



UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
NATIONAL VEHICLE AND FUEL EMISSIONS LABORATORY
2565 PLYMOUTH ROAD
ANN ARBOR, MI 48105-2498

OFFICE OF
AIR AND RADIATION

April 16, 2007

MEMORANDUM

SUBJECT: Redline Version Showing Proposed Changes to 40 CFR Part 1065

FROM: Alan Stout
Office of Transportation and Air Quality

TO: Docket EPA-HQ-OAR-2004-0008

The attached pages highlight the proposed changes to the engine-based test procedures in 40 CFR part 1065. These changes were proposed as part of the rulemaking for setting new emission standards for locomotive and marine diesel engines (72 FR 15938, April 3, 2007).

PART 1065—ENGINE-TESTING PROCEDURES

1. The authority citation for part 1065 continues to read as follows:
Authority: 42 U.S.C. 7401-7671q.

Subpart A—[Amended]

2. Section 1065.1 is revised to read as follows:

§1065.1 Applicability.

Formatted: Font: Bold

(a) This part describes the procedures that apply to testing we require for the following engines or for vehicles using the following engines:

(1) Locomotives we regulate under 40 CFR part 1033. For earlier model years, manufacturers may use the test procedures in this part or those specified in 40 CFR part 92 according to §1065.10.

(2) Model year 2010 and later heavy-duty highway engines we regulate under 40 CFR part 86. For earlier model years, manufacturers may use the test procedures in this part or those specified in 40 CFR part 86, subpart N, according to §1065.10.

(3) ~~Land-based n~~Nonroad diesel engines we regulate under 40 CFR part 1039 and stationary diesel engines that are certified to the standards in 40 CFR part 1039 as specified in 40 CFR part 60, subpart IIII. For earlier model years, manufacturers may use the test procedures in this part or those specified in 40 CFR part 89 according to §1065.10.

(4) Marine diesel engines we regulate under 40 CFR part 1042. For earlier model years, manufacturers may use the test procedures in this part or those specified in 40 CFR part 94 according to §1065.10.

(5) Marine spark-ignition engines we regulate under 40 CFR part 1045. For earlier model years, manufacturers may use the test procedures in this part or those specified in 40 CFR part 91 according to §1065.10.

(6) Large nonroad spark-ignition engines we regulate under 40 CFR part 1048, and stationary engines that are certified to the standards in 40 CFR part 1048 as specified in 40 CFR part 60, subpart JJJJ.

(7) Vehicles we regulate under 40 CFR part 1051 (such as snowmobiles and off-highway motorcycles) based on engine testing. See 40 CFR part 1051, subpart F, for standards and procedures that are based on vehicle testing.

(8) Small nonroad spark-ignition engines we regulate under 40 CFR part 1054 and stationary engines that are certified to the standards in 40 CFR part 1054 as specified in 40 CFR part 60, subpart JJJJ. For earlier model years, manufacturers may use the test procedures in this part or those specified in 40 CFR part 90 according to §1065.10.

(b) The procedures of this part may apply to other types of engines, as described in this part and in the standard-setting part.

(c) This part is addressed to you as a manufacturer of engines, vehicles, equipment, and vessels, but it applies equally to anyone who does testing for you. For example, if you manufacture engines that must be tested according to this part, this part applies to you. This part is also addressed 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. For example, if you are an instrument manufacturer, this part applies to you.

(d) Paragraph (a) of this section identifies the parts of the CFR that define emission standards and other requirements for particular types of engines. In this part, we refer to each of these other parts generically as the "standard-setting part." For example, 40 CFR part 1051 is always the standard-setting part for snowmobiles.

(e) Unless we specify otherwise, the terms "procedures" and "test procedures" in this part include all aspects of engine testing, including the equipment specifications, calibrations, calculations, and other protocols and procedural specifications needed to measure emissions.

(f) For vehicles, equipment, or vessels subject to this part and regulated under vehicle-based, equipment-based, or vessel-based standards, use good engineering judgment to interpret the term "engine" in this part to include vehicles, equipment, or vessels, where appropriate.

(g) For additional information regarding these test procedures, visit our Web site at www.epa.gov, and in particular <http://www.epa.gov/otaq/testingregs.htm>.

3. Section 1065.2 is amended by revising paragraph (c) to read as follows:

§1065.2 Submitting information to EPA under this part.

* * * * *

Formatted: Font: Bold

(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 engines 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.

* * * * *

4. Section 1065.5 is revised to read as follows:

§1065.5 Overview of this part 1065 and its relationship to the standard-setting part.

(a) This part specifies procedures that apply generally to testing various categories of engines. See the standard-setting part for directions in applying specific provisions in this part for a particular type of engine. Before using this part's procedures, read the standard-setting part to answer at least the following questions:

(1) What duty cycles must I use for laboratory testing?

(2) Should I warm up the test engine before measuring emissions, or do I need to measure cold-start emissions during a warm-up segment of the duty cycle?

(3) Which exhaust gases do I need to measure?

~~(4) Does testing require full flow dilute sampling? Is raw sampling prohibited? Is partial flow sampling prohibited?~~

~~(5) Do any unique specifications apply for test fuels?~~

~~(6) What maintenance steps may I take before or between tests on an emission-data engine?~~

~~(7) Do any unique requirements apply to stabilizing emission levels on a new engine?~~

~~(8) Do any unique requirements apply to test limits, such as ambient temperatures or pressures?~~

~~(9) Is field testing required or allowed, and are there different emission standards or procedures that apply to field testing?~~

(940) Are there any emission standards specified at particular engine-operating conditions or ambient conditions?

(104) 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:

Table 1 of §1065.5—Description of Part 1065 subparts.

| This subpart | Describes these specifications or procedures |
|--------------|---|
| Subpart A | Applicability and general provisions. |
| Subpart B | Equipment for testing. |
| Subpart C | Measurement instruments for testing. |
| Subpart D | Calibration and performance verifications for measurement systems. |
| Subpart E | How to prepare engines for testing, including service accumulation. |
| Subpart F | How to run an emission test <u>over a predetermined duty cycle.</u> |
| Subpart G | Test procedure calculations. |
| Subpart H | Fuels, engine fluids, analytical gases, and other calibration standards <u>for testing.</u> |
| Subpart I | Special procedures related to oxygenated fuels. |
| Subpart J | How to test with portable emission measurement systems (PEMS). |

5. Section 1065.10 is amended by revising paragraphs (c)(1) introductory text and (c)(7) introductory text to read as follows:

§1065.10 Other procedures.

* * * * *

(c) * * *

(1) The objective of the procedures in this part is to produce emission measurements equivalent to those that would result from measuring emissions during in-use operation using the same engine configuration as installed in a vehicle, equipment, or vessel. However, in unusual circumstances these procedures may result in measurements that do not represent in-use operation. You must notify us if good engineering judgment indicates that the specified procedures cause unrepresentative emission measurements for your engines. Note that you need not notify us of unrepresentative aspects of the test procedure if measured emissions are equivalent to in-use emissions. This provision does not obligate you to pursue new information regarding the different ways your engine might operate in use, nor does it obligate you to collect any other in-use information to verify whether or not these test procedures are representative of your engine's in-use operation. If you notify us of unrepresentative procedures under this paragraph (c)(1), we will cooperate with you to establish whether and how the procedures should be appropriately changed to result in more representative measurements. While the provisions of this paragraph (c)(1) allow us to be responsive to issues as they arise, we would generally work toward making these testing changes generally applicable through rulemaking. We will allow reasonable lead time for compliance with any resulting change in procedures. We will consider the following factors in determining the importance of pursuing changes to the procedures:

Formatted: Font: Bold

(7) You may request to use alternate procedures ~~that are equivalent to allowed procedures~~, or procedures that are more accurate or more precise than the allowed procedures. ~~You may request to use a particular device or method for laboratory testing even though it was originally designed for field testing.~~ The following provisions apply to requests for alternate procedures:

* * * * *

6. Section 1065.12 is amended by revising paragraphs (a) and (d)(1) to read as follows:

§1065.12 Approval of alternate procedures.

Formatted: Font: Bold

(a) To get approval for an alternate procedure under §1065.10(c), send the Designated Compliance Officer an initial written request describing the alternate procedure and why you believe it is equivalent to the specified procedure. Anyone may request alternate procedure approval. This means that an individual engine manufacturer may request to use an alternate procedure. This also means that an instrument manufacturer may request to have an instrument, equipment, or procedure approved as an alternate procedure to those specified in this part. We may approve your request based on this information alone, or, as described in this section, we may ask you to submit to us in writing supplemental information showing that your alternate procedure is consistently and reliably at least as accurate and repeatable as the specified procedure.

* * * * *

(d) * * *

(1) Theoretical basis. Give a brief technical description explaining why you believe the proposed alternate procedure should result in emission measurements equivalent to those using the specified procedure. You may include equations, figures, and references. You should consider the full range of parameters that may affect equivalence. For example, for a request to use a different NO_x measurement procedure, you should theoretically relate the alternate detection principle to the specified detection principle over the expected concentration ranges for NO, NO₂, and interference gases. For a request to use a different PM measurement procedure, you should explain the principles by which the alternate procedure quantifies particulate mass similarly to the specified procedures. ~~For any proportioning or integrating procedure, such as a partial flow dilution system, you should compare the alternate procedure's theoretical response to the expected response of the specified procedures.~~

* * * * *

7. Section 1065.15 is amended by revising paragraphs (c)(1) and (e) to read as follows:

§1065.15 Overview of procedures for laboratory and field testing.

Formatted: Font: Bold

* * * * *

(c) * * *

(1) Engine operation. Engine operation is specified over a test interval. A test interval is the time over which an engine's total mass of emissions and its total work are determined. Refer to the standard-setting part for the specific test intervals that apply to each engine. Testing may involve measuring emissions and work during the following types of engine operation:

(i) Laboratory testing. Under this type of testing, you determine brake-specific emissions for duty-cycle testing by using an engine dynamometer in a laboratory or other environment. This typically consists of one or more test intervals, each defined by a duty cycle, which is a sequence

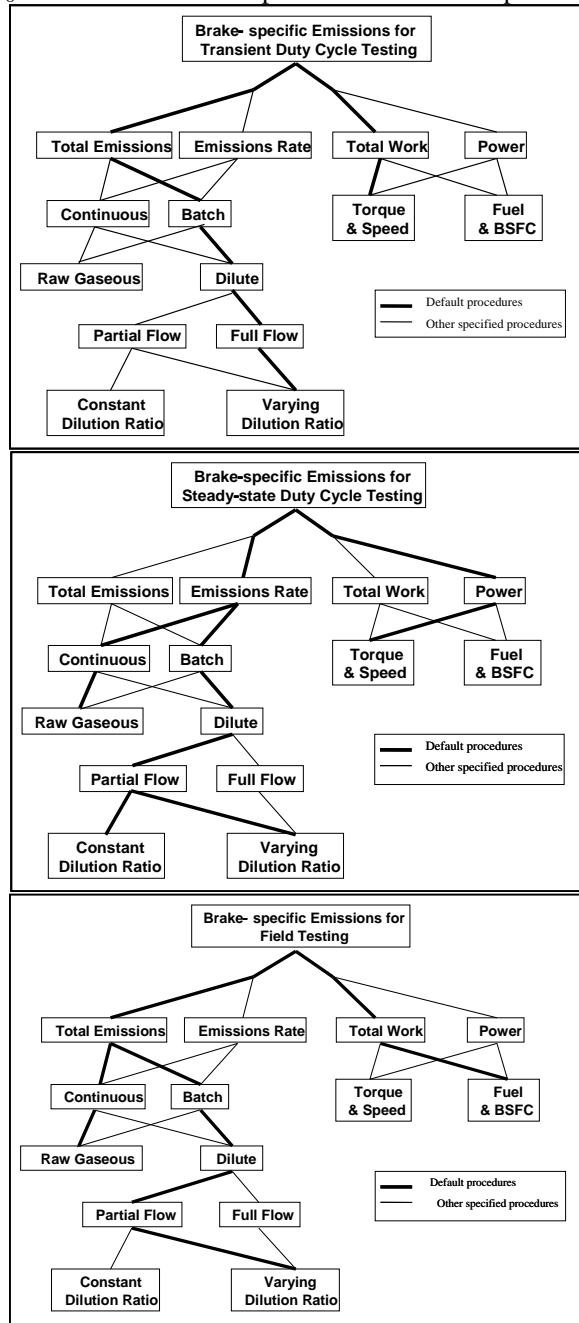
of modes, speeds, and/or torques that an engine must follow. If the standard-setting part allows it, you may also simulate field testing by running on an engine dynamometer in a laboratory or other environment.

(ii) Field testing. This type of testing consists of normal in-use engine operation while an engine is installed in a vehicle, equipment, or vessel. The standard-setting part specifies how test intervals are defined for field testing.

* * * * *

(e) The following figure illustrates the allowed measurement configurations described in this part 1065:

Figure 1 of §1065.15—Default test procedures and other specified procedures.



8. Section 1065.20 is amended by revising paragraphs (f) and (g) to read as follows:

§1065.20 Units of measure and overview of calculations.

Formatted: Font: Bold

(f) Interpretation of ranges. Interpret a range as a tolerance unless we explicitly identify it as an accuracy, repeatability, linearity, or noise specification. See §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 such as “±10 % of maximum pressure”, “(40 to 50) kPa”, 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”. Interpret a range as a tolerance unless we explicitly identify it as an accuracy, repeatability, linearity, or noise specification. See §1065.1001 for the definition of Tolerance.

(g) Scaling of specifications with respect to an applicable standard. Because this part 1065 is applicable to a wide range of engines and emission standards, some of the specifications in this part are scaled with respect to an engine’s applicable emission-standard or maximum power. 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. Refer to §1065.602 for information needed to estimate and calculate flow-weighted means. Wherever a specification is scaled to a value based upon an applicable standard, interpret the standard to be the family emission limit if the engine is certified under an emission credit program in the standard-setting part.

Subpart B—[Amended]

1. Section 1065.101 is amended by revising paragraph (a) to read as follows:

§1065.101 Overview.

(a) This subpart specifies equipment, other than measurement instruments, related to emission testing. The provisions of this subpart apply for all testing in laboratories or other environments where engine speeds and loads are controlled to follow a prescribed duty cycle. See subpart J of this part to determine which of the provisions of this subpart apply for field testing. This equipment includes three broad categories ~~of equipment~~—dynamometers, engine fluid systems (such as fuel and intake-air systems), and emission-sampling hardware.

* * * * *

2. Section 1065.110 is amended by revising paragraphs (a) and (e) to read as follows:

§1065.110 Work inputs and outputs, accessory work, and operator demand.

(a) Work. Use good engineering judgment to simulate all engine work inputs and outputs as they typically would operate in use. Account for work inputs and outputs during an emission test by measuring them; or, if they are small, you may show by engineering analysis that disregarding them does not affect your ability to determine the net work output by more than ± 0.5 % of the net reference-expected work output over the test interval. Use equipment to simulate the specific types of work, as follows:

Formatted: Underline

(1) Shaft work. Use an engine dynamometer that is able to meet the cycle-validation criteria in §1065.514 over each applicable duty cycle.

(i) You may use eddy-current and water-brake dynamometers for any testing that does not involve engine motoring, which is identified by negative torque commands in a reference duty cycle. See the standard setting part for reference duty cycles that are applicable to your engine.

(ii) You may use alternating-current or direct-current motoring dynamometers for any type of testing.

(iii) You may use one or more dynamometers.

(iv) You may use any device that is already installed on a vehicle, equipment, or vessel to absorb work from the engine's output shaft(s). Examples of these types of devices include a vessel's propeller and a locomotive's generator.

(2) Electrical work. Use one or more of the following to simulate electrical work:

(i) Use storage batteries or capacitors that are of the type and capacity installed in use.

(ii) Use motors, generators, and alternators that are of the type and capacity installed in use.

(iii) Use a resistor load bank to simulate electrical loads.

(3) Pump, compressor, and turbine work. Use pumps, compressors, and turbines that are of the type and capacity installed in use. Use working fluids that are of the same type and thermodynamic state as normal in-use operation.

* * * * *

(e) Operator demand for shaft work. Operator demand is defined in §1065.1001.

