40 CFR Part 1066

Vehicle-Testing Procedures

DRAFT Working Document

(LD Tier III NPRM changes denoted by “track changes”)

6/14/12

Part 1066—Vehicle-Testing Procedures

Subpart A—Applicability and General Provisions

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

Subpart C—Dynamometer Specifications

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Subpart D—Coastdown

Subpart E—Vehicle Preparation and Running a Test

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Subpart I—Exhaust Emission Test Procedures for Vehicles Under 14,000 GVWR

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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 the standard setting part for guidelines for implementation of 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 part for light-duty vehicles.

(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.

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(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.
(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 is 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. We may approve your request to omit measurement of N_2O and CH_4 for a vehicle, provided it is not subject to an N_2O or CH_4 emission standard and we determine that other information is available to give us a reasonable basis for estimating or approximating the vehicle's emission rates.
(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) Are there any emission standards specified at particular operating conditions or ambient conditions?
(9) 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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(8) Is field testing required or allowed, and are there different emission standards or procedures that apply to field testing?
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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	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 for laboratory testing 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.

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§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.

(v) Nonmethane organic gases, NMOG, which are calculated either from fully or partially speciated measurement of hydrocarbons including oxygenates, or by adjusting NMHC based on fuel 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 and road load are controlled to follow a prescribed duty cycle. We generally set emission standards over test phases and/or drive schedules, as follows:
(1) Vehicle operation. Testing involves measuring emissions and miles travelled in a laboratory environment. 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) The regulation highlights several specific cases where good engineering judgment is especially relevant. You must use good engineering judgment for all aspects of testing under this part, not only for 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 follows 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.

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(b) Units conversion. Use good engineering judgment to convert units between measurement systems as needed. 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) 1 µmol/mol = 1 ppm.

(5) 10 mmol/mol = 1 %.

(c) Rounding. The rounding provisions of 40 CFR 1065.20 apply for calculations in this part, unless the standard setting part states otherwise. 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, target any associated control point to that single value. Examples of this type of range include "±10 % of maximum pressure", or "(30 ±10) kPa".

(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.

Deleted: Refer to 40 CFR 1065.602 for information needed to estimate and calculate flow-weighted means.

§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 one year after you send an associated application for certification, or one year 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.

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, specify equipment for exhaust dilution and sampling systems as described in §1066.110.

(2) The provisions of 40 CFR part 1065, subpart C, specify measurement instruments as described in §1066.120.

(3) The provisions of 40 CFR part 1065, subpart D, specify measurement instrument calibrations and verifications as described in §1066.130.

(4) The provisions of 40 CFR part 1065, subpart H, specify fuels, engine fluids, and analytical gases as described in §1066.140.

(5) The provisions of 40 CFR part 1065, subpart I, specify requirements for testing with oxygenated fuels as described for NMOG determination 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. We may waive or modify the specifications and requirements of this part for testing highway motorcycles or nonroad 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 (as described 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), specify engine fluids and analytical gases (§1066.140), and specify requirements for interference verification of N_2O analyzers (§1066.145).

(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 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-

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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.

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 of 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 universal 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) Minimize leaks as needed to ensure that any remaining leaks do not affect your ability to demonstrate compliance with the applicable standards.
(vi) For vehicle's 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, follow the requirements in 40 CFR 1065.140(b) with the following exceptions:
(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 to be 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) 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 determine in equation 1066.620-2 is within the range of (10:1 to 20:1). When determining dilution factor for PM samples utilizing secondary dilution air, multiply dilution factor by the dilution ratio of secondary dilution air to primary dilute exhaust.

(iv) In addition to the allowances in 40 CFR 1065.140(c) 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 to prevent or limit aqueous condensation.

(v) CVS construction. If you choose to dilute the exhaust by using a remote mix tee, which dilutes the exhaust at the tailpipe, you may use the following provisions, using good engineering judgment, provided they do not affect your ability to show that you comply with the standard:

(A) You may use accordion style or smooth walled flexible tubing in the dilution tunnel upstream of where flow or gaseous emission measurements are made.

(B) You may use smooth walled electrically conductive flexible tubing in the dilution tunnel upstream of where PM emission measurements are made.

(C) Materials used are limited to inside surfaces of 300 series stainless steel and polymer based materials.

(D) Use good engineering judgment to ensure that the materials you choose do not contribute, or cause unrepresentative loss of PM to your sample.

(vi) Paragraph (b)(1)(vi) applies instead of the provisions in 40 CFR 1065.145(b).

(c) The following table summarizes the requirements of paragraph (b)(2) of this section:

Table 2 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: Use 40 CFR 1065.140(c)(6) as 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.

§1066.122 Data updating, recording, and control for measurement instruments.
Your test system must be able to update and record data. It must also control the systems related to driver demand, the dynamometer, sampling equipment, and measurement instruments. 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
§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[a]	—	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

[a]For power analyzers follow SAE J1711 (incorporated by reference in §1066.1010) for sampling frequency.

§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 apply for flow rates (except intake air and fuel flow), gas division, concentration, temperature, and mass. The provisions of 40 CFR 1065.303 do not apply for engine speed, torque, electrical power, 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 apply for flow rates (except intake air and fuel flow), gas division, concentration, temperature, and mass. The provisions of 40 CFR 1065.307 do not apply for engine speed, torque, electrical power, 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) If you are measuring flow volumetrically, replace references in 40 CFR 1065.340 to mean molar flow rate of the reference flow meter, $\bar{\dot{n}}_{\mathrm{ref}}$, with the mean volumetric flow rate of the reference flow meter, $\bar{\dot{V}}_{\mathrm{ref}}$.

(e) The provisions of §1066.145 apply instead 40 CFR 1065.375(c).

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

§1066.133 Summary of calibrations and verifications.

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]
§1066.137: Linearity verification	Dynamometer Speed: See §1066.220. Dynamometer Torque: See §1066.220. Current: Upon initial installation, within 370 days before testing and after major maintenance. Voltage: Upon initial installation, within 370 days before testing and after major maintenance. Electrical power, Fuel flow rate, and Intake air flow: Linearity verification is not required for testing under this subpart.
40 CFR 1065.310: Torque	This calibration does not apply for testing under this part.
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 1065.345: 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 1065.395: Inertial PM balance and weighing..	These verifications do not apply for testing under this part.

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

§1066.137 Linearity verification.

This section describes requirements for linearity verification that are unique to testing under this part. Perform other required or recommended calibration and verifications as described in 40 CFR 1065.307, with the exceptions noted in this section.

(a) For testing under this subpart, linearity verification under 40 CFR part 1065 is not required for speed, torque, electrical power, 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 a range of values that you expect would prevent extrapolation beyond these values 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 percent 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 percent at any point, the best-fit non-linear equation which represents the data to within 2 percent of each test point shall be used to determine concentration.

(2) Use the linearity requirements of 40 CFR part 1065.307. 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 current and voltage using a reference meter and controlled sources of current and voltage. We recommend using a complete calibration system that is suitable for the electrical power distribution industry.

(d) 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, if applicable.

(4) Chiller sample, for gaseous sampling systems that use thermal chillers to dry samples and use chiller temperature to calculate the dewpoint at the outlet of the chiller. For testing, if you choose to use the alarm high temperature setpoint for the chiller temperature as a constant value in determining the amount of water removed from the emission sample, you may optionally use good engineering judgment to verify the accuracy of the high alarm temperature setpoint instead of the linearity verification on the 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.

(e) 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 removed water from the emission sample, you may use good engineering judgment to verify the accuracy of the low alarm pressure setpoint instead of the linearity verification on the 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.

(f) When following procedures or practices incorporated by reference that contain analytical instruments not covered under 40 CFR 1065.307 (for example, GC-FID or HPLC), you must meet the linearity requirements given by the procedure or practice.

Table 1 of §1066.137–Measurement systems that require linearity verifications.

Measurement system	Quantity	Linearity criteria			
		$\lvert x_{min}(a_1-1)+a_0 \rvert$	a_1	SEE	r^2
Current	I	$\leq 1\ \% \cdot I_{max}$	0.98-1.02	$\leq 2\ \% \cdot I_{max}$	≥ 0.990
Voltage	U	$\leq 1\ \% \cdot U_{max}$	0.98-1.02	$\leq 2\ \% \cdot U_{max}$	≥ 0.990

§1066.140 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 oils 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.

§1066.145 Analyzer interference and quench verification limit.

Analyzers must meet the interference and quench verification limits in Table 1 in place of those in 40 CFR 1065 subpart D.

Table 1 of §1066.145–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	±5 % of full scale

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 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, during a test.
(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 roll diameter must be a nominal 1.20 meters or greater. The dynamometer must have an independent drive roll for each drive axle, 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 force and speed at 10 Hz or faster; you may use good engineering judgment to convert measured values to 1-Hz, 2-Hz, or 5-Hz values.
(3) The load applied by the dynamometer simulates forces acting on the vehicle during normal driving according to the following equation:

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

Eq. 1066.210-1

Where:
FR = total road-load force to be applied at the surface of the roll. The total force is the sum of the individual tractive forces applied at each roll surface.
i = a counter to indicate a point in time over the driving schedule. For a dynamometer operating at 10-Hz intervals over a 600-second driving schedule, the maximum value of *i* is 6,000.

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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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A = constant value representing the vehicle's frictional load in lbf or newtons. See subpart C 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 C of this part.
v = linear speed at the roll surfaces as measured by the dynamometer, in mph or m/s. Let $v_{i-1} = 0$.
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 C of this part.
M = mass of vehicle in lbm or kg. For vehicles with GVWR at or below 14,000 lbs, determine the vehicle's mass based on equivalent test weight (ETW), as specified in §1066.410(h). For vehicles with GVWR above 14,000 lbs, 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 $t_{i-1} = 0$.
(4) We recommend that the dynamometer is 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.
(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:

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	Upon initial installation and after major maintenance.
§1066.230: Time	Upon initial installation and after major maintenance.
§1066.235: Speed measurement	Upon initial installation, within 370 days before testing, and after major maintenance.
§1066.240: Torque (load) transducer	Upon initial installation, within 7 days of testing, and after major maintenance.
§1066.245: Response time	Upon initial installation, within 370 days before testing, and after major

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	maintenance.
§1066.250: Base inertia	Upon initial installation and after major maintenance.
§1066.255: Parasitic loss	Upon initial installation, after major maintenance, and upon failure of the verifications in §1066.270 or §1066.280.
§1066.260: Parasitic friction compensation evaluation	Upon initial installation, after major maintenance, and upon failure of the verifications in §1066.270 or §1066.280.
§1066.265: Acceleration and deceleration	Upon initial installation and after major maintenance.
§1066.270: Unloaded coastdown	Upon initial installation, within 7 days of testing, and after major maintenance.
§1066.280 Dynamometer readiness verification	Upon initial installation, within 13 hours before testing, and after major maintenance.

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

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(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. 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 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.

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(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 $\bar{y}$), 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, $\bar{y}_i$. 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, $\bar{y}_i$, and reference values, y_{refi}, to calculate least-squares linear regression parameters and statistical values to compare to the minimum performance criteria specified in Table 1 of this section. Use the calculations described 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			
		$\lvert y_{min}(a_1-1)+a_0 \rvert$	a_1	SEE	r^2
Speed	v	$\leq$0.05 % · v_{max}	0.98-1.02	$\leq$2 % · v_{max}	$\geq$0.990
Torque (load)	T	$\leq$1 % · T_{max}	0.99-1.01	$\leq$1 % · T_{max}	$\geq$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).

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§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.

(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

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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 ±0.25 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 Equation 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:

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(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 Equation 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:

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

Eq. 1066.235-1

Comment [CAL3]: Equation updated.

Where:
f = frequency of the dynamometer speed sensing device, in s^{-1}, accurate to at least four significant figures.
d_{roll} = nominal roll diameter, in m, accurate to the nearest 0.25 mm, consistent with §1066.225(d).
n = the number of pulses per revolution from the dynamometer roll speed sensor.

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

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

Comment [CAL4]: Equation updated.

v_{act} = 8.3053 m/s

(ii) Repeat the steps in paragraph (c)(1)(i) of this section for at least three additional evenly spaced speed points between the starting speed and the maximum speed expected during testing. The maximum speed point should be considered one of these points.
(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 Equation 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 at least three additional evenly spaced speed points between the starting speed and the maximum speed expected during testing. The maximum speed point should be considered one of these points.
(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 Equation 1066.235-2.
(d) Performance evaluation. The speed error determined in paragraph (c) of this section may not exceed ±0.02 m/s (0.05 mph) at any speed set point.

§1066.240 Torque transducer verification.
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

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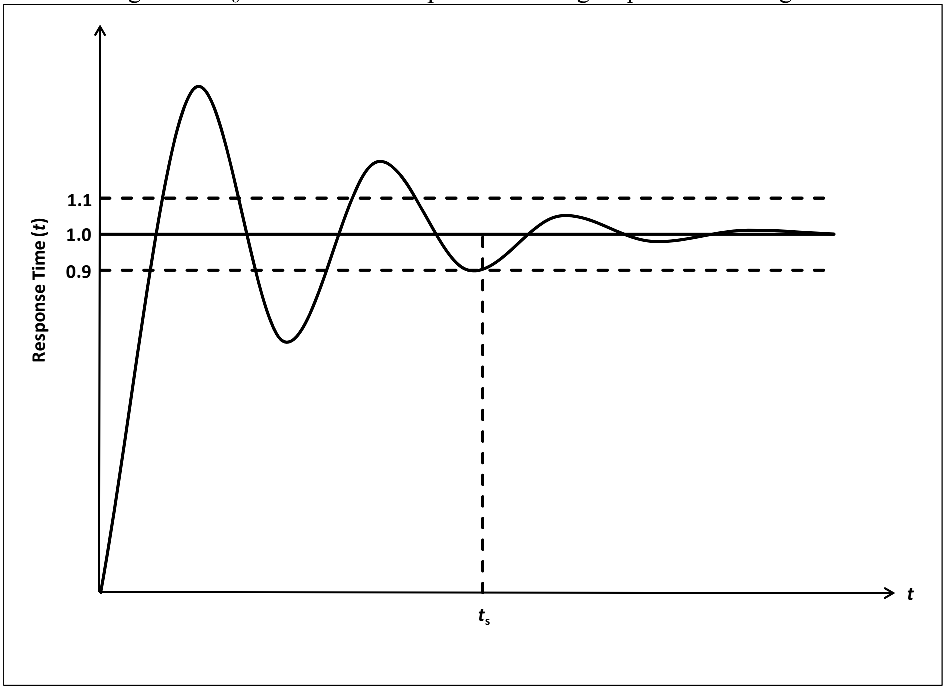
and two acceleration rates that cover the range of acceleration rates experienced during testing (for example 0.5 and 8 mph/s). Use good engineering judgment to select road-load coefficients representing vehicles of the appropriate weight. Determine the dynamometer's settling response time, t_s, based 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.

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, in ft·lbm/s^2.
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} = 33.01 lbm

$$I_{berror} = \frac{32.96 - 33.01}{32.96} \cdot 100\ \%$$

I_{berror} = –0.15 %

(7) Determine the base inertia arithmetic mean value, $\bar{I}_b$, 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 Equation 1066.250-2, substituting the mean base inertias associated with each acceleration and deceleration rate for the individual base inertias.

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(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 %.

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§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 the verifications in §1066.270 or §1066.280.

