]~~ See paragraph (f)(2) of this section for the values to use for molar masses. Note that in the cases of NO_x and HC, the regulations specify effective molar masses based on assumed speciation rather than actual speciation.

[b] ~~[2]~~ Note that mole fractions for THC, THCE, NMHC, NMHCE, and NOTHC are expressed on a C_1-equivalent basis.

* * * * *

(c) Prefixes. This part uses the following prefixes ~~to define a quantity~~for units and unit symbols:

Symbol	~~Quantity~~Prefix name	~~Value~~Factor

μ	micro	10^{-6}
m	milli	10^{-3}
c	centi	10^{-2}
k	kilo	10^{3}
M	mega	10^{6}

(d) Superscripts. This part uses the following superscripts ~~to define a~~for modifying quantity symbols:

Superscript	~~Quantity~~Meaning
overbar (such as $\overline{y}$)	arithmetic mean
overdot (such as $\dot{y}$)	quantity per unit time

(e) Subscripts. This part uses the following subscripts ~~to define a~~for modifying quantity symbols:

Subscript	~~Quantity~~Meaning
a	absolute (e.g., absolute difference or error)
abs	absolute quantity
act	actual condition
air	air, dry
amb	ambient
atmos	atmospheric
bkgnd	background
C	carbon mass
cal	calibration quantity
CFV	critical flow venturi
comb	combined
comp~~osite~~	composite value
cor	corrected quantity
dil	dilution air
dew	dewpoint
dexh	diluted exhaust
dry	dry condition
dutycycle	duty cycle
ϵ	related to a difference or error quantity
exh	raw exhaust
exp	expected quantity
fluid	fluid stream
fn	feedback speed
frict	friction
fuel	fuel consumption
hi,idle	condition at high-idle
i	an individual of a series
idle	condition at idle
in	quantity in
init	initial quantity, typically before an emission test
int	intake air
j	an individual of a series
mapped	conditions over which an engine can operate
max	the maximum (i.e., peak) value expected at the standard over a test interval; not the maximum of an instrument range
meas	measured quantity
media	PM sample media
mix	mixture of diluted exhaust and air
norm	normalized
out	quantity out
P	power

part	partial quantity
PDP	positive-displacement pump
post	after the test interval
pre	before the test interval
prod	stoichiometric product
r	relative (e.g., relative difference or error)
rate	rate (divided by time)
record	record rate
ref	reference quantity
rev	revolution
sat	saturated condition
s	slip
span	span quantity
SSV	subsonic venturi
std	standard condition
stroke	engine strokes per power stroke
T	torque
test	test quantity
test,alt	alternate test quantity
uncor	uncorrected quantity
vac	vacuum side of the sampling system
weight	calibration weight
zero	zero quantity

(f) * *

(2) This part uses the following molar masses or effective molar masses of chemical species:

Symbol	Quantity	g/mol ($10^{-3}\cdot kg\cdot mol^{-1}$)
M_{air}	molar mass of dry air[a][1]	28.96559
M_{Ar}	molar mass of argon	39.948
M_{C}	molar mass of carbon	12.0107
M_{CH3OH}	molar mass of methanol	32.04186
M_{C2H5OH}	molar mass of ethanol	46.06844
M_{C2H4O}	molar mass of acetaldehyde	44.05256
M_{CH4N2O}	molar mass of urea	60.05526
M_{C2H6}	molar mass of ethane	30.06904
M_{C3H8}	molar mass of propane	44.09562
M_{C3H7OH}	molar mass of propanol	60.09502
M_{CO}	molar mass of carbon monoxide	28.0101
M_{CH4}	molar mass of methane	16.0425
M_{CO2}	molar mass of carbon dioxide	44.0095
M_{H}	molar mass of atomic hydrogen	1.00794
M_{H2}	molar mass of molecular hydrogen	2.01588
M_{H2O}	molar mass of water	18.01528
M_{CH2O}	molar mass of formaldehyde	30.02598
M_{He}	molar mass of helium	4.002602
M_{N}	molar mass of atomic nitrogen	14.0067
M_{N2}	molar mass of molecular nitrogen	28.0134
M_{NH3}	molar mass of ammonia	17.03052
M_{NMHC}	effective C_1 molar mass of nonmethane hydrocarbon[b][2]	13.875389
M_{NMHCE}	effective C_1 molar mass of nonmethane hydrocarbon equivalent[b][2]	13.875389
M_{NMNEHC}	effective C_1 molar mass of nonmethane-nonethane hydrocarbon[b][2]	13.875389
M_{NOx}	effective molar mass of oxides of nitrogen[c][3]	46.0055
M_{N2O}	molar mass of nitrous oxide	44.0128
M_{O}	molar mass of atomic oxygen	15.9994

M_{O2}	molar mass of molecular oxygen	31.9988
M_S	molar mass of sulfur	32.065
M_{THC}	effective C_1 molar mass of total hydrocarbon[b2]	13.875389
M_{THCE}	effective C_1 molar mass of total hydrocarbon equivalent[b2]	13.875389

[a1]See paragraph (f)(1) of this section for the composition of dry air.

[b2]The effective molar masses of THC, THCE, NMHC, NMHCE, and NMNEHC are defined on a C_1 basis and are based on an atomic hydrogen-to-carbon ratio, α, of 1.85 (with β, γ, and δ equal to zero).

[c3]The effective molar mass of NO_x is defined by the molar mass of nitrogen dioxide, NO_2.

* * * * *

(g) Other acronyms and abbreviations. This part uses the following additional abbreviations and acronyms:

Acronym	Meaning
ABS	acrylonitrile-butadiene-styrene
ASTM	~~American Society for Testing and Materials~~ASTM International
BMD	bag mini-diluter
BSFC	brake-specific fuel consumption
CARB	California Air Resources Board
CFR	Code of Federal Regulations
CFV	critical-flow venturi
CI	compression-ignition
CITT	Curb Idle Transmission Torque
CLD	chemiluminescent detector
CVS	constant-volume sampler
DEF	diesel exhaust fluid
DF	deterioration factor
ECM	electronic control module
EFC	electronic flow control
e.g.	exempli gratia, for example
EGR	exhaust gas recirculation
EPA	Environmental Protection Agency
FEL	Family Emission Limit
FID	flame-ionization detector
FTIR	Fourier transform infrared
GC	gas chromatograph
GC-ECD	gas chromatograph with an electron-capture detector
GC-FID	gas chromatograph with a flame ionization detector
HEPA	high-efficiency particulate air
IBP	initial boiling point
IBR	incorporated by reference
i.e.	id est, in other words
ISO	International Organization for Standardization
LPG	liquefied petroleum gas
MPD	magnetopneumatic detection
NDIR	nondispersive infrared
NDUV	nondispersive ultraviolet
NIST	National Institute for Standards and Technology
NMC	nonmethane cutter
PDP	positive-displacement pump
PEMS	portable emission measurement system
PFD	partial-flow dilution
PLOT	porous layer open tubular
PMD	paramagnetic detection
PMP	Polymethylpentene
pt.	a single point at the mean value expected at the standard.

psi	pounds per square inch
PTFE	polytetrafluoroethylene (commonly known as Teflon™)
RE	rounding error
RESS	rechargeable energy storage system
RFPF	response factor penetration fraction
RMC	ramped-modal cycle
rms	root-mean square
RTD	resistive temperature detector
SAW	surface acoustic wave
SEE	standard error of the estimate ~~of error~~
SSV	subsonic venturi
SI	spark-ignition
THC-FID	total hydrocarbon flame ionization detector
TINV	inverse student *t*-test function in Microsoft Excel
UCL	upper confidence limit
UFM	ultrasonic flow meter
U.S.C.	United States Code

374. Amend § 1065.1010 by revising paragraph (b) to read as follows:

§ 1065.1010 Incorporation by reference.

* * * * *

(b) *ASTM material*. The following standards are available from ASTM International, 100 Barr Harbor Dr., P.O. Box C700, West Conshohocken, PA 19428–2959, (877) 909–ASTM, or *http://www.astm.org*:

(1) ASTM D86-12, Standard Test Method for Distillation of Petroleum Products at Atmospheric Pressure, approved December 1, 2012 (“ASTM D86”), IBR approved for §§ 1065.703(b) and 1065.710(b) and (c).

(2) ASTM D93-13, Standard Test Methods for Flash Point by Pensky- Martens Closed Cup Tester, approved July 15, 2013 (“ASTM D93”), IBR approved for § 1065.703(b).

(3) ASTM D130-12, Standard Test Method for Corrosiveness to Copper from Petroleum Products by Copper Strip Test, approved November 1, 2012 (“ASTM D130”), IBR approved for § 1065.710(b).

(4) ASTM D381-12, Standard Test Method for Gum Content in Fuels by Jet Evaporation, approved April 15, 2012 (“ASTM D381”), IBR approved for § 1065.710(b).

(5) ASTM D445-12, Standard Test Method for Kinematic Viscosity of Transparent and Opaque Liquids (and Calculation of Dynamic Viscosity), approved April 15, 2012 (“ASTM D445”), IBR approved for § 1065.703(b).

(6) ASTM D525-12a, Standard Test Method for Oxidation Stability of Gasoline (Induction Period Method), approved September 1, 2012 (“ASTM D525”), IBR approved for § 1065.710(b).

(7) ASTM D613-13, Standard Test Method for Cetane Number of Diesel Fuel Oil, approved December 1, 2013 (“ASTM D613”), IBR approved for § 1065.703(b).

(8) ASTM D910-13a, Standard Specification for Aviation Gasolines, approved December 1, 2013 (“ASTM D910”), IBR approved for § 1065.701(f).

(9) ASTM D975-13a, Standard Specification for Diesel Fuel Oils, approved December 1, 2013 (“ASTM D975”), IBR approved for § 1065.701(f).

(10) ASTM D1267-12, Standard Test Method for Gage Vapor Pressure of Liquefied Petroleum (LP) Gases (LP-Gas Method), approved November 1, 2012 (“ASTM D1267”), IBR approved for § 1065.720(a).

(11) ASTM D1319-13, Standard Test Method for Hydrocarbon Types in Liquid Petroleum Products by Fluorescent Indicator Adsorption, approved May 1, 2013 ("ASTM D1319"), IBR approved for § 1065.710(c).
(12) ASTM D1655-13a, Standard Specification for Aviation Turbine Fuels, approved December 1, 2013 ("ASTM D1655"), IBR approved for § 1065.701(f).
(13) ASTM D1837-11, Standard Test Method for Volatility of Liquefied Petroleum (LP) Gases, approved October 1, 2011 ("ASTM D1837"), IBR approved for § 1065.720(a).
(14) ASTM D1838-12a, Standard Test Method for Copper Strip Corrosion by Liquefied Petroleum (LP) Gases, approved December 1, 2012 ("ASTM D1838"), IBR approved for § 1065.720(a).
(15) ASTM D1945-03 (Reapproved 2010), Standard Test Method for Analysis of Natural Gas by Gas Chromatography, approved January 1, 2010 ("ASTM D1945"), IBR approved for § 1065.715(a).
(16) ASTM D2158-11, Standard Test Method for Residues in Liquefied Petroleum (LP) Gases, approved January 1, 2011 ("ASTM D2158"), IBR approved for § 1065.720(a).
(17) ASTM D2163-07, Standard Test Method for Determination of Hydrocarbons in Liquefied Petroleum (LP) Gases and Propane/Propene Mixtures by Gas Chromatography, approved December 1, 2007 ("ASTM D2163"), IBR approved for § 1065.720(a).
(18) ASTM D2598-12, Standard Practice for Calculation of Certain Physical Properties of Liquefied Petroleum (LP) Gases from Compositional Analysis, approved November 1, 2012 ("ASTM D2598"), IBR approved for § 1065.720(a).
(19) ASTM D2622-16, Standard Test Method for Sulfur in Petroleum Products by Wavelength Dispersive X-ray Fluorescence Spectrometry, approved January 1, 2016 ("ASTM D2622"), IBR approved for §§ 1065.703(b) and 1065.710(b) and (c).
(20) ASTM D2699-13b, Standard Test Method for Research Octane Number of Spark-Ignition Engine Fuel, approved October 1, 2013 ("ASTM D2699"), IBR approved for § 1065.710(b).
(21) ASTM D2700-13b, Standard Test Method for Motor Octane Number of Spark-Ignition Engine Fuel, approved October 1, 2013 ("ASTM D2700"), IBR approved for § 1065.710(b).
(22) ASTM D2713-13, Standard Test Method for Dryness of Propane (Valve Freeze Method), approved October 1, 2013 ("ASTM D2713"), IBR approved for § 1065.720(a).
(23) ~~ASTM D2784-11, Standard Test Method for Sulfur in Liquefied Petroleum Gases (Oxy-Hydrogen Burner or Lamp), approved January 1, 2011 ("ASTM D2784"), IBR approved for § 1065.720(a).~~
~~(24)~~ ASTM D2880-13b, Standard Specification for Gas Turbine Fuel Oils, approved November 15, 2013 ("ASTM D2880"), IBR approved for § 1065.701(f).
(24~~5~~) ASTM D2986-95a, Standard Practice for Evaluation of Air Assay Media by the Monodisperse DOP (Dioctyl Phthalate) Smoke Test, approved September 10, 1995 ("ASTM D2986"), IBR approved for § 1065.170(c). (Note: This standard was withdrawn by ASTM.)
(25~~6~~) ASTM D3231-13, Standard Test Method for Phosphorus in Gasoline, approved June 15, 2013 ("ASTM D3231"), IBR approved for § 1065.710(b) and (c).
(26~~7~~) ASTM D3237-12, Standard Test Method for Lead in Gasoline By Atomic Absorption Spectroscopy, approved June 1, 2012 ("ASTM D3237"), IBR approved for § 1065.710(b) and (c).
(27~~8~~) ASTM D4052-11, Standard Test Method for Density, Relative Density, and API Gravity of Liquids by Digital Density Meter, approved October 15, 2011 ("ASTM D4052"), IBR approved for § 1065.703(b).

(289) ASTM D4629-12, Standard Test Method for Trace Nitrogen in Liquid Petroleum Hydrocarbons by Syringe/Inlet Oxidative Combustion and Chemiluminescence Detection, approved April 15, 2012 ("ASTM D4629"), IBR approved for § 1065.655(e).
(2930) ASTM D4814-13b, Standard Specification for Automotive Spark-Ignition Engine Fuel, approved December 1, 2013 ("ASTM D4814"), IBR approved for § 1065.701(f).
(301) ASTM D4815-13, Standard Test Method for Determination of MTBE, ETBE, TAME, DIPE, tertiary-Amyl Alcohol and C_1 to C_4 Alcohols in Gasoline by Gas Chromatography, approved October 1, 2013 ("ASTM D4815"), IBR approved for § 1065.710(b).
(312) ASTM D5186-03 (Reapproved 2009), Standard Test Method for Determination of the Aromatic Content and Polynuclear Aromatic Content of Diesel Fuels and Aviation Turbine Fuels By Supercritical Fluid Chromatography, approved April 15, 2009 ("ASTM D5186"), IBR approved for § 1065.703(b).
(323) ASTM D5191-13, Standard Test Method for Vapor Pressure of Petroleum Products (Mini Method), approved December 1, 2013 ("ASTM D5191"), IBR approved for § 1065.710(b) and (c).
(334) ASTM D5291-10, Standard Test Methods for Instrumental Determination of Carbon, Hydrogen, and Nitrogen in Petroleum Products and Lubricants, approved May 1, 2010 ("ASTM D5291"), IBR approved for § 1065.655(e).
(345) ASTM D5453-19a , Standard Test Method for Determination of Total Sulfur in Light Hydrocarbons, Spark Ignition Engine Fuel, Diesel Engine Fuel, and Engine Oil by Ultraviolet Fluorescence, approved July 1, 2019 ("ASTM D5453"), IBR approved for §§ 1065.703(b) and 1065.710(b).
(356) ASTM D5599-00 (Reapproved 2010), Standard Test Method for Determination of Oxygenates in Gasoline by Gas Chromatography and Oxygen Selective Flame Ionization Detection, approved October 1, 2010 ("ASTM D5599"), IBR approved for §§ 1065.655(e) and 1065.710(b).
(367) ASTM D5762-12 Standard Test Method for Nitrogen in Petroleum and Petroleum Products by Boat-Inlet Chemiluminescence, approved April 15, 2012 ("ASTM D5762"), IBR approved for § 1065.655(e).
(378) ASTM D5769-10, Standard Test Method for Determination of Benzene, Toluene, and Total Aromatics in Finished Gasolines by Gas Chromatography/Mass Spectrometry, approved May 1, 2010 ("ASTM D5769"), IBR approved for § 1065.710(b).
(389) ASTM D5797-13, Standard Specification for Fuel Methanol (M70- M85) for Automotive Spark-Ignition Engines, approved June 15, 2013 ("ASTM D5797"), IBR approved for § 1065.701(f).
(3940) ASTM D5798-13a, Standard Specification for Ethanol Fuel Blends for Flexible Fuel Automotive Spark-Ignition Engines, approved June 15, 2013 ("ASTM D5798"), IBR approved for § 1065.701(f).
(401) ASTM D6348-12$^{\varepsilon 1}$, Standard Test Method for Determination of Gaseous Compounds by Extractive Direct Interface Fourier Transform Infrared (FTIR) Spectroscopy, approved February 1, 2012 ("ASTM D6348"), IBR approved for §§ 1065.266(b) and 1065.275(b).
(412) ASTM D6550-10, Standard Test Method for Determination of Olefin Content of Gasolines by Supercritical-Fluid Chromatography, approved October 1, 2010 ("ASTM D6550"), IBR approved for § 1065.710(b).
(423) ASTM D6615-11a, Standard Specification for Jet B Wide-Cut Aviation Turbine Fuel, approved October 1, 2011 ("ASTM D6615"), IBR approved for § 1065.701(f).

(43) ASTM D6667-14 (Reapproved 2019), Standard Test Method for Determination of Total Volatile Sulfur in Gaseous Hydrocarbons and Liquefied Petroleum Gases by Ultraviolet Fluorescence, approved May 1, 2019 ("ASTM D6667"), IBR approved for § 1065.720(a).
(44) ASTM D6751-12, Standard Specification for Biodiesel Fuel Blend Stock (B100) for Middle Distillate Fuels, approved August 1, 2012 ("ASTM D6751"), IBR approved for § 1065.701(f).
(45) ASTM D6985-04a, Standard Specification for Middle Distillate Fuel Oil—Military Marine Applications, approved November 1, 2004 ("ASTM D6985"), IBR approved for § 1065.701(f). (Note: This standard was withdrawn by ASTM.)
(46) ASTM D7039-15a (Reapproved 2020), Standard Test Method for Sulfur in Gasoline, Diesel Fuel, Jet Fuel, Kerosine, Biodiesel, Biodiesel Blends, and Gasoline-Ethanol Blends by Monochromatic Wavelength Dispersive X-ray Fluorescence Spectrometry, approved May 1, 2020 ("ASTM D7039"), IBR approved for §§ 1065.703(b) and 1065.710(b).
(47) ASTM F1471-09, Standard Test Method for Air Cleaning Performance of a High-Efficiency Particulate Air Filter System, approved March 1, 2009 ("ASTM F1471"), IBR approved for § 1065.1001.
*   *   *   *   *

Part 1066—VEHICLE-TESTING PROCEDURES

375. The authority citation for part 1066 continues to read as follows:

Authority: 42 U.S.C. 7401 - 7671q.

376. Amend § 1066.1 by revising paragraph (g) to read as follows:

§ 1066.1 Applicability.

* * * * *

(g) For additional information regarding these test procedures, visit our Web site at www.epa.gov, and in particular https://www.epa.gov/vehicle-and-fuel-emissions-testing/vehicle-testing-regulations~~http://www.epa.gov/nvfel/testing/regulations.htm~~.

377. Amend § 1066.135 by revising paragraph (a)(1) to read as follows:

§ 1066.135 Linearity verification.

* * * * *

(a) * * *

(1) Use instrument manufacturer recommendations and good engineering judgment to select at least ten reference values, y_{refi}, that cover the range of values that you expect during testing (to prevent extrapolation beyond the verified range during emission testing). We recommend selecting zero as one of your reference values. For each range calibrated, if the deviation from a least-squares best-fit straight line is 2 % or less of the value at each data point, concentration values may be calculated by use of a straight-line curve fit for that range. If the deviation exceeds 2 % at any point, use the best-fit nonlinear equation that represents the data to within 2 % of each test point to determine concentration. If you use a gas divider to blend calibration gases, you may verify that the calibration curve produced names a calibration gas within 2 % of its certified concentration. Perform this verification between ~~15~~ 10 and ~~50~~ 60 % of the full-scale analyzer range.

* * * * *

378. Amend § 1066.210 by revising paragraph (d)(3) to read as follows:

§ 1066.210 Dynamometers.

* * * * *

(d) * * *

(3) The load applied by the dynamometer simulates forces acting on the vehicle during normal driving according to the following equation:

$$FR_{\text{i}} = A\cdot\cos\left(\text{atan}\left(G_{\text{i-1}}\right)\right) + B\cdot v_{\text{i}} + C\cdot v_{\text{i}}^{2} + M_{\text{e}}\cdot\frac{v_{\text{i}} - v_{\text{i-1}}}{t_{\text{i}} - t_{\text{i-1}}} + M\cdot a_{\text{g}}\cdot\sin\left(\text{atan}\left(G_{\text{i-1}}\right)\right)$$

Eq. 1066.210-1

Where:

FR = total road-load force to be applied at the surface of the roll. The total force is the sum of the individual tractive forces applied at each roll surface.

i = a counter to indicate a point in time over the driving schedule. For a dynamometer operating at 10-Hz intervals over a 600-second driving schedule, the maximum value of *i* should be 6,000.

A = a vehicle-specific constant value representing the vehicle’s frictional load in lbf or newtons. See subpart D of this part.

G_i = instantaneous road grade, in percent. If your duty cycle is not subject to road grade, set this value to 0.
B = a vehicle-specific coefficient representing load from drag and rolling resistance, which are a function of vehicle speed, in lbf/(mi/hr) or N·s/m. See subpart D of this part.
v = instantaneous linear speed at the roll surfaces as measured by the dynamometer, in mi/hr or m/s. Let $v_{i-1} = 0$ for $i = 0$.
C = a vehicle-specific coefficient representing aerodynamic effects, which are a function of vehicle speed squared, in lbf/(mi/hr)^2 or N·s^2/m^2. See subpart D of this part.
M_e = the vehicle's effective mass in lbm or kg, including the effect of rotating axles as specified in § 1066.310(b)(7).
t = elapsed time in the driving schedule as measured by the dynamometer, in seconds. Let t_{i-1} = 0 for $i = 0$.
M = the measured vehicle mass, in lbm or kg.
a_g = acceleration of Earth's gravity = 9.80665 m/s^2~~, as described in 40 CFR 1065.630~~.
*   *   *   *   *

379. Amend § 1066.255 by revising paragraph (c) to read as follows:

§ 1066.255 Parasitic loss verification.

*   *   *   *   *

(c) Procedure. Perform this verification by following the dynamometer manufacturer's specifications to establish a parasitic loss curve, taking data at fixed speed intervals to cover the range of vehicle speeds that will occur during testing. You may zero the load cell at a selected speed if that improves your ability to determine the parasitic loss. Parasitic loss forces may never be negative. Note that the torque transducers must be mathematically zeroed and spanned prior to performing this procedure.

*   *   *   *   *

380. Amend § 1066.260 by revising paragraph (c)(4) to read as follows:

§ 1066.260 Parasitic friction compensation evaluation.

*   *   *   *   *

(c)   *   *   *

(4) Calculate the power equivalent of friction compensation error, FC_{error}, using the following equation:

$$FC_{error} = \frac{I}{2 \cdot t} \cdot \left(v_{init}^2 - v_{final}^2\right)$$

Eq. 1066.260-1

Where:
I = dynamometer inertia setting.
t = duration of the measurement interval, accurate to at least 0.01 s.
v_{init} = the roll speed corresponding to the start of the measurement interval, accurate to at least 0.05 mi/hr.
v_{final} = the roll speed corresponding to the end of the measurement interval, accurate to at least 0.05 mi/hr.

Example:
I = 2000 lbm = 62.16 lbf·s^2/ft

t = 60.0 s
v_{init} = 9.2 mi/hr = 13.5 ft/s
v_{final} = 10.0 mi/hr = 14.7 ft/s

$$FC_{error} = \frac{62.16}{2 \cdot 60.00} \cdot \left(13.5^2 - 14.7^2\right)$$

FC_{error} = –177.5 ft·lbf/s = –0.0322 hp
* * * * *

381. Amend § 1066.265 by revising paragraph (d)(1) to read as follows:

§ 1066.265 Acceleration and deceleration verification.

* * * * *

(d) * * *

(1) Calculate the force setting, *F*, using the following equation:

$$F = I_b \cdot |a|$$

Eq. 1066.265-4

Where:

I_b = the dynamometer manufacturer's stated base inertia, in lbf·s^2/ft.
a = nominal acceleration rate, in ft/s^2.

Example:

I_b = 2967 lbm = 92.217 lbf·s^2/ft
a = 1 (mi/hr)/s = 1.4667 ft/s^2

$$F = 92.217 \cdot |1.4667|$$

Commented [CAL77]: Equation updated.

F = 135.25 lbf
* * * * *

382. Amend § 1066.270 by revising paragraphs (c)(4) and (d)(2) to read as follows:

§ 1066.270 Unloaded coastdown verification.

* * * * *

(c) * * *

(4) Determine the mean coastdown force, $\bar{F}$, for each speed and inertia setting for each of the coastdowns performed using the following equation:

$$\bar{F} = \frac{I \cdot (v_{init} - v_{final})}{t}$$

Eq. 1066.270-1

Where:

$\bar{F}$ = the mean force measured during the coastdown for each speed interval and inertia setting, expressed in lbf and rounded to four significant figures.
I = the dynamometer's inertia setting, in lbf·s^2/ft.
v_{init} = the speed at the start of the coastdown interval, expressed in ft/s to at least four significant figures.
v_{final} = the speed at the end of the coastdown interval, expressed in ft/s to at least four significant figures.
t = coastdown time for each speed interval and inertia setting, accurate to at least 0.01 s.

Example:
I = 2000 lbm = 62.16 lbf·s²/ft
v_{init} = 25 mi/hr = 36.66 ft/s
v_{final} = 15 mi/hr = 22.0 ft/s
t = 5.00 s

$$\bar{F} = \frac{62.16\cdot(36.66-22.0)}{5.00}$$

$\bar{F}$ = 182.2 3 lbf

* * * * *

(d) * * *

(2) For vehicles above 20,000 pounds GVWR, the maximum allowable error, $F_{errormax}$, for all speed intervals and inertia settings is ±1.0 % or ±39.2 Nthe value determined from Eq. 1066.270-3 (substituting 8.8 lbf for 2.2 lbf in the numerator), whichever is greater.

* * * * *

383. Amend § 1066.275 by revising paragraphs (b) and (d) to read as follows:

§ 1066.275 Daily dynamometer readiness verification.

* * * * *

(b) Scope and frequency. Perform this verification upon initial installation, within 1 day before testing, and after major maintenance. You may run this within 7 days before testing if you accumulate , over a period of time, you have data to support a less frequent verification interval.

* * * * *

(d) Performance evaluation. The coastdown force error determined in paragraph (c) of this section may not exceed the following:

(1) For vehicles at or below 20,000 pounds GVWR, ±1.0 % or the value determined from Eq. 1066.270-3±(±2.2 lbf) ±9.8 N , whichever is greater.

(2) For vehicles above 20,000 pounds GVWR, ±1.0 % or ±39.2 Nthe value determined from Eq. 1066.270-3 (substituting (±8.8 lbf) for 2.2 lbf), whichever is greater.

* * * * *

384. Revise § 1066.405 to read as follows:

§ 1066.405 Vehicle preparation, and preconditioning, and maintenance.

(a) Prepare the vehicle for testing (including measurement of evaporative and refueling emissions if appropriate), as described in the standard-setting part.

(b) If you inspect a vehicle, keep a record of the inspection and update your application for certification to document any changes that result. You may use any kind of equipment, instrument, or tool that is available at dealerships and other service outlets to identify bad enginemalfunctioning components or perform maintenance if it is available at dealerships and other service outlets.

(c) You may repair a test vehicle as needed for defective parts from a test vehicle if they that are unrelated to emission control. You must ask us to approve repairs that might affect the vehicle's emission controls. If we determine that a part failure, system malfunction, or associated repairs makes the vehicle's emission controls unrepresentative of production engines, you may not longer use it as an emission-data vehicle. Also, if the engine installed in the test vehicle has a major mechanical failure that requires you to take the vehicle apart, you may no longer use the vehicle as an emission-data vehicle for exhaust measurements.

385. Amend § 1066.420 by revising paragraph (d) to read as follows:

§ 1066.420 Test preparation.

* * * * *

(d) Control test cell ambient air humidity as follows:

(1) For vehicles at or below 14,000 pounds GVWR, follow the humidity requirements in Table 1 of this section, unless the standard-setting part specifies otherwise. When complying with humidity requirements in the table, where no tolerance is specified, use good engineering judgment to maintain the humidity level near the specified value within the limitations of your test facility.

(2) For vehicles above 14,000 pounds GVWR, you may test vehicles at any humidity.

(3) Table 1 follows:

TABLE 1 OF § 1066.420–TEST CELL HUMIDITY REQUIREMENTS

Test cycle	Humidity requirement (grains H_2O per pound dry air)	Tolerance (grains H_2O per pound dry air)
AC17	69	± 5 average, ± 10 instantaneous
FTP[a1] and LA-92	50	
HFET	50	
SC03	100	± 5 average
US06	50	

[a1]FTP humidity requirement does not apply for cold (–7°C), intermediate (10 °C), and hot (35 °C) temperature testing.

* * * * *

386. Amend § 1066.605 by revising paragraphs (c)(4) and (h)(2)(i) to read as follows:

§ 1066.605 Mass-based and molar-based exhaust emission calculations.

* * * * *

(c) * * *

(4) For vehicles at or below 14,000 pounds GVWR, calculate HC concentrations, including dilution air background concentrations, as described in this section, and as described in § 1066.635 for NMOG. For emission testing of vehicles above 14,000 pounds GVWR, with fuels that contain 25 % or more oxygenated compounds by volume, calculate THCE and NMHCE concentrations, including dilution air background concentrations, as described in 40 CFR part 1065, subpart I.

* * * * *

(h) * * *

(2) * * *

(i) Varying flow rate. If you continuously sample from a varying exhaust flow rate, calculate $V_{[\text{flow}]}$ using the following equation:

$$V_{[\text{flow}]} = \sum_{i=1}^{N} \dot{Q}_i \cdot \Delta t$$

Commented [CAL78]: Equation updated.

Eq. 1066.605-10

Where:
$\Delta t = 1/f_{\text{record}}$ Eq. 1066.605-11

Example:
$N = 505$
$\dot{Q}_{CVS1} = 0.276\ \text{m}^3/\text{s}$

$\dot{Q}_{CVS2} = 0.294\ \text{m}^3/\text{s}$
$f_{\text{record}} = 1\ \text{Hz}$
Using Eq. 1066.605-11,
$\Delta t = 1/1 = 1\ \text{s}$
$V_{CVS} = (0.276 + 0.294 + ... + \dot{Q}_{CVS505}) \cdot 1$
$V_{CVS} = 170.721\ \text{m}^3$
* * * * *

387. Amend § 1066.610 by revising paragraph (d) to read as follows:
§ 1066.610 Dilution air background correction.
* * * * *
(d) Determine the time-weighted dilution factor, DF_w, over the duty cycle using the following equation:

$$DF_w = \frac{\sum_{i=1}^{N} t_i}{\sum_{i=1}^{N} \frac{1}{DF_i} \cdot t_i}$$

Eq. 1066.610-4

Commented [CAL79]: Equation updated.

Where:
N = number of test intervals.
i = test interval number
t = duration of the test interval.
DF = dilution factor over the test interval.

Example:
$N = 3$
$DF_1 = 14.40$
$t_1 = 505\ \text{s}$
$DF_2 = 24.48$
$t_2 = 867\ \text{s}$
$DF_3 = 17.28$
$t_3 = 505\ \text{s}$

$$DF_w = \frac{505 + 867 + 505}{\left(\frac{1}{14.40} \cdot 505\right) + \left(\frac{1}{24.48} \cdot 867\right) + \left(\frac{1}{17.28} \cdot 505\right)} = 18.82$$

388. Amend § 1066.710 by revising paragraph (c) to read as follows:

§ 1066.710 Cold temperature testing procedures for measuring CO and NMHC emissions and determining fuel economy.

* * * * *

(c) Heater and defroster. During the test, operate the vehicle's interior climate control system with the heat on and ~~set to primarily defrost the front window. Turn~~ air conditioning off. You may not use any supplemental auxiliary heat during this testing. You may set the heater to any temperature and fan setting during vehicle preconditioning.

(1) Manual and automatic temperature control. Unless you rely on full automatic control as specified in paragraph (c)(2) of this section, take the following steps to control heater settings:

(i) Set the climate control system as follows before the first acceleration (t = 20 s), or before starting the vehicle if the climate control system allows it:

(A) Temperature. Set controls to maximum heat. For automatic temperature control systems ~~running in manual mode~~that allow the operator to select a specific temperature, set the heater control to 72 °F or higher.

(B) Fan speed. Set the fan speed to full off or the lowest available speed if a full off position is not available.

(C) Airflow direction. Direct airflow to the front window (window defrost mode).

(D) Air source. If independently controllable, set the system to draw in outside air.

(ii) At the second idle of the test cycle, which occurs 125 seconds after the start of the test, set the fan speed to maximum. Complete by 130 seconds after the start of the test. Leave temperature and air source settings unchanged

(iii) At the sixth idle of the test interval, which occurs at the deceleration to zero miles per hour 505 seconds after the start of the test, set the fan speed to the lowest setting that maintains air flow. Complete these changes by 510 seconds after the start of the test. You may use different vent and fan speed settings for the remainder of the test. Leave the temperature and air source settings unchanged.

(2) ~~Automatic~~ Full automatic control. ~~For v~~Vehicles with full automatic control systems ~~running in automatic mode, s~~may instead operate as described in this paragraph (c)(2). Set the temperature to 72 °F ~~and~~ in full automatic control for the whole test, allowing the vehicle to adjust the air temperature and direction of the airflow. ~~If the system allows the operator to select the location of the output airflow without disabling automatic control, set the air flow control to the front window defrost mode for the whole test.~~

(3) Multiple-zone systems. For vehicles that have separate driver and passenger controls or separate front and rear controls, you must set all temperature and fan controls as described in paragraphs (c)(1) and (2) of this section, except that rear controls need not be set to defrost the front window.

(4) Alternative test procedures. We may approve the use of other settings under 40 CFR 86.1840 if a vehicle's climate control system is not compatible with the provisions of this section.

* * * * *

389. Amend § 1066.801 by revising paragraph (e) to read as follows:

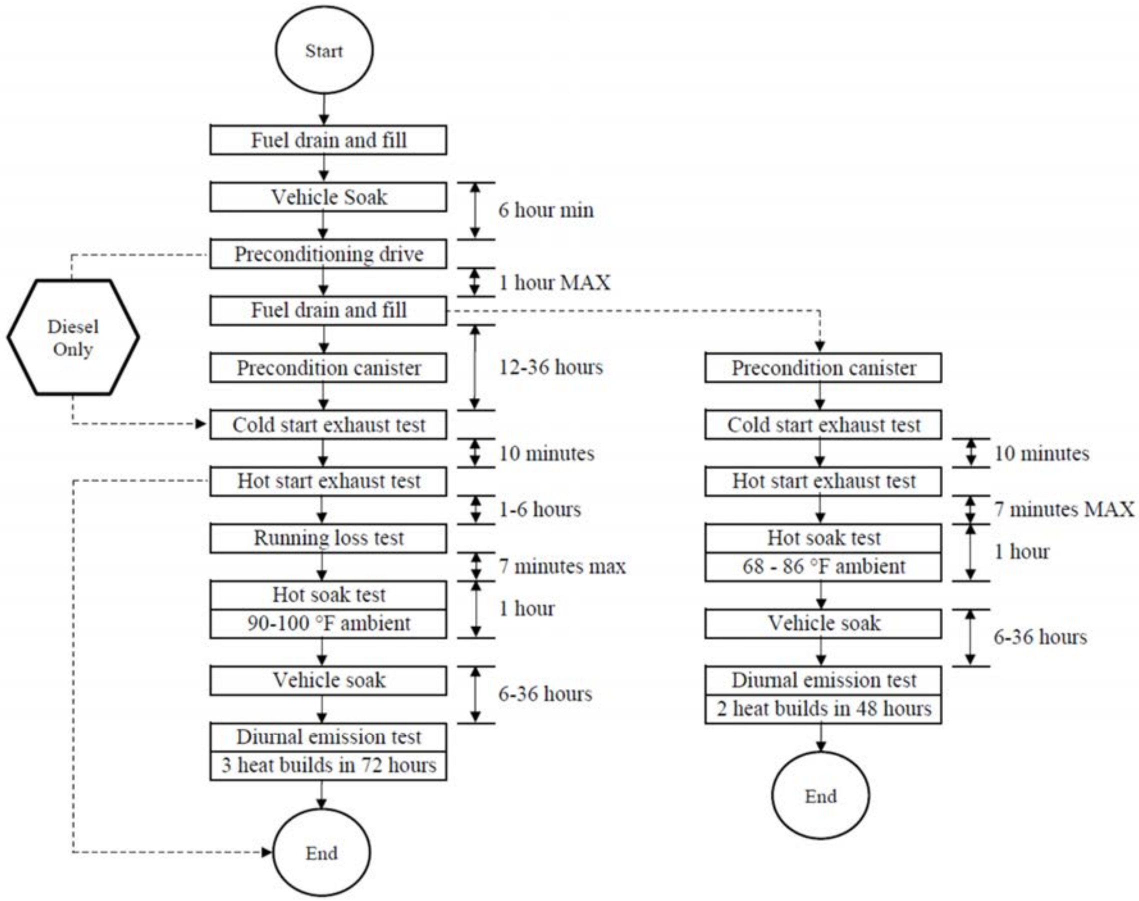
§ 1066.801 Applicability and general provisions.

* * * * *

(e) The following figure illustrates the FTP test sequence for measuring exhaust and evaporative emissions:

Figure 1 of § 1066.801–FTP test sequence

Commented [CAL80]: Figure updated.



390. Amend § 1066.835 by revising paragraphs (a) and (f)(2) to read as follows:

§ 1066.835 Exhaust emission test procedure for SC03 emissions.

* * * * *

(a) Drain and refill the vehicle's fuel tank(s) if testing starts more than 72 hours after the most recent FTP or HFET measurement ~~after the last drain and fill operation~~(with or without evaporative emission measurements).

* * * * *

(f) * * *

(2) Conditions before and after testing. Use good engineering judgment to demonstrate that you meet the specified ~~instantaneous~~ temperature and humidity tolerances in paragraph~~s~~ (f)(1) of this section at all times before and between emission measurements.

* * * * *

391. Revise § 1066.930 to read as follows:

§ 1066.930 Equipment for point-source measurement of running losses.

For point-source measurement of running loss emissions, use equipment meeting the specifications in 40 CFR 86.107-96(i).

392. Amend § 1066.1005 by revising paragraphs (a), (c), (d), and (f) to read as follows:

§ 1066.1005 Symbols, abbreviations, acronyms, and units of measure.