Formatted: Underline

Command the operator demand and the dynamometer(s) to follow ~~the a~~ prescribed duty

cycle with set points for engine speed and torque at 5 Hz (or more frequently) for transient testing or 1 Hz (or more frequently) for steady-state testing. Refer to the standard-setting part to determine the specifications for your duty cycle(s). Use a mechanical or electronic input to control operator demand such that the engine is able to meet the validation criteria in §1065.514 over each applicable duty cycle. Record feedback values for engine speed and torque at 5 Hz or more frequently for evaluating performance relative to the cycle validation criteria. Using good engineering judgment, you may improve control of operator demand by altering on-engine speed and torque controls. However, if these changes result in unrepresentative testing, you must notify us and recommend other test procedures under §1065.10(c)(1).

3. Section 1065.120 is amended by revising paragraph (a) to read as follows:

§1065.120 Fuel properties and fuel temperature and pressure.

(a) Use fuels as specified in the standard-setting part, or as specified in subpart H of this part if fuels are not specified in the standard-setting part.

* * * * *

4. Section 1065.122 is amended by revising paragraphs (a) introductory text and (a)(1) to read as follows:

§1065.122 Engine cooling and lubrication.

(a) Engine cooling. Cool the engine during testing so its intake-air, oil, coolant, block, and head temperatures are within their expected ranges for normal operation. You may use ~~laboratory~~ auxiliary coolers and fans.

(1) For air-cooled engines only. ~~If~~ if you use ~~laboratory~~ auxiliary fans you must account for work input to the fan(s) according to §1065.110.

* * * * *

Formatted: Underline

5. Section 1065.125 is revised to read as follows:

§1065.125 Engine intake air.

(a) Use the intake-air system installed on the engine or one that represents a typical in-use configuration. This includes the charge-air cooling and exhaust gas recirculation systems.

(b) Measure temperature, humidity, and atmospheric pressure near the entrance to the engine's air filter, or at the inlet to the air intake system for engines that have no air filter. You may use a shared atmospheric pressure meter as long as your equipment for handling intake air maintains ambient pressure where you test the engine within ± 1 kPa of the shared atmospheric pressure. You may use a shared humidity measurement for intake air as long as your equipment for handling intake air maintains dewpoint where you test the engine to within ± 0.5 °C of the shared humidity measurement.

(c) Unless stated otherwise in the standard-setting part, maintain the temperature of intake air to (25 ± 5) °C, as measured upstream of any engine component.

(de) Use an ~~air-intake~~ intake-air restriction that represents production engines. Make sure the intake-air restriction is between the manufacturer's specified maximum for a clean filter and the manufacturer's specified maximum allowed. Measure the static differential

pressure of the restriction at the location and at the speed and torque set points specified by the manufacturer. If the manufacturer does not specify a location, measure this pressure upstream of any turbocharger or exhaust gas recirculation system connection to the intake air system. If the manufacturer does not specify speed and torque points, measure this pressure while the engine outputs maximum power. As the manufacturer, you are liable for emission compliance for all values up to the maximum restriction you specify for a particular engine.

(ed) This paragraph (ed) includes provisions for simulating charge-air cooling in the laboratory. This approach is described in paragraph (ed)(1) of this section. Limits on using this approach are described in paragraphs (ed)(2) and (3) of this section.

(1) Use a charge-air cooling system with a total intake-air capacity that represents production engines' in-use installation. Design any laboratory charge-air cooling system to minimize accumulation of condensate. Drain any accumulated condensate before emission testing. Modulate any condensate drain during an emission test as it would normally operate in use. Maintain coolant conditions as follows:

(i) Maintain a coolant temperature of at least 20 °C at the inlet to the charge-air cooler throughout testing.

(ii) At the engine conditions specified by the manufacturer, set the coolant flow rate to achieve an air temperature within ±5 °C of the value specified by the manufacturer at the charge-air cooler's outlet.~~At maximum engine power, set the coolant flow rate to achieve an air temperature within ±5 °C of the value specified by the manufacturer at the charge-air cooler outlet.~~ Measure the air-outlet temperature at the location specified by the manufacturer. Use this coolant flow rate set point throughout testing. If the engine manufacturer does not specify engine conditions or the corresponding charge-air cooler air outlet temperature, set the coolant flow rate at maximum engine power to achieve a charge-air cooler air outlet temperature that represents in-use operation.

(iii) If the engine manufacturer specifies pressure-drop limits across the charge-air cooling system, ensure that the pressure drop across the charge-air cooling system at engine conditions specified by the manufacturer is within the manufacturer's specified limit(s). Measure the pressure drop at the manufacturer's specified locations.

(2) The objective of this section is to produce emission results that are representative of in-use operation. If good engineering judgment indicates that the specifications in this section would result in unrepresentative testing (such as overcooling of the intake air), you may use more sophisticated setpoints and controls of charge-air pressure drop, coolant temperature, and flowrate to achieve more representative results.~~Using a constant flow rate as described in paragraph (d)(1)(ii) of this section may result in unrepresentative overcooling of the intake air. If this causes any regulated emission to decrease, then you may still use this approach, but only if the effect on emissions is smaller than the degree to which you meet the applicable emission standards. If the effect on emissions is larger than the degree to which you meet the applicable emission standards, you must use a variable flow rate that controls intake air temperatures to be representative of in-use operation.~~

(3) This approach does not apply for field testing. You may not correct measured emission levels from field testing to account for any differences caused by the simulated cooling in the laboratory.

6. Section 1065.130 is revised to read as follows:

§1065.130 Engine exhaust.

(a) General. Use the exhaust system installed with the engine or one that represents a typical in-use configuration. This includes any applicable aftertreatment devices.

Formatted: Underline

(b) Aftertreatment configuration. If you do not use the exhaust system installed with the engine, configure any aftertreatment devices as follows:

Formatted: Underline

(1) Position any aftertreatment device so its distance from the nearest exhaust manifold flange or turbocharger outlet is within the range specified by the engine manufacturer in the application for certification. If this distance is not specified, position aftertreatment devices to represent typical in-use vehicle configurations.

(2) You may use laboratory exhaust tubing upstream of any aftertreatment device that is of diameter(s) typical of in-use configurations. If you use laboratory exhaust tubing upstream of any aftertreatment device, position each aftertreatment device according to paragraph (b)(1) of this section.

(c) Sampling system connections. Connect an engine's exhaust system to any raw sampling location or dilution stage, as follows:

Formatted: Underline

(1) Minimize laboratory exhaust tubing lengths and use a total length of laboratory tubing of no more than 10 m or 50 outside diameters, whichever is greater. If laboratory exhaust tubing consists of several different outside tubing diameters, count the number of diameters of length of each individual diameter, then sum all the diameters to determine the total length of exhaust tubing in diameters. Use the mean outside diameter of any converging or diverging sections of tubing. Use outside hydraulic diameters of any noncircular sections.

(2) You may install short sections of flexible laboratory exhaust tubing at any location in the engine or laboratory exhaust systems. You may use up to a combined total of 2 m or 10 outside diameters of flexible exhaust tubing.

(3) Insulate any laboratory exhaust tubing downstream of the first 25 outside diameters of length.

(4) Use laboratory exhaust tubing materials that are smooth-walled, electrically conductive, and not reactive with exhaust constituents. Stainless steel is an acceptable material.

(5) 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.

(6) We recommend that you connect multiple exhaust stacks from a single engine into one stack upstream of any emission sampling. 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 single stack. $Re\#$ is defined in §1065.640.

Formatted: Font: Italic

Formatted: Font: Italic

Formatted: Font: Italic

Formatted: Underline

(d) In-line instruments. You may insert instruments into the laboratory exhaust tubing, such as an in-line smoke meter. If you do this, you may leave a length of up to 5 outside diameters of laboratory exhaust tubing uninsulated on each side of each instrument, but you must leave a length of no more than 25 outside diameters of laboratory exhaust tubing uninsulated in total, including any lengths adjacent to in-line instruments.

(e) Leaks. Minimize leaks sufficiently to ensure your ability to demonstrate compliance with the applicable standards. We recommend performing a chemical balance of fuel, intake air, and exhaust according to §1065.655 to verify exhaust system integrity.

Formatted: Underline

(fe) Grounding. Electrically ground the entire exhaust system.

Formatted: Underline

(gf) Forced cooldown. You may install a forced cooldown system for an exhaust aftertreatment device according to §1065.530(a)(1)(i).

Formatted: Underline

(hg) Exhaust restriction. As the manufacturer, you are liable for emission compliance for all values up to the maximum restriction(s) you specify for a particular engine. Measure and set exhaust restriction(s) at the location(s) and at the speed, torque and aftertreatment set points specified by the manufacturer. If the manufacturer does not specify any location, measure this pressure downstream of any turbocharger or exhaust gas recirculation system connection to the exhaust system. If the manufacturer does not specify speed and torque points, measure this pressure while the engine produces maximum power. Use an exhaust restriction setpoint that represents a typical in-use value, if available.

Formatted: Underline

(1) If a typical in-use value for exhaust restriction is not available for exhaust systems with a fixed restriction, set the exhaust restriction at (80 to 100) % of the maximum exhaust restriction specified by the manufacturer, or if the maximum is 5 kPa or less, the set point must be no less than 1.0 kPa from the maximum. For example, if the maximum back pressure is 4.5 kPa, do not use an exhaust restriction set point that is less than 3.5 kPa.

(2) If a typical value for exhaust restriction is not available for exhaust systems with variable restriction, set the exhaust restriction between the maximum clean and dirty values specified by the manufacturer. Use an exhaust restriction that represents the performance of production engines. Make sure the exhaust restriction set point is either (80 to 100) % of the maximum exhaust restriction specified by the manufacturer; or if the maximum is 5 kPa or less, make sure the set point is no less than 1.0 kPa from the maximum. For example, if the maximum back pressure is 4.5 kPa, do not use an exhaust restriction set point that is less than 3.5 kPa. Measure and set this pressure at the location and at the speed, torque and aftertreatment set points specified by the manufacturer. As the manufacturer, you are liable for emission compliance for all values up to the maximum restriction you specify for a particular engine.

(ih) Open crankcase emissions. If the standard-setting part requires measuring open crankcase emissions, you may either measure open crankcase emissions separately using a method that we approve in advance, or route open crankcase emissions directly into the exhaust system for emission measurement. If the engine is not already configured to route open crankcase emissions for emission measurement, route open crankcase emissions as follows:

Formatted: Underline

(1) Use laboratory tubing materials that are smooth-walled, electrically conductive, and not reactive with crankcase emissions. Stainless steel is an acceptable material. Minimize tube lengths. We also recommend using heated or thin-walled or air gap-insulated tubing to minimize temperature differences between the wall and the crankcase emission constituents.

(2) Minimize the number of bends in the laboratory crankcase tubing and maximize the radius of any unavoidable bend.

- (3) Use laboratory crankcase exhaust tubing that meets the engine manufacturer's specifications for crankcase back pressure.
- (4) Connect the crankcase exhaust tubing into the raw exhaust downstream of any aftertreatment system, downstream of any installed exhaust restriction, and sufficiently upstream of any sample probes to ensure complete mixing with the engine's exhaust before sampling. Extend the crankcase exhaust tube into the free stream of exhaust to avoid boundary-layer effects and to promote mixing. You may orient the crankcase exhaust tube's outlet in any direction relative to the raw exhaust flow.

7. Section 1065.140 is revised to read as follows:

§1065.140 Dilution for gaseous and PM constituents.

(a) General. You may dilute exhaust with ambient air, synthetic air, or nitrogen, ~~that is at least 15 °C.~~ Note that the composition of the diluent affects some gaseous emission measurement instruments' response to emissions. We recommend diluting exhaust at a location as close as possible to the location where ambient air dilution would occur in use.

Formatted: Underline

(b) Dilution-air conditions and background concentrations. Before a diluent is mixed with exhaust, you may precondition it by increasing or decreasing its temperature or humidity. You may also remove constituents to reduce their background concentrations. The following provisions apply to removing constituents or accounting for background concentrations:

Formatted: Underline

(1) You may measure constituent concentrations in the diluent and compensate for background effects on test results. See §1065.650 for calculations that compensate for background concentrations.

(2) Either measure these background concentrations the same way you measure diluted exhaust constituents, or measure them in a way that does not affect your ability to demonstrate compliance with the applicable standards. For example, you may use the following simplifications for background sampling:

(i) You may disregard any proportional sampling requirements.

(ii) You may use unheated gaseous sampling systems.

(iii) You may use unheated PM sampling systems ~~only if we approve it in advance.~~

(iv) You may use continuous sampling if you use batch sampling for diluted emissions.

(v) You may use batch sampling if you use continuous sampling for diluted emissions.

(3) For removing background PM, we recommend that you filter all dilution air, including primary full-flow dilution air, with high-efficiency particulate air (HEPA) filters that have an initial minimum collection efficiency specification of 99.97 % (see §1065.1001 for procedures related to HEPA-filtration efficiencies). Ensure that HEPA filters are installed properly so that background PM does not leak past the HEPA filters. If you choose to correct for background PM without using HEPA filtration, demonstrate that the background PM in the dilution air contributes less than 50 % to the net PM collected on the sample filter. You may correct net PM without restriction if you use HEPA filtration.

(c) Full-flow dilution; constant-volume sampling (CVS). You may dilute the full flow of raw exhaust in a dilution tunnel that maintains a nominally constant volume flow rate, molar flow rate or mass flow rate of diluted exhaust, as follows:

Formatted: Underline

(1) Construction. Use a tunnel with inside surfaces of 300 series stainless steel. Electrically ground the entire dilution tunnel. We recommend a thin-walled and insulated dilution tunnel to minimize temperature differences between the wall and the exhaust gases.

(2) Pressure control. Maintain static pressure at the location where raw exhaust is introduced into the tunnel within ± 1.2 kPa of atmospheric pressure. You may use a booster blower to control this pressure. If you test an engine using more careful pressure control and you show by engineering analysis or by test data that you require this level of control to demonstrate compliance at the applicable standards, we will maintain the same level of static pressure control when we test that engine.

(3) Mixing. Introduce raw exhaust into the tunnel by directing it downstream along the centerline of the tunnel. You may introduce a fraction of dilution air radially from the tunnel's inner surface to minimize exhaust interaction with the tunnel walls. You may configure the 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 diluted exhaust stream, where Re# is based on the inside diameter of the dilution tunnel. Re# is defined in §1065.640.

(4) Flow measurement preconditioning. You may condition the diluted exhaust before measuring its flow rate, as long as this conditioning takes place downstream of any sample probes, as follows:

(i) You may use flow straighteners, pulsation dampeners, or both of these.

(ii) You may use a filter.

(iii) You may use a heat exchanger to control the temperature upstream of any flow meter. Note paragraph (c)(6) of this section regarding aqueous condensation.

(5) Flow measurement. Section 1065.240 describes measurement instruments for diluted exhaust flow.

(6) Aqueous condensation. To ensure that you measure a flow that corresponds to a measured concentration, you may either prevent aqueous condensation throughout between the sample probe location and the flow meter inlet in the dilution tunnel or you may allow aqueous condensation to occur and then measure humidity at the flow meter inlet. Calculations in §1065.645 and §1065.650 account for either method of addressing humidity in the diluted exhaust. Note that preventing aqueous condensation involves more than keeping pure water in a vapor phase (see §1065.1001).

(7) Flow compensation. Maintain nominally constant molar, volumetric or mass flow of diluted exhaust. You may maintain nominally constant flow by either maintaining the temperature and pressure at the flow meter or by directly controlling the flow of diluted exhaust. You may also directly control the flow of proportional samplers to maintain proportional sampling. For an individual test, validate proportional sampling as described in §1065.545.

(d) Partial-flow dilution (PFD). ~~Except as specified in this paragraph (d), you~~ You may dilute a partial flow of raw or previously diluted exhaust before measuring emissions. §1065.240 describes PFD-related flow measurement instruments. PFD may consist of constant or varying dilution ratios as described in paragraphs (d)(2) and (3) of this section. An example of a constant dilution ratio PFD is a “secondary dilution PM” measurement system. An example of a varying dilution ratio PFD is a “bag mini-diluter” or BMD.