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(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.

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(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 (±2.0 lbf).

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§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 the verifications in §1066.270 or §1066.280. Note that this procedure relies on proper verification or calibration of speed and torque, as described in §§1066.235 and1066.240. You must also first verify the dynamometer's parasitic loss curve as specified in §1066.255.

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(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 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 20 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:

$$FC_{\mathrm{error}} = \frac{I}{2 \cdot t} \cdot \left(v_{\mathrm{init}}^2 - v_{\mathrm{final}}^2\right)$$

Eq. 1066.260-1

Where:

I = dynamometer inertia setting, in lbf·s^2/ft.

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 0.01 mph.

v_{final} = the roll speed corresponding to the end of the measurement interval, accurate to at least 0.01 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

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

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

(5) The friction compensation error may not exceed ±0.1 hp.

§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 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

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Comment [CAL6]: Equation updated.

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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:

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

Eq. 1066.265-1

Comment [CAL7]: Equation updated.

Where:

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

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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:

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

Eq. 1066.265-2

Comment [CAL8]: Equation updated.

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}.

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Example:

v_{final} = 40 mph

v_{init} = 10 mph

t = 30.003 s

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

a_{act} = 0.999 mph/s

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

(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, $\overline{a}_{\text{act}}$, at each setting.

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

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

Eq. 1066.265-3

Example:

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

$a_{\text{ref}} = 1$ mph/s

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

$a_{\text{error}} = –0.100$ %

(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:

$$F = I_{\text{b}} \cdot |a|$$

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 Equation 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 mph. Average the five repeat runs to calculate a mean acceleration rate, $\overline{a}_{\text{act}}$, 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 Equation 1066.265-4

(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 and final speed and the inertial 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 a coastdown two times 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

v_{init} = 25 mph = 36.66 ft/s

v_{final} = 15 mph = 22.0 ft/s

t = 5.00 s

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Comment [CAL9]: Equation revised.

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

F = 191.1 lbf

Comment [CAL10]: Example revised.

(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

Comment [CAL11]: Equation updated.

Example:

F_{ref} = 192 lbf

$\overline{F}_{act}$ = 191 lbf

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

F_{error} = 0.5 %

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(7) For vehicles with GVWR above 14,000 lbs, the maximum allowable error, $F_{errormax}$, for all speed and inertia settings is 1.0 %. For vehicles with GVWR at or below 14,000 lbs, calculate $F_{errormax}$ from the following formula:

$F_{errormax}$ (%) = (2.2 lbf/F_{ref})·100

Eq. 1066.270-3

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Example:

F_{ref} = 192 lbf

$F_{errormax}$ (%) = (2.2/192)·100 = 1.14%

(8) If the dynamometer is not able to meet this requirement, diagnose and repair the dynamometer prior to continuing with emissions testing. Diagnosis should include performing the verification and evaluation 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 emissions testing.

(b) Scope and frequency. Perform this verification upon initial installation, within 13 hours before testing, and after major maintenance.

(c) Procedure. This procedure provides a quality measure of the state of a dynamometer's readiness for emissions testing. For dynamometers that have an automated process for this 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 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) If the result differs from the expected value by more than the value given in paragraph (d), repeat the steps in this paragraph (c) up to two additional times.
(d) Performance evaluation. The coastdown force error determined in paragraph (c) of this section may not exceed 2.2 lbf.
(e) If the dynamometer is not able to meet this requirement, diagnose and repair the dynamometer prior to continuing with emissions testing. Diagnosis should include performing the verification and evaluation 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 driver's aid speed accuracy 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.

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(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 vehicles with GVWR at or below 14,000 lbs.

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

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

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This section describes coastdown procedures that are unique to heavy-duty vehicles with GVWR above 14,000 lbs. These procedures are valid for calculating road-load coefficients for chassis and post-transmission powerpack testing and for calculating drag area ($C_D A$) for use in the Greenhouse Gas Emissions Model (GEM) simulation tool under 40 CFR part 1037.

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(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.

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(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 in 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, whichever is greater. Data collection must occur through a minimum speed at or below 15 mph. Data

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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) [Reserved]
(iii) 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.
(iv) 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.
(v) Mount the anemometer at a height that is within 6 inches of half the test vehicle's maximum height.
(vi) Place the anemometer at least 50 feet from the nearest tree and at least 25 feet from the nearest bush (or equivalent roadside features).
(vii) 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 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) For the GEM simulation tool, determine drag area, C_DA, 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

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altitude corresponding to each interval as described in SAE J2263 if you need to incorporate the effects of road grade.

(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, 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. Let v_0 = 0 m/s.

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_DA, 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.

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

Eq. 1066.310-4

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

$\bar{P}_B$ = 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

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B = 0
C = D_{adj}

Subpart E—Vehicle Preparation and Running an Exhaust Emission Test

§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:

(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.

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

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standard setting part. Other preliminary procedures may apply as specified in the standard-setting part.
(a) Prepare the vehicle for testing as described in the standard-setting part.
(b) If testing will include measurement of refueling emissions, perform the vehicle preconditioning steps as described in the standard setting part.

§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 on dynamometer without starting engine 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 with GVWR at or below 14,000 lbs, use the following cooling fan configurations as allowed under Table 1:
(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 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.
(ii) 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 7.10 m^3/s and the fan should be placed within 61 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.
(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 in a location in front of the vehicles 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 18 square feet (4.25×4.25), however, other sizes can be used. The discharge nozzle should be placed within the range of (0.6 to 0.92) m 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

Comment [CAL12]: Confirm that SS part has vehicle prep for HDV > 14k.
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Deleted: Otherwise, perform the vehicle preconditioning steps as described in 40 CFR 86.132-00.
Deleted: See the standard-setting part for test cycles and soak times for the appropriate vehicle category. A test phase consists of engine startup (with accessories operated according to the standard-setting part), operation over the drive cycle, and engine shutdown.
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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.
(B) The fan air flow velocity vector perpendicular to the axial flow velocity vector shall be less than 10 percent 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 percent 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 percent of the measured air flow speed.

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

Test cycle	Allowable cooling fan configurations
FTP	1066.410(b)(1)(i), 1066.410(b)(1)(iii)
US06	1066.410(b)(1)(ii), 1066.410(b)(1)(iii)
SC03, AC1, AC2	1066.410(b)(1)(iv)
HFET	1066.410(b)(1)(i), 1066.410(b)(1)(iii)

(2) For vehicles with GVWR above 14,000 lbs, 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.

Deleted: The fan must provide no cooling air for vehicle speeds below 5 mph, unless we approve your request to provide cooling during low-speed operation based on a demonstration that this is appropriate to simulate the cooling experienced by in-use vehicles. We

(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 to 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. You may measure exhaust flow but not emissions during a practice run. 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.

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(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

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dynamometer coastdown procedures used for determining road-load coefficients. Report these tire pressure values with the test results.
(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. 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 with a GVWR at or below 14,000 lbs, determine ETW as described in 40 CFR part 86.129-00. Set dynamometer vehicle inertia, *I*, based on dynamometer type, as follows:
(i) For two-wheel drive dynamometers, set *I* = 1.015·ETW.
(ii) For four-wheel drive dynamometers, set *I* = ETW.
(2) For vehicles with a GVWR above 14,000 lbs, determine the vehicle's effective mass as described in 1066.310.
(i) Warm up the dynamometer as recommended by the dynamometer manufacturer.
(i) 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.
(a) Start the vehicle as follows:
(1) At the beginning of the test cycle, start the vehicle 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 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 disconnect the exhaust tube from the tailpipe during the diagnostic period. Reschedule

Deleted: For vehicles with GVWR above 14,000 lbs, you must use a vehicle pull down mechanism that allows simulation of the actual

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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".

(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 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, 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.

(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) 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 as follows:

(i) For vehicles with automatic transmission, use the brakes or accelerator pedal as necessary, without 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 engine stalling is imminent. You may recommend shift guidance 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 based on the shift pattern you describe in your 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 with compression-ignition engines and GVWR above 14,000 lbs, 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 (b). 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 with GVWR at or below 14,000 lbs, see the standard-setting part or Table 1 of §1066.425 for humidity requirements.
(2) For vehicles with GVWR above 14,000 lbs, you may test vehicles at any humidity.

Table 1 of §1066.425–Test cell nominal humidity requirements.

Test cycle	Humidity requirement (grains H_2O/lb of dry air)	Tolerance (grains H_2O/lb of dry air)
AC17	69	± 5
AC idle	50	± 5
FTP[1]	50	
HFET	50	
SC03, AC1, AC2	100	± 5
US06	50	

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

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Deleted: (2) Atmospheric pressure must be (80.000 to 103.325) kPa. You are not required to verify atmospheric pressure prior to a hot-start test interval for testing that also includes a cold start.¶
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(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)(iii)(C).
(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 automatically or manually switch gas analyzer ranges during a test only if switching is performed by changing the range 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).
(9) Zero and span all continuous gas analyzers using 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 ppm (µmol/mol), span the FID to respond with a value of 600 ppm (µmol/mol). 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.

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Deleted: (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. ¶

(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 paragraph (c)(5) of this section, 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.

Deleted: 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, unle ... [1]

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

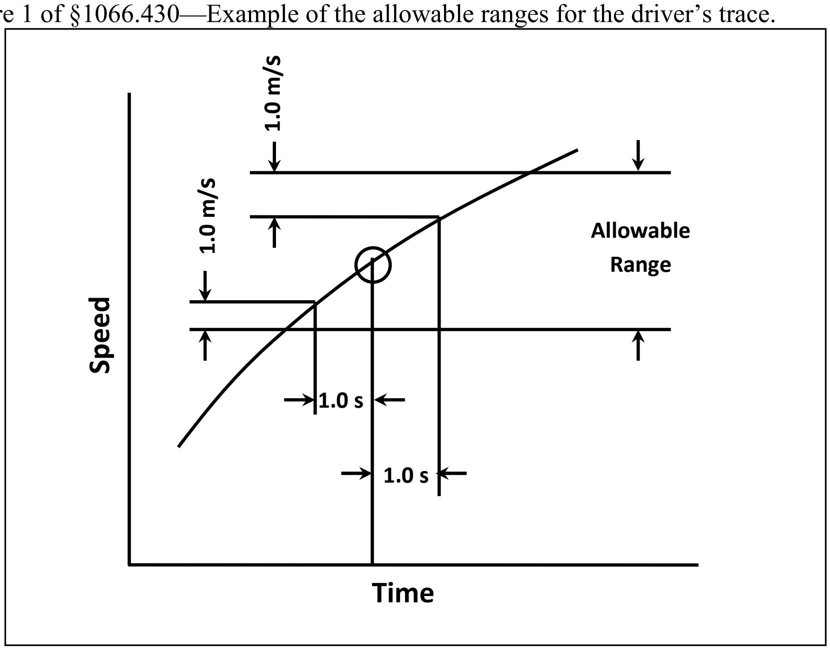
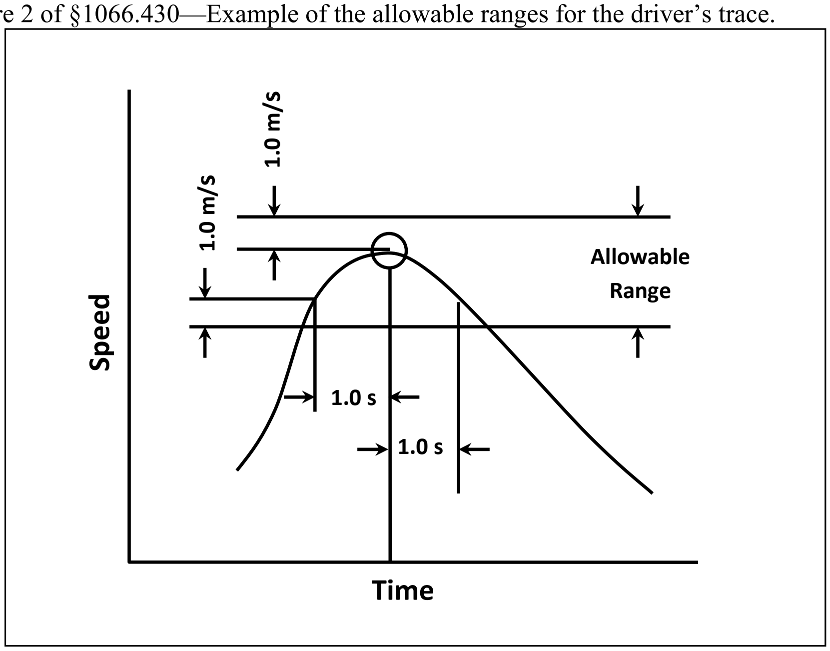


Figure 2 of §1066.430—Example of the allowable ranges for the driver's trace.



(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:
(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 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.
(5) 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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- **Deleted:** Drift
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- **Deleted:** Analyze nonconventional gaseous batch samples, such as NMHCEsampling with ethanol, as soon as practicable using good engineering judgment.
- **Deleted:** Analyze background samples no later than 60 minutes after the test cycle is complete.

(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.
(6) 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.
(j) For vehicles with GVWR at or below 14,000 lbs, validate 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) Submit a plot of the driven cycle energy trace for the test cycle compared to the target drive cycle energy trace.
(3) Determine the inertial work ratio as described in Section 7.2.3 of SAE J2951.

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Deleted: For testing vehicles with the following engines, you must record ambient temperature continuously to verify that it remains within the temperature range specified in §1066.420(b)(1) throughout the test:¶
(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).

Comment [CAL13]: Make effective in standard setting part for first MY of the Tier III program.

Subpart F—Hybrids

§1066.501 Overview.

To correct fuel economy or emission results for Net Energy Change of the RESS, use the following procedures:

(a) For vehicles with GVWR at or below 14,000 lbs, follow SAE J1711 (incorporated by reference in §1066.1010) except as noted in this paragraph (a). Use ±1 % of reading or ±0.1 % of full scale, whichever is greater, in place of the current measurement accuracy in Section 4.2a.

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

Comment [CAL14]: This is TBD, as it isn't clear if 0.1% FS is achievable across the range of measurements. The Alliance will get back to EPA on this item.

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Deleted: in SAE J2711 (incorporated by reference in §1066.710)

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. For all systems, make preliminary calculations as described in paragraph (c) of this section to correct concentrations.

(1) Concentration corrections. Perform the following sequence of preliminary calculations on recorded concentrations:

(2) For vehicles with GVWR above 14,000 lbs, 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. Correction is optional for vehicles with GVWR at or below 14,000 lbs.

(3) Correct all concentrations measured on a “dry” basis to a “wet” basis, including dilution air background concentrations.

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

(5) 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.

(6) Correct all NO_x emission values for test cell ambient air humidity as described in 40 CFR 1066.630.

(7) Correct all gaseous concentrations for dilution air background as described in 40 CFR 1066.620.

(8) 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:

$$m = V_{\mathrm{mix}} \cdot \rho \cdot x \cdot c$$

Deleted: as

Deleted: 40 CFR 86.144 or

Eq. 1066.610-1

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} = 170.925 m^3 (from paragraph (e) of this section)

ρ_{NOx} = 1.913 kg/m^3

x_{NOx} = 0.9663 ppm

$c = 10^{-6}$

$$m_{NOx} = 170.925 \cdot 1.913 \cdot 0.9666 \cdot 10^{-6} = 0.000327 \text{ kg}$$

(e) Calculate the mass of particulate matter emission using the following equation:

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

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 sample flow through the filter over the test phase at standard temperature and pressure.

