40 CFR Part 1066

Vehicle-Testing Procedures

DRAFT Working Document

(LD Tier III NPRM changes denoted by "track changes")

11/28/12

Part 1066—Vehicle-Testing Procedures

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Subpart A—Applicability and General Provisions

§1066.1 Applicability.

(a) This part describes the procedures that apply to testing we require for the following vehicles:
(1) Model year 2014 and later heavy-duty highway vehicles we regulate under 40 CFR part 1037 that are not subject to chassis testing for exhaust emissions under 40 CFR part 86.
(2) Model year 2022 and later highway vehicles that are subject to chassis testing for exhaust emissions under 40 CFR part 86. See 40 CFR part 86 for provisions describing how to implement this part 1066.
(b) The procedures of this part may apply to other types of vehicles, as described in this part and in the standard-setting part.
(c) The term "you" means anyone performing testing under this part other than EPA.
(1) This part is addressed primarily to manufacturers of vehicles, but it applies equally to anyone who does testing under this part for such manufacturers.
(2) This part applies to any manufacturer or supplier of test equipment, instruments, supplies, or any other goods or services related to the procedures, requirements, recommendations, or options in this part.
(d) Paragraph (a) of this section identifies the parts of the CFR that define emission standards and other requirements for particular types of vehicles. In this part, we refer to each of these other parts generically as the "standard-setting part." For example, 40 CFR part 1037 is the standard-setting part for heavy-duty highway vehicles and parts 86 and 600 are the standard-setting parts for light-duty vehicles. For vehicles subject to 40 CFR part 86, subpart S, references to the standard-setting part include subpart I of this part.
(e) Unless we specify otherwise, the terms "procedures" and "test procedures" in this part include all aspects of vehicle testing, including the equipment specifications, calibrations, calculations, and other protocols and procedural specifications needed to measure emissions.
(f) For additional information regarding these test procedures, visit our Web site at www.epa.gov, and in particular http://www.epa.gov/nvfel/testing/regulations.htm.

§1066.2 Submitting information to EPA under this part.

(a) You are responsible for statements and information in your applications for certification, requests for approved procedures, selective enforcement audits, laboratory audits, production-line test reports, or any other statements you make to us related to this part 1066. If you provide statements or information to someone for submission to EPA, you are responsible for these statements and information as if you had submitted them to EPA yourself.
(b) In the standard-setting part and in 40 CFR 1068.101, we describe your obligation to report truthful and complete information and the consequences of failing to meet this obligation. See also 18 U.S.C. 1001 and 42 U.S.C. 7413(c)(2). This obligation applies whether you submit this information directly to EPA or through someone else.
(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 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.

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(d) We may require an authorized representative of your company to approve and sign the submission, and to certify that all the information submitted is accurate and complete. This includes everyone who submits information, including manufacturers and others.
(e) See 40 CFR 1068.10 for provisions related to confidential information. Note however that under 40 CFR 2.301, emission data are generally not eligible for confidential treatment.
(f) Nothing in this part should be interpreted to limit our ability under Clean Air Act section 208 (42 U.S.C. 7542) to verify that vehicles conform to the regulations.

§1066.5 Overview of this part 1066 and its relationship to the standard-setting part.
(a) This part specifies procedures that can apply generally to testing various categories of vehicles. See the standard-setting part for directions in applying specific provisions in this part for a particular type of vehicle. Before using this part's procedures, read the standard-setting part to answer at least the following questions:
(1) What drive schedules must I use for testing?
(2) Should I warm up the test vehicle before measuring emissions, or do I need to measure cold-start emissions during a warm-up segment of the duty cycle?
(3) Which exhaust constituents do I need to measure? Measure all exhaust constituents that are subject to emission standards, any other exhaust constituents needed for calculating emission rates, and any additional exhaust constituents as specified in the standard-setting part. See 40 CFR 1065.5 regarding requests to omit measurement of N_2O and CH_4 for vehicles, not subject to N_2O or CH_4 emission standards.
(4) Do any unique specifications apply for test fuels?
(5) What maintenance steps may I take before or between tests on an emission-data vehicle?
(6) Do any unique requirements apply to stabilizing emission levels on a new vehicle?
(7) Do any unique requirements apply to test limits, such as ambient temperatures or pressures?
(8) [Reserved]
(9) Are there any emission standards specified at particular operating conditions or ambient conditions?
(10) Do any unique requirements apply for durability testing?
(b) The testing specifications in the standard-setting part may differ from the specifications in this part. In cases where it is not possible to comply with both the standard-setting part and this part, you must comply with the specifications in the standard-setting part. The standard-setting part may also allow you to deviate from the procedures of this part for other reasons.
(c) The following table shows how this part divides testing specifications into subparts:

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Table 1 of §1066.5—Description of Part 1066 subparts.

This subpart	Describes these specifications or procedures
Subpart A	Applicability and general provisions.
Subpart B	Equipment for testing.
Subpart C	Dynamometer specifications.
Subpart D	Coastdowns for testing.
Subpart E	How to prepare your vehicle and run an emission test.
Subpart F	How to test hybrid vehicles.
Subpart G	Test procedure calculations.
Subpart H	Cold temperature testing.
Subpart I	Exhaust emission test procedures for motor vehicles.
Subpart J	Reserved.
Subpart K	Definitions and reference material.

§1066.10 Other procedures.

(a) Your testing. The procedures in this part apply for all testing you do to show compliance with emission standards, with certain exceptions listed in this section. In some other sections in this part, we allow you to use other procedures (such as less precise or less accurate procedures) if they do not affect your ability to show that your vehicles comply with the applicable emission standards. This generally requires emission levels to be far enough below the applicable emission standards so that any errors caused by greater imprecision or inaccuracy do not affect your ability to state unconditionally that the engines meet all applicable emission standards.

(b) Our testing. These procedures generally apply for testing that we do to determine if your vehicles comply with applicable emission standards. We may perform other testing as allowed by the Act.

(c) Exceptions. We may allow or require you to use procedures other than those specified in this part as described in 40 CFR 1065.10(c). All the test procedures noted as exceptions to the specified procedures are considered generically as "other procedures." Note that the terms "special procedures" and "alternate procedures" have specific meanings; "special procedures" are those allowed by 40 CFR 1065.10(c)(2) and "alternate procedures" are those allowed by 40 CFR 1065.10(c)(7). If we require you to request approval to use other procedures under this paragraph (c), you may not use them until we approve your request.

§1066.15 Overview of test procedures.

This section outlines the procedures to test vehicles that are subject to emission standards.

(a) In the standard-setting part, we set emission standards in g/mile (or g/km), for the following constituents:

(1) Total oxides of nitrogen, NO_x.

(2) Hydrocarbons, HC, which may be expressed in the following ways:

(i) Total hydrocarbons, THC.

(ii) Nonmethane hydrocarbons, NMHC, which results from subtracting methane (CH_4) from THC.

(iii) Total hydrocarbon-equivalent, THCE, which results from adjusting THC mathematically to be equivalent on a carbon-mass basis.

(iv) Nonmethane hydrocarbon-equivalent, NMHCE, which results from adjusting NMHC mathematically to be equivalent on a carbon-mass basis.

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(v) Nonmethane organic gases, NMOG, which are calculated either from fully or partially speciated measurement of hydrocarbons including oxygenates, or by adjusting measured NMHC values based on fuel oxygenate properties.
(3) Particulate mass, PM.
(4) Carbon monoxide, CO.
(5) Carbon dioxide, CO_2.
(6) Methane, CH_4.
(7) Nitrous oxide, N_2O.
(8) Formaldehyde, CH_2O.
(b) Note that some vehicles may not be subject to standards for all the emission constituents identified in paragraph (a) of this section.
(c) The provisions of this part apply for chassis dynamometer testing where vehicle speed is controlled to follow a prescribed duty cycle while simulating vehicle driving through the dynamometer's road-load settings. We generally set emission standards over test phases and/or drive schedules, as follows:
(1) Vehicle operation. Testing involves measuring emissions and miles travelled while operating the vehicle on a chassis dynamometer. Refer to the definitions of "duty cycle" and "test phase" in §1066.1001. Note that a single drive schedule may have multiple test phases and require weighting of results from multiple test phases to calculate a composite distance-based emission value to compare to the standard.
(2) Constituent determination. Determine the total mass of each constituent over a test phase by selecting from the following methods:
(i) Continuous sampling. In continuous sampling, measure the constituent's concentration continuously from raw or dilute exhaust. Multiply this concentration by the continuous (raw or dilute) flow rate at the emission sampling location to determine the constituent's flow rate. Sum the constituent's flow rate continuously over the test phase. This sum is the total mass of the emitted constituent.
(ii) Batch sampling. In batch sampling, continuously extract and store a sample of raw or dilute exhaust for later measurement. Extract a sample proportional to the raw or dilute exhaust flow rate, as applicable. You may extract and store a proportional sample of exhaust in an appropriate container, such as a bag, and then measure HC, CO, and NO_x concentrations in the container after the test phase. You may deposit PM from proportionally extracted exhaust onto an appropriate substrate, such as a filter. In this case, divide the PM by the amount of filtered exhaust to calculate the PM concentration. Multiply batch sampled concentrations by the total (raw or dilute) flow from which it was extracted during the test phase. This product is the total mass of the emitted constituent.
(iii) Combined sampling. You may use continuous and batch sampling simultaneously during a test phase, as follows:
(A) You may use continuous sampling for some constituents and batch sampling for others.
(B) You may use continuous and batch sampling for a single constituent, with one being a redundant measurement, subject to the provisions of 40 CFR 1065.201.
(d) Refer to the standard-setting part for calculations to determine g/mile emission rates.
(e) You must use good engineering judgment for all aspects of testing under this part. While the regulation highlights several specific cases where good engineering judgment is especially relevant, the requirement to use good engineering judgment is not limited to those provisions where we specifically re-state this requirement.

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§1066.20 Units of measure and overview of calculations.

(a) System of units. The procedures in this part follow both conventional English Units and the International System of Units (SI), as detailed in NIST Special Publication 811, which we incorporate by reference in §1066.1010.

(b) Units conversion. Use good engineering judgment to convert units between measurement systems as needed. For example, if you measure vehicle speed as mph and we specify a precision requirement in terms of m/s, convert your measured mph value to m/s before comparing it to our specification. The following conventions are used throughout this document and should be used to convert units as applicable:

(1) 1 hp = 33,000 ft·lbf/min = 550 ft·lbf/s = 0.7457 kW.

(2) 1 lbf = 32.174 ft·lbm/s^2 = 4.4482 N.

(3) 1 inch = 25.4 mm.

(4) For ideal gases, 1 µmol/mol = 1 ppm.

(5) For ideal gases, 10 mmol/mol = 1 %.

(c) Rounding. The rounding provisions of 40 CFR 1065.20 apply for calculations in this part. This generally specifies that you round final values but not intermediate values. Use good engineering judgment to record the appropriate number of significant digits for all measurements.

(d) Interpretation of ranges. Interpret a range as a tolerance unless we explicitly identify it as an accuracy, repeatability, linearity, or noise specification. See 40 CFR 1065.1001 for the definition of tolerance. In this part, we specify two types of ranges:

(1) Whenever we specify a range by a single value and corresponding limit values above and below that value (such as X ±Y), target the associated control point to that single value (X). Examples of this type of range include "±10 % of maximum pressure", or "(30 ±10) kPa". In these examples, you would target the maximum pressure or 30 kPa, respectively.

(2) Whenever we specify a range by the interval between two values, you may target any associated control point to any value within that range. An example of this type of range is "(40 to 50) kPa".

(e) Scaling of specifications with respect to an applicable standard. Because this part 1066 applies to a wide range of vehicles and emission standards, some of the specifications in this part are scaled with respect to a vehicle's applicable standard or weight. This ensures that the specification will be adequate to determine compliance, but not overly burdensome by requiring unnecessarily high-precision equipment. Many of these specifications are given with respect to a "flow-weighted mean" that is expected at the standard or during testing. 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 flow rate, divided by the sum of the recorded flow rates. 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.

§1066.25 Recordkeeping.

The procedures in this part include various requirements to record data or other information. Refer to the standard-setting part regarding recordkeeping requirements. If the standard-setting part does not specify recordkeeping requirements, store these records in any format and on any media and keep them readily available for eight years after you send an associated application

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for certification, or eight years after you generate the data if they do not support an application for certification. You must promptly send us organized, written records in English if we ask for them. We may review them at any time.

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Subpart B—Equipment, Measurement Instruments, Fuel, and Analytical Gas Specifications

§1066.101 Overview.

(a) This subpart addresses equipment related to emission testing, as well as test fuels and analytical gases. This section addresses emission sampling and analytical equipment, test fuels, and analytical gases.

(b) The provisions of 40 CFR part 1065 specify engine-based procedures for measuring emissions. Except as specified otherwise in this part, the provisions of 40 CFR part 1065 apply for testing required by this part as follows:

(1) The provisions of 40 CFR part 1065, subpart B, describe equipment specifications for exhaust dilution and sampling systems; these specifications apply for testing under this part as described in §1066.110.

(2) The provisions of 40 CFR part 1065, subpart C, describe specifications for measurement instrument; these specifications apply for testing under this part as described in §1066.120.

(3) The provisions of 40 CFR part 1065, subpart D, describe specifications for measurement instrument calibrations and verifications; these specifications apply for testing under this part as described in §1066.130.

(4) The provisions of 40 CFR part 1065, subpart H, describe specifications for fuels, engine fluids, and analytical gases; these specifications apply for testing under this part as described in §1066.145.

(5) The provisions of 40 CFR part 1065, subpart I, describe specifications for testing with oxygenated fuels; these specifications apply for NMOG determinations as described in §1066.665.

(c) The provisions of this subpart are intended to specify systems that can very accurately and precisely measure emissions from motor vehicles such as light-duty vehicles. To the extent that this level of accuracy and/or precision is not necessary for testing highway motorcycles or nonroad vehicles, we may waive or modify the specifications and requirements of this part for testing these other vehicles, consistent with good engineering judgment. For example, it may be appropriate to allow the use of a hydrokinetic dynamometer that is not able to meet all the performance specifications described in this subpart.

§1066.110 Equipment specifications.

(a) This section specifies equipment related to emission testing, other than measurement instruments. This equipment includes two broad categories—dynamometers (described further in subpart C of this part) and emission-sampling hardware. Other related sections in this subpart identify measurement instruments (§1066.120), describe how to evaluate the performance of these instruments (§§1066.130 and 1066.137), describe how to calibrate a CVS (§1066.140), specify engine fluids and analytical gases (§1066.145), and specify requirements for analyzer interference and quench verification (§1066.150).

(b) The following equipment specifications apply for testing under this part:

(1) Sampling system connections. Connect a vehicle's exhaust system to any dilution stage as follows:

(i) Minimize laboratory exhaust tubing lengths. You may use a total length of laboratory tubing up to 4 m. However, you may use a total length of laboratory tubing up to 10 m if you insulate

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(4) The provisions of 40 CFR part 1065, subpart J, describe how to measure emissions from vehicles operating outside of a laboratory, except that provisions related to measuring engine work do not apply.
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or heat the tubing to minimize the temperature difference between the exhaust gas and the tubing wall over the course of the emission test. The laboratory exhaust tubing starts at the end of the vehicle's tailpipe. The laboratory exhaust tubing ends at the first sample point or the point of first dilution. You may use flexible laboratory exhaust tubing at any location in the laboratory exhaust system. For multiple-tailpipe configurations where the tailpipes combine into a single flow path for emission sampling, the start of the laboratory exhaust tubing may be taken at the last joint where the exhaust flow first becomes a single, combined flow.

(ii) You may insulate or heat any laboratory exhaust tubing.

(iii) Use laboratory exhaust tubing materials that are smooth-walled and not chemically reactive with exhaust constituents. For measurements involving PM, tubing materials must also be electrically conductive. Stainless steel is an acceptable material for any measurements. You may use short sections of nonconductive flexible tubing to connect a PM sampling system to the vehicle's tailpipe; use good engineering judgment to limit the amount of nonconductive surface area exposed to the vehicle's exhaust.

(iv) We recommend that you use laboratory exhaust tubing that has either a wall thickness of less than 2 mm or is air gap-insulated to minimize temperature differences between the wall and the exhaust.

(v) Seal your system to the extent necessary to ensure that any remaining leaks do not affect your ability to demonstrate compliance with the applicable standards.

(vi) Electrically ground the entire exhaust system, with the exception of nonconductive flexible tubing, as allowed under paragraph (b)(1)(iii) of this section.

(vii) For vehicles with multiple tailpipes, route the exhaust into a single flow. To ensure mixing of the multiple exhaust streams before emission sampling, you may configure the exhaust system with turbulence generators, such as orifice plates or fins, to achieve good mixing. We recommend a minimum Reynolds number, *Re#*, of 4000 for the combined exhaust stream, where *Re#* is based on the inside diameter of the combined flow at the first sampling point. *Re#* is defined in 40 CFR 1065.640.

(2) Provisions from 40 CFR part 1065. Use equipment specifications in sections 40 CFR 1065.140 through 40 CFR 1065.190, except as follows:

(i) For PM background measurement, the following provisions apply instead of the analogous provisions in 40 CFR 1065.140(b):

(A) You need not measure PM background for every test. You may apply PM background correction using a moving-average background value as long as your background PM sample media (e.g., filters) were all made by the same manufacturer from the same material . Use good engineering judgment to determine how many background samples make up the moving average and how frequently to update those values. For example, you might take one background sample per week and average that sample into previous background values, maintaining five observations for each calculated average value. Background sampling time should be representative of the test phase duration to which the background correction is applied.

(B) You may sample background PM from the dilution tunnel at any time before or after an emission test using the same sample train used during the emission test. For this background sampling, the dilution tunnel blower must be turned on, the vehicle must be disconnected from the exhaust transfer tube, and the exhaust transfer tube must be capped.

(C) Using good engineering judgment, the duration of your background sample does not need to be the same as the test cycle in which you are applying the background correction.

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(D) Your background correction may not exceed 5 µg or 5 % of the net PM mass expected at the standard, whichever is greater.
(ii) The provisions of 40 CFR 1065.140(d)(2)(iv) do not apply.
(iii) For PM samples, configure dilution systems using the following limits:
(A) Control the diluent temperature as described in 40 CFR 1065.140(e)(1), except that the temperature may set to (15 to 52) °C. Use good engineering judgment to control PM sample temperature as required under 40 CFR 1065.140(e)(4).
(B) Apply the provisions of this paragraph (b)(2)(iii)(B) instead of 40 CFR 1065.140(e)(2). Add diluent to the raw exhaust such that the overall dilution factor of diluted exhaust to raw exhaust, as determined in Eq. 1066.620-2 or 1066.620-3, is within the range of (7:1 to 20:1) for each test phase. The maximum dilution factor limit of 20:1 does not apply for plug-in hybrid electric vehicles (PHEVs) and hybrid electric vehicles (HEVs), since the dilution factor is infinite when the engine is off; however we strongly recommend that you stay under the maximum dilution factor limit when the engine is running. For partial-flow sampling systems, determine dilution factor using Eq. 1066.620-3. When determining dilution factor for PM samples utilizing secondary dilution air, multiply the dilution factor by the dilution ratio of secondary dilution air to primary diluted exhaust.
(iv) In addition to the allowances in 40 CFR 1065.140(c)(6) to address aqueous condensation in the CVS, you may also heat the dilution air as described in paragraph (b)(2)(iii)(A) of this section.
(v) If you choose to dilute the exhaust by using a remote mix tee, you may use the following provisions, using good engineering judgment, provided they do not affect your ability to demonstrate compliance with the standard:
(A) You may use accordion-style or smooth-walled flexible tubing in the dilution tunnel upstream of flow or gaseous emission measurement locations.
(B) You may use smooth-walled electrically conductive flexible tubing in the dilution tunnel upstream of where PM emission measurements are made.
(C) Materials for inside surfaces are limited to 300 series stainless steel and polymer-based materials.
(D) Use good engineering judgment to ensure that the materials you choose do not cause or contribute to unrepresentative loss of PM to your sample.
(vi) Paragraph (b)(1)(vi) of this section applies instead of 40 CFR 1065.145(b).
(c) The following table summarizes the requirements of paragraph (b)(2) of this section:

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Table 1 of §1066.110–Summary of equipment specifications from 40 CFR part 1065, subpart B, that apply for chassis testing

40 CFR part 1065 references	Applicability for chassis testing under this part
40 CFR 1065.140	Use all except: 40 CFR 1065.140(b) applies as described in this section. Use 40 CFR 1065.140(c)(6), with the additional allowance described in this section. Do not use 40 CFR 1065.140(d)(2)(iv). Use 40 CFR 1065.140(e)(1) as described in this section. Do not use 40 CFR 1065.140(e)(2).
40 CFR 1065.145	Use all except 40 CFR 1065.145(b).
40 CFR 1065.150 through 1065.190	Use all.

§1066.120 Measurement instruments.

The measurement instrument requirements in 40 CFR part 1065, subpart C, apply with the following exceptions:

(a) The provisions of §1066.122 apply instead of 40 CFR 1065.202.

(b) The provisions of 40 CFR 1065.210 and 1065.295 do not apply.

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§1066.122 Data updating, recording, and control for measurement instruments.

This section specifies criteria that your test system must meet for updating and recording data. It also specifies criteria for controlling the systems related to driver demand, the dynamometer, sampling equipment, and measurement instruments.

(a)(1) This paragraph (a)(1) applies where we specify a minimum command and control frequency that is greater than the minimum recording frequency, such as for sample flow rates from a CVS that does not have a heat exchanger. For these measurements, the rate at which you read and interpret the signal must be at least as frequent as the minimum command and control frequency. Values may be recorded at the same frequency. They may also be recorded as means of the values, provided the frequency of the mean values meets the minimum recording frequency. All values read must be either recorded or used to calculate the mean values. For example, if your system reads and controls the sample flow rate at 10 Hz, you may record these values at 10 Hz, record them at 5 Hz by averaging pairs of consecutive points together, or record them at 1 Hz by averaging five consecutive points together.

(2) For all other measured values covered by this section, you may record the values instantaneously or as mean values, consistent with good engineering judgment.

(3) You may not use rolling averages of measured values where a given measured value is included in more than one recorded mean value.

(b) Use data acquisition and control systems that can command, control, and record at the following minimum frequencies:

Table 1 of §1066.122–Data recording and control minimum frequencies

Applicable Section	Measured Values	Minimum Command and Control Frequency	Minimum Recording Frequency[a]
§1066.310 §1066.320	Vehicle speed	—	10 Hz
§1066.430	Continuous concentrations of raw or dilute analyzers	—	1 Hz
§1066.430 §1066.501	Power analyzer[b]	—	1 Hz
§1066.430	Bag concentrations of raw or dilute analyzers	—	1 mean value per test phase
40 CFR 1065.545 §1066.430	Diluted exhaust flow rate from a CVS with a heat exchanger upstream of the flow measurement	—	1 Hz
40 CFR 1065.545 §1066.430	Diluted exhaust flow rate from a CVS without a heat exchanger upstream of the flow measurement	5 Hz	1 Hz means
40 CFR 1065.545 §1066.430	Dilution air flow if actively controlled (for example, a partial flow PM sampler)	5 Hz	1 Hz means
40 CFR 1065.545 §1066.430	Sample flow from a CVS that has a heat exchanger	1 Hz	1 Hz
40 CFR 1065.545 §1066.430	Sample flow from a CVS that does not have a heat exchanger	5 Hz	1 Hz means
§1066.425	Ambient temperature	—	1 Hz
§1066.425	Ambient humidity	—	1 Hz
§1066.425	Heated sample system temperatures, including PM filter face	—	1 Hz

[b] 1 Hz means are data reported from the instrument at a higher frequency, but recorded as a series of mean

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values at a rate of 1 Hz.

[b]For power analyzers' sampling frequency, follow SAE J1711 (incorporated by reference in §1066.1010).

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§1066.130 Measurement instrument calibrations and verifications.

The measurement instrument calibration and verification requirements in 40 CFR 1065, subpart D, apply with the following exceptions:

(a) The calibration and verification provisions of 40 CFR 1065.303 do not apply for engine speed, torque, fuel rate, or intake air flow. Section 1066.133 specifies additional calibration and verification provisions that apply specifically for chassis testing.

(b) The linearity verification provisions of 40 CFR 1065.307 do not apply for engine speed, torque, fuel rate, or intake air flow. Section 1066.137 specifies additional linearity verification provisions that apply specifically for chassis testing.

(c) The provisions of §1066.220 apply instead 40 CFR 1065.310.

(d) The provisions of 40 CFR 1065.320, 1065.325, and 1065.395 do not apply.

(e) If you are measuring flow volumetrically, the provisions of §1066.140 apply instead of 40 CFR 1065.340.

(f) The provisions of §1066.150 apply instead 40 CFR 1065.350(c), 1065.355(c), 1065.370(c), and 1065.375(c).

(g) Table 1 of this section summarizes the required and recommended calibrations and verifications that are unique to testing under this part and indicates when these have to be performed. Perform other required or recommended calibration and verifications as described in 40 CFR 1065.303, with the exceptions noted in this section. Table 1 follows:

Table 1 of §1066.133–Summary of required calibration and verifications.

Type of calibration or verification	Minimum frequency[a]
40 CFR 1065.303: Flow rates	This calibration does not apply for testing under this part; see §1066.133 for alternative provisions.
40 CFR 1065.307: Linearity verification	The linearity calibrations from 40 CFR part 1065 do not apply under this part for engine speed, torque, fuel rate, or intake air flow; the linearity verification described in §1066.137 applies for the following measurements: ~~Dynamometer Speed: See §1066.220.~~ Dynamometer Torque: See §1066.220.
40 CFR 1065.310: Torque	This calibration does not apply for testing under this part; see §1066.220.
40 CFR 1065.320: Fuel flow	This calibration does not apply for testing under this part.
40 CFR 1065.325: Intake flow	This calibration does not apply for testing under this part.
40 CFR 1065.340: CVS calibration	This calibration does not apply for CVS flow meters calibrated volumetrically as described in §1066.140.
40 CFR 1065.345: Vacuum leak	Required upon initial installation of the sampling system; recommended within 35 days before the start of an emissions test and after maintenance such as pre-filter changes.
40 CFR 1065.350(c), 1065.355(c), 1065.370(c), and 1065.375(c)	These provisions do not apply for testing under this part; see §1066.150.
40 CFR 1065.395: Inertial PM balance and weighing	These verifications do not apply for testing under this part.

[a]Perform calibrations and verifications more frequently if needed to conform to the measurement system manufacturer's instructions and good engineering judgment.

§1066.137 Linearity verification.

This section describes requirements for linearity verification that are unique to testing under this part. (Note: see the definition of "linearity" in 40 CFR 1065.1001, where we explain that linearity means the degree to which measured values agree with respective reference values and that the term "linearity" is not used to refer to the shape of a measurement instrument's unprocessed response curve.) Perform other required or recommended calibration and verifications as described in 40 CFR 1065.307, with the exceptions noted in this section.

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(f) The provisions of 40 CFR 1065.320, 1065.325, and 1065.395 do not apply.

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§1066.133 Summary of calibrations and verifications.¶
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(a) For testing under this subpart, linearity verification under 40 CFR part 1065 is not required for speed, torque, fuel flow rate, or intake air flow.

(b) For gas analyzer linearity, you may use one of the following options:

(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 single calibration factor 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, verify that the calibration curve produced names a calibration gas within 2 % of its certified concentration. Perform this verification between 15 and 50 % of the full scale analyzer range.

(2) Use the linearity requirements of 40 CFR 1065.307, except for CO_2 measurements used for determining fuel economy and GHG emissions for motor vehicles at or below 14,000 pounds. If you choose this linearity option, you must drift check and drift correct your emission data according to 40 CFR 1065.672.

(c) Perform linearity verifications for the following temperature measurements instead of those specified at 40 CFR 1065.307(e)(7):

(1) Test cell ambient air.

(2) Dilution air for PM sampling, including CVS, double-dilution, and partial-flow systems.

(3) PM sample.

(4) Chiller sample, for gaseous sampling systems that use thermal chillers to dry samples and that use chiller temperature to calculate dewpoint at the chiller outlet. For testing, if you choose to use the high alarm temperature setpoint for the chiller temperature as a constant value in determining the amount of water removed from the emission sample, you may verify the accuracy of the high alarm temperature setpoint using good engineering judgment without following the linearity verification for chiller temperature. We recommend that you input a simulated reference temperature signal below the alarm setpoint, increase this signal until the high alarm trips, and verify that the alarm setpoint value is no less than 2 °C below the reference value at the trip point.

(5) CVS inlet temperature.

(d) Perform linearity verifications for the following pressure measurements instead of those specified at 40 CFR 1065.307(e)(8):

(1) Exhaust back pressure.

(2) Barometric pressure.

(3) CVS inlet gage pressure or absolute pressure transducer.

(4) Sample dryer, for gaseous sampling systems that use either osmotic-membrane or thermal chillers to dry samples. For your testing, if you choose to use a low alarm pressure setpoint for the sample dryer pressure as a constant value in determining the amount of water removed from the emission sample, you may verify the accuracy of the low alarm pressure setpoint using good engineering judgment without following the linearity verification for sample dryer pressure. We recommend that you input a reference pressure signal above the alarm setpoint, decrease this signal until the low alarm trips, and verify that the alarm setpoint value is no more than 4 kPa above the reference value at the trip point.

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(e) When following procedures or practices that we incorporate by reference in §1066.1010, you must meet the linearity requirements given by the procedure or practice for any analytical instruments not covered under 40 CFR 1065.307, such as GC-FID or HPLC.

§1066.140 Diluted exhaust flow calibration.

(a) Overview. This section describes how to calibrate flow meters for diluted exhaust constant-volume sampling (CVS) systems. You may follow the molar flow calibration procedures in 40 CFR 1065.340 instead of the procedures in this section.

(b) Scope and frequency. Perform this calibration while the flow meter is installed in its permanent position, except as allowed in paragraph (c) of this section. Perform this calibration after you change any part of the flow configuration upstream or downstream of the flow meter that may affect the flow-meter calibration. Perform this calibration upon initial CVS installation and whenever corrective action does not resolve a failure to meet the diluted exhaust flow verification (i.e., propane check) in 40 CFR 1065.341.

(c) Ex-situ CFV and SSV calibration. You may remove a CFV or SSV from its permanent position for calibration as long as it meets the requirements in 40 CFR 1065.340(c).

(d) Reference flow meter. Calibrate a CVS flow meter using a reference flow meter such as a subsonic venturi flow meter, a long-radius ASME/NIST flow nozzle, a smooth approach orifice, a laminar flow element, a set of critical flow venturis, or an ultrasonic flow meter. Use a reference flow meter that reports quantities that are NIST-traceable within ±1 % uncertainty. Use this reference flow meter's response to flow as the reference value for CVS flow-meter calibration.

(e) Configuration. Calibrate the system with any upstream screens or other restrictions that will be used during testing and that could affect the flow ahead of the reference flow meter. You may not use any upstream screen or other restriction that could affect the flow ahead of the reference flow meter, unless the flow meter has been calibrated with such a restriction.

(f) PDP calibration. Calibrate a positive-displacement pump (PDP) to determine a flow-versus-PDP speed equation that accounts for flow leakage across sealing surfaces in the PDP as a function of PDP inlet pressure. Determine unique equation coefficients for each speed at which you operate the PDP. Calibrate a PDP flow meter as follows:

(1) Connect the system as shown in Figure 1 of this section.

(2) Leaks between the calibration flow meter and the PDP must be less than 0.3 % of the total flow at the lowest calibrated flow point; for example, at the highest restriction and lowest PDP-speed point.

(3) While the PDP operates, maintain a constant temperature at the PDP inlet within ±2 % of the mean absolute inlet temperature, $\overline{T}_{in}$.

(4) Set the PDP speed to the first speed point at which you intend to calibrate.

(5) Set the variable restrictor to its wide-open position.

(6) Operate the PDP for at least 3 min to stabilize the system. Continue operating the PDP and record the mean values of at least 30 seconds of sampled data of each of the following quantities:

(i) The mean flow rate of the reference flow meter, $\overline{\dot{Q}}_{ref}$. This may include several measurements of different quantities, such as reference meter pressures and temperatures, for calculating $\overline{\dot{Q}}_{ref}$.

(ii) The mean temperature at the PDP inlet, $\overline{T}_{in}$.