* * * * *

(a) Symbols for quantities. This part uses the following symbols and units of measure for various quantities:

Symbol	Quantity	Unit	Unit symbol	Unit in terms of SI base units
α	atomic hydrogen to carbon ratio	mole per mole	mol/mol	1
A	area	square meter	m^2	m^2
A	vehicle frictional load	pound force or newton	lbf or N	$m\cdot kg\cdot s^{-2}$
a_g	acceleration of Earth's gravity	meters per second squared	m/s^2	$m\cdot s^{-2}$
A_m	calculated vehicle frictional load	pound force or newton	lbf or N	$m\cdot kg\cdot s^{-2}$
a_0	intercept of least squares regression			
a_1	slope of least squares regression			
a	acceleration	feet per second squared or meters per second squared	ft/s^2 or m/s^2	$m\cdot s^{-2}$
B	vehicle load from drag and rolling resistance	pound force per mile per hour or newton second per meter	lbf/(mi/hr) or N·s/m	$kg\cdot s^{-1}$
β	ratio of diameters	meter per meter	m/m	1
β	atomic oxygen to carbon ratio	mole per mole	mol/mol	1
c	conversion factor			
C	vehicle-specific aerodynamic effects	pound force per mile per hour squared or newton-second squared per meter squared	$lbf/(mi/hr)^2$ or $N\cdot s^2/m^2$	$m^{-1}\cdot kg$
$C_\#$	number of carbon atoms in a molecule	$C_\#$	number of carbon atoms in a molecule	$C_\#$
C_d	discharge coefficient			
C_dA	drag area	meter squared	m^2	m^2
C_f	flow coefficient			

C_p	heat capacity at constant pressure	joule per kelvin	J/K	$m^2 \cdot kg \cdot s^{-2} \cdot K^{-1}$
C_v	heat capacity at constant volume	joule per kelvin	J/K	$m^2 \cdot kg \cdot s^{-2} \cdot K^{-1}$
d	diameter	meters	m	m
D	distance	miles or meters	mi or m	m
D	slope correlation	pound force per mile per hour squared or newton second squared per meter squared	$lbf/(mi/hr)^2$ or $N \cdot s^2/m^2$	$m^{-2} \cdot kg$
DF	dilution factor			1
e	mass weighted emission result	grams/mile	g/mi	
F	force	pound force or newton	lbf or N	$kg \cdot s^{-2}$
f	frequency	hertz	Hz	s^{-1}
f_n	angular speed (shaft)	revolutions per minute	r/min	$\pi \cdot 30 \cdot s^{-1}$
FC	friction compensation error	horsepower or watt	W	$m^2 \cdot kg \cdot s^{-3}$
FR	road-load force	pound force or newton	lbf or N	$kg \cdot s^{-2}$
γ	ratio of specific heats	(joule per kilogram kelvin) per (joule per kilogram kelvin)	(J/(kg·K))/(J/(kg·K))	1
H	ambient humidity	grams water vapor per kilogram dry air	g H_2O vapor/kg dry air	g H_2O vapor/kg dry air
Δh	change in height	meters	m	m
I	inertia	pound mass or kilogram	lbm or kg	kg
I	current	ampere	A	A
i	indexing variable			
IR	inertia work rating			
K	correction factor			1
K_v	calibration coefficient		$m^4 \cdot s \cdot K^{0.5}/kg$	$m^4 \cdot kg^{-1} \cdot s \cdot K^{0.5}$
μ	viscosity, dynamic	pascal second	Pa·s	$m^{-1} \cdot kg \cdot s^{-1}$
M	molar mass	gram per mole	g/mol	$10^{-3} \cdot kg \cdot mol^{-1}$
M_e	effective mass	kilogram	kg	kg
m	mass	pound mass or kilogram	lbm or kg	kg
N	total number in series			
n	total number of pulses in a series			
p	pressure	pascal	Pa	$m^{-1} \cdot kg \cdot s^{-2}$
Δp	differential static pressure	pascal	Pa	$m^{-1} \cdot kg \cdot s^{-2}$
p_d	saturated vapor pressure at ambient dry bulb temperature	kilopascal	kPa	$m^{-1} \cdot kg \cdot s^{-2}$
PF	penetration fraction			
ρ	mass density	kilogram per cubic meter	kg/m^3	$m^{-3} \cdot kg$
R	dynamometer roll revolutions	revolutions per minute	rpm	$\pi \cdot 30^{-1} \cdot s^{-1}$
r	ratio of pressures	pascal per pascal	Pa/Pa	1
r^2	coefficient of determination			
$Re^{\#}$	Reynolds number			
RF	response factor			
RH	relative humidity			
S	Sutherland constant	kelvin	K	K
SEE	standard error of the estimate ~~of error~~			
SG	specific gravity			

Δs	distance traveled during measurement interval	meters	m	m
T	absolute temperature	kelvin	K	K
T	Celsius temperature	degree Celsius	°C	K − 273.15
T	torque (moment of force)	newton meter	N·m	$m^2 \cdot kg \cdot s^{-2}$
t	time	hour or second	hr or s	s
Δt	time interval, period, 1/frequency	second	s	s
U	voltage	volt	V	$m^2 \cdot kg \cdot s^{-3} \cdot A^{-1}$
v	speed	miles per hour or meters per second	mi/hr or m/s	$m \cdot s^{-1}$
V	volume	cubic meter	m^3	m^3
$\dot{V}$	flow volume rate	cubic feet per minute or cubic meter per second	ft^3/min or m^3/s	$m^3 \cdot /s^{-1}$
VP	volume percent			
x	concentration of emission over a test interval	part per million	ppm	
y	generic variable			
Z	compressibility factor			

*   *   *   *   *

(c) Superscripts. This part uses the following superscripts ~~to define a~~for modifying quantity symbols:

Superscript	~~Quantity~~Meaning
overbar (such as $\bar{y}$)	arithmetic mean
overdot (such as $\dot{y}$)	quantity per unit time

(d) Subscripts. This part uses the following subscripts ~~to define a~~for modifying quantity symbols:

Subscript	~~Quantity~~Meaning
0	reference
abs	absolute quantity
AC17	air conditioning 2017 test interval
act	actual or measured condition
actint	actual or measured condition over the speed interval
adj	adjusted
air	air, dry
atmos	atmospheric
b	base
bkgnd	background
c	cold
comp	composite
cor	corrected
cs	cold stabilized
ct	cold transient
cUDDS	cold-start UDDS
D	driven
dew	dewpoint
dexh	dilute exhaust quantity

dil	dilute
e	effective
emission	emission specie
error	error
EtOH	ethanol
exh	raw exhaust quantity
exp	expected quantity
fil	filter
final	final
flow	flow measurement device type
gas	gaseous
h	hot
HFET	highway fuel economy test
hs	hot stabilized
ht	hot transient
hUDDS	hot-start UDDS
i	an individual of a series
ID	driven inertia
in	inlet
int	intake
init	initial quantity, typically before an emission test
IT	target inertia
liq	liquid
max	the maximum (i.e., peak) value expected at the standard over a test interval; not the maximum of an instrument range
meas	measured quantity
mix	dilute exhaust gas mixture
out	outlet
PM	particulate matter
record	record
ref	reference quantity
rev	revolution
roll	dynamometer roll
s	settling
s	slip
s	stabilized
sat	saturated condition
SC03	air conditioning driving schedule
span	span quantity
sda	secondary dilution air
std	standard conditions
T	target
t	throat
test	test quantity
uncor	uncorrected quantity
w	weighted
zero	zero quantity

*   *   *   *   *

(f) This part uses the following densities of chemical species:

Symbol	Quantity[a1],[b2]	g/m^3	g/ft^3
ρ_{CH4}	density of methane	666.905	18.8847
ρ_{CH3OH}	density of methanol	1332.02	37.7185
ρ_{C2H5OH}	C_1-equivalent density of ethanol	957.559	27.1151
ρ_{C2H4O}	C_1-equivalent density of acetaldehyde	915.658	25.9285
ρ_{C3H8}	density of propane	611.035	17.3026
ρ_{C3H7OH}	C_1-equivalent density of propanol	832.74	23.5806
ρ_{CO}	density of carbon monoxide	1164.41	32.9725
ρ_{CO2}	density of carbon dioxide	1829.53	51.8064
$\rho_{HC\text{-}gas}$	effective density of hydrocarbon - gaseous fuel[c3]	(see 3)	(see 3)
ρ_{CH2O}	density of formaldehyde	1248.21	35.3455
$\rho_{HC\text{-}liq}$	effective density of hydrocarbon - liquid fuel[d4]	576.816	16.3336
$\rho_{NMHC\text{-}gas}$	effective density of nonmethane hydrocarbon - gaseous fuel[c3]	(see 3)	(see 3)
$\rho_{NMHC\text{-}liq}$	effective density of nonmethane hydrocarbon - liquid fuel[d4]	576.816	16.3336
$\rho_{NMHCE\text{-}gas}$	effective density of nonmethane equivalent hydrocarbon - gaseous fuel[c3]	(see 3)	(see 3)
$\rho_{NMHCE\text{-}liq}$	effective density of nonmethane equivalent hydrocarbon - liquid fuel[d4]	576.816	16.3336
ρ_{NOx}	effective density of oxides of nitrogen[e5]	1912.5	54.156
ρ_{N2O}	density of nitrous oxide	1829.66	51.8103
$\rho_{THC\text{-}liq}$	effective density of total hydrocarbon - liquid fuel[d4]	576.816	16.3336
$\rho_{THCE\text{-}liq}$	effective density of total equivalent hydrocarbon - liquid fuel[d4]	576.816	16.3336

[a1]Densities are given at 20 °C and 101.325 kPa.

[b2]Densities for all hydrocarbon containing quantities are given in g/m^3-carbon atom and g/ft^3-carbon atom.

[c3]The effective density for natural gas fuel and liquefied petroleum gas fuel are defined by an atomic hydrogen-to-carbon ratio, α, of the hydrocarbon components of the test fuel. $\rho_{HCgas} = 41.57 \cdot (12.011 + (\alpha \cdot 1.008))$.

[d4]The effective density for gasoline and diesel fuel are defined by an atomic hydrogen-to-carbon ratio, α, of 1.85.

[e5]The effective density of NO_x is defined by the molar mass of nitrogen dioxide, NO_2.

*   *   *   *   *

Attachment B

PART 9—OMB APPROVALS UNDER THE PAPERWORK REDUCTION ACT

1. The authority citation for part 9 continues to read as follows:
Authority: 7 U.S.C. 135 et seq., 136-136y; 15 U.S.C. 2001, 2003, 2005, 2006, 2601-2671; 21 U.S.C. 331j, 346a, 31 U.S.C. 9701; 33 U.S.C. 1251 et seq., 1311, 1313d, 1314, 1318, 1321, 1326, 1330, 1342, 1344, 1345 (d) and (e), 1361; E.O. 11735, 38 FR 21243, 3 CFR, 1971-1975 Comp. p. 973; 42 U.S.C. 241, 242b, 243, 246, 300f, 300g, 300g-1, 300g-2, 300g-3, 300g-4, 300g-5, 300g-6, 300j-1, 300j-2, 300j-3, 300j-4, 300j-9, 1857 et seq., 6901-6992k, 7401-7671q, 7542, 9601-9657, 11023, 11048.

2. Amend §9.1 by:
a. Removing entries for 85.1403 through 85.1415, 85.1514, 85.1712, 85.1808, 85.2208, and 85.2401 through 85.2409;
b. Revising the entries under the heading “Control of Emissions From New and In-Use Highway Vehicles and Engine”;
c. Removing the heading “Clean-Fuel Vehicles” and the items under that heading;
d. Removing the heading “Control of Emissions From New and In-Use Nonroad Compression-Ignition Engines” and the items under that heading;
e. Removing the heading “Control of Emissions From New and In-use Nonroad Engines” and the items under that heading;
f. Removing the heading “Control of Emissions From New and In-Use Marine Compression-Ignition Engines” and the items under that heading;
g. Revising the entries under the heading “Fuel Economy of Motor Vehicles”;
h. Revising the entry for “1033.825” to read as “1033.925” and
i. Revising the entry for “1042.825” to read as “1042.925”.
The revisions read as follows:

§9.1 OMB approvals under the Paperwork Reduction Act.

* * * * *

* * * * * *	
Control of Air Pollution From Motor Vehicles and Motor Vehicle Engines	
85.503	2060-0104
85.505	2060-0104
85.1504	2060-0095
85.1505	2060-0095
85.1507	2060-0095
85.1508	2060-0095
85.1509	2060-0095
85.1511	2060-0095
85.1512	2060-0095
85.1705	2060-0104
85.1706	2060-0104
85.1708	2060-0104
85.1710	2060-0104
85.1802	2060-0104
85.1803	2060-0104
85.1806	2060-0104

85.1903	2060-0104
85.1904	2060-0104
85.1905	2060-0104
85.1906	2060-0104
85.1908	2060-0104
85.1909	2060-0104
85.2110	2060-0104
85.2114	2060-0060
85.2115	2060-0060
85.2116	2060-0060
85.2117	2060-0060
85.2118	2060-0060
85.2119	2060-0060
85.2120	2060-0060
Control of Emissions From New and In-Use Highway Vehicles and Engines	
86.000-7	2060-0104
86.000-24	2060-0104
86.001-21	2060-0104
86.001-23	2060-0104
86.001-24	2060-0104
86.004-28	2060-0104
86.004-38	2060-0104
86.004-40	2060-0104
86.079-31—86.079-33	2060-0104
86.079-39	2060-0104
86.080-12	2060-0104
86.082-34	2060-0104
86.085-37	2060-0104
86.090-27	2060-0104
86.091-7	2060-0104
86.094-21	2060-0104
86.094-25	2060-0104
86.094-30	2060-0104
86.095-14	2060-0104
86.095-35	2060-0104
86.096-24	2060-0104
86.098-23	2060-0104
86.099-10	2060-0104
86.107-98	2060-0104
86.108-00	2060-0104
86.111-94	2060-0104
86.113-15	2060-0104
86.113-94	2060-0104
86.129-00	2060-0104
86.142-90	2060-0104
86.144-94	2060-0104
86.150-98	2060-0104
86.155-98	2060-0104

86.159-08	2060-0104
86.160-00	2060-0104
86.161-00	2060-0104
86.162-03	2060-0104
86.163-00	2060-0104
86.412-78	2060-0104
86.414-78	2060-0104
86.415-78	2060-0104
86.416-80	2060-0104
86.421-78	2060-0104
86.423-78	2060-0104
86.427-78	2060-0104
86.428-80	2060-0104
86.429-78	2060-0104
86.431-78	2060-0104
86.432-78	2060-0104
86.434-78	2060-0104
86.435-78	2060-0104
86.436-78	2060-0104
86.437-78	2060-0104
86.438-78	2060-0104
86.439-78	2060-0104
86.440-78	2060-0104
86.445-2006	2060-0104
86.446-2006	2060-0104
86.447-2006	2060-0104
86.448-2006	2060-0104
86.449	2060-0104
86.513	2060-0104
86.537-90	2060-0104
86.542-90	2060-0104
86.603-98	2060-0104
86.604-84	2060-0104
86.605-98	2060-0104
86.606-84	2060-0104
86.607-84	2060-0104
86.609-98	2060-0104
86.612-97	2060-0104
86.614-84	2060-0104
86.615-84	2060-0104
86.884-5	2060-0104
86.884-7	2060-0104
86.884-9	2060-0104
86.884-10	2060-0104
86.884-12	2060-0104
86.884-13	2060-0104
86.1106-87	2060-0104
86.1107-87	2060-0104
86.1108-87	2060-0104

86.1110-87	2060-0104
86.1111-87	2060-0104
86.1113-87	2060-0104
86.1114-87	2060-0104
86.1805-17	2060-0104
86.1806-17	2060-0104
86.1809-12	2060-0104
86.1811-17	2060-0104
86.1823-08	2060-0104
86.1826-01	2060-0104
86.1829-15	2060-0104
86.1839-01	2060-0104
86.1840-01	2060-0104
86.1842-01	2060-0104
86.1843-01	2060-0104
86.1844-01	2060-0104
86.1845-04	2060-0104
86.1847-01	2060-0104
86.1862-04	2060-0104
86.1920-86.1925	2060-0287
* * * * * * *	
Fuel Economy of Motor Vehicles	
600.005	2060-0104
600.006	2060-0104
600.007	2060-0104
600.010	2060-0104
600.113-12	2060-0104
600.206-12	2060-0104
600.207-12	2060-0104
600.209-12	2060-0104
600.301 – 600.314-08	2060-0104
600.507-12	2060-0104
600.509-12	2060-0104
600.510-12	2060-0104
600.512-12	2060-0104
* * * * * *	

PART 59—NATIONAL VOLATILE ORGANIC COMPOUND EMISSION STANDARDS FOR CONSUMER AND COMMERCIAL PRODUCTS

3. The authority citation for part 59 continues to read as follows:

Authority: 42 U.S.C. 7414 and 7511b(e).

Subpart F—[Amended]

4. Amend § 59.626 by revising paragraph (e) to read as follows:

§59.626 What emission testing must I perform for my application for a certificate of conformity?

* * * * *

(e) We may require you to test units of the same or different configuration in addition to the units tested under paragraph (b) of this section.

* * * * *

5. Amend § 59.628 by revising paragraph (b) to read as follows:

§59.628 What records must I keep and what reports must I send to EPA?

* * * * *

(b) Keep required data from emission tests and all other information specified in this subpart for five years after we issue the associated certificate of conformity. If you use the same emission data or other information for a later production period, the five-year period restarts with each new production period if you continue to rely on the information.

* * * * *

6. Amend § 59.650 by revising paragraph (c) to read as follows:

§59.650 General testing provisions.

* * * * *

(c) The specification for gasoline to be used for testing is given in 40 CFR 1065.710(c). Use the grade of gasoline specified for general testing. Blend this grade of gasoline with reagent grade ethanol in a volumetric ratio of 90.0 percent gasoline to 10.0 percent ethanol to achieve a blended fuel that has 10.0 ±1.0 percent ethanol by volume. You may use ethanol that is less pure if you can demonstrate that it will not affect your ability to demonstrate compliance with the applicable emission standards.

* * * * *

7. Amend § 59.653 by revising paragraphs (a)(1), (a)(3), and (a)(4)(ii)(C) to read as follows:

§59.653 How do I test portable fuel containers?

* * * * *

(a) * * *

(1) *Pressure cycling*. Perform a pressure test by sealing the container and cycling it between + 13.8 and −3.4 kPa (+2.0 and −0.5 psig) for 10,000 cycles at a rate of 60 seconds per cycle. For this test, the spout may be removed, and the pressure applied through the opening where the spout attaches. The purpose of this test is to represent environmental wall stresses caused by pressure changes and other factors (such as vibration or thermal expansion). If your container cannot be tested using the pressure cycles specified by this paragraph (a)(1), you may ask to use special test procedures under §59.652(c).

* * * * *

(3) *Slosh testing*. Perform a slosh test by filling the portable fuel container to 40 percent of its capacity with the fuel specified in paragraph (e) of this section and rocking it at a rate of 15 cycles per minute until you reach one million total cycles. Use an angle deviation of + 15° to

−15° from level. Take steps to ensure that the fuel remains at 40 percent of its capacity throughout the test run.

(4) * * *

(ii) * * *

(C) Actuate the spout by fully opening and closing without dispensing fuel. The spout must return to the closed position without the aid of the operator (e.g., pushing or pulling the spout closed). Repeat for a total of 10 actuations. If at any point the spout fails to return to the closed position, the container fails the diurnal test.

* * * * *

8. Amend § 59.660 by revising paragraph (b) to read as follows:

§59.660 Exemption from the standards.

* * * * *

(b) Manufacturers and other persons subject to the prohibitions in §59.602 may ask us to exempt portable fuel containers to purchase, sell, or distribute them for the sole purpose of testing them.

* * * * *

9. Amend § 59.664 by revising paragraph (c) to read as follows:

§59.664 What are the requirements for importing portable fuel containers into the United States?

* * * * *

(c) You may meet the bond requirements of this section by obtaining a bond from a third-party surety that is cited in the U.S. Department of Treasury Circular 570, "Companies Holding Certificates of Authority as Acceptable Sureties on Federal Bonds and as Acceptable Reinsuring Companies" (*https://www.fiscal.treasury.gov/surety-bonds/circular-570.html*).

* * * * *

10. Amend § 59.680 by revising the definition of "Portable fuel container" to read as follows:

§59.680 What definitions apply to this subpart?

* * * * *

Portable fuel container means a reusable container of any color that is designed and marketed ~~(~~or otherwise intended~~)~~ for use by consumers for receiving, transporting, storing, and dispensing gasoline, diesel fuel, or kerosene. For the purposes of this subpart, all utility jugs that are red, yellow or blue in color are deemed to be portable fuel containers, regardless of how they are labeled or marketed.

* * * * *

PART 60—STANDARDS OF PERFORMANCE FOR NEW STATIONARY SOURCES

11. The authority statement for part 60 continues to read as follows:

Authority: 42 U.S.C. 7401 et seq.

12. Amend § 60.4200 by revising paragraph (d) to read as follows:

§60.4200 Am I subject to this subpart?

* * * * *

(d) Stationary CI ICE may be eligible for exemption from the requirements of this subpart as described in 40 CFR part 1068, subpart C, except that owners and operators, as well as manufacturers, may be eligible to request an exemption for national security.

13. Amend § 60.4201 by revising paragraph (a), paragraph (d) introductory text, paragraph (f) introductory text, and paragraph (h) to read as follows:

§60.4201 What emission standards must I meet for non-emergency engines if I am a stationary CI internal combustion engine manufacturer?

(a) Stationary CI internal combustion engine manufacturers must certify their 2007 model year and later non-emergency stationary CI ICE with a maximum engine power less than or equal to 2,237 kilowatt (KW) (3,000 horsepower (HP)) and a displacement of less than 10 liters per cylinder to the certification emission standards for new nonroad CI engines in 40 CFR 1039.101, 40 CFR 1039.102, 40 CFR 1039.104, 40 CFR 1039.105, 40 CFR 1039.107, and 40 CFR 1039.115 and 40 CFR part 1039, Appendix I, as applicable, for all pollutants, for the same model year and maximum engine power.

* * * * *

(d) Stationary CI internal combustion engine manufacturers must certify the following non-emergency stationary CI ICE to the appropriate Tier 2 emission standards for new marine CI engines as described in 40 CFR part 1042, Appendix I, for all pollutants, for the same displacement and rated power:

* * * * *

(f) Notwithstanding the requirements in paragraphs (a) through (c) of this section, stationary non-emergency CI ICE identified in paragraphs (a) and (c) of this section may be certified to the provisions of 40 CFR part 1042 for commercial engines that are applicable for the engine's model year, displacement, power density, and maximum engine power if the engines will be used solely in either or both of the following locations:

* * * * *

(h) Stationary CI ICE certified to the standards in 40 CFR part 1039 and equipped with auxiliary emission control devices (AECDs) as specified in 40 CFR 1039.665 must meet the Tier 1 certification emission standards for new nonroad CI engines in 40 CFR part 1039, Appendix I while the AECD is activated during a qualified emergency situation. A qualified emergency situation is defined in 40 CFR 1039.665. When the qualified emergency situation has ended and the AECD is deactivated, the engine must resume meeting the otherwise applicable emission standard specified in this section.

14. Amend § 60.4202 by revising paragraphs (a)(1)(i), (a)(2), (b)(2), paragraph (e) introductory text, and paragraph (g) introductory text to read as follows:

§60.4202 What emission standards must I meet for emergency engines if I am a stationary CI internal combustion engine manufacturer?

(a) * * *

(1) * * *

(i) The Tier 2 emission standards for new nonroad CI engines for the appropriate rated power as described in 40 CFR part 1039, Appendix I, for all pollutants and the smoke standards as specified in 40 CFR 1039.105 for model year 2007 engines, and

* * * * *

(2) For engines with a rated power greater than or equal to 37 KW (50 HP), the Tier 2 or Tier 3 emission standards for new nonroad CI engines for the same rated power as described in 40 CFR part 1039, Appendix I for all pollutants and the smoke standards as specified in 40 CFR 1039.105 beginning in model year 2007.

(b) * * *

(2) For 2011 model year and later, the Tier 2 emission standards as described in 40 CFR part 1039, Appendix I for all pollutants and the smoke standards as specified in 40 CFR 1039.105.

* * * * *

(e) Stationary CI internal combustion engine manufacturers must certify the following emergency stationary CI ICE that are not fire pump engines to the appropriate Tier 2 emission standards for new marine CI engines as described in 40 CFR part 1042, Appendix I, , for all pollutants, for the same displacement and rated power:

* * * * *

(g) Notwithstanding the requirements in paragraphs (a) through (d) of this section, stationary emergency CI ICE identified in paragraphs (a) and (c) of this section may be certified to the provisions of 40 CFR part 1042 for commercial engines that are applicable for the engine's model year, displacement, power density, and maximum engine power if the engines will be used solely in either or both of the locations identified in paragraphs (g)(1) and (2) of this section. Engines that would be subject to the Tier 4 standards in 40 CFR part 1042 that are used solely in either or both of the locations identified in paragraphs (g)(1) and (2) of this section may instead continue to be certified to the appropriate Tier 3 standards in 40 CFR part 1042.

* * * * *

15. Amend § 60.4204 by revising paragraphs (a) and (f) to read as follows:

§60.4204 What emission standards must I meet for non-emergency engines if I am an owner or operator of a stationary CI internal combustion engine?

(a) Owners and operators of pre-2007 model year non-emergency stationary CI ICE with a displacement of less than 10 liters per cylinder must comply with the emission standards in table 1 to this subpart. Owners and operators of pre-2007 model year non-emergency stationary CI ICE with a displacement of greater than or equal to 10 liters per cylinder and less than 30 liters per cylinder must comply with the Tier 1 emission standards in 40 CFR part 1042, Appendix I.

* * * * *

(f) Owners and operators of stationary CI ICE certified to the standards in 40 CFR part 1039 and equipped with AECDs as specified in 40 CFR 1039.665 must meet the Tier 1 certification emission standards for new nonroad CI engines in 40 CFR part 1039, Appendix I while the AECD is activated during a qualified emergency situation. A qualified emergency situation is defined in 40 CFR 1039.665. When the qualified emergency situation has ended and the AECD is deactivated, the engine must resume meeting the otherwise applicable emission standard specified in this section.

16. Amend § 60.4205 by revising paragraph (a) to read as follows:

§60.4205 What emission standards must I meet for emergency engines if I am an owner or operator of a stationary CI internal combustion engine?

(a) Owners and operators of pre-2007 model year emergency stationary CI ICE with a displacement of less than 10 liters per cylinder that are not fire pump engines must comply with the emission standards in Table 1 to subpart IIII. Owners and operators of pre-2007 model year emergency stationary CI ICE with a displacement of greater than or equal to 10 liters per cylinder and less than 30 liters per cylinder that are not fire pump engines must comply with the Tier 1 emission standards in 40 CFR part 1042, appendix I.

* * * * *

17. Amend § 60.4210 by revising paragraphs (a) and (b), paragraph (c) introductory text, paragraphs (c)(3), (d), (i), and (j) and adding paragraph (k) to read as follows:

§60.4210 What are my compliance requirements if I am a stationary CI internal combustion engine manufacturer?

(a) Stationary CI internal combustion engine manufacturers must certify their stationary CI ICE with a displacement of less than 10 liters per cylinder to the emission standards specified in §60.4201(a) through (c) and §60.4202(a), (b) and (d) using the certification procedures required in 40 CFR part 1039, subpart C, and must test their engines as specified in 40 CFR part 1039. For the purposes of this subpart, engines certified to the standards in table 1 to this subpart shall be subject to the same certification procedures required for engines certified to the Tier 1 standards in 40 CFR part 1039, appendix I. For the purposes of this subpart, engines certified to the standards in table 4 to this subpart shall be subject to the same certification procedures required for engines certified to the Tier 1 standards in 40 CFR part 1039, appendix I, except that engines with NFPA nameplate power of less than 37 KW (50 HP) certified to model year 2011 or later standards shall be subject to the same requirements as engines certified to the standards in 40 CFR part 1039.

(b) Stationary CI internal combustion engine manufacturers must certify their stationary CI ICE with a displacement of greater than or equal to 10 liters per cylinder and less than 30 liters per cylinder to the emission standards specified in §60.4201(d) and (e) and §60.4202(e) and (f) using the certification procedures required in 40 CFR part 1042, subpart C, and must test their engines as specified in 40 CFR part 1042.

(c) Stationary CI internal combustion engine manufacturers must meet the requirements of 40 CFR 1039.120, 1039.125, 1039.130, and 1039.135, and 40 CFR part 1068 for engines that are certified to the emission standards in 40 CFR part 1039. Stationary CI internal combustion engine manufacturers must meet the corresponding provisions of 40 CFR part 1042 for engines that would be covered by that part if they were nonroad (including marine) engines. Labels on such engines must refer to stationary engines, rather than or in addition to nonroad or marine engines, as appropriate. Stationary CI internal combustion engine manufacturers must label their engines according to paragraphs (c)(1) through (3) of this section.

* * * * *

(3) Stationary CI internal combustion engines manufactured after January 1, 2007 (for fire pump engines, after January 1 of the year listed in table 3 to this subpart, as applicable) must be labeled according to paragraphs (c)(3)(i) through (iii) of this section.

(i) Stationary CI internal combustion engines that meet the requirements of this subpart and the corresponding requirements for nonroad (including marine) engines of the same model year and HP must be labeled according to the provisions in 40 CFR part 1039 or 1042, as appropriate.

(ii) Stationary CI internal combustion engines that meet the requirements of this subpart, but are not certified to the standards applicable to nonroad (including marine) engines of the same model year and HP must be labeled according to the provisions in 40 CFR part 1039 or 1042, as appropriate, but the words "stationary" must be included instead of "nonroad" or "marine" on the label. In addition, such engines must be labeled according to 40 CFR 1039.20.
(iii) Stationary CI internal combustion engines that do not meet the requirements of this subpart must be labeled according to 40 CFR 1068.230 and must be exported under the provisions of 40 CFR 1068.230.
(d) An engine manufacturer certifying an engine family or families to standards under this subpart that are identical to standards applicable under 40 CFR part 1039 or 1042 for that model year may certify any such family that contains both nonroad (including marine) and stationary engines as a single engine family and/or may include any such family containing stationary engines in the averaging, banking and trading provisions applicable for such engines under those parts.
* * * * *
(i) The replacement engine provisions of 40 CFR 1068.240 are applicable to stationary CI engines replacing existing equipment that is less than 15 years old.
(j) Stationary CI ICE manufacturers may equip their stationary CI internal combustion engines certified to the emission standards in 40 CFR part 1039 with AECDs for qualified emergency situations according to the requirements of 40 CFR 1039.665. Manufacturers of stationary CI ICE equipped with AECDs as allowed by 40 CFR 1039.665 must meet all the requirements in 40 CFR 1039.665 that apply to manufacturers. Manufacturers must document that the engine complies with the Tier 1 standard in 40 CFR part 1039, appendix I, when the AECD is activated. Manufacturers must provide any relevant testing, engineering analysis, or other information in sufficient detail to support such statement when applying for certification (including amending an existing certificate) of an engine equipped with an AECD as allowed by 40 CFR 1039.665.
(k) Manufacturers of any size may certify their emergency stationary CI internal combustion engines under this section using assigned deterioration factors established by EPA, consistent with 40 CFR 1039.240 and 1042.240.

18. Amend § 60.4211 by revising paragraphs (a)(3) and (b)(1) to read as follows:

§60.4211 What are my compliance requirements if I am an owner or operator of a stationary CI internal combustion engine?

(a) * * *
(3) Meet the requirements of 40 CFR part 1068, as they apply to you.
(b) * * *
(1) Purchasing an engine certified to emission standards for the same model year and maximum engine power as described in 40 CFR part 1039 and part 1042, as applicable. The engine must be installed and configured according to the manufacturer's specifications.
* * * * *

19. Amend § 60.4212 by revising paragraphs (a) and (c) to read as follows:

§60.4212 What test methods and other procedures must I use if I am an owner or operator of a stationary CI internal combustion engine with a displacement of less than 30 liters per cylinder?

* * * * *

(a) The performance test must be conducted according to the in-use testing procedures in 40 CFR part 1039, subpart F, for stationary CI ICE with a displacement of less than 10 liters per cylinder, and according to 40 CFR part 1042, subpart F, for stationary CI ICE with a displacement of greater than or equal to 10 liters per cylinder and less than 30 liters per cylinder. Alternatively, stationary CI ICE that are complying with Tier 2 or Tier 3 emission standards as described in 40 CFR part 1039, appendix I, or with Tier 2 emission standards as described in 40 CFR part 1042, Appendix I, may follow the testing procedures specified in §60.4213, as appropriate.

* * * * *

(c) Exhaust emissions from stationary CI ICE subject to Tier 2 or Tier 3 emission standards as described in 40 CFR part 1039, appendix I, or Tier 2 emission standards as described in 40 CFR part 1042, Appendix I, must not exceed the NTE numerical requirements, rounded to the same number of decimal places as the applicable standard, determined from the following equation:

NTE requirement for each pollutant = (1.25) × (STD) (Eq. 1)

Where:

STD = The standard specified for that pollutant in 40 CFR part 1039 or part 1042, as applicable.

* * * * *

20. Amend § 60.4216 by revising paragraphs (b) and (c) to read as follows:

§60.4216 What requirements must I meet for engines used in Alaska?

* * * * *

(b) Except as indicated in paragraph (c) of this section, manufacturers, owners and operators of stationary CI ICE with a displacement of less than 10 liters per cylinder located in remote areas of Alaska may meet the requirements of this subpart by manufacturing and installing engines meeting the Tier 2 or Tier 3 emission standards described in 40 CFR part 1042 for the same model year, displacement, and maximum engine power, as appropriate, rather than the otherwise applicable requirements of 40 CFR part 1039, as indicated in §§60.4201(f) and 60.4202(g).

(c) Manufacturers, owners, and operators of stationary CI ICE that are located in remote areas of Alaska may choose to meet the applicable emission standards for emergency engines in §§ 60.4202 and 60.4205, and not those for non-emergency engines in §§ 60.4201 and 60.4204, except that for 2014 model year and later nonemergency CI ICE, the owner or operator of any such engine must have that engine certified as meeting at least the Tier 3 PM standards identified in appendix I of 40 CFR part 1039 or in 40 CFR 1042.101.

* * * * *

21. Amend § 60.4219 by revising the definition for “Certified emissions life” to read as follows:

§60.4219 What definitions apply to this subpart?

* * * * *

Certified emissions life means the period during which the engine is designed to properly function in terms of reliability and fuel consumption, without being remanufactured, specified as a number of hours of operation or calendar years, whichever comes first. The values for certified emissions life for stationary CI ICE with a displacement of less than 10 liters per cylinder are given in 40 CFR 1039.101(g). The values for certified emissions life for stationary CI ICE with a displacement of greater than or equal to 10 liters per cylinder and less than 30 liters per cylinder are given in 40 CFR 1042.101(e).

* * * * *

22. Amend § 60.4230 by revising paragraph (e) to read as follows:

§60.4230 Am I subject to this subpart?

* * * * *

(e) Stationary SI ICE may be eligible for exemption from the requirements of this subpart as described in 40 CFR part 1068, subpart C (or the exemptions described in 40 CFR parts 1048 and 1054, for engines that would need to be certified to standards in those parts), except that owners and operators, as well as manufacturers, may be eligible to request an exemption for national security.

* * * * *

23. Amend § 60.4231 by revising paragraphs (a) through (d) to read as follows:

§60.4231 What emission standards must I meet if I am a manufacturer of stationary SI internal combustion engines or equipment containing such engines?

(a) Stationary SI internal combustion engine manufacturers must certify their stationary SI ICE with a maximum engine power less than or equal to 19 KW (25 HP) manufactured on or after July 1, 2008 to the certification emission standards and other requirements for new nonroad SI engines in 40 CFR part 1054, as follows:

If engine displacement is * * *	**and manufacturing dates are * * ***	**the engine must meet the following non-handheld emission standards identified in 40 CFR part 1054 and related requirements:**
(1) below 225 cc	July 1, 2008 to December 31, 2011	Phase 2.
(2) below 225 cc	January 1, 2012 or later	Phase 3.
(3) at or above 225 cc	July 1, 2008 to December 31, 2010	Phase 2.
(4) at or above 225 cc	January 1, 2011 or later	Phase 3.

(b) Stationary SI internal combustion engine manufacturers must certify their stationary SI ICE with a maximum engine power greater than 19 KW (25 HP) (except emergency stationary ICE with a maximum engine power greater than 25 HP and less than 130 HP) that use gasoline and that are manufactured on or after the applicable date in §60.4230(a)(2), or manufactured on or after the applicable date in §60.4230(a)(4) for emergency stationary ICE with a maximum engine power greater than or equal to 130 HP, to the certification emission standards and other requirements for new nonroad SI engines in 40 CFR part 1048. Stationary SI internal combustion engine manufacturers must certify their emergency stationary SI ICE with a maximum engine power greater than 25 HP and less than 130 HP that use gasoline and that are manufactured on or after the applicable date in §60.4230(a)(4) to the Phase 1 emission standards in 40 CFR part 1054, Appendix I, applicable to class II engines, and other requirements for new nonroad SI engines in 40 CFR part 1054. Stationary SI internal combustion engine manufacturers may certify their stationary SI ICE with a maximum engine power less than or equal to 30 KW (40 HP) with a total displacement less than or equal to 1,000 cubic centimeters (cc) that use gasoline to the certification emission standards and other requirements as appropriate for new nonroad SI engines in 40 CFR part 1054.

(c) Stationary SI internal combustion engine manufacturers must certify their stationary SI ICE with a maximum engine power greater than 19 KW (25 HP) (except emergency stationary ICE with a maximum engine power greater than 25 HP and less than 130 HP) that are rich burn engines that use LPG and that are manufactured on or after the applicable date in §60.4230(a)(2), or manufactured on or after the applicable date in §60.4230(a)(4) for emergency stationary ICE with a maximum engine power greater than or equal to 130 HP, to the certification emission standards and other requirements for new nonroad SI engines in 40 CFR part 1048. Stationary SI internal combustion engine manufacturers must certify their emergency stationary SI ICE greater than 25 HP and less than 130 HP that are rich burn engines that use LPG and that are manufactured on or after the applicable date in §60.4230(a)(4) to the Phase 1 emission standards in 40 CFR part 1054, appendix I, applicable to class II engines, and other requirements for new nonroad SI engines in 40 CFR part 1054. Stationary SI internal combustion engine manufacturers may certify their stationary SI ICE with a maximum engine power less than or equal to 30 KW (40 HP) with a total displacement less than or equal to 1,000 cc that are rich burn engines that use LPG to the certification emission standards and other requirements as appropriate for new nonroad SI engines in 40 CFR part 1054.

(d) Stationary SI internal combustion engine manufacturers who choose to certify their stationary SI ICE with a maximum engine power greater than 19 KW (25 HP) and less than 75 KW (100 HP) (except gasoline and rich burn engines that use LPG and emergency stationary ICE with a maximum engine power greater than 25 HP and less than 130 HP) under the voluntary manufacturer certification program described in this subpart must certify those engines to the certification emission standards for new nonroad SI engines in 40 CFR part 1048. Stationary SI internal combustion engine manufacturers who choose to certify their emergency stationary SI ICE greater than 25 HP and less than 130 HP (except gasoline and rich burn engines that use LPG), must certify those engines to the Phase 1 emission standards in 40 CFR part 1054, Appendix I, applicable to class II engines, for new nonroad SI engines in 40 CFR part 1054. Stationary SI internal combustion engine manufacturers may certify their stationary SI ICE with a maximum engine power less than or equal to 30 KW (40 HP) with a total displacement less than or equal to 1,000 cc (except gasoline and rich burn engines that use LPG) to the certification emission standards and other requirements as appropriate for new nonroad SI engines in 40 CFR part 1054. For stationary SI ICE with a maximum engine power greater than 19 KW (25 HP) and less than 75 KW (100 HP) (except gasoline and rich burn engines that use LPG and emergency stationary ICE with a maximum engine power greater than 25 HP and less than 130 HP) manufactured prior to January 1, 2011, manufacturers may choose to certify these engines to the standards in Table 1 to this subpart applicable to engines with a maximum engine power greater than or equal to 100 HP and less than 500 HP.

*   *   *   *   *

24. Revise § 60.4238 to read as follows:

§60.4238 What are my compliance requirements if I am a manufacturer of stationary SI internal combustion engines ≤19 KW (25 HP) or a manufacturer of equipment containing such engines?

Stationary SI internal combustion engine manufacturers who are subject to the emission standards specified in §60.4231(a) must certify their stationary SI ICE using the certification and testing procedures required in 40 CFR part 1054, subparts C and F. Manufacturers of equipment containing stationary SI internal combustion engines meeting the provisions of 40 CFR part 1054 must meet the provisions of 40 CFR part 1060, subpart C, to the extent they apply to equipment manufacturers.

25. Revise § 60.4239 to read as follows:

§60.4239 What are my compliance requirements if I am a manufacturer of stationary SI internal combustion engines >19 KW (25 HP) that use gasoline or a manufacturer of equipment containing such engines?

Stationary SI internal combustion engine manufacturers who are subject to the emission standards specified in §60.4231(b) must certify their stationary SI ICE using the certification procedures required in 40 CFR part 1048, subpart C, and must test their engines as specified in that part. Stationary SI internal combustion engine manufacturers who certify their stationary SI ICE with a maximum engine power less than or equal to 30 KW (40 HP) with a total displacement less than or equal to 1,000 cc to the certification emission standards and other requirements for new nonroad SI engines in 40 CFR part 1054, and manufacturers of stationary SI emergency engines that are greater than 25 HP and less than 130 HP who meet the Phase 1 emission standards in 40 CFR part 1054, appendix I, applicable to class II engines, must certify their stationary SI ICE using the certification and testing procedures required in 40 CFR part 1054, subparts C and F. Manufacturers of equipment containing stationary SI internal combustion engines meeting the provisions of 40 CFR part 1054 must meet the provisions of 40 CFR part 1060, subpart C, to the extent they apply to equipment manufacturers.

26. Revise § 60.4240 to read as follows:

§60.4240 What are my compliance requirements if I am a manufacturer of stationary SI internal combustion engines >19 KW (25 HP) that are rich burn engines that use LPG or a manufacturer of equipment containing such engines?

Stationary SI internal combustion engine manufacturers who are subject to the emission standards specified in §60.4231(c) must certify their stationary SI ICE using the certification procedures required in 40 CFR part 1048, subpart C, and must test their engines as specified in that part. Stationary SI internal combustion engine manufacturers who certify their stationary SI ICE with a maximum engine power less than or equal to 30 KW (40 HP) with a total displacement less than or equal to 1,000 cc to the certification emission standards and other requirements for new nonroad SI engines in 40 CFR part 1054, and manufacturers of stationary SI emergency engines that are greater than 25 HP and less than 130 HP who meet the Phase 1 emission standards in 40 CFR part 1054, appendix I, applicable to class II engines, must certify their stationary SI ICE using the certification and testing procedures required in 40 CFR part 1054, subparts C and F. Manufacturers of equipment containing stationary SI internal combustion engines meeting the provisions of 40 CFR part 1054 must meet the provisions of 40 CFR part 1060, subpart C, to the extent they apply to equipment manufacturers.