V_{sdastd} = total volume of secondary dilution air flow 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} = 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 Equation 1066.610-3

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 Equation 1066.610-3

Comment [CAL15]: Identify units and precision for all.

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 Equation 1066.610-3

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 Equation 1066.610-3

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

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

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. 1066.610-3

Where:

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

$V_{[flow]act}$ = 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, dry-to-wet corrected.
$x_{[emission]bkgnd}$ = amount of measured emission in the dilution air, dry-to-wet corrected.
DF = dilution factor determined in §1066.620(b).

Example:
$x_{NOxdexh}$ = 1.07411 ppm
$x_{NOxbkgnd}$ = 0.12 ppm
DF = 9.516

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

(b) Determine the dilution factor, *DF*, over the test phase using Equation 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.

$$DF = \frac{100 \cdot \dfrac{1}{1 + \dfrac{\alpha}{2} + 3.76 \cdot \left(1 + \dfrac{\alpha}{4} - \dfrac{\beta}{2}\right)}}{x_{CO2} + \left(x_{NMHC} + x_{CH4} + x_{CO}\right) \cdot 10^{-4}}$$

Eq. 1066.620-2

Where:
x_{CO2} = amount of CO_2 measured in the sample over the test phase.
x_{NMHC} = amount of C_{-1} equivalent NMHC measured in the sample over the test.
x_{CH4} = amount of CH_4 measured in the sample over the test phase.
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_{NMHC} = 0.8 ppm
x_{CH4} = 0.2 ppm
x_{CO} = 80 ppm
α = 1.85
β = 0

$$DF = \frac{100 \cdot \dfrac{1}{1 + \dfrac{1.85}{2} + 3.76 \cdot \left(1 + \dfrac{1.85}{4} - \dfrac{0}{2}\right)}}{1.4 + \left(0.8 + 0.2 + 80\right) \cdot 10^{-4}} = 9.5659$$

§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 with GVWR at or below 14,000 lbs, apply a correction for any reciprocating engines for the following test cycles:

(1) For the FTP, US06, AC1, and AC2 test cycles, use the following equation:

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

Eq. 1066.630-1

$$H = \frac{M_{\mathrm{H2O}} \cdot RH\% \cdot p_{\mathrm{d}}}{M_{\mathrm{air}} \cdot (p_{\mathrm{B}} - p_{\mathrm{d}} \cdot RH\%)}$$

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

$$H = \frac{18.01528 \cdot 37.5 \cdot 0.01 \cdot 2.93}{0.02896559 \cdot (96.71 - 2.93 \cdot 37.5 \cdot 0.01)} = 7.14741 \text{ g H}_2\text{O vapor/kg dry air}$$

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

(2) For the SC03 test cycle, use the following equation:

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

Eq. 1066.630-3

Where:

H = Absolute humidity in grams of H_2O vapor per kilogram of dry air according to Equation 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

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

(b) For vehicles with GVWR above 14,000 lbs, apply correction factors as described in 40 CFR part 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.

Comment [CAL16]: Define a procedure.

§1066.650 Flow meter calibration calculations.
Calibrate flow meters as described in 40 CFR 1065.640. Note that 40 CFR 1065.640 presents all flow meter calibration 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 calibrate your flow meters volumetrically using Equation 1065.640-1 to convert the molar flow calibration equations throughout all of 40 CFR 1065.640 to volumetric flow equations. After you calibrate a flow meter using these calculations, use the calculations described in §1066.652 to calculate flow during an emission test.

§1066.652 SSV, CFV, and PDP 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 in 40 CFR 1065.642 to calculate flow during an emission test. 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.

§1066.665 NMOG determination.
For vehicles subject to an NMOG standard, determine NMOG as described in paragraph (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 (e) of this section.
(a) Determine NMOG by independently measuring alcohols and carbonyls as described

in 40 CFR 1065.805 and 1065.845. See the standard-setting part to determine which alcohols and carbonyls you need to measure. Note that the effective density used for NMHC mass determination should be based on $\rho_{\text{NMHC-liq}}$ as given in §1066.1005(f), regardless of the ethanol content of the test fuel. Calculate NMOG using the following equations:

Comment [CAL17]: Make sure this is in part 86.

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

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 Equation 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 Equation 1066.610-1. Note that the effective density used for NMHC mass determination should be based on $\rho_{\text{NMHC-liq}}$ as given in §1066.1005(f).

$\rho_{\text{NMHC-liq}}$ = 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).

$RF_{\text{OHCi[THC-FID]}}$ = 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:

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 (b) of this section based on ethanol (C_2H_5OH), methanol (CH_3OH), acetaldehyde (C_2H_4O), and formaldehyde (HCHO) 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

m_{C2H4O} = 0.00000005 kg

$RF_{\text{CH3OH[THC-FID]}}$ = 0.63

$RF_{\text{C2H5OH[THC-FID]}}$ = 0.75

$RF_{\text{HCHO[THC-FID]}}$ = 0.00

$RF_{\text{C2H4O[THC-FID]}}$ = 0.50

$\rho_{NMHC\text{-}liq}$ = 0.576816 kg/m^3
ρ_{CH3OH} = 1.33202 kg/m^3
ρ_{C2H5OH} = 0.957559 kg/m^3
ρ_{HCHO} = 1.24821 kg/m^3
ρ_{C2H4O} = 0.915658 kg/m^3

$$m_{NMOG} = 0.0000125 - 0.576816 \cdot \left(\begin{array}{l} \dfrac{0.0000002}{1.33202} \cdot 0.63 + \dfrac{0.0000009}{0.957559} \cdot 0.75 + \\ \dfrac{0.0000001}{1.24821} \cdot 0.00 + \dfrac{0.00000005}{0.915658} \cdot 0.5 \end{array} \right) +$$
$$0.0000002 + 0.0000009 + 0.0000001 + 0.00000005$$
$$= 0.000013273 \text{ kg}$$

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

(1) For hot running test cycles, you may determine NMOG based on the test cycle NMHC emission rate using Equation 1066.665-2.

$$e_{NMOGcomp} = e_{NMHC} \cdot 1.03$$

Eq. 1066.665-2

Where:

e_{NMOG} = mass emission rate of NMOG over the test cycle.

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

Example:

$e_{NMHCcomp}$ = 0.000025 kg/mi

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

(2) You may determine FTP composite NMOG based on the test cycle composite NMHC emission rate and the volume percent of ethanol in the fuel using Equation 1066.665-3.

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

Eq. 1066.665-3

Where:

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

$e_{NMHCcomp}$ = composite mass emission rate of NMHC over the test cycle calculated using $\rho_{NMHC\text{-}liq}$ 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 %

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

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

$$e_{\text{NMOGcomp}} = e_{\text{NMHCcomp}} \cdot (1.0246 + 0.0079 \cdot VP_{\text{EtOH}})$$

Eq. 1066.665-4

Where:

e_{NMOGcomp} = composite mass emission rate of NMOG over the FTP cold start test phase.

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

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

Example:

e_{NMHCcomp} = 0.000052 kg/mi

VP_{EtOH} = 15.1 %

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

(d) For diesel fuel, we consider NMOG emission values to be equivalent to NMHC emission values for all test cycles.

(e) 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.

Subpart H—Cold-Temperature Test Procedures

§1066.701 Applicability and general provisions.

(a) The procedures of this part 1066 generally apply as described in the standard-setting part for testing conducted at a nominal temperature of –7 °C (20 °F) and for testing at temperatures up to 20 °C (68 °F). See, for example, 40 CFR part 86, subpart C, for exhaust emission standards and 40 CFR part 600 for calculating fuel economy for light-duty motor vehicles.

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

Subpart I—Exhaust Emission Test Procedures for Vehicles Under 14,000 GVWR

§1066.801 Applicability and general provisions.

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

(b) This subpart covers the following test procedures:

(1) FTP.

(2) US06.

(3) SC03.

(4) AC1.

(5) AC2.

(6) AC17.

§1066.803 EPA dynamometer driving schedules.

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(a) Perform emission tests over certain driving schedules as follows:

(1) 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 driving 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.

(2) 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.

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

(4) 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. 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.

(b) Starting in model year 2022, speed tolerances and cycle-validation criteria apply as specified in 40 CFR part 1066, subpart E; however, for any driving that does not involve measuring exhaust emissions, the upper and lower speed tolerances are ±2.0 m/s (±4 mph), and up to three additional occurrences of speed variations greater than the tolerance are acceptable, 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) Flywheels, electrical, or other means of simulating test weight as shown in Table 1 of §1066.810 shall be used. If the equivalent test weight specified is not available on the dynamometer being used, the next higher equivalent test weight (not to exceed 250 pounds) available shall be used:

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Table 1 of §1066.810–Equivalent test weights.

Test weight basis[1]	Test equivalent test weight (pounds)	Inertia weight class (pounds)
Up to 1062	1,000	1,000
1063 to 1187	1,125	1,000
1188 to 1312	1,250	1,250
1313 to 1437	1,375	1,250
1438 to 1562	1,500	1,500
1563 to 1687	1,625	1,500
1688 to 1812	1,750	1,750
1813 to 1937	1,875	1,750
1938 to 2062	2,000	2,000
2063 to 2187	2,125	2,000
2188 to 2312	2,250	2,250
2313 to 2437	2,375	2,250
2438 to 2562	2,500	2,500
2563 to 2687	2,625	2,500
2688 to 2812	2,750	2,750
2813 to 2937	2,875	2,750
2938 to 3062	3,000	3,000
3063 to 3187	3,125	3,000
3188 to 3312	3,250	3,000
3313 to 3437	3,375	3,500
3438 to 3562	3,500	3,500
3563 to 3687	3,625	3,500
3688 to 3812	3,750	3,500
3813 to 3937	3,875	4,000
3938 to 4125	4,000	4,000
4126 to 4375	4,250	4,000
4376 to 4625	4,500	4,500
4626 to 4875	4,750	4,500

4876 to 5125	5,000	5,000
5126 to 5375	5,250	5,000
5376 to 5750	5,500	5,500
5751 to 6250	6,000	6,000
6251 to 6750	6,500	6,500
6751 to 7250	7,000	7,000
7251 to 7750	7,500	7,500
7751 to 8250	8,000	8,000
8251 to 8750	8,500	8,500
8751 to 9250	9,000	9,000
9251 to 9750	9,500	9,500
9751 to 10250	10,000	10,000
10251 to 10750	10,500	10,500
10751 to 11250	11,000	11,000
11251 to 11750	11,500	11,500
11751 to 12250	12,000	12,000
12251 to 12750	12,500	12,500
12751 to 13250	13,000	13,000
13251 to 13750	13,500	13,500
13751 to 14000	14,000	14,000

[4]For model year 1994 and later heavy light-duty trucks not subject to the Tier 0 standards of 40 CFR part 86.094–9, test weight basis is as follows: for emissions tests, the basis shall be adjusted loaded vehicle weight, as defined in 40 CFR part 86.094–2; and for fuel economy tests, the basis shall be loaded vehicle weight, as defined in 40 CFR part 86.082–2, or, at the manufacturer's option, adjusted loaded vehicle weight as defined in 40 CFR part 86.094–2. For all other vehicles, test weight basis shall be loaded vehicle weight, as defined in 40 CFR part 86.082–2.

(b)(1) For each test vehicle from an engine family required to comply with SFTP requirements, the manufacturer shall supply representative road load forces for the vehicle at speeds between 15 km/hr (9.3 mph) and 115 km/hr (71.5 mph). The road load force shall represent vehicle operation on a smooth level road, during calm winds, with no precipitation, at an ambient temperature of 20 °C (68 °F), and atmospheric pressure of 98.21 kPa. Road load force for low speed may be extrapolated. Manufacturers may, at their option, use road load forces meeting the objectives of paragraph (c) of this section for any vehicle.

(2) Set the dynamometer's power absorption for each vehicle's emission test sequence such that the force imposed during dynamometer operation matches actual road load force at all speeds.

(c)(1) Dynamometer inertia weight class selections for the test elements of FTP, US06, and SC03 are determined by the test vehicles test weight basis and corresponding equivalent weight as listed in Table 1 of §1066.810. All light-duty vehicles and light

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light-duty trucks must be tested at the inertia weight class corresponding to their equivalent test weight.

(i) For light-duty vehicles and light light-duty trucks, test weight basis is loaded vehicle weight, which is the vehicle weight plus 300 pounds.

(ii) For heavy light-duty trucks (HLDTs), the test weight basis for FTP and SFTP testing (both US06 and SC03), is the vehicle curb weight plus 300 pounds. For medium-duty passenger vehicles (MDPVs) certified to standards in bin 11 in Tables S04–1 and 2 in 40 CFR part 86.1811–04, the test weight basis must be adjusted loaded vehicle weight (ALVW) as defined in the standard setting part.

(2) Dynamic inertia load adjustments may be made by the dynamometer to the test inertia weight during specific US06 acceleration events.

(i) Any time the duration of throttle operation greater than or equal to 85% of wide open throttle (WOT) is greater than or equal to eight seconds, the test inertia load may be adjusted during any of five EPA specified acceleration events by an amount of load that will eliminate additional throttle operation greater than or equal to 85% of WOT. The dynamic inertia weight adjustment procedure must be approved in advance of conducting official US06 testing. We will perform confirmatory US06 testing using the same dynamometer inertia adjustment procedures as the manufacturer if:

(A) The manufacturer submits a request to us; and

(B) The manufacturer provides the dynamometer hardware and/or software necessary for these adjustments to EPA.

(ii) The specific US06 schedule accelerations time periods where inertia load adjustments may be applied are:

(A) 49 through 69 seconds;

(B) 83 through 97 seconds;

(C) 135 through 165 seconds;

(D) 315 through 335 seconds; and

(E) 568 through 583 seconds.

(iii) During these five time intervals when inertia load adjustment is occurring, inertia load adjustment is discontinued when throttle operation is less than 85% of WOT or at the end of the specified time interval.

§1066.812 Test sequence; general requirements.

Paragraphs (a) through (d) of this section apply to vehicles tested for the FTP test. Paragraph (e) of this section applies to vehicles tested for the SFTP supplemental tests of aggressive driving (US06) and air conditioning (SC03). Paragraph (f) of this section applies to all emission testing.

(a)(1) Gasoline-fueled vehicles. The test sequence shown in Figure 1 of §1066.820 shows the steps encountered as the test vehicle undergoes the procedures subsequently described to show compliance with the standards. The full three- diurnal sequence depicted in Figure 1 of §1066.820 tests vehicles for all sources of evaporative emissions. The supplemental two-diurnal test sequence is designed to verify that vehicles sufficiently purge their evaporative canisters during the exhaust emission test. 40 CFR parts 86.132–96, 86.133–96 and 86.138–96 describe the separate specifications of the supplemental two-diurnal test sequence.

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(A) For the aggressive driving cycle (US06), the test weight basis is the vehicle curb weight plus 300 pounds.¶
(B) For the FTP and the air conditioning (SC03) element of the SFTP, the test weight is the average of the curb weight plus GVWR.¶
(C) Regardless of other requirements in this section relating to the testing of HLDTs, for Tier 2 HLDTs,

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(2) Gaseous-fueled vehicles. The test sequence shown in Figure 1 of §1066.820 shows the steps encountered as the test vehicle undergoes the procedures subsequently described to show compliance with the standards, with the exception that the fuel drain and fill and precondition canister steps are not required for gaseous-fueled vehicles. In addition, the supplemental two-diurnal test and the running loss test are not required.