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(iii) The mean static absolute pressure at the PDP inlet, $\overline{p}_{in}$.

(iv) The mean static absolute pressure at the PDP outlet, $\overline{p}_{out}$.

(v) The mean PDP speed, $\overline{f}_{nPDP}$.

(7) Incrementally close the restrictor valve to decrease the absolute pressure at the inlet to the PDP, p_{in}.

(8) Repeat the steps in paragraphs (e)(6) and (7) of this section to record data at a minimum of six restrictor positions ranging from the wide-open restrictor position to the minimum expected pressure at the PDP inlet.

(9) Calibrate the PDP by using the collected data and the equations in §1066.650(a).

(10) Repeat the steps in paragraphs (e)(6) through (9) of this section for each speed at which you operate the PDP.

(11) Use the equations in §1066.652(a) to determine the PDP flow equation for emission testing.

(12) Verify the calibration by performing a CVS verification (i.e., propane check) as described in 40 CFR 1065.341.

(13) Ensure that the lowest inlet pressure tested during calibration is at least as low as the lowest PDP inlet pressure that will occur during emission testing. You may not use the PDP below the lowest inlet pressure tested during calibration.

(g) SSV calibration. Calibrate a subsonic venturi (SSV) to determine its discharge coefficient, C_d, for the expected range of inlet pressures. Calibrate an SSV flow meter as follows:

(1) Connect the system as shown in Figure 1 of this section.

(2) Verify that any leaks between the calibration flow meter and the SSV are less than 0.3 % of the total flow at the highest restriction.

(3) Start the blower downstream of the SSV.

(4) While the SSV operates, maintain a constant temperature at the SSV inlet within ±2 % of the mean absolute inlet temperature, $\overline{T}_{in}$.

(5) Set the variable restrictor or variable-speed blower to a flow rate greater than the greatest flow rate expected during testing. You may not extrapolate flow rates beyond calibrated values, so we recommend that you make sure the Reynolds number, $Re^{\#}$, at the SSV throat at the greatest calibrated flow rate is greater than the maximum $Re^{\#}$ expected during testing.

(6) Operate the SSV for at least 3 min to stabilize the system. Continue operating the SSV and record the mean of at least 30 seconds of sampled data of each of the following quantities:

(i) The mean flow rate of the reference flow meter, $\overline{\dot{Q}}_{ref}$. This may include several measurements of different quantities, such as reference meter pressures and temperatures, for calculating $\overline{\dot{Q}}_{ref}$.

(ii) The mean temperature at the venturi inlet, $\overline{T}_{in}$.

(iii) The mean static absolute pressure at the venturi inlet, $\overline{p}_{in}$.

(iv) Static differential pressure between the static pressure at the venturi inlet and the static pressure at the venturi throat, $\Delta\overline{p}_{SSV}$.

(7) Incrementally close the restrictor valve or decrease the blower speed to decrease the flow rate.

(8) Repeat the steps in paragraphs (g)(6) and (7) of this section to record data at a minimum of ten flow rates.

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(9) Determine a functional form of C_d versus $Re^{\#}$ by using the collected data and the equations in §1066.650(b).
(10) Verify the calibration by performing a CVS verification (i.e., propane check) as described in 40 CFR 1065.341 using the new C_d versus $Re^{\#}$ equation.
(11) Use the SSV only between the minimum and maximum calibrated flow rates.
(12) Use the equations in §1066.652(b) to determine SSV flow during a test.
(h) CFV calibration. The calibration procedure described in this paragraph (h) establishes the value of the calibration coefficient at measured values of pressure, temperature and air flow. Calibrate a critical-flow venturi (CFV) to verify its calibration coefficient, K_v, at the lowest expected static differential pressure between the CFV inlet and outlet. Calibrate a CFV flow meter as follows:
(1) Connect the system as shown in Figure 1 of this section.
(2) Verify that any leaks between the calibration flow meter and the CFV are less than 0.3 % of the total flow at the highest restriction.
(3) Start the blower downstream of the CFV.
(4) While the CFV operates, maintain a constant temperature at the CFV inlet within ±2 % of the mean absolute inlet temperature, $\overline{T}_{in}$.
(5) Set the variable restrictor to its wide-open position. Instead of a variable restrictor, you may alternately vary the pressure downstream of the CFV by varying blower speed or by introducing a controlled leak. Note that some blowers have limitations on nonloaded conditions.
(6) Operate the CFV for at least 3 min to stabilize the system. Continue operating the CFV and record the mean values of at least 30 seconds of sampled data of each of the following quantities:
(i) The mean flow rate of the reference flow meter, $\overline{\dot{Q}}_{ref}$. This may include several measurements of different quantities, such as reference meter pressures and temperatures, for calculating $\overline{\dot{Q}}_{ref}$.
(ii) The mean temperature at the venturi inlet, $\overline{T}_{in}$.
(iii) The mean static absolute pressure at the venturi inlet, $\overline{p}_{in}$.
(iv) The mean static differential pressure between the CFV inlet and the CFV outlet, $\Delta\overline{p}_{CFV}$.
(7) Incrementally close the restrictor valve or decrease the downstream pressure to decrease the differential pressure across the CFV, $\Delta\overline{p}_{CFV}$.
(8) Repeat the steps in paragraphs (f)(6) and (7) of this section to record mean data at a minimum of ten restrictor positions, such that you test the fullest practical range of $\Delta\overline{p}_{CFV}$ expected during testing. We do not require that you remove calibration components or CVS components to calibrate at the lowest possible restriction.
(9) Determine K_v and the lowest allowable pressure ratio, r, according to §1066.650.
(10) Use K_v to determine CFV flow during an emission test. Do not use the CFV below the lowest allowed r, as determined in §1066.650.
(11) Verify the calibration by performing a CVS verification (i.e., propane check) as described in 40 CFR 1065.341.
(12) If your CVS is configured to operate multiple CFVs in parallel, calibrate your CVS using one of the following methods:

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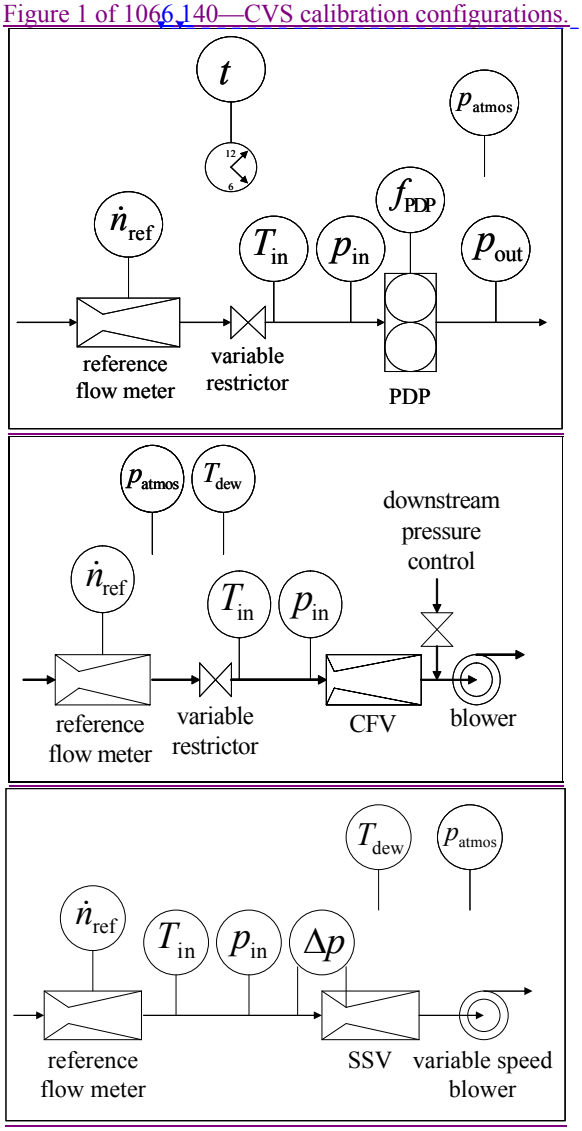
(i) Calibrate every combination of CFVs according to this section and §1066.650(c). Refer to §1065.652(c) for instructions on calculating flow rates for this option.
(ii) Calibrate each CFV according to this section and §1066.650. Refer to §1066.652 for instructions on calculating flow rates for this option.
(i) Ultrasonic flow meter calibration. [Reserved]

Figure 1 of 1066.140—CVS calibration configurations.



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§1066.145 Test fuel, engine fluids, analytical gases, and other calibration standards.

(a) Test fuel. Use test fuel as specified in the standard-setting part, or as specified in 40 CFR part 1065, subpart H, if it is not specified in the standard-setting part.

(b) Lubricating oil. Use lubricating oil as specified in 40 CFR 1065.740. For two-stroke engines that involve a specified mixture of fuel and lubricating oil, mix the lubricating oil with the fuel according to the manufacturer's specifications.

(c) Coolant. For liquid-cooled engines, use coolant as specified in 40 CFR 1065.745.

(d) Analytical gases. Use analytical gases that meet the requirements of 40 CFR 1065.750.

(e) Mass standards. Use mass standards that meet the requirements of 40 CFR 1065.790.

§1066.150 Analyzer interference and quench verification limit.

Analyzers must meet the interference and quench verification limits in the following table on the lowest instrument range that will be used during emission testing, instead of those specified in 40 CFR part 1065, subpart D:

Table 1 of §1066.150–Analyzer interference and quench verification limits.

Verification	Limit
40 CFR 1065.350	±2 % of full scale
40 CFR 1065.355	±2 % of full scale
40 CFR 1065.370	±2 % of full scale
40 CFR 1065.375	±2 % of the flow-weighted mean concentration of N_2O expected at the standard

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Subpart C—Dynamometer Specifications

§1066.201 Dynamometer overview.
This subpart addresses chassis dynamometers and related equipment.

§1066.210 Dynamometers.
(a) General requirements. A chassis dynamometer typically uses electrically generated load forces combined with its rotational inertia to recreate the mechanical inertia and frictional forces that a vehicle exerts on road surfaces (known as "road load"). Load forces are calculated using vehicle-specific coefficients and response characteristics. The load forces are applied to the vehicle tires by rolls connected to motor/absorbers. The dynamometer uses a load cell to measure the forces the dynamometer rolls apply to the vehicle's tires.
(b) Accuracy and precision. The dynamometer's output values for road load must be NIST-traceable. We may determine traceability to a specific international standards organization to be sufficient to demonstrate NIST-traceability. The force-measurement system must be capable of indicating force readings as follows:
(1) For dynamometers testing of vehicles at or below 20,000 pounds GVWR, the dynamometer force-measurement system must be capable of indicating force readings during a test to a resolution of ±0.05 % of the maximum load-cell force simulated by the dynamometer or ±9.0 N (±2.0 lbf), whichever is greater.
(2) For dynamometers testing of vehicles above 20,000 pounds GVWR the force-measurement system must be capable of indicating force readings during a test to a resolution of ±0.05 % of the maximum load-cell force simulated by the dynamometer or ±36.0 N (±8.0 lbf), whichever is greater.
(c) Test cycles. The dynamometer must be capable of fully simulating vehicle performance over applicable test cycles for the vehicles being tested as referenced in the corresponding standard-setting part, including operation at the combination of inertial and road-load forces corresponding to maximum road load conditions and maximum simulated inertia at the highest acceleration rate experienced during testing.
(d) Component requirements. The following specifications apply:
(1) The nominal roll diameter must be 120 cm or greater. The dynamometer must have an independent drive roll for each drive axle as tested under §1066.410(g), except that two drive axles may share a single drive roll. Use good engineering judgment to ensure that the dynamometer roll diameter is large enough to provide sufficient tire-roll contact area to avoid tire overheating and power losses from tire-roll slippage.
(2) Measure and record force and speed at 10 Hz or faster. You may convert measured values to 1-Hz, 2-Hz, or 5-Hz values before your calculations, using good engineering judgment.
(3) The load applied by the dynamometer simulates forces acting on the vehicle during normal driving according to the following equation:

$$FR_i = A + B \cdot v_i + C \cdot v_i^2 + M \cdot \frac{v_i - v_{i-1}}{t_i - t_{i-1}}$$

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(1) For vehicles with a gross vehicle weight rating (GVWR) at or below 14,000 lbs, the dynamometer must be able to fully simulate a driving schedule with a maximum speed of 36 m/s (80 mph) and a maximum acceleration rate of 3.6 m/s^2 (8 mph/s) in two-wheel drive and four-wheel drive configurations.'
(2) For vehicles with GVWR above 14,000 lbs, the dynamometer must be able to fully simulate a driving schedule with a maximum speed of 29 m/s (65 mph) and a maximum acceleration rate of 1.3 m/s^2 (3 mph/s) in either two-wheel drive or four-wheel drive configurations.
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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 = constant value representing the vehicle's frictional load in lbf or newtons. See subpart D of this part.
B = coefficient representing load from drag and rolling resistance, which are a function of vehicle speed, in lbf/mph or N·s/m. See subpart D of this part.
v = linear speed at the roll surfaces as measured by the dynamometer, in mph or m/s. Let $v_{i-1} = 0$ for $i = 0$.
C = coefficient representing aerodynamic effects, which are a function of vehicle speed squared, in lbf/mph^2 or N·s^2/m^2. See subpart D of this part.
M = mass of vehicle in lbm or kg. For vehicles at or below 14,000 pounds GVWR, determine the vehicle's mass based on equivalent test weight (ETW) as specified in §1066.810 and set dynamometer inertia simulation as specified in §1066.410(h). For vehicles above 14,000 pounds GVWR, determine the vehicle's mass based on the test weight, taking into account the effect of rotating axles, as specified in §1066.310(b)(7) and dividing the weight by the acceleration due to gravity as specified in 40 CFR 1065.630, consistent with good engineering judgment.
t = elapsed time in the driving schedule as measured by the dynamometer, in seconds. Let $t_{i-1} = 0$ for $i = 0$.
(4) We recommend that a dynamometer capable of testing vehicles at or below 20,000 pounds GVWR be designed to apply an actual road-load force within ±1 % or ±9.0 N (±2.0 lbf) of the reference value, whichever is greater. Dynamometers that do not fully meet this specification may be used consistent with good engineering judgment. For example, slightly higher errors may be permissible during highly transient operation for vehicles with a GVWR above 8500 pounds.
(e) Dynamometer manufacturer instructions. This part specifies that you follow the dynamometer manufacturer's recommended procedures for things such as calibrations and general operation. If you perform testing with a dynamometer that you manufactured or if you otherwise do not have these recommended procedures, use good engineering judgment to establish the additional procedures and specifications we specify in this part, unless we specify otherwise. Keep records to describe these recommended procedures and how they are consistent with good engineering judgment, including any quantified error estimates.

§1066.215 Summary of verification and calibration procedures for chassis dynamometers.
(a) Overview. This section describes the overall process for verifying and calibrating the performance of chassis dynamometers.
(b) Scope and frequency. The following table summarizes the required and recommended calibrations and verifications described in this subpart and indicates when they must occur:

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Table 1 of §1066.215–Summary of required dynamometer calibrations and verifications.

Type of calibration or verification	Minimum frequency[a]
§1066.220: Linearity verification	Speed: Upon initial installation, within 370 days before testing, and after major maintenance. Torque (load): Upon initial installation and after major maintenance.
§1066.225: Roll runout and diameter verification	Upon initial installation and after major maintenance.
§1066.230: Time verification	Upon initial installation and after major maintenance.
§1066.235: Speed measurement verification	Upon initial installation, within 370 days before testing, and after major maintenance.
§1066.240: Torque (load) transducer verification	Upon initial installation, within 7 days of testing, and after major maintenance.
§1066.245: Response time verification	Upon initial installation, within 370 days before testing, and after major maintenance.
§1066.250: Base inertia verification	Upon initial installation and after major maintenance.
§1066.255: Parasitic loss verification	Upon initial installation, after major maintenance, and upon failure of a verification in §1066.270 or §1066.280.
§1066.260: Parasitic friction compensation evaluation	Upon initial installation, after major maintenance, and upon failure of a verification in §1066.270 or §1066.280.
§1066.265: Acceleration and deceleration verification	Upon initial installation and after major maintenance.
§1066.270: Unloaded coastdown verification	Upon initial installation, within 7 days of testing, and after major maintenance.
§1066.280 Dynamometer readiness verification	Upon initial installation, within 1 day before testing, and after major maintenance.

[a]Perform calibrations and verifications more frequently, according to measurement system manufacturer instructions and good engineering judgment.

(c) Automated dynamometer verifications and calibrations. In some cases, dynamometers are designed with internal diagnostic and control features to accomplish the verifications and calibrations specified in this subpart. You may use these automated functions instead of following the procedures we specify in this subpart to demonstrate compliance with applicable requirements, consistent with good engineering judgment.

(d) Sequence of verifications and calibrations. Upon initial installation and after major maintenance, perform the verifications and calibrations in the same sequence as noted in Table 1 of this section, except that you may perform speed linearity verification after the verifications in §§1066.225 and 1066.230. At other times, you may need to perform specific verifications or calibrations in a certain sequence, as noted in this subpart. If you perform major maintenance on a specific component, you are required to perform verifications and calibrations only on components or parameters that are affected by the maintenance.

(e) Corrections. Unless the regulation directs otherwise, if the dynamometer fails to meet any specified calibration or verification, make any necessary adjustments or repairs such that the dynamometer meets the specification before running a test. Repairs required to meet specifications are generally considered major maintenance under this part.

§1066.220 Linearity verification for chassis dynamometer systems.

(a) Scope and frequency. Perform linearity verification for dynamometer speed and torque at least as frequently as indicated in Table 1 of §1066.215. The intent of linearity verification is to determine that the system responds accurately and proportionally over the measurement range of interest. Linearity verification generally consists of

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introducing a series of at least 10 reference values to a measurement system. The measurement system quantifies each reference value. The measured values are then collectively compared to the reference values by using a least-squares linear regression and the linearity criteria specified in Table 1 of this section.

(b) Performance requirements. If a measurement system does not meet the applicable linearity criteria in Table 1 of this section, correct the deficiency by re-calibrating, servicing, or replacing components as needed. Repeat the linearity verification after correcting the deficiency to ensure that the measurement system meets the linearity criteria. Before you may use a measurement system that does not meet linearity criteria, you must demonstrate to us that the deficiency does not adversely affect your ability to demonstrate compliance with the applicable standards.

(c) Procedure. Use the following linearity verification protocol, or use good engineering judgment to develop a different protocol that satisfies the intent of this section, as described in paragraph (a) of this section:

(1) In this paragraph (c), the letter "y" denotes a generic measured quantity, the superscript over-bar denotes an arithmetic mean (such as $\overline{y}$), and the subscript "$_{ref}$" denotes the known or reference quantity being measured.

(2) Operate the dynamometer system at the specified operating conditions. This may include any specified adjustment or periodic calibration of the dynamometer system.

(3) Set dynamometer speed and torque to zero.

(4) Verify the dynamometer speed or torque signal based on the dynamometer manufacturer's recommendations.

(5) After verification, check for zero speed and torque. Use good engineering judgment to determine whether or not to rezero or re-verify speed and torque before continuing.

(6) For both speed and torque, use the dynamometer manufacturer's recommendations and good engineering judgment to select reference values, y_{refi}, that cover a range of values that you expect would prevent extrapolation beyond these values during emission testing. We recommend selecting zero speed and zero torque as reference values for the linearity verification.

(7) Use the dynamometer manufacturer's recommendations and good engineering judgment to select the order in which you will introduce the series of reference values. For example, you may select the reference values randomly to avoid correlation with previous measurements and to avoid the influence of hysteresis; you may select reference values in ascending or descending order to avoid long settling times of reference signals; or you may select values to ascend and then descend to incorporate the effects of any instrument hysteresis into the linearity verification.

(8) Set the dynamometer to operate at a reference condition.

(9) Allow time for the dynamometer to stabilize while it measures the reference values.

(10) At a recording frequency of at least 1 Hz, measure speed and torque values for 30 seconds and record the arithmetic mean of the recorded values, $\overline{y}_i$. Refer to 40 CFR 1065.602 for an example of calculating an arithmetic mean.

(11) Repeat the steps in paragraphs (c)(8) though (10) of this section until you measure speeds and torques at each of the reference settings.

(12) Use the arithmetic means, $\overline{y}_i$, 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 described

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in 40 CFR 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. Table 1 follows:

Table 1 of §1066.220–
Dynamometer measurement systems that require linearity verifications

Measurement system	Quantity	Linearity criteria			
		$\lvert y_{min}(a_1\text{-}1)+a_0 \rvert$	a_1	*SEE*	r^2
Speed	y	≤0.05 % · y_{max}	0.98-1.02	≤2 % · y_{max}	≥0.990
Torque (load)	T	≤1 % · T_{max}	0.99-1.01	≤1 % · T_{max}	≥0.990

(d) Reference signals. Generate reference values for the linearity-verification protocol in paragraph (c) of this section as described for speed and torque in 40 CFR 1065.307(d).

§1066.225 Roll runout and diameter verification procedure.

(a) Overview. This section describes the verification procedure for roll runout and roll diameter. Roll runout is a measure of the variation in roll radius around the circumference of the roll.

(b) Scope and frequency. Perform these verifications upon initial installation and after major maintenance that could affect roll surface finish or dimensions (such as resurfacing or polishing).

(c) Roll runout procedure. Verify roll runout based on the following procedure, or an equivalent procedure based on good engineering judgment:

(1) Perform this verification with laboratory and dynamometer temperatures stable and at equilibrium. Release the roll brake and shut off power to the dynamometer. Remove any dirt, rubber, rust, and debris from the roll surface. Mark measurement locations on the roll surface using a permanent marker. Mark the roll at a minimum of four equally spaced locations across the roll width; we recommend taking measurements every 150 mm across the roll. Secure the marker to the deck plate adjacent to the roll surface and slowly rotate the roll to mark a clear line around the roll circumference. Repeat this process for all measurement locations.

(2) Measure roll runout using an indicator with a probe that allows for measuring the position of the roll surface relative to the roll centerline as it turns through a complete revolution. The indicator must have some means of being securely mounted adjacent to the roll. The indicator must have sufficient range to measure roll runout at all points, with a minimum accuracy and precision of ±0.025 mm. Calibrate the indicator according to the instrument manufacturer's instructions.

(3) Position the indicator adjacent to the roll surface at the desired measurement location. Position the shaft of the indicator perpendicular to the roll such that the point of the indicator is slightly touching the surface of the roll and can move freely through a full rotation of the roll. Zero the indicator according to the instrument manufacturer's instructions. Avoid distortion of the runout measurement from the weight of a person standing on or near the mounted dial indicator.

(4) Slowly turn the roll through a complete rotation and record the maximum and minimum values from the indicator. Calculate runout as the difference between these maximum and minimum values.

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(5) Repeat the steps in paragraphs (c)(3) and (4) of this section for all measurement locations.
(6) The roll runout must be less than 0.254 mm (0.0100 inches) at all measurement locations.
(d) Diameter procedure. Verify roll diameter based on the following procedure, or an equivalent procedure based on good engineering judgment:
(1) Prepare the laboratory and the dynamometer as specified in paragraph (c)(1) of this section.
(2) Measure roll diameter using a Pi Tape®. Orient the Pi Tape® to the marker line at the desired measurement location with the Pi Tape® hook pointed outward. Temporarily secure the Pi Tape® to the roll near the hook end with adhesive tape. Slowly turn the roll, wrapping the Pi Tape® around the roll surface. Ensure that the Pi Tape® is flat and adjacent to the marker line around the full circumference of the roll. Attach a 2.26-kg weight to the hook of the Pi Tape® and position the roll so that the weight dangles freely. Remove the adhesive tape without disturbing the orientation or alignment of the Pi Tape®.
(3) Overlap the gage member and the vernier scale ends of the Pi Tape® to read the diameter measurement to the nearest 0.01 mm. Follow the manufacturer's recommendation to correct the measurement to 20 °C, if applicable.
(4) Repeat the steps in paragraphs (d)(2) and (3) of this section for all measurement locations.
(5) The measured roll diameter must be within ±0.254 mm of the specified nominal value at all measurement locations. You may revise the nominal value to meet this specification, as long as you use the corrected nominal value for all calculations in this subpart.

§1066.230 Time verification procedure.
(a) Overview. This section describes how to verify the accuracy of the dynamometer's timing device.
(b) Scope and frequency. Perform this verification upon initial installation and after major maintenance.
(c) Procedure. Perform this verification using one of the following procedures:
(1) WWV method. You may use the time and frequency signal broadcast by NIST from radio station WWV as the time standard if the trigger for the dynamometer timing circuit has a frequency decoder circuit, as follows:
(i) Dial station WWV at (303) 499-7111 and listen for the time announcement. Verify that the trigger started the dynamometer timer. Use good engineering judgment to minimize error in receiving the time and frequency signal.
(ii) After at least 1000 seconds, re-dial station WWV and listen for the time announcement. Verify that the trigger stopped the dynamometer timer.
(iii) Compare the measured elapsed time, y_{act}, to the corresponding time standard, y_{ref}, to determine the time error, y_{error}, using the following equation:

$$y_{error} = \frac{y_{act} - y_{ref}}{y_{ref}} \cdot 100\ \%$$

Eq. 1066.230-1

(2) Ramping method. You may set up an operator-defined ramp function to serve as the time standard as follows:
(i) Set up the signal generator to output a marker voltage at the peak of each ramp to trigger the dynamometer timing circuit. Output the designated marker voltage to start the verification period.
(ii) After at least 1000 seconds, output the designated marker voltage to end the verification period.
(iii) Compare the measured elapsed time between marker signals, y_{act}, to the corresponding time standard, y_{ref}, to determine the time error, y_{error}, using Eq. 1066.230-1.
(3) Dynamometer coastdown method. You may use a signal generator to output a known speed ramp signal to the dynamometer controller to serve as the time standard as follows:
(i) Generate upper and lower speed values to trigger the start and stop functions of the coastdown timer circuit. Use the signal generator to start the verification period.
(ii) After at least 1000 seconds, use the signal generator to end the verification period.
(iii) Compare the measured elapsed time between trigger signals, y_{act}, to the corresponding time standard, y_{ref}, to determine the time error, y_{error}, using Eq. 1066.230-1.
(d) Performance evaluation. The time error determined in paragraph (c) of this section may not exceed ±0.001 %.

§1066.235 Speed verification procedure.
(a) Overview. This section describes how to verify the accuracy and resolution of the dynamometer speed determination. When performing this verification, you must also verify the dynamometer speed at any devices used to display or record vehicle speed (for example a driver's aid) is representative of the speed input from the dynamometer speed determination.
(b) Scope and frequency. Perform this verification upon initial installation, within 370 days before testing, and after major maintenance.
(c) Procedure. Use one of the following procedures to verify the accuracy and resolution of the dynamometer speed simulation:
(1) Pulse method. Connect a universal frequency counter to the output of the dynamometer's speed-sensing device in parallel with the signal to the dynamometer controller. The universal frequency counter must be calibrated according to the instrument manufacturer's instructions and be capable of measuring with enough accuracy to perform the procedure as specified in this paragraph (c)(1). Make sure the instrumentation does not affect the signal to the dynamometer control circuits. Determine the speed error as follows:
(i) Set the dynamometer to speed-control mode. Set the dynamometer speed to a value of approximately 4.5 m/s (10 mph); record the output of the frequency counter after 10 seconds. Determine the roll speed, v_{act}, using the following equation:

$$v_{act} = \frac{f \cdot d_{roll} \cdot \pi}{n}$$

Eq. 1066.235-1

Where:
f = frequency of the dynamometer speed sensing device, accurate to at least four significant figures.

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d_{roll} = nominal roll diameter, accurate to the nearest 1.0 mm, consistent with §1066.225(d).
n = the number of pulses per revolution from the dynamometer roll speed sensor.

Example:
f = 2.9231 Hz = 2.9231 s^{-1}
d_{roll} = 904.40 mm = 0.90440 m
n = 1 pulse/rev

$$v_{act} = \frac{2.9231 \cdot 0.90440 \cdot \pi}{1}$$

v_{act} = 8.3053 m/s

(ii) Repeat the steps in paragraph (c)(1)(i) of this section for the maximum speed expected during testing and at least two additional evenly spaced speed points between the starting speed and the maximum speed point.
(iii) Compare the calculated roll speed, v_{act}, to each corresponding speed set point, v_{ref}, to determine values for speed error at each set point, v_{error}, using the following equation:

$$v_{error} = v_{act} - v_{ref}$$

Eq. 1066.235-2

Example:
v_{act} = 8.3053 m/s
v_{ref} = 8.3000 m/s
v_{error} = 8.3053 – 8.3000 = 0.0053 m/s

(2) Frequency method. Install a piece of tape in the shape of an arrowhead on the surface of the dynamometer roll near the outer edge. Put a reference mark on the deck plate in line with the tape. Install a stroboscope or photo tachometer on the deck plate and direct the flash toward the tape on the roll. The stroboscope or photo tachometer must be calibrated according to the instrument manufacturer's instructions and be capable of measuring with enough accuracy to perform the procedure as specified in this paragraph (c)(2). Determine the speed error as follows:
(i) Set the dynamometer to speed control mode. Set the dynamometer speed to a speed value of approximately 4.5 m/s (10 mph). Tune the stroboscope or photo tachometer until the signal matches the dynamometer roll speed. Record the frequency. Determine the roll speed, v_{act}, using Eq. 1066.235-1, using the stroboscope or photo tachometer's frequency for f.
(ii) Repeat the steps in paragraph (c)(2)(i) of this section for the maximum speed expected during testing and at least two additional evenly spaced speed points between the starting speed and the maximum speed point.
(iii) Compare the calculated roll speed, v_{act}, to each corresponding speed set point, v_{ref}, to determine values for speed error at each set point, v_{error}, using Eq. 1066.235-2.
(d) Performance evaluation. The speed error determined in paragraph (c) of this section may not exceed ±0.02 m/s at any speed set point.

§1066.240 Torque transducer verification.

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Verify torque-measurement systems by performing the verifications described in §1066.270 and 280.

§1066.245 Response time verification.

(a) Overview. This section describes how to verify the dynamometer's response time.

(b) Scope and frequency. Perform this verification upon initial installation, within 370 days before testing, and after major maintenance.

(c) Procedure. Use the dynamometer's automated process to verify response time. You may perform this test either at two different inertia settings corresponding approximately to the minimum and maximum vehicle weights you expect to test or using base inertia and two acceleration rates that cover the range of acceleration rates experienced during testing (for example 0.5 and 8 mph/s). Use good engineering judgment to select road-load coefficients representing vehicles of the appropriate weight. Determine the dynamometer's settling response time, t_s, based on the point at which there are no measured results more than 10 % above or below the final equilibrium value, as illustrated in Figure 1 of this section. The observed settling response time must be less than 100 milliseconds for each inertia setting.

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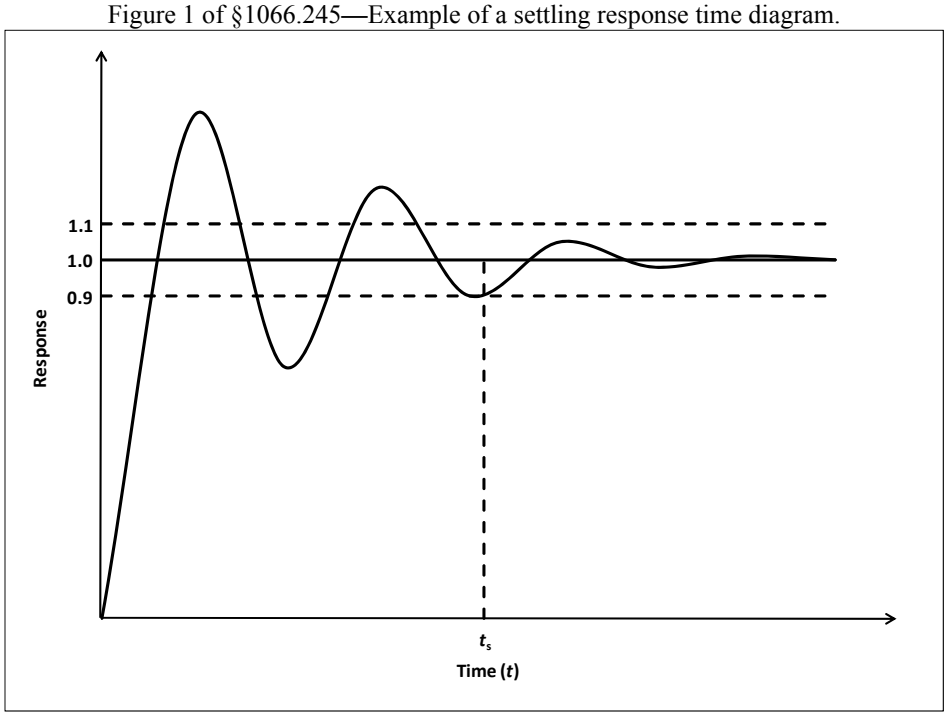
Figure 1 of §1066.245—Example of a settling response time diagram.