(1) Applicability. ~~(i) You may not use PFD if the standard setting part prohibits it.~~

Formatted: Underline

(ii) You may use PFD to extract a proportional raw exhaust sample for any batch or continuous PM emission sampling over any transient duty cycle ~~only, any steady-state duty cycle or any ramped-modal cycle (RMC).~~

~~if we have explicitly approved it according to §1065.10 as an alternative procedure to the specified procedure for full-flow CVS.~~

(iii) ~~You may use PFD to extract a proportional raw exhaust sample for any batch or continuous gaseous emission sampling over any transient duty cycle, any steady-state duty cycle or any ramped-modal cycle (RMC). You may use PFD to extract a proportional raw exhaust sample for any batch or continuous gaseous emission sampling.~~

~~(iv) You may use PFD to extract a proportional raw exhaust sample for any batch or continuous PM emission sampling over any steady-state duty cycle or its ramped-modal cycle (RMC) equivalent.~~

~~(iii*)~~ You may use PFD to extract a proportional raw exhaust sample for any batch or continuous field-testing.

~~(*)iv~~ You may use PFD to extract a proportional diluted exhaust sample from a CVS for any batch or continuous emission sampling.

~~(vii)~~ You may use PFD to extract a constant raw or diluted exhaust sample for any continuous emission sampling.

~~(vi) You may use PFD to extract a constant raw or diluted exhaust sample for any steady-state emission sampling.~~

(2) Constant dilution-ratio PFD. Do one of the following for constant dilution-ratio PFD:

(i) Dilute an already proportional flow. For example, you may do this as a way of performing secondary dilution from a CVS tunnel to achieve temperature control for PM sampling.

(ii) Continuously measure constituent concentrations. For example, you might dilute to precondition a sample of raw exhaust to control its temperature, humidity, or constituent concentrations upstream of continuous analyzers. In this case, you must take into account the dilution ratio before multiplying the continuous concentration by the sampled exhaust flow rate.

(iii) Extract a proportional sample from ~~a separate~~ constant dilution ratio PFD system. For example, you might use a variable-flow pump to proportionally fill a gaseous storage medium such as a bag from a PFD system. In this case, the proportional sampling must meet the same specifications as varying dilution ratio PFD in paragraph (d)(3) of this section.

~~(iv) For each mode of a discrete-mode test (such as a locomotive notch setting or a specific setting for speed and torque), use a constant dilution ratio for any batch or continuous sampling. You may change the dilution ratio between modes, but you must account for this change in dilution ratio in your emission calculations. Also, you may not sample emissions at the same time you are changing the dilution ratio from one constant dilution ratio to another.~~

(3) Varying dilution-ratio PFD. All the following provisions apply for varying dilution-ratio PFD:

(i) Use a control system with sensors and actuators that can maintain proportional sampling over intervals as short as 200 ms (i.e., 5 Hz control).

(ii) For control input, you may use any sensor output from one or more measurements; for example, intake-air flow, fuel flow, exhaust flow, engine speed, and intake manifold temperature and pressure.

(iii) Account for any emission transit time in the PFD system, as necessary.

(iv) You may use preprogrammed data if they have been determined for the specific test site, duty cycle, and test engine from which you dilute emissions.

(v) We recommend that you run practice cycles to meet the validation criteria in §1065.545. Note that you must validate every emission test by meeting the validation criteria with the data from that specific test; ~~not Data from previously validated from~~ practice cycles or other tests may not be used to validate a different emission test.

(vi) You may not use a PFD system that requires preparatory tuning or calibration with a CVS or with the emission results from a CVS. Rather, you must be able to independently calibrate the PFD.

(e) Dilution air temperature, dilution ratio, residence time, and temperature control of PM samples. Dilute PM samples at least once upstream of transfer lines. You may dilute PM samples upstream of a transfer line using full-flow dilution, or partial-flow dilution immediately downstream of a PM probe. Configure dilution systems as follows:

Formatted: Underline

(1) Control dilution air temperature just upstream of the mixing zones to (25 ± 5) °C. We recommend controlling dilution air temperature to within a narrower tolerance of (25 ± 1) °C.

(2) Adjust the dilution system's dilution ratio for your particular engine and duty cycle to achieve a maximum dewpoint of the diluted exhaust of (20 ± 3) °C.

Formatted: Not Highlight

(3) Configure your dilution system to achieve a sample residence time of (1 to 5) seconds from the initial point at which dilution air was first introduced into the exhaust to the sample media. When calculating residence time, use an assumed flow temperature of 25 °C.

Formatted: Not Highlight

(4) Control ~~sample-inside wall~~ temperature to a ~~(47+542 to 52)~~ °C tolerance, as measured anywhere within 20 cm upstream or downstream of the PM storage media (such as a filter). Measure this temperature with a bare-wire junction thermocouple with wires that are (0.500 ± 0.025) mm diameter, or with another suitable instrument that has equivalent performance. If heat must be rejected from the sample to meet this requirement, reject the heat after the point at which the last dilution air was introduced into the diluted exhaust and reject as little heat as practical to meet this specification. ~~Heat or cool the PM sample primarily by dilution.~~

8. Section 1065.145 is revised to read as follows:

§1065.145 Gaseous and PM probes, transfer lines, and sampling system components.

(a) Continuous and batch sampling. Determine the total mass of each constituent with continuous or batch sampling, as described in §1065.15(c)(2). Both types of sampling systems have probes, transfer lines, and other sampling system components that are described in this section.

Formatted: Underline

(b) Gaseous and PM sample probes. A probe is the first fitting in a sampling system. It protrudes into a raw or diluted exhaust stream to extract a sample, such that its inside and outside surfaces are in contact with the exhaust. A sample is transported out of a probe

Formatted: Underline

into a transfer line, as described in paragraph (c) of this section. The following provisions apply to sample probes:

(1) Probe design and construction. Use sample probes with inside surfaces of 300 series stainless steel or, for raw exhaust sampling, use any nonreactive material capable of withstanding raw exhaust temperatures. Locate sample probes where constituents are mixed to their mean sample concentration. Take into account the mixing of any crankcase emissions that may be routed into the raw exhaust. Locate each probe to minimize interference with the flow to other probes. We recommend that all probes remain free from influences of boundary layers, wakes, and eddies—especially near the outlet of a raw-exhaust tailpipe where unintended dilution might occur. Make sure that purging or back-flushing of a probe does not influence another probe during testing. You may use a single probe to extract a sample of more than one constituent as long as the probe meets all the specifications for each constituent.

Formatted: Underline

(2) Probe installation on multi-stack engines. We recommend combining multiple exhaust streams from multi-stack engines before emission sampling as described in §1065.130(c)(6). If this is impractical, you may install symmetrical probes and transfer lines in each stack. In this case, each stack must be installed such that similar exhaust velocities are expected at each probe location. Use identical probe and transfer line diameters, lengths, and bends for each stack. Minimize the individual transfer line lengths, and manifold the individual transfer lines into a single transfer line to route the combined exhaust sample to analyzers and/or batch samplers. For PM sampling the manifold design must merge the individual sample streams within 12.5° of the single sample stream's flow. Note that the manifold must meet the same specifications as the transfer line according to paragraph (c) of this section. If you use this probe configuration and you determine your exhaust flow rates with a chemical balance of exhaust gas concentrations and either intake air flow or fuel flow, then show by prior testing that the concentration of O₂ in each stack remains within 5 % of the mean O₂ concentration throughout the entire duty cycle.

Formatted: Underline

(3) Gaseous sample probes. Use either single-port or multi-port probes for sampling gaseous emissions. You may orient these probes in any direction relative to the raw or diluted exhaust flow. For some probes, you must control sample temperatures, as follows:

Formatted: Underline

(i) For probes that extract NO_x from diluted exhaust, control the probe's wall temperature to prevent aqueous condensation.

(ii) For probes that extract hydrocarbons for NMHC or NMHCE analysis from the diluted exhaust of compression-ignition engines, 2-stroke spark-ignition engines, or 4-stroke spark-ignition engines below 19 kW, maintain a probe wall temperature tolerance of (191 ± 11) °C.

(4) PM sample probes. Use PM probes with a single opening at the end. Orient PM probes to face directly upstream. If you shield a PM probe's opening with a PM pre-classifier such as a hat, you may not use the preclassifier we specify in paragraph ~~(d)(4)(i)~~ (e)(1) of this section. We recommend sizing the inside diameter of PM probes to approximate isokinetic sampling at the expected mean flow rate.

Formatted: Underline

(c) Transfer lines. You may use transfer lines to transport an extracted sample from a probe to an analyzer, storage medium, or dilution system. Minimize the length of all transfer lines by locating analyzers, storage media, and dilution systems as close to

Formatted: Underline

probes as practical. We recommend that you minimize the number of bends in transfer lines and that you maximize the radius of any unavoidable bend. Avoid using 90 °elbows, tees, and cross-fittings in transfer lines. Where such connections and fittings are necessary, take steps, using good engineering judgment, to ensure that you meet the temperature tolerances in this paragraph (c). This may involve measuring temperature at various locations within transfer lines and fittings. You may use a single transfer line to transport a sample of more than one constituent, as long as the transfer line meets all the specifications for each constituent. The following construction and temperature tolerances apply to transfer lines:

(1) Gaseous samples. Use transfer lines with inside surfaces of 300 series stainless steel, PTFE, Viton™, or any other material that you demonstrate has better properties for emission sampling. For raw exhaust sampling, use a non-reactive material capable of withstanding raw exhaust temperatures. You may use in-line filters if they do not react with exhaust constituents and if the filter and its housing meet the same temperature requirements as the transfer lines, as follows:

Formatted: Underline

(i) For NO_x transfer lines upstream of either an NO₂-to-NO converter that meets the specifications of §1065.378 or a chiller that meets the specifications of §1065.376, maintain a sample temperature that prevents aqueous condensation.

(ii) For THC transfer lines for testing compression-ignition engines, 2-stroke spark-ignition engines, or 4-stroke spark-ignition engines below 19 kW, maintain a wall temperature tolerance throughout the entire line of (191 ±11) °C. If you sample from raw exhaust, you may connect an unheated, insulated transfer line directly to a probe. Design the length and insulation of the transfer line to cool the highest expected raw exhaust temperature to no lower than 191 °C, as measured at the transfer line's outlet.

(2) PM samples. We recommend heated transfer lines or a heated enclosure to minimize temperature differences between transfer lines and exhaust constituents. Use transfer lines that are inert with respect to PM and are electrically conductive on the inside surfaces. We recommend using PM transfer lines made of 300 series stainless steel. Electrically ground the inside surface of PM transfer lines.

Formatted: Underline

(d) Optional sample-conditioning components for gaseous sampling. You may use the following sample-conditioning components to prepare gaseous samples for analysis, as long as you do not install or use them in a way that adversely affects your ability to show that your engines comply with all applicable gaseous emission standards.

Formatted: Underline

(1) NO₂-to-NO converter. You may use an NO₂-to-NO converter that meets the efficiency-performance check specified in §1065.378 at any point upstream of a NO_x analyzer, sample bag, or other storage medium.

Formatted: Underline

(2) Sample dryer. You may use either type of sample dryer described in this paragraph (d)(2) to decrease the effects of water on gaseous emission measurements. You may not use a chemical dryer, or used dryers upstream of PM sample filters.

Formatted: Underline

(i) Osmotic-membrane. You may use an osmotic-membrane dryer upstream of any gaseous analyzer or storage medium, as long as it meets the temperature specifications in paragraph (c)(1) of this section. Because osmotic-membrane dryers may deteriorate after prolonged exposure to certain exhaust constituents, consult with the membrane manufacturer regarding your application before incorporating an osmotic-membrane dryer. Monitor the dewpoint, T_{dew} , and absolute pressure, p_{total} , downstream of an osmotic-membrane dryer. You may use continuously recorded values of T_{dew} and p_{total} in

Formatted: Underline

the amount of water calculations specified in §1065.645. If you do not continuously record these values, you may use their peak values observed during a test or their alarm setpoints as constant values in the calculations specified in §1065.645. You may also use a nominal p_{total} , which you may estimate as the dryer's lowest absolute pressure expected during testing.

(ii) Thermal chiller. You may use a thermal chiller upstream of some gas analyzers and storage media. You may not use a thermal chiller upstream of a THC measurement system for compression-ignition engines, 2-stroke spark-ignition engines, or 4-stroke spark-ignition engines below 19 kW. If you use a thermal chiller upstream of an NO₂-to-NO converter or in a sampling system without an NO₂-to-NO converter, the chiller must meet the NO₂ loss-performance check specified in §1065.376. Monitor the dewpoint, T_{dew} , and absolute pressure, p_{total} , downstream of a thermal chiller. You may use continuously recorded values of T_{dew} and p_{total} in the emission calculations specified in §1065.650. If you do not continuously record these values, you may use the ~~if~~ maximum temperature and minimum pressure peak-values observed during a test or the ~~if~~ high alarm temperature setpoint and the low alarm pressure setpoints as constant values in the amount of water calculations specified in §1065.645. You may also use a nominal p_{total} , which you may estimate as the dryer's lowest absolute pressure expected during testing. If it is valid to assume the degree of saturation in the thermal chiller, you may calculate T_{dew} based on the known chiller efficiency and continuous monitoring of chiller temperature, $T_{chiller}$. If you do not continuously record values of $T_{chiller}$, you may use its peak value observed during a test, or its alarm setpoint, as a constant value to determine a constant amount of water according to §1065.645. If it is valid to assume that $T_{chiller}$ is equal to T_{dew} , you may use $T_{chiller}$ in lieu of T_{dew} according to §1065.645. If it is valid to assume a constant temperature offset between $T_{chiller}$ and T_{dew} , due to a known and fixed amount of sample reheat between the chiller outlet and the temperature measurement location, you may factor in this assumed temperature offset value into emission calculations. If we ask for it, you must show by engineering analysis or by data the validity of any assumptions allowed by this paragraph (d)(2)(ii).

(3) Sample pumps. You may use sample pumps upstream of an analyzer or storage medium for any gas. Use sample pumps with inside surfaces of 300 series stainless steel, PTFE, or any other material that you demonstrate has better properties for emission sampling. For some sample pumps, you must control temperatures, as follows:

(i) If you use a NO_x sample pump upstream of either an NO₂-to-NO converter that meets §1065.378 or a chiller that meets §1065.376, it must be heated to prevent aqueous condensation.

(ii) For testing compression-ignition engines, 2-stroke spark-ignition engines, or 4-stroke compression ignition engines below 19 kW, if you use a THC sample pump upstream of a THC analyzer or storage medium, its inner surfaces must be heated to a tolerance of (191 ± 11) °C

(e) Optional sample-conditioning components for PM sampling. You may use the following sample-conditioning components to prepare PM samples for analysis, as long as you do not install or use them in a way that adversely affects your ability to show that your engines comply with the applicable PM emission standards. You may condition PM samples to minimize positive and negative biases to PM results, as follows:

Formatted: Underline

Formatted: Font: Italic

Formatted: Subscript

Formatted: Font: Italic

Formatted: Subscript

Formatted: Underline

Formatted: Underline

(1) PM preclassifier. You may use a PM preclassifier to remove large-diameter particles. The PM preclassifier may be either an inertial impactor or a cyclonic separator. It must be constructed of 300 series stainless steel. The preclassifier must be rated to remove at least 50 % of PM at an aerodynamic diameter of 10 µm and no more than 1 % of PM at an aerodynamic diameter of 1 µm over the range of flow rates for which you use it. Follow the preclassifier manufacturer's instructions for any periodic servicing that may be necessary to prevent a buildup of PM. Install the preclassifier in the dilution system downstream of the last dilution stage. Configure the preclassifier outlet with a means of bypassing any PM sample media so the preclassifier flow may be stabilized before starting a test. Locate PM sample media within 50-75 cm downstream of the preclassifier's exit. You may not use this preclassifier- if you use a PM probe that already has a preclassifier. For example, if you use a hat-shaped preclassifier that is located immediately upstream of the probe in such a way that it forces the sample flow to change direction before entering the probe, you may not use any other preclassifier in your PM sampling system.

Formatted: Underline

(2) Other components. You may request to use other PM conditioning components upstream of a PM preclassifier, such as components that condition humidity or remove gaseous-phase hydrocarbons from the diluted exhaust stream. You may use such components only if we approve them under §1065.10.

Formatted: Underline

9. Section 1065.170 is amended by revising the introductory text and paragraphs (a) and (c)(1) to read as follows:

§1065.170 Batch sampling for gaseous and PM constituents.

Batch sampling involves collecting and storing emissions for later analysis. Examples of batch sampling include collecting and storing gaseous emissions in a bag ~~and-or~~ collecting and storing PM on a filter. You may use batch sampling to store emissions that have been diluted at least once in some way, such as with CVS, PFD, or BMD. You may use batch-sampling to store undiluted emissions.