(b) The vehicle test for fuel spitback during fuel dispensing is conducted as a stand-alone test described in 40 CFR part 86.146. This test is not required for gaseous-fueled vehicles.

(c) Ambient temperature levels encountered by the test vehicle shall be (20 to 30) °C, unless otherwise specified. If a different ambient temperature is specified for soaking the vehicle, the soak period may be interrupted once for up to 10 minutes to transport the vehicle from one soak area to another, provided 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.

(d) Use good engineering judgment to ensure that the vehicle remains approximately level during all phases of the test sequence to prevent abnormal fuel distribution.

(e) The supplemental tests for exhaust emissions related to US06 and SC03 use are conducted as stand-alone tests as described in §§1066.830, 1066.831, and 1066.832. These tests may be performed in any sequence that maintains the appropriate preconditioning requirements for these tests as specified in §1066.816.

(f) If tests are void after collection of emission data from previous test segments, the test may be repeated to collect only those data points needed to complete emission measurements. Compliance with emission standards may be determined by combining emission measurements from different test runs. If any emission measurements are repeated, the new measurements supersede previous values.

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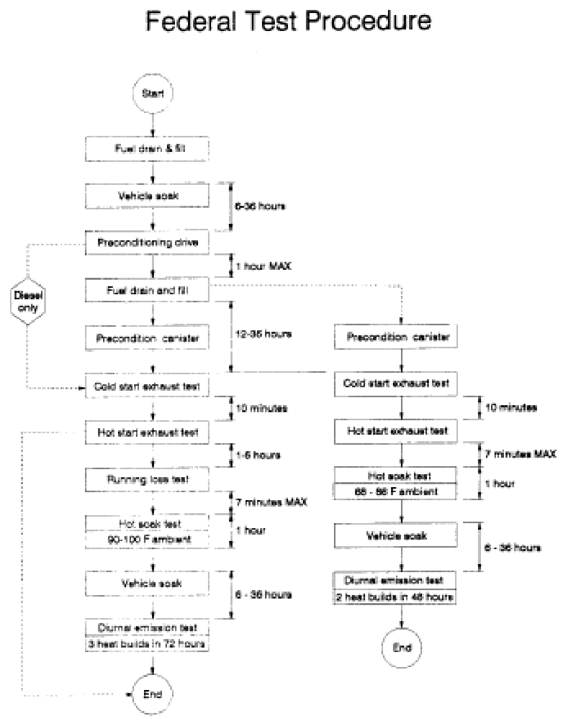

Figure B96-10 Test sequence

§1066.814 Vehicle preparation.

(a) For gasoline-fueled vehicles prepare the fuel tank(s) for recording the temperature of the prescribed test fuel, as described in 40 CFR part 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 the evaporative emission canister(s) with butane, provide valving or other means as necessary to allow purging and loading of the canister(s).

(d) For vehicles to be tested for running loss emissions, prepare the fuel tank(s) for measuring and recording the temperature and pressure of the fuel tank as specified in 40 CFR part 86.107–98(e) and (f). Measurement of vapor temperature 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. The exhaust system shall be tested or inspected to ensure that detectable exhaust hydrocarbons are not emitted into the running loss enclosure during the running loss test.

(f) For vehicles to be tested for US06 emissions, provide a throttle position sensing signal that is compatible with the test dynamometer. This signal provides the input information that controls dynamometer dynamic inertia weight adjustments described in

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§1066.810(b)(2). If a manufacturer chooses not to implement dynamic inertia adjustments for a portion or all of their product line, this requirement is not applicable.
(g) 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 part 86.1813:
(1) Manufacturers must notify EPA 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.

§1066.816 SFTP vehicle preconditioning.
(a) The SFTP test elements of US06 and SC03 can be run immediately or up to 72 hours after the official FTP and/or evaporative test sequence without refueling provided the vehicle has remained under laboratory ambient temperature conditions. If the time interval exceeds 72 hours or the vehicle leaves the ambient temperature conditions of the laboratory, the manufacturer must repeat the refueling operation.
(b) US06 preconditioning. (1) If the US06 test follows the exhaust emission FTP or evaporative testing, the refueling step may be deleted and the vehicle may be preconditioned using the fuel remaining in the tank as described in paragraph (a) of this section. The test vehicle may be pushed or driven onto the test dynamometer. Acceptable cycles for preconditioning are as follows:
(i) Preconditioning may consist of a 505, 866, highway, US06, or SC03 test cycles.
(ii) If a manufacturer has concerns about fuel effects on adaptive memory systems, a manufacturer may precondition a test vehicle on test fuel and the US06 cycle. Upon request from a manufacturer, we will also perform the preconditioning with the US06 cycle.
(iii) The preconditioning cycles for the US06 test schedule are conducted at the same ambient test conditions as the certification US06 test.
(2) Following the preconditioning specified in paragraphs (b)(1)(i), (ii), and (iii) of this section, the test vehicle must be returned to idle for one to two minutes before the start of the official US06 test cycle.
(c) SC03 preconditioning. (1) If the SC03 test follows the exhaust emission FTP or evaporative testing, the refueling step may be deleted and the vehicle may be preconditioned using the fuel remaining in the tank as described in paragraph (a) of this section. The test vehicle may be pushed or driven onto the test dynamometer. Acceptable cycles for preconditioning are as follows:
(i) If the soak period since the last exhaust test element is less than or equal to two hours, preconditioning may consist of a 505, 866, or SC03 test cycles.
(ii) If the soak period since the last exhaust test element is greater than two hours, preconditioning consists of one full UDDS. Manufacturers, at their option, may elect to

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use the preconditioning in paragraph (c)(1)(i) of this section when the soak period exceeds two hours.
(2) Following the preconditioning, the test vehicle is turned off, the vehicle cooling fan(s) is turned off, and the vehicle is allowed to soak for 10 minutes prior to the start of the official SC03 test.
(3) The preconditioning cycles for the SC03 test and the 10 minute soak are conducted at the same ambient test conditions as the SC03 certification test.

§1066.818 Records required.
The following information shall be recorded with respect to each test:
(a) Test number.
(b) System or device tested (brief description).
(c) Date and time of day for each part of the test schedule.
(d) Test results. Also include a validation of driver accuracy as described in §1066.430(j).
(e) Driver and equipment operator IDs.
(f) Vehicle. ID number, manufacturer, model year, standards, engine family, evaporative emissions family, basic engine description (including displacement, number of cylinders, turbo-/supercharger used, and catalyst usage), fuel system (including number of carburetors, number of carburetor barrels, fuel injection type, and fuel tank(s) capacity and location), engine code, gross vehicle weight rating, inertia weight class, actual curb weight at zero miles, actual road load at 50 mph (80 kph), transmission configuration, axle ratio, car line, system miles, idle rpm, and drive wheel tire pressure, as applicable.
(g) Dynamometer. Dynamometer ID, inertia weight setting, indicated power absorption setting, records to verify compliance with the vehicle speed versus time requirements of the test, and driving distance for each of the three phases of the test, calculated from the measured roll or shaft revolutions.
(h) Gas analyzers. Analyzer bench ID, analyzer ranges, recordings of analyzer output during zero, span, and sample readings.
(i) Recorder charts: Test number, date, vehicle ID, operator ID, and identification of the measurements recorded.
(j) Test cell barometric pressure, ambient temperature, and humidity. A central laboratory barometer may be used provided, that individual test cell barometric pressures are shown to be within ±0.1 percent of the barometric pressure at the central barometer location.
(k) Temperatures. Records to verify compliance with the ambient temperature requirements throughout the test procedure and recordings of vehicle fuel temperature(s) during the diurnal test and of the enclosure temperatures during the diurnal and hot soak tests.
(l) CVS. (1) CFV and SSV. V_{mix} for each phase of the exhaust test.
(2) PDP. Test measurements required to calculate the V_{mix}. V_{mix} for each phase of the exhaust test.
(3) Dilution factor for each phase of the exhaust test.
(m) The humidity of the dilution air if you remove H_2O from an emissions sample prior to measurement.

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(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(s) or flow instrumentation used for particulate sampling.
(p) The maximum gas temperature within 20 cm upstream or downstream of the filter media.
(q) If applicable, the temperature of the gas flowing in the heated sample line before the heated filter, and also before the HFID, and the temperature of the control system of the heated hydrocarbon detector.
(r) Gas meter or flow measurement instrumentation readings at the start of each sample period and at the end of each sample period.
(s) The stabilized pre-test weight and post-test weight of each particulate sample filter.
(t) Continuous temperature and humidity recording of the ambient air in which the particulate filters were stabilized.
(u) Additional required records for natural gas-fueled vehicles. Composition, including all carbon containing compounds; e.g. CO_2, of the natural gas-fuel used during the test. C_1 and C_2 compounds shall be individually reported. C_3 and heavier hydrocarbons, and C_6 and heavier compounds may be reported as a group.
(v) Additional required records for liquefied petroleum gas-fueled vehicles. Composition of the liquefied petroleum gas-fuel used during the test. Each hydrocarbon compound present, through C_4 compounds, shall be individually reported. C_5 and heavier hydrocarbons may be reported as a group.

§1066.820 Exhaust emission test procedures for FTP emissions.

(a) General. The dynamometer run consists of two tests, a "cold" start test, after a minimum 12-hour and a maximum 36-hour soak according to the provisions of 40 CFR parts 86.132 and 86.133, and a "hot" start test following the "cold" start by 10 minutes and is described in 1066.803(a)(1). Composite samples collected in bags are analyzed for PM, THC or NMOG, CO, CO_2, CH_4 and NO_x. For diesel cycle vehicles, THC emissions are measured on a continuous basis according to 40 CFR part 1065.
(b) The following steps shall be taken for the FTP test in place of the procedures in §§1066.410, 1066.420, 1066.425, and 1066.430:
(1) Start sampling and recording simultaneously with the start of 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 according to the Urban Dynamometer Driving Schedule as described in §1066.803.
(5) At the end of the deceleration which is scheduled to occur at 505 seconds, simultaneously switch the sample flows from the cold start phase transient samples to the stabilized phase samples, stopping all cold start phase sampling and recording, including background sampling. Finally, 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 (at 1,369 seconds).

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(7) Five seconds after the engine stops running, stop all stabilized phase sampling and recording, including background sampling and stop integrating devices for the stabilized phase, indicating the end of the phase in the recorded data.

(8) Repeat the steps in paragraphs (b)(1) through (b)(4) of this section for the hot start test, noting that the step in paragraph (b)(1) of this section shall begin between 9 and 11 minutes after the end of the sample period for the cold start UDDS.

(9) At the end of the deceleration which is scheduled to occur at 505 seconds, simultaneously stop all hot start phase sampling and recording, including background sampling.

(10) Vehicles that are to be tested for evaporative emissions shall proceed according to 40 CFR part 86.134. Vehicles that are to be tested with the supplemental two-diurnal test sequence for evaporative emissions shall proceed according to 40 CFR part 86.138–96(k). For all others this completes the test sequence.

§1066.822 Calculations; FTP exhaust emissions.

(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, $e_{\text{[emission]FTPcomp}}$, in grams/mile using equation §1066.822-1:

$$e_{\text{[emission]FTPcomp}} = 0.43 \cdot \left(\frac{m_{1,2}}{D_{\text{ct}} + D_{\text{s}}} \right) + 0.57 \cdot \left(\frac{m_{2,3}}{D_{\text{s}} + D_{\text{ht}}} \right)$$

Eq. 1066.822-1

Where:

$m_{1,2}$ = Mass emissions determined from the test phase consisting of the cold start UDDS (generally known as bags 1 and 2), in grams per test phase.

$m_{2,3}$ = Mass emissions determined from the test phase consisting of a full hot start UDDS in grams per test phase. This may involve 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).

D_{ct} = The measured driving distance from the transient portion of the cold start test (bag 1), in miles.

D_{s} = The measured driving distance from the stabilized portion of the cold start or hot start test (bag 2 or bag 4), as applicable, in miles.

D_{ht} = The measured driving distance from the transient portion of the hot start test (bag 3), in miles.

(c) For all pollutants, mass emissions for the cold start UDDS may alternatively be collected separately for the cold start transient portion and the stabilized portion, then added together for a single cold start mass, $m_{1,2}$. Similarly, mass emissions for the hot start UDDS may alternatively be collected separately for the hot start transient portion and the stabilized portion, then added together for a single hot start mass, $m_{2,3}$.

§1066.830 Supplemental Federal Test Procedures; overview.

The procedures described in §§1066.830, 1066.831, 1066.832, and 1066.834 discuss the aggressive driving (US06) and air conditioning (SC03) elements of the Supplemental Federal Test Procedures (SFTP). These test procedures consist of two separable test

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elements: A sequence of vehicle operation that tests exhaust emissions with a driving schedule (US06) that tests exhaust emissions under high speeds and accelerations (aggressive driving); and a sequence of vehicle operation that tests exhaust emissions with a driving schedule (SC03) which includes the impacts of actual air conditioning operation. These test procedures, and the associated standards set forth in 40 CFR part 86 subpart S, are applicable to light-duty vehicles and light-duty trucks.

(a) Vehicles are tested for the exhaust emissions of PM (if applicable), THC or NMOG, CO, NO_x, CH_4, and CO_2.

(b) Each test procedure follows the vehicle preconditioning specified in §1066.816.

(c) US06 Test Cycle. The US06 test procedure in §1066.831 is designed to determine gaseous exhaust emissions from light-duty vehicles and light-duty trucks while simulating high speed and acceleration on a chassis dynamometer (aggressive driving). The full test consists of preconditioning the engine to a hot stabilized condition, as specified in §1066.816, and an engine idle period of 1 to 2 minutes, after which the vehicle is accelerated into the US06 cycle. A proportional part of the diluted exhaust is collected continuously for subsequent analysis. Optionally, as specified in §1066.831 and in 40 CFR part 600, a proportional part of the diluted exhaust may be collected continuously in two bag samples, one representing US06 City driving and the other representing US06 Highway driving.

(d) SC03 Test Cycle. The SC03 test procedure in §1066.832 is designed to determine gaseous exhaust emissions from light-duty vehicles and light-duty trucks while simulating an urban trip during ambient conditions of 35 °C, 100 grains of water/pound of dry air (approximately 40 percent relative humidity), and a solar heat load intensity of 850 W/m^2. The full test consists of vehicle preconditioning as described in §1066.816 paragraphs (c)(1) and (2)), an engine key-off 10 minute soak, an engine start, and operation over the SC03 cycle. A proportional part of the diluted exhaust is collected continuously during the engine start and the SC03 driving cycle for subsequent analysis.

(e) The emission results from the aggressive driving test (§1066.831), air conditioning test (§1066.832), and FTP test (§1066.820 (a) through (d) and (f)) conducted on a dynamometer that meets the requirements of subpart C of this part, are analyzed according to the calculation methodology in §1066.836 and compared to the applicable SFTP emission standards in 40 CFR part 86, subpart S.

(f) These test procedures may be run in any sequence that maintains the applicable preconditioning elements specified in §1066.816.

§1066.831 Exhaust emission test procedures for US06 emissions.