§1066.250 Base inertia verification.

(a) Overview. This section describes how to verify the dynamometer's base inertia.

(b) Scope and frequency. Perform this verification upon initial installation and after major maintenance (such as maintenance that could affect roll assembly inertia).

(c) Procedure. Verify the base inertia using the following procedure:

(1) Warm up the dynamometer according to the dynamometer manufacturer's instructions. Set the dynamometer's road-load inertia to zero, turning off any electrical simulation of road load and inertia so that the base inertia of the dynamometer is the only inertia present, and motor the rolls to 5 mph. Apply a constant force to accelerate the roll at a nominal rate of 1 mph/s. Measure the elapsed time to accelerate from 10 to 40 mph, noting the corresponding speed and time points to the nearest 0.01 mph and 0.01 s. Also determine average force over the measurement interval.

(2) Starting from a steady roll speed of 45 mph, apply a constant force to the roll to decelerate the roll at a nominal rate of 1 mph/s. Measure the elapsed time to decelerate from 40 to 10 mph, noting the corresponding speed and time points to the nearest 0.01 mph and 0.01 s. Also determine average force over the measurement interval.

(3) Repeat the steps in paragraphs (c)(1) and (2) of this section for a total of five sets of results at the nominal acceleration rate and the nominal deceleration rate.

(4) Use good engineering judgment to select two additional acceleration and deceleration rates that cover the middle and upper rates expected during testing. Repeat the steps in paragraphs (c)(1) through (3) of this section at each of these additional acceleration and deceleration rates.

(5) Determine the base inertia, I_b, for each measurement interval using the following equation:

$$I_b = \frac{F}{\left| \frac{v_{final} - v_{initial}}{\Delta t} \right|}$$

Eq. 1066.250-1

Where:

F = average dynamometer force over the measurement interval as measured by the dynamometer.

v_{final} = roll surface speed at the end of the measurement interval to the nearest 0.01 mph.

$v_{initial}$ = roll surface speed at the start of the measurement interval to the nearest 0.01 mph.

Δt = elapsed time during the measurement interval to the nearest 0.01 s.

Example:

F = 1.500 lbf = 48.26 ft·lbm/s^2

v_{final} = 40.00 mph = 58.67 ft/s

$v_{initial}$ = 10.00 mph = 14.67 ft/s

Δt = 30.00 s

$$I_b = \frac{48.26}{\left| \frac{58.67 - 14.67}{30.00} \right|}$$

I_b = 32.90 lbm

(6) Calculate the base inertia error, I_{berror}, for each of the thirty measured base inertia values, I_b, by comparing it to the manufacturer's stated base inertia, I_{bref}, using the following equation:

$$I_{berror} = \frac{I_{bref} - I_{bact}}{I_{bref}} \cdot 100\ \%$$

Eq. 1066.250-2

Example:

I_{bref} = 32.96 lbm

I_{bact} = 32.90 lbm (from paragraph (c)(5) of this section)

$$I_{berror} = \frac{32.96 - 32.90}{32.96} \cdot 100\ \%$$

I_{berror} = 0.18 %

(7) Determine the base inertia arithmetic mean value, $\overline{I}_b$, from the sum of the ten acceleration and deceleration interval base inertia values for each of the three acceleration/deceleration rates. Calculate base inertia mean values as described in 40 CFR 1065.602(b)

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(8) Calculate the inertia error for each of the three mean values of base inertia from paragraph (c)(7) of this section. Use Eq. 1066.250-2, substituting the mean base inertias associated with each acceleration and deceleration rate for the individual base inertias.
(d) Performance evaluation. The dynamometer must meet the following specifications to be used for testing under this part:
(1) All base inertia errors determined under paragraph (c)(6) of this section may not exceed ±1.0 %.
(2) All mean base inertia errors determined under paragraph (c)(8) of this section may not exceed ±0.20 %.

§1066.255 Parasitic loss verification.
(a) Overview. Verify and correct the dynamometer's parasitic loss. This procedure determines the dynamometer's internal losses that it must overcome to simulate road load. These losses are characterized in a parasitic loss curve that the dynamometer uses to apply compensating forces to maintain the desired road-load force at the roll surface.
(b) Scope and frequency. Perform this verification upon initial installation, after major maintenance, and upon failure of a verification in either §1066.270 or §1066.280.
(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 zeroed and spanned prior to performing this procedure.
(d) Performance evaluation. In some cases, the dynamometer automatically updates the parasitic loss curve for further testing. If this is not the case, compare the new parasitic loss curve to the original parasitic loss curve from the dynamometer manufacturer or the most recent parasitic loss curve you programmed into the dynamometer. You may reprogram the dynamometer to accept the new curve in all cases, and you must reprogram the dynamometer if any point on the new curve departs from the earlier curve by more than ±9.0 N for dynamometers capable of testing vehicles at or below 20,000 pounds GVWR or ±36.0 N (±8.0 lbf) for dynamometers not capable of testing vehicles at or below 20,000 pounds GVWR.

§1066.260 Parasitic friction compensation evaluation.
(a) Overview. This section describes how to verify the accuracy of the dynamometer's friction compensation.
(b) Scope and frequency. Perform this verification upon initial installation, after major maintenance, and upon failure of a verification in either §1066.270 or §1066.280. Note that this procedure relies on proper verification or calibration of speed and torque, as described in §§1066.235 and 1066.240. You must also first verify the dynamometer's parasitic loss curve as specified in §1066.255.
(c) Procedure. Use the following procedure to verify the accuracy of the dynamometer's friction compensation:
(1) Warm up the dynamometer as specified by the dynamometer manufacturer.
(2) Perform a torque verification as specified by the dynamometer manufacturer. For torque verifications relying on shunt procedures, if the results do not conform to

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specifications, recalibrate the dynamometer using NIST-traceable standards as appropriate until the dynamometer passes the torque verification. Do not change the dynamometer's base inertia to pass the torque verification.

(3) Set the dynamometer inertia to the base inertia with the road-load coefficients A, B, and C set to 0. Set the dynamometer to speed-control mode with a target speed of 50 mph or a higher speed recommended by the dynamometer manufacturer. Once the speed stabilizes at the target speed, switch the dynamometer from speed control to torque control and allow the roll to coast for 60 seconds. Record the initial and final speeds and the corresponding start and stop times. If friction compensation is executed perfectly, there will be no change in speed during the measurement interval.

(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 mph.

v_{final} = the roll speed corresponding to the end of the measurement interval, accurate to at least 0.05 mph.

Example:

I = 2000 lbm = 62.16 lbf· s^2/ft

t = 60.0 s

v_{init} = 9.2 mph = 13.5 ft/s

v_{final} = 10.0 mph = 14.7 ft/s

$$FC_{error} = \frac{62.16}{2 \cdot 60.00} \cdot \left(13.5^2 - 14.7^2 \right)$$

FC_{error} = –16.5 ft·lbf/s = –0.031 hp

(5) The friction compensation error may not exceed ±0.15 hp for dynamometers capable of testing vehicles at or below 20,000 pounds GVWR, or ±0.6 hp for dynamometers not capable of testing vehicles at or below 20,000 pounds GVWR.

§1066.265 Acceleration and deceleration verification.

(a) Overview. This section describes how to verify the dynamometer's ability to achieve targeted acceleration and deceleration rates. Paragraph (c) of this section describes how this verification applies when the dynamometer is programmed directly for a specific acceleration or deceleration rate. Paragraph (d) of this section describes how this verification applies when the dynamometer is programmed with a calculated force to achieve a targeted acceleration or deceleration rate.

(b) Scope and frequency. Perform this verification or an equivalent procedure upon initial installation and after major maintenance that could affect acceleration and

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deceleration accuracy. Note that this procedure relies on proper verification or calibration of speed as described in §1066.235.

(c) Verification of acceleration and deceleration rates. Activate the dynamometer's function generator for measuring roll revolution frequency. If the dynamometer has no such function generator, set up a properly calibrated external function generator consistent with the verification described in this paragraph (c). Use the function generator to determine actual acceleration and deceleration rates as the dynamometer traverses speeds between 10 and 40 mph at various nominal acceleration and deceleration rates. Verify the dynamometer's acceleration and deceleration rates as follows:

(1) Set up start and stop frequencies specific to your dynamometer by identifying the roll-revolution frequency, f, in revolutions per second (or Hz) corresponding to 10 mph and 40 mph vehicle speeds, accurate to at least four significant figures, using the following equation:

$$f = \frac{v \cdot n}{d_{roll} \cdot \pi}$$

Eq. 1066.265-1

Where:

v = the target roll speed, in inches per second (corresponding to drive speeds of 10 mph or 40 mph).

n = the number of pulses from the dynamometer's roll-speed sensor per roll revolution.

d_{roll} = roll diameter, in inches.

(2) Program the dynamometer to accelerate the roll at a nominal rate of 1 mph/s from 10 mph to 40 mph. Measure the elapsed time to reach the target speed, to the nearest 0.01 s. Repeat this measurement for a total of five runs. Determine the actual acceleration rate for each run, a_{act}, using the following equation:

$$a_{act} = \frac{v_{final} - v_{init}}{t}$$

Eq. 1066.265-2

Where:

a_{act} = acceleration rate (decelerations have negative values).

v_{final} = the target value for the final roll speed.

v_{init} = the setpoint value for the initial roll speed.

t = time to accelerate from v_{init} to v_{final}.

Example:

v_{final} = 40 mph

v_{init} = 10 mph

t = 30.003 s

$$a_{act} = \frac{40.00 - 10.00}{30.03}$$

a_{act} = 0.999 mph/s

(3) Program the dynamometer to decelerate the roll at a nominal rate of 1 mph/s from 40 mph to 10 mph. Measure the elapsed time to reach the target speed, to the nearest 0.01 s.

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Repeat this measurement for a total of five runs. Determine the actual acceleration rate, a_{act}, using Eq. 1066.265-2

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(4) Repeat the steps in paragraphs (c)(2) and (3) of this section for additional acceleration and deceleration rates in 1 mph/s increments up to and including one increment above the maximum acceleration rate expected during testing. Average the five repeat runs to calculate a mean acceleration rate, $\overline{a}_{act}$, at each setting.

(5) Compare each mean acceleration rate, $\overline{a}_{act}$, to the corresponding nominal acceleration rate, a_{ref}, to determine values for acceleration error, a_{error}, using the following equation:

$$a_{error} = \frac{\overline{a}_{act} - a_{ref}}{a_{ref}} \cdot 100\ \%$$

Eq. 1066.265-3

Example:

$\overline{a}_{act} = 0.999$ mph/s

$a_{ref} = 1$ mph/s

$$a_{error} = \frac{0.999 - 1}{1} \cdot 100\ \%$$

$a_{error} = -0.100\ \%$

(d) Verification of forces for controlling acceleration and deceleration. Program the dynamometer with a calculated force value and determine actual acceleration and deceleration rates as the dynamometer traverses speeds between 10 and 40 mph at various nominal acceleration and deceleration rates. Verify the dynamometer's ability to achieve certain acceleration and deceleration rates with a given force as follows:

(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

$a = 1$ mph/s $= 1.4667$ ft/s^2

$$F = 92.217 \cdot |1.4667|$$

$F = 135.25$ lbf

(2) Set the dynamometer to road-load mode and program it with a calculated force to accelerate the roll at a nominal rate of 1 mph/s from 10 mph to 40 mph. Measure the elapsed time to reach the target speed, to the nearest 0.01 s. Repeat this measurement for a total of five runs. Determine the actual acceleration rate, a_{act}, for each run using Eq. 1066.265-2. Repeat this step to determine measured "negative acceleration" rates using a calculated force to decelerate the roll at a nominal rate of 1 mph/s from 40 mph to 10

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mph. Average the five repeat runs to calculate a mean acceleration rate, $\bar{a}_{act}$, at each setting.
(3) Repeat the steps in paragraph (d)(2) of this section for additional acceleration and deceleration rates as specified in paragraph (c)(4) of this section.
(4) Compare each mean acceleration rate, $\bar{a}_{act}$, to the corresponding nominal acceleration rate, a_{ref}, to determine values for acceleration error, a_{error}, using Eq. 1066.265-3
(e) Performance evaluation. The acceleration error from paragraphs (c)(5) and (d)(4) of this section may not exceed ±1.0 %.

§1066.270 Unloaded coastdown verification.
(a) Overview. Use force measurements to verify the dynamometer's settings based on coastdown procedures.
(b) Scope and frequency. Perform this verification upon initial installation, within 7 days of testing, and after major maintenance.
(c) Procedure. This procedure verifies the dynamometer's settings derived from coastdown testing. For dynamometers that have an automated process for this procedure, perform this evaluation by setting the initial speed, final speed, inertial coefficients, and road-load coefficients as required for each test, using good engineering judgment to ensure that these values properly represent in-use operation. Use the following procedure if your dynamometer does not perform this verification with an automated process:
(1) Warm up the dynamometer as specified by the dynamometer manufacturer.
(2) With the dynamometer in coastdown mode, set the dynamometer inertia for the smallest vehicle weight that you expect to test and set A, B, and C road-load coefficients to values typical of those used during testing. Program the dynamometer to coast down over the dynamometer operational speed range (typically from a speed of 80 mph through a minimum speed at or below 10 mph). Perform at least one coastdown over this speed range, collecting data over each 10 mph interval.
(3) Repeat the steps in paragraph (c)(2) of this section with the dynamometer inertia and road-load coefficients set for the largest vehicle weight that you expect to test.
(4) Determine the average coastdown force, F, for each speed and inertia setting for each of the coastdowns performed using the following equation:

$$F = \frac{I \cdot \left(v_{init} - v_{final}\right)}{t}$$

Eq. 1066.270-1

Where:
F = the average force measured during the coastdown for each speed interval and inertia setting, expressed in lbf· s^2/ft 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, expressed in ft/s and rounded to four significant figures.
v_{final} = the speed at the end of the coastdown interval, rounded to four significant figures.
t = coastdown time for each speed and inertia setting, accurate to at least 0.01 s.

Example:
I = 2000 lbm = 65.17 lbf · s^2/ft

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v_{init} = 25 mph = 36.66 ft/s
v_{final} = 15 mph = 22.0 ft/s
t = 5.00 s

$$F = \frac{65.17 \cdot (36.66 - 22.0)}{5.00}$$

F = 191.1 lbf

(5) Calculate the target value of coastdown force, F_{ref}, based on the applicable dynamometer parameters for each speed and inertia setting.
(6) Compare the mean value of the coastdown force measured for each speed and inertia setting, $\overline{F}_{act}$, to the corresponding F_{ref} to determine values for coastdown force error, F_{error}, using the following equation:

$$F_{error} = \left| \frac{\overline{F}_{act} - F_{ref}}{F_{ref}} \right| \cdot 100\ \%$$

Eq. 1066.270-2

Example:
F_{ref} = 192 lbf
$\overline{F}_{act}$ = 191 lbf

$$F_{error} = \left| \frac{191 - 192}{192} \right| \cdot 100\ \%$$

F_{error} = 0.5 %

(d) Performance evaluation. The coastdown force error determined in paragraph (c) of this section may not exceed the following:
(i) For vehicles at or below 20,000 pounds GVWR, calculate $F_{errormax}$ from the following formula:

$F_{errormax}$ (%) = (2.0 lbf/F_{ref})·100

Eq. 1066.270-3

Example:
F_{ref} = 192 lbf
$F_{errormax}$ (%) = (2.0/192)·100 = 1.04%

(ii) For vehicles above 20,000 pounds GVWR, the maximum allowable error, $F_{errormax}$, for all speed and inertia settings is ±1.0 % or ±36.0 N, whichever is greater.
(e) If the dynamometer is not able to meet this requirement, diagnose and repair the dynamometer before continuing with emission testing. Diagnosis should include performing the verifications in §1066.255 and §1066.260.

§1066.280 Dynamometer readiness verification.
(a) Overview. This section describes how to verify that the dynamometer is ready for emission testing.
(b) Scope and frequency. Perform this verification upon initial installation, within 1 day before testing, and after major maintenance.

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Eq. 1066.270-3¶
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Example:¶
F_{ref} = 192 lbf¶
$F_{errormax}$ (%) = (2.2/192)·100 = 1.14%¶
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(c) Procedure. For dynamometers that have an automated process for this verification procedure, perform this evaluation by setting the initial speed and final speed and the inertial and road-load coefficients as required for the test, using good engineering judgment to ensure that these values properly represent in-use operation. Use the following procedure if your dynamometer does not perform this verification with an automated process:

(1) With the dynamometer in coastdown mode, set the dynamometer inertia to the base inertia with the road-load coefficient A set to 20 lbf (or a force that results in a coastdown time of less than 10 minutes) and coefficients B and C set to 0. Program the dynamometer to coast down for one 10 mph interval from 55 mph down to 45 mph. If your dynamometer is not capable of performing one discrete coastdown, then coast down with preset 10 mph intervals that include a 55 mph to 45 mph interval.

(2) Perform the coastdown.

(3) Determine the coastdown force and coastdown force error using Eqs. 1066.270-1 and 1066.270-2.

(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 ±9.0 N, whichever is greater.

(2) For vehicles above 20,000 pounds GVWR, ±1.0 % or ±36.0 N (±8.0 lbf), whichever is greater.

(e) If the verification results fail to meet the performance criteria in paragraph (d) of this section, perform the procedure up to two additional times. If the dynamometer is consistently unable to meet the performance criteria, diagnose and repair the dynamometer before continuing with emission testing. Diagnosis should include performing the verifications in §1066.255 and §1066.260.

§1066.290 Driver's aid.

Use good engineering judgment to provide a driver's aid that facilitates compliance with the requirements of §1066.430. Verify the speed accuracy of the driver's aid as described in §1066.235.

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Subpart D—Coastdown

§1066.301 Overview of coastdown procedures.

(a) The coastdown procedures described in this subpart are used to determine the load coefficients (A, B, and C) for the simulated road-load equation in §1066.210(d)(3).

(b) The general procedure for performing coastdown tests and calculating load coefficients is described in SAE J1263 and SAE J2263 (incorporated by reference in §1066.1010). This subpart specifies certain deviations from those procedures for certain applications.

(c) Use good engineering judgment for all aspects of coastdown testing. For example, minimize the effects of grade by performing coastdown testing on reasonably level surfaces and determining coefficients based on average values from vehicle operation in opposite directions over the course.

§1066.305 Coastdown procedures for motor vehicles at or below 14,000 pounds GVWR.

Calculate road-load coefficients for chassis testing of motor vehicles at or below 14,000 pounds GVWR by performing coastdowns using the provisions of SAE J1263 and SAE J2263 (incorporated by reference in §1066.1010).

§1066.310 Coastdown procedures for vehicles above 14,000 pounds GVWR.

This section describes coastdown procedures that are unique to vehicles above 14,000 pounds GVWR. These procedures are valid for calculating road-load coefficients for chassis and post-transmission powerpack testing and for calculating drag area (C_DA) for use in the GEM simulation tool under 40 CFR part 1037.

(a) Determine load coefficients by performing a minimum of 16 valid coastdown runs (8 in each direction).

(b) Follow the provisions of Sections 1 through 9 of SAE J1263, and SAE J2263 (incorporated by reference in §1066.1010), except as described in this paragraph (b). The terms and variables identified in this paragraph (b) have the meaning given in SAE J1263 or J2263 unless specified otherwise.

(1) The test condition specifications of SAE J1263 apply except as follows for wind and road conditions:

(i) We recommend that you do not perform coastdown testing on days for which winds are forecast to exceed 6.0 mph.

(ii) The grade of the test track or road must not be excessive (considering factors such as road safety standards and effects on the coastdown results). Road conditions should follow Section 7.4 of SAE J1263, except that road grade may exceed 0.5%. If road grade is greater than 0.02% over the length of the test surface, then the road grade as a function of distance along the length of the test surface must be incorporated into the analysis. To calculate the force due to grade use Section 11.5 of SAE J2263.

(2) Operate the vehicle at a top speed above 70 mph, or at its maximum achievable speed if it cannot reach 70 mph. If a vehicle is equipped with a vehicle speed limiter that is set for a maximum speed below 70 mph, you must disable the vehicle speed limiter. Start the test at or above 70 mph or at the vehicle's maximum achievable speed if it cannot reach 70 mph. Data collection must occur through a minimum speed at or below 15 mph.

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Deleted: Note as specified in the standard setting parts, this section does not apply for certain heavy-duty vehicles, such as those regulated under 40 CFR part 86, subpart S.

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Data analysis for valid coastdown runs must include a maximum speed as described in this paragraph (b)(2) and a minimum speed of 15 mph.

(3) Gather data regarding wind speed and direction, in coordination with time-of-day data, using at least one stationary electro-mechanical anemometer and suitable data loggers meeting the specifications of SAE J1263, as well as the following additional specifications for the anemometer placed adjacent to the test surface:

(i) Calibrate the equipment by running the zero-wind and zero-angle calibrations within 24 hours before conducting the coastdown procedures. If the coastdown procedures are not complete 24 hours after calibrating the equipment, repeat the calibration for another 24 hours of data collection.

(ii) Record the location of the anemometer using a GPS measurement device adjacent to the test surface (approximately) at the midway distance along the test surface used for coastdowns.

(iii) Position the anemometer such that it will be at least 2.5 but not more than 3.0 vehicle widths from the test vehicle's centerline as the test vehicle passes the location of that anemometer.

(iv) Mount the anemometer at a height that is within 6 inches of half the test vehicle's maximum height.

(v) Place the anemometer at least 50 feet from the nearest tree and at least 25 feet from the nearest bush (or equivalent roadside features).

(vi) The height of the grass surrounding the stationary anemometer may not exceed 10% of the anemometer's mounted height, within a radius equal to the anemometer's mounted height.

(4) You may split runs as per Section 9.3.1 of SAE J2263, but we recommend whole runs. If you split a run, analyze each portion separately, but count the split runs as one run with respect to the minimum number of runs required.

(5) You may perform consecutive runs in a single direction, followed by consecutive runs in the opposite direction, consistent with good engineering judgment. Harmonize starting and stopping points to the extent practicable to allow runs to be paired.

(6) All valid coastdown run times in each direction must be within 2.0 standard deviations of the mean of the valid coastdown run times (from 70 mph down to 15 mph) in that direction. Eliminate runs outside this range. After eliminating these runs you must have at least eight valid runs in each direction. You may use coastdown run times that do not meet these standard deviation requirements if we approve it in advance. In your request, describe why the vehicle is not able to meet the specified standard deviation requirements and propose an alternative set of requirements.

(7) Analyze data for chassis and post-transmission powerpack testing or for use in the GEM simulation tool as follows:

(i) Follow the procedures specified in Section 10 of SAE J1263 or Section 11 of SAE J2263 to calculate coefficients for chassis and post-transmission powerpack testing.

(ii) Determine drag area, $C_D A$, as follows instead of using the procedure specified in Section 10 of SAE J1263:

(A) Measure vehicle speed at fixed intervals over the coastdown run (generally at 10 Hz), including speeds at or above 15 mph and at or below 70 mph. Establish the height or altitude corresponding to each interval as described in SAE J2263 if you need to incorporate the effects of road grade.

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(ii) The anemometer must have had its outputs recorded at a wind speed of 0.0 mph within 24 hours before each coastdown test in which it is used.

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(B) Calculate the vehicle's effective mass, M_e, in kg by adding 56.7 kg to the vehicle mass for each tire making road contact. This accounts for the rotational inertia of the wheels and tires.

(C) Calculate the road-load force for each measurement interval, F_i, for values of $i \geq 1$ using the following equation:

$$F_i = -M_e \cdot \frac{v_i - v_{i-1}}{\Delta t}$$

Eq. 1066.310-1

Where:

M_e = the vehicle's effective mass, expressed to the nearest 0.1 kg.

v = vehicle speed at the beginning and end of the measurement interval.

Δt = elapsed time over the measurement interval, in seconds.

(D) Plot the data from all the coastdown runs on a single plot of F_i vs. v_i^2 to determine the slope correlation, D, based on the following equation:

$$F_i - M_e \cdot g \cdot \frac{\Delta h}{\Delta s} = A_m + D \cdot v_i^2$$

Eq. 1066.310-2

Where:

g = gravitational acceleration = 9.81 m/s^2.

Δh = change in height or altitude over the measurement interval, in m. Assume $\Delta h = 0$ if you are not correcting for grade.

Δs = distance the vehicle travels down the road during the measurement interval, in m.

A_m = the calculated value of the y-intercept based on the curve-fit.

(E) Calculate drag area, $C_D A$, in m^2 using the following equation:

$$C_D A = \frac{2 \cdot D_{adj}}{\rho}$$

Eq. 1066.310-3

Where:

ρ = air density at reference conditions = 1.17 kg/m^3.

$$D_{adj} = D \cdot \left(\frac{\overline{T}}{293}\right) \cdot \left(\frac{98.21}{\overline{p}_B}\right)$$

Eq. 1066.310-4

$\overline{T}$ = average ambient temperature during testing, in K.

$\overline{p}_B$ = average ambient pressuring during the test, in kPa.

(8) Determine the A, B, and C coefficients identified in §1066.210 as follows:

(i) For chassis and post-transmission powerpack testing, follow the procedures specified in Section 10 of SAE J1263 or Section 12 of SAE J2263.

(ii) For the GEM simulation tool, use the following values:

A = A_m

B = 0

C = D_{adj}

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§1066.320 Dynamometer road-load setting.

Determine dynamometer road-load settings for chassis testing by following SAE J2264 (incorporated by reference in §1066.1010).

Subpart E— Preparing Vehicles and Running an Exhaust Emission Test

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§1066.401 Overview.

(a) Use the procedures detailed in this subpart to measure vehicle emissions over a specified drive schedule. Different procedures may apply for criteria pollutants and greenhouse gas emissions as described in subpart I of this part or the standard-setting part. This subpart describes how to:

(1) Determine road-load power, test weight, and inertia class.

(2) Prepare the vehicle, equipment, and measurement instruments for an emission test.

(3) Perform pre-test procedures to verify proper operation of certain equipment and analyzers and to prepare them for testing.

(4) Record pre-test data.

(5) Sample emissions.

(6) Record post-test data.

(7) Perform post-test procedures to verify proper operation of certain equipment and analyzers.

(8) Weigh PM samples.

(b) The overall test consists of prescribed sequences of fueling, parking, and driving at specified test conditions. An exhaust emission test generally consists of measuring emissions and other parameters while a vehicle follows the drive schedules specified in the standard-setting part. There are two general types of test cycles:

(1) Transient cycles. Transient test cycles are typically specified in the standard-setting part as a second-by-second sequence of vehicle speed commands. Operate a vehicle over a transient cycle such that the speed follows the target values. Proportionally sample emissions and other parameters and use the calculations in 40 CFR part 1065, subpart G, or subpart G of this part to calculate emissions. The standard-setting part may specify three types of transient testing based on the approach to starting the measurement, as follows:

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(i) A cold-start transient cycle where you start to measure emissions just before starting an engine that has not been warmed up.

(ii) A hot-start transient cycle where you start to measure emissions just before starting a warmed-up engine.

(iii) A hot running transient cycle where you start to measure emissions after an engine is started, warmed up, and running.

(2) Cruise cycles. Cruise test cycles are typically specified in the standard-setting part as a discrete operating point that has a single speed command.

(i) Start a cruise cycle as a hot running test, where you start to measure emissions after the engine is started and warmed up and the vehicle is running at the target test speed.

(ii) Sample emissions and other parameters for the cruise cycle in the same manner as a transient cycle, with the exception that the reference speed value is constant. Record instantaneous and mean speed values over the cycle.

§1066.407 Vehicle preparation and preconditioning.

Prepare the vehicle for testing, including measurement of evaporative and refueling emissions, as described in the standard-setting part.

Deleted: This section describes steps to take before measuring exhaust emissions for those vehicles that are subject to evaporative or refueling emission tests as specified in the standard setting part. Other preliminary procedures may apply as specified in the standard-setting part.¶
(a)

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Deleted: (b) If testing will include measurement of refueling emissions, perform the vehicle preconditioning steps as described in 40 CFR 86.153-98the standard setting part. Otherwise, perform the vehicle preconditioning steps as described in 40 CFR 86.132-00.

§1066.410 Dynamometer test procedure.

(a) Dynamometer testing may consist of multiple drive cycles with both cold-start and hot-start portions, including prescribed soak times before each test phase. The standard-setting part identifies the driving schedules and the associated sample phases, soak periods, engine startup and shutdown procedures, and operation of accessories, as applicable. Not every test phase includes all these elements.

(b) Place the vehicle onto the dynamometer without starting the engine (cold start test cycles only) or drive the vehicle onto dynamometer and position a fan that appropriately directs cooling air to the vehicle during dynamometer operation as described in this paragraph (b). This generally requires squarely positioning the fan in front of the vehicle and directing the airflow to the vehicle's radiator. Use good engineering judgment to design and configure fans to cool the test vehicle in a way that properly simulates in-use operation.

(1) For vehicles at or below 14,000 pounds GVWR, use the following cooling fan configurations as allowed under Table 1 of this section:

(i) Use a fixed-speed fan to appropriately direct cooling air to the vehicle with the engine compartment cover open. The fan capacity may not exceed 2.50 m^3/s and the fan should be placed nominally within 31 cm of the front of the vehicle. If you determine that additional cooling is needed to properly represent in-use operation, use good engineering judgment to increase the fan's capacity or use additional fans, subject to our approval. When testing under this option, the engine compartment cover must be open.

(ii) Use a fixed-speed fan to direct cooling air to the vehicle with the engine compartment cover open. The fan capacity may not exceed 7.10 m^3/s and the fan should be placed approximately 30 to 60 cm of the front of the vehicle. If you determine that additional cooling is needed to properly represent in-use operation, use good engineering judgment to increase the fan's capacity or use additional fans, subject to our approval. When testing under this option, the engine compartment cover must be open.

(iii) Use a road-speed modulated fan system that achieves a linear speed of cooling air at the blower outlet that is within ±3.0 mph (±1.3 m/s) of the corresponding roll speed when vehicle speeds are between 5 and 30 mph (2.2 to 13.4 m/s), and within ±6.5 mph (±2.9 m/s) of the corresponding roll speed at higher vehicle speeds. We recommend that the cooling fan have a minimum opening of 0.2 m^2 and a minimum width of 0.8 m. The discharge nozzle shall be placed nominally within 61 cm of the front of the vehicle to provide representative cooling. When testing under this option, the engine compartment cover must be closed.

(iv) Use a road-speed modulated fan system with a minimum air flow nozzle discharge area that is equal to or exceeds the vehicle frontal inlet area. The optimum discharge area is 1.7 m^2 (1.3 m × 1.3 m), however, other sizes can be used. The discharge nozzle should be placed nominally within the range of (60 to 92) cm from the front of the vehicle and 0 to 16 cm from the floor of the test cell. When testing under this option, the engine compartment cover must be closed.

(A) Air flow volumes must be proportional to vehicle speed. With the above optimum discharge size, the fan volume would vary from 0 cubic feet/ minute (cfm) at 0 mph to approximately 95,000 cfm at 60 mph. If this fan is also the only source of cell air circulation or if fan operational mechanics make the 0 mph air flow requirement impractical, air flow of 2 mph or less will be allowed at 0 mph vehicle speed.

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(B) The fan air flow velocity vector perpendicular to the axial flow velocity vector shall be less than 10 % of the mean velocity measured at fan speeds corresponding to vehicle speeds of 20 and 40 mph.

(C) Fan axial air flow velocity is measured two feet from nozzle outlet at each point of a one foot grid over the entire discharge area. The uniformity of axial flow tolerance is 20 % of the fan speeds corresponding to vehicle speeds of 20 and 40 mph.

(D) The instrument used to verify the air velocity must have an accuracy of 2 % of the measured air flow speed.