27. Amend § 60.4241 by revising paragraphs (a), (b), and (i) to read as follows:

§60.4241 What are my compliance requirements if I am a manufacturer of stationary SI internal combustion engines participating in the voluntary certification program or a manufacturer of equipment containing such engines?

(a) Manufacturers of stationary SI internal combustion engines with a maximum engine power greater than 19 KW (25 HP) that do not use gasoline and are not rich burn engines that use LPG can choose to certify their engines to the emission standards in §60.4231(d) or (e), as applicable, under the voluntary certification program described in this subpart. Manufacturers who certify their engines under the voluntary certification program must meet the requirements as specified in paragraphs (b) through (g) of this section. In addition, manufacturers of stationary SI internal combustion engines who choose to certify their engines under the voluntary certification program, must also meet the requirements as specified in §60.4247. Manufacturers of stationary SI internal combustion engines who choose not to certify their engines under this section must notify the ultimate purchaser that testing requirements apply as described in §60.4243(b)(2); manufacturers must keep a copy of this notification for five years after shipping each engine and make those documents available to EPA upon request.

(b) Manufacturers of engines other than those certified to standards in 40 CFR part 1054 must certify their stationary SI ICE using the certification procedures required in 40 CFR part 1048, subpart C, and must follow the same test procedures that apply to large SI nonroad engines under 40 CFR part 1048, but must use the D-1 cycle of International Organization of Standardization 8178-4: 1996(E) (incorporated by reference, see 40 CFR 60.17) or the test cycle requirements specified in Table 3 to 40 CFR 1048.505, except that Table 3 of 40 CFR 1048.505 applies to high load engines only. Manufacturers of any size may certify their stationary emergency engines at or above 130 hp using assigned deterioration factors established by EPA, consistent with 40 CFR 1048.240. Stationary SI internal combustion engine manufacturers who certify their stationary SI ICE with a maximum engine power less than or equal to 30 KW (40 HP) with a total displacement less than or equal to 1,000 cc to the certification emission standards and other requirements for new nonroad SI engines in 40 CFR part 1054, and manufacturers of emergency engines that are greater than 25 HP and less than 130 HP who meet the Phase 1 standards in 40 CFR part 1054, appendix I, applicable to class II engines, must certify their stationary SI ICE using the certification and testing procedures required in 40 CFR part 1054, subparts C and F. Manufacturers of equipment containing stationary SI internal combustion engines meeting the provisions of 40 CFR part 1054 must meet the provisions of 40 CFR part 1060, subpart C, to the extent they apply to equipment manufacturers.

*   *   *   *   *

(i) For engines being certified to the voluntary certification standards in Table 1 of this subpart, the VOC measurement shall be made by following the procedures in 40 CFR part 1065, subpart C, ~~.260 and 1065.265 in order~~ to determine the total NMHC emissions ~~by using a flame-ionization detector and non-methane cutter~~. As an alternative ~~to the nonmethane cutter~~, manufacturers ~~may use a gas chromatograph as allowed under 40 CFR 1065.267 and~~ may measure ethane, as well as methane, for excluding such levels from the total VOC measurement.

28. Revise § 60.4242 to read as follows:

§60.4242 What other requirements must I meet if I am a manufacturer of stationary SI internal combustion engines or equipment containing stationary SI internal combustion engines or a manufacturer of equipment containing such engines?

(a) Stationary SI internal combustion engine manufacturers must meet the provisions of 40 CFR parts 1048, 1054, and 1068, as applicable, except that engines certified pursuant to the voluntary certification procedures in §60.4241 are subject only to the provisions indicated in §60.4247 and are permitted to provide instructions to owners and operators allowing for deviations from certified configurations, if such deviations are consistent with the provisions of paragraphs §60.4241(c) through (f). Manufacturers of equipment containing stationary SI internal combustion engines meeting the provisions of 40 CFR part 1054 must meet the provisions of 40 CFR part 1060, as applicable. Labels on engines certified to 40 CFR part 1048 must refer to stationary engines, rather than or in addition to nonroad engines, as appropriate.

(b) An engine manufacturer certifying an engine family or families to standards under this subpart that are identical to standards identified in 40 CFR part 1048 or 1054 for that model year may certify any such family that contains both nonroad and stationary engines as a single engine family and/or may include any such family containing stationary engines in the averaging, banking and trading provisions applicable for such engines under those parts. This provision also applies to equipment or component manufacturers certifying to standards under 40 CFR part 1060.

(c) Manufacturers of engine families certified to 40 CFR part 1048 may meet the labeling requirements referred to in paragraph (a) of this section for stationary SI ICE by either adding a separate label containing the information required in paragraph (a) of this section or by adding the words “and stationary” after the word “nonroad” to the label.

(d) For all engines manufactured on or after January 1, 2011, and for all engines with a maximum engine power greater than 25 HP and less than 130 HP manufactured on or after July 1, 2008, a stationary SI engine manufacturer that certifies an engine family solely to the standards applicable to emergency engines must add a permanent label stating that the engines in that family are for emergency use only. The label must be added according to the labeling requirements specified in 40 CFR 1048.135(b).

(e) All stationary SI engines subject to mandatory certification that do not meet the requirements of this subpart must be labeled and exported according to 40 CFR 1068.230. Manufacturers of stationary engines with a maximum engine power greater than 25 HP that are not certified to standards and other requirements under 40 CFR part 1048 are subject to the labeling provisions of 40 CFR 1048.20 pertaining to excluded stationary engines.

(f) For manufacturers of gaseous-fueled stationary engines required to meet the warranty provisions in 1054.120, we may establish an hour-based warranty period equal to at least the certified emissions life of the engines (in engine operating hours) if we determine that these engines are likely to operate for a number of hours greater than the applicable useful life within 24 months. We will not approve an alternate warranty under this paragraph (f) for nonroad engines. An alternate warranty period approved under this paragraph (f) will be the specified number of engine operating hours or two years, whichever comes first. The engine manufacturer shall request this alternate warranty period in its application for certification or in an earlier submission. We may approve an alternate warranty period for an engine family subject to the following conditions:

(1) The engines must be equipped with non-resettable hour meters.

(2) The engines must be designed to operate for a number of hours substantially greater than the applicable certified emissions life.

(3) The emission-related warranty for the engines may not be shorter than any published warranty offered by the manufacturer without charge for the engines. Similarly, the emission-related warranty for any component shall not be shorter than any published warranty offered by the manufacturer without charge for that component.

29. Amend § 60.4243 by revising paragraph (f) to read as follows:

§60.4243 What are my compliance requirements if I am an owner or operator of a stationary SI internal combustion engine?

* * * * *

(f) If you are an owner or operator of a stationary SI internal combustion engine that is less than or equal to 500 HP and you purchase a non-certified engine or you do not operate and maintain your certified stationary SI internal combustion engine and control device according to the manufacturer's written emission-related instructions, you are required to perform initial performance testing as indicated in this section, but you are not required to conduct subsequent performance testing unless the stationary engine ~~is rebuilt or~~ undergoes rebuild, major repair or maintenance. ~~A rebuilt stationary SI ICE means an engine that has been rebuilt as that term is defined in 40 CFR 1068.120(b).~~ Engine rebuilding means to overhaul an engine or to otherwise perform extensive service on the engine (or on a portion of the engine or engine system). For the purpose of this definition, perform extensive service means to disassemble the engine (or portion of the engine or engine system), inspect and/or replace many of the parts, and reassemble the engine (or portion of the engine or engine system) in such a manner that significantly increases the service life of the resultant engine.

* * * * *

30. Amend § 60.4245 by revising paragraph (a)(3) to read as follows:

§60.4245 What are my notification, reporting, and recordkeeping requirements if I am an owner or operator of a stationary SI internal combustion engine?

* * * * *

(a) * * *

(3) If the stationary SI internal combustion engine is a certified engine, documentation from the manufacturer that the engine is certified to meet the emission standards and information as required in 40 CFR parts 1048, 1054, and 1060, as applicable.

* * * * *

31. Amend § 60.4247 by revising paragraph (a) to read as follows:

§60.4247 What parts of the mobile source provisions apply to me if I am a manufacturer of stationary SI internal combustion engines or a manufacturer of equipment containing such engines?

(a) Manufacturers certifying to emission standards in 40 CFR part 1054 must meet the provisions of 40 CFR part 1054. Note that 40 CFR part 1054, Appendix I, describes various provisions that do not apply for engines meeting Phase 1 standards. Manufacturers of equipment containing stationary SI internal combustion engines meeting the provisions of 40 CFR part 1054 must meet the provisions of 40 CFR part 1060 to the extent they apply to equipment manufacturers.

* * * * *

32. Amend § 60.4248 by revising the definition for “Certified emissions life” and “Certified stationary internal combustion engine” to read as follows:

§60.4248 What definitions apply to this subpart?

* * * * *

Certified emissions life means the period during which the engine is designed to properly function in terms of reliability and fuel consumption, without being remanufactured, specified as a number of hours of operation or calendar years, whichever comes first. The values for certified emissions life for stationary SI ICE with a maximum engine power less than or equal to 19 KW (25 HP) are given in 40 CFR 1054.107 and 40 CFR 1060.101, as appropriate. The values for certified emissions life for stationary SI ICE with a maximum engine power greater than 19 KW (25 HP) certified to 40 CFR part 1048 are given in 40 CFR 1048.101(g). The certified emissions life for stationary SI ICE with a maximum engine power greater than 75 KW (100 HP) certified under the voluntary manufacturer certification program of this subpart is 5,000 hours or 7 years, whichever comes first. You may request in your application for certification that we approve a shorter certified emissions life for an engine family. We may approve a shorter certified emissions life, in hours of engine operation but not in years, if we determine that these engines will rarely operate longer than the shorter certified emissions life. If engines identical to those in the engine family have already been produced and are in use, your demonstration must include documentation from such in-use engines. In other cases, your demonstration must include an engineering analysis of information equivalent to such in-use data, such as data from research engines or similar engine models that are already in production. Your demonstration must also include any overhaul interval that you recommend, any mechanical warranty that you offer for the engine or its components, and any relevant customer design specifications. Your demonstration may include any other relevant information. The certified emissions life value may not be shorter than any of the following:

(1) 1,000 hours of operation.

(2) Your recommended overhaul interval.

(3) Your mechanical warranty for the engine.

Certified stationary internal combustion engine means an engine that belongs to an engine family that has a certificate of conformity that complies with the emission standards and requirements in this part, or of 40 CFR part 1048 or 40 CFR part 1054, as appropriate.

* * * * *

PART 85— CONTROL OF AIR POLLUTION FROM MOBILE SOURCES

33. The authority citation for part 85 continues to read as follows:

Authority: 42 U.S.C. 7401-7671q.

Subpart O—[Removed and Reserved]

34. Remove and reserve Subpart O, consisting of §§ 85.1401 through 85.1415

35. Amend § 85.1501 by revising paragraph (a) to read as follows:

§85.1501 Applicability.

(a) Except where otherwise indicated, this subpart is applicable to motor vehicles offered for importation or imported into the United States for which the Administrator has promulgated regulations under 40 CFR part 86, subpart D or subpart S, prescribing emission standards, but which are not covered by certificates of conformity issued under section 206(a) of the Clean Air Act (i.e., which are nonconforming vehicles as defined below), as amended, and part 86 at the time of conditional importation. Compliance with regulations under this subpart shall not relieve any person or entity from compliance with other applicable provisions of the Clean Air Act. This subpart no longer applies for heavy-duty engines certified under 40 CFR part 86, subpart A; references in this subpart to "engines" therefore ~~do not~~ apply only for replacement engines intended for installation in motor vehicles that are subject to this subpart.

* * * * *

36. Amend § 85.1511 by adding introductory text and paragraph (b)(5) to read as follows:

§85.1511 Exemptions and exclusions.

The exemption provisions of 40 CFR part 1068, subpart D, apply instead of the provisions of this section for heavy-duty motor vehicles and heavy-duty motor vehicle engines regulated under 40 CFR part 86, subpart A, 40 CFR part 1036, and 40 CFR part 1037. The following provisions apply for other motor vehicles and motor vehicle engines:

* * * * *

(b) * * *

(5) *Export exemption*. Vehicles may qualify for a temporary exemption under the provisions of 40 CFR 1068.325(d).

* * * * *

37. Revise § 85.1514 to read as follows:

§85.1514 Treatment of confidential information.

The provisions of 40 CFR 1068.10 apply for information you consider confidential.

38. Amend § 85.1701 by revising paragraph (a)(1) to read as follows:

§85.1701 General applicability.

(a) * * *

(1) Beginning January 1, 2014, the exemption provisions of 40 CFR part 1068, subpart C, apply instead of the provisions of this subpart for heavy-duty motor vehicle engines regulated under 40 CFR part 86, subpart A, except that the nonroad competition exemption of 40 CFR 1068.235 and the nonroad hardship exemption provisions of 40 CFR 1068.245, 1068.250, and 1068.255 do not apply for motor vehicle engines. Note that the provisions for emergency vehicle field modifications in §85.1716 continue to apply for heavy-duty engines.

* * * * *

39. Revise § 85.1712 to read as follows:

§85.1712 Treatment of confidential information.
The provisions of 40 CFR 1068.10 apply for information you consider confidential.

40. Revise § 85.1801 to read as follows:
§85.1801 Applicability and definitions.
(a) The recall provisions of 40 CFR part 1068, subpart E, apply instead of the provisions of this subpart for heavy-duty motor vehicles and heavy-duty motor vehicle engines regulated under 40 CFR part 86, subpart A, 40 CFR part 1036, and 40 CFR part 1037. The provisions of this subpart S apply for other motor vehicles and motor vehicle engines.
(b) For the purposes of this subpart, except as otherwise provided, words shall be defined as provided for by sections 214 and 302 of the Clean Air Act, 42 U.S.C. 1857, as amended.
(1) *Act* shall mean the Clean Air Act, 42 U.S.C. 1857, as amended.
(2) *Days* shall mean calendar days.

41. Revise § 85.1807 to read as follows:
§85.1807 Public hearings.
Manufacturers may request a hearing as described in 40 CFR part 1068, subpart G.

42. Revise § 85.1808 to read as follows:
§85.1808 Treatment of confidential information.
The provisions of 40 CFR 1068.10 apply for information you consider confidential.

43. Amend § 85.1902 by revising paragraph (b)(2) to read as follows:
§85.1902 Definitions.
* * * * *
(b) * * *
(2) A defect in the design, materials, or workmanship in one or more emission-related parts, components, systems, software or elements of design which must function properly to ensure continued compliance with greenhouse gas emission standards.
* * * * *

44. Amend § 85.2102 revising paragraph (a)(18) and by adding and reserving paragraph (b) to read as follows:
§85.2102 Definitions.
(a) * * *
(18) *MOD Director* has the meaning given for “Designated Compliance Officer” in 40 CFR 1068.30.
(b) [Reserved].

45. Amend § 85.2115 by revising paragraph (a)(4) to read as follows:
§ 85.2115 Notification of intent to certify.
(a) * * *
(4) Two complete and identical copies of the notification and any subsequent industry comments on any such notification shall be submitted by the aftermarket manufacturer to: MOD Director.
* * * * *

46. Revise § 85.2301 to read as follows:

§85.2301 Applicability.

The definitions provided by this subpart are effective February 23, 1995 and apply to all motor vehicles regulated under 40 CFR part 86, subpart S, and to highway motorcycles regulated under 40 CFR part 86, subparts E and F. The definitions and related provisions in 40 CFR part 1036, 40 CFR part 1037, and 40 CFR part 1068 apply instead of the provisions in this subpart for heavy-duty motor vehicles and heavy-duty motor vehicle engines regulated under 40 CFR part 86, subpart A, 40 CFR part 1036, and 40 CFR part 1037.

PART 86— CONTROL OF EMISSIONS FROM NEW AND IN-USE HIGHWAY VEHICLES AND ENGINES

47. The authority statement for part 86 continues to read as follows:

Authority: 42 U.S.C. 7401-7671q.

48. Section 86.1 is amended by:

a. Revising the last sentence of paragraph (a);

b. Redesignating paragraphs (b)(19) through (21) as paragraphs (b)(21) through (23); and

c. Adding new paragraphs (b)(19) and (20).

The revision and additions read as follows:

§86.1 Incorporation by reference.

(a) * * * For information on the availability of this material at NARA, email fedreg.legal@nara.gov, or go to www.archives.gov/federal-register/cfr/ibr-locations.html.

* * * * *

(b) * * *

(19) ASTM D5769-20~~15~~, Standard Test Method for Determination of Benzene, Toluene, and Total Aromatics in Finished Gasolines by Gas Chromatography/Mass Spectrometry, approved June 1, 2020~~December 1, 2015~~ (“ASTM5769”), IBR approved for §§ 86.113-04(a), 86.213(a), and 86.513(a)

(20) ASTM D6550-20~~15~~, Standard Test Method for Determination of Olefin Content of Gasolines by Supercritical-Fluid Chromatography, approved July 1, 2020~~December 1, 2015~~ (“ASTM D6550”), IBR approved for §§ 86.113-04(a), 86.213(a), and 86.513(a).

* * * * *

49. Section 86.004-15 is amended by revising paragraph (a)(1) to read as follows:

§86.004-15 NOx plus NMHC and particulate averaging, trading, and banking for heavy-duty engines.

(a)(1) Heavy-duty engines eligible for NOx plus NMHC and particulate averaging, trading and banking programs are described in the applicable emission standards sections in this subpart. For manufacturers not selecting Options 1 or 2 contained in §86.005-10(f), the ABT program requirements contained in §86.000-15 apply for 2004 model year Otto-cycle engines, rather than the provisions contained in this §86.004-15. Participation in these programs is voluntary.

* * * * *

50. Section 86.010-18 is amended by–

a. Revising paragraphs ~~(a)(5),~~ (g)(2)(ii)(B), and (g)(2)(iii)(C).

b. Adding paragraph (g)(2)(iii)(D).

c. Removing and reserving paragraph (l)(2)(ii).

d. Revising paragraphs ~~(l)(2)(iii) and (m)(3).e. Adding paragraph (m)(4).f. Revising paragraphs~~ (p)(3) and (p)(4).

The revisions and additions read as follows:

§86.010-18 On-board Diagnostics for engines used in applications greater than 14,000 pounds GVWR.

~~(a) * * *~~

~~(5) Engines families that we determine conform to the requirements of this paragraph (a)(5) are deemed to comply with the requirements of this section, irrespective of complete conformance with the provisions of paragraphs (b) through (l) of this section.~~

~~(i) A manufacturer may demonstrate how the OBD system they have designed to comply with California OBD requirements for engines used in applications greater than 14,000 pounds also complies with the intent of the provisions of paragraphs (b) through (l) of this section. To make use of this alternative, the manufacturer must demonstrate to the Administrator how the OBD system they intend to certify meets the intent behind all of the requirements of this section, where applicable (e.g., paragraph (h) of this section would not apply for a diesel fueled/CI engine). Furthermore, if making use of this alternative, the manufacturer must comply with the specific certification documentation requirements of paragraph (m)(3) of this section.~~
~~(ii) A manufacturer may demonstrate how the OBD system of a new engine family is sufficiently equivalent to the OBD system of a previously certified engine family (including engine families previously certified under paragraph (a)(5)(i)) of this section to demonstrate that the new engine family complies with the intent of the provisions of paragraphs (b) through (l) of this section. To make use of this alternative, manufacturers must demonstrate to the Administrator how the OBD systems they intend to certify meet the intent behind all the requirements of this section, where applicable. For example, paragraph (h) of this section would not apply for a diesel-fueled engine. Furthermore, if making use of this alternative, the manufacturer must comply with the specific certification documentation requirements of paragraph (m)(4) of this section.~~

*   *   *   *   *

(g) *   *   *

(2) *   *   *

(ii) *   *   *

(B) For model years 2013 and later, on engines equipped with sensors that can detect combustion or combustion quality (e.g., for use in engines with homogeneous charge compression ignition (HCCI) control systems), the OBD system must detect a misfire malfunction when the percentage of misfire is 5 percent or greater.

(iii)   *   *   *

(C) For model years 2013 through 2018, on engines equipped with sensors that can detect combustion or combustion quality, the OBD system must monitor continuously for engine misfire when positive torque is between 20 and 75 percent of peak torque, and engine speed is less than 75 percent of maximum engine speed. If a monitoring system cannot detect all misfire patterns under all required engine speed and load conditions, the manufacturer may request that the Administrator approve the monitoring system nonetheless. In evaluating the manufacturer's request, the Administrator will consider the following factors: the magnitude of the region(s) in which misfire detection is limited; the degree to which misfire detection is limited in the region(s) (i.e., the probability of detection of misfire events); the frequency with which said region(s) are expected to be encountered in-use; the type of misfire patterns for which misfire detection is troublesome; and demonstration that the monitoring technology employed is not inherently incapable of detecting misfire under required conditions (i.e., compliance can be achieved on other engines). The evaluation will be based on the following misfire patterns: equally spaced misfire occurring on randomly selected cylinders; single cylinder continuous misfire; and, paired cylinder (cylinders firing at the same crank angle) continuous misfire.

(D) For 20 percent of 2019 model year, 50 percent of 2020 model, and 100 percent of 2021 and later model year diesel engines (percentage based on the manufacturer's projected sales volume of all diesel engines subject to this regulation) equipped with sensors that can detect combustion or combustion quality, the OBD system must monitor continuously for engine misfire under all positive torque engine speed conditions except within the following range: the engine operating region bound by the positive torque line (i.e., engine torque with transmission in neutral) and the two following points: engine speed of 50 percent of maximum engine speed with the engine torque at the positive torque line, and 100 percent of the maximum engine speed with the engine torque at 10 percent of peak torque above the positive torque line. If a monitoring system cannot detect all misfire patterns under all required engine speed and load conditions, the manufacturer may request that the Administrator approve the monitoring system nonetheless. In evaluating the manufacturer's request, the Administrator will consider the following factors: the magnitude of the region(s) in which misfire detection is limited; the degree to which misfire detection is limited in the region(s) (i.e., the probability of detection of misfire events); the frequency with which said region(s) are expected to be encountered in-use; the type of misfire patterns for which misfire detection is troublesome; and demonstration that the monitoring technology employed is not inherently incapable of detecting misfire under required conditions (i.e., compliance can be achieved on other engines). The evaluation will be based on the following misfire patterns: equally spaced misfire occurring on randomly selected cylinders; single cylinder continuous misfire; and, paired cylinder (cylinders firing at the same crank angle) continuous misfire.

*   *   *   *   *

~~(l) * * *~~

~~(2) * * *~~

~~(iii) *For model years 2013 and later*. (A) A manufacturer certifying one to five engine families in a given model year must provide emissions test data for a single test engine from one engine rating. A manufacturer certifying six to ten engine families in a given model year must provide emissions test data for a single test engine from two different engine ratings. A manufacturer certifying eleven or more engine families in a given model year must provide emissions test data for a single test engine from three different engine ratings. A manufacturer may forego submittal of test data for one or more of these test engines if data have been submitted previously for all of the engine ratings and/or if all requirements for certification carry-over from one model year to the next are satisfied, and/or if differences from previously submitted engines are not relevant to emissions or diagnostic demonstration (such as changes to supported data stream parameters or changes to monitors not associated with demonstrating or enabling demonstrated emission threshold diagnostics). For purposes of this paragraph (l)(2)(iii), you may ask to exclude special families (such as California variants) from your count of engine families.~~

~~* * * * *~~

~~(m) * * *~~

~~(3) In addition to the documentation required by paragraphs (m)(1) and (2) of this section, a manufacturer making use of paragraph (a)(5)(i) of this section must submit the following information with their application for certification:~~

~~(i) A detailed description of how the OBD system meets the intent of this section.~~

~~(ii) A detailed description of why the manufacturer has chosen not to design the OBD system to meet the requirements of this section and has instead designed the OBD system to meet the applicable California OBD requirements.~~

~~(iii) A detailed description of any deficiencies granted by the California staff and any concerns raised by California staff. A copy of a California Executive Order alone will not be considered acceptable toward meeting this requirement. This description shall also include, to the extent feasible, a plan with timelines for resolving deficiencies and/or concerns.~~

~~(4) In addition to the documentation required by paragraphs (m)(1) and (2) of this section, a manufacturer making use of paragraph (a)(5)(ii) of this section must submit the following information with their application for certification:~~
~~(i) A detailed description of how the OBD system meets the intent of this section.~~
~~(ii) A detailed description of changes made from the previously certified OBD system.~~
~~*   *   *   *   *~~

(p) *   *   *

(3) *For model years 2016 through 2018*. (i) On the engine ratings tested according to paragraph (l)(2)(iii) of this section, the certification emissions thresholds shall apply in-use.

(ii) On the manufacturer's remaining engine ratings, separate in-use emissions thresholds shall apply. These thresholds are determined by doubling the applicable thresholds as shown in Table 1 of paragraph (g) of this section and Table 2 of paragraph (h) of this section. The resultant thresholds apply only in-use and do not apply for certification or selective enforcement auditing.

(iii) For monitors subject to meeting the minimum in-use monitor performance ratio of 0.100 in paragraph (d)(1)(ii) of this section, the OBD system shall not be considered noncompliant unless a representative sample indicates the in-use ratio is below 0.088 except for filtering performance monitors for PM filters (paragraph (g)(8)(ii)(A) of this section) and missing substrate monitors (paragraph (g)(8)(ii)(D) of this section) for which the OBD system shall not be considered noncompliant unless a representative sample indicates the in-use ratio is below 0.050.

(iv) An OBD system shall not be considered noncompliant solely due to a failure or deterioration mode of a monitored component or system that could not have been reasonably foreseen to occur by the manufacturer.

(4) *For model years 2019 and later*. (i) On all engine ratings, the certification emissions thresholds shall apply in-use.

(ii) For monitors subject to meeting the minimum in-use monitor performance ratio of 0.100 in paragraph (d)(1)(ii) of this section, the OBD system shall not be considered noncompliant unless a representative sample indicates the in-use ratio is below 0.088.

(iii) An OBD system shall not be considered noncompliant solely due to a failure or deterioration mode of a monitored component or system that the manufacturer could not have reasonably foreseen.

*   *   *   *   *

51. Section 86.113-04 is amended by revising paragraph (a)(1) to read as follows:

§ 86.113-04   Fuel specifications.

*   *   *   *   *

(a) *   *   *

(1) Gasoline meeting the following specifications, or substantially equivalent specifications approved by the Administrator, must be used for exhaust and evaporative testing:

Table 1 to §86.113-04(a)(1)–Test fuel specifications for gasoline without ethanol

Item	Regular	Reference Procedure[1]
Research octane, Minimum[2]	93	ASTM D2699 ASTM D2700
Octane sensitivity[2]	7.5	
Distillation Range (°F): Evaporated initial boiling point[3] 10% evaporated 50% evaporated 90% evaporated Evaporated final boiling point	 75 – 95 120 - 135 200 - 230 300 - 325 415 Maximum	ASTM D86
Total Aromatic Hydrocarbon (vol %)	35% Maximum	ASTM D1319 or ASTM D5769
Olefins (vol %)[4]	10% Maximum	ASTM D1319 or ASTM D6550
Lead, g/gallon (g/liter), Maximum	0.050 (0.013)	ASTM D3237
Phosphorous, g/gallon (g/liter), Maximum	0.005 (0.0013)	ASTM D3231
Total sulfur, wt. %[5]	0.0015 – 0.008	ASTM D2622
Dry Vapor Pressure Equivalent (*DVPE*), kPa (psi)[6]	60.0-63.4 (8.7-9.2)	ASTM D5191

[1]Incorporated by reference, see §86.1.
[2]Octane specifications are optional for manufacturer testing.
[3]For testing at altitudes above 1,219 m (4000 feet), the specified range is 75-105° F.
[4]ASTM D6550 prescribes measurement of olefin concentration in mass %. Multiply this result by 0.857 and round to the first decimal place to determine the olefin concentration in volume %.
[5]Sulfur concentration will not exceed 0.0045 weight percent for EPA testing.
[6]For testing unrelated to evaporative emission control, the specified range is 54.8-63.7 kPa (8.0-9.2 psi). For testing at altitudes above 1,219 m (4000 feet), the specified range is 52.0-55.4 kPa (7.6-8.0 psi). Calculate dry vapor pressure equivalent, *DVPE*, based on the measured total vapor pressure, p_T, using the following equation: $DVPE$ (kPa) = $0.956 \cdot p_T - 2.39$ (or $DVPE$ (psi) = $0.956 \cdot p_T – 0.347$). *DVPE* is intended to be equivalent to Reid Vapor Pressure using a different test method.

* * * * *

52. Section 86.129-00 is amended by revising paragraph (f)(1)(ii)(C) to read as follows:

§86.129-00 Road load power, test weight, and inertia weight class determination.

* * * * *

(f)(1) * * *

(ii) * * *

(C) Regardless of other requirements in this section relating to the testing of HLDTs, for Tier 2 and Tier 3 HLDTs, the test weight basis for FTP and SFTP testing (both US06 and SC03), if applicable, is the vehicle curb weight plus 300 pounds. For MDPVs certified to standards in bin 11 in Tables S04-1 and 2 in §86.1811-04, the test weight basis must be adjusted loaded vehicle weight (ALVW) as defined in this part.

* * * * *

53. Section 86.130-96 is amended by revising paragraph (a) to read as follows:

§86.130-96 Test sequence; general requirements.

* * * * *

(a)(1) *Gasoline- and methanol-fueled vehicles*. The test sequence shown in Figure 1 of 40 CFR 1066.801 shows the steps encountered as the test vehicle undergoes the procedures subsequently described to determine conformity with the standards set forth. The full three- diurnal sequence depicted in Figure 1 of 40 CFR 1066.801 tests vehicles for all sources of evaporative emissions. The supplemental two-diurnal test sequence is designed to verify that vehicles sufficiently purge their evaporative canisters during the exhaust emission test. Sections 86.132-96, 86.133-96 and 86.138-96 describe the separate specifications of the supplemental two-diurnal test sequence.
(2) *Gaseous-fueled vehicles*. The test sequence shown in ~~figure~~ Figure 1 of 40 CFR 1066.801 shows the steps encountered as the test vehicle undergoes the procedures subsequently described to determine conformity with the standards set forth, with the exception that the fuel drain and fill and precondition canister steps are not required for gaseous-fueled vehicles. In addition, the supplemental two-diurnal test and the running loss test are not required.
*   *   *   *   *

54. Section 86.213 is amended by revising paragraph (a)(2) to read as follows:

§ 86.213 Fuel specifications.

(a) *   *   *

(2) You may use the test fuel specified in this paragraph (a)(2) for vehicles that are not yet subject to exhaust testing with an ethanol-blend test fuel under §86.113. Manufacturers may certify based on this fuel using carryover data until testing with the ethanol-blend test fuel is required. The following specifications apply for gasoline test fuel without ethanol:

Table 1 of § 86.213(a)(2)–Cold temperature test fuel specifications for gasoline without ethanol

Item	Regular	Premium	Reference Procedure[1]
(RON+MON)/2[2]	87.8±0.3	92.3±0.5	ASTM D2699 ASTM D2700
Sensitivity[3]	7.5	7.5	ASTM D2699 ASTM D2700
Distillation Range (°F): Evaporated initial boiling point 10% evaporated 50% evaporated 90% evaporated Evaporated final boiling point	 76 – 96 98 - 118 179 - 214 316 - 346 413 Maximum	 76 – 96 105 - 125 195 - 225 316 - 346 413 Maximum	ASTM D86
Total Aromatic Hydrocarbon (vol %)	26.4±4.0	32.0±4.0	ASTM D1319 or ASTM D5769
Olefins (vol %)[4]	12.5±5.0	10.5±5.0	ASTM D1319 or ASTM D6550
Lead, g/gallon	0.01, Maximum	0.01, Maximum	ASTM D3237
Phosphorous, g/gallon	0.005 Maximum	0.005 Maximum	ASTM D3231
Total sulfur, wt. %[3]	0.0015 – 0.008	0.0015 – 0.008	ASTM D2622
RVP, psi	11.5±0.3	11.5±0.3	ASTM D5191

[1]Incorporated by reference, see § 86.1.
[2]Octane specifications are optional for manufacturer testing. The premium fuel specifications apply for vehicles designed to use high-octane premium fuel.
[3]Sulfur concentration will not exceed 0.0045 weight percent for EPA testing.
[4]ASTM D6550 prescribes measurement of olefin concentration in mass %. Multiply this result by 0.857 and round to the first decimal place to determine the olefin concentration in volume %.

* * * * *

§86.401-97—[Removed]

55. Remove §86.401-97.

56. Amend §86.408-78 by adding paragraphs (c) and (d) to read as follows:

§86.408-78 General standards; increase in emissions; unsafe conditions.

* * * * *

(c) If a new motorcycle is designed to require manual adjustment to compensate for changing altitude, the manufacturer must include the appropriate instructions in the application for certification. EPA will review the instructions to ensure that properly adjusted motorcycles will meet emission standards at both low altitude and high altitude.

(d) An action to install parts, modify engines, or perform other adjustments to compensate for changing altitude is not prohibited under 42 U.S.C. 7522 as long as it is done consistent with the manufacturer's instructions.

§86.413-78—[Removed]

57. Remove §86.413-78.

58. Amend §86.419-2006 by revising paragraph (b) introductory text to read as follows:

§86.419-2006 Engine displacement, motorcycle classes.

* * * * *

(b) Motorcycles will be divided into classes and subclasses based on engine displacement.
* * * * *

59. Amend §86.427-78 by revising paragraph (a)(1) to read as follows:

§ 86.427-78 Emission tests.

(a)(1) Each test vehicle shall be driven with all emission control systems installed and operating for the following total test distances, or for such lesser distances as the Administrator may agree to as meeting the objectives of this procedure. (See §86.419 for class explanation.)

Displacement class	Total test distance (kilometers)	Minimum test distance (kilometers)	Minimum number of tests
I-A	6,000	2,500	4
I-B	6,000	2,500	4
II	9,000	2,500	4
III	15,000	3,500	4

* * * * *

60. Amend §86.435-78 by revising paragraph (b)(1) to read as follows:

§86.435-78 Extrapolated emission values.

* * * * *

(b) * * *

(1) If the useful life emissions are at or below the standards, certification will be granted.

* * * * *

61. Amend §86.436-78 by revising paragraph (d) to read as follows:

§86.436-78 Additional service accumulation.

* * * * *

(d) To qualify for certification:

(1) The full life emission test results must be at or below the standards, and

(2) The deterioration line must be below the standard at the minimum test distance and the useful life, or all points used to generate the line, must be at or below the standard.

* * * * *

62. Amend §86.513 by revising paragraphs (a)(1) and (a)(3) to read as follows:

§86.513 Fuel and engine lubricant specifications.

(a) *Gasoline*. (1) Use gasoline meeting the following specifications for exhaust and evaporative emission testing:

Table 1 of § 86.513(a)(1)—Gasoline Test Fuel Specifications

Item	Value	Procedure[1]
Distillation Range:		
1. Initial boiling point, °C	23.9—35.0 [2]	ASTM D86
2. 10% point, °C	48.9—57.2	
3. 50% point, °C	93.3—110.0	
4. 90% point, °C	148.9—162.8	
5. End point, °C	212.8 maximum	
Total aromatic hydrocarbon, volume %	35 maximum	ASTM D1319 or ASTM D5769
Olefins, volume %[3]	10 maximum	ASTM D1319 or ASTM D6550
Lead (organic), g/liter	0.013 maximum	ASTM D3237
Phosphorous, g/liter	0.0013 maximum	ASTM D3231
Sulfur, weight %	0.008 maximum	ASTM D2622
Dry Vapor Pressure Equivalent (*DVPE*), kPa	55.2 to 63.4 [4]	ASTM D5191

[1]Incorporated by reference, see § 86.1.
[2]For testing at altitudes above 1,219 m, the specified initial boiling point range is (23.9 to 40.6) °C.
[3]ASTM D6550 prescribes measurement of olefin concentration in mass %. Multiply this result by 0.857 and round to the first decimal place to determine the olefin concentration in volume %.
[4]For testing at altitudes above 1,219 m, the specified volatility range is 52 to 55 kPa. Calculate dry vapor pressure equivalent, *DVPE*, based on the measured total vapor pressure, p_T, using the following equation: *DVPE* (kPa) = $0.956 \cdot p_T - 2.39$ (or *DVPE* (psi) = $0.956 \cdot p_T - 0.347$). *DVPE* is intended to be equivalent to Reid Vapor Pressure using a different test method.

* * * * *

(3) Manufacturers may alternatively use ethanol-blended gasoline meeting the specifications described in 40 CFR 1065.710(b) for general testing without our advance approval. Manufacturers using the ethanol-blended fuel for certifying a given engine family may also use it for any testing for that engine family under this part. If manufacturers use the ethanol-blended fuel for certifying a given engine family, EPA may use the ethanol-blended fuel or the neat gasoline test fuel specified in this section for that engine family. Manufacturers may also request to use fuels meeting alternate specifications as described in 40 CFR 1065.701(b).

* * * * *

63. Revise §86.531-78 to read as follows:

§86.531-78 Vehicle preparation.

(a) The manufacturer shall provide additional fittings and adapters, as required by the Administrator, to accommodate a fuel drain at the lowest point possible in the tank(s) as installed on the vehicle, and to provide for exhaust sample collection.

(b) Connect the motorcycle’s exhaust system to the analyzer for all exhaust emission measurements. Seal all known leaks in the exhaust system. Make sure ~~Seal the exhaust system as needed to ensure that~~ any remaining leaks do not affect the demonstration that the motorcycle complies with standards. ~~Sealing all known leaks is recommended.~~

64. Revise §86.1362 to read as follows:

§86.1362 Steady-state testing with a ramped-modal cycle.

(a) This section describes how to test engines under steady-state conditions. Perform ramped-modal testing as described in 40 CFR 1036.505 and 40 CFR part 1065, except as specified in this section.

(b) Measure emissions by testing the engine on a dynamometer with the following ramped-modal duty cycle to determine whether it meets the applicable steady-state emission standards:

RMC Mode	Engine testing			Powertrain testing				CO_2 weighting (percent)[5]
	Time in mode (sec~~onds~~)	Engine Speed[1,2]	Torque (percent)[2,3]	Vehicle speed (mi/hr)[4]	Road-grade coefficients[4]			
					a	*b*	*c*	
1a Steady-state	170	Warm Idle	0	Warm Idle	0	0	0	6
1b Transition	20	Linear Transition	Linear Transition	Linear Transition	5.6E-6	-4.6E-3	-9.1E+0	
2a Steady-state	173	A	100	53.38	-1.6E-6	691.3E-6	2.1E+0	9
2b Transition	20	Linear Transition	Linear Transition	Linear Transition	0	0	0	
3a Steady-state	219	B	50	65.00	-12.8E-6	10.2E-3	-1.6E+0	10
3b Transition	20	B	Linear Transition	65.00	0	0	0	
4a Steady-state	217	B	75	65.00	-10.2E-6	7.8E-3	-268.9E-3	10
4b Transition	20	Linear Transition	Linear Transition	Linear Transition	-8.8E-6	6.7E-3	2.2E+0	
5a Steady-state	103	A	50	53.38	-8.0E-6	6.2E-3	-623.0E-3	12
5b Transition	20	A	Linear Transition	53.38	-5.6E-6	4.4E-3	92.1E-3	
6a Steady-state	100	A	75	53.38	-5.0E-6	3.5E-3	712.4E-3	12
6b Transition	20	A	Linear Transition	53.38	-6.9E-6	5.4E-3	-473.1E-3	
7a Steady-state	103	A	25	53.38	-11.1E-6	8.8E-3	-2.0E+0	12
7b Transition	20	Linear Transition	Linear Transition	Linear Transition	-8.6E-6	6.9E-3	-3.1E+0	
8a Steady-state	194	B	100	65.00	-7.4E-6	5.5E-3	798.2E-3	9
8b Transition	20	B	Linear Transition	65.00	-13.2E-6	10.1E-3	-1.2E+0	
9a Steady-state	218	B	25	65.00	-16.9E-6	13.6E-3	-3.2E+0	9
9b Transition	20	Linear Transition	Linear Transition	Linear Transition	-16.7E-6	13.6E-3	-5.2E+0	
10a Steady-state	171	C	100	77.80	-16.5E-6	13.1E-3	-1.3E+0	2
10b Transition	20	C	Linear Transition	77.80	-18.5E-6	15.4E-3	-2.9E+0	
11a Steady-state	102	C	25	77.80	-24.7E-6	20.2E-3	-5.0E+0	1
11b Transition	20	C	Linear Transition	77.80	-22.1E-6	17.9E-3	-3.8E+0	
12a Steady-state	100	C	75	77.80	-19.2E-6	15.5E-3	-2.5E+0	1
12b Transition	20	C	Linear Transition	77.80	-20.4E-6	16.5E-3	-3.1E+0	
13a Steady-state	102	C	50	77.80	-21.8E-6	17.7E-3	-3.7E+0	1
13b Transition	20	Linear Transition	Linear Transition	Linear Transition	-11.8E-6	7.6E-3	17.6E+0	
14 Steady-state	168	Warm Idle	0	Warm Idle	0	0	0	6

[1]Engine speed terms are defined in 40 CFR part 1065.
[2]Advance from one mode to the next within a 20 second transition phase. During the transition phase, command a linear progression from the settings of the current mode to the settings of the next mode.
[3]The percent torque is relative to maximum torque at the commanded engine speed.
[4]See 40 CFR 1036.505(c) for a description of powertrain testing with the ramped-modal cycle, including the equation that uses the road-grade coefficients.
[5]Use the specified weighting factors to calculate composite emission results for CO_2 as specified in 40 CFR 1036.501.