(a) General. The dynamometer operation consists of a single, 600 second test on the US06 driving schedule, as described in appendix I, paragraph (g), of 40 CFR part 86. The vehicle is preconditioned in accordance with §1066.816, to bring it to a warmed-up stabilized condition. Preconditioning is followed by a 1 to 2 minute idle period that proceeds directly into the US06 driving schedule during which emissions are measured. US06 emissions may optionally be collected in two bag samples representing US06 City and US06 Highway emissions, as provided for in this section and in 40 CFR part 600. Emissions from seconds 0–130 and seconds 495–596 are collected in one bag to represent US06 City emissions, and emissions from seconds 130–495 are collected in a second bag to represent US06 Highway emissions. Composite samples collected in bags

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are analyzed for PM (if applicable), THC or NMOG, CO, CO_2, CH_4, and NO_x. For diesel cycle vehicles, THC emissions are measured on a continuous basis according to 40 CFR part 1065.

(b) The following steps shall be taken for the US06 test in place of the procedures in §§1066.410, 1066.420, 1066.425, and 1066.430:

(1) Required US06 schedule test 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).

(2) Set the dynamometer test inertia weight and roadload horsepower requirements for the test vehicle according to §1066.810 (b) and (c). The dynamometer's horsepower adjustment settings shall be set to match the force imposed during dynamometer operation with actual road load force at all speeds.

(3) Practice runs over the prescribed driving schedule may be performed, provided an emission sample is not taken, for the purpose of determining the appropriate throttle action to maintain proper speed-time relationship, or to permit sampling system adjustment.

(4) Follow the vehicle preconditioning requirements in §1066.830(c). The test cycle equivalent dynamometer mileage is 8.0 miles (1.29 km).

(5) Start sampling and recording simultaneously with placing the vehicle in gear. Begin the first acceleration 5 seconds after placing the vehicle in gear.

(6) Operate the vehicle according to the US06 driving schedule, as described in appendix I, paragraph (g), of 40 CFR part 86.

(7) Paragraphs (b)(7)(i) and (ii) of this section apply to vehicles for which the manufacturer is collecting US06 City and US06 Highway emissions for subsequent analysis according to the provisions of 40 CFR part 600. Vehicles for which emissions are being collected in a single continuous sample for subsequent analysis must be tested according to paragraph (8) of this section, and this paragraph (f)(7) will not apply.

(i) Two seconds after the end of the deceleration which is scheduled to occur at 128 seconds (i.e., at 130 seconds), simultaneously stop all "US06 City", and start all "US06 Highway" sampling, recording, and integrating; including background sampling. Before the acceleration which is scheduled to occur at 136 seconds, record the measured roll or shaft revolutions.

(ii) Two seconds after the end of the deceleration which is scheduled to occur at 493 seconds (i.e., at 495 seconds), simultaneously stop all "US06 Highway", and start all "US06 City" sampling, recording, and integrating; including background sampling. Before the acceleration which is scheduled to occur at 500 seconds, record the measured roll or shaft revolutions.

(8) Turn the engine off 2 seconds after the end of the last deceleration (i.e., engine off at 596 seconds).

(9) Five seconds after the engine stops running, 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.

(10) NO_x humidity correction. Calculated NO_x exhaust emissions from US06 tests conducted in a standard test cell at a nominal 50 grains of H_2O/pound of dry air are to be corrected for humidity to 50 grains of H_2O/pound of dry air according to §1066.630(a)(1).

Deleted: For petroleum-fueled diesel-cycle vehicles, THC is sampled and analyzed continuously according to the provisions of §86.110. Parallel bag samples of dilution air are analyzed for THC, CO, CO_2, CH_4, and NO_x.

Deleted: *Dynamometer activities.* (1) All official US06 tests shall be run on a large single roll electric dynamometer, or an approved equivalent dynamometer configuration, that satisfies the requirements of §86.108–00.

Deleted: (2) Position (vehicle can be driven) the test vehicle on the dynamometer and restrai ... [21]

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Deleted: (e) Perform the test bench sampling sequence outlined in §86.140–94 prior to or in conjunction with each series of exhaust emission measurements.¶
(f) *Test activities.* (1) The US06 consists of a single test which is directly preceded by a vehicle preconditioning in accordance with §86.132–00. Following the vehicle preconditioning, the vehicle is idled for not less than one minute and not more than two minutes.…4) Follow the vehicle precon ... [24]

Deleted: (2) The following steps shall be taken for each test:¶
(i) Immediately after completion of the preconditioning, idle the vehicle. The idle period is not to be less than one minute or greater than two minutes.¶
(ii) With the sample selector valves in the "standby" position, connect evacuated sample collection bags to the dilute exhaust and dilution air sample collection systems.¶
(iii) Start the CVS (if not already on), the sample pumps, the temperature recorder, the vehicle cooling fan, and the heated THC analysis recorder (diesel-cycle only). The heat exchanger of the constant volume sampler, if used, petroleum-fueled diesel-cycle THC analyzer continuous sample line should be preheated to their respective operating temperatures before the test begins.¶
(iv) Adjust the sample flow rates to the desired flow rate and set the gas flow measuring devices to zero.¶
(A) For gaseous bag samples (except THC samples), the minimum flow rate is 0.17 cfm (0.08 liters/sec).¶
(B) For THC samples, the minimum FID (or HFID in the case of diesel-cycle vehicles) flow rate is 0.066 cfm (0.031 liters/sec).¶
(C) CFV sample flow rate is fixed by the venturi design.¶
(v) Attach the exhaust tube to the vehicle tai ... [25]

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§ 1066.832 Exhaust emission test procedure for SC03 emissions.

(a) General. The dynamometer operation consists of a single, 600 second test on the SC03 driving schedule, as described in appendix I, paragraph (h), of 40 CFR part 86. The vehicle is preconditioned, in accordance with §1066.816 of this subpart, to bring the vehicle to a warmed-up stabilized condition. This preconditioning is followed by a 10 minute vehicle soak (engine off) that proceeds directly into the SC03 driving schedule, during which gaseous emissions are measured. The entire test, including the preconditioning driving, vehicle soak, and SC03 official test cycle, is either conducted in an environmental test facility or under test conditions that simulate testing in an environmental test cell. Alternative procedures which appropriately simulate full environmental cell testing may be approved under the provisions of §§1066.833(a) and 1066.834. The environmental test facility must be capable of providing the following nominal ambient test conditions of: 35 °C air temperature, 100 grains of water/pound of dry air (approximately 40 percent 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 vehicle's air conditioner is operated or appropriately simulated for the duration of the test procedure, including the preconditioning, with the exception of the 10 minute soak. Composite samples collected in bags are analyzed for THC or NMOG, CO, CO_2, CH_4, and NO_x. For diesel cycle vehicles, THC emissions are measured on a continuous basis according to 40 CFR part 1065.

(b) The following steps shall be taken for the SC03 test in place of the procedures in §§1066.410, 1066.420, 1066.425, and 1066.430:

(1) Required SC03 schedule test 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).

(2) Set the dynamometer test inertia weight and roadload horsepower requirements for the test vehicle according to §1066.810 (b) and (c). The dynamometer's horsepower adjustment settings shall be set such that the force imposed during dynamometer operation matches actual road load force at all speeds.

(3) Drain and fill the vehicle's fuel tank to 40 percent capacity with test fuel. If a vehicle has gone through the drain and fuel sequence less than 72 hours previously and has remained under laboratory ambient temperature conditions, this drain and fill operation can be omitted as described in §1066.816(a).

(4) In addition to the cooling fan requirements of §1066.410(b)(1)(iv), for cases where vehicles have rear 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 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 part 1065.10.

(5) Close all vehicle windows prior to testing.

(6)(i) Set the environmental test cell ambient test conditions to the conditions defined in §1066.833.

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Deleted: *Dynamometer activities.* (1) All official air conditioning tests shall be run on a large single roll electric dynamometer or an equivalent dynamometer configuration that satisfies the requirements of §86.108–00.

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Deleted: 4…) Set the dynamometer test in ... [34]

Deleted: (5) The vehicle speed as measured from the dynamometer rolls shall be used. A speed vs. time recording, as evidence of dynamometer test validity, shall be supplied at request of the Administrator.¶
(6) The drive wheel tires may be inflated up to a gauge pressure of 45 psi (310 kPa), or the manufacturer's recommended pressure if higher than 45 psi, in order to prevent tire damage. The drive wheel tire pressure shall be reported with the test results.¶
(7) The driving distance, as measured by counting the number of dynamometer roll or shaft revolutions, shall be determined for the test.¶
(8) Four-wheel drive and all-wheel drive vehicles may be tested either in a four-wheel drive or a two-wheel drive mode of operation. In order to test in the two-wheel drive mode, four-wheel drive and all-wheel drive vehicles may have one set of drive wheels disengaged; four-wheel and all-wheel drive vehicles which can be shifted to a two-wheel mode by the driver may be tested in a two-wheel drive mode of operation.¶
(c) *Vehicle and test activities for testing in a full environmental cell.* The SFTP air conditioning test in an environmental test cell is composed of the following sequence of activities. Alternative procedures which appropriately simulate full environmental cell testing may be approved under the provisions of §§86.162–00(a) and 86.16 ... [35]

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Deleted: (4) Connect the emission test sampling system to the vehicle's exhaust tail pipe(s).¶ ... [37]

(ii) Turn on the solar heating system.
(iii) All vehicle test phases of preconditioning, soak, and the official SC03 test cycle are to be performed at this set of ambient test conditions.
(7) Set the air conditioning system controls as follows:
(i) Select A/C mode and the Maximum setting.
(ii) Set airflow to Recirculate, if so equipped.
(iii) Set the fan to the Highest setting.
(iv) Set the A/C Temperature at full cool (for automatic systems set at 72 °F).
(v) Place air conditioning controls in the "on" position prior to vehicle starting so that the air conditioning system is active whenever the engine is running.
(8) Start the vehicle with air conditioning system on and conduct a preconditioning cycle as described in §1066.816(c)(1).
(8) Following the preconditioning cycle, the test vehicle (and consequently the air conditioning system) and cooling fan(s) are turned off and the vehicle is allowed to soak in the ambient conditions of paragraph (c)(6) of this section for 10 ±1 minutes.
(9) Initiate data logging, sampling of exhaust gases, and integrating measured values before starting the engine.
(10) 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.
(11) Eighteen seconds after the engine starts, begin the initial vehicle acceleration of the SC03 driving schedule.
(12) Operate the vehicle according to the SC03 driving schedule, as described in appendix I, paragraph (h), of 40 CFR part 86.
(13) Turn the engine off 2 seconds after the end of the last deceleration (i.e., engine off at 596 seconds).
(14) Five seconds after the engine stops running, 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.
(15) NO_x humidity correction. Calculated NO_x exhaust emissions from air conditioning tests conducted in an environmental test cell at a nominal 100 grains of H_2O/pound of dry air are to be corrected for humidity to 100 grains of H_2O/pound of dry air according to §1066.630(a)(2).

§ 1066.833 Air conditioning environmental test facility ambient requirements.
The goal of an air conditioning test facility is to simulate the impact of an ambient heat load on the power requirements of the vehicle's air conditioning compressor while operating on a specific driving cycle. The test facility environmental control elements put in place to facilitate this test are ambient air temperature and humidity, minimum test cell size, solar heating, and vehicle frontal air flow.
(a) Ambient air temperature. (1) Control ambient air temperature in the test cell during all phases of the air conditioning test sequence to 95 ±2 °F on average and 95 ±5 °F as an instantaneous measurement.
(2) 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

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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.

(b) Ambient humidity. (1) Ambient humidity is controlled, within the test cell, during all phases of the air conditioning test sequence as described in §1066.425(d)(2).

(2) Recorded 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.

(c) Minimum test cell size. (1) The recommended minimum environmental test cell size for measuring exhaust emissions is 20 feet wide, 40 feet long, and 10 feet high.

(2) Test cells with smaller size dimensions may be approved by EPA if it can be shown that all of the ambient test condition performance requirements are satisfied.

(d) Solar heat loading. (1)(i) The following types of radiant energy emitters are acceptable for simulating solar heat load:

(A) Metal halide;

(B) Quartz halogen with dichroic mirrors; and

(C) Sodium iodide.

(ii) Other types of radiant energy emitters may be used with our approval if the manufacturer can show they satisfy the requirements of this section.

(2) The height of the minimal cell size will dictate the type of radiant energy source that will satisfy the spectral distribution and uniformity definitions of this section.

(3) Radiant energy specifications. (i) Simulated solar radiant energy intensity is determined as an average of the two points measured at:

(A) Centerline of the test vehicle at the base of the windshield.

(B) Centerline of the vehicle at the base of the rear window (truck and van locations are defined as the bottom of vertical window or where an optional window would be located).

(ii) The radiant energy intensity set point is 850 ±45 w/m^2.

(iii) The definition of an acceptable spectral distribution can be found in Table 1 of §1066.833:

Table 1 of §1066.833–Definition of the Spectral Distribution[a]

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

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

(iv) The angle of incidence of radiant energy is defined as 90 degrees from the test cell floor.

(v) The requirements for measuring the uniformity of radiant energy are as follows:

(A) The radiant energy uniformity tolerance is ±15 % of the radiant energy intensity set point of 850 w/m^2.

(B) The uniformity of radiant energy intensity is measured at each point of a 0.5 m grid over the entire footprint of the test vehicle at the elevation of 1 m, including the footprint edges.

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(C) Check radiant energy uniformity at least every 500 hours of emitter usage or every six months depending on which covers the shorter time period; and every time major changes in the solar simulation hardware occur.

(vi) The minimum measurement instrument specifications for radiant energy intensity are as follows:

(A) Sensitivity of 9 microvolts per watt/m^2;

(B) Response time of 1 second;

(C) Linearity of ± 0.5 percent; and

(D) Cosine of ± 1 percent from normalization 0–70 degree zenith angle.

(e) Vehicle frontal air flow. The Administrator will approve frontal air flow based on “blower in box” technology as an acceptable simulation of environmental air flow cooling for the air conditioning compressor and engine, provided the requirements of §1066.410(b)(1)(iv) are satisfied. Verify the design specifications of §1066.410(b)(1)(iv) prior to conducting certification air conditioning tests.

§ 1066.834 Approval of alternative air conditioning test simulations and descriptions of AC1 and AC2.

The alternative air conditioning test procedures AC1 and AC2 are approved by EPA for all light-duty vehicles and light-duty trucks only for the model years of 2000, 2001, and 2002. To obtain Administrator approval of other simulation test procedures a manufacturer must satisfy the requirements of paragraph (a) of this section and meet the requirements of §1066.836. Air conditioning tests AC1 and AC2 are simulations of the environmental test cell air conditioning test discussed in §1066.832. AC1 simulates, in standard test cell ambient conditions and with the air conditioning off, the exhaust emission results of air conditioning operation in an environmental test cell by adding additional power requirements to roadload dynamometer requirements. AC2 simulates, in standard test cell ambient conditions and with the air conditioning controls in the heat position, the exhaust emission results of air conditioning operation in an environmental test cell by adding a heat load to the passenger compartment. The only differences between the test activities described in §1066.832 and those for AC1 and AC2 occur as the result of how the effect of the environmental cell ambient test conditions, defined in §1066.832(b)(6)(i), are simulated in a standard test cell nominal ambient conditions of 76 °F and 50 grains of water/pound of dry air. Paragraph (a) of this section discusses the procedure by which a manufacturer can obtain EPA approval of other air conditioning test simulation procedures. Paragraph (b) of this section describes the AC1 test procedure and paragraph (c) of this section describes the AC2 test procedure.