Table 1 of §1066.410–Test cell vehicle cooling fan requirements.

Test cycle	Allowable cooling fan configurations
FTP, AC idle, and LA-92	1066.410(b)(1)(i), 1066.410(b)(1)(iii)
US06	1066.410(b)(1)(ii), 1066.410(b)(1)(iii)
SC03 and AC17	1066.410(b)(1)(iv)
HFET	1066.410(b)(1)(i), 1066.410(b)(1)(iii)

(2) For vehicles above 14,000 pounds GVWR, use a road-speed modulated fan system that achieves a linear speed of cooling air at the blower outlet that is within ±3.0 mph (±1.3 m/s) of the corresponding roll speed when vehicle speeds are between 5 and 30 mph (2.2 to 13.4 m/s), and within ±10 mph (±4.5 m/s) of the corresponding roll speed at higher vehicle speeds. For vehicles with GVWR above 19,500 lbs, we recommend that the cooling fan have a minimum opening of 2.75 m^2, a minimum flow rate of 3,600 m^3/min at 50 mph, and that it maintain a minimum speed profile across the duct, in the free stream flow, of ±15 % of the target flow rate. The discharge nozzle shall be placed approximately 30 to 60 cm of the front of the vehicle to provide representative cooling. When testing under this option, the engine compartment cover must be closed.

(3) If the cooling specifications in this paragraph (b) are impractical for special vehicle designs, such as vehicles with rear-mounted engines, you may arrange for an alternative fan configuration that allows for proper simulation of vehicle cooling during in-use operation, subject to our approval.

(c) Record the vehicle's speed trace based on the time and speed data from the dynamometer. Record speed to at least the nearest 0.01 m/s or 0.01 mph and time to at least the nearest 0.1 s.

(d) You may perform practice runs for operating the vehicle and the dynamometer controls to meet the driving tolerances specified in §1066.430 or adjust the emission sampling equipment. Verify that the accelerator pedal allows for enough control to closely follow the prescribed driving schedule. We recommend that you verify your ability to meet the minimum dilution factor requirements of §1066.110(b)(2)(iii)(B) during these practice runs.

(e) Inflate tires on drive wheels according to the vehicle manufacturer's specifications. The tire pressure for drive wheels must be the same for dynamometer operation and for dynamometer coastdown procedures used for determining road-load coefficients. Report these tire pressure values with the test results.

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(f) Tie down or load the test vehicle as needed to provide a normal force at the tire and dynamometer roll interface to prevent wheel slip. For vehicles above 14,000 pounds GVWR, report this force with the test results.
(g) For vehicles which provide four-wheel drive or all-wheel drive operation, utilize the vehicle's normal (default) mode of operation. This may involve testing four-wheel drive or all-wheel drive on a dynamometer with a separate dynamometer roll for each drive axle. Alternatively, two drive axles may use a single roll, as described in §1066.210(d)(1). You may also test the vehicle on a single roll by deactivating the second set of drive wheels, but only if this mode of operation does not decrease emissions or energy consumption relative to normal in-use operation. We may test such vehicles in multiple-wheel or all-wheel mode on one or more rolls to confirm that the alternate dynamometer procedures did not decrease emissions.
(h) Determine test weight as follows:
(1) For vehicles at or below 14,000 pounds GVWR, determine ETW as described in §1066.810. Set dynamometer vehicle inertia, I, based on dynamometer type, as follows:
(i) For two-wheel drive dynamometers, set $I = ETW$.
(ii) For four-wheel drive dynamometers, set $I = 0.985 \cdot ETW$.
(2) For vehicles above 14,000 pounds GVWR, determine the vehicle's effective mass as described in 1066.310.
(i) Warm up the dynamometer as recommended by the dynamometer manufacturer.
(j) Following the test, determine the actual driving distance by counting the number of dynamometer roll or shaft revolutions, or by integrating speed over the course of testing from a high-resolution encoder system.

§1066.420 Vehicle operation.

This section describes how to test a conventionally configured vehicle (vehicles with transmission shifters, foot pedal accelerators, etc). You may ask us to modify these procedures for vehicles that do not have these control features.
(a) Start the vehicle as follows:
(1) At the beginning of the test cycle, start the vehicle according to the procedure described in the owners manual. In the case of hybrid vehicles, this would generally involve activating vehicle systems such that the engine will start when the vehicle's control algorithms determine that the engine should provide power instead of or in addition to power from the rechargeable energy storage system (RESS). Unless we specify otherwise, engine starting throughout this part generally refers to this step of activating the system on hybrid vehicles, whether or not that causes the engine to start running.
(2) Place the transmission in gear as described by the test cycle in the standard-setting part. During idle operation, you may apply the brakes if necessary to keep the drive wheels from turning.
(b) If the vehicle does not start after your recommended maximum cranking time, wait and restart cranking according to your recommended practice. If you don't recommend such a cranking procedure, stop cranking after 10 seconds, wait for 10 seconds, then start cranking again for up to 10 seconds. You may repeat this for up to three start attempts. If the vehicle does not start after three attempts, you must determine and record the reason for failure to start. Shut off sampling systems and either turn the CVS off or

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disconnect the exhaust tube from the tailpipe during the diagnostic period to prevent flow through the exhaust system. Reschedule the vehicle for testing. This may require performing vehicle preparation and preconditioning if the testing needs to be rerun from a cold start. If failure to start occurs during a hot start test, you may reschedule the hot start test without repeating the cold start test, as long as you bring the vehicle to a hot start condition before starting the hot start test.

(c) Repeat the recommended starting procedure if the engine has a false start (i.e., an incomplete start).

(d) Take the following steps if the engine stalls:

(1) If the engine stalls during an idle period, restart the engine immediately and continue the test. If you cannot restart the engine soon enough to allow the vehicle to follow the next acceleration, stop the driving schedule indicator and reactivate it when the vehicle restarts.

(2) Void the test if the vehicle stalls during vehicle operation. If this happens, remove the vehicle from the dynamometer, take corrective action, and reschedule the vehicle for testing. Record the reason for the malfunction (if determined) and any corrective action. See the standard-setting part for instructions about reporting these malfunctions.

(e) Operate vehicles during testing as follows:

(1) Where we do not give specific instructions, operate the vehicle according to the recommendations in the owners manual, unless those recommendations are unrepresentative of what may reasonably be expected for in-use operation.

(2) If vehicles have features that preclude dynamometer testing, you may modify these features as necessary to allow testing, consistent with good engineering judgment, as long as it does not affect your ability to show that your vehicles comply with standards. Send us written notification describing these changes along with supporting rationale.

(3) Operate vehicles during idle as follows:

(i) For vehicles with automatic transmission, operate at idle with the transmission in "Drive" with the wheels braked, except that you may shift to "Neutral" for the first idle period and for any idle period longer than one minute. If you put the vehicle in "Neutral" during an idle, you must shift the vehicle into "Drive" with the wheels braked at least 5 seconds before the end of the idle period. Note that this does not preclude vehicle designs involving engine operation with stop-start functions where the engine stops when the brake is applied below a certain threshold speed and restarts upon release of the brake.

(ii) For vehicles with manual transmission, operate at idle with the transmission in gear with the clutch disengaged, except that you may shift to "Neutral" with the clutch engaged for the first idle period and for any idle period longer than one minute. If you put the vehicle in "Neutral" during idle, you must shift to first gear with the clutch disengaged at least 5 seconds before the end of the idle period. Note that this does not preclude vehicle designs involving engine operation with stop-start functions where the engine stops when the clutch is disengaged below a certain threshold speed and restarts upon reengagement of the clutch.

(4) Use the appropriate accelerator pedal to achieve the speed versus time relationship prescribed by the driving schedule. Avoid smoothing speed variations and excessive accelerator pedal perturbations.

(5) Operate the vehicle smoothly, following representative shift speeds and procedures. For manual transmissions, the operator shall release the accelerator pedal during each

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shift and accomplish the shift with minimum time. If the vehicle cannot accelerate at the specified rate, operate it at maximum available power until the vehicle speed reaches the value prescribed for that time in the driving schedule.
(6) Decelerate as follows:
(i) For vehicles with automatic transmission, use the brakes or accelerator pedal as necessary, without manually changing gears, to maintain the desired speed.
(ii) For vehicles with manual transmission, shift gears in a way that represents reasonable shift patterns for in-use operation, considering vehicle speed, engine speed, and any other relevant variables. Disengage the clutch when the speed drops below 6.7 m/s (15 mph), when engine roughness is evident, or when good engineering judgment indicates the engine is likely to stall. Manufacturers may recommend shift guidance in the owners manual that differs from the shift schedule during testing as long as both shift schedules are included in the application for certification. In this case, we may use the shift schedule based on the shift pattern described in the owners manual.

§1066.425 Test preparation.
(a) Follow the procedures for PM sample preconditioning and tare weighing as described in 40 CFR 1065.590 if you need to measure PM emissions.
(b) For vehicles above 14,000 pounds GVWR with compression-ignition engines, verify the amount of nonmethane hydrocarbon contamination as described in 40 CFR 1065.520(g).
(c) Unless the standard-setting part specifies different tolerances, verify at some point before the test that ambient conditions are within the tolerances specified in this paragraph (c). For purposes of this paragraph (c), "before the test" means any time from a point just prior to engine starting (excluding engine restarts) to the point at which emission sampling begins.
(1) Ambient temperature must be (20 to 30) °C. See §1066.430(j) for circumstances under which ambient temperatures must remain within this range during the test.
(2) Dilution air conditions must meet the specifications in §1066.110(b)(2). We recommend verifying dilution air conditions just before starting each test phase.
(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.
(2) For vehicles above 14,000 pounds GVWR, you may test vehicles at any humidity.

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Table 1 of §1066.425–Test cell humidity requirements.

Test cycle	Humidity requirement (grains H_2O/lb of dry air)	Tolerance (grains H_2O/lb of dry air)
AC17	69	± 5 average, ± 10 instantaneous
AC idle	(40 to 60)	
FTP[1] and LA-92	50	
HFET	50	
SC03	100	± 5
US06	50	

[1]FTP humidity requirement does not apply for cold (-7°C), intermediate (10 °C), and hot (35 °C) temperature testing.

(e) You may perform a final calibration of proportional-flow control systems, which may include performing practice runs.

(f) You may perform the following procedure to precondition sampling systems:

(1) Operate the vehicle over the test cycle.

(2) Operate any dilution systems at their expected flow rates. Prevent aqueous condensation in the dilution systems as described in 40 CFR 1065.140(c)(6), taking into account allowances given in §1066.110(b)(2)(iv).

(3) Operate any PM sampling systems at their expected flow rates.

(4) Sample PM using any sample media. You may change sample media during preconditioning. You must discard preconditioning samples without weighing them.

(5) You may purge any gaseous sampling systems during preconditioning.

(6) You may conduct calibrations or verifications on any idle equipment or analyzers during preconditioning.

(g) Take the following steps before emission sampling begins:

(1) For batch sampling, connect clean storage media, such as evacuated bags or tare-weighed filters.

(2) Start all measurement instruments according to the instrument manufacturer's instructions and using good engineering judgment.

(3) Start dilution systems, sample pumps, and the data-collection system.

(4) Pre-heat or pre-cool heat exchangers in the sampling system to within their operating temperature tolerances for a test.

(5) Allow heated or cooled components such as sample lines, filters, chillers, and pumps to stabilize at their operating temperatures.

(6) Adjust the sample flow rates to desired levels using bypass flow, if desired.

(7) Zero or re-zero any electronic integrating devices before the start of any test phase.

(8) Select gas analyzer ranges. You may not switch the gain of an analyzer's analog operational amplifier(s) during a test. However, you may switch (automatically or manually) gas analyzer ranges during a test if such switching changes only the range over which the digital resolution of the instrument is applied.

(9) Zero and span all continuous gas analyzers using gases that meet the specifications of 40 CFR 1065.750. For FID analyzers, you may account for the carbon number of your span gas either during the calibration process or when calculating your final emission

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value. For example, if you use a C_3H_8 span gas of concentration 200 ppm (μmol/mol), you may span the FID to respond with a value of 600 ppm (μmol/mol) of carbon or 200 ppm of propane. However, if your FID response is equivalent to propane, include a factor of three to make the final calculated hydrocarbon mass consistent with a molar mass of 13.875389. When utilizing an NMC-FID, span the FID analyzer consistent with the determination of their respective response factors, *RF*, and penetration fractions, *PF*, according to 40 CFR 1065.365.

(10) We recommend that you verify gas analyzer responses after zeroing and spanning by sampling a calibration gas that has a concentration near one-half of the span gas concentration. Based on the results and good engineering judgment, you may decide whether or not to re-zero, re-span, or re-calibrate a gas analyzer before starting a test.

(11) If you correct for dilution air background concentrations of associated engine exhaust constituents, start sampling and recording background concentrations at the same time you start sampling exhaust gases.

(12) Turn on cooling fans immediately before starting the test.

(h) Proceed with the test sequence described in §1066.430.

§1066.430 Performing emission tests.

(a) See the standard-setting part for drive schedules. These are defined by a smooth trace drawn through the specified speed vs. time sequence.

(b) The driver must attempt to follow the target schedule as closely as possible, consistent with the specifications in paragraph (b) of this section. Instantaneous speeds must stay within the following tolerances:

(1) The upper limit is 1.0 m/s (2 mph) higher than the highest point on the trace within 1.0 s of the given point in time.

(2) The lower limit is 1.0 m/s (2 mph) lower than the lowest point on the trace within 1.0 s of the given time.

(3) The same limits apply for vehicle preconditioning and warm-up, except that the upper and lower limits for speed values are ±2.0 m/s (±4 mph).

(4) Void the test if you do not maintain speed values as specified in this paragraph (b). Speed variations (such as may occur during gear changes or braking spikes) may occur as follows, provided that such variations are clearly documented, including the time and speed values and the reason for the deviation:

(i) Speed variations greater than the specified limits are acceptable for up to 2.0 seconds on any occasion.

(ii) For vehicles that are not able to maintain acceleration as specified in §1066.420(e)(5), do not count the insufficient acceleration as being outside the specified limits.

(c) Figure 1 and Figure 2 of this section show the range of acceptable speed tolerances for typical points during testing. Figure 1 of this section is typical of portions of the speed curve that are increasing or decreasing throughout the 2-second time interval. Figure 2 of this section is typical of portions of the speed curve that include a maximum or minimum value.

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§1066.425 Engine starting and restarting.¶
(a) Start the vehicle's engine as follows:¶
(1) At the beginning of the test cycle, start the engine according to the procedure you describe in your owners manual. In the case of hybrid vehicles, this would generally involve activating vehicle systems such that the engine will start when the vehicle's control algorithms determine that the engine should provide power instead of or in addition to power from the rechargeable energy storage system (RESS). Unless we specify otherwise, engine starting throughout this part generally refers to this step of activating the system on hybrid vehicles, whether or not that causes the engine to start running.¶
(2) Place the transmission in gear as described by the test cycle in the standard-setting part. During idle operation, you may apply the brakes if necessary to keep the drive wheels from turning.¶
(b) If the vehicle does not start after your recommended maximum cranking time, wait and restart cranking according to your recommended practice. If you don't recommend such a cranking procedure, stop cranking after 10 seconds, wait for 10 seconds, then start cranking gain for up to 10 seconds. You may repeat this for up to three start attempts. If the vehicle does not start after three attempts, you must determine and record the reason for failure to start. Shut off sampling systems and either turn the CVS off, or disconnect the exhaust tube from the tailpipe during the diagnostic period. Reschedule the vehicle for testing from a cold start.¶
(c) Repeat the recommended starting procedure if the engine has a "false start".¶
(d) Take the following steps if the engine stalls:¶
(1) If the engine stalls during an idle period, restart the engine immediately and continue the test. If you cannot restart the engine soon enough to allow the vehicle to follow the next acceleration, stop th ... [1]

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Figure 1 of §1066.430—Example of the allowable ranges for the driver's trace.

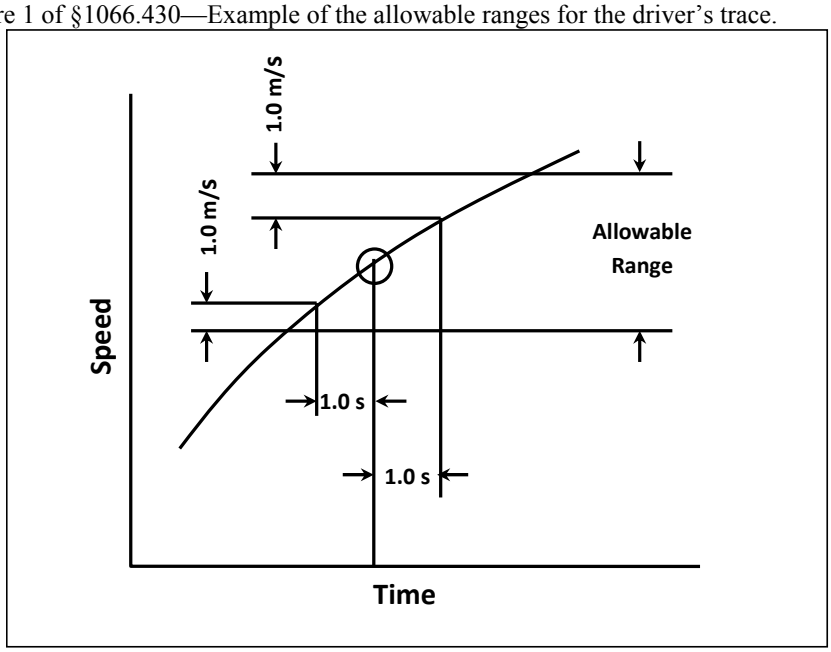
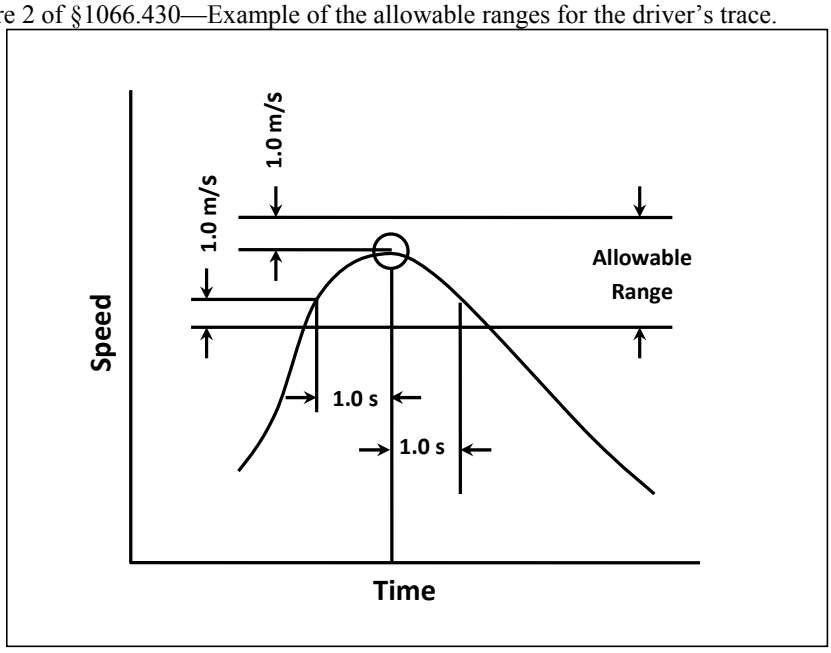


Figure 2 of §1066.430—Example of the allowable ranges for the driver's trace.



(d) Start testing as follows:
(1) If a vehicle is already running and warmed up, and starting is not part of the test cycle, operate the vehicle as follows:
(i) For transient test cycles, control vehicle speeds to follow a drive schedule consisting of a series of idles, accelerations, cruises, and decelerations.
(ii) For cruise test cycles, control the vehicle operation to match the speed of the first phase of the test cycle. Follow the instructions in the standard-setting part to determine how long to stabilize the vehicle during each phase, how long to sample emissions at each phase, and how to transition between phases.
(2) If engine starting is part of the test cycle, initiate data logging, sampling of exhaust gases, and integrating measured values before starting the engine. Initiate the driver's trace when the engine starts.
(e) Perform the following at the end of each test phase, except as specified in subpart I of this part:
(i) Shut down the vehicle if it is part of the test cycle or if testing is complete.
(ii) Continue to operate all sampling and dilution systems to allow the response times to elapse. Then stop all sampling and recording, including background sampling. Finally, stop any integrating devices and indicate the end of the duty cycle in the recorded data.
(f) If testing involves engine shutdown followed by another test phase, start a timer for the vehicle soak when the engine shuts down. Turn off cooling fans, close the vehicle hood (if applicable), and turn off the CVS or disconnect the exhaust tube from the tailpipe(s) of the vehicle unless otherwise instructed in the standard setting part. If testing is complete, disconnect the exhaust tube from the vehicle tailpipe(s) and drive the vehicle from dynamometer.
(g) Take the following steps after emission sampling is complete:
(1) For any proportional batch sample, such as a bag sample or PM sample, verify that proportional sampling was maintained according to 40 CFR 1065.545. Void any samples that did not maintain proportional sampling according to those specifications.
(2) Place any used PM samples into covered or sealed containers and return them to the PM-stabilization environment. Follow the PM sample post-conditioning and total weighing procedures in 40 CFR 1065.595.
(3) As soon as practical after the phase or test cycle is complete, or optionally during the soak period if practical, perform the following:
(i) Begin drift check for all continuous gas analyzers as described in paragraph (g)(6) of this section and zero and span all batch gas analyzers as soon as practical prior to any batch sample analysis. You may perform this batch analyzer zero and span prior to the end of the test cycle or phase.
(ii) Analyze any conventional gaseous batch samples (HC, CO, NO_x, and CO_2) no later than 30 minutes after a phase or test cycle is complete, or during the soak period if practical. Analyze background samples no later than 60 minutes after the test cycle is complete.
(iii) Analyze nonconventional gaseous batch samples (including background), such as NMHCE, N_2O, or NMOG sampling with ethanol, as soon as practicable using good engineering judgment.
(4) Range validation. If an analyzer operated above 100 % of its range at any time during the test, perform the following steps:

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(i) For batch sampling, re-analyze the sample using the lowest analyzer range that results in a maximum instrument response below 100 %. Report the result from the lowest range from which the analyzer operates below 100 % of its range.
(ii) For continuous sampling, repeat the entire test using the next higher analyzer range. If the analyzer again operates above 100 % of its range, repeat the test using the next higher range. Continue to repeat the test until the analyzer consistently operates at less than 100 % of its range.
(5) After quantifying exhaust gases, verify drift as follows:
(i) For batch and continuous gas analyzers, record the mean analyzer value after stabilizing a zero gas to the analyzer. Stabilization may include time to purge the analyzer of any sample gas, plus any additional time to account for analyzer response.
(ii) Record the mean analyzer value after stabilizing the span gas to the analyzer. Stabilization may include time to purge the analyzer of any sample gas, plus any additional time to account for analyzer response.
(iii) Use these data to validate that analyzer drift does not exceed 2.0 % of the analyzer full scale.
(h) [Reserved]
(i) Measure and record ambient pressure. Measure and record ambient temperature continuously to verify that it remains within the temperature range specified in §1066.425(c)(1) throughout the test. Also measure humidity if required, such as for correcting NO_x emissions, or meeting the requirements of §1066.425(d).
(j) For vehicles at or below 14,000 pounds GVWR, determine overall driver accuracy as follows:
(1) Compare the driven cycle energy, based on measured vehicle speeds, to a reference value based on the target cycle energy that would have been generated by driving exactly to the target trace as described in Section 5.1.9 of SAE J2951 (incorporated by reference in §1066.1010).
(2) The standard-setting part may require you to provide to us 10 Hz data to characterize both target and actual values for cycle energy. Calculate target values based on the vehicles speeds from the specified test cycle.
(3) Determine the inertial work ratio as described in Section 7.2.3 of SAE J2951.

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(1) Air-cooled engines.¶
(2) Engines equipped with emission control devices that sense and respond to ambient temperature.¶
(3) Any other engine for which good engineering judgment indicates that this is necessary to remain consistent with 40 CFR 1065.10(c)(1).

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Subpart F—Hybrids and Electric Vehicles

§1066.501 Overview.

For HEV, PHEV, and pure electric vehicle (EV), use the following procedures:

(a) Correct the results for Net Energy Change of the RESS as follows:

(1) For vehicles at or below 14,000 pounds GVWR, follow SAE J1711 (incorporated by reference in §1066.1010) except as noted in this paragraph (a). Use ±1 % of reading or ±0.3 % of full scale, whichever is greater, in place of the current measurement accuracy in Section 4.2a of SAE J1711.

(2) For vehicles above 14,000 pounds GVWR, follow SAE J2711 (incorporated by reference in §1066.1010) for requirements related to charge-sustaining operation.

(3) For pure EVs, irrespective of GVWR, follow SAE J1634 (incorporated by reference in §1066.1010).

(b) This paragraph (b) applies for vehicles that include an engine-powered generator or other auxiliary power unit that indirectly provides motive power. For example, this would include a vehicle that has a small gasoline engine that generates electricity to charge batteries. Unless we approve otherwise, measure emissions for all test cycles when such an engine is operating. For each test cycle for which emissions are not measured, you must validate that such engines are not operating at any time during the test cycle.

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Subpart G—Calculations

§1066.601 Overview.

(a) This subpart describes how to–

(1) Use the signals recorded before, during, and after an emission test to calculate distance-specific emissions of each regulated pollutant.

(2) Perform calculations for calibrations and performance checks.

(3) Determine statistical values.

(b) You may use data from multiple systems to calculate test results for a single emission test, consistent with good engineering judgment. You may also make multiple measurements from a single batch sample, such as multiple weighing of a PM filter or multiple readings from a bag sample. You may not use test results from multiple emission tests to report emissions. We allow weighted means where appropriate. You may discard statistical outliers, but you must report all results.

§1066.610 Mass-based and molar-based exhaust emission calculations.

(a) Calculate your total mass of emissions over a test cycle using the equations specified in paragraph (c) of this section or in 40 CFR part 1065, subpart G, as applicable.

(b) For composite emission calculations over multiple test phases and corresponding weighting factors, see the standard-setting part or subpart I.

(c) To calculate the total mass of an emission, multiply a concentration by its respective flow and density as specified in Eq. 1066.610-1. Before calculating mass emissions as specified in paragraph (d) of this section, perform the following sequence of preliminary calculations to correct recorded concentration measurements:

(1) For vehicles above 14,000 pounds GVWR, correct all THC and CH_4 concentrations for initial contamination as described in 40 CFR 1065.660(a), including continuous readings, sample bags readings, and dilution air background readings. This correction is optional for vehicles at or below 14,000 pounds GVWR.

(2) Correct all concentrations measured on a "dry" basis to a "wet" basis, including dilution air background concentrations.

(3) Calculate all NMHC and CH_4 concentrations, including dilution air background concentrations, as described in 40 CFR 1065.660.

(4) For emission testing with an oxygenated fuel, calculate any HC concentrations, including dilution air background concentrations, as described in 40 CFR part 1065, subpart I, for THCE and NMHCE, and in §1066.665 for NMOG, depending on the requirements of the standard setting part.

(5) Correct all NO_x emission values for test cell ambient air humidity as described in §1066.630.

(6) Correct all gaseous concentrations for dilution air background as described in §1066.620.

(7) Correct all PM filter masses for sample media buoyancy in air as described in 40 CFR 1065.690.

(d) Calculate the emission mass of each gaseous pollutant using the following equation:

$$m_{[\text{emission}]} = V_{\text{mix}} \cdot \rho_{[\text{emission}]} \cdot x_{[\text{emission}]} \cdot c$$

Eq. 1066.610-1

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(1) Concentration corrections. Perform the following sequence of preliminary calculations on recorded concentrations before calculating mass emissions as specified in paragraph (d) of this section:

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Where:
$m_{[emission]}$ = mass of emissions over the test phase.
V_{mix} = total dilute exhaust volume over the test phase at standard reference conditions of 293.15 K and 101.3 kPa, corrected for any volume removed for emission sampling and the addition of secondary dilution air (if applicable).
$\rho_{[emission]}$ = density of the emission as given in §1066.1005(f).
$x_{[emission]}$ = amount of measured emission in the sample, after dry-to-wet and background corrections.
$c = 10^{-2}$ for emission concentrations measured in % and 10^{-6} for emission concentrations measured in ppm.

Example:
V_{mix} = 170.919 m^3 (from paragraph (e) of this section)
ρ_{NOx} = 1.913 kg/m^3
x_{NOx} = 0.9663 ppm
$c = 10^{-6}$

$$m_{NOx} = 170.919 \cdot 1.913 \cdot 0.9666 \cdot 10^{-6} = 0.000327 \text{ kg}$$

(e) Calculate the mass of particulate matter emissions using the following equations:
(1) If you sample PM onto a single filter per test phase as described in §1066.822(c) or onto a single filter per UDDS test phase as described in §1066.820(b)(3) or §1066.820(b)(4), calculate m_{PM} using Eq. 1066.610-2.

$$m_{PM} = \left(\frac{V_{mix}}{V_{PMstd} - V_{sdastd}} \right) \cdot \left(m_{PMfil} - m_{PMbkgnd} \right)$$

Eq. 1066.610-2

Where:
m_{PM} = mass of particulate matter emissions over the test phase.
V_{mix} = total dilute exhaust volume over the test phase at standard reference conditions of 293.15 K and 101.3 kPa, corrected for any volume removed for emissions sampling and the addition of secondary dilution air (if applicable).
V_{gasstd} = total volume of sample flow through the gaseous emission bench over the test phase at standard temperature and pressure.
V_{PMstd} = total volume of dilute exhaust sampled through the filter over the test phase at standard temperature and pressure.
V_{sdastd} = total volume of secondary dilution air flow sampled through the filter over the test phase at standard temperature and pressure.
m_{PMfil} = mass of particulate matter emissions on the filter over the test phase.
$m_{PMbkgnd}$ = mass of particulate matter on the background filter.
V_{mixstd} = total dilute exhaust volume over the test phase at the flow meter at standard reference conditions of 293.15 K and 101.3 kPa.

Example:
Using Eq. 1066.610-5

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V_{mixstd} = 170.492 m^3, where V_{mixact} = 170.72 m^3, p_B = 101.7 kPa, p_{in} = 0 kPa, and T_{in} = 294.7 K

Using Eq. 1066.610-5

V_{gasstd} = 0.0291 m^3, where V_{gasact} = 0.0337 m^3, p_B = 101.7 kPa, p_{in} = 0 kPa, and T_{in} = 340.5 K

Using Eq. 1066.610-5

V_{PMstd} = 0.9248 m^3, where V_{PMact} = 1.07 m^3, p_B = 101.7 kPa, p_{in} = 0 kPa, and T_{in} = 340.5 K

Using Eq. 1066.610-5

V_{sdastd} = 0.527 m^3, where V_{sdaact} = 0.531 m^3, p_B = 101.7 kPa, p_{in} = 0 kPa, and T_{in} = 296.3 K

V_{mix} = 170.492 + 0.0291 + 0.9248 – 0.527 = 170.919 m^3

m_{PMfil} = 0.0000045 g

$m_{PMbkgnd}$ = 0.0000014 g

$$m_{PM} = \left(\frac{170.919}{0.9248 - 0.527}\right) \cdot (0.0000045 - 0.0000014) = 0.00133 \text{ g}$$

(2) If you sample PM onto a single filter for all test phases as described in §1066.820(b)(1), calculate m_{PM} using Eq. 1066.610-3.

$$m_{PM} = \left(\frac{V_{mix}}{\frac{(V_{ct\text{-}PMstd} - V_{ct\text{-}sdastd})}{0.43} + (V_{s\text{-}PMstd} - V_{s\text{-}sdastd}) + \frac{(V_{ht\text{-}PMstd} - V_{ht\text{-}sdastd})}{0.57}} \right) \cdot (m_{PMfil} - m_{PMbkgnd})$$

Eq. 1066.610-3

Where:

m_{PM} = mass of particulate matter emissions over the entire FTP as sampled according to §1066.820(b)(1).

V_{mix} = total dilute exhaust volume over the test phase at standard reference conditions of 293.15 K and 101.3 kPa, corrected for any volume removed for emissions sampling and the addition of secondary dilution air (if applicable).

$V_{[phase]\text{-}PMstd}$ = total volume of dilute exhaust sampled through the filter over the test phase (ct = cold transient, s = stabilized, ht = hot transient) at standard temperature and pressure.