Subpart P—[Removed and Reserved]

65. Remove and reserve Subpart P.

Subpart Q—[Removed and Reserved]

66. Remove and reserve Subpart Q.

67. Amend §86.1803-01 by revising the definitions for "Heavy-duty vehicle" and "Light-duty truck" to read as follows:

§86.1803-01 Definitions.

* * * * *

Heavy-duty vehicle means any complete or incomplete motor vehicle rated at more than 8,500 pounds GVWR. Heavy-duty vehicle also includes incomplete vehicles that have a curb weight above 6,000 pounds or a basic vehicle frontal area greater than 45 square feet. Note that MDPVs are heavy-duty vehicles that are in many cases subject to requirements that apply for light-duty trucks.

* * * * *

Light-duty truck means any motor vehicle that is not a heavy-duty vehicle, but is:

(1) Designed primarily for purposes of transportation of property or is a derivation of such a vehicle; or

(2) Designed primarily for transportation of persons and has a capacity of more than 12 persons; or

(3) Available with special features enabling off-street or off-highway operation and use.

* * * * *

~~68. Amend §86.1810-17 by adding paragraph (j) to read as follows:~~

~~**§86.1810-17 General requirements.**~~

~~* * * * *~~

~~(j) Small-volume manufacturers that modify a vehicle already certified by a different company may recertify that vehicle under this subpart S based on the vehicle supplier's compliance with fleet average standards for criteria exhaust emissions and evaporative emissions, as follows:~~

~~(1) The recertifying manufacturer must certify the vehicle at bin levels and family emission limits that are the same as or more stringent than the corresponding bin levels and family emission limits for the vehicle supplier.~~

~~(2) The recertifying manufacturer must meet all the standards and requirements described in this subpart S, except for the fleet average standards for criteria exhaust emissions and evaporative emissions.~~

~~(3) The vehicle supplier must send the small-volume manufacturer a written statement accepting responsibility to include the subject vehicles in the vehicle supplier's fleet average calculations.~~

~~(4) The small-volume manufacturer must describe in the application for certification how the two companies are working together to demonstrate compliance for the subject vehicles. The application must include the statement from the vehicle supplier described in paragraph (j)(3) of this section.~~

68. Amend §86.1811-17 by revising paragraph (b)(8)(iii)(C) to read as follows:

§86.1811-17 Exhaust emission standards for light-duty vehicles, light-duty trucks and medium-duty passenger vehicles.

* * * * *

(b) * * *

(8) * * *

(iii) * * *

(C) Vehicles must comply with the Tier 2 SFTP emission standards for NMHC + NOx and CO for 4,000-mile testing that are specified in §86.1811-04(f)(1) if they are certified to transitional Bin 85 or Bin 110 standards, or if they are certified based on a fuel without ethanol, or if they are not certified to the Tier 3 PM standard. Note that these standards apply under this section for alternative fueled vehicles, for flexible fueled vehicles when operated on a fuel other than gasoline or diesel fuel, and for MDPVs, even though these vehicles were not subject to the SFTP standards in the Tier 2 program.

* * * * *

69. Amend §86.1813-17 by revising the introductory text and paragraph (a)(2)(i) to read as follows:

§86.1813-17 Evaporative and refueling emission standards.

Vehicles must meet evaporative and refueling emission standards as specified in this section. These emission standards apply for heavy duty vehicles above 14,000 pounds GVWR as specified in §86.1801. These emission standards apply for total hydrocarbon equivalent (THCE) measurements using the test procedures specified in subpart B of this part, as appropriate. Note that §86.1829 allows you to certify without testing in certain circumstances. These evaporative and refueling emission standards do not apply for electric vehicles, fuel cell vehicles, or diesel-fueled vehicles, except as specified in paragraph (b) of this section. Unless otherwise specified, MDPVs are subject to all the same provisions of this section that apply to LDT4.

(a) * * *

(2) * * *

(i) The emission standard for the sum of diurnal and hot soak measurements from the two-diurnal test sequence and the three-diurnal test sequence is based on a fleet average in a given model year. You must specify a family emission limit (FEL) for each evaporative family. The FEL serves as the emission standard for the evaporative family with respect to all required diurnal and hot soak testing. Calculate your fleet-average emission level as described in §86.1860 based on the FEL that applies for low-altitude testing to show that you meet the specified standard. For multi-fueled vehicles, calculate fleet-average emission levels based only on emission levels for testing with gasoline. You may generate emission credits for banking and trading and you may use banked or traded credits for demonstrating compliance with the diurnal plus hot soak emission standard for vehicles required to meet the Tier 3 standards, other than gaseous-fueled vehicles, as described in §86.1861 starting in model year 2017. You comply with the emission standard for a given model year if you have enough credits to show that your fleet-average emission level is at or below the applicable standard. You may exchange credits between or among evaporative families within an averaging set as described in §86.1861. Separate diurnal plus hot soak emission standards apply for each evaporative/refueling emission family as shown for high-altitude conditions. The sum of diurnal and hot soak measurements may not exceed the following Tier 3 standards:

* * * * *

70. Amend §86.1817-05 by revising paragraph (a)(1) to read as follows:

§86.1817-05   Complete heavy-duty vehicle averaging, trading, and banking program.

(a) *   *   *

(1) Complete heavy-duty vehicles eligible for the NOx averaging, trading and banking program are described in the applicable emission standards section of this subpart. Participation in this averaging, trading, and banking program is voluntary.

*   *   *   *   *

71. Amend §86.1818-12 by revising paragraph (d) to read as follows:

§86.1818-12   Greenhouse gas emission standards for light-duty vehicles, light-duty trucks, and medium-duty passenger vehicles.

*   *   *   *   *

(d) *In-use CO_2 exhaust emission standards*. The in-use CO_2 exhaust emission standard shall be the combined city/highway carbon-related exhaust emission value calculated for the appropriate vehicle carline/subconfiguration according to the provisions of §600.113-12(g)(4) of this chapter adjusted by the deterioration factor from §86.1823-08(m). Multiply the result by 1.1 and round to the nearest whole gram per mile. For in-use vehicle carlines/subconfigurations for which a combined city/highway carbon-related exhaust emission value was not determined under §600.113-12(g)(4) of this chapter, the in-use CO_2 exhaust emission standard shall be the combined city/highway carbon-related exhaust emission value calculated according to the provisions of §600.208 of this chapter for the vehicle model type (except that total model year production data shall be used instead of sales projections) adjusted by the deterioration factor from §86.1823-08(m). Multiply the result by 1.1 and round to the nearest whole gram per mile. For vehicles that are capable of operating on multiple fuels, except plug-in hybrid electric vehicles, a separate in-use standard shall be determined for each fuel that the vehicle is capable of operating on. These standards apply to in-use testing performed by the manufacturer pursuant to regulations at §§86.1845 and 86.1846 and to in-use testing performed by EPA.

*   *   *   *   *

72. Amend §86.1838-01 by revising paragraph (c)(2)(iii) to read as follows:

§86.1838-01   Small-volume manufacturer certification procedures.

*   *   *   *   *

(c) *   *   *

(2) *   *   *

(iii) The provisions of §86.1845-04(c)(2) that require one vehicle of each test group during high mileage in-use verification testing to have a minimum odometer mileage of 75 percent of the full useful life mileage do not apply.

*   *   *   *   *

73. Amend §86.1868-12 by revising paragraph (g) introductory text and adding paragraph (g)(5) to read as follows:

§86.1868-12 CO_2 credits for improving the efficiency of air conditioning systems.

*   *   *   *   *

(g) *AC17 validation testing and reporting requirements*. For 2020 and later model years, manufacturers must validate air conditioning credits by using the AC17 Test Procedure as follows:

*   *   *   *   *

(5) AC17 testing requirements apply as follows for electric vehicles and plug-in hybrid electric vehicles:

(i) Manufacturers may omit AC17 testing for electric vehicles. Electric vehicles may qualify for air conditioning efficiency credits based on identified technologies, without testing. The application for certification must include a detailed description of the vehicle's air conditioning system and identify any technology items eligible for air conditioning efficiency credits. Include additional supporting information to justify the air conditioning credit for each technology.

(ii) The provisions of paragraph (g)(5)(i) of this section also apply for plug-in hybrid electric vehicles if they have an all electric range of at least 60 miles (combined city and highway) after adjustment to reflect actual in-use driving conditions (see 40 CFR 600.311(j)), and they do not rely on the engine to cool the vehicle's cabin for the ambient and driving conditions represented by the AC17 test.

(iii) If AC17 testing is required for plug-in hybrid electric vehicles, perform this testing in charge-sustaining mode.

*   *   *   *   *

74. Part 88 is revised to read as follows:

PART 88—CLEAN-FUEL VEHICLES

Sec.

88.1 General applicability.

88.2 through 88.3 [Reserved]

Authority: 42 U.S.C. 7410, 7418, 7581, 7582, 7583, 7584, 7586, 7588, 7589, 7601(a).

§88.1 General applicability.

(a) The Clean Air Act includes provisions intended to promote the development and sale of clean-fuel vehicles (see 42 U.S.C. 7581-7589). This takes the form of credit incentives for State Implementation Plans. The specified clean-fuel vehicle standards to qualify for these credits are now uniformly less stringent than the emission standards that apply for new vehicles and new engines under 40 CFR part 86 and part 1036.

(b) The following provisions apply for purposes of State Implementation Plans that continue to reference the Clean Fuel Fleet Program:

(1) Vehicles and engines certified to current emission standards under 40 CFR part 86 or part 1036 are deemed to also meet the Clean Fuel Fleet standards as Ultra Low-Emission Vehicles.

(2) Vehicles and engines meeting requirements as specified in paragraph (a)(1) of this section with a fuel system designed to not vent fuel vapors to the atmosphere are also deemed to meet the Clean Fuel Fleet standards as Inherently Low-Emission Vehicles. The applies for vehicles using diesel fuel, liquefied petroleum gas, or compressed natural gas. It does not apply for vehicles using gasoline, ethanol, methanol, or liquefied natural gas.

(3) The following types of vehicles qualify as Zero Emission Vehicles:

(i) Electric vehicles (see 40 CFR 86.1803).

(ii) Any other vehicle with a fuel that contains no carbon or nitrogen compounds, that has no evaporative emissions, and that burns without forming oxides of nitrogen, carbon monoxide, formaldehyde, particulate matter, or hydrocarbon compounds. This applies equally for all engines installed on the vehicle.

§§88.2 through 88.3 [Reserved]

75. Part 89 is revised to read as follows:

PART 89—CONTROL OF EMISSIONS FROM NEW AND IN-USE NONROAD COMPRESSION-IGNITION ENGINES

Sec.

Authority: 42 U.S.C. 7401-7671q.

§89.1 Applicability.

The Environmental Protection Agency adopted emission standards for model year 1996 and later nonroad compression-ignition engines under this part 89. EPA has migrated regulatory requirements for these engines to 40 CFR part 1039, with additional testing and compliance provisions in 40 CFR part 1065 and part 1068. The Tier 1, Tier 2, and Tier 3 standards originally adopted in this part 89 are identified in 40 CFR part 1039, Appendix I. See 40 CFR 1039.1 for information regarding the timing of the transition to 40 CFR part 1039, and for information regarding regulations that continue to apply for engines that manufacturers originally certified or otherwise produced under this part 89.

§§89.2 through 89.3 [Reserved]

76. Part 90 is revised to read as follows:

PART 90—CONTROL OF EMISSIONS FROM NONROAD SPARK-IGNITION ENGINES AT OR BELOW 19 KILOWATTS

Sec.

Authority: 42 U.S.C. 7401-7671q.

§90.1 Applicability.

The Environmental Protection Agency adopted emission standards for model year 1997 and later nonroad spark-ignition engines below 19 kW under this part 90. EPA has migrated regulatory requirements for these engines to 40 CFR part 1054, with additional testing and compliance provisions in 40 CFR part 1065 and part 1068. The Phase 1 and Phase 2 standards originally adopted in this part 90 are identified in 40 CFR part 1054, Appendix I. See 40 CFR 1054.1 for information regarding the timing of the transition to 40 CFR part 1054, and for information regarding regulations that continue to apply for engines that manufacturers originally certified or otherwise produced under this part 90.1

§§90.2 through 90.3 [Reserved]

77. Part 91 is revised to read as follows:

PART 91—CONTROL OF EMISSIONS FROM MARINE SPARK-IGNITION ENGINES

Sec.

Authority: 42 U.S.C. 7401-7671q.

§91.1 Applicability.

The Environmental Protection Agency adopted emission standards for model year 1998 and later marine spark-ignition engines under this part 91, except that the standards of this part did not apply to sterndrive/inboard engines. EPA has migrated regulatory requirements for these engines to 40 CFR part 1045, with additional testing and compliance provisions in 40 CFR part 1065 and part 1068. The standards originally adopted in this part 91 are identified in 40 CFR part 1045, Appendix I. See 40 CFR 1045.1 for information regarding the timing of the transition to 40 CFR part 1045, and for information regarding regulations that continue to apply for engines that manufacturers originally certified or otherwise produced under this part 91.

§§91.2 through 91.3 [Reserved]

78. Part 92 is revised to read as follows:

PART 92—CONTROL OF AIR POLLUTION FROM LOCOMOTIVES AND LOCOMOTIVE ENGINES

Authority: 42 U.S.C. 7401-7671q.

§92.1 Applicability.

The Environmental Protection Agency first adopted emission standards for freshly manufactured and remanufactured locomotives under this part 92 in 1998. EPA has migrated regulatory requirements for these engines to 40 CFR part 1033, with additional testing and compliance provisions in 40 CFR part 1065 and part 1068. The Tier 0, Tier 1, and Tier 2 standards originally adopted in this part 92 are identified in 40 CFR part 1033, Appendix I. See 40 CFR 1033.1 for information regarding the timing of the transition to 40 CFR part 1033, and for information regarding regulations that continue to apply for engines that manufacturers originally certified or otherwise produced or remanufactured under this part 92. Emission standards started to apply for locomotive and locomotive engines if they were–

(a) Manufactured on or after January 1, 2000;

(b) Manufactured on or after January 1, 1973 and remanufactured on or after January 1, 2000; or

(c) Manufactured before January 1, 1973 and upgraded on or after January 1, 2000.

§§92.2 through 92.3 [Reserved]

79. Part 94 is revised to read as follows:

PART 94—CONTROL OF EMISSIONS FROM MARINE COMPRESSION-IGNITION ENGINES

Sec.

Authority: 42 U.S.C. 7401-7671q.

§94.1 Applicability.

The Environmental Protection Agency adopted emission standards for model year 2004 and later marine compression-ignition engines under this part 94. EPA has migrated regulatory requirements for these engines to 40 CFR part 1042, with additional testing and compliance provisions in 40 CFR part 1065 and part 1068. The Tier 1 and Tier 2 standards originally adopted in this part 94 are identified in 40 CFR part 1042, Appendix I. See 40 CFR 1042.1 for information regarding the timing of the transition to 40 CFR part 1042, and for information regarding regulations that continue to apply for engines that manufacturers originally certified or otherwise produced under this part 94.

§§94.2 through 94.3 [Reserved]

PART 1027 — FEES FOR VEHICLE AND ENGINE COMPLIANCE PROGRAMS

80. The authority statement for part 1027 continues to read as follows:

Authority: 42 U.S.C. 7401-7671q.

81. The heading for part 1027 is revised to read as set forth above.

82. Amend §1027.101 by:

a. Revising paragraph (a); and

b. Removing and reserving paragraph (b).

The revision reads as follows:

§1027.101 To whom do these requirements apply?

(a) This part prescribes fees manufacturers must pay for activities related to EPA's motor vehicle and engine compliance program (MVECP). This includes activities related to approving certificates of conformity and performing tests and taking other steps to verify compliance with emission standards. You must pay fees as described in this part if you are a manufacturer of any of the following products:

(1) Motor vehicles and motor vehicle engines we regulate under 40 CFR part 86. This includes light-duty vehicles, light-duty trucks, medium-duty passenger vehicles, highway motorcycles, and heavy-duty highway engines and vehicles.

(2) The following nonroad engines and equipment:

(i) Locomotives and locomotive engines we regulate under 40 CFR part 1033.

(ii) Nonroad compression-ignition engines we regulate under 40 CFR part 1039.

(iii) Marine compression-ignition engines we regulate under 40 CFR part 1042 or 1043.

(iv) Marine spark-ignition engines and vessels we regulate under 40 CFR part 1045 or 1060. We refer to these as Marine SI engines.

(v) Nonroad spark-ignition engines above 19 kW we regulate under 40 CFR part 1048. We refer to these as Large SI engines.

(vi) Recreational vehicles we regulate under 40 CFR part 1051.

(vii) Nonroad spark-ignition engines and equipment at or below 19 kW we regulate under 40 CFR part 1054 or 1060. We refer to these as Small SI engines.

(3) The following stationary internal combustion engines:

(i) Stationary compression-ignition engines we certify under 40 CFR part 60, subpart IIII.

(ii) Stationary spark-ignition engines we certify under 40 CFR part 60, subpart JJJJ.

(4) Portable fuel containers we regulate under 40 CFR part 59, subpart F.

* * * * *

83. Revise §1027.105 to read as follows:

§1027.105 How much are the fees?

(a) Fees are determined based on the date we receive a complete application for certification. Each reference to a year in this subpart refers to the calendar year, unless otherwise specified. Paragraph (b) of this section specifies baseline fees that apply for certificates received in 2020 See paragraph (c) of this section for provisions describing how we calculate fees for 2021 and later years.

(b) The following baseline fees apply for each application for certification:

(1) Except as specified in paragraph (b)(2) of this section for Independent Commercial Importers, the following fees apply in 2020 for motor vehicles and motor vehicle engines:

Category[a]	Certificate type	Fee
(i) Light-duty vehicles, light-duty trucks, medium-duty passenger vehicle, and complete heavy-duty highway vehicles	Federal	$27,347
(ii) Light-duty vehicles, light-duty trucks, medium-duty passenger vehicle, and complete heavy-duty highway vehicles	California-only	$14,700
(iii) Heavy-duty highway engine	Federal	$56,299
(iv) Heavy-duty highway engine	California-only	$563
(v) Heavy-duty vehicle	Evap	$563
(vi) Highway motorcycle, including Independent Commercial Importers	All	$1,852

[a]The specified categories include engines and vehicles that use all applicable fuels.

(2) A fee of $87,860 applies in 2020 for Independent Commercial Importers with respect to the following motor vehicles:

(i) Light-duty vehicles and light-duty trucks.

(ii) Medium-duty passenger vehicles.

(iii) Complete heavy-duty highway vehicles.

(3) The following fees apply in 2020 for nonroad and stationary engines, vehicles, equipment, and components:

Category	Certificate type	Fee
(i) Locomotives and locomotive engines	All	$563
(ii) Marine compression-ignition engines and stationary compression-ignition engines with per-cylinder displacement at or above 10 liters	All, including EIAPP	$563
(iii) Other nonroad compression-ignition engines and stationary compression-ignition engines with per-cylinder displacement below 10 liters	All	$2,940
(iv) Large SI engines and stationary spark-ignition engines above 19 kW	All	$563
(v) Marine SI engines. Small SI engines, and stationary spark-ignition engines at or below 19 kW	Exhaust only	$563
(vi) Recreational vehicles	Exhaust (or combined exhaust and evap)	$563
(vii) Equipment and fuel-system components associated with nonroad and stationary spark-ignition engines, including portable fuel containers.	Evap (where separate certification is required)	$397

(c) We will calculate adjusted fees for 2021 and later years based on changes in the Consumer Price Index and the number of certificates. We will announce adjusted fees for a given year by March 31 of the preceding year.

(1) We will adjust the values specified in paragraph (b) of this section for years after 2020 as follows:

(i) Use the following equation for certification related to evaporative emissions from nonroad and stationary engines when a separate fee applies for certification to evaporative emission standards:

$$\text{Certificate Fee}_{CY} = \left[\left(Op + L \cdot \frac{CPI_{CY\text{-}2}}{CPI_{2006}}\right)\right] \cdot \frac{OH}{\left[\left(cert\#_{MY\text{-}2} + cert\#_{MY\text{-}3}\right) \cdot 0.5\right]}$$

Where:

Certificate FeeCY = Fee per certificate for a given year.

Op = operating costs are all of EPA's nonlabor costs for each category's compliance program, including any fixed costs associated with EPA's testing laboratory, as described in paragraph (d)(1) of this section.

L = the labor costs, to be adjusted by the Consumer Price Index, as described in paragraph (d)(1) of this section.

CPICY-2 = the Consumer Price Index for the month of November two years before the applicable calendar year, as described in paragraph (d)(2) of this section.

CPI2006 = 201.8. This is based on the October 2006 value of the Consumer Price Index. as described in paragraph (d)(2) of this section

OH = 1.169. This is based on EPA overhead, which is applied to all costs.

cert#MY-2 = the total number of certificates issued for a fee category in the model year two years before the calendar year for the applicable fees as described in paragraph (d)(3) of this section.

cert#MY-3 = the total number of certificates issued for a fee category in the model year three years before the calendar year for the applicable fees as described in paragraph (d)(3) of this section.

(ii) Use the following equation for all other certificates:

$$\text{Certificate Fee}_{CY} = \left[\left(Op + L \cdot \frac{CPI_{CY\text{-}2}}{CPI_{2002}}\right)\right] \cdot \frac{OH}{\left[\left(cert\#_{MY\text{-}2} + cert\#_{MY\text{-}3}\right) \cdot 0.5\right]}$$

Where:

CPI2002 = 180.9. This is based on the December 2002 value of the Consumer Price Index as described in paragraph (d)(2) of this section.

(2) The fee for any year will remain at the previous year’s amount until the value calculated in paragraph (c)(1) of this section differs by at least $50 from the amount specified for the previous year.

(d) Except as specified in §1027.110(a) for motor vehicles and motor vehicle engines, we will use the following values to determine adjusted fees using the equation in paragraph (c) of this section:

(1) The following values apply for operating costs and labor costs:

Engine or Vehicle Category	Op	L
(i) Light-duty, medium-duty passenger, and complete heavy-duty highway vehicle certification	$3,322,039	$2,548,110
(ii) Light-duty, medium-duty passenger, and complete heavy-duty highway vehicle in-use testing	$2,858,223	$2,184,331
(iii) Independent Commercial Importers identified in §1027.105(b)(2)	$344,824	$264,980
(iv) Highway motorcycles	$225,726	$172,829
(v) Heavy-duty highway engines	$1,106,224	$1,625,680
(vi) Nonroad compression-ignition engines that are not locomotive or marine engines, and stationary compression-ignition engines with per-cylinder displacement below 10 liters	$486,401	$545,160
(vii) Evaporative certificates related to nonroad and stationary engines	$5,039	$236,670
(viii) All other	$177,425	$548,081

(2) The applicable Consumer Price Index is based on the values published by the Bureau of Labor Statistics for All Urban Consumers at https://www.usinflationcalculator.com/ under "Inflation and Prices" and "Consumer Price Index Data from 1913 to....". For example, we calculated the 2006 fees using the Consumer Price Index for November 2004, which is 191.0.
(3) Fee categories for counting the number of certificates issued are based on the grouping shown in paragraph (d)(1) of this section.

84. Amend §1027.110 by revising paragraph (a) introductory text to read as follows:
§1027.110 What special provisions apply for certification related to motor vehicles?
(a) We will adjust fees for light-duty, medium-duty passenger, and complete heavy-duty highway vehicles as follows:
* * * * *

85. Amend §1027.125 by revising paragraph (e) to read as follows:
§1027.125 Can I get a refund?
* * * * *
(e) Send refund and correction requests online at www.Pay.gov, or as specified in our guidance.
* * * * *

86. Amend §1027.130 by revising paragraphs (a) and (b) to read as follows:
§1027.130 How do I make a fee payment?
(a) Pay fees to the order of the Environmental Protection Agency in U.S. dollars using electronic funds transfer or any method available for payment online at www.Pay.gov, or as specified in EPA guidance.
(b) Submit a completed fee filing form at www.Pay.gov.
* * * * *

87. Amend §1027.135 by revising paragraph (b) to read as follows:
§1027.135 What provisions apply to a deficient filing?
* * * * *

(b) We will hold a deficient filing along with any payment until we receive a completed form and full payment. If the filing remains deficient at the end of the model year, we will continue to hold any funds associated with the filing so you can make a timely request for a refund. We will not process an application for certification if the associated filing is deficient.

88. Revise §1027.155 to read as follows:

§1027.155 What abbreviations apply to this subpart?

The following symbols, acronyms, and abbreviations apply to this part:

CFR	Code of Federal Regulations.
CPI	Consumer Price Index.
EPA	U.S. Environmental Protection Agency.
Evap	Evaporative emissions.
EIAPP	Engine International Air Pollution Prevention (from MARPOL Annex VI).
ICI	Independent Commercial Importer.
MVECP	Motor vehicle and engine compliance program.
MY	Model year.
U.S.	United States.

PART 1033—CONTROL OF EMISSIONS FROM LOCOMOTIVES

89. The authority citation for part 1033 continues to read as follows:

Authority: 42 U.S.C. 7401-7671q.

90. Amend §1033.150 by—

a. Removing and reserving paragraphs (a) and (d).

b. Revising paragraph (e) introductory text.

c. Removing and reserving paragraphs (h) through (j).

d. Removing paragraphs (l) and (m).

The revision reads as follows:

§1033.150 Interim provisions.

* * * * *

(e) *Producing switch locomotives using certified nonroad engines*. You may use the provisions of this paragraph (e) to produce any number of freshly manufactured or refurbished switch locomotives in model years 2008 through 2017. Locomotives produced under this paragraph (e) are exempt from the standards and requirements of this part subject to the following provisions:

* * * * *

~~92. Amend §1033.225 by revising paragraph (e) to read as follows:~~

~~§1033.225 Amending applications for certification.~~

~~* * * * *~~

~~(e) The amended application applies starting with the date you submit the amended application, as follows:~~

~~(1) For engine families already covered by a certificate of conformity, you may start producing a new or modified locomotive anytime after you send us your amended application, before we make a decision under paragraph (d) of this section. However, if we determine that the affected locomotives do not meet applicable requirements, we will notify you to cease production of the locomotives and may require you to recall the locomotives at no expense to the owner. Choosing to produce locomotives under this paragraph (e) is deemed to be consent to recall all locomotives that we determine do not meet applicable emission standards or other requirements and to remedy the nonconformity at no expense to the owner. If you do not provide information required under paragraph (c) of this section within 30 days after we request it, you must stop producing the new or modified locomotives.~~

~~(2) If you amend your application to make the amended application correct and complete, these changes do not apply retroactively. Also, if we determine that your amended application is not correct and complete, or otherwise does not conform to the regulation, we will notify you and describe how to address the error.~~

~~* * * * *~~

91. Revise §1033.255 to read as follows:

§1033.255 EPA decisions.

(a) If we determine an application is complete and shows that the engine family meets all the requirements of this part and the Clean Air Act, we will issue a certificate of conformity for the engine family for that model year. We may make the approval subject to additional conditions.

(b) We may deny an application for certification if we determine that an engine family fails to comply with emission standards or other requirements of this part or the Clean Air Act. We will base our decision on all available information. If we deny an application, we will explain why in writing.

(c) In addition, we may deny your application or suspend or revoke a certificate of conformity if you do any of the following:

(1) Refuse to comply with any testing or reporting requirements.

(2) Submit false or incomplete information. This includes doing anything after submitting an application that causes submitted information to be false or incomplete.

(3) Cause any test data to become inaccurate.

(4) Deny us from completing authorized activities (see 40 CFR 1068.20). This includes a failure to provide reasonable assistance.

(5) Produce locomotives for importation into the United States at a location where local law prohibits us from carrying out authorized activities.

(6) Fail to supply requested information or amend an application to include all locomotives being produced.

(7) Take any action that otherwise circumvents the intent of the Clean Air Act or this part~~, with respect to an engine family~~.

(d) We may void a certificate of conformity ~~for an engine family~~ if you fail to keep records, send reports, or give us information as required under this part or the Act. Note that these are also violations of 40 CFR 1068.101(a)(2).

(e) We may void a certificate of conformity ~~for an engine family~~ if we find that you intentionally submitted false or incomplete information. This includes doing anything after submitting an application that causes submitted information to be false or incomplete.

(f) If we deny an application or suspend, revoke, or void a certificate, you may ask for a hearing (see §1033.920).

92. Amend §1033.601 by revising paragraphs (c)(4) and (5) to read as follows:

§ 1033.601 General compliance provisions.

* * * * *

(c) * * *

(4) The provisions for importing engines and equipment under the identical configuration exemption of 40 CFR 1068.315(h) do not apply for locomotives.

(5) The provisions for importing engines and equipment under the ancient engine exemption of 40 CFR 1068.315(i) do not apply for locomotives.

* * * * *

93. Amend §1033.701 by revising paragraph (k)(1) to read as follows:

§ 1033.701 General provisions.

* * * * *

(k) * * *

(1) You may retire emission credits generated from any number of your locomotives. This may be considered donating emission credits to the environment. Identify any such credits in the reports described in § 1033.730. Locomotives must comply with the applicable FELs even if you donate or sell the corresponding emission credits under this paragraph (k). Those credits may no longer be used by anyone to demonstrate compliance with any EPA emission standards.

* * * * *

94. Amend §1033.740 by revising the introductory text and paragraph (a) to read as follows:

§1033.740 Credit restrictions.

Use of emission credits generated under this part 1033 is restricted depending on the standards against which they were generated.

(a) *Pre-2008 cCredits from 40 CFR part 92*. NOx and PM credits generated before model year 2008 under 40 CFR part 92 may be used under this part in the same manner as NOx and PM credits generated under this part.

* * * * *

95. Amend §1033.901 by revising paragraph (1) of the definition of "New" to read as follows:

§1033.901 Definitions.

* * * * *

New, * * *

(1) A locomotive or engine is new if its equitable or legal title has never been transferred to an ultimate purchaser. Where the equitable or legal title to a locomotive or engine is not transferred prior to its being placed into service, the locomotive or engine ceases to be new when it is placed into service. A locomotive or engine also becomes new if it is remanufactured or refurbished (as defined in this section). A remanufactured locomotive or engine ceases to be new when placed back into service. With respect to imported locomotives or locomotive engines, the term "new locomotive" or "new locomotive engine" also means a locomotive or locomotive engine that is not covered by a certificate of conformity under this part or 40 CFR part 92 at the time of importation, and that was manufactured or remanufactured after January 1, 2000, which would have been applicable to such locomotive or engine had it been manufactured or remanufactured for importation into the United States. Note that replacing an engine in one locomotive with an unremanufactured used engine from a different locomotive does not make a locomotive new.

* * * * *

96. Amend §1033.925 by revising paragraph (e) introductory text to read as follows:

§ 1033.925 Reporting and recordkeeping requirements.

* * * * *

(e) Under the Paperwork Reduction Act (44 U.S.C. 3501 *et seq.*), the Office of Management and Budget approves the reporting and recordkeeping specified in the applicable regulations. The following items illustrate the kind of reporting and recordkeeping we require for locomotives regulated under this part:

* * * * *

PART 1039—CONTROL OF EMISSIONS FROM NEW AND IN-USE NONROAD COMPRESSION-IGNITION ENGINES

179. The authority statement for part 1039 continues to read as follows:
Authority: 42 U.S.C. 7401-7671q.

180. Amend §1039.1 by revising paragraphs (b)(3) and (c) to read as follows:

§1039.1   Does this part apply for my engines?

* * * * *

(b) * * *

(3) Engines originally meeting Tier 1, Tier 2, or Tier 3 standards as specified in Appendix I of this part remain subject to those standards. This includes uncertified engines that meet standards under 40 CFR 1068.265. Affected engines remain subject to recall provisions as specified in 40 CFR part 1068, subpart F, throughout the useful life corresponding to the original certification. Also, tampering and defeat-device prohibitions continue to apply for those engines as specified in 40 CFR 1068.101.

* * * * *

(c) The definition of nonroad engine in 40 CFR 1068.30 excludes certain engines used in stationary applications. These engines may be required by 40 CFR part 60, subpart IIII, to comply with some of the provisions of this part 1039; otherwise, these engines are only required to comply with the requirements in §1039.20. In addition, the prohibitions in 40 CFR 1068.101 restrict the use of stationary engines for nonstationary purposes unless they are certified to the same standards that would apply to certain nonroad engines for the same model year.

* * * * *

181. Amend §1039.20 by revising paragraph (a) introductory text, paragraphs (b)(2), (4), and (c) to read as follows:

§1039.20   What requirements from this part apply to excluded stationary engines?

* * * * *

(a) You must add a permanent label or tag to each new engine you produce or import that is excluded under §1039.1(c) as a stationary engine and is not required by 40 CFR part 60, subpart IIII, to meet the requirements described in this part 1039, or the requirements described in 40 CFR part 1042, that are equivalent to the requirements applicable to marine or land-based nonroad engines for the same model year. To meet labeling requirements, you must do the following things:

* * * * *

(b) * * *

(2) Include your full corporate name and trademark.

* * * * *

(4) State: “THIS ENGINE IS EXEMPTED FROM NONROAD CERTIFICATION REQUIREMENTS AS A “STATIONARY ENGINE.” INSTALLING OR USING THIS ENGINE IN ANY OTHER APPLICATION MAY BE A VIOLATION OF FEDERAL LAW SUBJECT TO CIVIL PENALTY.”

(c) Stationary engines required by 40 CFR part 60, subpart IIII, to meet the requirements described in this part 1039 or 40 CFR part 1042, must meet the labeling requirements of 40 CFR 60.4210.

182. Amend §1039.101 by revising the introductory text and paragraph (b) to read as follows:

§1039.101 What exhaust emission standards must my engines meet after the 2014 model year?

The exhaust emission standards of this section apply after the 2014 model year. Certain of these standards also apply for model year 2014 and earlier. This section presents the full set of emission standards that apply after all the transition and phase-in provisions of §1039.102 and §1039.104 expire. Section 1039.105 specifies smoke standards.

*   *   *   *   *

(b) *Emission standards for steady-state testing*. Steady-state exhaust emissions from your engines may not exceed the applicable emission standards in Table 1 of this section. Measure emissions using the applicable steady-state test procedures described in subpart F of this part.

Table 1 of §1039.101—Tier 4 Exhaust Emission Standards After the 2014 Model Year, g/kW-hr[~~1~~a]

Maximum Engine Power	Application	PM	NOx	NMHC	NOx+NMHC	CO
kW < 19	All	0.40[~~2~~b]	-	-	7.5	6.6[~~3~~c]
19 ≤ kW < 56	All	0.03	-	-	4.7	5.0[~~4~~d]
56 ≤ kW < 130	All	0.02	0.40	0.19	-	5.0
130 ≤ kW ≤560	All	0.02	0.40	0.19	-	3.5
kW > 560	Generator sets	0.03	0.67	0.19	-	3.5
kW > 560	All except generator sets	0.04	3.5	0.19	-	3.5

[a~~1~~]Note that some of these standards also apply for 2014 and earlier model years. This table presents the full set of emission standards that apply after all the transition and phase-in provisions of §1039.102 expire.

[b~~2~~]See paragraph (c) of this section for provisions related to an optional PM standard for certain engines below 8 kW.

[c~~3~~]The CO standard is 8.0 g/kW-hr for engines below 8 kW.

[d~~4~~]The CO standard is 5.5 g/kW-hr for engines below 37 kW.

*   *   *   *   *

183. Amend §1039.102 by:

a. Revising the introductory text and paragraph (a)(2);

b. Revising Tables 1, 3, and 6 in paragraph (b); and

c. Revising paragraphs (d)(1), (e)(3), (g)(1)(iv), and (g)(2).

The revisions read as follows:

§1039.102 What exhaust emission standards and phase-in allowances apply for my engines in model year 2014 and earlier?

The exhaust emission standards of this section apply for 2014 and earlier model years. See §1039.101 for exhaust emission standards that apply to later model years.

(a) *   *   *

(2) The transient standards in this section for gaseous pollutants do not apply to phase-out engines that you certify to the same numerical standards (and FELs if the engines are certified using ABT) for gaseous pollutants as you certified under the Tier 3 requirements identified in Appendix I of this part. However, except as specified by paragraph (a)(1) of this section, the transient PM emission standards apply to these engines.

(b) *   *   *

Table 1 of §1039.102—Tier 4 Exhaust Emission Standards (g/kW-hr): kW <19

Maximum engine power	Model years	PM	NOx + NMHC	CO
kW <8	2008-2014	0.40~~[1]~~[a]	7.5	8.0
8 ≤kW <19	2008-2014	0.40	7.5	6.6

[a]~~[1]~~For engines that qualify for the special provisions in §1039.101(c), you may delay certifying to the standards in this part 1039 until 2010. In 2009 and earlier model years, these engines must instead meet the applicable Tier 2 standards and other requirements identified in Appendix I of this part. Starting in 2010, these engines must meet a PM standard of 0.60 g/kW-hr, as described in §1039.101(c). Engines certified to the 0.60 g/kWhr PM standard may not generate ABT credits.

* * * * *

Table 3 of §1039.102—Interim Tier 4 Exhaust Emission Standards (g/kW-hr): 37 ≤kW <56

Option~~[1]~~[a]	Model years	PM	NOx + NMHC	CO
#1	2008-2012	0.30	4.7	5.0
#2	2012	0.03	4.7	5.0
All	2013-2014	0.03	4.7	5.0

[a]~~[1]~~You may certify engines to the Option #1 or Option #2 standards starting in the listed model year. Under Option #1, all engines at or above 37 kW and below 56 kW produced before the 2013 model year must meet the applicable Option #1 standards in this table. These engines are considered to be “Option #1 engines.” Under Option #2, all these engines produced before the 2012 model year must meet the applicable standards identified in Appendix I of this part. Engines certified to the Option #2 standards in model year 2012 are considered “Option #2 engines.”

* * * * *

Table 6 of §1039.102—Interim Tier 4 Exhaust Emission Standards (g/kW-hr): 130 < kW < 560

Model years	Phase-in Option	PM	NOx	NMHC	NOx+NMHC	CO
2011-2013	Phase-in	0.02	0.40	0.19	-	3.5
	Phase-out	0.02	-	-	4.0	3.5
2014	All engines	0.02	0.40	0.19	-	3.5

* * * * *

(d) * * *

(1) For model years 2012 through 2014, you may use banked NOx + NMHC credits from any Tier 2 engine at or above 37 kW certified under the standards identified in Appendix I of this part to meet the NOx phase-in standards or the NOx + NMHC phase-out standards under paragraphs (b) and (c) of this section, subject to the additional ABT provisions in §1039.740.

* * * * *

(e) * * *

(3) You use NOx + NMHC emission credits to certify an engine family to the alternate NOx + NMHC standards in this paragraph (e)(3) instead of the otherwise applicable alternate NOx and NMHC standards. Calculate the alternate NOx + NMHC standard by adding 0.1 g/kW-hr to the numerical value of the applicable alternate NOx standard of paragraph (e)(1) or (2) of this section. Engines certified to the NOx + NMHC standards of this paragraph (e)(3) may not generate emission credits. The FEL caps for engine families certified under this paragraph (e)(3) are the previously applicable NOx + NMHC standards identified in Appendix I of this part (generally the Tier 3 standards).

* * * * *

(g) * * *

(1) * * *

(iv) Gaseous pollutants for phase-out engines that you certify to the same numerical standards and FELs for gaseous pollutants to which you certified under the Tier 3 requirements identified in Appendix I of this part. However, the NTE standards for PM apply to these engines.

(2) *Interim FEL caps*. As described in §1039.101(d), you may participate in the ABT program in subpart H of this part by certifying engines to FELs for PM, NOx, or NOx + NMHC instead of the standards in Tables 1 through 7 of this section for the model years shown. The FEL caps listed in the following table apply instead of the FEL caps in §1039.101(d)(1), except as allowed by §1039.104(g):

Table 8 of §1039.102—Interim Tier 4 FEL Caps, g/kW-hr

Maximum engine power	**Phase-in option**	**Model years**[~~1~~][a]	**PM**	**NOx**	**NOx + NMHC**
kW <19	—	2008-2014	0.80	—	~~2~~9.5[b]
19 ≤ kW < 37	—	2008-2012	0.60	—	9.5
37 ≤ kW < 56	—	~~3~~2008-2012[c]	0.40	—	7.5
56 ≤ kW < 130	phase-in	2012-2013	0.04	0.80	—
56 ≤ kW <130	phase-out	2012-2013	0.04	—	~~4~~6.6[d]
130 ≤ kW ≤ 560	phase-in	2011-2013	0.04	0.80	—
130 ≤ kW ≤ 560	phase-out	2011-2013	0.04	—	~~5~~6.4[e]
kW > 560	—	2011-2014	0.20	6.2	—

[a][~~1~~]For model years before 2015 where this table does not specify FEL caps, apply the FEL caps shown in §1039.101.