(a) Upon petition from a manufacturer or upon our own initiative, we will approve a simulation of the environmental cell for SC03 testing described in §1066.832 providing that the procedure can be run by EPA for selective enforcement audits (SEA) and in-use enforcement testing and providing that the criteria of paragraphs (a)(1)(2), and (3) of this section are satisfied.

(1) In deciding whether approvals will be granted, we will consider data showing how well the simulation matches environmental cell test data for the range of vehicles to be covered by the simulation including items such as the tailpipe emissions, air conditioning compressor load, and fuel economy.

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(1) The minimum air flow nozzle discharge area must be equal or exceed the vehicle frontal inlet area. Optimum discharge area is 18 square feet (4.25×4.25), however, other sizes can be used.¶
(2) 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.¶
(3) The fan air flow velocity vector perpendicular to the axial flow velocity vector shall be less than 10 percent of the mean velocity measured at fan speeds corresponding to vehicle speeds of 20 and 40 mph.¶
(4)(i) 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.¶
(ii) The uniformity of axial flow tolerance is 20 percent of the fan speeds corresponding to vehicle speeds of 20 and 40 mph.¶ ... [42]

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(2) We have approved test procedures AC1 and AC2 for only the model years of 2000, 2001, and 2002.

(3) Excluding the AC1 and AC2 procedures described in paragraphs (b) and (c) of this section for model years 2000, 2001, and 2002, for any simulation approved under paragraph (a) of this section, the manufacturer must agree to be subject to an ongoing yearly correlation spot check as described in §1066.836.

(4) Once a simulation is approved and used by a manufacturer for testing for a given vehicle, we will agree to use the simulation test procedure for all official testing conducted on that vehicle by EPA for certification, SEA, and recall purposes, excluding spot check testing and vehicles which fail the spot check criteria as described in §1066.836.

(5) EPA will monitor the aggregate results of spot check testing and full environmental test cells. If we determine, based on such aggregate results, that any simulation (other than the AC1 and AC2 procedures described in paragraphs (b) and (c) of this section for the 2000, 2001, and 2002 model years) is producing test results consistently below those from a full environmental test cell, EPA may review its approval of the simulation.

(b) AC1 test procedure. (1) Section 1066.832(a) is applicable to the AC1 test procedure with the exception of the discussion of environmental test requirements. The AC1 test procedure simulates the effect of air conditioning operation in the environmental test cell conditions by adding the measured horsepower of the air conditioning system compressor, converted to an equivalent roadload component, to the normal dynamometer roadload horsepower.

(2) Section 1066.832(b) is applicable to the AC1 test procedure except that the dynamometer horsepower settings procedure of §1066.832(b)(2) is expanded to include a horsepower increase adjustment.

(i) The following describes one acceptable method of obtaining the required compressor horsepower and the corresponding roadload equivalent horsepower adjustment. Air compressor horsepower is measured during a SC03 air conditioning test cycle while operating in an environmental test cell as described in §1066.832.

(A) Install an air conditioning (A/C) compressor with a strain-gauged input shaft that measures shaft torque in foot pounds. Other measurement techniques that produce data that can be shown to estimate A/C compressor horsepower are also acceptable.

(B) Determine the engine crankshaft to A/C compressor pulley diameter ratio (*ACPR*) using equation §1066.834-1.

$$ACPR = \frac{d_{\mathrm{cp}}}{d_{\mathrm{ACp}}}$$

Eq. 1066.834-1

Where:

ACPR = the engine crankshaft to A/C compressor pulley diameter ratio

d_{cp} = crankshaft pulley diameter

d_{ACp} = AC pulley diameter

(C) Record the following parameters, as a function of accumulated time (t), at atleast 1 Hz from second 0 to second 600 while driving the SC03 cycle with the air conditioning system operating.

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(*1*) Engine revolutions/minute ($ERPM_t$).
(*2*) Compressor input torque in foot pounds (CT_t).
(D) For each second of data recorded from paragraph (b)(2)(i)(C) of this section, calculate compressor horsepower (CHP_t) using equation §1066.834-2.

$$CHP_t = \frac{CT_t \cdot ERPM_t \cdot ACPR}{5252}$$

Eq. 1066.834-2

(E) For each second of accumulated time and the data of paragraph (b)(2)(i) (B) and (D) of this section, determine air conditioning compressor roadload force ($ACRF_t$) that is equivalent to the air conditioning compressor force on the engine using equation §1066.834-3.

$$ACRF_t = \frac{CHP_t \cdot 375}{V_t}$$

Eq. 1066.834-3

Where:
V_t = the vehicle SC03 cycle speed in miles per hour for each accumulated second of time.
375 = a units constant to convert $ACRF_t$ to foot pounds of force.
(F) Values of $ACRF_t$ at each second of time are added to the corresponding roadload dynamometer force requirements of §1066.810(b) to obtain an approximation of the force generated by the vehicle engine during a SC03 test in an environmental test cell.
(ii) The method by which additional dynamometer $ACRF_t$ load is applied by the dynamometer to the vehicle tire surface will vary with dynamometer design and its force simulation capabilities. If the dynamometer has grade simulation capabilities, increasing load by simulating varying grades is one acceptable method of applying $ACRF_t$ values.
(iii) For those calculated values of $ACRF_t$ which exceed the force capacity of the dynamometer being used for simulation test, replace the calculated values with the maximum road force capacity of the dynamometer. We would normally not expect $ACRF_t$ values to exceed dynamometer capability for time periods of more than a second.
(iv) $ACRF_t$ values for application to AC1 testing should be an average of at least two runs unless the manufacturer can demonstrate to us that one run is acceptable.
(v) $ACRF_t$ values for application to AC1 testing are to be obtained for each vehicle and engine family combination. If only one vehicle configuration is selected to represent an engine family, the selected configuration is the vehicle expected to produce the highest air conditioning load requirements. A manufacturer may petition us to reduce the number of $ACRF_t$ test vehicles for their product line, if they can show that the highest air conditioning loads are covered with a lesser number than one per family.
(vi) Test results, calculations, and dynamometer setting values associated with making these roadload determinations are to be retained by the manufacturer as part of their certification records.
(3) Perform the SC03 air conditioning test sequence as described in §1066.832(b) with the following exceptions:
(i) The variable speed cooling fan of §1066.410(b)(1)(iv) is replaced with the fixed speed cooling fan requirements of §1066.410(b)(1)(ii).
(ii) The position of vehicle windows is optional.

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(iii) The nominal ambient air test conditions of §1066.832(a) are replaced with 76 °F and 50 grains of water/pound of dry air and the solar heat load of §1066.832(a) is omitted.
(iv) The air conditioning system is not operated during the SC03 test cycle. Operation of the air conditioning during preconditioning test cycles is optional.
(4) NO_x humidity correction. Calculated NO_x exhaust emissions from air conditioning tests conducted in a standard test cell at a nominal 50 grains of water/pound of dry air are corrected for humidity to 75 grains of water/pound of dry air according to §1066.630(a)(1).
(c) AC2 test procedure. (1) Section 1066.832(a) is applicable the AC2 test procedure except for the discussion of the environmental test requirements. The AC2 test procedure simulates the effect of air conditioning operation in the environmental cell test conditions by adding heat from the vehicle's heating system to the interior of the passenger compartment.
(2) Section 1066.832(b) is applicable to the AC2 test procedure, except for the following:
(i) Section 1066.832(b)(5) is applicable except the drivers side front window is left open and all the others are closed.
(ii) The nominal ambient air test conditions of §1066.832(a) are replaced with 76 °F and 50 grains of water/pound of dry air and the solar heat load of §1066.832(a) is omitted.
(iii) The control position instruction of §1066.832(c)(7)(iv) is replaced with set the A/C temperature control to the highest warm position (maximum for automatic systems).
(3) NO_x humidity correction. Calculated NO_x exhaust emissions from air conditioning tests conducted in a standard test cell at a nominal 50 grains of H_2O/pound of dry air are to be corrected for humidity to 75 grains of H_2O/pound of dry air according to §1066.630(a)(1).

§ 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. The environmental test facility must be capable of providing the following nominal ambient test conditions of: 77 °F air temperature, 50 percent 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

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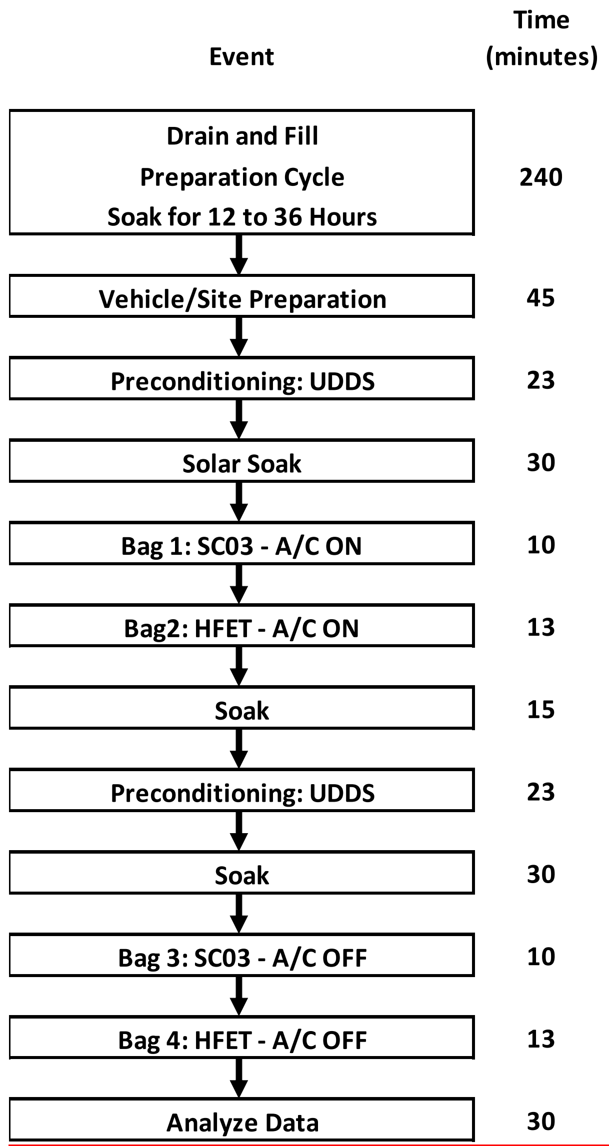
continuous basis according to 40 CFR part 1065. Figure 1 of §1066.835 shows the basic sequence of test procedure events.

Figure 1 of §1066.835–AC17 sequence of events



(b) Dynamometer inertia settings. (1) Required AC17 dynamometer inertia weight class selections are determined 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). The dynamometer's horsepower adjustment settings shall be set 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 phases of the AC17 test sequence to 77 ±2 °F on average and 77 ±5 °F as an instantaneous measurement.
(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 phases of the AC17 test sequence as described in §1066.425(d)(2).
(ii) Recorded 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 shall apply. The solar load of 850 W/m^2 is applied only during specified portions of the test sequence.
(d) Interior temperature measurement. The interior temperature of the vehicle shall be measured 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. The location of the temperature measuring devices shall be 30 mm behind each headrest and 330 mm below the roof.
(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.
(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 55 ° F at the center dash air outlet, and the airflow setting changed to "outside air."
(f) Vehicle and test activities. 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) Drain and fill the vehicle's fuel tank to 40 percent capacity with test fuel. If a vehicle has gone through the drain and fuel sequence less than 72 hours previously and has remained under laboratory ambient temperature conditions, this drain and fill operation can be omitted as described in §1066.816(a).
(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 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 part 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, and the vehicle is allowed to soak in the ambient conditions of paragraph (c)(1) of this section for 30 ±1 minutes. The solar heat system must be turned on and generating 850 W/m^2 within 1 minute of turning the engine off.
(8) Air conditioning on test. (i) Initiate data logging, sampling of exhaust gases, and integrating measured values before starting the engine.
(ii) 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.
(iii) Eighteen seconds after the engine starts, begin the initial vehicle acceleration of the SC03 driving schedule.
(iv) Operate the vehicle according to the SC03 driving schedule, as described in appendix I, paragraph (h), of 40 CFR part 86.
(v) At the end of the deceleration which is scheduled to occur at 594 seconds, simultaneously stop all SC03 and start all HFET sampling, recording, and integrating; including background sampling. Record the measured roll or shaft revolutions.
(vi) Allow the vehicle to idle for 14-16 seconds.
(vii) Operate the vehicle according to the HFET driving schedule, as described in appendix I of 40 CFR part 600.
(viii) Turn the engine off 2 seconds after the end of the last deceleration (i.e., engine off at 765 seconds).
(ix) Five seconds after the engine stops running, stop all HFET sampling, recording, and integrating; including background sampling, indicating the end of the test cycle.
(9) Air conditioning off test. The air conditioning off test is identical to the steps identified in paragraphs (d)(1) through (8) of this section, except that the air conditioning system and fan speeds are set to complete off or the lowest. It is preferred that the air conditioning off test be conducted sequentially after the air conditioning on test, following a 10-15 minute soak.
(g) Records required and reporting requirements. For each test the manufacturer shall record the information specified in §1066.818. Emission results must be reported for each phase of the test. The manufacturer must also report the following information for each vehicle tested: vehicle class, model type, carline, curb weight engine displacement, transmission class and configuration, interior volume, climate control system type and

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characteristics, refrigerant used, compressor type, and evaporator/condenser characteristics.

§ 1066.836 Spot check correlation procedures for vehicles tested using a simulation of the environmental test cell for air conditioning emission testing.

This section is applicable for vehicles which are tested using a simulation of the environmental test cell approved under the provisions of §1066.834(a).

(a) We may select up to five emission data vehicles (one emission data vehicle for small volume manufacturers), including vehicles submitted for running change approval, for each model year for any manufacturer undergoing the spot checking procedures of this section.

(b) Testing conducted under this section (including testing performed in an environmental test cell) will be considered as official data as described in 40 CFR part 86.091–29 and used in determining compliance with the standards. This testing must comply with all applicable emission standards of subpart A of this part. Retests for the purpose of emission compliance will be allowed using the procedures described in 40 CFR part 86.091–29.

(c) Spot check procedures. (1) Subject to the limitations of paragraphs (a) and (d)(2)(iii) of this section, we may require that one or more of the test vehicles which use a simulation rather than actual testing in an environmental test cell for air conditioning emission testing be submitted at a place we will designate for air conditioning emission testing in an environmental test cell as described in §1066.832. We may order this testing to be conducted at a manufacturer facility. All manufacturers which use a simulation instead of environmental cell testing must have access to an environment test cell meeting the requirements of §1066.833 to perform this testing.

(2) An air conditioning emission simulation test will be performed as described in §1066.834.

(i) The results of the original simulation test and the full environmental test cell required in paragraph (c)(1) of this section are compared. In order to pass the spot check, the test results must pass both of the following two criteria:

(A) The NO_x emission results of the simulation test must be at least 85% of the NO_x emission results of the environmental chamber test.

(B) The fuel consumption of the simulation test must be at least 95% of the fuel consumption of the environmental chamber test.