$V_{[phase]\text{-}sdastd}$ = total volume of secondary dilution air sampled through the filter over the test phase (ct = cold transient, s = stabilized, ht = hot transient) at standard temperature and pressure.

m_{PMfil} = mass of particulate matter emissions on the filter over the test phase.

$m_{PMbkgnd}$ = mass of particulate matter on the background filter.

Example:

V_{mix} = 633.69 m^3

$V_{ct\text{-}PMstd}$ = 0.9248 m^3

$V_{ct\text{-}sdastd}$ = 0.527 m^3

$V_{s\text{-}PMstd}$ = 1.9676 m^3

$V_{s\text{-}sdastd}$ = 1.1212 m^3

$V_{ht\text{-}PMstd}$ = 1.1215 m^3

$V_{ht\text{-}sdastd}$ = 0.639 m^3

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m_{PMfil} = 0.0000106 g
$m_{PMbkgnd}$ = 0.0000014 g

$$m_{PM} = \left(\frac{633.69}{\frac{(0.9248 - 0.527)}{0.43} + (1.9676 - 1.1212) + \frac{(1.1215 - 0.639)}{0.57}} \right) \cdot (0.0000106 - 0.0000014)$$

m_{PM} = 0.00223 g

(3) If you sample PM onto a single filter for all test phases as described in §1066.820(b)(2), calculate m_{PM} using Eq. 1066.610-4.

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$$m_{PM} = \left(\frac{V_{mix}}{\frac{(V_{ct\text{-}PMstd} - V_{ct\text{-}sdastd}) + (V_{cs\text{-}PMstd} - V_{cs\text{-}sdastd})}{0.43} + \frac{(V_{ht\text{-}PMstd} - V_{ht\text{-}sdastd}) + (V_{hs\text{-}PMstd} - V_{hs\text{-}sdastd})}{0.57}} \right) \cdot (m_{PMfil} - m_{PMbkgnd})$$

Eq. 1066.610-4

Where:
m_{PM} = mass of particulate matter emissions over the entire FTP as sampled according to §1066.820(b)(2).
V_{mix} = total dilute exhaust volume over the test phase at standard reference conditions of 293.15 K and 101.3 kPa, corrected for any volume removed for emissions sampling and the addition of secondary dilution air (if applicable).
$V_{[phase]\text{-}PMstd}$ = total volume of dilute exhaust sampled through the filter over the test phase (ct = cold transient, cs = cold stabilized, ht = hot transient, hs = cold stabilized) at standard temperature and pressure.
$V_{[phase]\text{-}sdastd}$ = total volume of secondary dilution air sampled through the filter over the test phase (ct = cold transient, cs = cold stabilized, ht = hot transient, hs = cold stabilized) at standard temperature and pressure.
m_{PMfil} = mass of particulate matter emissions on the filter over the test phase.
$m_{PMbkgnd}$ = mass of particulate matter on the background filter.

Example:
V_{mix} = 972.12 m^3
$V_{ct\text{-}PMstd}$ = 0.9236 m^3
$V_{ct\text{-}sdastd}$ = 0.529 m^3
$V_{cs\text{-}PMstd}$ = 1.9666 m^3
$V_{cs\text{-}sdastd}$ = 1.1209 m^3
$V_{ht\text{-}PMstd}$ = 1.1218 m^3
$V_{ht\text{-}sdastd}$ = 0.641 m^3
$V_{hs\text{-}PMstd}$ = 1.9674 m^3
$V_{hs\text{-}sdastd}$ = 1.1213 m^3
m_{PMfil} = 0.0000229 g
$m_{PMbkgnd}$ = 0.0000014 g

$$m_{PM} = \left(\frac{972.12}{\frac{(0.9236 - 0.529) + (1.9666 - 1.1209)}{0.43} + \frac{(1.1218 - 0.641) + (1.9674 - 1.1213)}{0.57}} \right) \cdot (0.0000129 - 0.0000014)$$

$m_{PM} = 0.00155$ g

(f) If your volumetric flow rate is not referenced to standard temperature and pressure, correct flow rates to standard temperature and pressure using the following equation:

$$V_{[flow]std} = \frac{V_{[flow]act} \cdot (p_B - p_{in}) \cdot T_{std}}{T_{in} \cdot p_{std}}$$

Eq. 1066.610-5

Where:

$V_{[flow]std}$ = total volume of flow at the flow meter at standard temperature and pressure.

$V_{[flow]act}$ = total volume of flow at the flow meter at test conditions.

p_B = barometric pressure.

p_{in} = pressure elevation above ambient at the sampler flow meter inlet (for most flow meters this can be set equal to 0.

T_{std} = standard temperature, 293.15 K.

T_{in} = average temperature of the dilute exhaust sample at the flow meter inlet.

P_{std} = standard pressure, 101.3 kPa.

Example:

V_{PMact} = 1.07 m^3

p_B = 101.7 kPa

p_{in} = 0 kPa

T_{in} = 340.5 K

T_{std} = 293.15 K

p_{std} = 101.3 kPa

$$V_{PMstd} = \frac{1.07 \cdot (101.7 - 0) \cdot 293.15}{340.5 \cdot 101.3} = 0.9248 \text{ m}^3$$

§1066.620 Dilution air background emission correction.

(a) Correct the emissions in a gaseous sample for background as follows:

$$x_{[emission]} = x_{[emission]dexh} - x_{[emission]bkgnd} \cdot \left(1 - \left(\frac{1}{DF}\right)\right)$$

Eq. 1066.620-1

Where:

$x_{[emission]dexh}$ = amount of measured emission in dilute exhaust (after dry-to-wet correction for emissions measured dry).

$x_{[emission]bkgnd}$ = amount of measured emission in the dilution air (after dry-to-wet correction for emissions measured dry).

DF = dilution factor determined in §1066.620(b).

Example:

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$x_{NOxdexh}$ = 1.07411 ppm
$x_{NOxbkgnd}$ = 0.12 ppm
DF = 9.5659

$$x_{NOx} = 1.07411 - 0.12 \cdot \left(1 - \left(\frac{1}{9.5659}\right)\right) = 0.9666 \text{ ppm}$$

(b) Determine the dilution factor, *DF*, over the test phase using Eq. 1066.620-2. Note that for determination of α and β you may use measured fuel properties or the default fuel properties in Table 1 of 40 CFR 1065.655.

$$DF = \frac{100 \cdot \frac{1}{1 + \frac{\alpha}{2} + 3.76 \cdot \left(1 + \frac{\alpha}{4} - \frac{\beta}{2}\right)}}{x_{CO2} + x_{THC} + x_{CO}}$$

Eq. 1066.620-2

Where:
x_{CO2} = amount of CO_2 measured in the sample over the test phase.
x_{THC} = amount of C_1-equivalent THC measured in the sample over the test.
x_{CO} = amount of CO measured in the sample over the test phase.
α = atomic hydrogen-to-carbon ratio of the mixture of fuel(s) being combusted, weighted by molar composition.
β = atomic oxygen-to-carbon ratio of the mixture of fuel(s) being combusted, weighted by molar composition.

Example:
x_{CO2} = 1.4 %
x_{THC} = 1.0 ppm
x_{CO} = 80 ppm
α = 1.85
β = 0

$$DF = \frac{100 \cdot \frac{1}{1 + \frac{1.85}{2} + 3.76 \cdot \left(1 + \frac{1.85}{4} - \frac{0}{2}\right)}}{1.4 + (1.0 + 80) \cdot 10^{-4}} = 9.5659$$

(c) Determine the dilution factor, *DF*, over the test phase for partial flow dilution sample systems that measure PM using Eq. 1066.620-3.

$$DF = \frac{V_{PMstd}}{V_{exhstd}}$$

Eq. 1066.620-3

Where:
V_{PMstd} = total dilute exhaust volume sampled through the filter over the test phase at standard reference conditions of 293.15 K and 101.3 kPa.

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x_{CH4} = 0.2 ppm
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V_{exhstd} = total dilute exhaust volume sampled from the CVS at standard reference conditions of 293.15 K and 101.3 kPa.

Example:
V_{mix} = 170.9 m^3
V_{exhstd} = 18.0 m^3

$$DF = \frac{170.9}{15.4} = 11.1$$

§1066.630 NO_x intake-air humidity and temperature corrections.

See the standard-setting part to determine if you may correct NO_x emissions for the effects of intake-air humidity or temperature. Correct NO_x emissions for intake-air humidity as described in this section. See §1066.610(c)(1) for the proper sequence for applying the NO_x intake-air humidity and temperature corrections. You may use a time-weighted mean combustion air humidity to calculate this correction if your combustion air humidity remains within a tolerance of ± 5% of the mean combustion air humidity value over the test phase.

(a) For vehicles at or below 14,000 pounds GVWR, apply a correction for any reciprocating engines for the following test cycles:

(1) For the FTP, US06, LA-92, and HFET test cycles, use the following equation to correct measured concentrations to a reference condition of 10.71 of H_2O vapor per kilogram of dry air:

$$x_{NOxdexhcor} = x_{NOxdexh} \cdot \frac{1}{1 - 0.0329 \cdot (H - 10.71)}$$

Eq. 1066.630-1

$$H = \frac{M_{H2O} \cdot RH\% \cdot p_d}{M_{air} \cdot (p_B - p_d \cdot RH\%)}$$

Eq. 1066.630-2

Where:
H = Absolute humidity in grams of H_2O vapor per kilogram of dry air.
M_{H2O} = molar mass of H_2O in g/mol.
RH = Relative humidity of ambient air.
M_{air} = molar mass of air in kg/mol.
p_d = Saturated vapor pressure at the ambient dry bulb temperature.
p_B = barometric pressure.

Example:
M_{H2O} = 18.01528 g/mol
RH % = 37.5 %
M_{air} = 0.02896559 kg/mol
P_d = 2.93 kPa
P_B = 96.71 kPa
$x_{NOxdexh}$ = 1.2 ppm

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$$H = \frac{18.01528 \cdot 37.5 \cdot 0.01 \cdot 2.93}{0.02896559 \cdot (96.71 - 2.93 \cdot 37.5 \cdot 0.01)} = 7.14741 \text{ g } H_2O \text{ vapor/kg dry air}$$

$$x_{NOxdexhcor} = 1.2 \cdot \frac{1}{1 - 0.0329 \cdot (7.14741 - 10.71)} = 1.07411 \text{ ppm}$$

(2) For the SC03 test cycle, use the following equation to correct measured concentrations to a reference condition of 10.71 of H_2O vapor per kilogram of dry air:

$$x_{NOxdexhcor} = x_{NOxdexh} \cdot \frac{0.8825}{1 - 0.0329 \cdot (H - 10.71)}$$

Eq. 1066.630-3

Where:
H = Absolute humidity in grams of H_2O vapor per kilogram of dry air according to Eq. 1066.630-2.

Example:
RH = 55.9 %
P_d = 2.93 kPa
P_B = 96.71 kPa
H = 10.7148 g H_2O vapor/kg dry air
$x_{NOxdexh}$ = 1.2 ppm

$$x_{NOxdexhcor} = 1.2 \cdot \frac{0.8825}{1 - 0.0329 \cdot (10.7148 - 10.71)} = 1.059 \text{ ppm}$$

(b) For vehicles above 14,000 pounds GVWR, apply correction factors as described in 40 CFR 1065.670.

§1066.640 Removed water correction.
If you remove water upstream of a concentration measurement, x, correct for the removed water. Perform this correction based on the amount of water at the concentration measurement and at the flow meter, whose flow is used to determine the mass emission rate or total mass over a test phase.

§1066.650 Flow meter calibration calculations.
This section describes the calculations for calibrating various flow meters. If you choose to determine molar flow rate, use the equations in 40 CFR 1065.640 to calibrate your flow meter. After you calibrate a flow meter using these calculations, use the calculations described in §1066.652 to calculate flow during an emission test.
(a) PDP calibration calculations. For each restrictor position, calculate the following values from the mean values determined in §1066.140, as follows:
(1) PDP volume pumped per revolution, V_{rev}:

$$V_{rev} = \frac{\overline{Q}_{ref} \cdot \overline{T}_{in} \cdot p_{std}}{\overline{p}_{in} \cdot T_{std} \cdot \overline{f}_{nPDP}}$$

Eq. 1066.650-1

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Where:

$\bar{\dot{Q}}_{ref}$ = air flow rate of reference flow meter.

$\bar{T}_{in}$ = mean pump inlet absolute temperature.

p_{std} = standard pressure.

$\bar{p}_{in}$ = mean pump inlet absolute static pressure.

T_{std} = standard temperature.

$\bar{f}_{nPDP}$ = mean pump speed.

Example:

$\bar{\dot{Q}}_{ref}$ = 0.1651 m^3/s

$\bar{T}_{in}$ = 299.5 K

p_{std} = 101325 Pa

$\bar{p}_{in}$ = 98290 Pa

T_{std} = 293.15 K

$\bar{f}_{nPDP}$ = 1205.1 r/min = 20.085 r/s

$$V_{rev} = \frac{0.1651 \cdot 299.5 \cdot 101325}{98290 \cdot 293.15 \cdot 20.085}$$

V_{rev} = 0.00866 m^3/r

(2) PDP slip correction factor, K_s:

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$$K_s = \frac{1}{\bar{f}_{nPDP}} \cdot \sqrt{\frac{\bar{p}_{out} - \bar{p}_{in}}{\bar{p}_{out}}}$$

Eq. 1066.650-2

Where:

$\bar{f}_{nPDP}$ = mean pump speed.

$\bar{p}_{out}$ = mean pump outlet absolute temperature.

$\bar{p}_{in}$ = mean pump inlet absolute static pressure.

Example:

$\bar{f}_{nPDP}$ = 1205.1 r/min = 20.085 r/s

$\bar{p}_{out}$ = 100.103 kPa

$\bar{p}_{in}$ = 98.290 kPa

$$K_s = \frac{1}{20.085} \cdot \sqrt{\frac{100.103 - 98.290}{100.103}}$$

K_s = 0.006700 s/r

(3) Perform a least-squares regression of PDP volume pumped per revolution, V_{rev}, versus PDP slip correction factor, K_s, by calculating slope, a_1, and intercept, a_0, as described in 40 CFR 1065.602.

(4) Repeat the procedure in paragraphs (a)(1) through (3) of this section for every speed that you run your PDP.

(5) The following example illustrates these calculations:

Table 1 of §1066.650–
Example of PDP calibration data

$\bar{f}_{nPDP}$ (r/min)	a_1 (m^3/min)	a_0 (m^3/r)
755.0	50.43	0.056
987.6	49.86	-0.013
1254.5	48.54	0.028
1401.3	47.30	-0.061

(6) For each speed at which you operate the PDP, use the corresponding slope, a_1, and intercept, a_0, to calculate flow rate during emission testing as described in §1066.652.

(b) SSV calibration. Perform the following steps to calibrate an SSV flow meter:

(1) Calculate the Reynolds number, $Re^{\#}$, for each reference volumetric flow rate, using the throat diameter of the venturi, d_t, and the mass air flow rate, $\dot{Q}_{m\text{-}ref}$, of the reference flow meter. Assume an initial value for C_d = 0.98 to calculate $\dot{Q}_{m\text{-}ref}$.

$$Re^{\#} = \frac{66670 \cdot \dot{Q}_{m\text{-}ref}}{\pi \cdot d_t \cdot \mu}$$

Eq. 1066.650-3

Where:

μ = viscosity of air in centipoises calculated using Eq. 1066.650-4.

$$\mu = 1.458 \cdot 10^{-3} \cdot \frac{T^{\frac{3}{2}}}{T + 110.4}$$

Eq. 1066.650-4

Where:

T = the temperature at the SSV inlet in Kelvin.

If the calibration venturi is used at the tunnel inlet (free standing), then assume a value of β = 0. If the SSV is installed in the CVS tunnel, use the actual inside tunnel diameter and the throat diameter to compute β, where β is the ratio of venturi throat to inlet diameters.

(2) From the initial calibration of the venturi, establish an equation of C_d as a function of $Re^{\#}$. The following functional forms should be reviewed, but a power series, least-squares fit polynomial equation may result in the best fit. Many factors involved in the installation of SSV and the operating range of the Reynolds number can affect the

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functional relationship of C_d with $Re^{\#}$. Calculate C_d based on this initial equation of $Re^{\#}$. Compute a final $\dot{Q}_m$ based on this calculated C_d for both the calibration nozzle and the inline SSV.

(3)(i) Compute the percent difference in air flow between the calibration venturi and the inline SSV. If the difference in percent of point is greater than 1%, compute a new C_d and $Re^{\#}$ for the in-tunnel venturi as follows:

$$C_{dnew} = \frac{\dot{Q}_{mact}}{\dot{Q}_{mtheo}}$$

Eq. 1066.650-5

Where:

C_{dnew} = the ratio of actual air flow/theoretical air flow.

$\dot{Q}_{mact}$ = flow measured by the calibration venturi, kg/min.

$\dot{Q}_{mtheo}$ = the theoretical calculated flow based on the in-tunnel SSV conditions with C_d set equal to 1, kg/min.

$$Re^{\#}_{new} = \frac{0.8 \cdot \dot{Q}_{m\text{-}ref}}{\pi \cdot d_t \cdot \mu}$$

Eq. 1066.650-6

Where:

$Re^{\#}_{new}$ = Reynolds number based on the calibrated venturi flow, but the in-tunnel SSV properties.

(ii) Recalculate a new curve fit of C_{dnew} for the inline venturi as a function of $Re^{\#}_{new}$ following the guidelines in paragraph (b)(1) of this section. Agreement of the fit should be within 1.0 % of point. Install the new C_d curve fit in the test cell flow computing device and conduct the propane injection flow verification test as described in 40 CFR 1065.341.

(c) CFV calibration. Some CFV flow meters consist of a single venturi and some consist of multiple venturis, where different combinations of venturis are used to meter different flow rates. For CFV flow meters that consist of multiple venturis, either calibrate each venturi independently to determine a separate calibration coefficient, K_v, for each venturi, or calibrate each combination of venturis as one venturi.

(1) To determine the K_v for a single venturi or a single combination of venturis, perform the following steps:

(i) For each restrictor position, use the data collected at each calibration set point to calculate an individual K_v for each point using Eq. 1066.650-7:

$$K_v = \frac{\bar{\dot{Q}}_{refstd} \cdot \sqrt{\bar{T}_{in}}}{\bar{P}_{in}}$$

Eq. 1066.650-7

Where:

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$\bar{\dot{Q}}_{refstd}$ = mean flow rate from the reference flow meter, at standard reference conditions of 293.15 K and 101.3 kPa.
$\bar{T}_{in}$ = mean temperature at the venturi inlet.
$\bar{p}_{in}$ = mean absolute static pressure at the venturi inlet.

(ii) Calculate the mean and standard deviation of all the K_v values according to 40 CFR part 1065 Eqs. 1065.602-1 and 1065.602-2. Plot K_v as a function of venturi inlet pressure. For choked flow, K_v will have a relatively constant value. As pressure decreases (vacuum increases), the venturi will become unchoked and K_v will decrease.
(iii) If the standard deviation of all the K_v values is less than or equal to 0.3 % of the mean K_v, use the mean K_v in Eq. 1066.652-7, and use the CFV only up to the highest venturi pressure ratio, r, measured during calibration using the following equation:

$$r = 1 - \frac{\Delta p_{CFV}}{p_{in}}$$

Eq. 1066.650-8

Where:
Δp_{CFV} = differential static pressure; venturi inlet minus venturi outlet.

(iv) If the standard deviation of all the K_v values exceeds 0.3 % of the mean K_v, omit the K_v value corresponding to the data point collected at the highest r measured during calibration.
(v) If the number of remaining data points is less than seven, take corrective action by checking your calibration data or repeating the calibration process. If you repeat the calibration process, we recommend checking for leaks, applying tighter tolerances to measurements and allowing more time for flows to stabilize.
(vi) If the number of remaining K_v values is seven or greater, recalculate the mean and standard deviation of the remaining K_v values.
(vii) If the standard deviation of the remaining K_v values is less than or equal to 0.3 % of the mean of the remaining K_v, use that mean K_v in Eq 1066.652-7, and use the CFV values only up to the highest r associated with the remaining K_v.
(viii) If the standard deviation of the remaining K_v still exceeds 0.3 % of the mean of the remaining K_v values, repeat the steps in paragraph (c)(1)(iv) through (vii) of this section.
(2) During exhaust emission tests, monitor sonic flow in the CFV by monitoring the CFV pressure ratio. Based upon the calibration data selected to meet the criteria for paragraphs (c)(1)(iv) and (vii) of this section, in which K_v is constant, select the data values associated with the calibration point with the lowest absolute venturi inlet pressure.
(i) Calculate r during the exhaust emission test using Eq. 1066.650-8.
(ii) The venturi pressure ratio during all emission tests must be less than or equal to the calibration pressure ratio limit derived from the CFV calibration data.

§1066.652 PDP, SSV, and CFV flow rate calculations.
This section describes the equations for calculating flow rates from various flow meters. After you calibrate a flow meter according to §1066.650, use the calculations described

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in this section to calculate flow during an emission test. If you choose to determine molar flow rate, use the equations in 40 CFR 1065.642 to calculate flow.

(a) PDP volumetric flow rate. Based upon the speed at which you operate the PDP for a test interval, select the corresponding slope, a_1, and intercept, a_0, as calculated in §1066.650(a), to calculate volumetric flow rate, $\dot{Q}$ as follows:

$$\dot{Q} = f_{nPDP} \cdot \frac{p_{in} \cdot V_{rev} \cdot T_{std}}{T_{in} \cdot p_{std}}$$

Eq. 1066.652-1

Where:

T_{in} = pump inlet absolute temperature.

p_{std} = standard pressure.

P_{in} = pump inlet absolute static pressure.

T_{std} = standard temperature.

f_{nPDP} = pump speed.

p_{out} = pump outlet absolute temperature.

p_{in} = pump inlet absolute static pressure.

$$V_{rev} = \frac{a_1}{f_{nPDP}} \cdot \sqrt{\frac{p_{out} - p_{in}}{p_{out}}} + a_0$$

Eq. 1066.652-2

Example:

a_1 = 50.43 m^3/min = 0.8405 m^3/s

f_{nPDP} = 755.0 r/min = 12.58 r/s

p_{out} = 99950 Pa

p_{in} = 98575 Pa

a_0 = 0.056 m^3/r

T_{in} = 323.5 K

C_p = 1000 J·m^{-3}/kPa

C_t = 60 s/min

$$V_{rev} = \frac{0.8405}{12.58} \cdot \sqrt{\frac{99950 - 98575}{99950}} + 0.056$$

V_{rev} = 0.06383 m^3/r

$$\dot{Q} = 12.58 \cdot \frac{98575 \cdot 0.06383 \cdot 293.15}{323.5 \cdot 101325}$$

$\dot{Q}$ = 0.7079 m^3/s

(b) SSV volumetric flow rate. Based on the C_d versus $Re^{\#}$ equation you determined according to §1066.650(b), calculate SSV volumetric flow rate, V_{mix} during an emission

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Deleted: Note that 40 CFR 1065.642 presents all flow rate equations on a molar basis; however, 40 CFR 1065.640(a) allows for conversion between volumetric and molar flow rate. If you are using mass-based emission calculations to determine your total mass of emissions over a test cycle, you may determine flow rate volumetrically using Equation 1065.640-1 to convert the molar flow rate equations in 40 CFR 1065.642 to volumetric flow equations.

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test as follows:

$$\dot{Q} = \frac{K_q}{\rho_s} \cdot \frac{C_d \cdot Y \cdot d^2}{\sqrt{1-\beta^4}} \cdot \sqrt{\rho_1 \cdot \Delta p}$$

Eq. 1066.652-3

Where:

$\dot{Q}$ = air flow rate of flow meter, scfm (m^3/min).

K_q = 0.0021074 (SI unit conversion).

ρ_s = density of air at standard conditions, lbm/ft^3 (kg/m^3) as determined in paragraph (b)(4) of this section.

ρ_1 = density of air at inlet conditions, lbm/ft^3 (kg/m^3), as determined in paragraph (b)(2) of this section.

C_d = discharge coefficient.

Y = Expansion factor, as determined in paragraph (b)(1) of this section.

d_t = venturi throat diameter, inch (mm).

β = ratio of venturi throat diameter to approach pipe diameter.

Δp = pressure drop between inlet and throat, in. H_2O (kPa).

(1) The expansion factor (Y) is calculated as follows:

$$Y = \left[r^{\frac{2}{k}} \cdot \left(\frac{k}{k-1} \right) \cdot \left(\frac{1-r^{\left(\frac{k-1}{k}\right)}}{1-r} \right) \cdot \left(\frac{1-\beta^4}{1-\beta^4 \cdot r^{\frac{2}{k}}} \right) \right]^{\frac{1}{2}}$$

Eq. 1066.652-4

Where:

$$r = 1 - \frac{\Delta p}{p_{abs}}$$

$$\beta = \frac{d}{D}$$

d = venturi throat diameter in inches (mm).

D = inlet pipe diameter in inches (mm).

k = ratio of specific heat (1.40 for air).

(2) The inlet density (ρ_1) is calculated as follows:

$$\rho_1 = \frac{p_{abs}}{R_{mix} \cdot T_{abs}}$$

Eq. 1066.652-5

Where:

$p_{abs} = p_1$ + barometric pressure

$T_{abs} = T_1 + 273.15$

$R_{mix} = R_u / MW_{mix}$

R_u = 8.3144 kJ/kg·mole·K

MW_{mix} = the molecular weight of the mix, as calculated in paragraph (b)(3) of this section.

(3) The molecular weight of the mix, is calculated as follows:

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$$MW_{mix} = \frac{MW_{air} \cdot (p_{abs} - p_v) + MW_{H_2O} \cdot p_v}{p_{abs}}$$

Eq. 1066.652-6

Where:

p_v = vapor pressure, in Hg (kPa)

MW_{air} = 28.964 kg/kg·mole

MW_{H2O} = 18.015 kg/kg·mole

(4) The density at standard conditions of 101.33 kPa and 20 °C is calculated as follows:

$$\rho_s = \frac{101.325}{\frac{8.314472}{28.96559} \cdot 293.15} = 1.2041 \text{ kg/m}^3$$

(c) CFV volumetric flow rate. Some CFV flow meters consist of a single venturi and some consist of multiple venturis, where different combinations of venturis are used to meter different flow rates. If you use multiple venturis and you calibrated each venturi independently to determine a separate calibration coefficient, K_v, for each venturi, calculate the individual volumetric flow rates through each venturi and sum all their flow rates to determine $\dot{Q}$. If you use multiple venturis and you calibrated each combination of venturis, calculate $\dot{Q}$ using the K_v that was determined for that combination of venturis.

(1) To calculate volumetric flow rate through one venturi or one combination of venturis, use its respective mean K_v you determined according to §1066.650(c) and calculate its volumetric flow rate $\dot{Q}$ during an emission test, as follows:

$$\dot{Q} = \frac{K_v \cdot P_{in}}{\sqrt{T_{in}}}$$

Eq. 1066.652-7

Where:

$\dot{Q}$ = air flow rate of flow meter.

K_v = flow meter calibration coefficient.

T_{in} = temperature at the venturi inlet.

P_{in} = absolute static pressure at the venturi inlet.

Example:

K_v = 0.000074954

p_{in} = 99654 Pa

T_{in} = 353.15 K

$$\dot{Q} = \frac{0.000074954 \cdot 98936}{\sqrt{353.15}}$$

$\dot{Q}$ = 0.39461 m^3/s

§1066.665 NMOG determination.

For vehicles subject to an NMOG standard, determine NMOG as described in paragraph

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(a) of this section. Except as specified in the standard-setting part, you may alternatively calculate NMOG results based on measured NMHC emissions as described in paragraphs (c) through (f) of this section.

(a) Determine NMOG by independently measuring alcohols and carbonyls as described in 40 CFR 1065.805 and 1065.845. Unless the standard-setting part specifies otherwise, use good engineering judgment to determine which alcohols and carbonyls you need to measure. Typically this would require you to measure all alcohols and carbonyls that you expect to contribute 1% or more of total NMOG emissions. Note that the effective density used for NMHC mass determination should be based on $\rho_{NMHC\text{-}liq}$ as given in §1066.1005(f), regardless of the ethanol content of the test fuel. Calculate NMOG using the following equation:

$$m_{NMOG} = m_{NMHC} - \rho_{NMHC} \cdot \sum_{i=1}^{N} \frac{m_{OHCi}}{\rho_{OHCi}} \cdot RF_{OHCi[THC\text{-}FID]} + \sum_{i=1}^{N} m_{OHCi}$$

Eq. 1066.665-1

Where:

m_{NMOG} = the C_1-equivalent sum of the mass of NMOG in the exhaust.

m_{OHCi} = the C_1-equivalent mass of oxygenated species *i* in the exhaust calculated using Eq. 1066.610-1 and the density of the oxygenated species *i* as given in §1066.1005(f).

m_{NMHC} = the C_1-equivalent mass of NONMHC and all OHCs in the exhaust, as determined by §1066.610(c)(4) and calculated using Eq. 1066.610-1. Note that the effective density used for NMHC mass determination should be based on $\rho_{NMHC\text{-}liq}$ as given in §1066.1005(f).

$\rho_{NMHC\text{-}liq}$ = the effective density of NMHC for liquid fuel as given in §1066.1005(f).

ρ_{OCHi} = the C_1-equivalent density of oxygenated species *i* as given in §1066.1005(f).

$RF_{OHCi[THC\text{-}FID]}$ = The response factor of the THC FID to oxygenated species *i* relative to propane on a C_1-equivalent basis. You may generate your own response factors or use the following response factors, consistent with good engineering judgment:

Table 1 of §1066.665–Default values for THC FID response factor relative to propane on a C_1-equivalent basis

Compound	Response factor (*RF*)
methanol	0.63
ethanol	0.75
propanol	0.85
formaldehyde	0.00
acetaldehyde	0.50

(b) The following example shows how to determine NMOG emissions as described in paragraph (a) of this section based on ethanol (C_2H_5OH), methanol (CH_3OH), acetaldehyde (C_2H_4O), and formaldehyde (C_2HO) as C_1-equivalent concentrations:

m_{NMHC} = 0.0000125 kg

m_{CH3OH} = 0.0000002 kg

m_{C2H5OH} = 0.0000009 kg

m_{HCHO} = 0.0000001 kg

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$m_{C2H4O} = 0.00000005$ kg
$RF_{CH3OH[THC-FID]} = 0.63$
$RF_{C2H5OH[THC-FID]} = 0.75$
$RF_{HCHO[THC-FID]} = 0.00$
$RF_{C2H4O[THC-FID]} = 0.50$
$\rho_{NMHC-liq} = 0.576816$ kg/m^3
$\rho_{CH3OH} = 1.33202$ kg/m^3
$\rho_{C2H5OH} = 0.957559$ kg/m^3
$\rho_{HCHO} = 1.24821$ kg/m^3
$\rho_{C2H4O} = 0.915658$ kg/m^3

$$m_{NMOG} = 0.0000125 - 0.576816 \cdot \left(\frac{0.0000002}{1.33202} \cdot 0.63 + \frac{0.0000009}{0.957559} \cdot 0.75 + \frac{0.0000001}{1.24821} \cdot 0.00 + \frac{0.00000005}{0.915658} \cdot 0.5 \right) +$$

$$0.0000002 + 0.0000009 + 0.0000001 + 0.00000005$$

$$= 0.000013273 \text{ kg}$$

(c) For ethanol-gasoline blends ranging from E0 to E25, you may calculate NMOG emissions using the following equations:

(1) For hot start and hot running test cycles or phases other than the FTP, you may determine NMOG for use in criteria pollutant, fuel economy, and carbon-related exhaust emission calculations based on the test cycle NMHC emission rate using Eq. 1066.665-2.

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$$e_{NMOGhot} = e_{NMHChot} \cdot 1.03$$

Eq. 1066.665-2

Where:

$e_{NMOGhot}$ = mass emission rate of NMOG over the hot running test cycle.

$e_{NMHChot}$ = mass emission rate of NMHC over the hot running test cycle calculated using $\rho_{NMHC-liq}$ as given in §1066.1005(f).