~~only if we approve it as an alternate procedure under §1065.10.~~

(a) Sampling methods. ~~For batch sampling, extract the sample at a rate proportional to the exhaust flow.~~ If you extract from a constant-volume flow rate, sample at a constant-volume flow rate. If you extract from a varying flow rate, vary the sample rate in proportion to the varying flow rate. Validate proportional sampling after an emission test as described in §1065.545. Use storage media that do not significantly change measured emission levels (either up or down). For example, do not use sample bags for storing emissions if the bags are permeable with respect to emissions or if they offgas emissions to the extent that it affects your ability to demonstrate compliance with the applicable gaseous emission standards. As another example, do not use PM filters that irreversibly absorb or adsorb gases to the extent that it affects your ability to demonstrate compliance with the applicable PM emission standard.

Formatted: Underline

* * * * *

(c) * * *

(1) If you use filter-based sampling media to extract and store PM for measurement, your procedure must meet the following specifications:

(i) If you expect that a filter’s total surface concentration of PM will exceed 0.473 ~~µmg/mm²~~ for a given test interval, you may use filter media with a minimum initial collection efficiency of 98 %; otherwise you must use a filter media with a minimum initial collection efficiency of 99.7 %. Collection efficiency must be measured as described in ASTM D 2986-95a (incorporated by reference in §1065.1010), though you may rely on the sample-media manufacturer’s measurements reflected in their product ratings to show that you meet ~~applicable requirements-this requirement.~~

(ii) The filter must be circular, with an overall diameter of 46.50 ± 0.6 mm and an exposed diameter of at least 38 mm. See the cassette specifications in paragraph

(c)(1)(vi) of this section.

(iii) We highly recommend that you use a pure PTFE filter material that does not have any flow-through support bonded to the back and has an overall thickness of 40 ±20 µm. An inert polymer ring may be bonded to the periphery of the filter material for support and for sealing between the filter cassette parts. We consider Polymethylpentene (PMP) and PTFE inert materials for a support ring, but other inert materials may be used. See the cassette specifications in paragraph (c)(1)(vi) of this section. We allow the use of PTFE-coated glass fiber filter material, as long as this filter media selection does not affect your ability to demonstrate compliance with the applicable standards, which we base on a pure PTFE filter material. Note that we will use pure PTFE filter material for compliance testing, and we may require you to use pure PTFE filter material for any compliance testing we require, such as for selective enforcement audits.

(iv) You may request to use other filter materials or sizes under the provisions of §1065.10.

(v) To minimize turbulent deposition and to deposit PM evenly on a filter, use a 12.5° (from center) divergent cone angle to transition from the transfer-line inside diameter to the exposed diameter of the filter face. Use 300 series stainless steel for this transition.

(vi) Maintain sample velocity at the filter face at or below 100 cm/s, where filter face velocity is the measured volumetric flow rate of the sample at the pressure and temperature upstream of the filter face, divided by the filter’s exposed area.

(vii) Use a clean cassette designed to the specifications of Figure 1 of §1065.170 and made of any of the following materials: Delrin™, 300 series stainless steel, polycarbonate, acrylonitrile-butadiene-styrene (ABS) resin, or conductive polypropylene. We recommend that you keep filter cassettes clean by periodically washing or wiping them with a compatible solvent applied using a lint-free cloth. Depending upon your cassette material, ethanol (C₂H₅OH) might be an acceptable solvent. Your cleaning frequency will depend on your engine’s PM and HC emissions.

(viii) If you store filters in cassettes in an automatic PM sampler, cover or seal individual filter cassettes after sampling to prevent communication of semi-volatile matter from one filter to another.

* * * * *

10. Section 1065.190 is amended by revising paragraph (e) and adding paragraph

(g)(6) to read as follows:

§1065.190 PM-stabilization and weighing environments for gravimetric analysis.

* * * * *

(e) Verify the following ambient conditions using measurement instruments that meet the specifications in subpart C of this part:

(1) Continuously measure dewpoint and ambient temperature. Use these values to determine if the stabilization and weighing environments have remained within the tolerances specified in paragraph (d) of this section for at least ~~the past~~ 60 min before weighing filters. We recommend that you provide an interlock that automatically prevents the balance from reporting values if either of the environments have not been within the applicable tolerances for the past 60 min.

(2) Continuously measure atmospheric pressure within the weighing environment. You may use a shared atmospheric pressure meter as long as you can show that your ~~ventilation equipment for handling system for~~ the weighing environment ~~air~~ maintains ambient pressure at the balance within ± 100 Pa of the shared atmospheric pressure meter. Provide a means to record the most recent atmospheric pressure when you weigh each PM sample. Use this value to calculate the PM buoyancy correction in §1065.690.

* * * * *
(g) * * *

(6) We recommend that you neutralize PM sample media to within ± 2.0 V of neutral.

Measure static voltages as follows:

(i) Measure static voltage of PM sample media according to the electrostatic voltmeter manufacturer's instructions.

(ii) Measure static voltage of PM sample media while the media is at least 15 cm away from any grounded surfaces to avoid mirror image charge interference.

11. Section 1065.195 is amended by revising paragraph (c)(4) to read as follows:

§1065.195 PM-stabilization environment for in-situ analyzers.

* * * * *
(c) * * *

(4) Absolute pressure. ~~Maintain an absolute pressure of (80.000 to 103.325) kPa.~~ Use good engineering judgment to maintain a ~~more stringent~~ tolerance of absolute pressure if your PM measurement instrument requires it.

* * * * *

Formatted: Underline

Subpart C— [Amended]

1. Section 1065.201 is amended by revising paragraphs (a), (b), and (d) and adding paragraph (h) to read as follows:

§1065.201 Overview and general provisions.

Formatted: Font: Bold

(a) Scope. This subpart specifies measurement instruments and associated system requirements related to emission testing in a laboratory or similar environment and in the field. This includes laboratory instruments and portable emission measurement systems (PEMS) for measuring engine parameters, ambient conditions, flow-related parameters, and emission concentrations.

Formatted: Underline

(b) Instrument types. You may use any of the specified instruments as described in this subpart to perform emission tests. If you want to use one of these instruments in a way that is not specified in this subpart, or if you want to use a different instrument, you must first get us to approve your alternate procedure under §1065.10. Where we specify more than one instrument for a particular measurement, we may identify which instrument serves as the reference for ~~showing that an alternative procedure is equivalent to the specified procedure~~ comparing with an alternate procedure.

Formatted: Underline

(d) Redundant systems. For all measurement instruments described in this subpart, you may use data from multiple instruments to calculate test results for a single test. If you use redundant systems, use good engineering judgment to use multiple measured values in calculations or to disregard individual measurements. Note that you must keep your results from all measurements, as described in §1065.25. This requirements applies whether or not you actually use the measurements in your calculations.

Formatted: Underline

(h) Recommended practices. This subpart identifies a variety of recommended but not required practices for proper measurements. We believe in most cases it is necessary to follow these recommended practices for accurate and repeatable measurements and we intend to follow them as much as possible for our testing. However, we do not specifically require you to follow these recommended practices to perform a valid test, as long as you meet the required calibrations and verifications of measurement systems specified in subpart D of this part.

Formatted: Underline

2. Section 1065.210 is amended by revising paragraph (a) before the figure to read as follows:

§1065.210 Work input and output sensors.

Formatted: Font: Bold

(a) Application. Use instruments as specified in this section to measure work inputs and outputs during engine operation. We recommend that you use sensors, transducers, and meters that meet the specifications in Table 1 of §1065.205. Note that your overall systems for measuring work inputs and outputs must meet the linearity verifications in §1065.307. We recommend that you measure work inputs and outputs where they cross the system boundary as shown in Figure 1 of §1065.210. The system boundary is different for air-cooled engines than for liquid-cooled engines. If you choose to measure work before or after a work conversion, relative to the system boundary, use good

Formatted: Underline

engineering judgment to estimate any work-conversion losses in a way that avoids overestimation of total work. For example, if it is impractical to instrument the shaft of an exhaust turbine generating electrical work, you may decide to measure its converted electrical work. As another example, you may decide to measure the tractive (i.e., electrical output) power of a locomotive, rather than the brake power of the locomotive engine. In ~~this case~~these cases, divide the electrical work by ~~an~~ accurate values of electrical generator efficiency ($\eta < 1$), or assume an efficiency of 1 ($\eta = 1$), which would over-estimate brake-specific emissions. For the example of using locomotive tractive power with a generator efficiency of 1 ($\eta = 1$), this means using the tractive power as the brake power in emission calculations. Do not underestimate ~~the any work conversion~~generator's efficiencies for any components outside the system boundary that do not return work into the system boundary. And do not overestimate any work conversion efficiencies for components outside the system boundary that do return work into the system boundary ~~y because this would result in an under estimation of brake-specific emissions.~~ In all cases, ensure that you are able to accurately demonstrate compliance with the applicable standards.

* * * * *

3. Section 1065.215 is amended by revising paragraph (e) to read as follows:

§1065.215 Pressure transducers, temperature sensors, and dewpoint sensors.

* * * * *

(e) Dewpoint. For PM-stabilization environments, we recommend chilled-surface hygrometers, which include chilled mirror detectors and chilled surface acoustic wave (SAW) detectors. For other applications, we recommend thin-film capacitance sensors. You may use other dewpoint sensors, such as a wet-bulb/dry-bulb psychrometer, where appropriate.

4. Section 1065.220 is amended by revising paragraph (d) to read as follows:

§1065.220 Fuel flow meter.

* * * * *

(d) Flow conditioning. For any type of fuel flow meter, condition the flow as needed to prevent wakes, eddies, circulating flows, or flow pulsations from affecting the accuracy or repeatability of the meter. You may accomplish this by using a sufficient length of straight tubing (such as a length equal to at least 10 pipe diameters) or by using specially designed tubing bends, straightening fins, or pneumatic pulsation dampeners to establish a steady and predictable velocity profile upstream of the meter. Condition the flow as needed to prevent any gas bubbles in the fuel from affecting the fuel meter.

5. Section 1065.265 is amended by revising paragraph (c) to read as follows:

§1065.265 Nonmethane cutter.

* * * * *

(c) Configuration. Configure the nonmethane cutter with a bypass line if it is needed for the verification described in §1065.365.

Formatted: Font: Bold

Formatted: Underline

Formatted: Font: Bold

Formatted: Underline

Formatted: Font: Bold

Formatted: Underline

* * * * *

6. Section 1065.270 is amended by revising paragraph (c) to read as follows:

§1065.270 Chemiluminescent detector.

* * * * *

Formatted: Font: Bold

(c) NO₂-to-NO converter. Place upstream of the CLD an internal or external NO₂-to-NO converter that meets the verification in §1065.378. Configure the converter with a bypass line if it is needed to facilitate this verification.

* * * * *

Formatted: Underline

7. Section 1065.280 is revised to read as follows:

§1065.280 Paramagnetic and magnetopneumatic O₂ detection analyzers.

(a) Application. You may use a paramagnetic detection (PMD) or magnetopneumatic detection (MPD) analyzer to measure O₂ concentration in raw or diluted exhaust for batch or continuous sampling. You may use O₂ measurements with intake air or fuel flow measurements to calculate exhaust flow rate according to §1065.650.

(b) Component requirements. We recommend that you use a PMD or ~~MPD~~ analyzer that meets the specifications in Table 1 of §1065.205. Note that it must meet the linearity verification in §1065.307. You may use a PMD or ~~MPD~~ that has compensation algorithms that are functions of other gaseous measurements and the engine's known or assumed fuel properties. The target value for any compensation algorithm is 0.0 % (that is, no bias high and no bias low), regardless of the uncompensated signal's bias.

Formatted: Font: Bold

Formatted: Underline

Formatted: Underline

8. Section 1065.290 is amended by revising paragraph (c)(1) to read as follows:

§1065.290 PM gravimetric balance.

* * * * *

(c) * * * * *
(1) Use a pan that centers the PM sample media (such as a filter) on the weighing pan. For example, use a pan in the shape of a cross that has upswept tips that center the PM sample media on the pan.

* * * * *

Formatted: Font: Bold

Subpart D—[Amended]

1. Section 1065.303 is revised to read as follows:

§1065.303 Summary of required calibration and verifications

Formatted: Font: Bold

The following table summarizes the required and recommended calibrations and verifications described in this subpart and indicates when these have to be performed:

Table 1 of §1065.303–Summary of required calibration and verifications

| Type of calibration or verification | Minimum frequency ^a |
|---|--|
| § 1065.305: accuracy <u>Accuracy</u> , repeatability and noise | Accuracy: Not required, but recommended for initial installation. Repeatability: Not required, but recommended for initial installation. Noise: Not required, but recommended for initial installation. |
| § 1065.307: linearity <u>Linearity</u> | Speed: Upon initial installation, within 370 days before testing and after major maintenance. Torque: Upon initial installation, within 370 days before testing and after major maintenance. Electrical power: Upon initial installation, within 370 days before testing and after major maintenance. Clean gas and diluted exhaust flows: Upon initial installation, within 370 days before testing and after major maintenance, unless flow is verified by propane check or by carbon or oxygen balance. Raw exhaust flow: Upon initial installation, within 185 days before testing and after major maintenance, unless flow is verified by propane check or by carbon or oxygen balance. Gas analyzers: Upon initial installation, within 35 days before testing and after major maintenance. PM balance: Upon initial installation, within 370 days before testing and after major maintenance. Stand-alone pressure and temperature: Upon initial installation, within 370 days before testing and after major maintenance. |
| § 1065.308: Continuous analyzer system response and recording | Upon initial installation, after system reconfiguration, and after major maintenance. |
| § 1065.309: Continuous analyzer uniform response | Upon initial installation, after system reconfiguration, and after major maintenance. |
| § 1065.310: torque <u>Torque</u> | Upon initial installation and after major maintenance. |
| § 1065.315: pressure <u>Pressure</u> , temperature, dewpoint | Upon initial installation and after major maintenance. |
| § 1065.320: fuel <u>Fuel</u> flow | Upon initial installation and after major maintenance. |
| § 1065.325: intake <u>Intake</u> flow | Upon initial installation and after major maintenance. |
| § 1065.330: exhaust <u>Exhaust</u> flow | Upon initial installation and after major maintenance. |
| § 1065.340: diluted <u>Diluted</u> exhaust flow (CVS) | Upon initial installation and after major maintenance. |
| § 1065.341: CVS and batch sampler verification | Upon initial installation, within 35 days before testing, and after major maintenance. |
| § 1065.345: vacuum <u>Vacuum</u> leak | Before each laboratory test according to subpart F of this part and before each field test according to subpart J of this part. |
| § 1065.350: CO ₂ NDIR H ₂ O interference | Upon initial installation and after major maintenance. |
| § 1065.355: CO NDIR CO ₂ and H ₂ O interference | Upon initial installation and after major maintenance. |
| § 1065.360: <u>FID calibration</u> , <u>THC FID optimization</u> , and <u>THC FID verification</u> . § 1065.360: FID calibration, THC FID optimization, and THC FID verification. | <u>Calibrate all FID analyzers: upon initial installation and after major maintenance.</u> <u>Optimize and determine CH₄ response for THC FID analyzers: upon initial installation and after major maintenance.</u> <u>Verify CH₄ response for THC FID analyzers: upon initial installation, within 185 days before testing, and after major maintenance.</u> Calibrate all FID analyzers: upon initial installation and after major maintenance. Optimize and determine CH₄ response for THC FID analyzers: upon initial installation and after major maintenance. Verify CH₄ response for THC FID analyzers: upon initial installation, within 185 days before testing, and after major maintenance. |
| § 1065.362: raw <u>Raw</u> exhaust FID O ₂ interference | <u>For all FID analyzers: u</u> Upon initial installation, <u>after FID optimization according to §1065.360,</u> and after major maintenance. <u>For THC FID analyzers: upon initial installation, after major maintenance, and after FID optimization according to §1065.360.</u> |

| | |
|--|--|
| §1065.365: nonmethane Nonmethane cutter penetration | Upon initial installation, within 185 days before testing, and after major maintenance. |
| §1065.370: CLD CO ₂ and H ₂ O quench | Upon initial installation and after major maintenance. |
| §1065.372: NDUV HC and H ₂ O interference | Upon initial installation and after major maintenance. |
| §1065.376: chiller-Chiller NO ₂ penetration | Upon initial installation and after major maintenance. |
| §1065.378: NO ₂ -to-NO converter conversion | Upon initial installation, within 35 days before testing, and after major maintenance. |
| §1065.390: PM balance and weighing | Independent verification: upon initial installation, within 370 days before testing, and after major maintenance. Zero, span, and reference sample verifications: within 12 hours of weighing, and after major maintenance. |
| §1065.395: Inertial PM balance and weighing | Independent verification: upon initial installation, within 370 days before testing, and after major maintenance. Other verifications: upon initial installation and after major maintenance. |

³Perform calibrations and verifications more frequently, according to measurement system manufacturer instructions and good engineering judgment.