(ii) If either of two criteria of paragraph (c)(2)(i) of this section are not met, a retest is allowed. The manufacturer may elect to conduct either a retest of the simulation procedure or the environmental chamber testing. In order to pass the spot check, the test results must pass both of the criteria set out in paragraphs (c)(2)(i) of this section.

(iii) If either of the two criteria of paragraph (c)(2)(ii) of this section were not met, a second retest is allowed. The procedure not selected for the first retest must be used for the second retest, yielding two test results for each procedure. In order to pass the spot check, the test results must pass both of the criteria set out in paragraphs (c)(2)(i) of this section.

(iv) If the spot check criteria have not passed after the initial test, the first retest, or the second retest the spot check is considered failed.

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(B) The fuel consumption of the simulation test must be at least 95% of the fuel consumption of the environmental chamber test.¶

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(d) Consequences of failing a spot check. (1) If the emission results of the testing using the environmental test chamber passes all the applicable standards, those test results may be used to obtain a certificate of conformity.

(2) We will allow up to 60 days for the manufacturer to supply additional data to address the correlation of the simulation with a full environmental test cell.

(i) If the data prove to our satisfaction that the simulation produces results that correlate sufficiently with the environmental test chamber, we may allow the continued use of the simulation.

(ii) Otherwise, we will determine that the simulation fails to meet adequate correlation levels with full environmental testing. As a consequence of this finding, all future air conditioning emission testing on the population of vehicles represented by the failing-spot-check test vehicle (which may include past model year configurations) will be conducted using an environment chamber or a different (or corrected) approved simulation procedure.

(iii) For each vehicle that fails a spot check, we may select up to two additional vehicles to test for the spot check that do not count against the five vehicle limit of paragraph (a) of this section.

(e) EPA will monitor the aggregate results of spot check testing and full environmental test cells. If we determine, based on such aggregate results, that any simulation (other than the AC1 and AC2 procedures described in §1066.834 for the 2000, 2001, and 2002 model years) is producing test results consistently below those from a full environmental test cell, EPA may review its approval of the simulation.

§ 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, the final reported test results for the $NMHC + NO_x$ SFTP composite and optional CO composite standards shall be calculated using equation §1066.837-1.

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

Eq. 1066.837-1

Where:

$e_{\text{[emission]SFTPcomp}}$ = 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.

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

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

$e_{\text{[emission]US06}}$ = mass of emissions in g/mile for a particulate pollutant measured over the driving distance of the US06 test schedule. 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 equation §1066.837-2.

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$$e_{\mathrm{NMHC+NO_xSFTPcomp}} = e_{\mathrm{NMHCSFTPcomp}} + e_{\mathrm{NO_xSFTPcomp}}$$

Eq. 1066.837-2

Where:

$e_{\mathrm{NMHCSFTPcomp}}$ = the composite emission results for NMHC over the SFTP test schedule.

$e_{\mathrm{NOxSFTPcomp}}$ = the composite emission results for NO_x over the SFTP test schedule.

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

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

Eq. 1066.837-3

Where:

$e_{\mathrm{[emission]SFTPcomp}}$ = 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.

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

$e_{\mathrm{[emission]US06}}$ = mass of emissions in g/mile for a particulate pollutant measured over the driving distance of the US06 test schedule. 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, $e_{\mathrm{NMHC+NOxSFTPcomp}}$, using equation §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 part 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) Ambient humidity within the test cell during all phases of the test sequence shall be controlled to an average of 50 ± 5 grains of H_2O/pound of dry air.

(2) Ambient air temperature within the test cell during all phases of the test sequence shall be controlled to 75 ± 2 °F on average and 75 ± 5 °F as an instantaneous measurement. Air temperature shall be recorded 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 part 86.1803–01, or a highway fuel economy test procedure, as defined in 40 CFR part 600.002–08. For soak periods longer than two hours, precondition the vehicle using one

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(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)¶ ... [56]

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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_2sampling 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 the emitted CO_2.

(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 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.

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(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.

§ 1066.840 Method for calculating emissions due to air conditioning leakage.

This section describes procedures used to determine a refrigerant leakage rate in grams per year (g/yr) from vehicle-based air conditioning units. The results of this test are used to determine air conditioning leakage credits according to 40 CFR part 86.1866–12(b).

(a) Emission totals. Calculate the annual rate of refrigerant leakage from an air conditioning system using equation §1066.840-1:

$$ACS_{TOT} = ACS_{RP} + ACS_{SP} + ACS_{FH} + ACS_{MC} + ACS_{C}$$

Eq. 1066.840-1

Where:

ACS_{TOT} = the total air conditioning system emission rate in g/yr, rounded to the nearest tenth of a gram per year.

ACS_{RP} = the emission rate for rigid pipe connections as described in paragraph (b) of this section.

ACS_{SP} = the emission rate for service ports and refrigerant control devices as described in paragraph (c) of this section.

ACS_{FH} = the emission rate for flexible hoses as described in paragraph (d) of this section.

ACS_{MC} = the emission rate for heat exchangers, mufflers, receiver/driers, and accumulators as described in paragraph (e) of this section.

ACS_{C} = the emission rate for compressors as described in paragraph (f) of this section.

(b) Rigid pipe connections. Determine the grams per year emission rate for rigid pipe connections using equation §1066.840-2:

$$ACS_{RP} = 0.00522 \cdot \left[\left(125 \cdot SO\right) + \left(75 \cdot SCO\right) + \left(50 \cdot MO\right) + \left(10 \cdot SW\right) + \left(5 \cdot SWO\right) + \left(MG\right)\right]$$

Eq. 1066.840-2

Where:

ACS_{RP} = the total emission rate for rigid pipe connections in grams per year.

SO = the number of single O-ring connections.

SCO = the number of single captured O-ring connections.

MO = the number of multiple O-ring connections.

SW = the number of seal washer connections.

SWO = the number of seal washer with O-ring connections.

MG = the number of metal gasket connections.

(c) Service ports and refrigerant control devices. Determine the g/yr emission rate for service ports and refrigerant control devices using equation §1066.840-3:

$$ACS_{SP} = 0.522 \cdot \left[\left(0.3 \cdot HSSP\right) + \left(0.2 \cdot LSSP\right) + \left(0.2 \cdot STV\right) + \left(0.2 \cdot TXV\right)\right]$$

Eq. 1066.840-3

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Grams/YR_{TOT}= Grams/YR_{RP}+ Grams/YR_{SP}+ Grams/YR_{FH}+ Grams/YR_{MC}+ Grams/YR_{C}

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Where:

ACS_{SP} = the total emission rate for service ports and refrigerant control devices in g/yr.
$HSSP$ = the number of high side service ports.
$LSSP$ = the number of low side service ports.
STV = the total number of switches, transducers, and pressure relief valves.
TXV = the number of refrigerant control devices.

(d) Flexible hoses. Determine the permeation emission rate in g/yr for each segment of flexible hose using equation §1066.840-4, and then sum the values for all hoses in the system to calculate a total flexible hose emission rate for the system. Hose end connections are included in the calculations in paragraph (b) of this section.

$$ACS_{FH} = 0.00522 \cdot (3.14159 \cdot ID \cdot L \cdot ER)$$

Eq. 1066.840-4

Where:

ACS_{FH} = the emission rate for a segment of flexible hose in g/yr.
ID = the inner diameter of hose, in millimeters.
L = the length of hose, in millimeters.
ER = the emission rate per unit internal surface area of the hose, in g/mm^2. Select the appropriate value for ER from Table 1 of §1066.840:

Table 1 of §1066.840–Permeation emission rate for flexible hose based on internal surface area.

Material/configuration	Emission rate (g/mm^2)	
	High-pressure side	low-pressure side
All rubber hose	0.0216	0.0144
Standard barrier or veneer hose	0.0054	0.0036
Ultra-low permeation barrier or veneer hose	0.00225	0.00167

(e) Heat exchangers, mufflers, receiver/driers, and accumulators. For ACS_{MC}, use an emission rate of 0.261 g/yr as a combined value for all heat exchangers, mufflers, receiver/driers, and accumulators.

(f) Compressors. Determine the emission rate for compressors using equation §1066.840-5, noting that the final term in the equation ("1500/SSL") should be set to zero for electric (or semi-hermetic) compressors:

$$ACS_{C} = 0.00522 \cdot \left[(300 \cdot OHS) + (200 \cdot MHS) + (150 \cdot FAP) + (100 \cdot GHS) + \left(\frac{1500}{SSL} \right) \right]$$

Eq. 1066.840-5

Where:

ACS_{C} = the emission rate for the compressors in the air conditioning system in g/yr.
OHS = the number of O-ring housing seals.
MHS = the number of molded housing seals.
FAP = the number of fitting adapter plates.
GHS = the number of gasket housing seals.
SSL = the number of lips on shaft seal (for belt-driven compressors only).

(g) Definitions. The following definitions apply to this section:

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(1) *All rubber hose* means a Type A or Type B hose as defined by SAE J2064 (incorporated by reference in §1066.1010) with a permeation rate not greater than 15 kg/m^2 /year when tested according to SAE J2064.

(2) *Standard barrier or veneer hose* means a Type C, D, E, or F hose as defined by SAE J2064 (incorporated by reference in §1066.1010) with a permeation rate not greater than 5 kg/m^2 /year when tested according to SAE J2064.

(3) *Ultra-low permeation barrier or veneer hose* means a hose with a permeation rate not greater than 1.5 kg/m^2 /year when tested according to SAE J2064 (incorporated by reference in §1066.1010).

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§1066.843 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 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 nitrogen 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 three minutes, 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}.

$$D_{\text{eff}} = 0.2153 \cdot \left(\frac{V_{\text{gas}}}{960 \cdot \sqrt{\frac{(P_1 - P_2) \cdot (P_1 + P_2)}{G \cdot (T + 459.67)}}} \right)^{0.5057}$$

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; however, you must perform the same number of tests for every vehicle from a given model year. The average value of replicate tests is the official result for a given vehicle.

(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

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§1066.1001 Definitions.

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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:

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.

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.

Nonmethane organic gas (NMOG) means the combination of organic gases other than methane as calculated in §1066.665. Note that 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 y equals $A + B \cdot y + C \cdot y^2$.

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Test phase means a duration over which a vehicle's emission rates are determined for comparison to an emission standard. 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 the standard-setting part.

Unloaded coastdown means a dynamometer coastdown run with the vehicle wheels off 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.

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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.

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

Symbol	Quantity	Unit	Unit symbol	Unit in terms of SI base units
α	atomic hydrogen to carbon ratio	mole per mole	mol/mol	1
a	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
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	$2 \cdot \pi \cdot 60^{-1} \cdot m \cdot m^{-1} \cdot s^{-1}$
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 mass

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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Deleted: maximum (i.e., peak) value expected at the standard over a test interval; not the maximum of an instrument range

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

ALVW	adjusted loaded vehicle weight
CFR	Code of Federal Regulations
EPA	Environmental Protection Agency
ETW	equivalent test weight
FID	flame-ionization detector
FTP	Federal test procedure
GVWR	gross vehicle weight rating
HFET	highway fuel economy test
HLDT	heavy light-duty truck
IBR	incorporated by reference
MDPV	medium-duty passenger vehicle
NIST	National Institute for Standards and Technology
RESS	rechargeable energy storage system
SAE	Society of Automotive Engineers
SC03	air conditioning driving schedule
SEA	Selective enforcement audit
SFTP	supplemental federal test procedure
UDDS	urban dynamometer driving cycle
US06	aggressive driving schedule
U.S.C.	United States Code

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

Symbol	Quantity[1,2]	kg/m³	g/ft³
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/m³-carbon atom and g/ft³-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 neat gasoline (E0) 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 (f)(1) of this section for the composition of dry air.

§1066.1010 Reference materials.

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(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.

(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 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.

(3) SAE J2064, R134a Refrigerant Automotive Air-Conditioned Hose, Revised December 2011, IBR approved for § 1066.840(g).

(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).

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(5) 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.

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(6) 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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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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The temperature of the dilute exhaust mixture inside the dilution tunnel near the inlet of the particulate probe

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(p) *Additional required records for methanol-fueled vehicles.* (1) Specification of the methanol-fuel or methanol-fuel mixtures used during the test.
(2) Volume of sample passed through the methanol sampling system and the volume of deionized water in each impinger.
(3) The concentration of the GC analyses of the test samples (methanol).
(4) Volume of sample passed through the formaldehyde sampling system and the volume of DNPH solution used.
(5) The concentration of the HPLC analysis of the test sample (formaldehyde).
(6) The temperatures of the sample lines before the HFID and the impinger, the temperature of the exhaust transfer duct (as applicable), and the temperature of the control system of the heated hydrocarbon detector.
(7) A continuous measurement of the dew point of the raw and diluted exhaust. This requirement may be omitted if the temperatures of all heated lines are kept above 220 °F, or if the manufacturer performs an engineering analysis demonstrating that the temperature of the heated systems remains above the maximum dew point of the gas stream throughout the course of the test.

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Engine startup (with all accessories turned off), operation over the UDDS and engine shutdown make a complete cold start test. Engine startup and operation over the first 505 seconds of the driving schedule complete the hot start test. The exhaust emissions are diluted with ambient air in the dilution tunnel as shown in Figure B94–5 and Figure B94–6. A dilution tunnel is not required for testing vehicles waived from the requirement to measure particulates. Six particulate samples are collected on filters for weighing; the first sample plus backup is collected during the first 505 seconds of the cold start test; the second sample plus backup is collected during the remainder of the cold start test (including shutdown); the third sample plus backup is collected during the hot start test. Continuous proportional samples of gaseous emissions are collected for analysis during each test phase.

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For gasoline-fueled, natural gas-fueled and liquefied petroleum gas-fueled Otto-cycle vehicles, the c

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For petroleum-fueled diesel-cycle vehicles (optional for natural gas-fueled, liquefied petroleum gas-fueled and methanol-fueled diesel-cycle vehicles), THC is sampled and analyzed continuously according to the provisions of §86.110. Parallel samples of the dilution air are similarly analyzed for THC, CO, CO2, CH4and NOX. For natural gas-fueled, liquefied petroleum gas-fueled and methanol-fueled vehicles, bag samples are collected and analyzed for THC (if not sampled continuously), CO, CO2, CH4and NOX. For methanol-fueled vehicles, methanol and formaldehyde samples are taken for both exhaust emissions and dilution air (a single dilution air formaldehyde sample, covering the total test period may be collected). Parallel bag samples of dilution air are analyzed for THC, CO, CO2, CH4and NOX. Methanol and formaldehyde samples may be omitted for 1990 through 1994 model years when a FID calibrated on methanol is used.

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(1) Place drive wheels of vehicle on dynamometer without starting engine.
(2) Open the vehicle engine compartment cover and position the cooling fan.
(3) For all vehicles, with the sample selector valves in the "standby" position, connect evacuated sample collection bags to the dilute exhaust and dilution air sample collection systems.
(4) For methanol-fueled vehicles, with the sample selector valves in the "standby" position, insert fresh sample collection impingers into the methanol sample collection system, the formaldehyde sample collection system and fresh impingers (or capsules for formaldehyde) into the dilution air sample collection systems for methanol and formaldehyde (may be omitted for 1990 through 1994 model years).
(5) Start the CVS (if not already on), the sample pumps (except the diesel particulate sample pump, if applicable), the temperature recorder, the vehicle cooling fan, and the heated hydrocarbon analysis recorder (diesels only). (The heat exchanger of the constant volume sampler, if used, petroleum-fueled diesel hydrocarbon analyzer continuous sample line and filter, methanol-fueled vehicle hydrocarbon, methanol and formaldehyde sample lines, if applicable, should be preheated to their respective operating temperatures before the test begins.)
(6) Adjust the sample flow rates to the desired flow rate and set the gas flow measuring devices to zero.
(i) For gaseous bag samples (except hydrocarbon samples), the minimum flow rate is 0.17 cfm (0.08 1/sec).