Example:

$e_{NMHChot} = 0.000025$ kg/mi

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$e_{NMOGhot} = 0.000025 \cdot 1.03 = 0.00002575$ kg/mi

(2) You may determine FTP weighted composite NMOG for use in criteria pollutant, fuel economy, and carbon-related exhaust emission (CREE) calculations based on the test cycle weighted composite NMHC emission rate and the volume percent of ethanol in the fuel using Eq. 1066.665-3.

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$$e_{NMOGcomp} = e_{NMHCcomp} \cdot \left(1.0302 + 0.0071 \cdot VP_{EtOH}\right)$$

Eq. 1066.665-3

Where:

$e_{NMOGcomp}$ = weighted composite mass emission rate of NMOG over the test cycle.

$e_{NMHCcomp}$ = weighted composite mass emission rate of NMHC over the test cycle calculated using $\rho_{NMHC-liq}$ as given in §1066.1005(f).

VP_{EtOH} = volume percentage of ethanol in the test fuel.

Example:

$e_{NMHCcomp}$ = 0.000025 kg/mi

VP_{EtOH} = 15.1 %

$$e_{NMOGcomp} = 0.000025 \cdot (1.0302 + 0.0071 \cdot 15.1) = 0.0000284 \text{ kg/mi}$$

(3) You may determine FTP cold start test phase NMOG for use in fuel economy and CREE calculations based on the phase NMHC emission rate and the volume percent of ethanol in the fuel using Eq. 1066.665-4.

$$e_{NMOG\text{-}FTPct} = e_{NMHC\text{-}FTPct} \cdot (1.0246 + 0.0079 \cdot VP_{EtOH})$$

Eq. 1066.665-4

Where:

$e_{NMOG\text{-}FTPct}$ = mass emission rate of NMOG over the FTP cold start test phase.

$e_{NMHC\text{-}FTPct}$ = mass emission rate of NMHC over the FTP cold start test phase calculated using $\rho_{NMHC\text{-}liq}$ as given in §1066.1005(f).

VP_{EtOH} = volume percentage of ethanol in the test fuel.

Example:

$e_{NMHC\text{-}FTPct}$ = 0.000052 kg/mi

VP_{EtOH} = 15.1 %

$$e_{NMOG\text{-}FTPct} = 0.000052 \cdot (1.0246 + 0.0079 \cdot 15.1) = 0.0000595 \text{ kg/mi}$$

(4) You may determine FTP cold or hot stabilize test phase NMOG for use in fuel economy and CREE calculations based on the phase NMHC emission rate and the volume percent of ethanol in the fuel using Eq. 1066.665-5.

$$e_{NMOG\text{-}FTPcs\text{-}hs} = e_{NMHC\text{-}FTPcs\text{-}hs} \cdot (1.1135 + 0.001 \cdot VP_{EtOH})$$

Eq. 1066.665-5

Where:

$e_{NMOG\text{-}FTPcs\text{-}hs}$ = mass emission rate of NMOG over the FTP cold or hot stabilized test phase.

$e_{NMHC\text{-}FTPcs\text{-}hs}$ = mass emission rate of NMHC over the FTP cold or hot stabilized test phase calculated using $\rho_{NMHC\text{-}liq}$ as given in §1066.1005(f).

VP_{EtOH} = volume percentage of ethanol in the test fuel.

(5) You may determine FTP hot start test phase NMOG for use in fuel economy and CREE calculations based on the phase NMHC emission rate and the volume percent of ethanol in the fuel using Eq. 1066.665-6.

$$e_{NMOG\text{-}FTPht} = e_{NMHC\text{-}FTPht} \cdot (1.0195 + 0.0031 \cdot VP_{EtOH})$$

Eq. 1066.665-6

Where:

$e_{NMOG\text{-}FTPht}$ = mass emission rate of NMOG over the FTP hot start test phase.

$e_{NMHC\text{-}FTPht}$ = mass emission rate of NMHC over the FTP hot start test phase calculated

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using $\rho_{NMHC\text{-}liq}$ as given in §1066.1005(f).
VP_{EtOH} = volume percentage of ethanol in the test fuel.
(d) In addition to the allowance for use of the equations in paragraphs (a) and (c) of this section, the following provisions apply:
(1) For determination of fuel economy and CREE that use individual FTP phase (bag) emission results in 40 CFR part 600, you may calculate NMOG by phase using Eq. 1066.665-3.
(2) For determination of fuel economy and CREE for hybrids as described in 40 CFR 600.114-12, you may calculate NMOG for 2-bag FTPs using Eq. 1066.665-3.
(e) For diesel fuel, we consider NMOG emission values to be equivalent to NMHC emission values for all test cycles.
(f) For all fuels not covered by paragraphs (c) and (d) of this section, manufacturers may propose a methodology to calculate NMOG results from measured NMHC emissions. We will approve adjustments based on comparative testing that demonstrates how to properly represent NMOG based on measured NMHC emissions.

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§1066.695 Data requirements.
Record the following information for each test:
(a) Test number.
(b) A brief description of the test vehicle (or other system/device tested).
(c) Date and time of day for each part of the test sequence.
(d) Test results. Also include a validation of driver accuracy as described in §1066.430(j).
(e) Driver and equipment operators.
(f) Vehicle information as applicable, including identification number, model year, applicable emission standards, vehicle model, test group, durability group, engine family, evaporative/refueling emission family, basic engine description (including displacement, number of cylinders, turbo-/supercharger used, and catalyst type), fuel system (type of fuel injection and fuel tank capacity and location), engine code, gross vehicle weight rating, equivalent test weight, inertia weight class, actual curb weight at zero miles, actual road load at 50 mph, transmission configuration, axle ratio, odometer reading, idle rpm, and drive wheel tire pressure.
(g) Dynamometer identification, inertia weight setting, indicated power absorption setting, records to verify compliance with the and driving distance and cycle-validation criteria as calculated from measured roll or shaft revolutions.
(h) Analyzer bench identification, analyzer ranges, recordings of analyzer output during zero, span, and sample readings.
(i) Associate the following information with the test record: test number, date, vehicle identification, vehicle and equipment operators, and identification of the measurements recorded.
(j) Test cell barometric pressure and humidity. You may use a central laboratory barometer if the barometric pressure in each test cell is shown to be within ±0.1 % of the barometric pressure at the central barometer location.
(k) Records to verify compliance with the ambient temperature requirements throughout the test procedure and records of fuel temperatures during the running loss test.
(l) [Reserved]

(m) For CVS systems record, dilution factor for each phase of the exhaust test and the following additional information:
(1) CFV and SSV V_{mix} for each phase of the exhaust test.
(2) PDP. Test measurements required to calculate V_{mix} for each phase of the exhaust test.
(n) The humidity of the dilution air if you remove H_2O from an emission sample before measurement.
(o) Temperature of the dilute exhaust mixture and secondary dilution air (in the case of a double-dilution system) at the inlet to the respective gas meter or flow instrumentation used for particulate sampling.
(p) The maximum gas temperature over the course of the test within 20 cm upstream or downstream of the sample media (e.g., filter).
(q) If applicable, the temperature of the heated FID, the gas in the heated sample line, and the heated filter.
(r) Gas meter or flow measurement instrumentation readings at the start and end of each test phase.
(s) The stabilized pre-test weight and post-test weight of each particulate sample media (e.g., filter).
(t) Continuous temperature and humidity of the ambient air in which the particulate sample media (e.g., filter).are stabilized.
(u) For vehicles fueled by natural gas, the test fuel composition, including all carbon-containing compounds; e.g. CO_2, of the natural gas-fuel used during the test. Record C_1 and C_2 compounds individually. You may record C_3 through C_5 hydrocarbons together, and you may record C_6 and heavier hydrocarbon compounds together. Record CO and CO_2 separately.
(v) Additional required records for liquefied petroleum gas-fueled vehicles. For vehicles fueled by liquefied petroleum gas, the test fuel composition, including all carbon-containing compounds. Each hydrocarbon compound present, through C_4 compounds, shall be individually reported. C_5 and heavier hydrocarbons may be reported as a group. Record C_1 and C_4 compounds individually. You may record C_5 and heavier hydrocarbon compounds together. Record CO and CO_2 separately.

Comment [CAL17]: Global search and replace.

Subpart H—Cold-Temperature Test Procedures

§1066.701 Applicability and general provisions.

(a) The procedures of this part 1066 may be used for testing at any ambient temperature. The standard-setting part may specify additional provisions for testing conducted at temperatures below 20 °C (68 °F). See, for example, 40 CFR part 86, subpart C, for testing related to exhaust emission standards and 40 CFR part 600 for calculating fuel economy for light-duty motor vehicles. See the standard-setting part to determine if your vehicle is required to meet emission standards outside the normal (20 to 30) °C (68 to 86 °F) temperature range.

(b) Do not apply the humidity correction factor in §1066.630(a) for cold-temperature testing.

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Subpart I—Exhaust Emission Test Procedures for Motor Vehicles

§1066.801 Applicability and general provisions.

This subpart I specifies how to apply the test procedures of this part for motor vehicles at or below 14,000 pounds GVWR, including light-duty vehicles, light-duty trucks, and heavy-duty vehicles at or below 14,000 pounds GVWR that are subject to chassis testing for exhaust emissions.

(a) Use the procedures detailed in this subpart to measure vehicle emissions over a specified drive schedule in conjunction with subpart E of this part. Where the procedures of subpart E of this part differ from this subpart I, the provisions in this subpart I take precedence.

(b) Collect samples of every pollutant for which an emission standard applies, unless specified otherwise.

(c) This subpart covers the following test procedures:

(1) General driving represented by the Federal Test Procedure (FTP). This procedure is also used for measuring evaporative emissions. This may be called the conventional test since it was first adopted for the earliest emission standards.

(i) The FTP driving schedule consists of one Urban Dynamometer Driving Schedule (UDDS) as specified in paragraph (a) of Appendix I of 40 CFR part 86, followed by a 10-minute soak with the engine off and repeat driving through the first 505 seconds of the UDDS. The UDDS represents about 7.5 miles of driving in an urban area. FTP measurements consist of a cold-start test and a hot-start test. Engine startup (with all accessories turned off), operation over the initial UDDS, and engine shutdown make a complete cold-start test. The hot-start test consists of the first 505 seconds of the UDDS following the 10-minute soak and a hot-running portion of the UDDS after the first 505 seconds. The hot-running portion is generally measured during the cold-start test; however, in certain cases, the hot-start test may involve a second full UDDS following the 10-minute soak.

(ii) Evaporative testing consists of a preconditioning drive with the UDDS and the FTP driving schedule (including exhaust measurement). The running loss test consists of a UDDS, then two New York City Cycles as specified in paragraph (f) of Appendix I of 40 CFR part 86, followed by another UDDS. The New York City Cycle represents about 1.7 miles of driving in a city center.

(iii) Refueling emission tests consist of preconditioning and purge drives using UDDS and FTP cycles as described in 40 CFR 86.146 through 86.154.

(2) Supplemental testing that involves more aggressive driving. This includes driving over the US06 test cycle. This additional driving is an essential element of the Supplemental Federal Test Procedure (SFTP). SFTP testing consists of additional driving over the US06 driving schedule and the SC03 driving schedule specified in paragraphs (g) and (h) of Appendix I of 40 CFR part 86, respectively. In the case of heavy-duty vehicles above 10,000 pounds GVWR and at or below 14,000 pounds GVWR, SFTP testing involves additional driving over the LA-92 driving schedule instead of the US06 driving schedule. See §§1066.830 through 1066.833. The US06 cycle represents about 8.0 miles of relatively aggressive driving. The SC03 cycle represents about 3.6 miles of urban driving with the air conditioner operating. The LA-92 cycle represents approximately __ miles of relatively aggressive driving for commercial trucks.

Comment [CAL18]: Alan, here is my start. This is now 801 combined with 803.

Comment [CAL19]: Global search for 1066.803 and replace with 1066.801.

Comment [CAL20]: This is really just a list of test cycles. We should take a more descriptive approach, which would help to establish the significance/ relevance of the different cycles. Paragraph (2) should probably focus on SFTP rather than just the US06 cycle.
Also, don't forget the LA-92 cycle for Class 3 HDVs

(3) SC03.
(4) AC17.
(5) HFET.
(6) AC idle.
(7) LA-92.

Comment [CAL21]: Not required after 2016. Therefore do not include in 1066. Delete 1066.838.

(d) Starting in model year 2022, speed tolerances and cycle-validation criteria apply as specified in 40 CFR part 1066, subpart E; however, for road load power determination in §1066.810, vehicle preconditioning, fuel dispensing spitback in 40 CFR 86.146, and canister purging in 40 CFR 86.153-98(d), the upper and lower speed tolerances are ±2.0 m/s (±4 mph). Up to three additional occurrences of speed variations greater than the tolerance are acceptable for road load power determination in §1066.810 and canister purging in 40 CFR 86.153-98(d), provided they occur for less than 15 seconds on any occasion, and are clearly documented as to the time and speed at that point of the driving schedule.

§1066.810 Road load power, test weight, and inertia weight class determination.

(a) Simulate a vehicle's test weight on the dynamometer using the appropriate equivalent test weight shown in Table 1 of this section. Equivalent test weights are established according to each vehicle's test weight basis, as described in paragraph (b) of this section. Table 1 also specifies the inertia weight class corresponding to each equivalent test weight; the inertia weight class allows for grouping vehicles with a range of equivalent test weights. Table 1 follows:

Table 1 of §1066.810–Equivalent test weights (pounds)

Test weight basis	Equivalent test weight	Inertia weight class
Up to 1062	1000	1000
1063 to 1187	1125	1000
1188 to 1312	1250	1250
1313 to 1437	1375	1250
1438 to 1562	1500	1500
1563 to 1687	1625	1500
1688 to 1812	1750	1750
1813 to 1937	1875	1750
1938 to 2062	2000	2000
2063 to 2187	2125	2000
2188 to 2312	2250	2250
2313 to 2437	2375	2250
2438 to 2562	2500	2500
2563 to 2687	2625	2500
2688 to 2812	2750	2750
2813 to 2937	2875	2750
2938 to 3062	3000	3000
3063 to 3187	3125	3000

3188 to 3312	3250	3000
3313 to 3437	3375	3500
3438 to 3562	3500	3500
3563 to 3687	3625	3500
3688 to 3812	3750	3500
3813 to 3937	3875	4000
3938 to 4125	4000	4000
4126 to 4375	4250	4000
4376 to 4625	4500	4500
4626 to 4875	4750	4500
4876 to 5125	5000	5000
5126 to 5375	5250	5000
5376 to 5750	5500	5500
5751 to 6250	6000	6000
6251 to 6750	6500	6500
6751 to 7250	7000	7000
7251 to 7750	7500	7500
7751 to 8250	8000	8000
8251 to 8750	8500	8500
8751 to 9250	9000	9000
9251 to 9750	9500	9500
9751 to 10250	10000	10000
10251 to 10750	10500	10500
10751 to 11250	11000	11000
11251 to 11750	11500	11500
11751 to 12250	12000	12000
12251 to 12750	12500	12500
12751 to 13250	13000	13000
13251 to 13750	13500	13500
13751 to 14000	14000	14000

(b) The test weight basis for establishing equivalent test weight is loaded vehicle weight, as defined in 40 CFR 86.1803, with the following exceptions:
(1) For heavy light-duty trucks (LDT3 and LDT4), test weight basis is adjusted loaded vehicle weight for emission tests and loaded vehicle weight for fuel economy tests. Manufacturers may choose instead to perform fuel economy tests at adjusted loaded vehicle weight. Weight terms are defined in 40 CFR 86.1803.
(2) For MDPVs and heavy-duty vehicles, test weight basis is adjusted loaded vehicle weight.
(c) For each test vehicle subject to SFTP standards, determine road load forces at speeds between 10 and 70 miles per hour. The road load force must represent vehicle operation on a smooth level road during with no wind or calm winds, no precipitation, an ambient

Comment [CAL22]: How does this relate to the road load procedure for FTP testing? ASK CHRIS NEVERS if there is a difference.

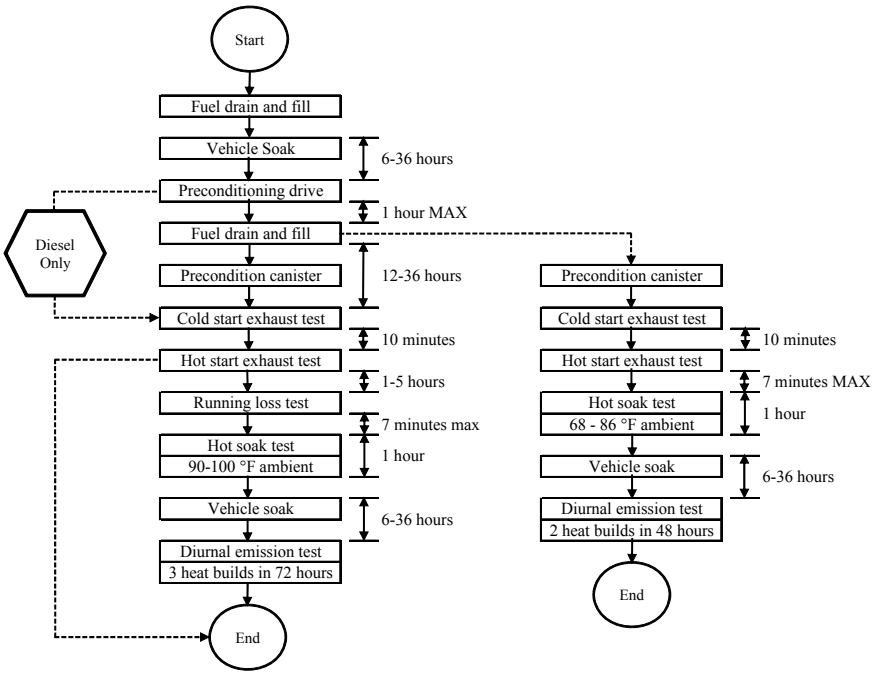
temperature of approximately 20 °C (68 °F), and atmospheric pressure of at least 98.21 kPa. You may extrapolate road load force for speeds below 10 mph.
(d) We may approve an alternate test cycle and cycle-validation criteria for vehicles that do not have enough power to follow the specified driving trace. The alternate driving specifications must be based on making best efforts to maintain acceleration and speed to follow the specified test cycle. We must approve these alternate driving specifications before you perform this testing.

§1066.812 Test sequence; general requirements.
(a) The following provisions apply for all testing:
(1) Ambient temperatures encountered by the test vehicle must be (20 to 30) °C, unless otherwise specified. For vehicle soaking steps, the soak period may be interrupted once for up to 10 minutes to transport the vehicle from one soak area to another, as long as the ambient temperature experienced by the vehicle is never below 20 °C. The temperatures monitored during testing must be representative of those experienced by the test vehicle.
(2) Use good engineering judgment to ensure that the vehicle remains approximately level throughout testing to prevent abnormal fuel distribution.
(3) If a test is void after collecting emission data from previous test segments, the test may be repeated to collect only those data points needed to complete emission measurements. You may combine emission measurements from different test runs to demonstrate compliance with emission standards.
(b) FTP testing consists of a sequence of steps for measuring both exhaust and evaporative emissions. Evaporative testing involves both a two-day test sequence and a three-day test sequence as shown in Figure 1 of this section. For vehicles with no evaporative canister, this defaults to a single test sequence for measuring FTP exhaust emissions. Evaporative test procedures are described in detail in 40 CFR part 86, subpart B.
(c) Test procedures for onboard refueling vapor recovery are described in 40 CFR 86.150 through 86.157. This testing is also integral with the FTP test sequence. Fuel spitback testing is conducted as a stand-alone test as described in 40 CFR 86.146.
(d) SFTP testing is performed as described in §§1066.830 through 1066.832. This testing may be performed in any sequence that follows the preconditioning protocol described in §1066.816.

Figure 1 of §1066.812–Federal test procedure test sequence.

Comment [CAL23]: ?

Comment [CAL24]: Alan, please rearrange this paragraph.



§1066.814 Vehicle preparation.

(a) For vehicles subject to running loss testing, prepare the fuel tank(s) for recording the temperature of the test fuel, as described in 40 CFR 86.107–98(e).

(b) Provide additional fittings and adapters, as required, to accommodate a fuel drain at the lowest point possible in the tank(s) as installed on the vehicle.

(c) For preconditioning that involves loading evaporative emission canisterwith butane, provide valving or other means as necessary to allow purging and loading of the canister.

(d) For vehicles to be tested for running loss emissions, prepare the fuel tankfor measuring and recording the temperature and pressure of the fuel tank as specified in 40 CFR 86.107–98(e) and (f). Vapor temperature measurement is optional during the running loss test. If vapor temperature is not measured, fuel tank pressure need not be measured.

(e) For vehicles to be tested for running loss emissions, prepare the exhaust system by sealing or plugging all detectable sources of exhaust gas leaks. Inspect or test the exhaust system to ensure that no detectable exhaust hydrocarbons are emitted into the running loss enclosure during testing.

(f) The following provisions apply for preconditioning steps to reduce nonfuel emissions to normal vehicle background levels for vehicles subject to Tier 3 evaporative emission standards under 40 CFR 86.1813:

(1) Manufacturers must notify us in advance if they plan to perform such preconditioning. This notice must include a detailed description of the intended procedures and any

measurements or thresholds for determining when stabilization is complete. Manufacturers need not repeat this notification for additional vehicle testing in the same or later model years as long as the preconditioning practice conforms to these procedures.
(2) Manufacturers may precondition a vehicle as described in paragraph (g)(1) of this section only within 12 months after the vehicle's original date of manufacture, except they may remove the spare tire for any testing.

§1066.820 Exhaust emission test procedures for FTP testing.
(a) General. The dynamometer run consists a cold start testing and hot start testing. Cold start testing begins after a 12 to 36 hour soak according to the provisions of 40 CFR 86.132. Hot start testing begins 10 minutes after the end of the cold start UDDS. .
(b) PM sampling options. You may collect PM using any of the procedures specified in paragraphs (b)(1) through (4) of this section, taking into account the FTP composite emission calculations in §1066.822, instead of collecting a separate PM sample for each phase of the FTP. In all cases, testing must meet the requirements related to filter face velocity as described in 40 CFR 1065.170(c)(1)(vi).
(1) You may collect PM on a single filter over the cold start UDDS and the first 505 seconds of the hot start UDDS. If you choose this option, you must adjust your sampling system flow rate to weight the filter face velocity over the three phases of the FTP, based on weighting targets of 0.43 for bag 1, 1.0 for bag 2, and 0.57 for bag 3.
(2) You may collect PM on a single filter over the cold start UDDS and the full hot start UDDS. If you choose this option, you must adjust your sampling system flow rate to weight the filter face velocity, based on weighting targets of 0.754 for the cold start UDDS and 1.0 for the hot start UDDS.
(3) You may collect PM on one filter over the cold start UDDS and on a separate filter over the hot start UDDS.
(4) You may collect PM on one filter over the cold start UDDS (bags 1 and 2) and on a separate filter over the 867 seconds of the stabilized portion of the cold start UDDS and the first 505 seconds of the hot start UDDS (bags 2 and 3) Note that this option involves duplicate measurements during the stabilized portion of the cold start UDDS.
(c) Test sequence. Perform FTP testing in the following sequence:
(1) Start sampling and recording simultaneously with starting the vehicle.
(2) Fifteen seconds after the engine starts, place the transmission in gear.
(3) Twenty seconds after the engine starts, begin the initial vehicle acceleration of the driving schedule.
(4) Operate the vehicle over the remainder of the UDDS as described in §1066.801.
(5) At the end of the deceleration scheduled to occur 505 seconds into the cold start UDDS, simultaneously switch all the sample flows from the cold start transient phase to the stabilized phase, stopping all cold start transient phase sampling and recording, including background sampling. Reset integrating devices for the stabilized phase and indicate the end of the cold start phase in the recorded data.
(6) Turn the engine off 2 seconds after the end of the last deceleration in the stabilized phase (1,369 seconds after the start of the test cycle).
(7) Five seconds after the engine stops running, stop all stabilized phase sampling and recording, including background sampling, stop integrating devices for the stabilized phase, and indicate the end of the stabilized phase in the recorded data.

(8) Take the following steps for the hot start test:
(i) Repeat the steps in paragraphs (c)(1) through (3) of this section. Operate the vehicle over the first 505 seconds of the UDDS as described in §1066.803. Begin hot start testing (9 to 11) minutes after the end of the sample period for the cold start UDDS.
(ii) At the end of the deceleration scheduled to occur 505 seconds into the hot start UDDS, turn off the engine and simultaneously stop all hot start sampling and recording, including background sampling, and integrating devices. As described in §1066.822, hot start testing may in some cases involve driving over the full UDDS as for cold start testing.
(9) This completes the procedures for measuring FTP exhaust emissions. See 40 CFR part 86, subpart B, to continue measurement procedures for evaporative or refueling tests.

§1066.822 FTP exhaust emission composite calculations.
(a) Determine the mass of exhaust emissions of each pollutant for each phase of FTP testing as described in §1066.610.
(b) Calculate the final reported test results as a mass-weighted value, $e_{[\text{emission}]\text{-FTPcomp}}$, in grams/mile using the following equation:

$$e_{[\text{emission}]\text{-FTPcomp}} = 0.43 \cdot \left(\frac{m_c}{D_{ct} + D_{cs}} \right) + 0.57 \cdot \left(\frac{m_h}{D_{ht} + D_{hs}} \right) \quad \text{Eq. 1066.822-1}$$

Where:
m_c = the combined mass emissions determined from the cold start UDDS (generally known as bags 1 and 2), in grams.
D_{ct} = the measured driving distance from the transient portion of the cold start test (bag 1), in miles.
D_{cs} = the measured driving distance from the stabilized portion of the cold start test (bag 2), as applicable, in miles.
m_h = the combined mass emissions determined from the hot start UDDS in grams. This is the hot stabilized portion from either the first or second UDDS, if applicable (bag 2 or bag 4), in addition to the hot transient portion (bag 3). See paragraph (d) of this section for special provisions that apply for PM measurement.
D_{ht} = the measured driving distance from the transient portion of the hot start test (bag 3), in miles.
D_{hs} = the measured driving distance from the stabilized portion of the hot start test (bag 4), as applicable, in miles. Set $D_{hs} = D_{cs}$ for testing where the hot stabilized portion of the UDDS is not run.
(c) For all pollutants, mass emissions for the cold start UDDS may alternatively be collected separately for the cold start transient portion and the cold stabilized portion, then added together for a single cold start mass, m_c. Similarly, mass emissions for the hot start UDDS may alternatively be collected separately for the hot start transient portion, then added together with the cold stabilized portion or hot stabilized portion for a single hot start mass, m_h.
(d) Calculate the final reported test results for PM as a mass-weighted value, $e_{\text{PM-FTPcomp}}$, in grams/mile as follows:
(1) Use the following equation for PM measured as described in §1066.820(b)(1):

$$e_{\text{PM-FTPcomp}} = \frac{m_{\text{PM}}}{(0.43 \cdot D_{\text{ct}}) + D_{\text{cs}} + (0.57 \cdot D_{\text{ht}})}$$

Eq. 1066.822-2

Where:
m_{PM} = PM mass emissions determined from the test consisting of the cold start UDDS and the first 505 seconds of the hot-start UDDS (bags 1, 2, and 3), in grams per test phase, as calculated using Eq. 1066.610-3.
(2) Use the following equation for PM measured as described in §1066.820(b)(2):

$$e_{\text{PM-FTPcomp}} = \frac{m_{\text{PM}}}{0.43 \cdot (D_{\text{ct}} + D_{\text{cs}}) + 0.57 \cdot (D_{\text{ht}} + D_{\text{hs}})}$$

Eq. 1066.822-3

Where:
m_{PM} = PM mass emissions determined from the test consisting of the cold start UDDS and the hot start UDDS (bags 1, 2, 3, and 4), in grams per test phase, as calculated using Eq. 1066.610-4.
(3) Use the following equation for PM measured as described in §1066.820(b)(3):

$$e_{\text{PM-FTPcomp}} = 0.43 \cdot \left(\frac{m_{\text{PM-cUDDS}}}{D_{\text{ct}} + D_{\text{cs}}} \right) + 0.57 \cdot \left(\frac{m_{\text{PM-hUDDS}}}{D_{\text{ht}} + D_{\text{hs}}} \right)$$

Eq. 1066.822-4

Where:
$m_{\text{PM-cUDDS}}$ = PM mass emissions determined from the test consisting of the cold start UDDS (bags 1 and 2), in grams per test phase, as calculated using Eq. 1066.610-2.
$m_{\text{PM-hUDDS}}$ = PM mass emissions determined from the test consisting of the hot start UDDS (bags 3 and 4), in grams per test phase, as calculated using Eq. 1066.610-2.
(4) For PM measured as described in §1066.820(b)(4), calculate PM emissions as described in paragraph (d)(3) of this section, except that $m_{\text{PM-hUDDS}}$ is the PM mass emissions determined from the stabilized portion of the cold start UDDS and the first 505 seconds of the hot start UDDS (bags 2 and 3).

§1066.830 Supplemental Federal Test Procedures; overview.

Comment [CAL25]: Global search for US06 and replace with "aggressive driving".

The procedures described in §§1066.831 through 1066.834 describe the Supplemental Federal Test Procedure (SFTP). This testing applies for all vehicles subject to the SFTP standards in 40 CFR part 86, subpart S. The SFTP test procedure consists of two separable test elements: A sequence of vehicle operation with more aggressive driving ; and a sequence of vehicle operation that includes the impact of the vehicle's air conditioner.
(a) Collect samples of every pollutant for which an emission standard applies, unless specified otherwise.
(b) The aggressive-driving procedure consists of preconditioning the engine to a hot stabilized condition, after which the vehicle starts operating over the test cycle. For most

vehicles, the US06 test cycle applies. Some heavy-duty vehicles operate over a subset of the US06 test cycle, or over the LA-92 test cycle.
(c) The SC03 test procedure in §1066.832 is designed to determine gaseous exhaust emissions while simulating an urban trip on a hot summer day. The full test consists of an engine key-off for 10 minutes following the preconditioning steps, an engine start, and operation over the SC03 test cycle. The provisions of 40 CFR part 86, subpart B, and 40 CFR part 600 waive SC03 testing for some vehicles; in those cases, SFTP composite emissions are calculated by adjusting the weighting calculation.
(d) The SFTP standard applies as a composite representing the constituent test cycles. The emission results from the aggressive driving test element (§1066.831), the air conditioning test element (§1066.832), and the FTP test element (§1066.812 (a) through (d) and (f)) are analyzed according to the calculation methodology in §1066.837 and compared to the applicable SFTP emission standards in 40 CFR part 86, subpart S.
(e) The SFTP elements may be run in any sequence that maintains the applicable preconditioning steps specified in §86.816.

§1066.830.5 SFTP vehicle preconditioning.
SFTP testing consists of three elements. Precondition and test vehicles as described in §1066.814 for the FTP test element. Take the following steps to precondition vehicles for the aggressive driving and air conditioning test elements:
(a) Drain and refill the vehicle's fuel tank(s) in any of the following cases:
(1) For testing unrelated to FTP or HFET testing.
(2) For a test element that starts more than 72 hours after the most recent FTP or HFET measurement (with or without evaporative emission measurements).
(3) For testing in which the test vehicle has not remained in an area where ambient temperatures were within the range specified for testing since the previous FTP or highway fuel economy test.
(b) Take the following steps to precondition vehicles before the aggressive driving test element:
(1) Keep ambient temperatures within the ranges specified for test measurements throughout the preconditioning sequence.
(2) Push or drive the test vehicle onto the dynamometer.
(3) Operate the test vehicle as needed to prepare it for testing and to perform practice runs (for the driver or for sampling equipment). For our testing, we will generally operate the vehicle over the same cycle that will be used for testing in §86.831. You may ask us to perform vehicle preconditioning in a certain way to address fuel effects on adaptive memory systems or other factors. Do not measure emissions during the preconditioning drive.
(3) Operate the test vehicle one time over one of the driving schedules specified in this paragraph (b)(3). You may ask us to use a particular preconditioning driving schedule if that is related to fuel effects on adaptive memory systems. Choose from the following driving schedules:
(i) The first 505 seconds of the UDDS (generally known as bag 1)
(ii) The last 866 seconds of the UDDS (generally known as bag 2).
(iii) The highway fuel economy test cycle.

Comment [CAL26]: This needs to stay with the rest of the SFTP procedures.

Comment [CAL27]: Not sure this is worth keeping. The canister state shouldn't be that important.