2. Section 1065.305 is amended by revising paragraphs (d)(4) and (d)(8) to read as follows:

§1065.305 Verifications for accuracy, repeatability, and noise.

Formatted: Font: Bold

* * * * *

(d) * * *

(4) Use the instrument to quantify a NIST-traceable reference quantity, y_{ref} . For gas analyzers the reference gas must meet the specifications of §1065.750. Select a reference quantity near the mean value expected during testing. For all gas analyzers, use a quantity near the flow-weighted mean concentration expected at the standard or expected during testing, whichever is greater. For a noise ~~verification~~verification, use the same zero gas from paragraph (e) of this section as the reference quantity. In all cases, allow time for the instrument to stabilize while it measures the reference quantity. Stabilization time may include time to purge an instrument and time to account for its response.

* * * * *

(8) Repeat the steps specified in paragraphs (d)(2) through (6~~7~~) of this section until you have ten arithmetic means ($\bar{y}_1, \bar{y}_2, \bar{y}_1, \dots, \bar{y}_{10}$), ten standard deviations, ($\sigma_1, \sigma_2, \sigma_1, \dots, \sigma_{10}$), and ten errors ($\varepsilon_1, \varepsilon_2, \varepsilon_1, \dots, \varepsilon_{10}$).

* * * * *

3. Section 1065.307 is amended by adding paragraph (d)(8) and revising Table 1 and paragraphs (b), (c)(6), and (c)(13) to read as follows:

§1065.307 Linearity verification.

Formatted: Font: Bold

* * * * *

(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

Formatted: Underline

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) * * *

(6) Use For all measured quantities except temperature, use instrument manufacturer recommendations and good engineering judgment to select at least 10 reference values, y_{refi} , that are within the range from zero to the highest values expected during emission testing. We recommend selecting a zero reference signal as one of the reference values of the linearity verification. For temperature linearity verifications, we recommend three to five reference values.

* * * *

(13) Use the arithmetic means, \bar{y}_i , and reference values, y_{refi} , to calculate least-squares linear regression parameters and statistical values to compare to the minimum performance criteria specified in Table 1 of this section. Use the calculations described in §1065.602. Using good engineering judgment, you may weight the results of individual data pairs (i.e. (y_{refi}, \bar{y}_i)), in the linear regression calculations.

(d) * * *

(8) Analog-to-digital conversion of stand-alone temperature signals. For reference values, select a temperature signal calibrator to simultaneously simulate and measure an analog signal similar to your temperature sensor(s). Analog signals may include voltage, current, resistance, frequency, and pulse signals. Use a calibrator that is independently linearized and cold-junction compensated, as necessary, and is NIST-traceable within $\pm 0.5\%$ uncertainty.

Formatted: Underline

Table 1 of §1065.307—Measurement systems that require linearity verifications

| Measurement System | Quantity | Minimum verification frequency ^a | Linearity Criteria | | | |
|--|-----------|---|---|------------------------|---|--------------|
| | | | $ a_0 $ ^b | a_1 ^c | SEE ^b | r^2 |
| Engine speed | f_n | Within 370 days before testing | $\leq 0.05 \% \cdot f_{\max}$ | 0.98-1.02 | $\leq 2 \% \cdot f_{\max}$ | ≥ 0.990 |
| Engine torque | T | Within 370 days before testing | $\leq 1 \% \cdot T_{\max}$ | 0.98-1.02 | $\leq 2 \% \cdot T_{\max}$ | ≥ 0.990 |
| Electrical work | W | Within 370 days before testing | $\leq 1 \% \cdot T_{\max}$ | 0.98-1.02 | $\leq 2 \% \cdot T_{\max}$ | ≥ 0.990 |
| Fuel flow rate | \dot{m} | Within 370 days before testing ^d | $\leq 1 \% \cdot \dot{m}_{\max}$ | 0.98-1.02 ^e | $\leq 2 \% \cdot \dot{m}_{\max}$ | ≥ 0.990 |
| Intake-air flow rate | \dot{n} | Within 370 days before testing ^d | $\leq 1 \% \cdot \dot{n}_{\max}$ | 0.98-1.02 ^e | $\leq 2 \% \cdot \dot{n}_{\max}$ | ≥ 0.990 |
| Dilution air flow rate | \dot{n} | Within 370 days before testing ^d | $\leq 1 \% \cdot \dot{n}_{\max}$ | 0.98-1.02 | $\leq 2 \% \cdot \dot{n}_{\max}$ | ≥ 0.990 |
| Diluted exhaust flow rate | \dot{n} | Within 370 days before testing ^d | $\leq 1 \% \cdot \dot{n}_{\max}$ | 0.98-1.02 | $\leq 2 \% \cdot \dot{n}_{\max}$ | ≥ 0.990 |
| Raw exhaust flow rate | \dot{n} | Within 185 days before testing ^d | $\leq 1 \% \cdot \dot{n}_{\max}$ | 0.98-1.02 ^e | $\leq 2 \% \cdot \dot{n}_{\max}$ | ≥ 0.990 |
| Batch sampler flow rates | \dot{n} | Within 370 days before testing ^d | $\leq 1 \% \cdot \dot{n}_{\max}$ | 0.98-1.02 | $\leq 2 \% \cdot \dot{n}_{\max}$ | ≥ 0.990 |
| Gas dividers | x | Within 370 days before testing | $\leq 0.5 \% \cdot x_{\max}$ | 0.98-1.02 | $\leq 2 \% \cdot x_{\max}$ | ≥ 0.990 |
| All gas analyzers | x | Within 35 days before testing | $\leq 0.51 \% \cdot x_{\max}$ m_{\max} | 0.99-1.01 | $\leq 1 \% \cdot x_{\max}$ | ≥ 0.998 |
| PM balance | m | Within 370 days before testing | $\leq 1 \% \cdot m_{\max}$ | 0.99-1.01 | $\leq 1 \% \cdot m_{\max}$ | ≥ 0.998 |
| Stand-alone pressures | p | Within 370 days before testing | $\leq 1 \% \cdot \frac{P_{\max}}{m_{\max}}$ | 0.99-1.01 | $\leq 1 \% \cdot \frac{P_{\max}}{m_{\max}}$ | ≥ 0.998 |
| <u>Analog-to-digital conversion of stand-alone temperature signals</u> | T | Within 370 days before testing | $\leq 1 \% \cdot \frac{T_{\max}}{m_{\max}}$ | 0.99-1.01 | $\leq 1 \% \cdot \frac{T_{\max}}{m_{\max}}$ | ≥ 0.998 |

Formatted: Left

^a Perform a linearity verification more frequently if the instrument manufacturer recommends it or based on good engineering judgment.

^b "max." refers to the peak value expected during testing or at the applicable standard over any test interval, whichever is greater. "max" refers to the maximum value expected during a test—the maximum value used for the linearity verification.

^c The specified ranges are inclusive. For example, a specified range of 0.98-1.02 for a_1 means $0.98 \leq a_1 \leq 1.02$.

^d These linearity verifications are not required for systems that pass the flow-rate verification for diluted exhaust as described in §1065.341 (the propane check) or for systems that agree within $\pm 2\%$ based on a chemical balance of carbon or oxygen of the intake air, fuel, and exhaust.

^e ~~a_0 and a_1 criteria~~ for these quantities ~~are required~~ **must be met** only if the ~~actual-absolute~~ value of the quantity is required, as opposed to a signal that is only linearly proportional to the actual value.

4. Section 1065.308 is revised to read as follows:

§1065.308 Continuous gas analyzer system-response and updating-recording verification.

Formatted: Font: Bold

(a) Scope and frequency. Perform this verification after installing or replacing a gas analyzer that you use for continuous sampling. Also perform this verification if you reconfigure your system in a way that would change system response. For example, perform this verification if you add a significant volume to the transfer lines by increasing their length or adding a filter; or if you change the frequency at which you sample and record gas-analyzer concentrations. You do not have to perform this verification for gas analyzer systems used only for discrete-mode testing.

Formatted: Underline

(b) Measurement principles. This test verifies that the updating and recording frequencies match the overall system response to a rapid change in the value of concentrations at the sample probe. Gas analyzer systems must be optimized such that their overall response to a rapid change in concentration is updated and recorded at an appropriate frequency to prevent loss of information. This test also verifies that continuous gas analyzer systems meet a minimum response time.

Formatted: Underline

(c) System requirements. To demonstrate acceptable updating and recording with respect to the system's overall response, use good engineering judgment to select one of the following criteria that your system must meet:

Formatted: Underline

(1) The product of the mean rise time and the frequency at which the system records an updated concentration must be at least 5, and the product of the mean fall time and the frequency at which the system records an updated concentration must be at least 5. This criteria makes no assumption regarding the frequency content of changes in emission concentrations during emission testing; therefore, it is valid for any testing. In any case the mean rise time and the mean fall time must be no more than 10 seconds.

(2) The frequency at which the system records an updated concentration must be at least 5 Hz. This criteria assumes that the frequency content of significant changes in emission concentrations during emission testing do not exceed 1 Hz. In any case the mean rise time and the mean fall time must be no more than 10 seconds.

(3) You may use other criteria if we approve the criteria in advance.

(4) For PEMS, you do not have to meet this criteria if your PEMS meets the overall PEMS check in §1065.920.

(d) Procedure. Use the following procedure to verify the response of a continuous gas analyzer system:

Formatted: Underline

(1) Instrument setup. Follow the analyzer system manufacturer's start-up and operating instructions. Adjust the system as needed to optimize performance.

Formatted: Underline

(2) Equipment setup. Using minimal gas transfer line lengths between all connections, connect a zero-air source to one inlet of a fast-acting 3-way valve (2 inlets, 1 outlet). Using a gas divider, equally blend an NO-CO-CO₂-C₃H₈-CH₄ (balance N₂) span gas with a span gas of NO₂, balance N₂. Connect the gas divider outlet to the other inlet of the 3-way valve. Connect the valve outlet to an overflow at the gas analyzer system's probe or

Formatted: Underline

to an overflow fitting between the probe and transfer line to all the analyzers being verified. Note that you may omit any of these gas constituents if they are not relevant to your analyzers for this verification.

(3) Data collection. (i) Switch the valve to flow zero gas.

Formatted: Underline

(ii) Allow for stabilization, accounting for transport delays and the slowest instrument's full response.

(iii) Start recording data at the frequency used during emission testing. Each recorded value must be a unique updated concentration measured by the analyzer; you may not use interpolation to increase the number of recorded values.

(iv) Switch the valve to flow the blended span gases.

(v) Allow for transport delays and the slowest instrument's full response.

(vi) Repeat the steps in paragraphs (d)(3)(i) through (v) of this section to record seven full cycles, ending with zero gas flowing to the analyzers.

(vii) Stop recording.

(e) Performance evaluation. (1) If you chose to demonstrate compliance with paragraph (c)(1) of this section, use the data from paragraph (d)(3) of this section to calculate the mean rise time, $T_{10\%10-90}$, and mean fall time, $T_{90\%90-10}$, for each of the analyzers. Multiply these times (in seconds) by their respective recording frequencies in Hertz (1/second).

Formatted: Underline

The value for each result must be at least 5. If the value is less than 5, increase the recording frequency or adjust the flows or design of the sampling system to increase the rise time and fall time as needed. You may also configure digital filters to increase rise and fall times. The mean rise time and mean fall time must be no greater than 10 seconds.

(2) If a measurement system fails the criterion in paragraph (e)(1) of this section, ensure that signals from the system are updated and recorded at a frequency of at least 5 Hz. In any case, the mean rise time and mean fall time must be no greater than 10 seconds.

(3) If a measurement system fails the criteria in paragraphs (e)(1) and (2) of this section, you may use the continuous analyzer system only if the deficiency does not adversely affect your ability to show compliance with the applicable standards.

5. Section 1065.309 is revised to read as follows:

§1065.309 Continuous gas analyzer uniform response verification.

Formatted: Font: Bold

(a) Scope and frequency. Perform this verification if you use more than one multiply or divide one continuous gas analyzer's response by another's to quantify a gaseous emission. Note that we consider water vapor a gaseous constituent. You do not have to perform this verification if you multiply one gas analyzer's response to another's to compensate for an interference that never requires a compensation more than 2 % of the flow-weighted mean concentration at the applicable standard or during testing, whichever is greatest. You also do not have to perform this verification for batch gas analyzer systems or for continuous analyzer systems that are only used for discrete-mode testing to quantify a gaseous constituent, you must perform this verification. For example, if you determine NMHC as the difference between continuous THC and CH₄ measurements, you must perform this verification on your NMHC measurement system. As another example if you determine NO_x as the sum of separate continuous measurements of NO and NO₂, you must perform this verification on your NO_x measurement system. Also, you must perform this verification if you use one continuous analyzer to apply an

Formatted: Underline

~~interference compensation algorithm to another continuous gas analyzer.~~ Perform this verification after initial installation or major maintenance. Also perform this verification if you reconfigure your system in a way that would change system response. For example, perform this verification if you add a significant volume to the transfer lines by increasing their length or by adding a filter; or if you change the frequency at which you sample and record gas-analyzer concentrations.

(b) Measurement principles. This procedure verifies the time-alignment and uniform response of ~~combined continuous~~continuously combined gas measurements.

Formatted: Underline

(c) System requirements. Demonstrate that ~~continuously combined~~continuously combined concentration measurements have a uniform rise and fall during a simultaneous to a step change in both concentrations. During a system response to a rapid change in multiple gas concentrations, demonstrate that the ~~50-150~~times of all combined analyzers all occur at the same recorded second of data or between the same two recorded seconds of data.

Formatted: Underline

(d) Procedure. Use the following procedure to verify the response of a continuous gas analyzer system:

Formatted: Font: Italic

Formatted: Subscript

Formatted: Underline

(1) Instrument setup. Follow the analyzer system manufacturer's start-up and operating instructions. Adjust the system as needed to optimize performance.

Formatted: Underline

(2) Equipment setup. ~~Using a gas divider, equally blend a span gas of NO-CO-CO₂-C₃H₈-CH₄, balance N₂, with a span gas of NO₂, balance N₂. Connect the gas divider outlet to a 100 °C heated line. Connect the other end of this line to a 100 °C heated three-way tee. Next connect a dewpoint generator, set at a dewpoint of 50 °C, to one end of a heated line at 100 °C. Connect the other end of this line to the heated tee and connect a third 100 °C heated line from the tee to an overflow at the inlet of a 100 °C heated fast-acting three-way valve (two inlets, one outlet). Connect a zero-air source, heated to 100 °C, to a separate overflow at the other inlet of the three-way valve. Using minimal gas transfer line lengths between all connections, connect a zero-air source to the inlet of a 100 °C heated line. Connect the heated line outlet to one inlet of a 100 °C heated fast-acting 3 way valve (2 inlets, 1 outlet). Using a gas divider, equally blend an NO-CO-CO₂-C₃H₈-CH₄ (balance N₂) span gas with a span gas of NO₂ (balance N₂). Connect the gas divider outlet to the inlet of a 50 °C heated line. Connect the heated line outlet to the inlet of a 50 °C gas bubbler filled with distilled water. Connect the outlet of the 100 °C line to the other inlet of the 3-way valve. Connect the three-way valve outlet to an overflow at the gas analyzer system's probe or to an overflow fitting between the probe and transfer line to all the analyzers being verified. Note that you may omit any of these gas constituents if they are not relevant to your analyzers for this verification.~~

Formatted: Underline

(3) Data collection. (i) Switch the valve to flow zero gas.

Formatted: Underline

(ii) Allow for stabilization, accounting for transport delays and the slowest instrument's full response.

(iii) Start recording data at the frequency used during emission testing.

(iv) Switch the valve to flow span gas.

(v) Allow for transport delays and the slowest instrument's full response.