[b][~~2~~]For engines below 8 kW, the FEL cap is 10.5 g/kW-hr for NOx + NMHC emissions.

[c][~~3~~]For manufacturers certifying engines to the standards of this part 1039 in 2012 under Option #2 of Table 3 of §1039.102, the FEL caps for 37-56 kW engines in the 19-56 kW category of Table 2 of §1039.101 apply for model year 2012 and later; see Appendix I of this part for provisions that apply to earlier model years.

[d][~~4~~]For engines below 75 kW, the FEL cap is 7.5 g/kW-hr for NOx + NMHC emissions.

[e][~~5~~]For engines below 225 kW, the FEL cap is 6.6 g/kW-hr for NOx + NMHC emissions.

184. Amend §1039.104 by revising paragraphs (c)(1), (c)(2)(ii), (c)(4), and (g)(4) to read as follows:

§1039.104 Are there interim provisions that apply only for a limited time?

* * * * *

(c) * * *

(1) You may delay complying with certain otherwise applicable Tier 4 emission standards and requirements as described in the following table:

If your engine's maximum power is . . .	You may delay meeting . . .	Until model year . . .	Before that model year the engine must comply with . . .
kW <19	The standards and requirements of this part	2011	The standards and requirements described in Appendix I of this part.
19 ≤kW <37	The Tier 4 standards and requirements of this part that would otherwise be applicable in model year 2013	2016	The Tier 4 standards and requirements that apply for model year 2008.
37 ≤kW <56	See paragraph (c)(2) of this section for special provisions that apply for engines in this power category.		
56 ≤kW <130	The standards and requirements of this part	2015	The standards and requirements described in Appendix I of this part.

(2) * * *
(ii) If you do not choose to comply with paragraph (c)(2)(i) of this section, you may continue to comply with the standards and requirements described in Appendix I of this part for model years through 2012, but you must begin complying in 2013 with Tier 4 standards and requirements specified in Table 3 of §1039.102 for model years 2013 and later.
* * * * *
(4) For engines not in the 19-56 kW power category, if you delay compliance with any standards under this paragraph (c), you must do all the following things for the model years when you are delaying compliance with the otherwise applicable standards:
(i) Produce engines that meet all the emission standards identified in Appendix I of this part and other requirements applicable for that model year, except as noted in this paragraph (c).
(ii) Meet the labeling requirements that apply for certified engines but use the following alternative compliance statement: "THIS ENGINE COMPLIES WITH U.S. EPA REGULATIONS FOR [CURRENT MODEL YEAR] NONROAD COMPRESSION-IGNITION ENGINES UNDER 40 CFR 1039.104(c).".
* * * * *
(g) * * *
(4) Do not apply TCAFs to gaseous emissions for phase-out engines that you certify to the same numerical standards (and FELs if the engines are certified using ABT) for gaseous pollutants as you certified under the Tier 3 requirements identified in Appendix I of this part.

Table 1 of §1039.104—Alternate FEL Caps

Maximum engine power	PM FEL cap, g/kW-hr	Model years for the alternate PM FEL cap	NOx FEL cap, g/kW-hr~~[1]~~[a]	Model years for the alternate NOx FEL cap
19 ≤ kW < 56	0.30	~~[2]~~2012-2015[b]		
56 ≤ kW < 130~~[3]~~[c]	0.30	2012-2015	3.8	~~[4]~~2012-2015[d]
130 ≤ kW ≤ 560	0.20	2011-2014	3.8	~~[5]~~2011-2014[e]
kW > 560~~[6]~~[f]	0.10	2015-2018	3.5	2015-2018

a~~1~~The FEL cap for engines demonstrating compliance with a NOx + NMHC standard is equal to the previously applicable NOx + NMHC standard specified in Appendix I of this part (generally the Tier 3 standards).

b~~2~~For manufacturers certifying engines under Option #1 of Table 3 of §1039.102, these alternate FEL caps apply to all 19-56 kW engines for model years from 2013 through 2016 instead of the years indicated in this table. For manufacturers certifying engines under Option #2 of Table 3 of §1039.102, these alternate FEL caps do not apply to 19-37 kW engines except in model years 2013 to 2015.

c~~3~~For engines below 75 kW, the FEL caps are 0.40 g/kW-hr for PM emissions and 4.4 g/kW-hr for NOx emissions.

d~~4~~For manufacturers certifying engines in this power category using a percentage phase-in/phase-out approach instead of the alternate NOx standards of §1039.102(e)(1), the alternate NOx FEL cap in the table applies only in the 2014-2015 model years if certifying under §1039.102(d)(1), and only in the 2015 model year if certifying under §1039.102(d)(2).

e~~5~~For manufacturers certifying engines in this power category using the percentage phase-in/phase-out approach instead of the alternate NOx standard of §1039.102(e)(2), the alternate NOx FEL cap in the table applies only for the 2014 model year.

f~~6~~For engines above 560 kW, the provision for alternate NOx FEL caps is limited to generator-set engines.

* * * * *

185. Amend §1039.135 by revising paragraph (e) introductory text to read as follows:

§1039.135 How must I label and identify the engines I produce?

* * * * *

(e) For model year 2019 and earlier, create a separate label with the statement: “ULTRA LOW SULFUR FUEL ONLY”. Permanently attach this label to the equipment near the fuel inlet or, if you do not manufacture the equipment, take one of the following steps to ensure that the equipment will be properly labeled:

* * * * *

186. Amend §1039.205 by adding paragraph (c) to read as follows:

§1039.205 What must I include in my application?

* * * * *

(c) If your engines are equipped with an engine diagnostic system as required under §1039.110, explain how it works, describing especially the engine conditions (with the corresponding diagnostic trouble codes) that cause the warning lamp ~~malfunction-indicator light~~ to go on and the design features that minimize the potential for operation without reductant. Also identify the communication protocol (SAE J1939, SAE J1979, etc.)

* * * * *

~~176. Amend §1039.225 by revising paragraph (e) to read as follows:~~

~~§1039.225 How do I amend my application for certification?~~

* * * * *

~~(e) The amended application applies starting with the date you submit the amended application, as follows:~~
~~(1) For engine families already covered by a certificate of conformity, you may start producing a new or modified engine configuration anytime after you send us your amended application and before we make a decision under paragraph (d) of this section. However, if we determine that the affected engines do not meet applicable requirements, we will notify you to cease production of the engines and may require you to recall the engines at no expense to the owner. Choosing to produce engines under this paragraph (e) is deemed to be consent to recall all engines that we determine do not meet applicable emission standards or other requirements and to remedy the nonconformity at no expense to the owner. If you do not provide information required under paragraph (c) of this section within 30 days after we request it, you must stop producing the new or modified engines.~~
~~(2) If you amend your application to make the amended application correct and complete, these changes do not apply retroactively. Also, if we determine that your amended application is not correct and complete, or otherwise does not conform to the regulation, we will notify you and describe how to address the error.~~
* * * * *

187. Amend §1039.245 by revising paragraph (a) to read as follows:

§1039.245 How do I determine deterioration factors from exhaust durability testing?

* * * * *

(a) You may ask us to approve deterioration factors for an engine family with established technology based on engineering analysis instead of testing. Engines certified to a NOx + NMHC standard or FEL greater than the Tier 3 NOx + NMHC standard described in Appendix I of this part are considered to rely on established technology for gaseous emission control, except that this does not include any engines that use exhaust-gas recirculation or aftertreatment. In most cases, technologies used to meet the Tier 1 and Tier 2 emission standards would be considered to be established technology.

* * * * *

188. Revise §1039.255 to read as follows:

§1039.255 What decisions may EPA make regarding a certificate of conformity?

(a) If we determine an application is complete and shows that the engine family meets all the requirements of this part and the Act, we will issue a certificate of conformity for the engine family for that model year. We may make the approval subject to additional conditions.
(b) We may deny an application for certification if we determine that an engine family fails to comply with emission standards or other requirements of this part or the Clean Air Act. We will base our decision on all available information. If we deny an application, we will explain why in writing.
(c) In addition, we may deny your application or suspend or revoke a certificate of conformity if you do any of the following:

(1) Refuse to comply with any testing or reporting requirements.
(2) Submit false or incomplete information. This includes doing anything after submitting an application that causes submitted information to be false or incomplete.
(3) Cause any test data to become inaccurate.

(4) Deny us from completing authorized activities (see 40 CFR 1068.20). This includes a failure to provide reasonable assistance.

(5) Produce engines for importation into the United States at a location where local law prohibits us from carrying out authorized activities.

(6) Fail to supply requested information or amend an application to include all engines being produced.

(7) Take any action that otherwise circumvents the intent of the Act or this part~~, with respect to an engine family~~.

(d) We may void a certificate of conformity ~~for an engine family~~ if you fail to keep records, send reports, or give us information as required under this part or the Act. Note that these are also violations of 40 CFR 1068.101(a)(2).

(e) We may void a certificate of conformity ~~for an engine family~~ if we find that you intentionally submitted false or incomplete information. This includes doing anything after submitting an application that causes submitted information to be false or incomplete.

(f) If we deny an application or suspend, revoke, or void a certificate, you may ask for a hearing (see §1039.820).

189. Amend §1039.601 by revising paragraph (b) to read as follows:

§ 1039.601 What compliance provisions apply?

* * * * *

(b) Subpart C of this part describes how to test and certify dual-fuel and flexible-fuel engines. Some multi-fuel engines may not fit either of those defined terms. For such engines, we will determine whether it is most appropriate to treat them as single-fuel engines, dual-fuel engines, or flexible-fuel engines based on the range of possible and expected fuel mixtures. For example, an engine might burn natural gas but initiate combustion with a pilot injection of diesel fuel. If the engine is designed to operate with a single fueling algorithm (i.e., fueling rates are fixed at a given engine speed and load condition), we would generally treat it as a single-fuel engine. In this context, the combination of diesel fuel and natural gas would be its own fuel type. If the engine is designed to also operate on diesel fuel alone, we would generally treat it as a dual-fuel engine. If the engine is designed to operate on varying mixtures of the two fuels, we would generally treat it as a flexible-fuel engine. To the extent that requirements vary for the different fuels or fuel mixtures, we may apply the more stringent requirements.

190. Amend §1039.620 by revising paragraph (b) to read as follows:

§1039.620 What are the provisions for exempting engines used solely for competition?

* * * * *

(b) The definition of nonroad engine in 40 CFR 1068.30 excludes engines used solely for competition. These engines are not required to comply with this part 1039, but 40 CFR 1068.101 prohibits the use of competition engines for noncompetition purposes.

* * * * *

191. Amend §1039.625 by revising the introductory text, paragraph (d)(4) introductory text, paragraphs (e)(1), (e)(3), and (g)(1)(vi), paragraph (j) introductory text, and paragraph (j)(1) to read as follows:

§1039.625 What requirements apply under the program for equipment-manufacturer flexibility?

The provisions of this section allow equipment manufacturers to produce equipment with engines that are subject to less stringent emission standards after the Tier 4 emission standards begin to apply. To be eligible to use these provisions, you must follow all the instructions in this section. See §1039.626 for requirements that apply specifically to companies that manufacture equipment outside the United States and to companies that import such equipment without manufacturing it. Engines and equipment you produce under this section are exempt from the prohibitions in 40 CFR 1068.101(a)(1), subject to the provisions of this section.

* * * * *

(d) * * *

(4) You may start using the allowances under this section for engines that are not yet subject to Tier 4 standards, as long as the seven-year period for using allowances under the Tier 2 or Tier 3 program has expired. Table 3 of this section shows the years for which this applies. To use these early allowances, you must use engines that meet the emission standards described in paragraph (e) of this section. You must also count these units or calculate these percentages as described in paragraph (c) of this section and apply them toward the total number or percentage of equipment with exempted engines we allow for the Tier 4 standards as described in paragraph (b) of this section. The maximum number of cumulative early allowances under this paragraph (d)(4) is 10 percent under the percent-of-production allowance or 100 units under the small-volume allowance. For example, if you produce 5 percent of your equipment with engines between 130 and 560 kW that use allowances under this paragraph (d)(4) in 2009, you may use up to an additional 5 percent of your allowances in 2010. If you use allowances for 5 percent of your equipment in both 2009 and 2010, your 80 percent allowance for 2011-2017 in the 130-560 kW power category decreases to 70 percent. Manufacturers using allowances under this paragraph (d)(4) must comply with the notification and reporting requirements specified in paragraph (g) of this section.

* * * * *

(e) * * *

(1) If you are using the provisions of paragraph (d)(4) of this section, engines must meet the applicable Tier 1 or Tier 2 emission standards described in Appendix I of this part.

* * * * *

(3) In all other cases, engines at or above 56 kW and at or below 560 kW must meet the appropriate Tier 3 standards described in Appendix I of this part. Engines below 56 kW and engines above 560 kW must meet the appropriate Tier 2 standards described in Appendix I of this part.

* * * * *

(g) * * *

(1) * * *

(vi) The number of units in each power category you have sold in years for which the Tier 2 and Tier 3 standards apply.

* * * * *

(j) *Provisions for engine manufacturers*. As an engine manufacturer, you may produce exempted engines as needed under this section. You do not have to request this exemption for your engines, but you must have written assurance from equipment manufacturers that they need a certain number of exempted engines under this section. Send us an annual report of the engines you produce under this section, as described in §1039.250(a). Exempt engines must meet the emission standards in paragraph (e) of this section and you must meet all the requirements of 40

CFR 1068.265, except that engines produced under the provisions of paragraph (a)(2) of this section must be identical in all material respects to engines previously certified under this part 1039. If you show under 40 CFR 1068.265(c) that the engines are identical in all material respects to engines that you have previously certified to one or more FELs above the standards specified in paragraph (e) of this section, you must supply sufficient credits for these engines. Calculate these credits under subpart H of this part using the previously certified FELs and the alternate standards. You must meet the labeling requirements in §1039.135, as applicable, with the following exceptions:

(1) Add the following statement instead of the compliance statement in §1039.135(c)(12):

THIS ENGINE MEETS U.S. EPA EMISSION STANDARDS UNDER 40 CFR 1039.625. SELLING OR INSTALLING THIS ENGINE FOR ANY PURPOSE OTHER THAN FOR THE EQUIPMENT FLEXIBILITY PROVISIONS OF 40 CFR 1039.625 MAY BE A VIOLATION OF FEDERAL LAW SUBJECT TO CIVIL PENALTY.

* * * * *

192. Amend §1039.626 by revising paragraph (b)(1)(iv) to read as follows:

§1039.626 What special provisions apply to equipment imported under the equipment-manufacturer flexibility program?

* * * * *

(b) * * *

(1) * * *

(iv) The number of units in each power category you have imported in years for which the Tier 2 and Tier 3 standards apply.

* * * * *

193. Amend §1039.655 by revising paragraphs (a)(2) and (b) to read as follows:

§1039.655 What special provisions apply to engines sold in Guam, American Samoa, or the Commonwealth of the Northern Mariana Islands?

(a) * * *

(2) The engine meets the latest applicable emission standards in Appendix I of this part.

* * * * *

(b) If you introduce an engine into commerce in the United States under this section, you must meet the labeling requirements in §1039.135, but add the following statement instead of the compliance statement in §1039.135(c)(12):

THIS ENGINE DOES NOT COMPLY WITH U.S. EPA TIER 4 EMISSION REQUIREMENTS. IMPORTING THIS ENGINE INTO THE UNITED STATES OR ANY TERRITORY OF THE UNITED STATES EXCEPT GUAM, AMERICAN SAMOA, OR THE COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS MAY BE A VIOLATION OF FEDERAL LAW SUBJECT TO CIVIL PENALTY.

* * * * *

194. Amend §1039.740 by revising paragraph (b) to read as follows:

§1039.740 What restrictions apply for using emission credits?

* * * * *

(b) *Emission credits from earlier tiers of standards*. (1) For purposes of ABT under this subpart, you may not use emission credits generated from engines subject to emission standards identified in Appendix I of this part, except as specified in §1039.102(d)(1) or the following table:

If the maximum power of the credit-generating engine is . . .	**And it was certified to the following standards identified in Appendix I of this part . . .**	**Then you may use those banked credits for the following Tier 4 engines . . .**
(i) kW <19	Tier 2	kW <19
(ii) 19 ≤kW <37	Tier 2	kW ≥19
(iii) 37 ≤kW ≤560	Tier 3	kW ≥19
(iv) kW >560	Tier 2	kW ≥19

(2) Emission credits generated from marine engines certified to the standards identified in Appendix I of this part for land-based engines may not be used under this part.
* * * * *

195. Amend §1039.801 by:
a. Revising the definition for “Low-hour”;
b. Revising paragraph (5)(ii) for the definition of “Model year”; and
c. Revising the definitions for “Small-volume engine manufacturer”, “Tier 1”, “Tier 2”, and “Tier 3”.
The revisions read as follows.

§1039.801 What definitions apply to this part?

* * * * *

Low-hour means relating to an engine with stabilized emissions and represents the undeteriorated emission level. This would generally involve less than 300 hours of operation for engines with NOx aftertreatment and 125 hours of operation for other engines~~ at or below 560 kW and less than 300 hours of operation for engines above 560 kW~~.

* * * * *

Model year means one of the following things:

* * * * *

(5) * * *

(ii) For imported engines described in paragraph (5)(ii) of the definition of “new nonroad engine,” model year means the calendar year in which the engine is modified.

* * * * *

Small-volume engine manufacturer means an engine manufacturer with 1,000 or fewer employees that has had annual U.S.-directed production volume of no more than 2,500 units. For manufacturers owned by a parent company, these limits apply to the total number of employees and production volume from the parent company and all its subsidiaries.

* * * * *

Tier 1 means relating to the Tier 1 emission standards identified in Appendix I of this part.
Tier 2 means relating to the Tier 2 emission standards identified in Appendix I of this part.
Tier 3 means relating to the Tier 3 emission standards identified in Appendix I of this part.

* * * * *

196. Add Appendix I to part 1039 to read as follows:

Appendix I to Part 1039— Summary of Previous Emission Standards

The following standards, which EPA originally adopted under 40 CFR part 89, apply to nonroad compression-ignition engines produced before the model years specified in §1039.1:

(a) Tier 1 standards apply as summarized in the following table:

Table 1 to Appendix I—Tier 1 Emission Standards (g/kW-hr)

<table>
<tr><th>Rated Power (kW)</th><th>Starting Model Year</th><th>NOx</th><th>HC</th><th>NOx+NMHC</th><th>CO</th><th>PM</th></tr>
<tr><td>kW< 8</td><td>2000</td><td>—</td><td>—</td><td>10.5</td><td>8.0</td><td>1.0</td></tr>
<tr><td>8 ≤ kW < 19</td><td>2000</td><td>—</td><td>—</td><td>9.5</td><td>6.6</td><td>0.80</td></tr>
<tr><td>19 ≤ kW < 37</td><td>1999</td><td>—</td><td>—</td><td>9.5</td><td>5.5</td><td>0.80</td></tr>
<tr><td>37 ≤ kW < 75</td><td>1998</td><td rowspan="2">9.2</td><td rowspan="2">—</td><td rowspan="2">—</td><td rowspan="2">—</td><td rowspan="2">—</td></tr>
<tr><td>75 ≤ kW < 130</td><td>1997</td></tr>
<tr><td>130 ≤ kW ≤ 560</td><td>1996</td><td rowspan="2">9.2</td><td rowspan="2">1.3</td><td rowspan="2">—</td><td rowspan="2">11.4</td><td rowspan="2">0.54</td></tr>
<tr><td>kW > 560</td><td>2000</td></tr>
</table>

(b) Tier 2 standards apply as summarized in the following table:

Table 2 to Appendix I—Tier 2 Emission Standards (g/kW-hr)

<table>
<tr><th>Rated Power (kW)</th><th>Starting Model Year</th><th>NOx+NMHC</th><th>CO</th><th>PM</th></tr>
<tr><td>kW< 8</td><td>2005</td><td>7.5</td><td>8.0</td><td>0.80</td></tr>
<tr><td>8 ≤ kW < 19</td><td>2005</td><td>7.5</td><td>6.6</td><td>0.80</td></tr>
<tr><td>19 ≤ kW < 37</td><td>2004</td><td>7.5</td><td>5.5</td><td>0.60</td></tr>
<tr><td>37 ≤ kW < 75</td><td>2004</td><td>7.5</td><td>5.0</td><td>0.40</td></tr>
<tr><td>75 ≤ kW < 130</td><td>2003</td><td>6.6</td><td>5.0</td><td>0.30</td></tr>
<tr><td>130 ≤ kW < 225</td><td>2003</td><td>6.6</td><td>3.5</td><td>0.20</td></tr>
<tr><td>225 ≤ kW < 450</td><td>2001</td><td rowspan="3">6.4</td><td rowspan="3">3.5</td><td rowspan="3">0.20</td></tr>
<tr><td>450 ≤ kW ≤ 560</td><td>2002</td></tr>
<tr><td>kW > 560</td><td>2006</td></tr>
</table>

(c) Tier 3 standards apply as summarized in the following table:

Table 3 to Appendix I—Tier 3 Emission Standards (g/kW-hr)

Rated Power (kW)	Starting Model Year	NOx+NMHC	CO	PM
37 ≤ kW < 75	2008	4.7	5.0	0.40
75 ≤ kW < 130	2007	4.0	5.0	0.30
130 ≤ kW ≤ 560	2006	4.0	3.5	0.20

(d) Tier 1 through Tier 3 standards applied only for discrete-mode steady-state testing. There were no not-to-exceed standards or transient testing.

PART 1042—CONTROL OF EMISSIONS FROM NEW AND IN-USE MARINE COMPRESSION-IGNITION ENGINES AND VESSELS

197. The authority statement for part 1042 continues to read as follows:

Authority: 42 U.S.C. 7401-7671q.

198. Amend §1042.1 by:

a. Revising paragraphs (b) and (c); and

b. Removing and reserving paragraph (d).

The revisions read as follows:

§1042.1 Applicability.

* * * * *

(b) New engines with maximum engine power below 37 kW and originally manufactured and certified before the model years identified in Table 1 to this section are subject to emission standards as specified in Appendix I of this part. The provisions of this part 1042 do not apply for such engines, except as follows beginning June 29, 2010:

(1) The allowances of this part apply.

(2) The definitions of “new marine engine” and “model year” apply.

(c) Marine engines originally meeting Tier 1 or Tier 2 standards as specified in Appendix I of this part remain subject to those standards. This includes uncertified engines that meet standards under 40 CFR 1068.265. Those engines remain subject to recall provisions as specified in 40 CFR part 1068, subpart F, throughout the useful life corresponding to the original certification. Also, tampering and defeat-device prohibitions continue to apply for those engines as specified in 40 CFR 1068.101. The remanufacturing provisions in subpart I of this part may apply for remanufactured engines originally manufactured in model years before the model years identified in Table 1 to this section.

* * * * *

199. Amend §1042.101 by revising paragraphs (a)(6), (c)(2), and (e)(2) to read as follows:

§1042.101 Exhaust emission standards for Category 1 and Category 2 engines.

(a) * * *

(6) Interim Tier 4 PM standards apply for 2014 and 2015 model year engines between 2000 and 3700 kW as specified in this paragraph (a)(6). These engines are considered Tier 4 engines.

(i) For Category 1 engines, the Tier 3 PM standards from Table 1 to this section continue to apply. PM FELs for these engines may not be higher than the applicable Tier 2 PM standards specified in Appendix I of this part.

(ii) For Category 2 engines with per-cylinder displacement below 15.0 liters, the Tier 3 PM standards from Table 2 to this section continue to apply. PM FELs for these engines may not be higher than 0.27 g/kW-hr.

(iii) For Category 2 engines with per-cylinder displacement at or above 15.0 liters, the PM standard is 0.34 g/kW-hr for engines at or above 2000 kW and below 3300 kW, and 0.27 g/kW-hr for engines at or above 3300 kW and below 3700 kW. PM FELs for these engines may not be higher than 0.50 g/kW-hr.

* * * * *

(c) * * *

(2) Determine the applicable NTE zone and subzones as described in §1042.515. Determine NTE multipliers for specific zones and subzones and pollutants as follows:

(i) For marine engines certified using the duty cycle specified in §1042.505(b)(1), except for variable-speed propulsion marine engines used with controllable-pitch propellers or with electrically coupled propellers, apply the following NTE multipliers:

(A) Subzone 1: 1.2 for Tier 3 NOx+HC standards.

(B) Subzone 1: 1.5 for Tier 4 standards and Tier 3 PM and CO standards.

(C) Subzone 2: 1.5 for Tier 4 NOx and HC standards and for Tier 3 NOx+HC standards.

(D) Subzone 2: 1.9 for PM and CO standards.

(ii) For recreational marine engines certified using the duty cycle specified in §1042.505(b)(2), except for variable-speed marine engines used with controllable-pitch propellers or with electrically coupled propellers, apply the following NTE multipliers:

(A) Subzone 1: 1.2 for Tier 3 NOx+HC standards.

(B) Subzone 1: 1.5 for Tier 3 PM and CO standards.

(C) Subzones 2 and 3: 1.5 for Tier 3 NOx+HC standards.

(D) Subzones 2 and 3: 1.9 for PM and CO standards.

(iii) For variable-speed marine engines used with controllable-pitch propellers or with electrically coupled propellers that are certified using the duty cycle specified in §1042.505(b)(1), (2), or (3), apply the following NTE multipliers:

(A) Subzone 1: 1.2 for Tier 3 NOx+HC standards.

(B) Subzone 1: 1.5 for Tier 4 standards and Tier 3 PM and CO standards.

(C) Subzone 2: 1.5 for Tier 4 NOx and HC standards and for Tier 3 NOx+HC standards.

(D) Subzone 2: 1.9 for PM and CO standards. However, there is no NTE standard in Subzone 2b for PM emissions if the engine family's applicable standard for PM is at or above 0.07 g/kW-hr.

(iv) For constant-speed engines certified using a duty cycle specified in §1042.505(b)(3) or (4), apply the following NTE multipliers:

(A) Subzone 1: 1.2 for Tier 3 NOx+HC standards.

(B) Subzone 1: 1.5 for Tier 4 standards and Tier 3 PM and CO standards.

(C) Subzone 2: 1.5 for Tier 4 NOx and HC standards and for Tier 3 NOx+HC standards.

(D) Subzone 2: 1.9 for PM and CO standards. However, there is no NTE standard for PM emissions if the engine family's applicable standard for PM is at or above 0.07 g/kW-hr.

(v) For variable-speed auxiliary marine engines certified using the duty cycle specified in §1042.505(b)(5)(ii) or (iii):

(A) Subzone 1: 1.2 for Tier 3 NOx+HC standards.

(B) Subzone 1: 1.5 for Tier 4 standards and Tier 3 PM and CO standards.

(C) Subzone 2: 1.2 for Tier 3 NOx+HC standards.

(D) Subzone 2: 1.5 for Tier 4 standards and Tier 3 PM and CO standards. However, there is no NTE standard for PM emissions if the engine family's applicable standard for PM is at or above 0.07 g/kW-hr.

*   *   *   *   *

(e) *   *   *

(2) Specify a longer useful life in hours for an engine family under either of two conditions:

(i) If you design your engine to operate longer than the minimum useful life. Indicators of design life include your recommended overhaul interval and may also include your advertising and marketing materials.

(ii) If your basic mechanical warranty is longer than the minimum useful life.

*   *   *   *   *

200. Amend §1042.104 by revising paragraphs (a)(2) and (c) to read as follows:

§1042.104 Exhaust emission standards for Category 3 engines.

(a) * * *

(2) NOx standards apply based on the engine's model year and maximum in-use engine speed as shown in the following table:

Table 1 to §1042.104—NOx Emission Standards for Category 3 Engines (g/kW-hr)

Emission standards	Model year	Maximum in-use engine speed		
		Less than 130 RPM	**130-2000 RPM[a]**	**Over 2000 RPM**
Tier 1	2004-2010	17.0	$45.0 \cdot n^{(-0.20)}$	9.8
Tier 2	2011-2015	14.4	$44.0 \cdot n^{(-0.23)}$	7.7
Tier 3[b]	2016 and later	3.4	$9.0 \cdot n^{(-0.20)}$	2.0

[a]Applicable standards are calculated from n (maximum in-use engine speed, in RPM, as specified in §1042.140). Round the standards to one decimal place.

[be]For engines designed with on-off controls as specified in §1042.115(g), the Tier 2 standards continue to apply any time the engine has disabled its Tier 3 NOx emission controls.

* * * * *

(c) *Mode caps*. Measured NOx emissions from Tier 3 engines may not exceed the cap specified in this paragraph (c) for any applicable duty-cycle test modes with power greater than 10 percent maximum engine power. Calculate the mode cap by multiplying the applicable Tier 3 NOx standard by 1.5 and rounding to the nearest 0.1 g/kW-hr. Note that mode caps do not apply for pollutants other than NOx and do not apply for any modes of operation outside of the applicable duty cycles in §1042.505. Category 3 engines are not subject to not-to-exceed standards.

* * * * *

201. Amend §1042.115 by revising paragraph (g) to read as follows:

§1042.115 Other requirements.

* * * * *

(g) *On-off controls for engines on Category 3 vessels*. Manufacturers may equip Category 3 propulsion engines with features that disable Tier 3 NOx emission controls subject to the provisions of this paragraph (g). For auxiliary engines allowed to use on-off controls as specified in §1042.650(d), read "Tier 2" to mean "IMO Tier II" and read "Tier 3" to mean "IMO Tier III".

(1) Features that disable Tier 3 NOx emission controls are considered to be AECDs whether or not they meet the definition of an AECD. For example, manually operated on-off features are AECDs under this paragraph (g). The features must be identified in your application for certification as AECDs. For purposes of this paragraph (g), the term "features that disable Tier 3 emission controls" includes (but is not limited to) any combination of the following that cause the engine's emissions to exceed any Tier 3 emission standard:

(i) Bypassing of exhaust aftertreatment.

(ii) Reducing or eliminating flow of reductant to an SCR system.

(iii) Modulating engine calibration in a manner that increases engine-out emissions of a regulated pollutant.

(2) You must demonstrate that the AECD will not disable NOx emission controls while operating shoreward of the boundaries of the North American ECA and the U.S. Caribbean Sea ECA. You must demonstrate that the AECD will not disable emission control while

operating in these waters. (Note: See the regulations in 40 CFR part 1043 for requirements related to operation in ECAs, including foreign ECAs.) Compliance with this paragraph will generally require that the AECD operation be based on Global Positioning System (GPS) inputs. We may consider any relevant information to determine whether your AECD conforms to this paragraph (g).

(3) The onboard computer log must record in nonvolatile computer memory all incidents of engine operation with the Tier 3 NOx emission controls disabled.

(4) The engine must comply with the Tier 2 NOx standard when the Tier 3 NOx emission controls are disabled.

202. Amend §1042.125 by revising paragraph (e) to read as follows:

§1042.125 Maintenance instructions.

* * * * *

(e) *Maintenance that is not emission-related*. For maintenance unrelated to emission controls, you may schedule any amount of inspection or maintenance. You may also take these inspection or maintenance steps during service accumulation on your emission-data engines, as long as they are reasonable and technologically necessary. This might include adding engine oil, changing air, fuel, or oil filters, servicing engine-cooling systems or fuel-water separator cartridges or elements, and adjusting idle speed, governor, engine bolt torque, valve lash, or injector lash. You may not perform this nonemission-related maintenance on emission-data engines more often than the least frequent intervals that you recommend to the ultimate purchaser.

* * * * *

203. Amend §1042.135 by revising paragraph (c)(13) to read as follows:

§1042.135 Labeling.

* * * * *

(c) * * *

(13) For engines above 130 kW that are intended for installation on domestic or public vessels, include the following statement: “THIS ENGINE DOES NOT COMPLY WITH INTERNATIONAL MARINE REGULATIONS UNLESS IT IS ALSO COVERED BY AN EIAPP CERTIFICATE.”

* * * * *

204. Amend §1042.145 by removing and reserving paragraphs (b), (c), (e), (h), and (i) and revising paragraph (j) to read as follows:

§1042.145 Interim provisions.

* * * * *

(j) *Installing land-based engines in marine vessels.* Vessel manufacturers and marine equipment manufacturers may apply the provisions of §§ 1042.605 and 1042.610 to land-based engines with maximum engine power at or above 37 kW and at or below 560 kW if they meet the Tier 3 emission standards in Appendix I of 40 CFR part 1039 as specified in 40 CFR 1068.265. All the provisions of § 1042.605 or §1042.610 apply as if those engines were certified to emission standards under 40 CFR part 1039. Similarly, engine manufacturers, vessel manufacturers, and marine equipment manufacturers must comply with all the provisions of 40 CFR part 1039 as if those engines were installed in land-based equipment. The following provisions apply for engine manufacturers shipping engines to vessel manufacturers or marine equipment manufacturers under this paragraph (j):

(1) You must label the engine as described in 40 CFR 1039.135, but identify the engine family name as it was last certified under 40 CFR part 1039 and include the following alternate compliance statement: "THIS ENGINE MEETS THE TIER 3 STANDARDS FOR LAND-BASED NONROAD DIESEL ENGINES UNDER 40 CFR PART 1039. THIS ENGINE MAY BE USED ONLY IN A MARINE VESSEL UNDER THE DRESSING PROVISIONS OF 40 CFR 1042.605 OR 40 CFR 1042.610."

(2) You must use the provisions of 40 CFR 1068.262 for shipping uncertified engines under this section to secondary engine manufacturers.

* * * * *

~~195. Amend §1042.225 by revising paragraph (e) to read as follows:~~

~~§1042.225 Amending applications for certification.~~

~~* * * * *~~

~~(e) The amended application applies starting with the date you submit the amended application, as follows:~~

~~(1) For engine families already covered by a certificate of conformity, you may start producing the new or modified engine configuration anytime after you send us your amended application and before we make a decision under paragraph (d) of this section. However, i f we determine that the affected engines do not meet applicable requirements, we will notify you to cease production of the engines and may require you to recall the engines at no expense to the owner. Choosing to produce engines under this paragraph (e) is deemed to be consent to recall all engines that we determine do not meet applicable emission standards or other requirements and to remedy the nonconformity at no expense to the owner. If you do not provide information required under paragraph (c) of this section within 30 days after we request it, you must stop producing the new or modified engines.~~

~~(2) If you amend your application to make the amended application correct and complete, these changes do not apply retroactively. Also, if we determine that your amended application is not correct and complete, or otherwise does not conform to the regulation, we will notify you and describe how to address the error.~~

~~* * * * *~~

205. Amend §1042.235 by revising paragraph (d)(3) to read as follows:

§1042.235 Emission testing related to certification.

* * * * *

(d) * * *

(3) The data show that the emission-data engine would meet all the requirements that apply to the engine family covered by the application for certification. For engines originally tested to demonstrate compliance with Tier 1 or Tier 2 standards, you may consider those test procedures to be equivalent to the procedures we specify in subpart F of this part.

* * * * *

206. Revise §1042.255 to read as follows:

§1042.255 EPA decisions.

(a) If we determine an application is complete and shows that the engine family meets all the requirements of this part and the Clean Air Act, we will issue a certificate of conformity for the engine family for that model year. We may make the approval subject to additional conditions.
(b) We may deny an application for certification if we determine that an engine family fails to comply with emission standards or other requirements of this part or the Clean Air Act. We will base our decision on all available information. If we deny an application, we will explain why in writing.
(c) In addition, we may deny your application or suspend or revoke a certificate of conformity if you do any of the following:

(1) Refuse to comply with any testing or reporting requirements.

(2) Submit false or incomplete information. This includes doing anything after submitting an application that causes submitted information to be false or incomplete.

(3) Cause any test data to become inaccurate.

(4) Deny us from completing authorized activities (see 40 CFR 1068.20). This includes a failure to provide reasonable assistance.

(5) Produce engines for importation into the United States at a location where local law prohibits us from carrying out authorized activities.

(6) Fail to supply requested information or amend an application to include all engines being produced.

(7) Take any action that otherwise circumvents the intent of the Clean Air Act or this part~~, with respect to an engine family~~.

(d) We may void a certificate of conformity ~~for an engine family~~ if you fail to keep records, send reports, or give us information as required under this part or the Clean Air Act. Note that these are also violations of 40 CFR 1068.101(a)(2).
(e) We may void a certificate of conformity ~~for an engine family~~ if we find that you intentionally submitted false or incomplete information. This includes doing anything after submitting an application that causes submitted information to be false or incomplete after submission.
(f) If we deny an application or suspend, revoke, or void a certificate, you may ask for a hearing (see §1042.920).

207. Amend §1042.302 by revising paragraph (a) to read as follows:

§1042.302 Applicability of this subpart for Category 3 engines.

* * * * *

(a) You must test each Category 3 engine at the sea trial of the vessel in which it is installed or within the first 300 hours of operation, whichever occurs first. This may involve testing a fully assembled production engine before it is installed in the vessel. For engines with on-off controls, you may omit testing to demonstrate compliance with Tier 2 standards if the engine does not rely on aftertreatment when Tier 3 emission controls are disabled. Since you must test each engine, the provisions of §§1042.310 and 1042.315(b) do not apply for Category 3 engines. If we determine that an engine failure under this subpart is caused by defective components or design deficiencies, we may revoke or suspend your certificate for the engine family as described in §1042.340. If we determine that an engine failure under this subpart is caused only by incorrect assembly, we may suspend your certificate for the engine family as described in §1042.325. If the engine fails, you may continue operating only to complete the sea trial and return to port. It is a violation of 40 CFR 1068.101(b)(1) to operate the vessel further until you remedy the cause of failure. Each two-hour period of such operation constitutes a separate offense. A violation lasting less than two hours constitutes a single offense.

* * * * *

208. Amend §1042.605 by revising paragraphs (a), (b), (c), (d)(1)(ii), (d)(2), (d)(3)(ii), (f), and (h) to read as follows:

§1042.605 Dressing engines already certified to other standards for nonroad or heavy-duty highway engines for marine use.

(a) *General provisions*. If you are an engine manufacturer (including someone who marinizes a land-based engine), this section allows you to introduce new marine engines into U.S. commerce if they are already certified to the requirements that apply to compression-ignition engines under 40 CFR parts 85 and 86 or 40 CFR part 1033 or 1039 for the appropriate model year. If you comply with all the provisions of this section, we consider the certificate issued under 40 CFR part 86, 1033, or 1039 for each engine to also be a valid certificate of conformity under this part 1042 for its model year, without a separate application for certification under the requirements of this part 1042. This section does not apply for Category 3 engines.

(b) *Vessel-manufacturer provisions*. If you are not an engine manufacturer, you may install an engine certified for the appropriate model year under 40 CFR part 86, 1033, or 1039 in a marine vessel as long as you do not make any of the changes described in paragraph (d)(3) of this section and you meet the requirements of paragraph (e) of this section. If you modify the non-marine engine in any of the ways described in paragraph (d)(3) of this section, we will consider you a manufacturer of a new marine engine. Such engine modifications prevent you from using the provisions of this section.

(c) *Liability*. Engines for which you meet the requirements of this section are exempt from all the requirements and prohibitions of this part, except for those specified in this section. Engines exempted under this section must meet all the applicable requirements from 40 CFR parts 85 and 86 or 40 CFR part1033 or 1039. This paragraph (c) applies to engine manufacturers, vessel manufacturers that use such an engine, and all other persons as if the engine were used in its originally intended application. The prohibited acts of 40 CFR 1068.101(a)(1) apply to these new engines and vessels; however, we consider the certificate issued under 40 CFR part 86, 1033, or 1039 for each engine to also be a valid certificate of conformity under this part 1042 for its model year. If we make a determination that these engines do not conform to the regulations during their useful life, we may require you to recall them under 40 CFR part 85 or 1068.

(d) * * *

(1) * * *

(ii) Land-based compression-ignition nonroad engines (40 CFR part 1039).

* * * * *

(2) The engine must have the label required under 40 CFR part 86, 1033, or 1039.

(3) * * *

(ii) Replacing an original turbocharger, except that small-volume engine manufacturers may replace an original turbocharger on a recreational engine with one that matches the performance of the original turbocharger.

* * * * *

(f) *Failure to comply*. If your engines do not meet the criteria listed in paragraph (d) of this section, they will be subject to the standards, requirements, and prohibitions of this part 1042 and the certificate issued under 40 CFR part~~(s)~~ 86, 1033, or 1039 will not be deemed to also be a certificate issued under this part 1042. Introducing these engines into U.S. commerce as marine engines without a valid exemption or certificate of conformity under this part violates the prohibitions in 40 CFR 1068.101(a)(1).

* * * * *

(h) *Participation in averaging, banking and trading*. Engines adapted for marine use under this section may not generate or use emission credits under this part 1042. These engines may generate credits under the ABT provisions in 40 CFR part(s) 86, 1033, or 1039, as applicable. These engines must use emission credits under 40 CFR part(s) 86, 1033, or 1039 as applicable if they are certified to an FEL that exceeds an emission standard.

* * * * *

209. Amend §1042.610 by revising paragraphs (a), (c), (d)(1), (f), and (g) to read as follows:

§1042.610 Certifying auxiliary marine engines to land-based standards.