(ii) For hydrocarbon samples, the minimum FID (or HFID in the case of diesel- and methanol-fueled Otto-cycle vehicles) flow rate is 0.066 cfm (0.031 1/sec).
(iii) For methanol samples, the minimum flow rate is 0.14 cfm (0.067 1/sec).
(iv) For formaldehyde samples, the minimum flow rate is 0.036 cfm (0.017 l/s) with capsule collector and 0.14 cfm (0.067 l/s) with impinger.
Note: CFV sample flow rate is fixed by the venturi design.
(7) Attach the exhaust tube to the vehicle tailpipe(s).
(8) Carefully install a particulate sample filter into each of the filter holders for diesel vehicle tests. The filters must be handled only with forceps or tongs. Rough or abrasive filter handling will result in erroneous weight determination.

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the gas flow measuring device, position the sample selector valves to direct the sample flow into the "transient" exhaust sample bag, the "transient" methanol exhaust sample, the "transient" formaldehyde exhaust sample, the "transient" dilution air sample bag, the "transient" methanol dilution air sample and the "transient" formaldehyde dilution air sample (turn on the petroleum-fueled diesel hydrocarbon analyzer system integrator, mark the recorder chart, start particulate sample pump No. 1, and record both gas meter or flow measurement instrument readings, if applicable), turn the key on, and start cranking the engine

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Note: During diesel vehicle testing, adjust the flow rate through the particulate sample probe to maintain a constant value within ±5 percent of the set flow rate. Record the average temperature and pressure at the gas meter or flow instrument inlet. If the set flow rate cannot be maintained because of high particulate loading on the filter, the test shall be terminated. The test shall be rerun using a lower flow rate, or larger diameter filter, or both.

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switch off gas flow measuring device No. 1, switch off the No. 1 petroleum-fueled diesel hydrocarbon integrator and the No. 1 particulate sample pump, mark the petroleum-fueled diesel hydrocarbon recorder chart, and close valves isolating particulate filter No. 1, if applicable, and start gas flow measuring device No. 2, and start the petroleum-fueled diesel hydrocarbon integrator No. 2 and the No. 2 particulate sample pump and open valves isolating particulate filter No. 2, if applicable. Before the acceleration which is scheduled to occur at 510 seconds, record the measured roll or shaft revolutions and reset the counter or switch to a second counter. As soon as possible transfer the "transient" exhaust and dilution air samples to the analytical system and process the samples according to §86.140 obtaining a stabilized reading of the bag exhaust sample on all analyzers within 20 minutes of the end of the sample collection phase of the test. Obtain methanol and formaldehyde sample analyses, if applicable, within 24 hours of the end of the sample collection phase of the test.

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(16) Immediately after the end of the sample period, turn off the cooling fan and close the engine compartment cover.
(17) Turn off the CVS or disconnect the exhaust tube from the tailpipe(s) of the vehicle.

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except only two evacuated sample bags, two methanol sample impingers, two formaldehyde sample impingers, and one pair of particulate sample filters, as appropriate, are required. The

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turn off gas flow measuring device No. 1 (and the petroleum-fueled diesel hydrocarbon integrator No. 1, mark the petroleum-fueled diesel hydrocarbon recorder chart and turn off the No. 1 particulate sample pump, if applicable) and position the sample selector valve to the "standby" position. (Engine shutdown is not part of the hot start test sample period.) Record the measured roll or shaft revolutions (and the No. 1 gas meter reading or flow measurement instrument). (Carefully remove the third pair of particulate sample filters from its holder and place in a clean petri dish and cover, if applicable.)

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(20) As soon as possible, transfer the hot start "transient" exhaust and dilution air samples to the analytical system and process the samples according to §86.140, obtaining a stabilized reading of the exhaust bag sample on all analyzers within 20 minutes of the end of the sample collection phase of the test. Obtain methanol and formaldehyde sample analyses, if applicable, within 24 hours of the end of the sample period. (If it is not possible to perform analysis on the methanol and formaldehyde samples, within 24 hours, the samples should be stored in a dark cold (4–10 °C) environment until analysis. The samples should be analyzed within fourteen days.)
(21) As soon as possible, and in no case longer than one hour after the end of the hot start phase of the test, transfer the six particulate filters to the weighing chamber for post-test conditioning, if applicable.
(22) Disconnect the exhaust tube from the vehicle tailpipe(s) and drive the vehicle from dynamometer.
(23) The CVS or CFV may be turned off, if desired.

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If two bag samples are collected, for petroleum-fueled diesel-cycle vehicles for which THC is sampled and analyzed continuously according to the provisions of §86.110, the analytical system shall be configured to calculate THC for the US06 City phase and the US06 Highway phase as described in §86.159–08.

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for determining exhaust emissions with the air conditioner operating (see §86.160–00)

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, using a constant volume (variable dilution) sampler or critical flow venturi sampler

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continuous proportional samples of gaseous

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If engine stalling should occur during cycle operation, follow the provisions of §86.136–90 (engine starting and restarting).

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For gasoline-fueled Otto-cycle vehicles, the c

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(2) Position (vehicle can be driven) the test vehicle on the dynamometer and restrain.

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(e) Perform the test bench sampling sequence outlined in §86.140–94 prior to or in conjunction with each series of exhaust emission measurements.

(f) *Test activities.* (1) The US06 consists of a single test which is directly preceded by a vehicle preconditioning in accordance with §86.132–00. Following the vehicle preconditioning, the vehicle is idled for not less than one minute and not more than two minutes.

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(e) Perform the test bench sampling sequence outlined in §86.140–94 prior to or in conjunction with each series of exhaust emission measurements.

(f) *Test activities.* (1) The US06 consists of a single test which is directly preceded by a vehicle preconditioning in accordance with §86.132–00. Following the vehicle preconditioning, the vehicle is idled for not less than one minute and not more than two minutes.

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(2) The following steps shall be taken for each test:
(i) Immediately after completion of the preconditioning, idle the vehicle. The idle period is not to be less than one minute or greater than two minutes.
(ii) With the sample selector valves in the “standby” position, connect evacuated sample collection bags to the dilute exhaust and dilution air sample collection systems.
(iii) Start the CVS (if not already on), the sample pumps, the temperature recorder, the vehicle cooling fan, and the heated THC analysis recorder (diesel-cycle only). The heat exchanger of the constant volume sampler, if used, petroleum-fueled diesel-cycle THC analyzer continuous sample line should be preheated to their respective operating temperatures before the test begins.
(iv) Adjust the sample flow rates to the desired flow rate and set the gas flow measuring devices to zero.
(A) For gaseous bag samples (except THC samples), the minimum flow rate is 0.17 cfm (0.08 liters/sec).
(B) For THC samples, the minimum FID (or HFID in the case of diesel-cycle vehicles) flow rate is 0.066 cfm (0.031 liters/sec).
(C) CFV sample flow rate is fixed by the venturi design.
(v) Attach the exhaust tube to the vehicle tailpipe(s).

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(C) CFV sample flow rate is fixed by the venturi design.
(v) Attach the exhaust tube to the vehicle tailpipe(s).

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(2) Position (vehicle can be driven) the test vehicle on the dynamometer and restrain.

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(5) The vehicle speed as measured from the dynamometer rolls shall be used. A speed vs. time recording, as evidence of dynamometer test validity, shall be supplied at request of the Administrator.

(6) The drive wheel tires may be inflated up to a gauge pressure of 45 psi (310 kPa), or the manufacturer's recommended pressure if higher than 45 psi, in order to prevent tire damage. The drive wheel tire pressure shall be reported with the test results.

(7) The driving distance, as measured by counting the number of dynamometer roll or shaft revolutions, shall be determined for the test.

(8) Four-wheel drive and all-wheel drive vehicles may be tested either in a four-wheel drive or a two-wheel drive mode of operation. In order to test in the two-wheel drive mode, four-wheel drive and all-wheel drive vehicles may have one set of drive wheels disengaged; four-wheel and all-wheel drive vehicles which can be shifted to a two-wheel mode by the driver may be tested in a two-wheel drive mode of operation.

(c) *Vehicle and test activities for testing in a full environmental cell.* The SFTP air conditioning test in an environmental test cell is composed of the following sequence of activities. Alternative procedures which appropriately simulate full environmental cell testing may be approved under the provisions of §§86.162–00(a) and 86.163–00.

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(5) The vehicle speed as measured from the dynamometer rolls shall be used. A speed vs. time recording, as evidence of dynamometer test validity, shall be supplied at request of the Administrator.
(6) The drive wheel tires may be inflated up to a gauge pressure of 45 psi (310 kPa), or the manufacturer's recommended pressure if higher than 45 psi, in order to prevent tire damage. The drive wheel tire pressure shall be reported with the test results.
(7) The driving distance, as measured by counting the number of dynamometer roll or shaft revolutions, shall be determined for the test.
(8) Four-wheel drive and all-wheel drive vehicles may be tested either in a four-wheel drive or a two-wheel drive mode of operation. In order to test in the two-wheel drive mode, four-wheel drive and all-wheel drive vehicles may have one set of drive wheels disengaged; four-wheel and all-wheel drive vehicles which can be shifted to a two-wheel mode by the driver may be tested in a two-wheel drive mode of operation.
(c) *Vehicle and test activities for testing in a full environmental cell.* The SFTP air conditioning test in an environmental test cell is composed of the following sequence of activities. Alternative procedures which appropriately simulate full environmental cell testing may be approved under the provisions of §§86.162–00(a) and 86.163–00.

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(5) The vehicle speed as measured from the dynamometer rolls shall be used. A speed vs. time recording, as evidence of dynamometer test validity, shall be supplied at request of the Administrator.
(6) The drive wheel tires may be inflated up to a gauge pressure of 45 psi (310 kPa), or the manufacturer's recommended pressure if higher than 45 psi, in order to prevent tire damage. The drive wheel tire pressure shall be reported with the test results.
(7) The driving distance, as measured by counting the number of dynamometer roll or shaft revolutions, shall be determined for the test.
(8) Four-wheel drive and all-wheel drive vehicles may be tested either in a four-wheel drive or a two-wheel drive mode of operation. In order to test in the two-wheel drive mode, four-wheel drive and all-wheel drive vehicles may have one set of drive wheels disengaged; four-wheel and all-wheel drive vehicles which can be shifted to a two-wheel mode by the driver may be tested in a two-wheel drive mode of operation.
(c) *Vehicle and test activities for testing in a full environmental cell.* The SFTP air conditioning test in an environmental test cell is composed of the following sequence of activities. Alternative procedures which appropriately simulate full environmental cell testing may be approved under the provisions of §§86.162–00(a) and 86.163–00.

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(4) Connect the emission test sampling system to the vehicle's exhaust tail pipe(s).

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(4) Connect the emission test sampling system to the vehicle's exhaust tail pipe(s).

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(4) Connect the emission test sampling system to the vehicle's exhaust tail pipe(s).

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(i) If engine stalling should occur during any air conditioning test cycle operation, follow the provisions of §86.136–90 (Engine starting and restarting).
(ii) For manual transmission vehicles, the vehicle shall be shifted according the provisions of §86.128–00.

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(d) *Exhaust Emission Measurement Activities.* The following activities are performed, when applicable, in order to meet the timing of the vehicle test and environmental facility activities.
(1) Perform the test bench sampling calibration sequence outlined in §86.140–94 prior to or in conjunction with each series of exhaust emission measurements.
(2) With the sample selector valves in the “standby” position, connect evacuated sample collection bags to the dilute exhaust and dilution air sample collection systems.
(3) Start the CVS (if not already on), the sample pumps, the temperature recorder, the vehicle cooling fan, and the heated THC analysis recorder (diesel-cycle only). The heat exchanger of the constant volume sampler, if used, petroleum-fueled diesel-cycle THC analyzer continuous sample line should be preheated to their respective operating temperatures before the test begins.
(4) Adjust the sample flow rates to the desired flow rate and set the gas flow measuring devices to zero.
(i) For gaseous bag samples (except THC samples), the minimum flow rate is 0.17 cfm (0.08 liters/sec).
(ii) For THC samples, the minimum FID (or HFID in the case of diesel-cycle vehicles) flow rate is 0.066 cfm (0.031 1/sec).
(iii) CFV sample flow rate is fixed by the venturi design.
(5) Attach the exhaust tube to the vehicle tailpipe(s).
(6) Start the gas flow measuring device, position the sample selector valves to direct the sample flow into the exhaust sample bag, the dilution air sample bag, turn on the petroleum-fueled diesel-cycle THC analyzer system integrator, mark the recorder chart, and record both gas meter or flow measurement instrument readings, if applicable.

(7) Start the engine (with air conditioning system also running). Fifteen seconds after the engine starts, place vehicle in gear.
(8) Twenty seconds after the engine starts, begin the initial vehicle acceleration of the driving schedule.
(9) Operate the vehicle according to the SC03 driving schedule.
(10) Turn the engine off 2 seconds after the end of the last deceleration (i.e., engine off at 596 seconds).

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simultaneously turn off gas flow measuring device No. 1 (and the petroleum-fueled diesel hydrocarbon integrator No. 1 and mark the petroleum-fueled diesel hydrocarbon recorder chart if applicable) and position the sample selector valves to the “standby” position. Record the measured roll or shaft revolutions and the No. 1 gas meter reading or flow measurement instrument)

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(12) As soon as possible, transfer the exhaust and dilution air bag samples to the analytical system and process the samples according to §86.140 obtaining a stabilized reading of the bag exhaust sample on all analyzers within 20 minutes of the end of the sample collection phase of the test.
(13) Immediately after the end of the sample period, turn off the cooling fan, disconnect the exhaust tube from the vehicle tailpipe(s), and drive the vehicle from dynamometer.
(14) The CVS or CFV may be turned off, if desired.

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(1) The minimum air flow nozzle discharge area must be equal or exceed the vehicle frontal inlet area. Optimum discharge area is 18 square feet (4.25×4.25), however, other sizes can be used.
(2) 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.
(3) The fan air flow velocity vector perpendicular to the axial flow velocity vector shall be less than 10 percent of the mean velocity measured at fan speeds corresponding to vehicle speeds of 20 and 40 mph.
(4)(i) 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.
(ii) The uniformity of axial flow tolerance is 20 percent of the fan speeds corresponding to vehicle speeds of 20 and 40 mph.
(5) The instrument used to verify the air velocity must have an accuracy of 2 percent of the measured air flow speed.
(6) The fan discharge nozzle must be located 2 to 3 feet from the vehicle and 0 to 6 inches above the test cell floor during air conditioning testing. This applies to non-wind tunnel environmental test cells only.
(7) The

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discussed in paragraphs (e)(1) through (e)(5)

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this section must be verified by the manufacturer

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This replaces 86.162-00 and -03.

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The Administrator

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The Administrator

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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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If engine stalling occurs during cycle operation, follow the provisions of §86.136–90 to restart the test. Measurement instruments must meet the specifications described in this subpart.

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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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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