(vi) Repeat the steps in paragraphs (d)(3)(i) through (v) of this section to record seven full cycles, ending with zero gas flowing to the analyzers.

(vii) Stop recording.

(e) Performance evaluations. Perform the following evaluations:

Formatted: Underline

- (1) Uniform response evaluation. (i) Calculate the mean rise time, t_{10-90} , mean fall time, t_{90-10} for each analyzer.
- (ii) Determine the maximum mean rise and fall times for the slowest responding analyzer in each combination of continuous analyzer signals that you use to determine a single emission concentration.
- (iii) If the maximum rise time or fall time is greater than one second, verify that all other gas analyzers combined with it have mean rise and fall times of at least 75 % of that analyzer's response. If the slowest analyzer has t_{10-90} and t_{90-10} values less than 1 sec. no dispersion is necessary for any of the analyzers.
- (iv) If any analyzer has shorter rise or fall times, disperse that signal so that it better matches the rise and fall times of the slowest signal with which it is combined. We recommend that you perform dispersion using SAE 2001-01-3536 (incorporated by reference in §1065.1010) as a guide.
- (v) Repeat this verification after optimizing your systems to ensure that you dispersed signals correctly. If after repeated attempts at dispersing signals your system still fails this verification, you may use the continuous analyzer system if the deficiency does not adversely affect your ability to show compliance with the applicable standards.
- (2) Time alignment evaluation. (i) After all signals are adjusted to meet the uniform response evaluation, determine the second at which—or the two seconds between which—each analyzer crossed the midpoint of its response, t_{50} .
- (ii) Verify that all combined gas analyzer signals are time-aligned such that all of their t_{50} times occurred at the same second or between the same two seconds in the recorded data.
- (iii) If your system fails to meet this criterion, you may change the time alignment of your system and retest the system completely. If after changing the time alignment of your system, some of the t_{50} times still are not aligned, take corrective action by dispersing analyzer signals that have the shortest rise and fall times.
- (iv) If some t_{50} times are still not aligned after repeated attempts at dispersion and time alignment, you may use the continuous analyzer system if the deficiency does not adversely affect your ability to show compliance with the applicable standards.

Formatted: Underline

6. Section 1065.310 is amended by revising paragraph (d) to read as follows:

§1065.310 Torque calibration.

* * * * *

(d) Strain gage or proving ring calibration. This technique applies force either by hanging weights on a lever arm (these weights and their lever arm length are not used as part of the reference torque determination) or by operating the dynamometer at different torques. Apply at least six force combinations for each applicable torque-measuring range, spacing the force quantities about equally over the range. Oscillate or rotate the dynamometer during calibration to reduce frictional static hysteresis. In this case, the reference torque is determined by multiplying the force output from the reference meter (such as a strain gage or proving ring) force output by its effective lever-arm length, which you measure from the point where the force measurement is made to the dynamometer's rotational axis. Make sure you measure this length perpendicular ~~to~~ gravity (i.e., horizontal) to the reference meter's measurement axis and perpendicular to the dynamometer's rotational axis.

Formatted: Font: Bold

Formatted: Underline

7. Section 1065.340 is amended by revising Figure 1 and paragraphs (f)(6)(ii), (f)(9), and (g)(6)(i) to read as follows:

§1065.340 Diluted exhaust flow (CVS) calibration.

* * * * *

(f) * * *

(6) * * *

(ii) ~~Optionally, the~~ mean dewpoint of the calibration air, \bar{T}_{dew} . See §1065.640 for permissible assumptions during emission measurements.

* * * * *

(9) Determine C_d and the lowest allowable $\Delta\bar{p}_{\text{CFV}}$ ~~as described in~~ according to §1065.640.

* * * * *

(g) * * *

(6) * * *

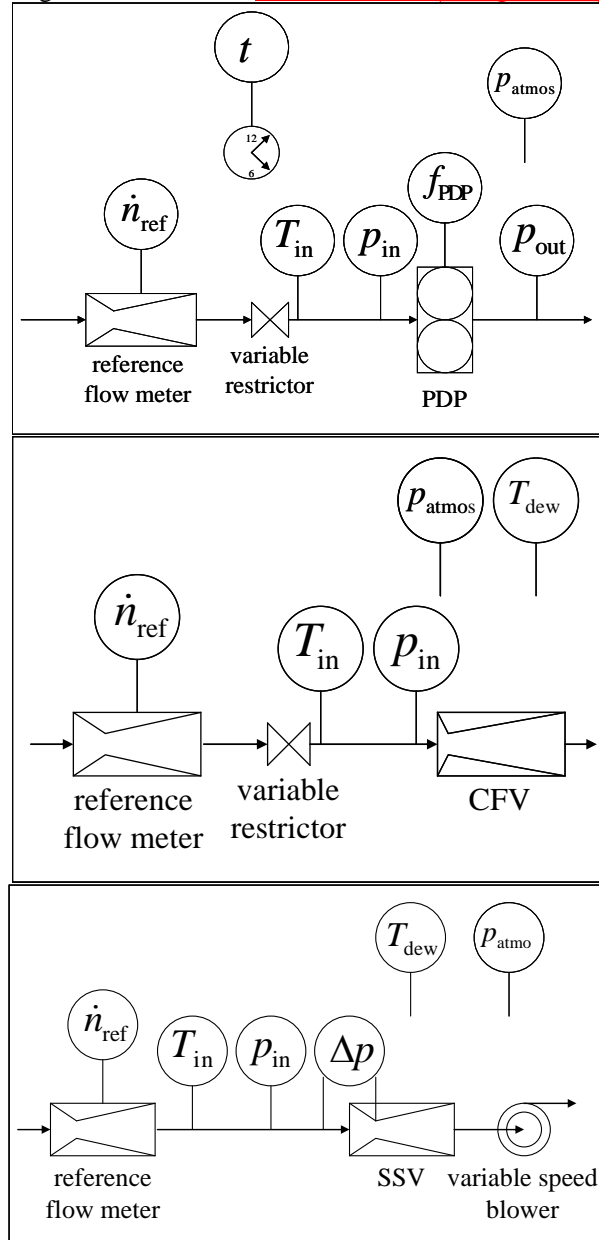
(i) The mean flow rate of the reference flow meter, \bar{n}_{ref} . This may include several

measurements of different quantities, such as reference meter pressures and temperatures, for ~~calculating~~ calculating \bar{n}_{ref} .

* * * * *

Figure 1 of 1065.340 **CVS calibration configurations.**

Comment [MWS1]: Updated figures.



8. Section 1065.341 is amended by revising paragraph (g) introductory text to read as follows:

§1065.341 CVS and batch sampler verification (propane check).

* * * * *

(g) ~~Batch sampler verification.~~ You may repeat the propane check to verify a batch sampler, such as a PM secondary dilution system.

* * * * *

9. Section 1065.345 is revised to read as follows:

§1065.345 Vacuum-side leak verification.

(a) Scope and frequency. Upon initial sampling system installation, after major maintenance, and before each test according to subpart F of this part for laboratory tests and according to subpart J of this part for field tests, verify that there are no significant vacuum-side leaks using one of the leak tests described in this section. This verification does not apply to any full-flow portion of a CVS dilution system. Formatted: Underline

(b) Measurement principles. A leak may be detected either by measuring a small amount of flow when there should be zero flow, or by detecting the dilution of a known concentration of span gas when it flows through the vacuum side of a sampling system. Formatted: Underline

(c) Low-flow leak test. Test a sampling system for low-flow leaks as follows: Formatted: Underline

- (1) Seal the probe end of the system by taking one of the following steps:
 - (i) Cap or plug the end of the sample probe.
 - (ii) Disconnect the transfer line at the probe and cap or plug the transfer line.
 - (iii) Close a leak-tight valve in-line between a probe and transfer line.
- (2) Operate all vacuum pumps. After stabilizing, verify that the flow through the vacuum-side of the sampling system is less than 0.5 % of the system's normal in-use flow rate. You may estimate typical analyzer and bypass flows as an approximation of the system's normal in-use flow rate.

(d) Dilution-of-span-gas leak test. You may use any gas analyzer for this test. Test any analyzer, other than a FID, for dilution of span gas as follows, noting that this configuration requires an overflow span gas system. If you use a FID for this test, correct for any HC contamination in the sampling system according to §1065.660. To avoid misleading results from this test, we recommend using only analyzers that have a repeatability of 0.5% or better at the span gas concentration used for this test. Perform a vacuum-side leak test as follows: Formatted: Underline

- (1) Prepare a gas analyzer as you would for emission testing.
- (2) Supply span gas to the analyzer port and verify that it measures the span gas concentration within its expected measurement accuracy and repeatability.
- (3) Route overflow span gas to one of the following locations in the sampling system:
 - (i) The end of the sample probe.
 - (ii) Disconnect the transfer line at the probe connection, and overflow the span gas at the open end of the transfer line.
 - (iii) A three-way valve installed in-line between a probe and its transfer line, such as a system overflow zero and span port.
- (4) Verify that the measured overflow span gas concentration is within the measurement accuracy and repeatability of the analyzer ±0.5% of the span gas concentration. A measured value lower than expected indicates a leak, but a value higher than expected may indicate a problem with the span gas or the analyzer itself. A measured value higher than expected does not indicate a leak.

(e) Vacuum-decay leak test. To perform this test you must apply a vacuum to the vacuum-side volume of your sampling system and then observe the leak rate of your system as a decay in the applied vacuum. To perform this test you must know the vacuum-side volume of your sampling system to within ±10% of its true volume. For this test you must also use measurement instruments that meet the specifications of subpart C of this part and of this subpart D. Perform a vacuum-decay leak test as follows:

(1) Seal the probe end of the system as close to the probe opening as possible by taking one of the following steps:

(i) Cap or plug the end of the sample probe.

(ii) Disconnect the transfer line at the probe and cap or plug the transfer line.

(iii) Close a leak-tight valve in-line between a probe and transfer line.

(2) Operate all vacuum pumps. Draw a vacuum that is representative of normal operating conditions. In the case of sample bags, we recommend that you repeat your normal sample bag pump-down procedure twice to minimize any trapped volumes.

(3) Turn off the sample pumps and seal the system. Measure and record the absolute pressure of the trapped gas, the time, and optionally the system absolute temperature. Wait at least 60 sec and again record the pressure, time, and optionally temperature. You may have to adjust your wait time by trial and error to accurately quantify a change in pressure over a time interval.

(4) Calculate the leak flow rate based on an assumed value of zero for pumped-down bag volumes and based on known values for the sample system volume, the initial and final pressures, optional temperatures, and elapsed time. Verify that the vacuum-decay leak flow rate is less than 0.5 % of the system's normal in-use flow rate.

Formatted: Underline

Formatted: Not Highlight

10. Section 1065.350 is amended by revising paragraphs (c) and (d) to read as follows:

§1065.350 H₂O interference verification for CO₂ NDIR analyzers.

* * * * *

(c) System requirements. A CO₂ NDIR analyzer must have an H₂O interference that is within (0 ±400) µmol/mol. ±2 % of the flow-weighted mean CO₂ concentration expected at the standard, though we strongly recommend a lower interference that is within (0 ±200) µmol/mol. ±1 %.

Formatted: Underline

(d) Procedure. Perform the interference verification as follows:

Formatted: Underline

(1) Start, operate, zero, and span the CO₂ NDIR analyzer as you would before an emission test.

(2) Create a ~~water saturated~~humidified test gas by bubbling zero air that meets the specifications in §1065.750 through distilled water in a sealed vessel at (25 ±10) °C.

(3) Downstream of the vessel, maintain the humidified test gas temperature at least 5° C above its dewpoint. We recommend using a heated transfer line.

(34) Introduce the ~~water saturated~~humidified test gas upstream of any sample dryer, if one is used during testing.

(54) Allow time for the analyzer response to stabilize. Stabilization time may include time to purge the transfer line and to account for analyzer response.

(65) While the analyzer measures the sample's concentration, record 30 seconds of sampled data. Calculate the arithmetic mean of this data. The analyzer meets the

interference verification if this value is within (0 ±400) μmol/mol ±2 % of the flow-weighted mean concentration of CO₂ expected at the standard.

* * * * *

11. Section 1065.355 is amended by revising paragraphs (d) and (e)(1) to read as follows:

§1065.355 H₂O and CO₂ interference verification for CO NDIR analyzers.

* * * * *

(d) Procedure. Perform the interference verification as follows:

Formatted: Underline

(1) Start, operate, zero, and span the CO NDIR analyzer as you would before an emission test.

(2) Create a water-saturated humidified CO₂ test gas by bubbling a CO₂ span gas through distilled water in a sealed vessel at (25 ±10) °C.

(3) Downstream of the vessel, maintain the humidified gas temperature at least 5 °C above its dewpoint. We recommend using a heated transfer line.

~~(4)~~ Introduce the water-saturated humidified CO₂ test gas upstream of any sample dryer, if one is used during testing.

(5) Measure the humidified CO₂ test gas dewpoint and pressure as close as possible to the inlet of the analyzer, or to the inlet of the sample dryer, if one is used.

~~(6)~~ Allow time for the analyzer response to stabilize. Stabilization time may include time to purge the transfer line and to account for analyzer response.

~~(7)~~ While the analyzer measures the sample's concentration, record its output for 30 seconds. Calculate the arithmetic mean of this data.

~~(8)~~ Multiply Scale the CO₂ interference by multiplying this mean value (from paragraph (d)(7) of this section) by the ratio of expected CO₂ to span gas CO₂ concentration. In other words, estimate the flow-weighted mean dry concentration of CO₂ expected during testing, and then divide this value by the concentration of CO₂ in the span gas used for this verification. Then multiply this ratio by the mean value recorded during this verification (from paragraph (d)(7) of this section).

(9) Scale the H₂O interference by estimating the flow-weighted mean concentration of H₂O expected during testing, then dividing this value by the concentration of H₂O in the span gas used for this verification. Then multiply this ratio by the CO₂-scaled result of paragraph (d)(8) of this section.

~~(10)~~ The analyzer meets the interference verification if the result of paragraph (d)~~(9)~~ of this section is within ±2 % of the flow-weighted mean concentration of CO expected at the standard.

(e) * * *

(1) You may omit this verification if you can show by engineering analysis that for your CO sampling system and your emission calculations procedures, the ~~the~~-combined CO₂ and H₂O interference for your CO NDIR analyzer always affects your brake-specific CO emission results within ±0.5 % of the applicable CO standard.

* * * * *

12. Section 1065.360 is revised to read as follows:

§1065.360 FID optimization and verification.

(a) Scope and frequency. For all FID analyzers, perform the following steps:

Formatted: Underline

(1) Calibrate the FID upon initial installation. Repeat the calibration as needed using good engineering judgment. For a FID that measures THC, perform the following steps:

(2) Optimize the FID's response to various hydrocarbons after initial analyzer installation and after major maintenance as described in paragraph (c) of this section.

(3) Determine the FID's methane (CH₄) response factor after initial analyzer installation and after major maintenance as described in paragraph (d) of this section.

(4) Verify the methane (CH₄) response within 185 days before testing as described in paragraph (e) of this section.

(b) Calibration. Use good engineering judgment to develop a calibration procedure, such as one based on the FID-analyzer manufacturer's instructions and recommended frequency for calibrating the FID. Alternately, you may remove system components for off-site calibration. For a FID that measures THC, calibrate using C₃H₈ calibration gases that meet the specifications of §1065.750. For a FID that measures CH₄, calibrate using CH₄ calibration gases that meet the specifications of §1065.750. We recommend FID analyzer zero and span gases that contain approximately the flow-weighted mean concentration of O₂ expected during testing. If you use a FID to measure methane (CH₄) downstream of a nonmethane cutter, you may calibrate that FID using CH₄ calibration gases with the cutter. Regardless of the calibration gas composition, calibrate on a carbon number basis of one (C₁). For example, if you use a C₃H₈ span gas of concentration 200 µmol/mol, span the FID to respond with a value of 600 µmol/mol. As another example, if you use a CH₄ span gas with a concentration of 200 µmol/mol, span the FID to respond with a value of 200 µmol/mol.