* * * * *

(a) *General provisions*. If you are an engine manufacturer, this section allows you to introduce new marine engines into U.S. commerce if they are already certified to the requirements that apply to compression-ignition engines under 40 CFR part 1039 for the appropriate model year. If you comply with all the provisions of this section, we consider the certificate issued under 40 CFR part 1039 for each engine to also be a valid certificate of conformity under this part 1042 for its model year, without a separate application for certification under the requirements of this part 1042.

* * * * *

(c) *Liability*. Engines for which you meet the requirements of this section are exempt from all the requirements and prohibitions of this part, except for those specified in this section. Engines exempted under this section must meet all the applicable requirements from 40 CFR part 1039. This paragraph (c) applies to engine manufacturers, vessel manufacturers that use such an engine, and all other persons as if the engine were used in its originally intended application. The prohibited acts of 40 CFR 1068.101(a)(1) apply to these new engines and vessels; however, we consider the certificate issued under 40 CFR part 1039 for each engine to also be a valid certificate of conformity under this part 1042 for its model year. If we make a determination that these engines do not conform to the regulations during their useful life, we may require you to recall them under 40 CFR part 1068.

(d) * * *

(1) The marine engine must be identical in all material respects to a land-based engine covered by a valid certificate of conformity for the appropriate model year showing that it meets emission standards for engines of that power rating under 40 CFR part 1039.

* * * * *

(f) *Failure to comply*. If your engines do not meet the criteria listed in paragraph (d) of this section, they will be subject to the standards, requirements, and prohibitions of this part 1042 and the certificate issued under 40 CFR part 1039 will not be deemed to also be a certificate issued under this part 1042. Introducing these engines into U.S. commerce as marine engines without a valid exemption or certificate of conformity under this part 1042 violates the prohibitions in 40 CFR 1068.101(a)(1).

(g) *Participation in averaging, banking and trading*. Engines using this exemption may not generate or use emission credits under this part 1042. These engines may generate credits under the ABT provisions in 40 CFR part 1039, as applicable. These engines must use emission credits under 40 CFR part 1039 as applicable if they are certified to an FEL that exceeds an emission standard.

* * * * *

210. Amend §1042.615 by revising paragraph (a) introductory text and paragraphs (a)(1) and (3) and adding paragraphs (f) and (g) to read as follows:

§1042.615 Replacement engine exemption.

* * * * *

(a) This paragraph (a) applies instead of the provisions of 40 CFR 1068.240(b)(2) for installing new marine engines in vessels that are not "new vessels". The prohibitions in 40 CFR 1068.101(a)(1) do not apply to a new replacement engine if all the following conditions are met:

(1) You use good engineering judgment to determine that no engine certified to the current requirements of this part is produced by any manufacturer with the appropriate physical or performance characteristics to repower the vessel. We have determined that Tier 4 engines with aftertreatment technology do not have the appropriate physical or performance characteristics to replace uncertified engines or engines certified to emission standards that are less stringent than the Tier 4 standards.

* * * * *

(3) Send us a report by September 30 of each year describing your engine shipments under this section from the preceding calendar year. Your report must include all the following things and be signed by an authorized representative of your company:

(i) Identify the number of Category 1 and Category 2 exempt replacement engines that meet Tier 1, Tier 2, or Tier 3 standards, or that meet no EPA standards. Count engines separately for each tier of standards. ~~(ii)~~ Identify the number of those engines that have been shipped (directly or indirectly) to a vessel owner. This includes engines shipped to anyone intending to install engines on behalf of a specific engine owner. Also include commercial Tier 3 engines with maximum engine power at or above 600 kW even if they have not been shipped to or designated for a specific vessel owner in the specified time frame.

(ii~~i~~) Describe how you made the determinations described in paragraph (a)(1) of this section for each Category 1 and Category 2 exempt replacement engine for each vessel during the preceding year. For Tier 3 replacement engines at or above 600 kW, describe why any engines certified to Tier 4 standards without aftertreatment are not suitable.

(iii~~v~~) Identify the number of Category 3 exempt replacement engines. We may require you to describe how you made the determinations described in paragraph (a)(1) of this section for each engine.

(iv) Include the following statement:

I certify that the statements and information in the enclosed document are true, accurate, and complete to the best of my knowledge. I am aware that there are significant civil and criminal penalties for submitting false statements and information, or omitting required statements and information.

* * * * *

(f) The provisions of 40 CFR 1068.240(c) allow you to ship a limited number of exempt replacement engines to vessel owners or distributors without making the determinations described in paragraph (a) of this section. Note that such engines do not count toward the production limits of 40 CFR 1068.240(c) if you meet all the requirements of ~~40 CFR 1068.240(b) and~~ this section by the due date for the annual report. You may count Tier 3 commercial marine replacement engines at or above 600 kW as tracked engines under 40 CFR 1068.240(b) even if they have not been shipped to or designated for a specific vessel owner in the specified time frame.

(g) In unusual circumstances, you may ask us to allow you to apply the replacement engine exemption of this section for repowering a vessel that becomes a "new vessel" under §1042.901 as a result of modifications, as follows:

(1) You must demonstrate that no manufacturer produces an engine certified to Tier 4 standards with the appropriate physical or performance characteristics to repower the vessel. We will consider concerns about the size of the replacement engine and its compatibility with vessel components relative to the overall scope of the project.

(2) Exempt replacement engines under this paragraph (g) must meet the Tier 3 standards specified in §1042.101 (or the Tier 2 standards if there are no Tier 3 standards).

(3) We will not approve a request for an exemption from the Tier 3 standards for any engines.

(4) You may not use the exemption provisions for untracked replacement engines under 40 CFR 1068.240(c) for repowering a vessel that becomes a "new vessel" under §1042.901 as a result of modifications.

211. Amend §1042.650 by revising the introductory text and paragraph (b)(4) to read as follows:

§1042.650 Migratory vessels.

The provisions of paragraphs (a) through (c) of this section apply for Category 1 and Category 2 engines, including auxiliary engines installed on vessels with Category 3 propulsion engines; these provisions do not apply for any Category 3 engines. All engines exempted under this section must comply with the applicable requirements of 40 CFR part 1043.

* * * * *

(b) * * *

(4) Operating a vessel containing an engine exempted under this paragraph (b) violates the prohibitions in 40 CFR 1068.101(a)(1) if the vessel is not in full compliance with applicable requirements for international safety specified in paragraph (b)(1)(i) of this section.

* * * * *

212. Amend §1042.655 by revising the paragraph (b) to read as follows:

§1042.655 Special certification provisions for Category 3 engines with aftertreatment.

* * * * *

(b) *Required testing*. The emission-data engine must be tested as specified in subpart F of this part. Testing engine-out emissions to simulate operation with disabled Tier 3 emission controls must simulate backpressure and other parameters as needed to represent in-use operation with an SCR catalyst. The catalyst material or other aftertreatment device must be tested under conditions that accurately represent actual engine conditions for the test points. This catalyst or aftertreatment testing may be performed on a bench scale.

* * * * *

§1042.701 [Amended]

213. Amend §1042.701 by removing and reserving paragraph (j).

214. Amend §1042.801 by revising paragraph (f)(1) to read as follows:

§1042.801 General provisions.

* * * * *

(f) * * *

(1) Only fuel additives registered under 40 CFR part 79 may be used under this paragraph (f).

* * * * *

215. Amend §1042.836 by revising the introductory text and paragraph (c) to read as follows:

§1042.836 Marine certification of locomotive remanufacturing systems.

If you certify a Tier 0, Tier 1, or Tier 2 remanufacturing system for locomotives under 40 CFR part 1033, you may also certify the system under this part 1042, according to the provisions of this section.

* * * * *

(c) Systems that were certified to the standards of 40 CFR part 92 are subject to the following restrictions:

(1) Tier 0 locomotive systems may not be used for any Category 1 engines or Tier 1 or later Category 2 engines.

(2) Where systems certified to the standards of 40 CFR part 1033 are also available for an engine, you may not use a system certified to the standards of 40 CFR part 92.

216. Amend §1042.901 by revising the definition for “Low-hour” and paragraph (3) of the definition for “Model year” to read as follows:

§1042.901 Definitions.

* * * * *

Low-hour means relating to an engine that has stabilized emissions and represents the undeteriorated emission level. This would generally involve less than 300 hours of operation for engines with NOx aftertreatment and 125 hours of operation for other engines ~~below 560 kW and less than 300 hours for engines at or above 560 kW~~. [*This definition is added for the final rule. Changes shown are relative to the Code of Federal Regulations.*]

* * * * *

Model year means * * *

* * * * *

(3) For an uncertified marine engine excluded under § 1042.5 that is later subject to this part 1042 as a result of being installed in a different vessel, model year means the calendar year in which the engine was installed in the non-excluded vessel. For a marine engine excluded under § 1042.5 that is later subject to this part 1042 as a result of reflagging the vessel, model year means the calendar year in which the engine was originally manufactured. For a marine engine that becomes new under paragraph (7) of the definition of "new marine engine," model year means the calendar year in which the engine was originally manufactured. (See definition of "new marine engine," paragraphs (3) and (7).)

* * * * *

217. Revise §1042.910 to read as follows:

§1042.910 Incorporation by reference.

(a) Certain material is incorporated by reference into this part with the approval of the Director of the Federal Register under 5 U.S.C. 552(a) and 1 CFR part 51. To enforce any edition other than that specified in this section, the Environmental Protection Agency must publish a document in the Federal Register and the material must be available to the public. All approved material is available for inspection at EPA Docket Center, WJC West Building, Room 3334, 1301 Constitution Avenue, N.W., Washington, DC 20004, www.epa.gov/dockets, (202) 202-1744, and is available from the sources listed below. It is also available for inspection at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, email fedreg.legal@nara.gov or go to: http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html.

(b) The International Maritime Organization, 4 Albert Embankment, London SE1 7SR, United Kingdom, or *www.imo.org*, or 44-(0)20-7735-7611.

(1) MARPOL Annex VI, Regulations for the Prevention of Air Pollution from Ships, Fourth Edition, 2017, and NOx Technical Code 2008.

(i) Revised MARPOL Annex VI, Regulations for the Prevention of Pollution from Ships, Fourth Edition, 2017 ("2008 Annex VI"); IBR approved for §1042.901.

(ii) NOx Technical Code 2008, Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines, 2017 Edition, ("NOx Technical Code"); IBR approved for §§1042.104(g), 1042.230(d), 1042.302(c) and (e), 1042.501(g), and 1042.901.

(2) [Reserved]

218. Amend Appendix I to part 1042 by revising paragraph (a) introductory text, paragraph (b) introductory text, and paragraph (b)(3) to read as follows:

Appendix I to Part 1042—Summary of Previous Emission Standards

* * * * *

(a) *Engines below 37 kW*. Tier 1 and Tier 2 standards for engines below 37 kW originally adopted under 40 CFR part 89 apply as follows:

* * * * *

(b) *Engines at or above 37 kW*. Tier 1 and Tier 2 standards for engines at or above 37 kW originally adopted under 40 CFR part 94 apply as follows:

* * * * *

(3) *Tier 2 supplemental standards*. Not-to-exceed emission standards apply for all engines subject to the Tier 2 standards described in paragraph (b)(2) of this appendix.

PART 1043—CONTROL OF NOx, SOx, AND PM EMISSIONS FROM MARINE ENGINES AND VESSELS SUBJECT TO THE MARPOL PROTOCOL

219. The authority statement for part 1043 continues to read as follows:

Authority: 33 U.S.C. 1901-1912.

220. Amend §1043.41 by revising paragraph (a) to read as follows:

§1043.41 EIAPP certification process.

* * * * *

(a) You must send the Designated Certification Officer a separate application for an EIAPP certificate for each engine family. An EIAPP certificate is valid starting with the indicated effective date and is valid for any production until such time as the design of the engine family changes or more stringent emission standards become applicable, whichever comes first. Note that an EIAPP certificate demonstrating compliance with Tier I or Tier II standards (but not the Tier III standard) is only a limited authorization to install engines on vessels. For example, you may produce such Tier I or Tier II engines, but those engines may not be installed in vessels that are subject to Tier III standards. You may obtain preliminary approval of portions of the application under 40 CFR 1042.210.

* * * * *

221. Revise §1043.100 to read as follows:

§1043.100 Incorporation by reference.

(a) Certain material is incorporated by reference into this part with the approval of the Director of the Federal Register under 5 U.S.C. 552(a) and 1 CFR part 51. To enforce any edition other than that specified in this section, the Environmental Protection Agency must publish a document in the Federal Register and the material must be available to the public. All approved material is available for inspection at EPA Docket Center, WJC West Building, Room 3334, 1301 Constitution Avenue, N.W., Washington, DC 20004, www.epa.gov/dockets, (202) 202-1744, and is available from the sources listed below. It is also available for inspection at the National Archives and Records Administration (NARA). For information on the availability of this material at NARA, email fedreg.legal@nara.gov, or go to: *http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html*.

(b) The International Maritime Organization, 4 Albert Embankment, London SE1 7SR, United Kingdom, or *www.imo.org*, or 44-(0)20-7735-7611.

(1) MARPOL Annex VI, Regulations for the Prevention of Air Pollution from Ships, Fourth Edition, 2017, and NOx Technical Code 2008.

(i) Revised MARPOL Annex VI, Regulations for the Prevention of Pollution from Ships, Fourth Edition, 2017 (“2008 Annex VI”); IBR approved for §§1043.1 introductory text, 1043.20, 1043.30(f), 1043.60(c), and 1043.70(a).

(ii) NOx Technical Code 2008, Technical Code on Control of Emission of Nitrogen Oxides from Marine Diesel Engines, 2017 Edition, (“NOx Technical Code”); IBR approved for §§1043.20, 1043.41(b) and (h), and 1043.70(a).

(2) [Reserved]

PART 1045—CONTROL OF EMISSIONS FROM SPARK-IGNITION PROPULSION MARINE ENGINES AND VESSELS

222. The authority statement for part 1045 continues to read as follows:
Authority: 42 U.S.C. 7401-7671q.

223. Amend §1045.1 by revising paragraph (c) to read as follows:

§1045.1 Does this part apply for my products?

* * * * *

(c) Outboard and personal watercraft engines originally meeting the standards specified in Appendix I remain subject to those standards. Those engines remain subject to recall provisions as specified in 40 CFR part 1068, subpart F, throughout the useful life corresponding to the original certification. Also, tampering and defeat-device prohibitions continue to apply for those engines as specified in 40 CFR 1068.101.

* * * * *

224. Amend §1045.145 by removing and reserving paragraphs (a) through (g), (i) through (k), and (m) and revising paragraph (n) to read as follows:

§1045.145 Are there interim provisions that apply only for a limited time?

* * * * *

(n) *Continued use of 40 CFR part 91 test data*. You may continue to use test data based on the test procedures that applied for engines built before the requirements of this part 1045 started to apply if we allow you to use carryover emission data under 40 CFR 1045.235(d) for your engine family. You may also use those test procedures for production-line testing with any engine family whose certification is based on testing with those procedures. For any EPA testing, we will rely on the procedures described in subpart F of this part, even if you used carryover data based on older test procedures as allowed under this paragraph (n).

* * * * *

225. Amend §1045.235 by revising paragraph (d)(3) to read as follows:

§1045.235 What testing requirements apply for certification?

* * * * *

(d) * * *

(3) The data show that the emission-data engine would meet all the requirements that apply to the engine family covered by the application for certification.

* * * * *

226. Revise §1045.255 to read as follows:

§1045.255 What decisions may EPA make regarding a certificate of conformity?

(a) If we determine an application is complete and shows that the engine family meets all the requirements of this part and the Clean Air Act, we will issue a certificate of conformity for the engine family for that model year. We may make the approval subject to additional conditions.

(b) We may deny an application for certification if we determine that an engine family fails to comply with emission standards or other requirements of this part or the Clean Air Act. We will base our decision on all available information. If we deny an application, we will explain why in writing.

(c) In addition, we may deny your application or suspend or revoke a certificate of conformity if you do any of the following:

(1) Refuse to comply with any testing or reporting requirements.

(2) Submit false or incomplete information. This includes doing anything after submitting an application that causes submitted information to be false or incomplete.

(3) Cause any test data to become inaccurate.

(4) Deny us from completing authorized activities (see 40 CFR 1068.20). This includes a failure to provide reasonable assistance.

(5) Produce engines for importation into the United States at a location where local law prohibits us from carrying out authorized activities.

(6) Fail to supply requested information or amend an application to include all engines being produced.

(7) Take any action that otherwise circumvents the intent of the Clean Air Act or this part, with respect to an engine family.

(d) We may void a certificate of conformity for an engine family if you fail to keep records, send reports, or give us information as required under this part or the Clean Air Act. Note that these are also violations of 40 CFR 1068.101(a)(2).

(e) We may void a certificate of conformity for an engine family if we find that you intentionally submitted false or incomplete information. This includes doing anything after submitting an application that causes submitted information to be false or incomplete after submission.

(f) If we deny an application or suspend, revoke, or void a certificate, you may ask for a hearing (see §1045.820).

227. Amend §1045.310 by revising paragraph (a)(1) introductory text and paragraph (a)(1)(iv) to read as follows:

§1045.310 How must I select engines for production-line testing?

(a) * * *

(1) For engine families with projected U.S.-directed production volume of at least 1,600, the test periods are defined as followsconsecutive quarters (3 months). However, if your annual production period is not 12 months long, you may take the following alternative approach to define quarterly test periods:

* * * * *

(iv) If your annual production period is 301 days or longer, divide the annual production period evenly into four test periods. For example, if your annual production period is 392 days (56 weeks), divide the annual production period into four test periods of 98 days (14 weeks).

* * * * *

228. Amend §1045.501 by revising paragraph (c) to read as follows:

§1045.501 How do I run a valid emission test?

* * * * *

(c) *Fuels*. Use the fuels and lubricants specified in 40 CFR part 1065, subpart H, for all the testing we require in this part, except as specified in §1045.515.

(1) Use gasoline meeting the specifications described in 40 CFR 1065.710(c) for general testing. For service accumulation, use the test fuel or any commercially available fuel that is representative of the fuel that in-use engines will use.

(2) You may alternatively use ethanol-blended ~~gasoline~~ fuel meeting the specifications described in 40 CFR 1065.710(b) for general testing without our advance approval. If you use the ethanol-blended fuel for certifying a given engine family, you may also use it for production-line testing or any other testing you perform for that engine family under this part. If you use the ethanol-blended fuel for certifying a given engine family, we may use the ethanol-blended fuel or the specified neat gasoline test fuel with that engine family.

* * * * *

229. Revise Appendix 1 to part 1045 to read as follows:

Appendix I to Part 1045— Summary of Previous Emission Standards

(a) The following standards, which EPA originally adopted under 40 CFR part 91, apply to outboard and personal watercraft engines produced from model year 2006 through 2009:

(1) For engines at or below 4.3 kW, the HC+NOx standard is 81.00 g/kW-hr.

(2) For engines above 4.3 kW, the following HC+NOx standard applies:

HC+NOx standard = (151 + 557/P0.9) · 0.250 + 6.00

Where:

STD = The HC+NOx emission standard, in g/kW-hr.

P = The average power of an engine family, in kW.

(b) Table 1 of this appendix describes the phase-in standards for outboard and personal watercraft engines for model years 1998 through 2005. For engines with maximum engine power above 4.3 kW, the standard is expressed by the following formula, in g/kW-hr, with constants for each year identified in Table 1 of this appendix:

$$HC + NOx\,\text{standard} = \left(151 + \frac{557}{P^{0.9}}\right) \cdot A + B$$

Table 1 of Appendix I—HC+NOx Phase-in Standards for Outboard and Personal Watercraft Engines

Model Year	Maximum engine power < 4.3 kW	Maximum engine power > 4.3 kW	
		A	B
1998	278.00	0.917	2.44
1999	253.00	0.833	2.89
2000	228.00	0.750	3.33
2001	204.00	0.667	3.78
2002	179.00	0.583	4.22
2003	155.00	0.500	4.67
2004	130.00	0.417	5.11
2005	105.00	0.333	5.56

PART 1048—CONTROL OF EMISSIONS FROM NEW, LARGE NONROAD SPARK-IGNITION ENGINES

230. The authority statement for part 1048 continues to read as follows:
Authority: 42 U.S.C. 7401-7671q.

231. Revise §1048.145 to read as follows:

§1048.145 Are there interim provisions that apply only for a limited time?

The provisions in this section apply instead of other provisions in this part. This section describes when these interim provisions expire.

(a) – (f) [Reserved]

(g) *Small-volume provisions*. If you qualify for the hardship provisions in §1068.250 of this chapter, we may approve extensions of up to four years total.

232. Revise §1048.255 to read as follows:

§1048.255 What decisions may EPA make regarding a certificate of conformity?

(a) If we determine an application is complete and shows that the engine family meets all the requirements of this part and the Act, we will issue a certificate of conformity for the engine family for that model year. We may make the approval subject to additional conditions.

(b) We may deny an application for certification if we determine that an engine family fails to comply with emission standards or other requirements of this part or the Clean Air Act. We will base our decision on all available information. If we deny an application, we will explain why in writing.

(c) In addition, we may deny your application or suspend or revoke a certificate of conformity if you do any of the following:

(1) Refuse to comply with any testing or reporting requirements.

(2) Submit false or incomplete information. This includes doing anything after submitting an application that causes submitted information to be false or incomplete.

(3) Cause any test data to become inaccurate.

(4) Deny us from completing authorized activities (see 40 CFR 1068.20). This includes a failure to provide reasonable assistance.

(5) Produce engines for importation into the United States at a location where local law prohibits us from carrying out authorized activities.

(6) Fail to supply requested information or amend an application to include all engines being produced.

(7) Take any action that otherwise circumvents the intent of the Act or this part~~, with respect to an engine family~~.

(d) We may void a certificate of conformity ~~for an engine family~~ if you fail to keep records, send reports, or give us information as required under this part or the Act. Note that these are also violations of 40 CFR 1068.101(a)(2).

(e) We may void a certificate of conformity ~~for an engine family~~ if we find that you intentionally submitted false or incomplete information. This includes doing anything after submitting an application that causes submitted information to be false or incomplete after submission.

(f) If we deny an application or suspend, revoke, or void a certificate, you may ask for a hearing (see §1048.820).

233. Amend §1048.501 by revising paragraph (c) to read as follows:

§1048.501 How do I run a valid emission test?

* * * * *

(c) Use the fuels and lubricants specified in 40 CFR part 1065, subpart H, to perform valid tests for all the testing we require in this part, except as noted in §1048.515.

(1) Use gasoline meeting the specifications described in 40 CFR 1065.710(c) for general testing. For service accumulation, use the test fuel or any commercially available fuel that is representative of the fuel that in-use engines will use.

(2) You may alternatively use ethanol-blended ~~gasoline~~ fuel meeting the specifications described in 40 CFR 1065.710(b) for general testing without our advance approval. If you use the ethanol-blended fuel for certifying a given engine family, you may also use it for production-line testing or any other testing you perform for that engine family under this part. If you use the ethanol-blended fuel for certifying a given engine family, we may use the ethanol-blended fuel or the specified neat gasoline test fuel with that engine family.

* * * * *

PART 1051—CONTROL OF EMISSIONS FROM RECREATIONAL ENGINES AND VEHICLES

234. The authority statement for part 1051 continues to read as follows:
Authority: 42 U.S.C. 7401-7671q.

235. Revise §1051.145 to read as follows:

§1051.145 What provisions apply only for a limited time?

(a) Apply the provisions in this section instead of others in this part for the periods and circumstances specified in this section.
(b) [Reserved]

236. Revise §1051.255 to read as follows:

§1051.255 What decisions may EPA make regarding a certificate of conformity?

(a) If we determine an application is complete and shows that the engine family meets all the requirements of this part and the Act, we will issue a certificate of conformity for the engine family for that model year. We may make the approval subject to additional conditions.
(b) We may deny an application for certification if we determine that an engine family fails to comply with emission standards or other requirements of this part or the Clean Air Act. We will base our decision on all available information. If we deny an application, we will explain why in writing.
(c) In addition, we may deny your application or suspend or revoke a certificate of conformity if you do any of the following:
(1) Refuse to comply with any testing or reporting requirements.
(2) Submit false or incomplete information. This includes doing anything after submitting an application that causes submitted information to be false or incomplete.
(3) Cause any test data to become inaccurate.
(4) Deny us from completing authorized activities (see 40 CFR 1068.20). This includes a failure to provide reasonable assistance.
(5) Produce engines for importation into the United States at a location where local law prohibits us from carrying out authorized activities.
(6) Fail to supply requested information or amend an application to include all engines being produced.
(7) Take any action that otherwise circumvents the intent of the Act or this part~~, with respect to an engine family~~.
(d) We may void a certificate of conformity ~~for an engine family~~ if you fail to keep records, send reports, or give us information as required under this part or the Clean Air Act. Note that these are also violations of 40 CFR 1068.101(a)(2).
(e) We may void a certificate of conformity ~~for an engine family~~ if we find that you intentionally submitted false or incomplete information. This includes doing anything after submitting an application that causes submitted information to be false or incomplete after submission.
(f) If we deny an application or suspend, revoke, or void a certificate, you may ask for a hearing (see §1051.820).

237. Amend §1051.310 by revising paragraph (a)(1) introductory text and paragraph (a)(1)(iv) to read as follows:

§1051.310 How must I select vehicles or engines for production-line testing?

(a) * * *

(1) For engine families with projected U.S.-directed production volume of at least 1,600, the test periods are defined as followsconsecutive quarters (3 months). However, if your annual production period is not 12 months long, you may take the following alternative approach to define quarterly test periods:

* * * * *

(iv) If your annual production period is 301 days or longer, divide the annual production period evenly into four test periods. For example, if your annual production period is 392 days (56 weeks), divide the annual production period into four test periods of 98 days (14 weeks).

* * * * *

238. Amend §1051.501 by revising paragraph (d) to read as follows:

§1051.501 What procedures must I use to test my vehicles or engines?

* * * * *

(d) *Fuels*. Use the fuels meeting the following specifications:

(1) *Exhaust*. Use the fuels and lubricants specified in 40 CFR part 1065, subpart H, for all the exhaust testing we require in this part. For service accumulation, use the test fuel or any commercially available fuel that is representative of the fuel that in-use engines will use. The following provisions apply for using specific fuel types:

(i) For gasoline-fueled engines, use the grade of gasoline specified in 40 CFR 1065.710(c) for general testing. You may alternatively use ethanol-blended gasoline fuel meeting the specifications described in 40 CFR 1065.710(b) for general testing without our advance approval. If you use the ethanol-blended fuel for certifying a given engine family, you may also use it for production-line testing or any other testing you perform for that engine family under this part. If you use the ethanol-blended fuel for certifying a given engine family, we may use the ethanol-blended fuel or the specified neat gasoline test fuel with that engine family.

(ii) For diesel-fueled engines, use either low-sulfur diesel fuel or ultra low-sulfur diesel fuel meeting the specifications in 40 CFR 1065.703. If you use sulfur-sensitive technology as defined in 40 CFR 1039.801 and you measure emissions using ultra low-sulfur diesel fuel, you must add a permanent label near the fuel inlet with the following statement: “ULTRA LOW SULFUR FUEL ONLY”.

(2) *Fuel Tank Permeation*. (i) For the preconditioning soak described in §1051.515(a)(1) and fuel slosh durability test described in §1051.515(d)(3), use the fuel specified in 40 CFR 1065.710(b), or the fuel specified in 40 CFR 1065.710(c) blended with 10 percent ethanol by volume. As an alternative, you may use Fuel CE10, which is Fuel C as specified in ASTM D 471-98 (see 40 CFR 1060.810) blended with 10 percent ethanol by volume.

(ii) For the permeation measurement test in §1051.515(b), use the fuel specified in 40 CFR 1065.710(c). As an alternative, you may use any of the fuels specified in paragraph (d)(2)(i) of this section.

(3) *Fuel Hose Permeation*. Use the fuel specified in 40 CFR 1065.710(b), or the fuel specified in 40 CFR 1065.710(c) blended with 10 percent ethanol by volume for permeation testing of fuel lines. As an alternative, you may use Fuel CE10, which is Fuel C as specified in ASTM D 471-98 (see 40 CFR 1060.810) blended with 10 percent ethanol by volume.

* * * * *

PART 1054—CONTROL OF EMISSIONS FROM NEW, SMALL NONROAD SPARK-IGNITION ENGINES AND EQUIPMENT

239. The authority statement for part 1054 continues to read as follows:

Authority: 42 U.S.C. 7401-7671q.

240. Amend §1054.1 by revising paragraphs (a)(1) and (5), (c), and (d) to read as follows:

§1054.1 Does this part apply for my engines and equipment?

(a) * * *

(1) The requirements of this part related to exhaust emissions apply to new, nonroad spark-ignition engines with maximum engine power at or below 19 kW. This includes auxiliary marine spark-ignition engines.

* * * * *

(5) We specify provisions in §1054.145(f) and in §1054.740 that allow for meeting the requirements of this part before the dates shown in Table 1 to this section. Engines, fuel-system components, or equipment certified to these standards are subject to all the requirements of this part as if these optional standards were mandatory.

* * * * *

(c) Engines originally meeting Phase 1 or Phase 2 standards as specified in Appendix I remain subject to those standards. Those engines remain subject to recall provisions as specified in 40 CFR part 1068, subpart F, throughout the useful life corresponding to the original certification. Also, tampering and defeat-device prohibitions continue to apply for those engines as specified in 40 CFR 1068.101.

(d) The regulations in this part 1054 optionally apply to engines with maximum engine power at or below 30 kW and with displacement at or below 1,000 cubic centimeters that would otherwise be covered by 40 CFR part 1048. See 40 CFR 1048.615 for provisions related to this allowance.

* * * * *

241. Revise §1054.2 to read as follows:

§1054.2 Who is responsible for compliance?

(a) The requirements and prohibitions of this part apply to manufacturers of engines and equipment, as described in §1054.1. The requirements of this part are generally addressed to manufacturers subject to this part’s requirements. The term "you" generally means the certifying manufacturer. For provisions related to exhaust emissions, this generally means the engine manufacturer, especially for issues related to certification (including production-line testing, reporting, etc.). For provisions related to certification with respect to evaporative emissions, this generally means the equipment manufacturer. Note that for engines that become new after being placed into service (such as engines converted from highway or stationary use), the requirements that normally apply for manufacturers of freshly manufactured engines apply to the importer or any other entity we allow to obtain a certificate of conformity.

(b) Equipment manufacturers must meet applicable requirements as described in §1054.20. Engine manufacturers that assemble an engine’s complete fuel system are considered to be the equipment manufacturer with respect to evaporative emissions (see 40 CFR 1060.5). Note that certification requirements for component manufacturers are described in 40 CFR part 1060.

242. Revise §1054.30 to read as follows:

§1054.30 Submission of information.

Unless we specify otherwise, send all reports and requests for approval to the Designated Compliance Officer (see § 1054.801). See § 1054.825 for additional reporting and recordkeeping provisions.

243. Amend §1054.103 by revising paragraph (c) introductory text to read as follows:

§1054.103 What exhaust emission standards must my handheld engines meet?

* * * * *

(c) *Fuel types*. The exhaust emission standards in this section apply for engines using the fuel type on which the engines in the emission family are designed to operate. You must meet the numerical emission standards for hydrocarbon in this section based on the following types of hydrocarbon emissions for engines powered by the following fuels:

* * * * *

244. Amend §1054.105 by revising paragraph (c) introductory text to read as follows:

§1054.105 What exhaust emission standards must my nonhandheld engines meet?

* * * * *

(c) *Fuel types*. The exhaust emission standards in this section apply for engines using the fuel type on which the engines in the emission family are designed to operate. You must meet the numerical emission standards for hydrocarbon in this section based on the following types of hydrocarbon emissions for engines powered by the following fuels:

* * * * *

245. Amend §1054.110 by revising paragraph (b) to read as follows:

§1054.110 What evaporative emission standards must my handheld equipment meet?

* * * * *

(b) *Tank permeation*. Fuel tanks must meet the permeation requirements specified in 40 CFR 1060.103. These requirements apply for handheld equipment starting in the 2010 model year, except that they apply starting in the 2011 model year for structurally integrated nylon fuel tanks, in the 2012 model year for handheld equipment using nonhandheld engines, and in the 2013 model year for all small-volume emission families. For nonhandheld equipment using engines at or below 80 cc, the requirements of this paragraph (b) apply starting in the 2012 model year. You may generate or use emission credits to show compliance with the requirements of this paragraph (b) under the averaging, banking, and trading program as described in subpart H of this part. FEL caps apply as specified in §1054.112(b)(1) through (3) starting in the 2015 model year.

* * * * *

246. Amend §1054.120 by revising paragraph (c) to read as follows:

§1054.120 What emission-related warranty requirements apply to me?

* * * * *

(c) *Components covered*. The emission-related warranty covers all components whose failure would increase an engine's emissions of any regulated pollutant, including components listed in 40 CFR part 1068, Appendix I, and components from any other system you develop to control emissions. The emission-related warranty covers these components even if another company produces the component. Your emission-related warranty does not need to cover components whose failure would not increase an engine's emissions of any regulated pollutant.

* * * * *

247. Amend §1054.125 by revising the introductory text and paragraphs (c) and (e) to read as follows:

§1054.125 What maintenance instructions must I give to buyers?

Give the ultimate purchaser of each new engine written instructions for properly maintaining and using the engine, including the emission control system as described in this section. The maintenance instructions also apply to service accumulation on your emission-data engines as described in §1054.245 and in 40 CFR part 1065.

* * * * *

(c) *Special maintenance*. You may specify more frequent maintenance to address problems related to special situations, such as atypical engine operation. You must clearly state that this additional maintenance is associated with the special situation you are addressing. You may also address maintenance of low-use engines (such as recreational or stand-by engines) by specifying the maintenance interval in terms of calendar months or years in addition to your specifications in terms of engine operating hours. All special maintenance instructions must be consistent with good engineering judgment. We may disapprove your maintenance instructions if we determine that you have specified special maintenance steps to address engine operation that is not atypical, or that the maintenance is unlikely to occur in use. For example, this paragraph (c) does not allow you to design engines that require special maintenance for a certain type of expected operation. If we determine that certain maintenance items do not qualify as special maintenance under this paragraph (c), you may identify this as recommended additional maintenance under paragraph (b) of this section.

* * * * *

(e) *Maintenance that is not emission-related*. For maintenance unrelated to emission controls, you may schedule any amount of inspection or maintenance. You may also take these inspection or maintenance steps during service accumulation on your emission-data engines, as long as they are reasonable and technologically necessary. This might include adding engine oil, changing fuel or oil filters, servicing engine-cooling systems, and adjusting idle speed, governor, engine bolt torque, valve lash, or injector lash. You may not perform this nonemission-related maintenance on emission-data engines more often than the least frequent intervals that you recommend to the ultimate purchaser.

* * * * *

248. Amend §1054.130 by revising paragraphs (b)(2) and (5) to read as follows:

§1054.130 What installation instructions must I give to equipment manufacturers?

* * * * *

(b) * * *

(2) State: "Failing to follow these instructions when installing a certified engine in a piece of equipment violates federal law (40 CFR 1068.105(b)), subject to fines or other penalties as described in the Clean Air Act."

* * * * *

(5) Describe how your certification is limited for any type of application. For example, if you certify engines only for rated-speed applications, tell equipment manufacturers that the engine must not be installed in equipment involving intermediate-speed operation. Also, if your wintertime engines are not certified to the otherwise applicable HC+NOx standards, tell equipment manufacturers that the engines must be installed in equipment that is used only in wintertime.

* * * * *

249. Amend §1054.135 by revising paragraphs (c)(2) and (e)(1) to read as follows:

§1054.135 How must I label and identify the engines I produce?

* * * * *

(c) * * *

(2) Include your full corporate name and trademark. You may identify another company and use its trademark instead of yours if you comply with the branding provisions of 40 CFR 1068.45.

* * * * *

(e) * * *

(1) You may identify other emission standards that the engine meets or does not meet (such as California standards), as long as this does not cause you to omit any of the information described in paragraph (c) of this section. You may include this information by adding it to the statement we specify or by including a separate statement.

* * * * *

250. Revise §1054.145 to read as follows:

§1054.145 Are there interim provisions that apply only for a limited time?

The provisions in this section apply instead of other provisions in this part. This section describes how and when these interim provisions apply.

(a) – (b) [Reserved]

(c) *Special provisions for handheld engines*. Handheld engines subject to Phase 3 emission standards must meet the standards at or above barometric pressures of 96.0 kPa in the standard configuration and are not required to meet emission standards at lower barometric pressures. This is intended to allow testing under most weather conditions at all altitudes up to 1,100 feet above sea level. In your application for certification, identify the altitude above which you rely on an altitude kit and describe your plan for making information and parts available such that you would reasonably expect that altitude kits would be widely used at all such altitudes.

(d) *Alignment of model years for exhaust and evaporative standards*. Evaporative emission standards generally apply based on the model year of the equipment, which is determined by the equipment's date of final assembly. However, in the first year of new emission standards, equipment manufacturers may apply evaporative emission standards based on the model year of the engine as shown on the engine's emission control information label. For example, for the fuel line permeation standards starting in 2012, equipment manufacturers may order a batch of 2011 model year engines for installation in 2012 model year equipment, subject to the anti-stockpiling provisions of 40 CFR 1068.105(a). The equipment with the 2011 model year engines would not need to meet fuel line permeation standards, as long as the equipment is fully assembled by December 31, 2012.

(e) [Reserved]

(f) *Early banking for evaporative emission standards—handheld equipment manufacturers*. You may earn emission credits for handheld equipment you produce before the evaporative emission standards of §1054.110 apply. To do this, your equipment must use fuel tanks with a family emission limit below 1.5 g/m2/day (or 2.5 g/m2/day for testing at 40°C). Calculate your credits as described in §1054.706 based on the difference between the family emission limit and 1.5 g/m2/day (or 2.5 g/m2/day for testing at 40°C).

(g) through (i) [Reserved]

(j) *Continued use of 40 CFR part 90 test data*. You may continue to use data based on the test procedures that apply for engines built before the requirements of this part 1054 start to apply if we allow you to use carryover emission data under 40 CFR 1054.235(d) for your emission family. You may also use those test procedures for measuring exhaust emissions for production-line testing with any engine family whose certification is based on testing with those procedures. For any EPA testing, we will rely on the procedures described in subpart F of this part, even if you used carryover data based on older test procedures as allowed under this paragraph (j).

(k) – (m) [Reserved]

(n) *California test fuel*. You may perform testing with a fuel meeting the requirements for certifying the engine in California instead of the fuel specified in § 1054.501(b)(2), as follows:

(1) You may certify individual engine families using data from testing conducted with California Phase 2 test fuel through model year 2019. Any EPA testing with such an engine family may use either this same certification fuel or the test fuel specified in § 1054.501.

(2) Starting in model year 2013, you may certify individual engine families using data from testing conducted with California Phase 3 test fuel. Any EPA testing with such an engine family may use either this same certification fuel or the test fuel specified in § 1054.501, unless you certify to the more stringent CO standards specified in this paragraph (n)(2). If you meet these alternate CO standards, we will also use California Phase 3 test fuel for any testing we perform with engines from that engine family. The following alternate CO standards apply instead of the CO standards specified in § 1054.103 or § 1054.105:

Table 1 to § 1054.145—Alternate CO Standards for Testing with California Phase 3 Test Fuel [g/kW-hr]

Engine type	Alternate CO standard
Class I	549
Class II	549
Class III	536
Class IV	536
Class V	536
Marine generators	4.5

251. Amend §1054.205 by revising paragraphs (o)(1), (p)(1), (v), and (x) to read as follows:

§1054.205 What must I include in my application?

* * * * *

(o) * * *

(1) Present emission data for hydrocarbon (such as THC, THCE, or NMHC, as applicable), NOx, and CO on an emission-data engine to show your engines meet the applicable exhaust emission standards as specified in §1054.101. Show emission figures before and after applying deterioration factors for each engine. Include test data from each applicable duty cycle specified in §1054.505(b). If we specify more than one grade of any fuel type (for example, low-temperature and all-season gasoline), you need to submit test data only for one grade, unless the regulations of this part specify otherwise for your engine.

* * * * *

(p) * * *

(1) Report all valid test results involving measurement of pollutants for which emission standards apply. Also indicate whether there are test results from invalid tests or from any other tests of the emission-data engine, whether or not they were conducted according to the test procedures of subpart F of this part. We may require you to report these additional test results.

We may ask you to send other information to confirm that your tests were valid under the requirements of this part and 40 CFR parts 1060 and 1065.

* * * * *

(v) Provide the following information about your plans for producing and selling engines:

(1) Identify the estimated initial and final dates for producing engines from the engine family for the model year.

(2) Identify the estimated date for initially introducing certified engines into U.S. commerce under this certificate. ~~We will not release or share any information from your application for certification before this date unless we learn separately that you have already introduced certified engines into U.S. commerce.~~

(3) Include good-faith estimates of U.S.-directed production volumes. Include a justification for the estimated production volumes if they are substantially different than actual production volumes in earlier years for similar models. Also indicate whether you expect the engine family to contain only nonroad engines, only stationary engines, or both.

* * * * *

(x) Include the information required by other subparts of this part. For example, include the information required by §1054.725 if you participate in the ABT program and include the information required by § 1054.690 if you need to post a bond under that section.

* * * * *

252. Amend §1054.220 by revising the section heading to read as follows.

§1054.220 How do I amend my maintenance instructions?