(iv) US06 cycle or, for heavy-duty vehicles above 10,000 pounds GVWR, just the highway portion of the US06 cycle.
(v) The SC03 test cycle.
(vi) The LA-92 test cycle.
(4) Allow the vehicle to idle for (1 to 2) minutes. This leads directly into the test measurements described in §1066.831.
(c) Take the following steps to precondition vehicles before the air conditioning test element:
(1) Keep the vehicle in an environment meeting the conditions described in §1066.833 throughout the preconditioning sequence.
(2) Push or drive the test vehicle onto the dynamometer.
(3) Operate the test vehicle one time over the first 505 seconds of the UDDS (bag 1), the last 867 seconds of the UDDS (bag 2), or the SC03 test cycle. If the air conditioning test sequence starts more than 2 hours after a different exhaust emission test, you may instead operate the vehicle over the full UDDS.
(4) Following the preconditioning drive, turn off the test vehicle and the vehicle cooling fan(s) and allow the vehicle to soak for (9 to 11) minutes. This leads directly into the test measurements described in §1066.832.

§1066.831 Exhaust emission test procedures for aggressive driving.
(a) Perform testing as described in this section using the US06 cycle described in paragraph (g) of 40 CFR part 86, appendix I or the LA-92 cycle as specified in paragraph (c) of 40 CFR part 86, appendix I. The US06 cycle can be divided into two test phases—the US06 City cycle comprises the portion of the cycle from 1 to 130 seconds and from 495 to 596 seconds, and the US06 Highway cycle comprises the portion of the cycle between 130 and 495 seconds. Collect samples of every pollutant for which an emission standard applies, unless specified otherwise.
(b) For testing based on the full US06 cycle, you may collect emissions as a single test phase, or you may collect emissions from city and highway test phases separately (see 40 CFR part 600). Take the following steps for separate city and highway measurements:
(1) At 130 seconds, simultaneously stop all "US06 City", and start all "US06 Highway" sampling, recording, and integrating (including background sampling). At 136 seconds (before the acceleration), record the measured dynamometer roll revolutions.
(2) At 495 seconds, simultaneously stop all "US06 Highway", and start all "US06 City" sampling, recording, and integrating (including background sampling). At 500 seconds (before the acceleration), record the measured dynamometer roll revolutions.
(3) Except as specified in paragraph (c)(4) of this section, treat the emissions from the two discrete portions of city driving as a single sample.
(4) If you collect gaseous emissions over two test phases, you may collect PM as a single test phase over the full US06. If you do, then calculate a composite dilution factor based on city and highway emissions to show that you meet the dilution requirements of §1066.110(b)(2)(iii)(B).
(c) For diesel fueled vehicles, measure THC emissions on a continuous basis as described in 40 CFR part 1065. For separate city and highway measurements as described in paragraph (c) of this section, perform separate calculations for each portion of the test cycle.

Comment [CAL28]: Make sure each test cycle is defined.

(d) The provisions of §§1066.410 through 1066.430 apply, subject to the following exceptions and additional provisions:
(1) Following the preconditioning specified in §1066.830, place the vehicle in gear and simultaneously start sampling and recording. Begin the first acceleration 5 seconds after placing the vehicle in gear.
(2) Operate the vehicle over one of the following test cycles:
(i) For heavy-duty vehicles above 10,000 pounds GVWR, operate the vehicle over the LA-92 driving schedule as specified in paragraph (c) of 40 CFR part 86, appendix I.
(ii) Heavy-duty vehicles above 8,500 pounds GVWR and at or below 10,000 pounds GVWR may be certified using only the highway portion of the US06 driving schedule. See 40 CFR 86.1816.
(iii) In all other cases, operate the vehicle over the full US06 driving schedule.
(3) Turn the engine off 2 seconds before the end of the driving schedule. Five seconds after the engine stops running, stop all sampling and recording (including background) and stop integrating devices, indicating the end of the test cycle in the recorded data.
(4) Correct calculated NO_x emissions tests as described in §1066.630(a)(1).

§1066.832 Exhaust emission test procedure for SC03 emissions.
(a) Perform testing as described in this section using the SC03 cycle as described in appendix I, paragraph (h), of 40 CFR part 86. Precondition the vehicle in accordance with §1066.816 of this subpart to bring the vehicle to a warmed-up stabilized condition. Section 1066.833 discusses the minimum facility requirements and corresponding control tolerances for air conditioning ambient test conditions.
(b) The provisions of §§1066.410 through 1066.430 apply, subject to the following exceptions and additional provisions:
(1) You may position additional cooling fans to provide sufficient air for vehicle cooling if the vehicle has a rear-mounted engine or if the fan configuration described in §1066.410(b)(1)(iv) is simply not adequate. The additional cooling fans may have a total capacity up to 2.50 m^3/s; however, you may ask us to approve a greater fan capacity under 40 CFR 1065.10(c)(1) by demonstrating that the greater airflow represents in-use operation in a way that has a meaningful effect on emissions.
(2) Close all vehicle's windows before testing.
(3) Keep the vehicle in an environment meeting the conditions described in §1066.833 throughout testing.
(4) Set the vehicle's air conditioning controls by selecting A/C mode and "maximum", setting airflow to "recirculate" (if so equipped), selecting the highest fan setting, and turning the A/C Temperature to full cool (or 72 °F for automatic systems). Turn the controls to the "on" position before testing so the air conditioning system is active whenever the engine is running.
(5) Initiate data logging, sampling of exhaust gases, and integrating measured values before starting the engine.
(6) Simultaneously start the engine and initiate the driver's trace. Place the vehicle in gear 15 seconds after the engine starts to prepare for the initial acceleration. Follow the SC03 driving schedule.

Comment [CAL29]: Review AC setting nomenclature.

(7) Turn the engine off 2 seconds before the end of the driving schedule. Five seconds after the engine stops running, stop all sampling and recording (including background) and stop integrating devices, indicating the end of the test cycle in the recorded data.
(8) Correct calculated NO_x emissions as described in §1066.630(a)(2).

1066.833 Test facility requirements for the air conditioning test element.
This section describes how to create an environment that simulates a hot summer day for testing how a vehicle's emission controls function under higher temperatures with a full air conditioning load. The air conditioning test is one element of the SFTP, as described in §86.830.
(a) Ambient air temperature. Measure and record ambient air temperature in the test cell at least once every 30 seconds during the sampling period. Control ambient air temperature during the test to a tolerance of 95 ±5 °F throughout the test and (93 to 97) °F on average. Use good engineering judgment to demonstrate that you meet the specified temperature tolerance throughout the preconditioning sequence.
(b) Ambient humidity. Measure and record ambient humidity in the test cell at least once every 30 seconds during the sampling period. Control ambient air temperature during the test as described in §1066.425(d) throughout the preconditioning and testing sequence. Use good engineering judgment to measure ambient humidity during the preconditioning sequence.
(c) Minimum test cell size. The test cell must be at least 20 feet wide, 40 feet long, and 10 feet high, unless we approve the use of a smaller test cell. We will approve this only if you demonstrate that the smaller test cell is capable of meeting all the requirements of this section.
(d) Solar heat loading. Simulate solar heating as follows:
(1) You may use a metal halide lamp, a sodium lamp, or a quartz halogen lamp with dichroic mirrors as a radiant energy emitter. We may also approve the use of a different type of radiant energy emitter if you demonstrate that it meets the requirements of this section.
(2) We recommend achieving radiant heating with spectral distribution characteristics as described in the following table:

Comment [CAL30]: EPA proposes deleting this paragraph.

Table 1 of §1066.833–Recommended Spectral Distribution

Band width (nm)	Percent of total spectrum	
	Lower limit (%)	Upper limit (%)
<320[a]	—	0
320–400	0	7
400–780	45	55
>780	35	53

[a]Filter the UV region between 280 and 320 nm.

(3) Determine radiant energy intensity experienced by the vehicle as the average value between two measurements along the vehicle's centerline, one at the base of the windshield and the other bottom of the rear window (or equivalent location for vehicles

without a rear window). This value must be 850 ±45 W/m^2. Instruments for measuring radiant energy intensity must meet the following minimum specifications:
(A) Sensitivity of 9 microvolts per watt/m^2.
(B) Response time of 1 second.
(C) Linearity of ± 0.5 %.
(D) Cosine of ± 1 % from normalization 0–70 degree zenith angle.
(4) Check radiant energy uniformity at least every 500 hours of emitter usage or every 6 months, whichever is shorter, and after any major modifications affecting the solar simulation. Measure the radiant energy uniformity at each point of a 0.5 m grid over the vehicle's full footprint, including the edges of the footprint, at an elevation 1 m above the floor. Radiant energy uniformity must be 850 ±128 W/m^2 at all points.
(e) Vehicle frontal air flow. You may use "blower in box" technology for frontal air flow as long as the system meets the requirements of §1066.410(b)(1)(iv). Verify that the test configuration meets the requirements of §1066.410(b)(1)(iv) before each test.

§1066.835 AC17 air conditioning efficiency test procedure.
(a) Overview. Dynamometer operation over this test procedure consists of four elements: a pre-conditioning cycle, a 30-minute soak period under simulated solar heat, an SC03 drive cycle, and a Highway Fuel Economy Test (HFET) drive cycle. The vehicle is preconditioned with the UDDS to bring the vehicle to a warmed-up stabilized condition. This preconditioning is followed by a 30 minute vehicle soak (engine off) that proceeds directly into the SC03 driving schedule, during which continuous proportional samples of gaseous emissions are collected for analysis. The SC03 driving schedule is followed immediately by the HFET cycle, during which continuous proportional samples of gaseous emissions are collected for analysis. The entire test, including the preconditioning driving, vehicle soak, and SC03 and HFET official test cycles, is conducted in an environmental test facility as specified in 1066.833. The environmental test facility must be capable of providing the following nominal ambient test conditions of: 77 °F air temperature, 50 % relative humidity, a solar heat load intensity of 850 W/m^2, and vehicle cooling air flow proportional to vehicle speed. Section 1066.833 discusses the minimum facility requirements and corresponding control tolerances for air conditioning ambient test conditions. The entire test sequence is run twice; with and without the vehicle's air conditioner operating during the SC03 and HFET test cycles. For gasoline-fueled Otto-cycle vehicles, the composite samples collected in bags are analyzed for THC, CO, CO_2, and CH_4. For diesel cycle vehicles, THC emissions are measured on a continuous basis according to 40 CFR part 1065.
(b) Dynamometer inertia settings. (1) Determine required AC17 dynamometer inertia weight class selections by the test vehicle's test weight basis and corresponding equivalent weight as listed in Table 1 of §1066.810 and discussed in §1066.810(b) and (c).
(2) Set the dynamometer test inertia weight and roadload horsepower requirements for the test vehicle according to §1066.810(b) and (c). Set the dynamometer's horsepower adjustment settings such that the force imposed during dynamometer operation matches actual road load force at all speeds.
(c) Test cell ambient conditions. (1) Ambient air temperature. (i) Control ambient air temperature in the test cell during all emission sampling phases of the AC17 test

Comment [CAL31]: Alan, rewrite this paragraph.

Comment [CAL32]: What is the intent of this sentence. EPA proposes deleting this.

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¶
Figure 1 of §1066.835–AC17 sequence of ev... [3]

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sequence to 77 ±2 °F on average and 77 ±5 °F as an instantaneous measurement. During non-emission sampling phases, you must still meet these tolerances, although you may have periods outside of the tolerances that do not exceed a cumulative total of 3 minutes.
(ii) Record the air temperature continuously at a minimum of 30 second intervals. Alternatively, you may use a moving average over a minimum of 30 second intervals to record and report air temperature. You must maintain records of test cell air temperatures and values of average test temperatures for all certification related programs.
(2) Ambient humidity. (i) Control ambient humidity in the test cell during all emission sampling phases of the AC17 test sequence as described in §1066.425(d)(2). During non-emission sampling phases, you must still meet these tolerances, although you may have periods outside of the tolerances that do not exceed a cumulative total of 3 minutes.
(ii) Record the humidity continuously at a minimum of 30 second intervals. You must maintain records of test cell humidity and values of average test humidity for all certification related programs.
(3) Solar heat loading. The requirements of §1066.833(d) regarding solar heat loading specifications apply. The solar load of 850 W/m^2 is applied only during specified portions of the test sequence.
(4) Minimum test cell size. The requirements of §1066.833(c) regarding test cell size requirements apply.
(5) Test cell air flow requirements. The requirements of §1066.833(e) regarding air flow supplied to the vehicle apply. Air flow at a maximum of 4 mph may be provided during periods of idle and key-off soak if required for maintenance of ambient requirements.
(d) Interior temperature measurement. Measure the interior temperature of the vehicle during the emission sampling phases of the test(s).
(1) Interior temperatures shall be measured by placement of thermocouples at the following locations:
(i) The outlet of the center duct on the dash.
(ii) Behind the driver and passenger seat headrests. Location of the temperature measuring devices approximately 30 mm behind each headrest.
(2) The temperature at each location shall be recorded a minimum of every 5 seconds.
(e) Air conditioning system settings. For the portion of the test where the air conditioner is required to be operating the settings shall be as follows:
(1) Automatic systems shall be set to automatic and the temperature control set to 72 °F, with blower or fan speed and vent location controlled by the automatic mode.
(2) Manual systems shall be set at the start of the SC03 drive cycle to full cool with the fan on the highest setting and the airflow setting to "recirculation." Within the first idle period of the SC03 drive cycle (186 to 204 seconds) the fan speed shall be reduced to the setting closest to 6 volts at the motor, the temperature setting shall be adjusted to provide nominally 55 °F at the center dash air outlet, and the airflow setting changed to "outside air."
(f) Test procedure. The following steps shall be taken for the AC17 test in place of the procedures in §§1066.410, 1066.420, 1066.425, and 1066.430:
(1) Prepare the vehicle for testing according to 40 CFR 86.132, paragraphs (a) through (g), concluding with a 12-36 hour soak.
(2) See §1066.833(e) for a discussion of cooling fan specifications. In addition to the cooling fan requirements of §1066.410(b)(1)(iv), for cases where vehicles have rear

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engine compartments (or if this front location provides inadequate engine cooling), an additional cooling fan shall be placed in a position to provide sufficient air to maintain vehicle cooling. The fan capacity shall normally not exceed 5300 cfm (2.50 m^3/s). If, however, it can be demonstrated that during road operation the vehicle receives additional cooling, and that such additional cooling is needed to provide a representative test, the fan capacity may be increased or additional fans used if approved using the provisions in 40 CFR 1065.10.

(3) Open all vehicle windows.

(4) Set the environmental test cell ambient test conditions to the conditions defined in paragraph (c) of this section, except that the solar heat shall be off.

(5) Set the air conditioning system controls to off.

(6) Start the vehicle (with air conditioning system off) and conduct a preconditioning UDDS.

(7) Following the preconditioning cycle, the test vehicle and cooling fan(s) are turned off, all windows are rolled up for tests where the air conditioning system is running, and the vehicle is allowed to soak in the ambient conditions of paragraph (c)(1) of this section for 30 ±1 minutes. Use good engineering judgement to ensure the windows are sealed where instrumentation and wiring pass through to the interior. If emissions are being measured with the air conditioner operating, the solar heat system must be turned on within one minute of turning the engine off. Otherwise the solar heat system shall be turned off. The 30 minute soak starts immediately after the solar load has achieved 850 ±45 W/m^2. Facility calibration data on solar lamp warm-up can be used to establish the start of solar soak time. Total soak time encompasses the time to turn on the lamps (e.g., one minute), lamp warm-up time (from calibration data), and the 30 minute solar soak. For example if it takes one minute to turn on the lamps and the facility calibration demonstrates that the lamps reach 850 W/m^2 within two minutes, the soak time can be standardized at 33 minutes after engine off for that facility.

(8) Initiate data logging, sampling of exhaust gases, and integrating measured values before starting the engine. If emissions are being measured with the air conditioner operating, you must start the engine with the air conditioning system running as specified in paragraph (e) of this section. Otherwise the air conditioning system should be completely off.

(9) Initiate the driver's trace when the engine starts. Start the engine with the air conditioning system running. Fifteen seconds after the engine starts, place vehicle in gear.

(10) Eighteen seconds after the engine starts, begin the initial vehicle acceleration of the SC03 driving schedule.

(11) Operate the vehicle according to the SC03 driving schedule, as described in appendix I, paragraph (h), of 40 CFR part 86.

(12) Allow the engine to remain on after the end of the last deceleration (i.e., engine remains on at 594 seconds).

(13) Seven seconds after the end of the last deceleration (i.e., at 601 seconds), simultaneously stop all SC03 and start all HFET sampling, recording, and integrating; including background sampling indicating the end of the test cycle in the recorded data. Record the measured roll or shaft revolutions.

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(14) Operate the vehicle according to the HFET driving schedule, as described in appendix I of 40 CFR part 600.
(vii) Turn the engine off 2 seconds after the end of the last deceleration (i.e., engine off at 765 seconds) and simultaneously stop all HFET sampling, recording, and integrating; including background sampling, indicating the end of the test cycle.
(15) Turn off the solar heat system, if applicable.
(g) Calculations. (1) Determine the mass of exhaust emissions of each pollutant for each phase of AC17 testing as described in §1066.610.
(2) Calculate the final reported test results as a mass-weighted value, $e_{[emission]\text{-}AC17comp}$, in grams/mile using Eq. §1066.835-1. The final reported test result is the average of the SC03 and HFET gram per mile emissions.

$$e_{CO2\text{-}AC17comp} = 0.5 \cdot \left(\frac{m_{SC03}}{D_{SC03}} \right) + 0.5 \cdot \left(\frac{m_{HFET}}{D_{HFET}} \right)$$

Eq. 1066.835-1

Where:
$e_{[emission]\text{-}AC17comp}$ = Weighted mass emission of CO_2, in grams per mile.
m_{SC03} = Mass emissions determined from the SC03 test phase, in grams per test phase.
m_{HFET} = Mass emissions determined from the HFET test phase, in grams per test phase.
D_{SC03} = The measured driving distance from the SC03 test phase, in miles.
D_{HFET} = The measured driving distance from the HFET test phase, in miles.
(h) Measuring the net impact of air conditioner operation. This test may be used to determine the net impact of air conditioner operation as may be required under 40 CFR 86.1868, which requires that CO_2 be measured using the procedures in this section with both air conditioning on and off. To do this, you must follow these steps:
(1) Conduct testing using the test procedure described in this section with the air conditioning system operating, being sure to follow the appropriate instructions regarding air conditioner operation and use of the solar heat system. Analyze the data and calculate the weighted CO_2 emissions in grams per mile according to paragraph (g) of this section.
(2) Allow the vehicle to remain on the dynamometer, with the engine off, for 10 to 15 minutes after emissions sampling has concluded. The solar heat system should be turned off.
(3) Conduct the test procedure described in paragraph (f) of this section with the air conditioning system turned off, being sure to follow the appropriate instructions regarding air conditioner operation (off) and use of the solar heat system (off). Analyze the data and calculate the weighted CO_2 emissions in grams per mile according to paragraph (g) of this section.
(4) Calculate the incremental CO_2 emissions due to air conditioning operation by subtracting the CO_2 grams per mile determined in paragraph (h)(3) of this section from the CO_2 grams per mile determined in paragraph (h)(1) of this section.
(j) Records required and reporting requirements. For each test, record the information specified in §1066.818. Emission results must be reported for each phase of the test. You must also report the following information for each vehicle tested: vehicle class, model type, carline, curb weight, engine displacement, transmission class and

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configuration, interior volume, climate control system type and characteristics, refrigerant used, compressor type, and evaporator/condenser characteristics.

§1066.837 Supplemental Federal Test Procedure calculations.

(a) This section provides procedures for calculating mass emission results of each regulated exhaust pollutant for the SFTP composite calculation.

(b)(1) If your test vehicle is equipped with air conditioning, calculate the final reported test results for the NMHC + NO_x SFTP composite and optional CO composite standards using Eq. §1066.837-1.

$$e_{[\text{emission}]\text{-SFTPcomp}} = 0.35 \cdot e_{[\text{emission}]\text{-FTPcomp}} + 0.37 \cdot e_{[\text{emission}]\text{-SC03}} + 0.28 \cdot e_{[\text{emission}]\text{-US06}}$$

Eq. 1066.837-1

Where:

$e_{[\text{emission}]\text{-SFTPcomp}}$ = mass-weighted value of emissions in g/mile for a particular pollutant weighted in terms of the contributions from the FTP, SC03, and US06 test schedules.

$e_{[\text{emission}]\text{-FTPcomp}}$ = mass-weighted value of emissions in g/mile for a particular pollutant over the FTP test schedule as determined in §1066.822.

$e_{[\text{emission}]\text{-SC03}}$ = mass of emissions in g/mile for a particular pollutant measured over the driving distance of the SC03 test schedule as determined in §1066.832.

$e_{[\text{emission}]\text{-US06}}$ = mass of emissions in g/mile for a particular pollutant measured over the driving distance of the US06 test schedule as determined in §1066.831. In the case where a 2-phase US06 test is run according to §1066.831(b)(7) and 40 CFR part 600, calculate the mass of emissions in g/mile, by using the summed mass emissions of the "US06 City" phase and the "US06 Highway" phase, based on the measured driving distance of the US06 test schedule.

(2) Determine composite emissions of NMHC + NO_x over the SFTP schedule, $e_{\text{NMHC+NOxSFTPcomp}}$, using Eq. §1066.837-2.

$$e_{\text{NMHC + NO}_x\text{-SFTPcomp}} = e_{\text{NMHC-SFTPcomp}} + e_{\text{NO}_x\text{-SFTPcomp}}$$

Eq. 1066.837-2

Where:

$e_{\text{NMHC-SFTPcomp}}$ = the composite emission results for NMHC over the SFTP test schedule.

$e_{\text{NOx-SFTPcomp}}$ = the composite emission results for NO_x over the SFTP test schedule.

(c)(1) If the test vehicle is not equipped with air conditioning, calculate the final reported test results for the NMHC + NO_x SFTP composite and optional CO composite standards using Eq. §1066.837-3.

$$e_{[\text{emission}]\text{-SFTPcomp}} = 0.72 \cdot e_{[\text{emission}]\text{-FTPcomp}} + 0.28 \cdot e_{[\text{emission}]\text{-US06}}$$

Eq. 1066.837-3

Where:

$e_{[\text{emission}]\text{-SFTPcomp}}$ = mass-weighted value of emissions in g/mile for a particular pollutant weighted in terms of the contributions from the FTP and US06 test schedules.

$e_{[\text{emission}]\text{-FTPcomp}}$ = mass-weighted value of emissions in g/mile for a particulate pollutant over the FTP test schedule as determined in §1066.822.

$e_{[\text{emission}]\text{-US06}}$ = mass of emissions in g/mile for a particulate pollutant measured over the driving distance of the US06 test schedule as determined in §1066.831. In the case where a 2-phase US06 test is run according to §1066.831(b)(7) and 40 CFR part 600, calculate the mass of emissions in g/mile, by using the summed mass emissions of the "US06 City"

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phase and the "US06 Highway" phase, based on the measured driving distance of the US06 test schedule.

(2) Determine composite emissions of NMHC + NO_x over the SFTP schedule, $e_{NMHC+NOx-SFTPcomp}$, using Eq. §1066.837-2.

§1066.838 Air conditioning idle test procedure.

(a) Applicability. This section describes procedures for determining air conditioning-related CO_2 emissions from light-duty vehicles, light-duty trucks, and medium-duty passenger vehicles. The results of this test are used to qualify for air conditioning efficiency CO_2 credits according to 40 CFR 86.1866–12(c).

(b) Overview. This test consists of a brief period to stabilize the vehicle at idle, followed by a ten-minute period at idle where CO_2 emissions are measured without any air conditioning systems operating, followed by a ten-minute period at idle where CO_2 emissions are measured with the air conditioning system operating. This test is designed to determine the air conditioning-related CO_2 emission value, in grams per minute.

(c) Test cell ambient conditions. (1) Control ambient humidity within the test cell during all phases of the test sequence to an average of (40 to 60) grains of H_2O/pound of dry air.

(2) Control ambient air temperature within the test cell during all phases of the test sequence to (73 to 80) °F on average and 75 ± 5 °F as an instantaneous measurement. Record air temperature continuously at a minimum of 30 second intervals.

(d) Test sequence. (1) Test the vehicle in a fully warmed-up condition. If the vehicle has soaked for two hours or less since the last exhaust test element, preconditioning may consist of a 505 Cycle, 866 Cycle, US06, or SC03, as these terms are defined in 40 CFR 86.1803–01, or a highway fuel economy test procedure, as defined in 40 CFR 600.002–08. For soak periods longer than two hours, precondition the vehicle using one full UDDS. Ensure that the vehicle has stabilized at test cell ambient conditions such that the vehicle interior temperature is not substantially different from the external test cell temperature. Windows may be opened during preconditioning to achieve this stabilization.

(2) Immediately after the preconditioning, turn off any cooling fans, if present, close the vehicle's hood, fully close all the vehicle's windows, ensure that all the vehicle's air conditioning systems are set to full off, start the CO_2 sampling system, and then idle the vehicle for not less than 1 minute and not more than 5 minutes to achieve normal and stable idle operation.

(3) Using raw or dilute sampling procedures measure and record the continuous CO_2 concentration for 600 seconds. Multiply this concentration by the continuous flow rate (raw or dilute) at the emission sampling location to determine the CO_2 flow rate. Determine the CO_2 cumulative flow rate over the test interval. This cumulative value is the total mass of CO_2 emitted.

(4) Within 60 seconds after completion of the measurement described in paragraph (d)(3) of this section, turn on the vehicle's air conditioning system. Set automatic air conditioning systems to a temperature 5 °C (9 °F) below the ambient temperature of the test cell. Set manual air conditioning systems to maximum cooling with recirculation turned off, except that recirculation shall be enabled if the air conditioning system automatically defaults to a recirculation mode when set to maximum cooling. Continue idling the vehicle while measuring and recording the continuous CO_2 concentration for

Deleted: computed by the following formulas.¶
(i) Y_{WSFTP}= 0.72(Y_{FTP})+0.28(Y_{US06})¶
Where:¶
(A) Y_{WSFTP}= Mass emissions per mile for a particular pollutant weighted in terms of the contributions from the FTP and US06 schedules. Values of Y_{WSFTP} are obtained for each of the exhaust emissions of NMHC, NO_x and CO.¶
(B) Y_{FTP}= Weighted mass emissions per mile (Ywm) based on the measured driving distance of the FTP test schedule.¶
(C)(*1*) Y_{US06}= Calculated mass emissions per mile based on the measured driving distance of the US06 test schedule; or,¶
(*2*) In the case of a 2-phase US06 test run according to the provisions of §86.159–08(f)(2) and part 600 of this chapter:¶
YUS06 = Calculated mass emissions per mile, using the summed mass emissions of the "US06 City" phase and the "US06 Highway" phase, based on the measured driving distance of the US06 test schedule. The "US06 City" phase shall be sampled during seconds 0–130 and from 495 seconds until five seconds after the engine stops running (*e.g.* 602 or 603 seconds) of the US06 driving schedule. ... [14]

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600 seconds as described in paragraph (d)(3) of this section. Air conditioning systems with automatic temperature controls are finished with the test after this 600 second idle period. Manually controlled air conditioning systems must complete one additional idle period as described in paragraph (d)(5) of this section.

(5) This paragraph (d)(5) applies only to manually controlled air conditioning systems. Within 60 seconds after completing the measurement described in paragraph (d)(4) of this section, leave the vehicle's air conditioning system on and set it as described in paragraph (d)(4) of this section but set the fan speed to the lowest setting that continues to provide air flow. Recirculation shall be turned off except that if the system defaults to a recirculation mode when set to maximum cooling and maintains recirculation with the low fan speed, then recirculation shall continue to be enabled. After the fan speed has been set, continue idling the vehicle while measuring and recording the continuous CO_2 concentration for a total of 600 seconds as described in paragraph (d)(3) of this section.

(e) Calculations. (1) For measurements made with no air conditioning operation, calculate the CO_2 emissions (in grams per minute) by dividing the total mass of CO_2 from paragraph (d)(3) of this section by 10.0 (the duration in minutes for which CO_2 is measured). Round this result to the nearest tenth of a gram per minute.

(2)(i) For measurements made with the air conditioning in operation for automatic air conditioning systems, calculate the CO_2 emissions (in grams per minute) by dividing the total mass of CO_2 from paragraph (d)(4) of this section by 10.0. Round this result to the nearest tenth of a gram per minute.

(ii) For measurements made with the air conditioning in operation for manually controlled air conditioning systems, calculate the CO_2 emissions (in grams per minute) by summing the total mass of CO_2 from paragraphs (d)(4) and (d)(5) of this section and dividing by 20.0. Round this result to the nearest tenth of a gram per minute.

(3) Calculate the increased CO_2 emissions due to air conditioning (in grams per minute) by subtracting the results of paragraph (e)(1) of this section from the results of paragraph (e)(2)(i) or (ii) of this section, whichever is applicable.

(f) We may prescribe procedures other than those in this section for air conditioning systems and/or vehicles that may not be susceptible to satisfactory testing by the procedures and methods in this section. For example, we may prescribe alternative air conditioning system settings for systems with controls that are not able to meet the requirements in this section.

§1066.839 Highway fuel economy test procedure.

This section provides the test procedure for the highway fuel economy test (HFET). The HFET consists of a preconditioning highway driving sequence and a measured highway driving sequence. This test procedure, and the associated standards set forth in 40 CFR parts 600 and 86 subpart S, are applicable to light-duty vehicles and light-duty trucks.

(a) General. The HFET is designated to simulate non-metropolitan driving with an average speed of 48.6 mph and a maximum speed of 60.0 mph. The cycle is 10.2 miles long with 0.2 stops per mile and consists of warmed-up vehicle operation on a chassis dynamometer through a specified driving cycle. A proportional part of the diluted exhaust emission is collected continuously for subsequent analysis of NMOG, CO, and CO_2 using a CVS. For diesel vehicles, NMHC emissions are measured on a continuous

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basis according to 40 CFR part 1065. For determination of NMHC from THC and CH_4, CH_4 may be measured either on a continuous or batch basis.
(b) The following steps shall be taken for the HFET in place of the procedures in §§1066.410, 1066.420, 1066.425, and 1066.430.
(1) Dynamometer inertia weight class selections are determined by the test vehicles test weight basis and corresponding equivalent weight as listed in Table 1 of §1066.810 and discussed in §1066.810 (b) and (c). The test weight for a fuel economy data vehicle will be that test weight specified by the Administrator from the test weights covered by that vehicle configuration. We will base our selection of a test weight on the relative projected sales volumes of the various test weights within the vehicle configuration.
(2) The HFET is designed to be performed immediately following the FTP. When conditions allow, the tests should be scheduled in this sequence. In the event the tests cannot be scheduled within three hours of the FTP (including one hour hot soak evaporative loss test, if applicable) the vehicle should be preconditioned as described in paragraphs (b)(2)(i) or (ii) of this section.
(i) If the vehicle has experienced more than three hours of soak at (20 to 30) °C since the completion of the FTP, or has experienced periods of storage outdoors, or in environments where soak temperature is not maintained to (20 to 30) °C, the vehicle must be preconditioned by operation on a dynamometer through one cycle of the EPA Urban Dynamometer Driving Schedule, as described in §1066.820.
(ii) EPA may approve a manufacturer's request for additional preconditioning in unusual circumstances.
(3) Use the following procedure to determine highway fuel economy:
(i) The dynamometer procedure consists of two cycles of the Highway Fuel Economy Driving Schedule (§600.109–08(b)) separated by 15 seconds of idle. Precondition the vehicle by operating it over one Highway Fuel Economy driving schedule, as described in appendix I of 40 CFR part 600.
(ii) At the conclusion of the HFET preconditioning cycle, allow the vehicle to idle for 15 seconds.
(iii) Start sampling and recording, simultaneously with the start of the second Highway Fuel Economy driving schedule. Begin the first acceleration 2 seconds after placing the vehicle in gear.
(iv) If the engine is not running at the initiation of the highway fuel economy test (preconditioning cycle), the start-up procedure must be according to the manufacturer's recommended procedures.
(v) Turn the engine off 2 seconds after the end of the last deceleration (i.e., engine off at 765 seconds), stop all sampling and recording, including background sampling and stop integrating devices for the test, indicating the end of the test cycle in the recorded data.