Formatted: Underline

(c) THC FID response optimization. This procedure is only for FID analyzers that measure THC. Use good engineering judgment for initial instrument start-up and basic operating adjustment using FID fuel and zero air. Heated FIDs must be within their required operating temperature ranges. Optimize FID response at the most common analyzer range expected during emission testing. Optimization involves adjusting flows and pressures of FID fuel, burner air, and sample to minimize response variations to various hydrocarbon species in the exhaust. Use good engineering judgment to trade off peak FID response to propane calibration gases to achieve minimal response variations to different hydrocarbon species. For an example of trading off response to propane for relative responses to other hydrocarbon species, see SAE 770141 (incorporated by reference in §1065.1010). Determine the optimum flow rates for FID fuel, burner air, and sample and record them for future reference.

Formatted: Font: Symbol

Formatted: Font: Symbol

Formatted: Underline

(d) THC FID CH₄ response factor determination. This procedure is only for FID analyzers that measure THC. Since FID analyzers generally have a different response to CH₄ versus C₃H₈, determine each THC FID analyzer's CH₄ response factor, RF_{CH_4} , after FID optimization. Use the most recent RF_{CH_4} measured according to this section in the calculations for HC determination described in §1065.660 to compensate for CH₄ response. Determine RF_{CH_4} as follows, noting that you do not determine RF_{CH_4} for FIDs that are calibrated and spanned using CH₄ with a nonmethane cutter:

Formatted: Underline

(1) Select a C₃H₈ span gas concentration that you use to span your analyzers before emission testing. Use only span gases that meets the specifications of §1065.750.

Record the C₃H₈ concentration of the gas.

(2) Select a CH₄ span gas concentration that you use to span your analyzers before emission testing. Use only span gases that meets the specifications of §1065.750.

Record the CH₄ concentration of the gas.

(3) Start and operate the FID analyzer according to the manufacturer's instructions.

(4) Confirm that the FID analyzer has been calibrated using C₃H₈. Calibrate on a carbon number basis of one (C₁). For example, if you use a C₃H₈ span gas of concentration 200 μmol/mol, span the FID to respond with a value of 600 μmol/mol.

(5) Zero the FID with a zero gas that you use for emission testing.

(6) Span the FID with the C₃H₈ span gas that you selected under paragraph (d)(1) of this section.

(7) Introduce at the sample port of the FID analyzer, the CH₄ span gas that you selected under paragraph (d)(2) of this section.

(8) Allow time for the analyzer response to stabilize. Stabilization time may include time to purge the analyzer and to account for its response.

(9) While the analyzer measures the CH₄ concentration, record 30 seconds of sampled data. Calculate the arithmetic mean of these values.

(10) Divide the mean measured concentration by the recorded span concentration of the CH₄ calibration gas. The result is the FID analyzer's response factor for CH₄, RF_{CH_4} .

(e) THC FID methane (CH₄) response verification. This procedure is only for FID analyzers that measure THC. If the value of RF_{CH_4} from paragraph (d) of this section is within ±5.0 % of its most recent previously determined value, the THC FID passes the methane response verification. For example, if the most recent previous value for RF_{CH_4} was 1.05 and it changed by ±0.05 to become 1.10 or it changed by -0.05 to become 1.00, either case would be acceptable because ±4.8 % is less than ±5.0 %. Verify RF_{CH_4} as follows:

Formatted: Underline

(1) Verify-First verify that the pressures and flow rates of FID fuel, burner air, and sample are each within ±0.5 % of their most recent previously recorded values, as described in paragraph (c) of this section. You may adjust these flow rates as necessary.

Then determine a new RF_{CH_4} as described in paragraph (d) of this section and verify that it is within the tolerance specified in this paragraph (e).

(2) If RF_{CH_4} is is not within the tolerance specified in this paragraph (e), still not within ±5.0 % of its most recently determined value after adjusting flow rates, re-optimize the FID response as described in paragraph (c) of this section.

(3) Determine a new RF_{CH_4} as described in paragraph (d) of this section. Use this new value of RF_{CH_4} in the calculations for HC determination, as described in §1065.660.

Formatted: Subscript

13. Section 1065.362 is amended by revising paragraph (d) to read as follows:

§1065.362 Non-stoichiometric raw exhaust FID O₂ interference verification.

* * * * *

(d) Procedure. Determine FID O₂ interference as follows, noting that you may use one or more gas dividers to create the reference gas concentrations that are required to perform this verification:

Formatted: Underline

(1) Select two span reference gases that meet the specifications in §1065.750 and contain a C₃H₈ near 100% of span for HC concentration that you use to span your analyzers before emission testing. Use only span gases that meet the specifications of §1065.750.

You may use CH₄ span reference gases for FIDs calibrated on CH₄ with a nonmethane cutter. Select the two balance gas concentrations such that the concentrations of O₂ and N₂ represent the minimum and maximum O₂ concentrations expected during testing.

- (2) Confirm that the FID analyzer meets all the specifications of §1065.360.
- (3) Start and operate the FID analyzer as you would before an emission test. Regardless of the FID burner's air source during testing, use zero air as the FID burner's air source for this verification.
- (4) Zero the FID analyzer using the zero gas used during emission testing.
- (5) Span the FID analyzer using ~~the a~~ span gas ~~used that you use~~ during emission testing.
- (6) Check the zero response of the FID analyzer using the zero gas used during emission testing. If the mean zero response of 30 seconds of sampled data is within $\pm 0.5\%$ of the span reference value used in paragraph (d)(5) of this section, then proceed to the next step; otherwise restart the procedure at paragraph (d)(4) of this section.
- (7) Check the analyzer response using the span gas that has the minimum concentration of O₂ expected during testing. Record the mean response of 30 seconds of stabilized sample data as $x_{O_2\min HC}$.
- (8) Check the zero response of the FID analyzer using the zero gas used during emission testing. If the mean zero response of 30 seconds of stabilized sample data is within $\pm 0.5\%$ of the span reference value used in paragraph (d)(5) of this section, then proceed to the next step; otherwise restart the procedure at paragraph (d)(4) of this section.
- (9) Check the analyzer response using the span gas that has the maximum concentration of O₂ expected during testing. Record the mean response of 30 seconds of stabilized sample data as $x_{O_2\max HC}$.
- (10) Check the zero response of the FID analyzer using the zero gas used during emission testing. If the mean zero response of 30 seconds of stabilized sample data is within $\pm 0.5\%$ of the span reference value used in paragraph (d)(5) of this section, then proceed to the next step; otherwise restart the procedure at paragraph (d)(4) of this section.
- (11) Calculate the percent difference between $x_{O_2\max HC}$ and its reference gas concentration. Calculate the percent difference between $x_{O_2\min HC}$ and its reference gas concentration. Determine the maximum percent difference of the two. This is the O₂ interference.
- (12) If the O₂ interference is within $\pm 1.5\%$, ~~then~~ the FID passes the O₂ interference ~~check verification~~; otherwise perform one or more of the following to address the deficiency:
 - (i) Repeat the verification to determine if a mistake was made during the procedure.
 - (ii) Select zero and span gases for emission testing that contain higher or lower O₂ concentrations and repeat the verification.
 - (iii) Adjust FID burner air, fuel, and sample flow rates. Note that if you adjust these flow rates on a THC FID to meet the O₂ interference verification, you must re-verify ~~RF_{CH4} with the adjusted flow rates that the FID meets the CH4 response factor verification~~ according to §1065.360. Repeat the O₂ interference verification after adjustment and RF_{CH4} verification.
 - (iv) Repair or replace the FID and repeat the O₂ interference verification.
 - (v) Demonstrate that the deficiency does not adversely affect your ability to demonstrate compliance with the applicable emission standards.

Formatted: Subscript

14. Section 1065.365 is revised to read as follows:

§1065.365 Nonmethane cutter penetration fractions.

(a) Scope and frequency. If you use a FID analyzer and a nonmethane cutter (NMC) to measure methane (CH_4), determine the nonmethane cutter's penetration fractions of methane, PF_{CH_4} , and ethane, $PF_{\text{C}_2\text{H}_6}$. As detailed in this section, these penetration fractions may be determined as a combination of NMC penetration fractions and FID analyzer response factors, depending on your particular NMC and FID analyzer configuration. Perform this verification after installing the nonmethane cutter. Repeat this verification within 185 days of testing to verify that the catalytic activity of the cutter has not deteriorated. Note that because nonmethane cutters can deteriorate rapidly and without warning if they are operated outside of certain ranges of gas concentrations and outside of certain temperature ranges, good engineering judgment may dictate that you determine a nonmethane cutter's penetration fractions more frequently.

Formatted: Underline

(b) Measurement principles. A nonmethane cutter is a heated catalyst that removes nonmethane hydrocarbons from ~~the an~~ exhaust sample stream before the FID analyzer measures the remaining hydrocarbon concentration. An ideal nonmethane cutter would have a methane penetration fraction, PF_{CH_4} , of 1.000, and the penetration fraction for all other nonmethane hydrocarbons would be 0.000, as represented by $PF_{\text{C}_2\text{H}_6}$. The emission calculations in §1065.660 use this section's the measured values of PF_{CH_4} and $PF_{\text{C}_2\text{H}_6}$ ~~to~~ from this verification to account for less than ideal NMC performance.

Formatted: Underline

(c) System requirements. We do not limit NMC penetration fractions to a certain range. However, we recommend that you optimize a nonmethane cutter by adjusting its temperature to achieve a $PF_{\text{CH}_4} > 0.895$ and a $PF_{\text{C}_2\text{H}_6} < 0.02$, as determined by paragraphs (d) ~~and~~, (e), or (f) of this section, as applicable. If we use a nonmethane cutter for testing, it will meet this recommendation. If adjusting NMC temperature does not result in achieving both of these specifications simultaneously, we recommend that you replace the catalyst material. Use the most recently determined penetration values from this section to calculate HC emissions according to §1065.660 and §1065.665 as applicable.

Formatted: Underline

(d) Procedure for a FID calibrated with the NMC. If your FID arrangement is such that a FID is always calibrated to measure CH_4 with the NMC, then span that FID with the NMC cutter using a CH_4 span gas, set the product of that FID's CH_4 response factor and CH_4 penetration fraction, $RF_{\text{CH}_4} \cdot PF_{\text{CH}_4}$, equal to 1.0 for all emission calculations, and determine its ethane (C_2H_6) penetration fraction, $PF_{\text{C}_2\text{H}_6}$ as follows:

Formatted: Underline

(1) Select a CH_4 gas mixture and a C_2H_6 analytical gas mixture and ensure that both mixtures meet the specifications of §1065.750. Select a CH_4 concentration that you would use for spanning the FID during emission testing and select a C_2H_6 concentration that is typical of the peak NMHC concentration expected at the hydrocarbon standard or equal to THC analyzer's span value.

Formatted: Font: Italic

Formatted: Subscript

Formatted: Superscript

(2) Start, operate, and optimize the nonmethane cutter according to the manufacturer's instructions, including any temperature optimization.

(3) Confirm that the FID analyzer meets all the specifications of §1065.360.

(4) Start and operate the FID analyzer according to the manufacturer's instructions.

(5) Zero and span the FID with the cutter and use CH_4 span gas to span the FID with the cutter. Note that you must span the FID on a C_1 basis. For example, if your span gas has a CH_4 reference value of $100 \mu\text{mol/mol}$, the correct FID response to that span gas is $100 \mu\text{mol/mol}$ because there is one carbon atom per CH_4 molecule.

- (6) Introduce the C_2H_6 analytical gas mixture upstream of the nonmethane cutter.
- (7) Allow time for the analyzer response to stabilize. Stabilization time may include time to purge the nonmethane cutter and to account for the analyzer's response.
- (8) While the analyzer measures a stable concentration, record 30 seconds of sampled data. Calculate the arithmetic mean of these data points.
- (9) Divide the mean by the reference value of C_2H_6 , converted to a C_1 basis. The result is the C_2H_6 penetration fraction, $PF_{C_2H_6}$. Use this penetration fraction and the product of the CH_4 response factor and CH_4 penetration fraction, $RF_{CH_4} \cdot PF_{CH_4}$, set to 1.0 ~~CH_4 penetration fraction, which is set equal to 1.0,~~ in emission calculations according to §1065.660 or §1065.665, as applicable.

(e) Procedure for a FID calibrated with propane, by bypassing the NMC. If you use a FID with an NMC that is calibrated with propane, C_3H_8 , by bypassing the NMC, determine penetration fractions as follows:

Formatted: Underline

- (1) Select CH_4 and C_2H_6 analytical gas mixtures that meet the specifications of §1065.750 with the CH_4 concentration typical of its peak concentration expected at the hydrocarbon standard and the C_2H_6 concentration typical of the peak total hydrocarbon (THC) concentration expected at the hydrocarbon standard or the THC analyzer span value.
- (2) Start and operate the nonmethane cutter according to the manufacturer's instructions, including any temperature optimization.
- (3) Confirm that the FID analyzer meets all the specifications of §1065.360.
- (4) Start and operate the FID analyzer according to the manufacturer's instructions.
- (5) Zero and span the FID as you would during emission testing. Span the FID by bypassing the cutter and by using C_3H_8 span gas to span the FID. Note that you must span the FID on a C_1 basis. For example, if your span gas has a propane reference value of 100 $\mu\text{mol/mol}$, the correct FID response to that span gas is 300 $\mu\text{mol/mol}$ because there are three carbon atoms per C_3H_8 molecule.
- (6) Introduce the C_2H_6 analytical gas mixture upstream of the nonmethane cutter.
- (7) Allow time for the analyzer response to stabilize. Stabilization time may include time to purge the nonmethane cutter and to account for the analyzer's response.
- (8) While the analyzer measures a stable concentration, record 30 seconds of sampled data. Calculate the arithmetic mean of these data points.
- (9) Reroute the flow path to bypass the nonmethane cutter, introduce the C_2H_6 analytical gas mixture to the bypass, and repeat the steps in paragraphs (e)(7) through (8) of this section.
- (10) Divide the mean C_2H_6 concentration measured through the nonmethane cutter by the mean concentration measured after bypassing the nonmethane cutter. The result is the C_2H_6 penetration fraction, $PF_{C_2H_6}$. Use this penetration fraction according to §1065.660 or §1065.665, as applicable.
- (11) Repeat the steps in paragraphs (e)(6) through (10) of this section, but with the CH_4 analytical gas mixture instead of C_2H_6 . The result will be the CH_4 penetration fraction, PF_{CH_4} . Use this penetration fraction according to §1065.660 or §1065.665, as applicable.

(f) Procedure for a FID calibrated with methane, bypassing the NMC. If you use a FID with an NMC that is calibrated with methane, CH_4 , by bypassing the NMC, determine penetration fractions as follows:

Formatted: Underline

- (1) Select CH₄ and C₂H₆ analytical gas mixtures that meet the specifications of §1065.750, with the CH₄ concentration typical of its peak concentration expected at the hydrocarbon standard and the C₂H₆ concentration typical of the peak total hydrocarbon (THC) concentration expected at the hydrocarbon standard or the THC analyzer span value.
- (2) Start and operate the nonmethane cutter according to the manufacturer's instructions, including any temperature optimization.
- (3) Confirm that the FID analyzer meets all the specifications of §1065.360.
- (4) Start and operate the FID analyzer according to the manufacturer's instructions.
- (5) Zero and span the FID as you would during emission testing. Span the FID with CH₄ span gas by bypassing the cutter. Note that you must span the FID on a C₁ basis. For example, if your span gas has a methane reference value of 100 µmol/mol, the correct FID response to that span gas is 100 µmol/mol because there is one carbon atom per CH₄ molecule.
- (6) Introduce the C₂H₆ analytical gas mixture upstream of the nonmethane cutter.
- (7) Allow time for the analyzer response to stabilize. Stabilization time may include time to purge the nonmethane cutter and to account for the analyzer's response.
- (8) While the analyzer measures a stable concentration, record 30 seconds of sampled data. Calculate the arithmetic mean of these data points.
- (9) Reroute the flow path to bypass the nonmethane cutter, introduce the C₂H₆ analytical gas mixture to the bypass, and repeat the steps in paragraphs (e)(7) and (8) of this section.
- (10) Divide the mean C₂H₆ concentration measured through the nonmethane cutter by the mean concentration measured after bypassing the nonmethane cutter. The result is the C₂H₆ penetration fraction, $PF_{C_2H_6}$. Use this penetration fraction according to §1065.660 or §1065.665, as applicable.
- (11) Repeat the steps in paragraphs (e)(6) through (10) of this section, but with the CH₄ analytical gas mixture instead of C₂H₆. The result will be the CH₄ penetration fraction, PF_{CH_4} . Use this penetration fraction according to §1065.660 or §1065.665, as applicable.