* * * * *

253. Amend §1054.225 by:

a. Revising the section heading and paragraphs (b) and (f) introductory text; and

b. Adding paragraph (g).

The revisions and addition read as follows:

§1054.225 How do I amend my application for certification?

* * * * *

(b) To amend your application for certification, send the relevant information to the Designated Compliance Officer.

(1) Describe in detail the addition or change in the model or configuration you intend to make.

(2) Include engineering evaluations or data showing that the amended emission family complies with all applicable requirements. You may do this by showing that the original emission-data engine or emission-data equipment is still appropriate for showing that the amended family complies with all applicable requirements.

(3) If the original emission-data engine for the engine family is not appropriate to show compliance for the new or modified engine configuration, include new test data showing that the new or modified engine configuration meets the requirements of this part.

(4) Include any other information needed to make your application correct and complete.

* * * * *

~~(e) The amended application applies starting with the date you submit the amended application, as follows:~~

~~(1) For emission families already covered by a certificate of conformity, you may start producing a new or modified configuration anytime after you send us your amended application and before we make a decision under paragraph (d) of this section. However, if we determine that the affected configurations do not meet applicable requirements, we will notify you to cease production of the configurations and may require you to recall the engine or equipment at no expense to the owner. Choosing to produce engines under this paragraph (e) is deemed to be consent to recall all engines or equipment that we determine do not meet applicable emission standards or other requirements and to remedy the nonconformity at no expense to the owner. If you do not provide information required under paragraph (c) of this section within 30 days after we request it, you must stop producing the new or modified engine or equipment.~~
~~(2) If you amend your application to make the amended application correct and complete, these changes do not apply retroactively. Also, if we determine that your amended application is not correct and complete, or otherwise does not conform to the regulation, we will notify you and describe how to address the error.~~
(f) You may ask us to approve a change to your FEL with respect to exhaust emissions in certain cases after the start of production. The changed FEL may not apply to engines you have already introduced into U.S. commerce, except as described in this paragraph (f). If we approve a changed FEL after the start of production, you must identify the month and year for applying the new FEL. You may ask us to approve a change to your FEL in the following cases:
* * * * *

(g) You may produce engines as described in your amended application for certification and consider those engines to be in a certified configuration if we approve a new or modified engine configuration during the model year under paragraph (d) of this section. Similarly, you may modify in-use engines as described in your amended application for certification and consider those engines to be in a certified configuration if we approve a new or modified engine configuration at any time under paragraph (d) of this section. Modifying a new or in-use engine to be in a certified configuration does not violate the tampering prohibition of 40 CFR 1068.101(b)(1), as long as this does not involve changing to a certified configuration with a higher family emission limit.

254. Amend §1054.235 by revising the section heading and paragraphs (a), (b), (c), and (d) to read as follows:

§1054.235 What testing requirements apply for certification?

* * * * *

(a) Select an emission-data engine from each engine family for testing as described in 40 CFR 1065.401. Select a configuration and set adjustable parameters in a way that is most likely to exceed the HC+NOx standard, using good engineering judgment. Configurations must be tested as they will be produced, including installed governors, if applicable.

(b) Test your emission-data engines using the procedures and equipment specified in subpart F of this part. In the case of dual-fuel engines, measure emissions when operating with each type of fuel for which you intend to certify the engine. In the case of flexible-fuel engines, measure emissions when operating with the fuel mixture that is most likely to cause the engine to exceed the applicable HC+NOx emission standard, though you may ask us to instead perform tests with both fuels separately if you can show that intermediate mixtures are not likely to occur in use.

(c) We may perform confirmatory testing by measuring emissions from any of your emission-data engines or other engines from the emission family, as follows:

(1) We may decide to do the testing at your plant or any other facility. If we do this, you must deliver the engine to a test facility we designate. The engine you provide must include appropriate manifolds, aftertreatment devices, electronic control units, and other emission-related components not normally attached directly to the engine block. If we do the testing at your plant, you must schedule it as soon as possible and make available the instruments, personnel, and equipment we need.

(2) If we measure emissions on one of your engines, the results of that testing become the official emission results for the engine.

(3) We may set the adjustable parameters of your engine to any point within the physically adjustable ranges (see §1054.115(b)).

(4) Before we test one of your engines, we may calibrate it within normal production tolerances for anything we do not consider an adjustable parameter. For example, this would apply for a parameter that is subject to production variability because it is adjustable during production, but is not considered an adjustable parameter (as defined in §1054.801) because it is permanently sealed.

(d) You may ask to use carryover emission data from a previous model year instead of doing new tests, but only if all the following are true:

(1) The emission family from the previous model year differs from the current emission family only with respect to model year, items identified in § 1054.225(a), or other

characteristics unrelated to emissions. We may waive this criterion for differences we determine not to be relevant.

(2) The emission-data engine from the previous model year remains the appropriate emission-data engine under paragraph (b) of this section.

(3) The data show that the emission-data engine would meet all the requirements that apply to the emission family covered by the application for certification.

* * * * *

255. Amend §1054.240 by revising paragraphs (a), (b), (c), and (d) to read as follows:

§1054.240 How do I demonstrate that my emission family complies with exhaust emission standards?

(a) For purposes of certification, your emission family is considered in compliance with the emission standards in §1054.101(a) if all emission-data engines representing that family have test results showing official emission results and deteriorated emission levels at or below these standards. This also applies for all test points for emission-data engines within the family used to establish deterioration factors. Note that your FELs are considered to be the applicable emission standards with which you must comply if you participate in the ABT program in subpart H of this part.

(b) Your engine family is deemed not to comply if any emission-data engine representing that family has test results showing an official emission result or a deteriorated emission level for any pollutant that is above an applicable emission standard. This also applies for all test points for emission-data engines within the family used to establish deterioration factors.

(c) Determine a deterioration factor to compare emission levels from the emission-data engine with the applicable emission standards. Section 1054.245 specifies how to test engines to develop deterioration factors that represent the expected deterioration in emissions over your engines' full useful life. Calculate a multiplicative deterioration factor as described in §1054.245(b). If the deterioration factor is less than one, use one. Specify the deterioration factor to one more significant figure than the emission standard. In the case of dual-fuel and flexible-fuel engines, apply deterioration factors separately for each fuel type. You may use assigned deterioration factors that we establish for up to 10,000 nonhandheld engines from small-volume emission families in each model year, except that small-volume engine manufacturers may use assigned deterioration factors for any or all of their engine families.

(d) Determine the official emission result for each pollutant to at least one more decimal place than the applicable standard. Apply the deterioration factor to the official emission result, as described in §1054.245(b), then round the adjusted figure to the same number of decimal places as the emission standard. Compare the rounded emission levels to the emission standard for each emission-data engine. In the case of HC+NOx standards, add the official emission results and apply the deterioration factor to the sum of the pollutants before rounding. However, if your deterioration factors are based on emission measurements that do not cover the engine's full useful life, apply deterioration factors to each pollutant and then add the results before rounding.

* * * * *

256. Amend §1054.245 by:

a. Revising paragraphs (a), (b)(1), (b)(2), (b)(3), (b)(5), and (c); and

b. Adding paragraph (d).

The revisions and addition read as follows:

§1054.245 How do I determine deterioration factors from exhaust durability testing?

* * * * *

(a) You may ask us to approve deterioration factors for an emission family based on emission measurements from similar engines if you have already given us these data for certifying other engines in the same or earlier model years. Use good engineering judgment to decide whether the two engines are similar. We will approve your request if you show us that the emission measurements from other engines reasonably represent in-use deterioration for the engine family for which you have not yet determined deterioration factors.

(b) * * *

(1) Measure emissions from the emission-data engine at a low-hour test point, at the midpoint of the useful life, and at the end of the useful life, except as specifically allowed by this paragraph (b). You may test at additional evenly spaced intermediate points. Collect emission data using measurements to at least one more decimal place than the emission standard.

(2) Operate the engine over a representative duty cycle that is representative of in-use operation for a period at least as long as the useful life (in hours). You may operate the engine continuously. You may also use an engine installed in nonroad equipment to accumulate service hours instead of running the engine only in the laboratory.

(3) In the case of dual-fuel or flexible-fuel engines, you may accumulate service hours on a single emission-data engine using the type or mixture of fuel expected to have the highest combustion and exhaust temperatures; you may ask us to approve a different fuel mixture for flexible-fuel engines if you demonstrate that a different criterion is more appropriate. For dual-fuel engines, you must measure emissions on each fuel type at each test point, either with separate engines dedicated to a given fuel, or with different configurations of a single engine.

* * * * *

(5) Calculate your deterioration factor using a linear least-squares fit of your test data, but treat the low-hour test point as occurring at hour zero. Your deterioration factor is the ratio of the calculated emission level at the point representing the full useful life to the calculated emission level at zero hours, expressed to one more decimal place significant figure than the applicable emission standard.

* * * * *

(c) If you qualify for using assigned deterioration factors under §1054.240, determine the deterioration factors as follows:

(1) For two-stroke engines without aftertreatment, use a deterioration factor of 1.1 for HC, NOx, and CO. For four-stroke engines without aftertreatment, use deterioration factors of 1.4 for HC, 1.0 for NOx, and 1.1 for CO for Class 2 engines, and use 1.5 for HC and NOx, and 1.1 for CO for all other engines.

(2) For Class 2 engines with aftertreatment, use a deterioration factor of 1.0 for NOx. For all other cases involving engines with aftertreatment, calculate separate deterioration factors for HC, NOx, and CO using the following equation:

$$DF = \frac{NE \cdot EDF - CC \cdot F}{NE - CC}$$

Where:

NE = engine-out emission levels (pre-catalyst) from the low-hour test result for a given pollutant, in g/kW-hr.

EDF = the deterioration factor specified in paragraph (c)(1) of this section for the type of engine for a given pollutant.
CC = the catalyst conversion from the low-hour test, in g/kW-hr. This is the difference between the official emission result and *NE*.
F = 1.0 for NOx and 0.8 for HC and CO.

(3) Combine separate deterioration factors for HC and NOx from paragraph (c)(2) of this section into a combined deterioration factor for HC+NOx using the following equation:

$$DF_{\mathrm{HC+NOx}} = \frac{(NE_{\mathrm{HC}} - CC_{\mathrm{HC}}) \cdot DF_{\mathrm{HC}} + (NE_{\mathrm{NOx}} - CC_{\mathrm{NOx}}) \cdot DF_{\mathrm{NOx}}}{(NE_{\mathrm{HC}} - CC_{\mathrm{HC}}) + (NE_{\mathrm{NOx}} - CC_{\mathrm{NOx}})}$$

(d) Include the following information in your application for certification:
(1) If you determine your deterioration factors based on test data from a different emission family, explain why this is appropriate and include all the emission measurements on which you base the deterioration factor.
(2) If you do testing to determine deterioration factors, describe the form and extent of service accumulation, including the method you use to accumulate hours.
(3) If you calculate deterioration factors under paragraph (c) of this section, identify the parameters and variables you used for the calculation.

257. Amend §1054.250 by:
a. Removing and reserving paragraph (a)(3); and
b. Revising paragraphs (b)(3)(iv) and (c).
The revisions read as follows:

§1054.250 What records must I keep and what reports must I send to EPA?

* * * * *
(b) * * *
(3) * * *
(iv) All your emission tests (valid and invalid), including the date and purpose of each test and documentation of test parameters as specified in part 40 CFR part 1065.
* * * * *
(c) Keep required data from emission tests and all other information specified in this section for eight years after we issue your certificate. If you use the same emission data or other information for a later model year, the eight-year period restarts with each year that you continue to rely on the information.
* * * * *

258. Revise §1054.255 to read as follows:

§1054.255 What decisions may EPA make regarding a certificate of conformity?

(a) If we determine an application is complete and shows that the emission family meets all the requirements of this part and the Clean Air Act, we will issue a certificate of conformity for the emission family for that model year. We may make the approval subject to additional conditions.
(b) We may deny an application for certification if we determine that an emission family fails to comply with emission standards or other requirements of this part or the Clean Air Act. We will base our decision on all available information. If we deny an application, we will explain why in writing.

(c) In addition, we may deny your application or suspend or revoke a certificate of conformity if you do any of the following:

(1) Refuse to comply with any testing, reporting, or bonding requirements.

(2) Submit false or incomplete information. This includes doing anything after submitting an application that causes submitted information to be false or incomplete.

(3) Cause any test data to become inaccurate.

(4) Deny us from completing authorized activities (see 40 CFR 1068.20). This includes a failure to provide reasonable assistance.

(5) Produce engines or equipment for importation into the United States at a location where local law prohibits us from carrying out authorized activities.

(6) Fail to supply requested information or amend an application to include all engines or equipment being produced.

(7) Take any action that otherwise circumvents the intent of the Clean Air Act or this part~~, with respect to an emission family~~.

(d) We may void a certificate of conformity ~~for an emission family~~ if you fail to keep records, send reports, or give us information as required under this part or the Clean Air Act. Note that these are also violations of 40 CFR 1068.101(a)(2).

(e) We may void a certificate of conformity ~~for an emission family~~ if we find that you intentionally submitted false or incomplete information. This includes doing anything after submitting your application that causes the submitted information to be false or incomplete.

(f) If we deny an application or suspend, revoke, or void a certificate of conformity, you may ask for a hearing (see §1054.820).

259. Amend §1054.301 by revising paragraph (a)(2) to read as follows:

§1054.301 When must I test my production-line engines?

(a) * * *

(2) We may exempt small-volume emission families from routine testing under this subpart. Submit your request for approval as described in §1054.210. In your request, describe your basis for projecting a production volume below 5,000 units. We will approve your request if we agree that you have made good-faith estimates of your production volumes. You must promptly notify us if your actual production exceeds 5,000 units during the model year. If you exceed the production limit or if there is evidence of a nonconformity, we may require you to test production-line engines under this subpart, or under 40 CFR part 1068, subpart E, even if we have approved an exemption under this paragraph (a)(2).

* * * * *

260. Amend §1054.310 by revising paragraph (a)(1) introductory text, paragraphs (a)(1)(iv), and (c)(2) introductory text to read as follows:

§1054.310 How must I select engines for production-line testing?

(a) * * *

(1) For engine families with projected U.S.-directed production volume of at least 1,600, the test periods are <u>defined as follows</u>~~consecutive quarters (3 months). However, if your annual production period is not 12 months long, you may take the following alternative approach to define quarterly test periods~~:

* * * * *

(iv) If your annual production period is 301 days or longer, divide the annual production period evenly into four test periods. For example, if your annual production period is 392 days (56 weeks), divide the annual production period into four test periods of 98 days (14 weeks).

*   *   *   *   *

(c) *   *   *

(2) Calculate the standard deviation, σ, for the test sample using the following formula:

*   *   *   *   *

261. Amend §1054.315 by revising paragraph (a)(1) to read as follows:

§1054.315 How do I know when my engine family fails the production-line testing requirements?

*   *   *   *   *

(a) *   *   *

(1) *Initial and final test results*. Calculate and round the test results for each engine. If you do multiple tests on an engine in a given configuration (without modifying the engine), calculate the initial results for each test, then add all the test results together and divide by the number of tests. Round this final calculated value for the final test results on that engine.

*   *   *   *   *

262. Amend §1054.320 by adding paragraph (c) to read as follows:

§1054.320 What happens if one of my production-line engines fails to meet emission standards?

*   *   *   *   *

(c) Use test data from a failing engine for the compliance demonstration under §1054.315 as follows:

(1) Use the original, failing test results as described in §1054.315, whether or not you modify the engine or destroy it.

(2) Do not use test results from a modified engine as final test results under §1054.315, unless you change your production process for all engines to match the adjustments you made to the failing engine. If this occurs, count the modified engine as the next engine in the sequence, rather than averaging the results with the testing that occurred before modifying the engine.

263. Amend §1054.501 by revising paragraphs (b)(1) and (2) and paragraph (b)(4) introductory text to read as follows:

§1054.501 How do I run a valid emission test?

*   *   *   *   *

(b) *   *   *

(1) Measure the emissions of all exhaust constituents subject to emission standards as specified in §1054.505 and 40 CFR part 1065. Measure CO_2, N_2O, and CH_4 as described in §1054.235. See §1054.650 for special provisions that apply for variable-speed engines (including engines shipped without governors).

(2) Use the appropriate fuels and lubricants specified in 40 CFR part 1065, subpart H, for all the testing we require in this part. Gasoline test fuel must meet the specifications in 40 CFR 1065.710(c), except as specified in §1054.145(n), 40 CFR 1065.10, and 40 CFR 1065.701. Use gasoline specified for general testing except as specified in paragraph (d) of this section. For service accumulation, use the test fuel or any commercially available fuel that is representative

of the fuel that in-use engines will use. Note that §1054.145(n) allows for testing with gasoline test fuels specified by the California Air Resources Board for any individual engine family.

* * * * *

(4) The provisions of 40 CFR 1065.405 describe how to prepare an engine for testing. However, you may consider emission levels stable without measurement after 12 hours of engine operation, except for the following special provisions that apply for engine families with a useful life of 300 hours or less:

* * * * *

264. Amend §1054.505 by revising paragraph (b)(2) to read as follows:

§1054.505 How do I test engines?

* * * * *

(b) * * *

(2) For nonhandheld engines, use the six-mode duty cycle or the corresponding ramped-modal cycle described in paragraph (b) of Appendix II of this part. Control engine speeds and torques during idle mode as specified in paragraph (c) of this section. Control engine speed during the full-load operating mode as specified in paragraph (d) of this section. For all other modes, control engine speed to within 5 percent of the nominal speed specified in paragraph (d) of this section or let the installed governor (in the production configuration) control engine speed. For all modes except idle, control torque as needed to meet the cycle-validation criteria in paragraph (a)(1) of this section. The governor may be adjusted before emission sampling to target the nominal speed identified in paragraph (d) of this section, but the installed governor must control engine speed throughout the emission-sampling period whether the governor is adjusted or not. Note that ramped-modal testing involves continuous sampling, so governor adjustments may not occur during such a test. Note also that our testing may involve running the engine with the governor in the standard configuration even if you adjust the governor as described in this paragraph (b)(2) for certification or production-line testing.

* * * * *

265. Amend §1054.601 by adding paragraph (d) to read as follows:

§1054.601 What compliance provisions apply?

* * * * *

(d) Subpart C of this part describes how to test and certify dual-fuel and flexible-fuel engines. Some multi-fuel engines may not fit either of those defined terms. For such engines, we will determine whether it is most appropriate to treat them as single-fuel engines, dual-fuel engines, or flexible-fuel engines based on the range of possible and expected fuel mixtures.

266. Amend §1054.612 by revising the introductory text to read as follows:

§1054.612 What special provisions apply for equipment manufacturers modifying certified nonhandheld engines?

The provisions of this section are limited to small-volume emission families.

* * * * *

267. Amend §1054.620 by revising paragraph (c)(2) to read as follows:

§1054.620 What are the provisions for exempting engines used solely for competition?

* * * * *

(c) * * *

(2) Sale of the equipment in which the engine is installed must be limited to professional competition teams, professional competitors, or other qualified competitors. Engine manufacturers may sell loose engines to these same qualified competitors, and to equipment manufacturers supplying competition models for qualified competitors.

* * * * *

§§1054.625 and 1054.626 [Removed]

268. Remove §§1054.625 and 1054.626.

§1054.635 [Amended]

269. Amend §1054.635 by removing and reserving paragraph (c)(6).

§1054.640 [Removed]

270. Remove §1054.640.

271. Revise §1054.655 to read as follows:

§1054.655 What special provisions apply for installing and removing altitude kits?

An action for the purpose of installing or modifying altitude kits and performing other changes to compensate for changing altitude is not considered a prohibited act under 40 CFR 1068.101(b) if it is done consistent with the manufacturer's instructions.

272. Amend §1054.690 by revising paragraphs (f) and (i) to read as follows:

§1054.690 What bond requirements apply for certified engines?

* * * * *

(f) If you are required to post a bond under this section, you must get the bond from a third-party surety that is cited in the U.S. Department of Treasury Circular 570, "Companies Holding Certificates of Authority as Acceptable Sureties on Federal Bonds and as Acceptable Reinsuring Companies" (https://www.fiscal.treasury.gov/surety-bonds/circular-570.html). You must maintain this bond for every year in which you sell certified engines. The surety agent remains responsible for obligations under the bond for two years after the bond is cancelled or expires without being replaced.

* * * * *

(i) If you are required to post a bond under this section, you must note that in your application for certification as described in §1054.205. Your certification is conditioned on your compliance with this section. Your certificate is automatically suspended if you fail to comply with the requirements of this section. This suspension applies with respect to all engines in your possession as well as all engines being imported or otherwise introduced into U.S. commerce. For example, if you maintain a bond sufficient to cover 500 engines, you may introduce into U.S. commerce only 500 engines under your certificate; your certificate would be automatically suspended for any additional engines. Introducing such additional engines into U.S. commerce would violate 40 CFR 1068.101(a)(1). For importation, U.S. Customs may deny entry of engines lacking the necessary bond. This would apply if there is no bond, or if the value of the bond is not sufficient for the appropriate production volumes. We may also revoke your certificate.

* * * * *

273. Amend §1054.701 by revising paragraph (c)(2), paragraph (i) introductory text, and paragraph (i)(1) to read as follows:

§1054.701 General provisions.

*   *   *   *   *

(c) *   *   *

(2) Handheld engines and nonhandheld engines are in separate averaging sets with respect to exhaust emissions except as specified in §1054.740(e). You may use emission credits generated with Phase 2 engines for Phase 3 handheld engines only if you can demonstrate that those credits were generated by handheld engines, except as specified in §1054.740(e). Similarly, you may use emission credits generated with Phase 2 engines for Phase 3 nonhandheld engines only if you can demonstrate that those credits were generated by nonhandheld engines, subject to the provisions of §1054.740.

*   *   *   *   *

(i) As described in §1054.730, compliance with the requirements of this subpart is determined at the end of the model year based on actual U.S.-directed production volumes. Do not include any of the following engines or equipment to calculate emission credits:

(1) Engines or equipment with a permanent exemption under subpart G of this part or under 40 CFR part 1068.

*   *   *   *   *

274. Amend §1054.710 by revising paragraph (c) to read as follows:

§1054.710 How do I average emission credits?

*   *   *   *   *

(c) If you certify a family to an FEL that exceeds the otherwise applicable standard, you must obtain enough emission credits to offset the family's deficit by the due date for the final report required in §1054.730. The emission credits used to address the deficit may come from your other families that generate emission credits in the same model year, from emission credits you have banked from previous model years, or from emission credits generated in the same or previous model years that you obtained through trading.

275. Amend §1054.715 by revising paragraph (b) to read as follows:

§1054.715 How do I bank emission credits?

*   *   *   *   *

(b) You may designate any emission credits you plan to bank in the reports you submit under §1054.730 as reserved credits. During the model year and before the due date for the final report, you may designate your reserved emission credits for averaging or trading.

*   *   *   *   *

276. Amend §1054.725 by revising paragraph (b)(2) to read as follows:

§1054.725 What must I include in my application for certification?

*   *   *   *   *

(b) *   *   *

(2) Detailed calculations of projected emission credits (positive or negative) based on projected production volumes. We may require you to include similar calculations from your other engine families to demonstrate that you will be able to avoid negative credit balances for the model

year. If you project negative emission credits for a family, state the source of positive emission credits you expect to use to offset the negative emission credits.

277. Amend §1054.730 by revising paragraphs (b)(1), (b)(3), (b)(4), (d)(1)(iii), and (d)(2)(iii) to read as follows:

§1054.730 What ABT reports must I send to EPA?

* * * * *

(b) * * *

(1) Family designation and averaging set.

* * * * *

(3) The FEL for each pollutant. If you change the FEL after the start of production, identify the date that you started using the new FEL and/or give the engine identification number for the first engine covered by the new FEL. In this case, identify each applicable FEL and calculate the positive or negative emission credits as specified in §1054.225.

(4) The projected and actual U.S.-directed production volumes for the model year as described in §1054.701(i). For fuel tanks, state the production volume in terms of surface area and production volume for each fuel tank configuration and state the total surface area for the emission family. If you changed an FEL during the model year, identify the actual U.S.-directed production volume associated with each FEL.

* * * * *

(d) * * *

(1) * * *

(iii) The averaging set corresponding to the families that generated emission credits for the trade, including the number of emission credits from each averaging set.

(2) * * *

(iii) How you intend to use the emission credits, including the number of emission credits you intend to apply for each averaging set.

* * * * *

278. Amend §1054.735 by revising paragraphs (a) and (b) to read as follows:

§1054.735 What records must I keep?

(a) You must organize and maintain your records as described in this section.

(b) Keep the records required by this section for at least eight years after the due date for the end-of-year report. You may not use emission credits for any engines or equipment if you do not keep all the records required under this section. You must therefore keep these records to continue to bank valid credits.

* * * * *

279. Amend §1054.740 by revising paragraph (c) and removing and reserving paragraph (d) to read as follows:

§1054.740 What special provisions apply for generating and using emission credits?

* * * * *

(c) You may not use emission credits generated by nonhandheld engines certified to Phase 2 emission standards to demonstrate compliance with the Phase 3 exhaust emission standards in 2014 and later model years.

* * * * *

280. Amend §1054.801 by:
a. Revising the definition for “Designated Compliance Officer”.
b. Removing the definition for “Dual-fuel engine”.
c. Adding a definition for “Dual-fuel” in alphabetical order.
d. Revising the definitions for “Engine configuration” and “Equipment manufacturer”.
e. Removing the definition for “Flexible-fuel engine”.
f. Adding a definition for “Flexible-fuel” in alphabetical order.
g. Revising the definitions for “Fuel type”, “Handheld”, “New nonroad engine”, “New nonroad equipment”, “Nonmethane hydrocarbon”. “Nonroad engine”, “Phase 1”, “Phase 2”, and “Placed into service”.
h. Removing the definition for “Pressurized oil system”.
i. Revising the definitions for “Small-volume emission family”, “Small-volume equipment manufacturer”, “Total hydrocarbon”, and “Total hydrocarbon equivalent”.
The new and revised definitions read as follows:

§1054.801 What definitions apply to this part?

* * * * *

Designated Compliance Officer means the Director, Gasoline Engine Compliance Center, U.S. Environmental Protection Agency, 2000 Traverwood Drive, Ann Arbor, MI 48105; complianceinfo@epa.gov.

* * * * *

Dual-fuel means relating to an engine designed for operation on two different fuels but not on a continuous mixture of those fuels (see §1054.601(d)). For purposes of this part, such an engine remains a dual-fuel engine even if it is designed for operation on three or more different fuels.

* * * * *

Engine configuration means a unique combination of engine hardware and calibration within an emission family. Engines within a single engine configuration differ only with respect to normal production variability or factors unrelated to emissions.

* * * * *

Equipment manufacturer means a manufacturer of nonroad equipment. All nonroad equipment manufacturing entities under the control of the same person are considered to be a single nonroad equipment manufacturer.

* * * * *

Flexible-fuel means relating to an engine designed for operation on any mixture of two or more different fuels (see §1054.601(d)).

* * * * *

Fuel type means a general category of fuels such as gasoline or natural gas. There can be multiple grades within a single fuel type, such as premium gasoline, regular gasoline, or low-level ethanol-gasoline blends.

* * * * *

Handheld means relating to equipment that meets any of the following criteria:
(1) It is carried by the operator throughout the performance of its intended function.
(2) It is designed to operate multi-positionally, such as upside down or sideways, to complete its intended function.
(3) It has a combined engine and equipment dry weight under 16.0 kilograms, has no more than two wheels, and at least one of the following attributes is also present:

(i) The operator provides support or carries the equipment throughout the performance of its intended function. Carry means to completely bear the weight of the equipment, including the engine. Support means to hold a piece of equipment in position to prevent it from falling, slipping, or sinking, without carrying it.
(ii) The operator provides support or attitudinal control for the equipment throughout the performance of its intended function. Attitudinal control involves regulating the horizontal or vertical position of the equipment.
(4) It is an auger with a combined engine and equipment dry weight under 22.0 kilograms.
(5) It is used in a recreational application with a combined total vehicle dry weight under 20.0 kilograms.
(6) It is a hand-supported jackhammer or rammer/compactor. This does not include equipment that can remain upright without operator support, such as a plate compactor.
* * * * *
New nonroad engine means any of the following things:
(1) A freshly manufactured nonroad engine for which the ultimate purchaser has never received the equitable or legal title. This kind of engine might commonly be thought of as "brand new." In the case of this paragraph (1), the engine is new from the time it is produced until the ultimate purchaser receives the title or the product is placed into service, whichever comes first.
(2) An engine originally manufactured as a motor vehicle engine or a stationary engine that is later used or intended to be used in a piece of nonroad equipment. In this case, the engine is no longer a motor vehicle or stationary engine and becomes a "new nonroad engine." The engine is no longer new when it is placed into nonroad service. This paragraph (2) applies if a motor vehicle engine or a stationary engine is installed in nonroad equipment, or if a motor vehicle or a piece of stationary equipment is modified (or moved) to become nonroad equipment.
(3) A nonroad engine that has been previously placed into service in an application we exclude under §1054.5, when that engine is installed in a piece of equipment that is covered by this part 1054. The engine is no longer new when it is placed into nonroad service covered by this part 1054. For example, this would apply to a marine-propulsion engine that is no longer used in a marine vessel but is instead installed in a piece of nonroad equipment subject to the provisions of this part.
(4) An engine not covered by paragraphs (1) through (3) of this definition that is intended to be installed in new nonroad equipment. This generally includes installation of used engines in new equipment. The engine is no longer new when the ultimate purchaser receives a title for the equipment or the product is placed into service, whichever comes first.
(5) An imported nonroad engine, subject to the following provisions:
(i) An imported nonroad engine covered by a certificate of conformity issued under this part that meets the criteria of one or more of paragraphs (1) through (4) of this definition, where the original engine manufacturer holds the certificate, is new as defined by those applicable paragraphs.
(ii) An imported engine that will be covered by a certificate of conformity issued under this part, where someone other than the original engine manufacturer holds the certificate (such as when the engine is modified after its initial assembly), is a new nonroad engine when it is imported. It is no longer new when the ultimate purchaser receives a title for the engine or it is placed into service, whichever comes first.
(iii) An imported nonroad engine that is not covered by a certificate of conformity issued under this part at the time of importation is new. This addresses uncertified engines and equipment

initially placed into service that someone seeks to import into the United States. Importation of this kind of engine (or equipment containing such an engine) is generally prohibited by 40 CFR part 1068. However, the importation of such an engine is not prohibited if the engine has a date of manufacture before January 1, 1997, since it is not subject to standards.

New nonroad equipment means either of the following things:

(1) A nonroad piece of equipment for which the ultimate purchaser has never received the equitable or legal title. The product is no longer new when the ultimate purchaser receives this title or the product is placed into service, whichever comes first.

(2) A nonroad piece of equipment with an engine that becomes new while installed in the equipment. For example, a complete piece of equipment that was imported without being covered by a certificate of conformity would be new nonroad equipment because the engine would be considered new at the time of importation.

* * * * *

Nonmethane hydrocarbon has the meaning given in 40 CFR 1065.1001. This generally means the difference between the emitted mass of total hydrocarbon and the emitted mass of methane.

* * * * *

Nonroad engine has the meaning given in 40 CFR 1068.30. In general, this means all internal-combustion engines except motor vehicle engines, stationary engines, engines used solely for competition, or engines used in aircraft.

* * * * *

Phase 1 means relating to the Phase 1 emission standards described in Appendix I of this part.

Phase 2 means relating to the Phase 2 emission standards described in Appendix I of this part.

* * * * *

Placed into service means put into initial use for its intended purpose. Engines and equipment do not qualify as being “placed into service” based on incidental use by a manufacturer or dealer.

* * * * *

Small-volume emission family means one of the following:

(1) For requirements related to exhaust emissions for nonhandheld engines and to exhaust and evaporative emissions for handheld engines, *small-volume emission family* means any emission family whose U.S.-directed production volume in a given model year is projected at the time of certification to be no more than 5,000 engines or pieces of equipment.

(2) For requirements related to evaporative emissions for nonhandheld equipment, *small-volume emission family* means any equipment manufacturer’s U.S.-directed production volume for identical fuel tank is projected at the time of certification to be no more than 5,000 units. Tanks are generally considered identical if they are produced under a single part number to conform to a single design or blueprint. Tanks should be considered identical if they differ only with respect to production variability, post-production changes (such as different fittings or grommets), supplier, color, or other extraneous design variables.

* * * * *

Small-volume equipment manufacturer means one of the following:

(1) For handheld equipment, an equipment manufacturer that had a U.S.-directed production volume of no more than 25,000 pieces of handheld equipment in any calendar year. For manufacturers owned by a parent company, this production limit applies to the production of the parent company and all its subsidiaries.

(2) For nonhandheld equipment, an equipment manufacturer with annual U.S.-directed production volumes of no more than 5,000 pieces of nonhandheld equipment in any calendar

year. For manufacturers owned by a parent company, this production limit applies to the production of the parent company and all its subsidiaries.
(3) An equipment manufacturer that we designate to be a small-volume equipment manufacturer under § 1054.635.
* * * * *
Total hydrocarbon has the meaning given in 40 CFR 1065.1001. This generally means the combined mass of organic compounds measured by the specified procedure for measuring total hydrocarbon, expressed as an atomic hydrocarbon with an atomic hydrogen-to-carbon ratio of 1.85:1.
Total hydrocarbon equivalent has the meaning given in 40 CFR 1065.1001. This generally means the sum of the carbon mass contributions of non-oxygenated hydrocarbon, alcohols and aldehydes, or other organic compounds that are measured separately as contained in a gas sample, expressed as exhaust hydrocarbon from petroleum-fueled engines. The atomic hydrogen-to-carbon ratio of the equivalent hydrocarbon is 1.85:1.
* * * * *

281. Revise §1054.815 to read as follows:
§1054.815 What provisions apply to confidential information?
The provisions of 40 CFR 1068.10 apply for information you consider confidential.

282. Revise §1054.825 to read as follows:
§1054.825 What reporting and recordkeeping requirements apply under this part?
(a) This part includes various requirements to submit and record data or other information. Unless we specify otherwise, store required records in any format and on any media and keep them readily available for eight years after you send an associated application for certification, or eight years after you generate the data if they do not support an application for certification. We may request these records at any time. You must promptly give us organized, written records in English if we ask for them. This applies whether or not you rely on someone else to keep records on your behalf. We may require you to submit written records in an electronic format.
(b) The regulations in § 1054.255, 40 CFR 1068.25, and 40 CFR 1068.101 describe your obligation to report truthful and complete information. This includes information not related to certification. Failing to properly report information and keep the records we specify violates 40 CFR 1068.101(a)(2), which may involve civil or criminal penalties.
(c) Send all reports and requests for approval to the Designated Compliance Officer (see § 1054.801).
(d) Any written information we require you to send to or receive from another company is deemed to be a required record under this section. Such records are also deemed to be submissions to EPA. We may require you to send us these records ~~whether or not you are a certificate holder~~.
(e) Under the Paperwork Reduction Act (44 U.S.C. 3501 *et seq*.), the Office of Management and Budget approves the reporting and recordkeeping specified in the applicable regulations. The following items illustrate the kind of reporting and recordkeeping we require for engines and equipment regulated under this part:
(1) We specify the following requirements related to engine and equipment certification in this part 1054:

(i) In §1054.20 we require equipment manufacturers to label their equipment if they are relying on component certification.

(ii) In §1054.135 we require engine manufacturers to keep certain records related to duplicate labels sent to equipment manufacturers.

(iii) In §1054.145 we include various reporting and recordkeeping requirements related to interim provisions.

(iv) In subpart C of this part we identify a wide range of information required to certify engines.

(v) In §§1054.345 and 1054.350 we specify certain records related to production-line testing.

(vi) [Reserved]

(vii) In subpart G of this part we identify several reporting and recordkeeping items for making demonstrations and getting approval related to various special compliance provisions.

(viii) In §§1054.725, 1054.730, and 1054.735 we specify certain records related to averaging, banking, and trading.

(2) We specify the following requirements related to component and equipment certification in 40 CFR part 1060:

(i) In 40 CFR 1060.20 we give an overview of principles for reporting information.

(ii) In 40 CFR part 1060, subpart C, we identify a wide range of information required to certify products.

(iii) In 40 CFR 1060.301 we require manufacturers to keep records related to evaluation of production samples for verifying that the products are as specified in the certificate of conformity.

(iv) In 40 CFR 1060.310 we require manufacturers to make components, engines, or equipment available for our testing if we make such a request.

(~~i~~v) In 40 CFR 1060.505 we specify information needs for establishing various changes to published test procedures.

(3) We specify the following requirements related to testing in 40 CFR part 1065:

(i) In 40 CFR 1065.2 we give an overview of principles for reporting information.

(ii) In 40 CFR 1065.10 and 1065.12 we specify information needs for establishing various changes to published test procedures.

(iii) In 40 CFR 1065.25 we establish basic guidelines for storing test information.

(iv) In 40 CFR 1065.695 we identify the specific information and data items to record when measuring emissions.

(4) We specify the following requirements related to the general compliance provisions in 40 CFR part 1068:

(i) In 40 CFR 1068.5 we establish a process for evaluating good engineering judgment related to testing and certification.

(ii) In 40 CFR 1068.25 we describe general provisions related to sending and keeping information.

(iii) In 40 CFR 1068.27 we require manufacturers to make engines available for our testing or inspection if we make such a request.

(iv) In 40 CFR 1068.105 we require equipment manufacturers to keep certain records related to duplicate labels from engine manufacturers.

(v) In 40 CFR 1068.120 we specify recordkeeping related to rebuilding engines.

(vi) In 40 CFR part 1068, subpart C, we identify several reporting and recordkeeping items for making demonstrations and getting approval related to various exemptions.
(vii) In 40 CFR part 1068, subpart D, we identify several reporting and recordkeeping items for making demonstrations and getting approval related to importing engines.
(viii) In 40 CFR 1068.450 and 1068.455 we specify certain records related to testing production-line engines in a selective enforcement audit.
(ix) In 40 CFR 1068.501 we specify certain records related to investigating and reporting emission-related defects.
(x) In 40 CFR 1068.525 and 1068.530 we specify certain records related to recalling nonconforming engines.
(xi) In 40 CFR part 1068, subpart G, we specify certain records for requesting a hearing.

283. Revise Appendix I to part 1054 to read as follows:

Appendix I to Part 1054—Summary of Previous Emission Standards

The following standards, which EPA originally adopted under 40 CFR part 90, apply to nonroad spark-ignition engines produced before the model years specified in §1054.1:

(a) *Handheld engines*. (1) Phase 1 standards apply for handheld engines as summarized in the following table starting with model year 1997:

Table 1 to Appendix I—Phase 1 Emission Standards for Handheld Engines (g/kW-hr)[a]

Engine displacement class	HC	NOx	CO
Class III	295	5.36	805
Class IV	241	5.36	805
Class V	161	5.36	603

[a] Phase 1 standards are based on testing with new engines only.

(2) Phase 2 standards apply for handheld engines as summarized in the following table starting with model year 2002 for Class III and Class IV, and starting in model year 2004 for Class V:

Table 2 to Appendix I—Phase 2 Emission Standards for Handheld Engines (g/kW-hr)

Engine displacement class	HC + NOx	CO
Class III	50[a]	805
Class IV	50[b]	805
Class V	72[c]	603

[a]Class III engines had alternate HC+NOx standards of 238, 175, and 113 for model years 2002, 2003, and 2004, respectively.
[b]Class IV engines had alternate HC+NOx standards of 196, 148, and 99 for model years 2002, 2003, and 2004, respectively.
[c]Class V engines had alternate HC+NOx standards of 143, 119, and 96 for model years 2004, 2005, and 2006, respectively.

(b) *Nonhandheld engines*. (1) Phase 1 standards apply for nonhandheld engines as summarized in the following table starting with model year 1997:

Table 3 to Appendix I—Phase 1 Emission Standards for Nonhandheld Engines (g/kW-hr)[a]

Engine displacement class	HC + NOx	CO
Class I	16.1	519
Class II	13.4	519

[a]Phase 1 standards are based on testing with new engines only.

(2) Phase 2 standards apply for nonhandheld engines as summarized in the following table starting with model year 2001 (except as noted for Class I engines):

Table 4 to Appendix I—Phase 2 Emission Standards for Nonhandheld Engines (g/kW-hr)

Engine displacement class	HC + NOx	NMHC + NOx	CO
Class I-A	50	—	610
Class I-B	40	37	610
Class I[a]	16.1	14.8	610
Class II[b]	12.1	11.3	610

[a]The Phase 2 standards for Class I engines apply for new engines produced starting August 1, 2007, and for any engines belonging to an engine model whose original production date was on or after August 1, 2003.

[b]Class II engines had alternate HC+NOx standards of 18.0, 16.6, 15.0, 13.6 and alternate NMHC+NOx standards of 16.7, 15.3, 14.0, 12.7 for model years 2001 through 2004, respectively.

(3) Note that engines subject to Phase 1 standards were not subject to useful life provisions as specified in §1054.107. In addition, engines subject to Phase 1 standards and engines subject to Phase 2 standards were both not subject to the following provisions:

(i) Evaporative emission standards as specified in §§1054.110 and 1054.112.

(ii) Altitude adjustments as specified in §1054.115(c).