§1066.840 Fuel storage system leak test procedure.
(a) Scope. Verify that there are no significant leaks in your fuel storage system using the leak test described in this section. Perform this check as required in the standard-setting part.
(b) Measurement principles. A leak may be detected by measuring pressure, temperature, and flow to calculate an equivalent orifice diameter for the system. Use good

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(4) The provisions of §86.128 of this chapter apply for vehicle transmission operation during highway fuel economy testing under this subpart.¶

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engineering judgment to develop and implement leak test equipment. Your leak test equipment must meet the following requirements:
(1) Pressure, temperature, and flow sensors must be calibrated with NIST-traceable standards.
(2) Correct flow measurements to standard temperature and pressure of 20 °C and 101.3 kPa.
(3) Leak test equipment must have the ability to pressurize fuel storage systems to 4.1 kPa and have an internal leak rate of less than 0.2 slpm.
(4) You must be able to attach the test equipment to the vehicle without permanent alteration of the fuel storage or evaporative emissions control systems.
(5) The point of attachment to the fuel storage system must allow pressurization to test system integrity of the fuel tank and fuel and vapor lines reaching up to and including the gas cap and the evaporative canister. An example of an effective attachment point is the evaporative emission system test port available on some vehicles.
(c) Leak test procedure. Test a vehicle's fuel storage system for leaks as follows:
(1) Fill the vehicle's fuel tank to 40 % capacity.
(2) Soak the vehicle for 6 to 24 hours at a temperature of (20 to 30) °C and maintain this temperature throughout the leak test.
(3) Before performing the test, purge the fuel storage system of any residual pressure, bringing the system into equilibration with the ambient.
(4) Seal the evaporative canister's vent to atmosphere and ensure that the system purge valve is closed.
(5) Attach the leak test equipment to the vehicle.
(6) Pressurize the fuel storage system with N_2 or another inert gas to at least 2.4 kPa. Use good engineering judgment to avoid overpressurizing the system.
(7) Maintain gas flow through the system for at least 180 seconds, ensuring that the flow reading is stable for an effective leak diameter of ± 0.002 inches.
(8) Use the following equation, or a different equation you develop based on good engineering judgment, to calculate the effective leak diameter, D_{eff}.

$$D_{eff} = 0.2153 \cdot \left(\frac{V_{gas}}{960 \cdot \sqrt{\frac{(p_1 - p_2) \cdot (p_1 + p_2)}{G \cdot (T + 459.67)}}} \right)^{0.5057}$$

Where:
D_{eff} = Effective leak diameter, rounded to the nearest 0.01 inch.
V_{gas} = Volumetric flow of gas (scfh).
p_1 = Inlet pressure to orifice (psia).
p_2 = Atmospheric pressure (psia).
G = Specific gravity of gas at 14.7 psia and 60°F.
T = Temperature of flowing medium (°F).

(9) You may perform any number of replicate tests. The average value of replicate tests is the official result for a given vehicle.

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(10) You may use special or alternative test procedures as described in 40 CFR 1065.10(c).
(d) Equipment calibration. Use good engineering judgment to calibrate the leak check device.

Subpart J—[Reserved]

Subpart K—Definitions and Other Reference Material

§1066.1001 Definitions.

The definitions in this section apply to this part. The definitions apply to all subparts unless we note otherwise. Other terms have the meaning given in 40 CFR part 1065. The definitions follow:

Base inertia means a value expressed in mass units to represent the rotational inertia of the rotating dynamometer components between the vehicle driving tires and the dynamometer torque-measuring device, as specified in §1066.250.

Driving schedule means a series of vehicle speeds that a vehicle must follow during a test. Driving schedules are specified in the standard-setting part. A driving schedule may consist of multiple test phases.

Duty cycle means a set of weighting factors and the corresponding test cycles, where the weighting factors are used to combine the results of multiple test phases into a composite result.

Footprint has the meaning given in the standard-setting part.

Nonmethane organic gas (NMOG) means the combination of organic gases other than methane as calculated in §1066.665. Note that for this part, the organic gases are summed on a mass basis without any adjustment for photochemical reactivity.

Parts-per-million (ppm) means ppm on a molar basis. For hydrocarbon concentrations including HC, THC, NMHC, and NMOG, ppm means ppm on a C_1-equivalent molar basis.

Road-load coefficients means sets of A, B, and C road-load force coefficients that are used in the dynamometer road-load simulation, where road-load force at speed v equals $A + B \cdot v + C \cdot v^2$.

Test phase means a period over which a vehicle's emission rates are determined separately. For many standards, compliance with the standard is based on a weighted average of the mass emissions from multiple test phases. For example, the standard-setting part may specify a complete duty cycle as a cold-start test phase and a hot-start test phase. In cases where multiple test phases 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.

Test weight has the meaning given in §1066.810.

Unloaded coastdown means a dynamometer coastdown run with the vehicle wheels removed from the roll surface.

We (us, our) means the Administrator of the Environmental Protection Agency and any authorized representatives.

§1066.1005 Symbols, abbreviations, acronyms, and units of measure.

The procedures in this part generally follow either the International System of Units (SI) or the United States customary units, as detailed in NIST Special Publication 811, which we incorporate by reference in §1066.1010. See 40 CFR 1065.20 for specific provisions related to these conventions. This section summarizes the way we use symbols, units of measure, and other abbreviations.

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

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1 Hz means are data reported from the instrument at a higher frequency, but recorded as a series of mean values at a rate of 1 Hz.

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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	acceleration	feet per second squared or meters per second squared	ft/s^2 or m/s^2	$m \cdot s^{-2}$
β	atomic oxygen to carbon ratio	mole per mole	mol/mol	1
C_d	discharge coefficient			
d	diameter	meters	m	m
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}
I	inertia	pound mass or kilogram	lbm or kg	kg
I	current	ampere	A	A
i	indexing variable			
M	mass	pound mass or kilogram	lbm or kg	kg
N	total number in series			
n	total number of pulses in a series			
ρ	mass density	kilogram per cubic meter	kg/m^3	$kg \cdot m^{-3}$
R	dynamometer roll revolutions	revolutions per minute	rpm	$2 \cdot \pi \cdot 60^{-1} \cdot m \cdot m^{-1} \cdot s^{-1}$
$Re^{\#}$	Reynolds number			
RL	road-load coefficient	horsepower or kilowatt	hp or kW	$10^3 \cdot m^2 \cdot kg \cdot s^{-3}$
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	second	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	mph or m/s	$m \cdot s^{-1}$
x	mass of emission over a test phase	kilogram	kg	kg
y	generic variable			

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(b) Symbols for chemical species. This part uses the following symbols for chemical species and exhaust constituents:

Symbol	Species
CH_4	methane
CO	carbon monoxide
CO_2	carbon dioxide
NMHC	nonmethane hydrocarbon
NMHCE	nonmethane hydrocarbon equivalent
NMOG	nonmethane organic gas
NONMHC	nonoxygenated nonmethane hydrocarbon
NO	nitric oxide
NO_2	nitrogen dioxide
NO_x	oxides of nitrogen
N_2O	nitrous oxide
O_2	molecular oxygen

OHC	oxygenated hydrocarbon
PM	particulate matter
THC	total hydrocarbon
THCE	total hydrocarbon equivalent

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

Superscript	Quantity
overbar (such as $\bar{y}$)	arithmetic mean

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

Subscript	Quantity
abs	absolute quantity
act	actual or measured condition
actint	actual or measured condition over the speed interval
atmos	atmospheric
b	base
c	coastdown
comp	composite
cor	corrected
dexh	dilute exhaust quantity
dil	dilute
e	effective
emission	emission specie
error	error
exh	raw exhaust quantity
exp	expected quantity
fil	filter
final	final
flow	flow measurement device type
i	an individual of a series
int	intake
init	initial quantity, typically before an emission test
max	the maximum (i.e. peak) value expected at the standard over a test phase; not the maximum of an instrument range
meas	measured quantity
ref	reference quantity
rev	revolution
roll	dynamometer roll
s	settling
sat	saturated condition
span	span quantity
std	standard conditions
test	test quantity
uncor	uncorrected quantity
zero	zero quantity

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

A/C	air conditioning
ALVW	adjusted loaded vehicle weight
CFR	Code of Federal Regulations
CFV	critical-flow venturi
CVS	constant-volume sampler
EPA	Environmental Protection Agency
ETW	equivalent test weight
EV	electric vehicle
FID	flame-ionization detector
FTP	Federal test procedure
GC	gas chromatograph
GHG	greenhouse gas (including CO_2, N_2O, and CH_4)
GVWR	gross vehicle weight rating
HEV	hybrid electric vehicle
HFET	highway fuel economy test
HLDT	heavy light-duty truck
HPLC	high pressure liquid chromatography
IBR	incorporated by reference
MDPV	medium-duty passenger vehicle
NIST	National Institute for Standards and Technology
PDP	positive-displacement pump
PHEV	plug-in hybrid electric vehicle
PM	particulate matter
RESS	rechargeable energy storage system
SAE	Society of Automotive Engineers
SC03	air conditioning driving schedule
SEA	selective enforcement audit
SFTP	supplemental federal test procedure
SSV	subsonic venturi
UDDS	urban dynamometer driving cycle
US06	aggressive driving schedule
U.S.C.	United States Code

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(f) This part uses the following densities of chemical species:

Symbol	Quantity[1,2]	kg/m^3	g/ft^3
ρ_{CH4}	density of methane	0.666905	18.8847
ρ_{CH3OH}	density of methanol	1.33202	37.7185
ρ_{C2H5OH}	C_1-equivalent density of ethanol	0.957559	27.1151
ρ_{C2H4O}	C_1-equivalent density of acetaldehyde	0.915658	25.9285
ρ_{C3H8}	density of propane	0.611035	17.3026
ρ_{C3H7OH}	C_1-equivalent density of propanol	0.83274	23.5806
ρ_{CO}	density of carbon monoxide	1.16441	32.9725
ρ_{CO2}	density of carbon dioxide	1.82953	51.8064
$\rho_{HC\text{-}gas}$	effective density of hydrocarbon - gaseous fuel[3]	(see 3)	(see 3)

ρ_{HCHO}	density of formaldehyde	1.24821	35.3455
$\rho_{HC\text{-}liq}$	effective density of hydrocarbon - liquid fuel[4]	0.576816	16.3336
$\rho_{NMHC\text{-}gas}$	effective density of nonmethane hydrocarbon - gaseous fuel[3]	(see 3)	(see 3)
$\rho_{NMHC\text{-}liq}$	effective density of nonmethane hydrocarbon - liquid fuel[4]	0.576816	16.3336
$\rho_{NMHCE\text{-}gas}$	effective density of nonmethane equivalent hydrocarbon - gaseous fuel[3]	(see 3)	(see 3)
$\rho_{NMHCE\text{-}liq}$	effective density of nonmethane equivalent hydrocarbon - liquid fuel[4]	0.576816	16.3336
ρ_{NOx}	effective density of oxides of nitrogen[5]	1.9125	54.156
ρ_{N2O}	density of nitrous oxide	1.82966	51.8103

[1]Densities are given at 20 °C and 101.3 kPa.

[2]Densities for all hydrocarbon containing quantities are given in kg/m^3-carbon atom and g/ft^3-carbon atom.

[3]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. $\rho_{HCgas} = 0.04157 \cdot (12.011 + (\alpha \cdot 1.008))$.

[4]The effective density for gasoline and diesel fuel are defined by an atomic hydrogen-to-carbon ratio, α, of 1.85.

[5]The effective density of NO_x is defined by the molar mass of nitrogen dioxide, NO_2.

(g) Constants. (1) This part uses the following constants for the composition of dry air:

Symbol	Quantity	mol/mol
x_{Arair}	amount of argon in dry air	0.00934
x_{CO2air}	amount of carbon dioxide in dry air	0.000375
x_{N2air}	amount of nitrogen in dry air	0.78084
x_{O2air}	amount of oxygen in dry air	0.209445

(2) This part uses the following molar masses or effective molar masses of chemical species:

Symbol	Quantity	g/mol (10^{-3}·kg·mol^{-1})
M_{air}	molar mass of dry air[1]	28.96559
M_{H2O}	molar mass of water	18.01528

[1]See paragraph (g)(1) of this section for the composition of dry air.

§1066.1010 Reference materials.

(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 change 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, 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, call 202–741–6030, or go to http://www.archives.gov/federal_register/code_of_federal_regulations/ibr_locations.html.

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(b) Society of Automotive Engineers, 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 J1263, Road Load Measurement and Dynamometer Simulation Using Coastdown Techniques, Revised March 2010, IBR approved for §§1066.301(b) and 1066.310(b).

(2) SAE J1634, Electric Vehicle Energy Consumption and Range Test Procedure, Revised October 2012, IBR approved for §1066.501.

(3) SAE J1711, Recommended Practice for Measuring the Exhaust Emissions and Fuel Economy of Hybrid-Electric Vehicles, Including Plug-In Hybrid Vehicles, Revised June 2010, IBR approved for §§1066.122 and 1066.501.

(4) SAE J2263, Road Load Measurement Using Onboard Anemometry and Coastdown Techniques, Revised December 2008, IBR approved for §§1066.301(b) and 1066.310(b).

(5) SAE J2264, Chassis Dynamometer Simulation of Road Load Using Coastdown Techniques, Issued April 1995, IBR approved for §1066.320.

(6) SAE J2711, Recommended Practice for Measuring Fuel Economy and Emissions of Hybrid-Electric and Conventional Heavy-Duty Vehicles, Issued September 2002, IBR approved for §1066.501.

(7) SAE J2951, Drive Quality Evaluation for Chassis Dynamometer Testing, Revised November 2011, IBR approved for §1066.430.

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

(1) NIST Special Publication 811, 2008 Edition, Guide for the Use of the International System of Units (SI), March 2008, IBR approved for §§1066.20(a) and 1066.1005.

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(f) Verify the amount of nonmethane hydrocarbon (or equivalent) contamination in the exhaust and background HC sampling systems within 8 hours before the start of the first test drive cycle for each individual vehicle tested as described in 40 CFR 1065.520(g).

§1066.425 Engine starting and restarting.

(a) Start the vehicle's engine as follows:

(1) At the beginning of the test cycle, start the engine according to the procedure you describe in your owners manual. In the case of hybrid vehicles, this would generally involve activating vehicle systems such that the engine will start when the vehicle's control algorithms determine that the engine should provide power instead of or in addition to power from the rechargeable energy storage system (RESS). Unless we specify otherwise, engine starting throughout this part generally refers to this step of activating the system on hybrid vehicles, whether or not that causes the engine to start running.

(2) Place the transmission in gear as described by the test cycle in the standard-setting part. During idle operation, you may apply the brakes if necessary to keep the drive wheels from turning.

(b) If the vehicle does not start after your recommended maximum cranking time, wait and restart cranking according to your recommended practice. If you don't recommend such a cranking procedure, stop cranking after 10 seconds, wait for 10 seconds, then start cranking gain for up to 10 seconds. You may repeat this for up to three start attempts. If the vehicle does not start after three attempts, you must determine and record the reason for failure to start. Shut off sampling systems and either turn the CVS off, or disconnect the exhaust tube from the tailpipe during the diagnostic period. Reschedule the vehicle for testing from a cold start.

(c) Repeat the recommended starting procedure if the engine has a "false start".

(d) Take the following steps if the engine stalls:

(1) If the engine stalls during an idle period, restart the engine immediately and continue the test. If you cannot restart the engine soon enough to allow the vehicle to follow the next acceleration, stop the driving schedule indicator and reactivate it when the vehicle restarts.

(2) If the engine stalls during operation other than idle, stop the driving schedule indicator, restart the engine, accelerate to the speed required at that point in the driving schedule, reactivate the driving schedule indicator, and continue the test.

(3) Void the test if the vehicle will not restart within one minute. If this happens, remove the vehicle from the dynamometer, take corrective action, and reschedule the vehicle for testing. Record the reason for the malfunction (if determined) and any corrective action. See the standard-setting part for instructions about reporting these malfunctions.

The overall test consists of prescribed sequences of fueling, parking, and driving at specified test conditions.

(a) Vehicles are tested for criteria pollutants and greenhouse gas emissions as described in the standard-setting part.

(b) Take the following steps before emission sampling begins:

(1) For batch sampling, connect clean storage media, such as evacuated bags or tare-weighed filters.

(2) Start all measurement instruments according to the instrument manufacturer's instructions and using good engineering judgment.

(3) Start dilution systems, sample pumps, and the data-collection system.
(4) Pre-heat or pre-cool heat exchangers in the sampling system to within their operating temperature tolerances for a test.
(5) Allow heated or cooled components such as sample lines, filters, chillers, and pumps to stabilize at their operating temperatures.
(6) Verify that there are no significant vacuum-side leaks according to 40 CFR 1065.345.
(7) Adjust the sample flow rates to desired levels using bypass flow, if desired.
(8) Zero or re-zero any electronic integrating devices before the start of any test interval.
(9) Select gas analyzer ranges. You may automatically or manually switch gas analyzer ranges during a test only if switching is performed by changing the span over which the digital resolution of the instrument is applied. During a test you may not switch the gains of an analyzer's analog operational amplifier(s).
(10) Zero and span all continuous gas analyzers using NIST-traceable gases that meet the specifications of 40 CFR 1065.750. Span FID analyzers on a carbon number basis of one (C_1). For example, if you use a C_3H_8 span gas of concentration 200 μmol/mol, span the FID to respond with a value of 600 μmol/mol. Span FID analyzers consistent with the determination of their respective response factors, *RF*, and penetration fractions, *PF*, according to 40 CFR 1065.365.
(11) We recommend that you verify gas analyzer responses after zeroing and spanning by sampling a calibration gas that has a concentration near one-half of the span gas concentration. Based on the results and good engineering judgment, you may decide whether or not to re-zero, re-span, or re-calibrate a gas analyzer before starting a test.
(12) If you correct for dilution air background concentrations of associated engine exhaust constituents, start sampling and recording background concentrations.
(13) Turn on cooling fans immediately before starting the test.
(c) Operate vehicles during testing as follows:
(1) Where we do not give specific instructions, operate the vehicle according to your recommendations in the owners manual, unless those recommendations are unrepresentative of what may reasonably be expected for in-use operation.
(2) If vehicles have features that preclude dynamometer testing, modify these features as necessary to allow testing, consistent with good engineering judgment.
(3) Operate vehicles during idle as follows:
(i) For a vehicle with an automatic transmission, operate at idle with the transmission in "Drive" with the wheels braked, except that you may shift to "Neutral" for the first idle period and for any idle period longer than one minute. If you put the vehicle in "Neutral" during an idle, you must shift the vehicle into "Drive" with the wheels braked at least 5 seconds before the end of the idle period.
(ii) For vehicles with manual transmission, operate at idle with the transmission in gear with the clutch disengaged, except that you may shift to "Neutral" with the clutch disengaged for the first idle period and for any idle period longer than one minute. If you put the vehicle in "Neutral" during idle, you must shift to first gear with the clutch disengaged at least 5 seconds before the end of the idle period.
(4) Operate the vehicle with the appropriate accelerator pedal movement necessary to achieve the speed versus time relationship prescribed by the driving schedule. Avoid smoothing speed variations and excessive accelerator pedal perturbations.
(5) Operate the vehicle smoothly, following representative shift speeds and procedures. For manual transmissions, the operator shall release the accelerator pedal during each shift and

accomplish the shift with minimum time. If the vehicle cannot accelerate at the specified rate, operate it at maximum available power until the vehicle speed reaches the value prescribed for that time in the driving schedule.
(6) Decelerate without changing gears, using the brakes or accelerator pedal as necessary to maintain the desired speed. Keep the clutch engaged on manual transmission vehicles and do not change gears after the end of the acceleration event. Depress manual transmission clutches when the speed drops below 6.7 m/s (15 mph), when engine roughness is evident, or when engine stalling is imminent.
(7) For test vehicles equipped with manual transmissions, shift gears in a way that represents reasonable shift patterns for in-use operation, considering vehicle speed, engine speed, and any other relevant variables. You may recommend a shift schedule in your owners manual that differs from your shift schedule during testing as long as you include both shift schedules in your application for certification. In this case, we may use the shift schedule you describe in your owners manual.

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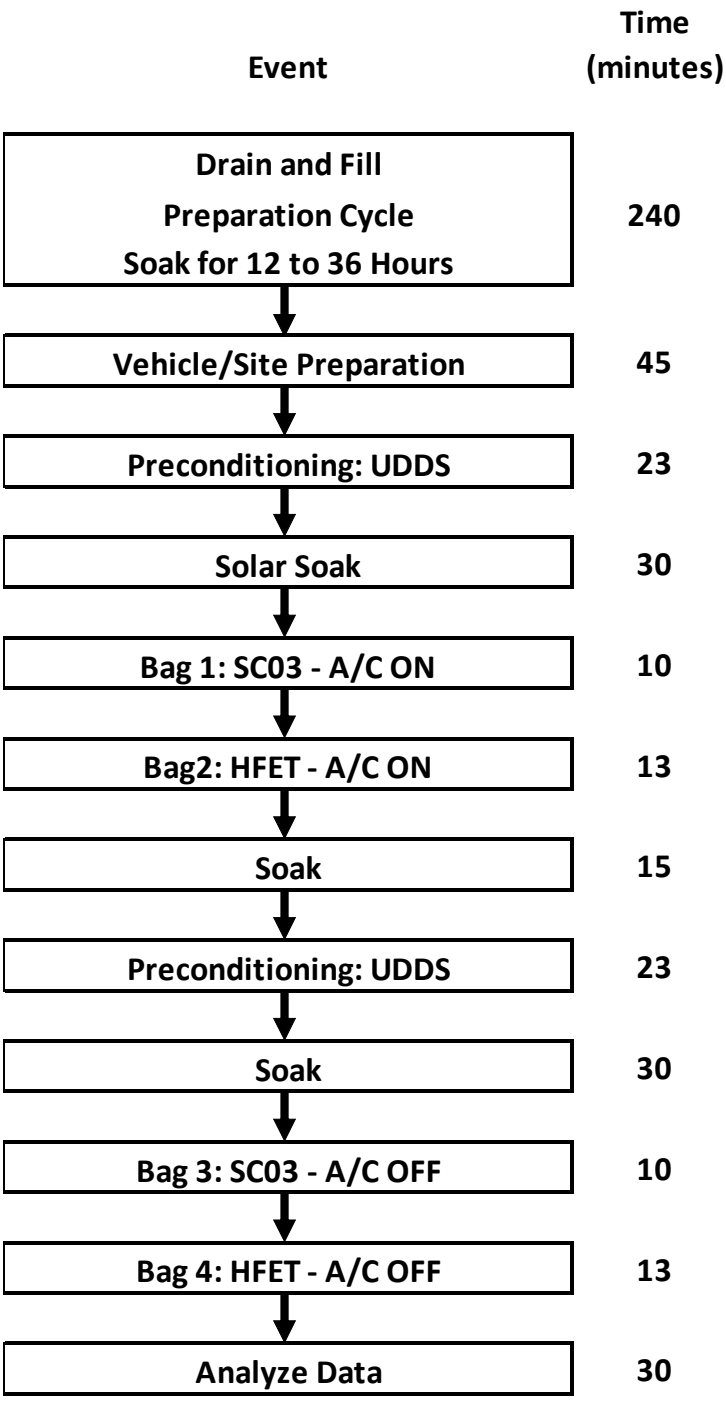
Figure 1 of §1066.835 shows the basic sequence of test procedure events.

Figure 1 of §1066.835–AC17 sequence of events



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The provisions of §86.144–94 (b) and (c) are applicable to this section except that the NO_x humidity correction factor of §86.144–94(c)(7)(iv) must be modified when adjusting SC03 environmental test cell NO_x results to 100 grains of water according to paragraph (d) of this section. These provisions

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The provisions of §86.144–94 (b) and (c) are applicable to this section except that the NO_x humidity correction factor of §86.144–94(c)(7)(iv) must be modified when adjusting SC03 environmental test cell NO_x results to 100 grains of water according to paragraph (d) of this section. These provisions

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The provisions of §86.144–94 (b) and (c) are applicable to this section except that the NO_x humidity correction factor of §86.144–94(c)(7)(iv) must be modified when adjusting SC03 environmental test cell NO_x results to 100 grains of water according to paragraph (d) of this section. These provisions

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computed by the following formulas.

(i) $Y_{WSFTP}= 0.72(Y_{FTP})+0.28(Y_{US06})$

Where:

(A) Y_{WSFTP}= Mass emissions per mile for a particular pollutant weighted in terms of the contributions from the FTP and US06 schedules. Values of Y_{WSFTP} are obtained for each of the exhaust emissions of NMHC, NO_x and CO.

(B) Y_{FTP}= Weighted mass emissions per mile (Ywm) based on the measured driving distance of the FTP test schedule.

(C)(*1*) Y_{US06}= Calculated mass emissions per mile based on the measured driving distance of the US06 test schedule; or,

(*2*) In the case of a 2-phase US06 test run according to the provisions of §86.159–08(f)(2) and part 600 of this chapter:

YUS06 = Calculated mass emissions per mile, using the summed mass emissions of the "US06 City" phase and the "US06 Highway" phase, based on the measured driving distance of the US06 test schedule. The "US06 City" phase shall be sampled during seconds 0–130 and from 495 seconds until five seconds after the engine stops running (*e.g.* 602 or 603 seconds) of the US06 driving schedule. The "US06 Highway" phase shall be sampled during seconds 130–495 of the US06 driving schedule),

(ii) Composite ($NMHC+ NO_x$) = $Y_{WSFTP}(NMHC) + Y_{WSFTP}(NO_x)$

Where:

(A) $Y_{WSFTP}(NMHC)$ = results of paragraph (c)(2)(i) of this section for NMHC.

(B) $Y_{WSFTP}(NO_x)$ = results of paragraph (c)(2)(i) of this section for NO_x.

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(d) The NO_x humidity correction factor for adjusting NO_x test results to the environmental test cell air conditioning ambient condition of 100 grains of water/pound of dry air is:

$K_H(100) = 0.8825/[1–0.0047(H–75)]$

Where:

H = measured test humidity in grains of water/pound of dry air.

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This goes away after 2016. EPA proposes to not include this in 1066.

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Connect the vehicle exhaust system to the raw sampling location or dilution stage according to the provisions of this subpart. For dilution systems, dilute the exhaust as described in this subpart. Continuous sampling systems must meet the specifications provided in this subpart.
(2)

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Connect the vehicle exhaust system to the raw sampling location or dilution stage according to the provisions of this subpart. For dilution systems, dilute the exhaust as described in this subpart. Continuous sampling systems must meet the specifications provided in this subpart.
(2)

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Alternatively, CO_2may be measured and recorded using a constant velocity sampling system as described in §§86.106–96(a)(2) and 86.109.

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9 °F

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9 °F

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of this chapter, including the provisions of part 86,

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FTP testing procedures. The test procedures to be followed for conducting the FTP test are those prescribed in §§86.127 through 86.138 of this chapter, as applicable, except as provided for in paragraph (b)(5) of this section. (The evaporative loss portion of the test procedure may be omitted unless specifically required by the Administrator.)

(b) Highway fuel economy testing procedures.

(1)

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The Highway Fuel Economy Dynamometer Procedure (HFET) consists of a preconditioning highway driving sequence and a measured highway driving sequence.

(2)

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constant volume (variable dilution) sampler

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Diesel dilute exhaust is continuously analyzed for hydrocarbons using a heated sample line and analyzer. Methanol and formaldehyde samples are collected and individually analyzed for methanol-fueled vehicles (measurement of methanol and formaldehyde may be omitted for 1993 through 1994 model year methanol-fueled vehicles provided a HFID calibrated on methanol is used for measuring HC plus methanol). Methanol, ethanol, formaldehyde, and acetaldehyde samples are collected and individually analyzed for ethanol fueled vehicles.

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Section 86.129 of this chapter applies for determination of road load power and test weight for highway fuel economy testing. The test weight for the testing of a certification vehicle will be that test weight specified by the Administrator under the provisions of part 86 of this chapter.

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Federal Emission Test Procedure, §§86.127 through 86.138 of this chapter

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is driven to precondition the test vehicle and the second is driven for the fuel economy measurement

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(ii) The provisions of §86.135 of this chapter, except for the overview and the allowance for practice runs, apply for highway fuel economy testing.
(iii) Only one exhaust sample and one background sample are collected and analyzed for hydrocarbons (except diesel hydrocarbons which are analyzed continuously), carbon monoxide, and carbon dioxide. Methanol and formaldehyde samples (exhaust and dilution air) are collected and analyzed for methanol-fueled vehicles (measurement of methanol and formaldehyde may be omitted for 1993 through 1994 model year methanol-fueled vehicles provided a HFID calibrated on methanol is used for measuring HC plus methanol). Methanol, ethanol, formaldehyde, and acetaldehyde samples are collected and analyzed for ethanol fueled vehicles.

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(iv) The fuel economy measurement cycle of the test includes two seconds of idle indexed at the beginning of the second cycle and two seconds of idle indexed at the end of the second cycle.

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False starts and stalls during the preconditioning cycle must be treated as in §86.136 of this chapter. If the vehicle stalls during the measurement cycle of the highway fuel economy test, the test is voided, corrective action may be taken according to §86.1834 of this chapter, and the vehicle may be rescheduled for testing. The person taking the corrective action shall report the action so that the test records for the vehicle contain a record of the action.

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(9) The following steps must be taken for each test:
(i) Place the drive wheels of the vehicle on the dynamometer. The vehicle may be driven onto the dynamometer.
(ii) Open the vehicle engine compartment cover and position the cooling fan(s) required. Manufacturers may request the use of additional cooling fans or variable speed fan(s) for additional engine compartment or under-vehicle cooling and for controlling high tire or brake temperatures during dynamometer operation. With prior EPA approval, manufacturers may

perform the test with the engine compartment closed, e.g., to provide adequate air flow to an intercooler (through a factory installed hood scoop). Additionally, the Administrator may conduct fuel economy testing using the additional cooling set-up approved for a specific vehicle.
(iii) Preparation of the CVS must be performed before the measurement highway driving cycle.
(iv) The provisions of §86.137–94(b)(3) through (6) of this chapter apply for highway fuel economy test, except that only one exhaust sample collection bag and one dilution air sample collection bag need to be connected to the sample collection systems.
(v) Operate the vehicle over one Highway Fuel Economy Driving Schedule cycle according to the dynamometer driving schedule specified in §600.109–08(b).
(vi) When the vehicle reaches zero speed at the end of the preconditioning cycle, the driver has 17 seconds to prepare for the emission measurement cycle of the test.
(vii) Operate the vehicle over one Highway Fuel Economy Driving Schedule cycle according to the dynamometer driving schedule specified in §600.109–08(b) while sampling the exhaust gas.

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Sampling must begin two seconds before beginning the first acceleration of the fuel economy measurement cycle and must end two seconds after the end of the deceleration to zero. At the end of the deceleration to zero speed, the roll or shaft revolutions must be recorded.
(10) For alcohol-based dual fuel automobiles, the procedures of §600.111–08(a) and (b) shall be performed for each of the fuels on which the vehicle is designed to operate.
(c) US06 Testing procedures. The test procedures to be followed for conducting the US06 test are those prescribed in §86.159 of this chapter, as applicable.
(d) SC03 testing procedures. The test procedures to be followed for conducting the SC03 test are prescribed in §§86.160 and 86.161 of this chapter, as applicable.
(e) Cold temperature FTP procedures. The test procedures to be followed for conducting the cold temperature FTP test are generally prescribed in subpart C of part 86 of this chapter, as applicable. For the purpose of fuel economy labeling, diesel vehicles are subject to cold temperature FTP testing, but are not required to measure particulate matter, as described in §86.210 of this chapter.
(f) Special test procedures. The Administrator may prescribe test procedures, other than those set forth in this subpart B, for any vehicle which is not susceptible to satisfactory testing and/or testing results by the procedures set forth in this part. For example, special test procedures may be used for advanced technology vehicles, including, but not limited to fuel cell vehicles, hybrid electric vehicles using hydraulic energy storage, and vehicles equipped with hydrogen internal combustion engines. Additionally, the Administrator may conduct fuel economy and carbon-related exhaust emission testing using the special test procedures approved for a specific vehicle.

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S	speed	miles per hour or meters per second	mph or m/s	$m \cdot s^{-1}$

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int	speed interval

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final	final

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si	speed interval