(iii) Warranty assurance provisions as specified in §1054.120(f).

(iv) Emission-related installation instructions as specified in §1054.130.

(v) Bonding requirements as specified in §1054.690.

284. Revise paragraph (b)(2) of Appendix II to part 1054 to read as follows:

Appendix II to Part 1054— Duty Cycles for Laboratory Testing

* * * * *

(b) * * *

(2) The following duty cycle applies for ramped-modal testing:

RMC Mode [a]	**Time in mode (seconds)**	**Torque (percent)** [b, c]
1a Steady-state	41	0
1b Transition	20	Linear transition
2a Steady-state	135	100
2b Transition	20	Linear transition
3a Steady-state	112	10
3b Transition	20	Linear transition
4a Steady-state	337	75
4b Transition	20	Linear transition
5a Steady-state	518	25
5b Transition	20	Linear transition
6a Steady-state	494	50
6b Transition	20	Linear transition
7 Steady-state	43	0

[a]Control engine speed as described in §1054.505. Control engine speed for Mode 6 as described in §1054.505(c) for idle operation.

[b]Advance from one mode to the next within a 20-second transition phase. During the transition phase, command a linear progression from the torque setting of the current mode to the torque setting of the next mode.

[c]The percent torque is relative to the value established for full-load torque, as described in §1054.505.

PART 1060—CONTROL OF EVAPORATIVE EMISSIONS FROM NEW AND IN-USE NONROAD AND STATIONARY EQUIPMENT

285. The authority citation for part 1060 continues to read as follows:
Authority: 42 U.S.C. 7401-7671q.

286. Amend §1060.1 by revising paragraphs (a)(8), (c), and (d) to read as follows:

§1060.1 Which products are subject to this part's requirements?

(a) * * *

(8) Portable nonroad fuel tanks are considered portable marine fuel tanks for purposes of this part 1060. Portable nonroad fuel tanks and fuel lines associated with such fuel tanks must therefore meet evaporative emission standards specified in 40 CFR 1045.112, whether or not they are used with marine vessels.

* * * * *

(c) Fuel caps are subject to evaporative emission standards at the point of installation on a fuel tank. When a fuel cap is certified for use with Marine SI engines or Small SI engines under the optional standards of §1060.103, it becomes subject to all the requirements of this part 1060 as if these optional standards were mandatory.

(d) This part 1060 does not apply to any diesel-fueled engine or any other engine that does not use a volatile liquid fuel. In addition, this part does not apply to any engines or equipment in the following categories even if they use a volatile liquid fuel:

(1) Light-duty motor vehicles (see 40 CFR part 86).

(2) Heavy-duty motor vehicles and heavy-duty motor vehicle engines (see 40 CFR part 86). This part 1060 also does not apply to fuel systems for nonroad engines where such fuel systems are subject to part 86 because they are part of a heavy-duty motor vehicle.

(3) Aircraft engines (see 40 CFR part 87).

(4) Locomotives (see 40 CFR part 1033).

* * * * *

287. Amend §1060.5 by revising paragraph (a)(1) to read as follows:

§1060.5 Do the requirements of this part apply to me?

* * * * *

(a) * * *

(1) Each person meeting the definition of manufacturer for a product that is subject to the standards and other requirements of this part must comply with such requirements. However, if one person complies with a specific requirement for a given product, then all manufacturers are deemed to have complied with that specific requirement. For example, if a Small SI equipment manufacturer uses fuel lines manufactured and certified by another company, the equipment manufacturer is not required to obtain its own certificate with respect to the fuel line emission standards. Such an equipment manufacturer remains subject to the standards and other requirements of this part. However, where a provision requires a specific manufacturer to comply with certain provisions, this paragraph (a) does not change or modify such a requirement. For example, this paragraph (a) does not allow you to rely on another company to certify instead of you if we specifically require you to certify.

* * * * *

288. Revise §1060.30 to read as follows:

§1060.30 Submission of information.
Unless we specify otherwise, send all reports and requests for approval to the Designated Compliance Officer (see § 1060.801). See § 1060.825 for additional reporting and recordkeeping provisions.

289. Amend §1060.104 by revising paragraph (b)(3) to read as follows:
§1060.104 What running loss emission control requirements apply?
* * * * *
(b) * * *
(3) Get an approved Executive Order or other written approval from the California Air Resources Board showing that your system meets applicable running loss standards in California.
* * * * *

290. Amend §1060.105 by revising paragraphs (c)(1) and (e) to read as follows:
§1060.105 What diurnal requirements apply for equipment?
* * * * *
(c) * * *
(1) They must be self-sealing when detached from the engines. The tanks may not vent to the atmosphere when attached to an engine, except as allowed under paragraph (c)(2) of this section. An integrated or external manually activated device may be included in the fuel tank design to temporarily relieve pressure before refueling or connecting the fuel tank to the engine. However, the default setting for such a vent must be consistent with the requirement in paragraph (c)(2) of this section.
* * * * *
(e) Manufacturers of nonhandheld Small SI equipment may optionally meet the diurnal emission standards adopted by the California Air Resources Board. To meet this requirement, equipment must be certified to the performance standards specified in Title 13 CCR §2754(a) based on the applicable requirements specified in CP-902 and TP-902, including the requirements related to fuel caps in Title 13 CCR §2756. Equipment certified under this paragraph (e) does not need to use fuel lines or fuel tanks that have been certified separately. Equipment certified under this paragraph (e) are subject to all the referenced requirements as if these specifications were mandatory.
* * * * *

291 Amend §1060.120 by revising paragraphs (b) and (c) to read as follows:
§1060.120 What emission-related warranty requirements apply?
* * * * *
(b) *Warranty period*. Your emission-related warranty must be valid for at least two years from the date the equipment is sold to the ultimate purchaser.
(c) *Components covered*. The emission-related warranty covers all components whose failure would increase the evaporative emissions, including those listed in 40 CFR part 1068, Appendix I, and those from any other system you develop to control emissions. Your emission-related warranty does not need to cover components whose failure would not increase evaporative emissions.
* * * * *

292 Amend §1060.130 by revising paragraph (b)(3) to read as follows:

§1060.130 What installation instructions must I give to equipment manufacturers?

* * * * *

(b) * * *

(3) Describe how your certification is limited for any type of application. For example:

(i) For fuel tanks sold without fuel caps, you must specify the requirements for the fuel cap, such as the allowable materials, thread pattern, how it must seal, etc. You must also include instructions to tether the fuel cap as described in §1060.101(f)(1) if you do not sell your fuel tanks with tethered fuel caps. The following instructions apply for specifying a certain level of emission control for fuel caps that will be installed on your fuel tanks:

(A) If your testing involves a default emission value for fuel cap permeation as specified in §1060.520(b)(5)(ii)(C), specify in your installation instructions that installed fuel caps must either be certified with a Family Emission Limit at or below 30 g/m2/day, or have gaskets made of certain materials meeting the definition of "low-permeability material" in §1060.801.

(B) If you certify your fuel tanks based on a fuel cap certified with a Family Emission Limit above 30 g/m2/day, specify in your installation instructions that installed fuel caps must either be certified with a Family Emission Limit at or below the level you used for certifying your fuel tanks, or have gaskets made of certain materials meeting the definition of "low-permeability material" in §1060.801.

(ii) If your fuel lines do not meet permeation standards specified in §1060.102 for EPA Low-Emission Fuel Lines, tell equipment manufacturers not to install the fuel lines with Large SI engines that operate on gasoline or another volatile liquid fuel.

* * * * *

293. Amend §1060.135 by revising the introductory text and paragraphs (a), (b) introductory text, (b)(2), (b)(3), and (b)(4) to read as follows:

§1060.135 How must I label and identify the engines and equipment I produce?

The labeling requirements of this section apply for all equipment manufacturers that are required to certify their equipment or use certified fuel-system components. Note that engine manufacturers are also considered equipment manufacturers if they install <u>a complete fuel system on an </u>engine~~s in equipment~~. See §1060.137 for the labeling requirements that apply separately for fuel lines, fuel tanks, and other fuel-system components.

(a) At the time of manufacture, you must affix a permanent and legible label identifying each engine or piece of equipment. The label must be–

(1) Attached in one piece so it is not removable without being destroyed or defaced.

(2) Secured to a part of the engine or equipment needed for normal operation and not normally requiring replacement.

(3) Durable and readable for the equipment's entire life.

(4) Written in English.

(5) Readily visible in the final installation. It may be under a hinged door or other readily opened cover. It may not be hidden by any cover attached with screws or any similar designs. Labels on marine vessels (except personal watercraft) must be visible from the helm.

(b) If you hold a certificate under this part for your engine or equipment, the engine or equipment label specified in paragraph (a) of this section must–

* * * * *(1) Include the heading "EMISSION CONTROL INFORMATION".

(2) Include your corporate name and trademark. You may identify another company and use its trademark instead of yours if you comply with the branding provisions of 40 CFR 1068.45.

(3) State the date of manufacture [MONTH and YEAR] of the equipment; however, you may omit this from the label if you stamp, engrave, or otherwise permanently identify it elsewhere on the equipment, in which case you must also describe in your application for certification where you will identify the date on the equipment.

(4) State: "THIS [equipment, vehicle, boat, etc.] MEETS U.S. EPA EVAP STANDARDS."

(5) Identify the emission family on the label using EPA's standardized designation or an abbreviated equipment code that you establish in your application for certification. Equipment manufacturers that also certify their engines with respect to exhaust emissions may use the same emission family name for both exhaust and evaporative emissions.

* * * * *

294. Amend §1060.137 by revising paragraphs (a)(4) and (c)(1) to read as follows:

§1060.137 How must I label and identify the fuel-system components I produce?

* * * * *

(a) * * *

(4) Fuel caps, as described in this paragraph (a)(4). Fuel caps must be labeled if they are separately certified under §1060.103. If the equipment has a diurnal control system that requires the fuel tank to hold pressure, identify the part number on the fuel cap.

* * * * *

(c) * * *

(1) Include your corporate name. You may identify another company instead of yours if you comply with the provisions of 40 CFR 1068.45.

* * * * *

295. Amend §1060.205 by revising paragraphs (a) and (m) to read as follows:

§1060.205 What must I include in my application?

* * * * *

(a) Describe the emission family's specifications and other basic parameters of the emission controls. Describe how you meet the running loss emission control requirements in §1060.104, if applicable. Describe how you meet any applicable equipment-based requirements of §1060.101(e) and (f). State whether you are requesting certification for gasoline or some other fuel type. List each distinguishable configuration in the emission family. For equipment that relies on one or more certified components, identify the EPA-issued emission family name for all the certified components and any associated component codes.

* * * * *

(m) Report all valid test results. Also indicate whether there are test results from invalid tests or from any other tests of the emission-data unit, whether or not they were conducted according to the test procedures of subpart F of this part. We may require you to report these additional test results. We may ask you to send other information to confirm that your tests were valid under the requirements of this part.

* * * * *

296. Amend §1060.225 by revising paragraphs (b) and (g) and adding paragraph (h) to read as follows:

§1060.225 How do I amend my application for certification?

* * * * *

(b) To amend your application for certification, send the relevant information to the Designated Compliance Officer.

(1) Describe in detail the addition or change in the configuration you intend to make.

(2) Include engineering evaluations or data showing that the amended emission family complies with all applicable requirements. You may do this by showing that the original emission data are still appropriate for showing that the amended family complies with all applicable requirements.

(3) If the original emission data for the emission family are not appropriate to show compliance for the new or modified configuration, include new test data showing that the new or modified configuration meets the requirements of this part.

(4) Include any other information needed to make your application correct and complete.

* * * * *

~~(e) The amended application applies starting with the date you submit the amended application, as follows:~~

~~(1) For emission families already covered by a certificate of conformity, you may start producing a new or modified configuration anytime after you send us your amended application and before we make a decision under paragraph (d) of this section. However, if we determine that the affected configurations do not meet applicable requirements, we will notify you to cease production of the configurations and may require you to recall the equipment at no expense to the owner. Choosing to produce equipment under this paragraph (e) is deemed to be consent to recall all equipment that we determine do not meet applicable emission standards or other requirements and to remedy the nonconformity at no expense to the owner. If you do not provide information we request under paragraph (c) of this section within 30 days after we request it, you must stop producing the new or modified equipment.~~

~~(2) If you amend your application to make the amended application correct and complete, these changes do not apply retroactively. Also, if we determine that your amended application is not correct and complete, or otherwise does not conform to the regulation, we will notify you and describe how to address the error.~~

* * * * *

(g) You may produce equipment or components as described in your amended application for certification and consider those equipment or components to be in a certified configuration if we approve a new or modified configuration during the model year or production period under paragraph (d) of this section. Similarly, you may modify in-use products as described in your amended application for certification and consider those products to be in a certified configuration if we approve a new or modified configuration at any time under paragraph (d) of this section. Modifying a new or in-use product to be in a certified configuration does not violate the tampering prohibition of 40 CFR 1068.101(b)(1), as long as this does not involve changing to a certified configuration with a higher family emission limit.

(h) Component manufacturers may not change an emission family's FEL under any circumstances. Changing the FEL would require submission of a new application for certification.

297. Amend §1060.230 by revising paragraph (d)(2) to read as follows:

§1060.230 How do I select emission families?

* * * * *

(d) * * *

(2) Type of material (such as type of charcoal used in a carbon canister). This criterion does not apply for materials that are unrelated to emission control performance.

* * * * *

298. Amend §1060.235 by:

a. Revising the section heading;

b. Redesignating paragraph (a) as (h).

c. Redesignating paragraph (b) as paragraph (a) and paragraph (h) as paragraph (b);

c. Revising paragraphs (d) and (e)(1).

The revisions read as follows:

§1060.235 What testing requirements apply for certification?

* * * * *

(d) We may perform confirmatory testing by measuring emissions from any of your products from the emission family, as follows:

(1) You must supply your products to us if we choose to perform confirmatory testing. We may require you to deliver your test articles to a facility we designate for our testing.

(2) If we measure emissions on one of your products, the results of that testing become the official emission results for the emission family. Unless we later invalidate these data, we may decide not to consider your data in determining if your emission family meets applicable requirements.

(e) * * *

(1) The emission family from the previous production period differs from the current emission family only with respect to production period, items identified in § 1060.225(a), or other characteristics unrelated to emissions. We may waive this criterion for differences we determine not to be relevant.

* * * * *

299. Amend §1060.240 by revising paragraph (e)(2)(i) to read as follows:

§1060.240 How do I demonstrate that my emission family complies with evaporative emission standards?

* * * * *

(e) * * *

(2) * * *

(i) You may use the measurement procedures specified by the California Air Resources Board in Attachment 1 to TP-902 to show that canister working capacity is least 3.6 grams of vapor storage capacity per gallon of nominal fuel tank capacity (or 1.4 grams of vapor storage capacity per gallon of nominal fuel tank capacity for fuel tanks used in nontrailerable boats).

* * * * *

300. Amend §1060.250 by revising paragraphs (a)(3)(ii) and (b) to read as follows:

§1060.250 What records must I keep?

(a) * * *

(3) * * *

(ii) All your emission tests (valid and invalid), including the date and purpose of each test and documentation of test parameters described in subpart F of this part.

* * * * *

(b) Keep required data from emission tests and all other information specified in this section for eight years after we issue your certificate. If you use the same emission data or other information for a later model year, the eight-year period restarts with each year that you continue to rely on the information.

* * * * *

301. Revise §1060.255 to read as follows:

§1060.255 What decisions may EPA make regarding a certificate of conformity?

(a) If we determine an application is complete and shows that the emission family meets all the requirements of this part and the Clean Air Act, we will issue a certificate of conformity for the emission family for that production period. We may make the approval subject to additional conditions.

(b) We may deny an application for certification if we determine that an emission family fails to comply with emission standards or other requirements of this part or the Clean Air Act. We will base our decision on all available information. If we deny an application, we will explain why in writing.

(c) In addition, we may deny your application or suspend or revoke a certificate of conformity if you do any of the following:

(1) Refuse to comply with any testing or reporting requirements.

(2) Submit false or incomplete information. This includes doing anything after submitting an application that causes submitted information to be false or incomplete.

(3) Cause any test data to become inaccurate.

(4) Deny us from completing authorized activities (see 40 CFR 1068.20). This includes a failure to provide reasonable assistance.

(5) Produce equipment or components for importation into the United States at a location where local law prohibits us from carrying out authorized activities.

(6) Fail to supply requested information or amend an application to include all equipment or components being produced.

(7) Take any action that otherwise circumvents the intent of the Clean Air Act or this part~~, with respect to an emission family~~.

(d) We may void a certificate of conformity ~~for an emission family~~ if you fail to keep records, send reports, or give us information as required under this part or the Clean Air Act. Note that these are also violations of 40 CFR 1068.101(a)(2).

(e) We may void a certificate of conformity ~~for an emission family~~ if we find that you intentionally submitted false or incomplete information. This includes doing anything after submitting an application that causes submitted information to be false or incomplete.

(f) If we deny an application or suspend, revoke, or void a certificate of conformity, you may ask for a hearing (see §1060.820).

302. Amend §1060.501 by revising paragraph (c) to read as follows:

§1060.501 General testing provisions.

* * * * *

(c) The specification for gasoline to be used for testing is given in 40 CFR 1065.710(b) or (c). Use the grade of gasoline specified for general testing. For testing specified in this part that requires blending gasoline and ethanol, blend this grade of neat gasoline with fuel-grade ethanol meeting the specifications of ASTM D4806 (incorporated by reference in §1060.810). You do not need to measure the ethanol concentration of such blended fuels and may instead calculate the blended composition by assuming that the ethanol is pure and mixes perfectly with the base fuel. For example, if you mix 10.0 liters of fuel-grade ethanol with 90.0 liters of gasoline, you may assume the resulting mixture is 10.0 percent ethanol. You may use more pure or less pure ethanol if you can demonstrate that it will not affect your ability to demonstrate compliance with the applicable emission standards. Note that unless we specify otherwise, any references to gasoline-ethanol mixtures containing a specified ethanol concentration means mixtures meeting the provisions of this paragraph (c). The following table summarizes test fuel requirements for the procedures specified in this subpart:

Procedure	**Reference**	**Test Fuel**[1][a]
Low-Emission Fuel Lines	§1060.510	CE10
Nonroad Fuel Lines	§1060.515	CE10[2][b]
Cold-Weather Fuel Lines	§1060.515	Splash-blended E10
Fuel tank and fuel cap permeation	§1060.520	Splash-blended E10; manufacturers may instead use CE10
Diurnal	§1060.525	E0

[a][1]Pre-mixed gasoline blends are specified in 40 CFR 1065.710(b). Splash-blended gasoline blends are a mix of neat gasoline specified in 40 CFR 1065.710(c) and fuel-grade ethanol.

[b][2]Different fuel specifications apply for fuel lines tested under 40 CFR part 1051 for recreational vehicles, as described in 40 CFR 1051.501.

* * * * *

303. Amend §1060.505 by revising paragraph (c)(3) to read as follows:

§1060.505 Other procedures.

* * * * *

(c) * * *

(3) You may request to use alternate procedures that are equivalent to the specified procedures, or procedures that are more accurate or more precise than the specified procedures. We may perform tests with your equipment using either the approved alternate procedures or the specified procedures. See 40 CFR 1065.12 for a description of the information that is generally required for such alternate procedures.

* * * * *

304. Amend §1060.515 by revising paragraph (a)(2) to read as follows:

§1060.515 How do I test EPA Nonroad Fuel Lines and EPA Cold-Weather Fuel Lines for permeation emissions?

* * * * *

(a) * * *

(2) For EPA Cold-Weather Fuel Lines, use gasoline blended with ethanol as described in §1060.501(c).

* * * * *

305. Amend §1060.520 by revising paragraphs (a), (b)(1), (b)(4), (d)(3), (d)(6), (d)(8)(ii), (d)(9), and (e) to read as follows:

§1060.520 How do I test fuel tanks for permeation emissions?

* * * * *

(a) *Preconditioning durability testing*. Take the following steps before an emission test, in any order, if your emission control technology involves surface treatment or other post-processing treatments such as an epoxy coating:

(1) *Pressure cycling*. Perform a pressure test by sealing the fuel tank and cycling it between +13.8 and -3.4 kPa (+2.0 and -0.5 psig) for 10,000 cycles at a rate of 60 seconds per cycle. The purpose of this test is to represent environmental wall stresses caused by pressure changes and other factors (such as vibration or thermal expansion). If your fuel tank cannot be tested using the pressure cycles specified by this paragraph (a)(1), you may ask to use special test procedures under §1060.505.

(2) *UV exposure*. Perform a sunlight-exposure test by exposing the fuel tank to an ultraviolet light of at least 24 W/m2 (0.40 W-hr/m2/min) on the fuel tank surface for at least 450 hours. Alternatively, the fuel tank may be exposed to direct natural sunlight for an equivalent period of time as long as you ensure that the fuel tank is exposed to at least 450 daylight hours.

(3) *Slosh testing*. Perform a slosh test by filling the fuel tank to 40-50 percent of its capacity with the fuel specified in paragraph (e) of this section and rocking it at a rate of 15 cycles per minute until you reach one million total cycles. Use an angle deviation of +15° to -15° from level. Take steps to ensure that the fuel remains at 40-50 percent of its capacity throughout the test run.

(4) *Cap testing*. Perform durability cycles on fuel caps intended for use with handheld equipment by putting the fuel cap on and taking it off 300 times. Tighten the fuel cap each time in a way that represents the typical in-use experience.

(b) * * *

(1) Fill the fuel tank to its nominal capacity with the fuel specified in paragraph (e) of this section, seal it, and allow it to soak at 28±5 °C for at least 20 weeks. Alternatively, the fuel tank may be soaked for at least 10 weeks at 43 5 °C. You may count the time of the preconditioning steps in paragraph (a) of this section as part of the preconditioning fuel soak as long as the ambient temperature remains within the specified temperature range and the fuel tank continues to be at least 40 percent full throughout the test; you may add or replace fuel as needed to conduct the specified durability procedures. Void the test if you determine that the fuel tank has any kind of leak.

* * * * *

(4) Allow the fuel tank and its contents to equilibrate to the temperatures specified in paragraph (d)(7) of this section. Seal the fuel tank as described in paragraph (b)(5) of this section once the fuel temperatures are stabilized at the test temperature. You must seal the fuel tank no more than eight hours after refueling. Until the fuel tank is sealed, take steps to minimize the vapor losses from the fuel tank, such as keeping the fuel cap loose on the fuel inlet or routing vapors through a vent hose.

* * * * *

(d) * * *

(3) Carefully place the test tank within a temperature-controlled room or enclosure. Do not spill or add any fuel.

* * * * *

(6) Leave the test tank in the room or enclosure for the duration of the test run, except that you may remove the tank for up to 30 minutes at a time to meet weighing requirements.

* * * * *

(8) * * *

(ii) If after ten days of testing your r2 value is below 0.95 and your measured value is more than 50 percent of the applicable standard, continue testing for a total of 20 days or until r2 is at or above 0.95. If r2 is not at or above 0.95 within 20 days of testing, discontinue the test and precondition the test tank further until it has stabilized emission levels, then repeat the testing.

(9) Record the difference in mass between the reference tank and the test tank for each measurement. This value is Mi, where i is a counter representing the number of days elapsed. Subtract Mi from Mo and divide the difference by the internal surface area of the fuel tank. Divide this g/m2 value by the number of test days (using at least two decimal places) to calculate the emission rate in g/m2/day. Example: If a fuel tank with an internal surface area of 0.720 m2 weighed 1.31 grams less than the reference tank at the beginning of the test and weighed 9.86 grams less than the reference tank after soaking for 10.03 days, the emission rate would be-

((-1.31 g) - (-9.86 g)) / 0.720 m2 / 10.03 days = 1.1839 g/m2/day

* * * * *

(e) *Fuel specifications*. Use a low-level ethanol-gasoline blend as specified in §1060.501(c). As an alternative, you may use Fuel CE10, as described in §1060.515(a)(1).

* * * * *

306. Amend §1060.525 by revising paragraph (a)(2) to read as follows:

§1060.525 How do I test fuel systems for diurnal emissions?

* * * * *

(a) * *

(2) Fill the fuel tank to 40 percent of nominal capacity with the gasoline specified in 40 CFR 1065.710(c) for general testing.

* * * * *

307. Amend §1060.601 by revising paragraphs (a) and (b)(2) to read as follows:

§1060.601 How do the prohibitions of 40 CFR 1068.101 apply with respect to the requirements of this part?

(a) As described in §1060.1, fuel tanks and fuel lines that are used with or intended to be used with new nonroad engines or equipment are subject to evaporative emission standards under this part 1060. This includes portable marine fuel tanks and fuel lines and other fuel-system components associated with portable marine fuel tanks. Note that §1060.1 specifies an implementation schedule based on the date of manufacture of nonroad equipment, so new fuel tanks and fuel lines are not subject to standards under this part 1060 if they will be installed for use in equipment built before the specified dates for implementing the appropriate standards, subject to the limitations in paragraph (b) of this section. Except as specified in paragraph (f) of this section, fuel-system components that are subject to permeation or diurnal emission standards under this part 1060 must be covered by a valid certificate of conformity before being introduced into U.S. commerce to avoid violating the prohibition of 40 CFR 1068.101(a). To the extent we allow it under the exhaust standard-setting part, fuel-system components may be certified with a family emission limit higher than the specified emission standard.

(b) * * *

(2) *Applicability of standards after January 1, 2020*. Starting January 1, 2020, it is presumed that replacement components will be used with nonroad engines regulated under this part 1060 if they can reasonably be used with such engines. Manufacturers, distributors, retailers, and importers are therefore obligated to take reasonable steps to ensure that any uncertified components are not used to replace certified components. This would require labeling the components and may also require restricting the sales and requiring the ultimate purchaser to agree to not use the components inappropriately. This requirement does not apply for components that are clearly not intended for use with fuels.

* * * * *

308. Add §1060.610 to subpart G to read as follows:

§1060.610 Temporary exemptions for manufacturing and assembling equipment and fuel-system components.

(a) If you are a certificate holder, you may ship components or equipment requiring further assembly between two of your facilities, subject to the provisions of this paragraph (a). Unless we approve otherwise, you must maintain ownership and control of the products until they reach their destination. We may allow for shipment where you do not maintain actual ownership and control of the engines (such as hiring a shipping company to transport the products) but only if you demonstrate that the products will be transported only according to your specifications. Notify us of your intent to use this exemption in your application for certification, if applicable. Your exemption is effective when we grant your certificate. You may alternatively request an exemption in a separate submission; for example, this would be necessary if you will not be the certificate holder for the products in question. We may require you to take specific steps to ensure that such products are in a certified configuration before reaching the ultimate purchaser. Note that since this is a temporary exemption, it does not allow you to sell or otherwise distribute equipment in an uncertified configuration to ultimate purchasers. Note also that the exempted equipment remains new and subject to emission standards until its title is transferred to the ultimate purchaser or it otherwise ceases to be new.

(b) If you certify equipment, you may ask us at the time of certification for an exemption to allow you to ship your equipment without a complete fuel system. We will generally approve this only if you can demonstrate that the exemption is necessary and that you will take steps to ensure that equipment assembly will be properly completed before reaching the ultimate purchaser. We may specify conditions that we determine are needed to ensure that shipping the equipment without such components will not result in the equipment operating with uncertified components or otherwise in an uncertified configuration. For example, we may require that you ship the equipment to manufacturers that are contractually obligated to install certain components. See 40 CFR 1068.261.

§1060.640 [Removed]

309. Remove §1060.640.

310. Amend §1060.801 by revising the definitions for “Configuration”, “Designated Compliance Officer”, “Fuel type”, “Model year”, “Placed into service”, “Portable nonroad fuel tank”, and “Small SI” to read as follows:

§1060.801 What definitions apply to this part?

* * * * *

Configuration means a unique combination of hardware (material, geometry, and size) and calibration within an emission family. Units within a single configuration differ only with respect to normal production variability or factors unrelated to emissions.

* * * * *

Designated Compliance Officer means the Director, Gasoline Engine Compliance Center, U.S. Environmental Protection Agency, 2000 Traverwood Drive, Ann Arbor, MI 48105; complianceinfo@epa.gov.

* * * * *

Fuel type means a general category of fuels such as gasoline or natural gas. There can be multiple grades within a single fuel type, such as premium gasoline, regular gasoline, or low-level ethanol-gasoline blends.

* * * * *

Model year means one of the following things:

(1) For equipment defined as "new nonroad equipment" under paragraph (1) of the definition of “new nonroad engine,” model year means one of the following:

(i) Calendar year of production.

(ii) Your annual new model production period if it is different than the calendar year. This must include January 1 of the calendar year for which the model year is named. It may not begin before January 2 of the previous calendar year and it must end by December 31 of the named calendar year.

(2) For other equipment defined as "new nonroad equipment" under paragraph (2) of the definition of “new nonroad engine,” model year has the meaning given in the exhaust standard-setting part.

(3) For other equipment defined as "new nonroad equipment" under paragraph (3) or paragraph (4) of the definition of “new nonroad engine,” model year means the model year of the engine as defined in the exhaust standard-setting part.

* * * * *

Placed into service means put into initial use for its intended purpose. Equipment does not qualify as being “placed into service” based on incidental use by a manufacturer or dealer.

* * * * *

Portable nonroad fuel tank means a fuel tank that meets each of the following criteria:

(1) It has design features indicative of use in portable applications, such as a carrying handle and fuel line fitting that can be readily attached to and detached from a nonroad engine.

(2) It has a nominal fuel capacity of 12 gallons or less.

(3) It is designed to supply fuel to an engine while the engine is operating.

(4) It is not used or intended to be used to supply fuel to a marine engine. Note that portable tanks excluded from this definition of “portable nonroad fuel tank” under this paragraph (4) because of their use with marine engines are portable marine fuel tanks.

* * * * *

Small SI means relating to engines that are subject to emission standards in 40 CFR part 1054.

* * * * *

311. Amend §1060.810 by:
a. Removing and reserving paragraph (d); and
b. Revising paragraph (e) introductory text.
The revision reads as follows:

§1060.810 What materials does this part reference?

* * * * *

(e) *American Boat and Yacht Council Material*. The following documents are available from the American Boat and Yacht Council, 613 Third Street, Suite 10, Annapolis, MD 21403 or (410) 990-4460 or *http://abycinc.org/*:

* * * * *

312. Revise §1060.815 to read as follows:

§1060.815 What provisions apply to confidential information?

The provisions of 40 CFR 1068.10 apply for information you consider confidential.

313. Revise §1060.825 to read as follows:

§1060.825 What reporting and recordkeeping requirements apply under this part?

(a) This part includes various requirements to submit and record data or other information. Unless we specify otherwise, store required records in any format and on any media and keep them readily available for eight years after you send an associated application for certification, or eight years after you generate the data if they do not support an application for certification. We may request these records at any time. You must promptly give us organized, written records in English if we ask for them. This applies whether or not you rely on someone else to keep records on your behalf. We may require you to submit written records in an electronic format.
(b) The regulations in § 1045.255, 40 CFR 1068.25, and 40 CFR 1068.101 describe your obligation to report truthful and complete information. This includes information not related to certification. Failing to properly report information and keep the records we specify violates 40 CFR 1068.101(a)(2), which may involve civil or criminal penalties.
(c) Send all reports and requests for approval to the Designated Compliance Officer (see § 1060.801).
(d) Any written information we require you to send to or receive from another company is deemed to be a required record under this section. Such records are also deemed to be submissions to EPA. We may require you to send us these records ~~whether or not you are a certificate holder~~.
(e) Under the Paperwork Reduction Act (44 U.S.C. 3501 *et seq*.), the Office of Management and Budget approves the reporting and recordkeeping specified in the applicable regulations. The following items illustrate the kind of reporting and recordkeeping we require for products regulated under this part:

(1) We specify the following requirements related to component and equipment certification in this part 1060:

(i) In §1060.20 we give an overview of principles for reporting information.
(ii) In subpart C of this part we identify a wide range of information required to certify engines.
(iii) In §1060.301 we require manufacturers to make components, engines, or equipment available for our testing if we make such a request, and to keep records related to

evaluation of production samples for verifying that the products are as specified in the certificate of conformity.

(iv) In §1060.505 we specify information needs for establishing various changes to published test procedures.

(2) We specify the following requirements related to the general compliance provisions in 40 CFR part 1068:

(i) In 40 CFR 1068.5 we establish a process for evaluating good engineering judgment related to testing and certification.

(ii) In 40 CFR 1068.25 we describe general provisions related to sending and keeping information.

(iii) In 40 CFR 1068.27 we require manufacturers to make equipment available for our testing or inspection if we make such a request.

(iv) In 40 CFR 1068.105 we require equipment manufacturers to keep certain records related to duplicate labels from engine manufacturers.

(v) [Reserved]

(vi) In 40 CFR part 1068, subpart C, we identify several reporting and recordkeeping items for making demonstrations and getting approval related to various exemptions.

(vii) In 40 CFR part 1068, subpart D, we identify several reporting and recordkeeping items for making demonstrations and getting approval related to importing equipment.

(viii) In 40 CFR 1068.450 and 1068.455 we specify certain records related to testing production-line products in a selective enforcement audit.

(ix) In 40 CFR 1068.501 we specify certain records related to investigating and reporting emission-related defects.

(x) In 40 CFR 1068.525 and 1068.530 we specify certain records related to recalling nonconforming equipment.

(xi) In 40 CFR part 1068, subpart G, we specify certain records for requesting a hearing.

PART 1068—GENERAL COMPLIANCE PROVISIONS FOR HIGHWAY, STATIONARY, AND NONROAD PROGRAMS

393. The authority statement for part 1068 continues to read as follows:

Authority: 42 U.S.C. 7401-7671q.

394. Amend §1068.1 by revising paragraph (a) and removing and reserving paragraph (d)(2) to n reads as follows:

§1068.1 Does this part apply to me?

(a) The provisions of this part apply to everyone with respect to the engine and equipment categories as described in this paragraph (a). They apply to everyone, including owners, operators, parts manufacturers, and persons performing maintenance. Where we identify an engine category, the provisions of this part also apply with respect to the equipment using such engines. This part 1068 applies to different engine and equipment categories as follows:

(1) This part 1068 applies to motor vehicles we regulate under 40 CFR part 86, subpart S, to the extent and in the manner specified in 40 CFR parts 85 and 86.

(2) This part 1068 applies for heavy-duty motor vehicles we regulate under 40 CFR part 1037, subject to the provisions of 40 CFR parts 85 and 1037. This includes trailers. This part 1068 applies to other heavy-duty motor vehicles and motor vehicle engines to the extent and in the manner specified in 40 CFR parts 85, 86, and 1036.

(3) This part 1068 applies to highway motorcycles we regulate under 40 CFR part 86, subparts E and F, to the extent and in the manner specified in 40 CFR parts 85 and 86.

(4) This part 1068 applies to aircraft we regulate under 40 CFR part 87 to the extent and in the manner specified in 40 CFR part 87.

(5) This part 1068 applies for locomotives that are subject to the provisions of 40 CFR part 1033. This part 1068 does not apply for locomotives or locomotive engines that were originally manufactured before July 7, 2008, and that have not been remanufactured on or after July 7, 2008.

(6) This part 1068 applies for land-based nonroad compression-ignition engines that are subject to the provisions of 40 CFR part 1039.

(7) This part 1068 applies for stationary compression-ignition engines certified using the provisions of 40 CFR parts 1039 and 1042 as described in 40 CFR part 60, subpart IIII.

(8) This part 1068 applies for marine compression-ignition engines that are subject to the provisions of 40 CFR part 1042.

(9) This part 1068 applies for marine spark-ignition engines that are subject to the provisions of 40 CFR part 1045.

(10) This part 1068 applies for large nonroad spark-ignition engines that are subject to the provisions of 40 CFR part 1048.

(11) This part 1068 applies for stationary spark-ignition engines certified using the provisions of 40 CFR part 1048 or part 1054, as described in 40 CFR part 60, subpart JJJJ.

(12) This part 1068 applies for recreational engines and vehicles, including snowmobiles, off-highway motorcycles, and all-terrain vehicles that are subject to the provisions of 40 CFR part 1051.

(13) This part applies for small nonroad spark-ignition engines that are subject to the provisions of 40 CFR part 1054.

(14) This part applies for fuel-system components installed in nonroad equipment powered by volatile liquid fuels that are subject to the provisions of 40 CFR part 1060.

*   *   *   *   *

395. Amend §1068.10 by revising the section heading and paragraphs (b) and (c) to read as follows:

§1068.10 Confidential business information.

*   *   *   *   *

(b) We will store your confidential business information as described in 40 CFR part 2. Also, we will disclose it only as specified in 40 CFR part 2. This applies both to any information you send us and to any information we collect from inspections, audits, or other site visits.

(c) If you send us a second copy without the confidential business information, we will assume it contains nothing confidential whenever we need to release information from it.

*   *   *   *   *

~~383. Amend §1068.30 by adding a definition for "Element of design" in alphabetical order to read as follows:~~

~~**§1068.30 Definitions.**~~

~~*   *   *   *   *~~

~~*Element of design* includes any computer software, electronic control system, emission control system, or computer logic, along with any related calibrations. Element of design also includes the results of related interaction with hardware items or other parameter settings on engines/equipment.~~

~~*   *   *   *   *~~

396. Amend §1068.240 by revising paragraphs (b)(6), (c)(1), and (c)(3) to read as follows:

§1068.240 Exempting new replacement engines.

*   *   *   *   *

(b) *   *   *

(6) Engines exempt under this paragraph (b) may not be introduced into U.S. commerce before you make the determinations under paragraph (b)(2) of this section, except as specified in this paragraph (b)(6). We may waive this restriction for engines ~~excluded~~ identified under paragraph (c)(5) of this section that you ship to a distributor. Where we waive this restriction, you must take steps to ensure that the engine is installed consistent with the requirements of this paragraph (b). For example, at a minimum you must report to us annually whether engines we allowed you to ship to a distributor under this paragraph (b)(6) have been placed into service or remain in inventory. After an engine is placed into service, your report must describe how the engine was installed consistent with the requirements of this paragraph (b). Send these reports to the Designated Compliance Officer by the deadlines we specify. [*This paragraph is added for the final rule. Changes shown are relative to the Code of Federal Regulations.*]

(c) *   *   *

(1) You may produce a limited number of replacement engines under this paragraph (c) representing 0.5 percent of your annual production volumes for each category and subcategory of engines identified in Table 1 to this section or five engines for each category and subcategory, whichever is greater~~(1.0 percent through 2013)~~. Calculate this number by multiplying your annual U.S.-directed production volume by 0.005 (or 0.01 through 2013) and rounding to the nearest whole number. Determine the appropriate production volume by identifying the highest total annual U.S.-directed production volume of engines from the previous three model years for

all your certified engines from each category or subcategory identified in Table 1 to this section, as applicable. In unusual circumstances, you may ask us to base your production limits on U.S.-directed production volume for a model year more than three years prior. You may include stationary engines and exempted engines as part of your U.S.-directed production volume. Include U.S.-directed engines produced by any affiliated companies and those from any other companies you license to produce engines for you. [*This definition is added for the final rule. Changes shown are relative to the Code of Federal Regulations.*]

* * * * *

(3) Send the Designated Compliance Officer a report by September 30 of the year following any year in which you produced exempted replacement engines under this paragraph (c).

(i) In your report include the total number of replacement engines you produce under this paragraph (c) for each category or subcategory, as appropriate, and the corresponding total production volumes determined under paragraph (c)(1) of this section. If you send us a report under this paragraph (c)(3), you must also include the total number of complete and partially complete replacement engines you produced under paragraphs (b)~~, (d),~~ and (e) of this section (including any replacement marine engines subject to reporting under 40 CFR 1042.615).

(ii) Count exempt engines as tracked under paragraph (b) of this section only if you meet all the requirements and conditions that apply under paragraph (b)(2) of this section by the due date for the annual report. In the annual report you must identify any replaced engines from the previous year that you were not able to recover by the due date for the annual report. Continue to report those engines in later reports until you recover the replaced engines. If any replaced engine is not recovered for the fifth annual report following the production report, treat this as an untracked replacement in the fifth annual report for the preceding year.

(iii) You may include the information required under this paragraph (c)(3) in production reports required under the standard-setting part.

* * * * *

PART 1074—PREEMPTION OF STATE STANDARDS AND PROCEDURES FOR WAIVER OF FEDERAL PREEMPTION FOR NONROAD ENGINES AND NONROAD VEHICLES

397. The authority statement for part 1074 continues to read as follows:

Authority: 42 U.S.C. 7401-7671q.

398. Add Appendix I to subpart A to read as follows:

Appendix I to subpart A of part 1074—State Regulation of the Use and Operation of Nonroad Internal Combustion Engines.

(a) This appendix describes EPA's interpretation of the Clean Air Act regarding the authority of states to regulate the use and operation of nonroad engines.

(b) EPA believes that states are not precluded under 42 U.S.C. 7543 from regulating the use and operation of nonroad engines, such as regulations on hours of usage, daily mass emission limits, or sulfur limits on fuel; nor are permits regulating such operations precluded, once the engine is no longer new. EPA believes that states are precluded from requiring retrofitting of used nonroad engines except that states are permitted to adopt and enforce any such retrofitting requirements identical to California requirements which have been authorized by EPA under 42 U.S.C. 7543.