15. Section 1065.370 is amended by revising paragraphs (e) and (g)(1) to read as follows:

§1065.370 CLD CO₂ and H₂O quench verification.

* * * * *

(e) H₂O quench verification procedure. Use the following method to determine H₂O quench, or use good engineering judgment to develop a different protocol:

Formatted: Underline

- (1) Use PTFE tubing to make necessary connections.
- (2) If the CLD has an operating mode in which it detects NO-only, as opposed to total NO_x, operate the CLD in the NO-only operating mode.
- (3) Measure an NO calibration span gas that meets the specifications of §1065.750 and is near the maximum concentration expected during testing. Record this concentration, ^{XNOdry.}
- (4) Humidify the NO span gas by bubbling it through distilled water in a sealed vessel. We recommend that you humidify the gas to the highest sample dewpoint that you estimate during emission sampling.

(5) Downstream of the vessel, maintain the humidified gas temperature at least 5 °C above its dewpoint.

(6) Introduce the humidified gas upstream of any sample dryer, if one is used during testing.

(7) Measure the humidified gas dewpoint, T_{dew} , and pressure, p_{total} , as close as possible to the inlet of the analyzer, or to the inlet of the sample dryer, if one is used.

(8) Allow time for the analyzer response to stabilize. Stabilization time may include time to purge the transfer line and to account for analyzer response.

(9) While the analyzer measures the sample's concentration, record the analyzer's output for 30 seconds. Calculate the arithmetic mean of these data. This mean is $x_{NO_{meas}}$.

(10) If your CLD is not equipped with a sample dryer, set $x_{NO_{wet}}$ equal to $x_{NO_{meas}}$ from paragraph (e)(9) of this section.

(11) If your CLD is equipped with a sample dryer, determine $x_{NO_{wet}}$ from $x_{NO_{meas}}$ by correcting for the removed water according to §1065.645. Use the amount of water at the sample dryer outlet as $x_{H_2O_{meas}}$ for this calculation. Refer to §1065.145(d)(2) and use the humidified gas dewpoint, T_{dew} , and pressure, p_{total} , to determine x_{H_2O} .

(12) Use $x_{NO_{wet}}$ to calculate the quench according to §1065.675.

~~(5) If you do not use any sample dryer for NO_x during emissions testing, record the vessel water temperature as T_{dew} , and its pressure as p_{total} and use these values according to §1065.645 to calculate the amount of water entering the CLD sample port, $x_{H_2O_{meas}}$. If you do use a sample dryer for NO_x during emissions testing, measure the humidity of the sample just upstream of the CLD sample port and use the measured humidity according to §1065.645 to calculate the amount of water entering the CLD sample port, $x_{H_2O_{meas}}$.~~

~~(6) To prevent subsequent condensation, make sure that any humidified sample will not be exposed to temperatures lower than T_{dew} during transport from the sealed vessel's outlet to the CLD. We recommend using heated transfer lines.~~

~~(7) Introduce the humidified sample upstream of any sample dryer, if one is used.~~

~~(8) Use the CLD to measure the NO concentration of the humidified span gas and record this value, $x_{NO_{wet}}$.~~

~~(9) Use the recorded values from this paragraph (e) to calculate the quench as described in §1065.675.~~

~~(10) Use the values recorded according to this paragraph (e) of this section and paragraph (d) of this section to calculate quench as described in §1065.675.~~

~~* * * * *~~

~~(g) * * *~~

(1) You may omit this verification if you can show by engineering analysis that for your NO_x sampling system and your emission calculations procedures, the ~~the~~ combined CO₂ and H₂O interference for your NO_x CLD analyzer always affects your brake-specific NO_x emission results within no more than ±1.0 % of the applicable NO_x standard.

~~* * * * *~~

16. Section 1065.372 is amended by revising paragraph (e)(1) to read as follows:

§1065.372 NDUV analyzer HC and H₂O interference verification.

~~* * * * *~~

(e) * * *

(1) You may omit this verification if you can show by engineering analysis that for your NO_x sampling system and your emission calculations procedures, the ~~the~~ combined HC and H₂O interference for your NO_x NDUV analyzer always affects your brake-specific NO_x emission results by less than 0.5 % of the applicable NO_x standard.

* * * *

17. Section 1065.376 is revised to read as follows:

§1065.376 Chiller NO₂ penetration.

(a) Scope and frequency. If you use a chiller to dry a sample upstream of a NO_x measurement instrument, but you don't use an NO₂-to-NO converter upstream of the chiller, you must perform this verification for chiller NO₂ penetration. Perform this verification after initial installation and after major maintenance. Formatted: Underline

(b) Measurement principles. A chiller removes water, which can otherwise interfere with a NO_x measurement. However, liquid water remaining in an improperly designed chiller can remove NO₂ from the sample. If a chiller is used without an NO₂-to-NO converter upstream, it could ~~therefore~~ remove NO₂ from the sample prior NO_x measurement. Formatted: Underline

(c) System requirements. A chiller must allow for measuring at least 95 % of the total NO₂ at the maximum expected concentration of NO₂. Formatted: Underline

(d) Procedure. Use the following procedure to verify chiller performance: Formatted: Underline

(1) Instrument setup. Follow the analyzer and chiller manufacturers' start-up and operating instructions. Adjust the analyzer and chiller as needed to optimize performance. Formatted: Underline

(2) Equipment setup and data collection. (i) ~~Zero and span the total NO_x gas analyzer(s) as you would before emission testing.~~ Formatted: Underline

(ii) Select an NO₂ calibration gas, balance gas of dry air, that has an NO₂ concentration within ±5 % of the maximum NO₂ concentration expected during testing.

(iii) Overflow this calibration gas at the gas sampling system's probe or overflow fitting. Allow for stabilization of the total NO_x response, accounting only for transport delays and instrument response.

(iv) Calculate the mean of 30 seconds of recorded total NO_x data and record this value as \bar{x}_{NOxref} .

(v) Stop flowing the NO₂ calibration gas.

(vi) Connect an ozonator's inlet to a zero air or oxygen source and connect its outlet to one port of a three-way tee fitting. Connect an NO span gas to another port of the tee. Connect a heated line at 100 °C to the last port, and connect a heated three-way tee to the other end of the line. ~~Connect~~ Next saturate the sampling system by overflowing a dewpoint generator's output, set at a dewpoint of 50 °C, to ~~one end of a heated line at 100 °C.~~ the gas sampling system's probe or overflow fitting. Sample the dewpoint generator's output through the sampling system and chiller for at least 10 minutes until the chiller is expected to be removing a constant rate of water.

(vii) Immediately switch back to overflowing the NO₂ calibration gas used to establish \bar{x}_{NOxref} . Allow for stabilization of the total NO_x response, accounting only for transport delays and instrument response. Calculate the mean of 30 seconds of recorded total NO_x data and record this value as $\bar{x}_{NOxmeas}$. ~~Connect the other end of the line to the heated tee~~

and connect a third 100 °C heated line to the chiller inlet. Provide an overflow vent line at the chiller inlet.

(3) Adjustments. For the following adjustment steps, set the analyzer to measure only NO (i.e., NO mode), or only read the NO channel of the analyzer:

(i) With the dewpoint generator and the ozonator off, adjust the NO and zero gas flows so the NO concentration at the analyzer is at least two times the peak total NO_x concentration expected during testing at the standard. Verify that gas is flowing out of the overflow vent line.

(ii) Turn on the dewpoint generator and adjust its flow so the NO concentration at the analyzer is at least at the peak total NO_x concentration expected during testing at the standard. Verify that gas is flowing out of the overflow vent line.

(iii) Turn on the ozonator and adjust the ozonator so the NO concentration measured by the analyzer decreases by the same amount as the maximum concentration of NO₂ expected during testing. This ensures that the ozonator is generating NO₂ at the maximum concentration expected during testing.

(4) Data collection. (viii) Correct $x_{NOx\text{meas}}$ to $x_{NOx\text{dry}}$ based upon the residual water vapor that passed through the chiller at the chiller's outlet temperature and pressure. Maintain the ozonator adjustment in paragraph (d)(3) of this section, and keep the NO_x analyzer in the NO only mode or only read the NO channel of the analyzer.

(i) Allow for stabilization, accounting only for transport delays and instrument response.

(ii) Calculate the mean of 30 seconds of sampled data from the analyzer and record this value as NO_{ref} .

(iii) Switch the analyzer to the total NO_x mode, (that is, sum the NO and NO₂ channels of the analyzer) and allow for stabilization, accounting only for transport delays and instrument response.

(iv) Calculate the mean of 30 seconds of sampled data from the analyzer and record this value as $NO_{x\text{meas}}$.

(v) Turn off the ozonator and allow for stabilization, accounting only for transport delays and instrument response.

(vi) Calculate the mean of 30 seconds of sampled data from the analyzer and record this value as $NO_{x\text{ref}}$.

(5) Performance evaluation. Divide the quantity of $(NO_{x\text{meas}} - NO_{\text{ref}})$ by the quantity of $(NO_{x\text{ref}} - NO_{\text{ref}})$. If $x_{NOx\text{dry}}$ the result is less than 95 % of $x_{NOx\text{ref}}$, repair or replace the chiller.

(e) Exceptions. The following exceptions apply:

(1) You may omit this verification if you can show by engineering analysis that for your NO_x sampling system and your emission calculations procedures, the ~~the~~ chiller always affects your brake-specific NO_x emission results by less than 0.5 % of the applicable NO_x standard.

(2) You may use a chiller that you determine does not meet this verification, as long as you try to correct the problem and the measurement deficiency does not adversely affect your ability to show that engines comply with all applicable emission standards.

Formatted: Font: Italic

Formatted: Subscript

Formatted: Subscript

Formatted: Font: Italic

Formatted: Subscript

Formatted: Underline

Formatted: Underline

18. Section 1065.378 is amended by revising paragraphs (d) and (e)(1) to read as follows:

§1065.378 NO₂-to-NO converter conversion verification.

* * * * *

(d) Procedure. Use the following procedure to verify the performance of a NO₂-to-NO converter:

(1) Instrument setup. Follow the analyzer and NO₂-to-NO converter manufacturers' start-up and operating instructions. Adjust the analyzer and converter as needed to optimize performance.

Formatted: Underline

(2) Equipment setup. Connect an ozonator's inlet to a zero-air or oxygen source and connect its outlet to one port of a ~~4~~three-way ~~cross-tee~~ fitting. Connect an NO span gas to another port, ~~and c.~~ Connect the NO₂-to-NO converter inlet ~~to another~~to the last port, ~~and connect an overflow vent line to the last port.~~

Formatted: Underline

(3) Adjustments. Take the following steps to make adjustments:

Formatted: Underline

(i) With the NO₂-to-NO converter in the bypass mode (i.e., NO mode) and the ozonator off, adjust the NO and zero-gas flows so the NO concentration at the analyzer is at the peak total NO_x concentration expected during testing.

~~Verify that gas is flowing out of the overflow vent.~~

(ii) With the NO₂-to-NO converter still in the bypass mode, turn on the ozonator and adjust the ozonator so the NO concentration measured by the analyzer decreases by the same amount as maximum concentration of NO₂ expected during testing. This ensures that the ozonator is generating NO₂ at the maximum concentration expected during testing.

(4) Data collection. Maintain the ozonator adjustment in paragraph (d)(3) of this section, and keep the NO_x analyzer in the NO only mode (i.e., bypass the NO₂-to-NO converter).

Formatted: Underline

(i) Allow for stabilization, accounting only for transport delays and instrument response.

(ii) Calculate the mean of 30 seconds of sampled data from the analyzer and record this value as $\bar{x}_{NO_{ref}}$.

(iii) Switch the analyzer to the total NO_x mode (that is, sample with the NO₂-to-NO converter) and allow for stabilization, accounting only for transport delays and instrument response.

(iv) Calculate the mean of 30 seconds of sampled data from the analyzer and record this value as $\bar{x}_{NO_{xmeas}}$.

(iii) Turn off the ozonator and allow for stabilization, accounting only for transport delays and instrument response.

(iv) Calculate the mean of 30 seconds of sampled data from the analyzer and record this value as $\bar{x}_{NO_{xref}}$.

(5) Performance evaluation. Divide the quantity of $(\bar{x}_{NO_{xmeas}} - \bar{x}_{NO_{ref}})$ by the quantity of $(\bar{x}_{NO_{xref}} - \bar{x}_{NO_{ref}})$. If the result is less than 95 %, repair or replace the NO₂-to-NO converter.

Formatted: Underline

(e) * * *

(1) You may omit this verification if you can show by engineering analysis that for your NO_x sampling system and your emission calculations procedures, the ~~the~~ converter always affects your brake-specific NO_x emission results by less than 0.5 % of the applicable NO_x standard.

* * * * *

19. Section 1065.390 is amended by revising paragraphs (d)(8) and (d)(9) and adding paragraph (d)(10) to read as follows:

§1065.390 PM balance verifications and weighing process verification.

* * * * *

(d) * * *

(8) Subtract each ~~of the reference's~~ buoyancy-corrected reference masses from ~~the its~~ most recent previously recorded buoyancy-corrected ~~determinations of their masses~~ mass.

(9) You may discard reference PM sample media if you positively identify a cause for the media's contamination, such as the media falling onto the floor. In this case, you do not have to include the contaminated reference media when determining compliance with paragraph (d)(10) of this section.

(10) If ~~the mean any~~ of the reference's masses changes by more than that allowed under ~~this~~ paragraph (d) ~~of this section~~, ~~then~~ invalidate all PM results that were determined between the two times that the reference masses were determined. If you discarded reference PM sample media according to paragraph (d)(9) of this section, you must still have at least one reference mass difference that meets the criteria in this paragraph (d). Otherwise, you must invalidate all PM results that were determined between the two times that the reference masses were determined.

Subpart E—[Amended]

1. Section 1065.405 is amended by revising paragraphs (b) and (e) introductory text to read as follows:

§1065.405 Test engine preparation and maintenance.

* * * * *

Formatted: Font: Bold

(b) Run the test engine, with all emission-control systems operating, long enough to stabilize emission levels to appropriately apply deterioration factors. You must use the same stabilization procedures for all emission-data engines for which you apply the same deterioration factors so that all low-hour emission-data engines are consistent with the low-hour engine used to develop the deterioration factor. ~~To ensure consistency between low-hour engines and deterioration factors, you must use the same stabilization procedures for all emission data engines within an engine family.~~

Formatted: Not Highlight

(1) Unless otherwise specified in the standard-setting part, you may consider emission levels stable without measurement if you accumulate 12 h of operation for a spark-ignition engine or 125 h for a compression-ignition engine.

(2) If the engine needs more or less operation to stabilize emission levels, record your reasons and the methods for doing this, and give us these records if we ask for them.

(3) You may stabilize emissions from a catalytic exhaust aftertreatment device by operating it on an engine that is different from the test engine, but only where it is consistent with good engineering judgment. You may alternatively stabilize emissions from a catalytic exhaust aftertreatment device by operating it on an engine-exhaust simulator if it is allowed in the standard-setting part, or if we have issued prior guidance, or if we otherwise approve of the use of an engine-exhaust simulator in advance. This process of stabilizing emissions from a catalytic exhaust aftertreatment device is often called “degreening”. Be sure to consider whether degreening under this paragraph (b)(3) will adversely affect your ability to develop and apply appropriate deterioration factors.

* * * * *

(e) If your engine will be used in a vehicle equipped with a canister for storing evaporative hydrocarbons for eventual combustion in the engine and the test sequence involves a cold-start or hot-start duty cycle, attach a canister to the engine before running an emission test. You may omit using an evaporative canister for any hot-stabilized duty cycles. You may request to omit using an evaporative canister during testing if you can show that it would not affect your ability to show compliance with the applicable emission standards. You do not have to accumulate engine operation before emission testing with an installed canister. Prior to an emission test, use the following steps to attach a canister to your engine:

* * * * *

1. The subpart heading of subpart F is revised to read as follows:

Subpart F— Performing an Emission Test ~~in the Laboratory~~ Over Specified Duty Cycles

2. Section 1065.501 is revised to read as follows:

§1065.501 Overview.

Formatted: Font: Bold

(a) Use the procedures detailed in this subpart to measure engine emissions ~~in a laboratory setting~~ over a specified duty cycle. Refer to subpart J of this part for field test procedures that describe how to measure emissions during in-use engine operation. This section describes how to:

- (1) Map your engine, if applicable, by recording specified speed and torque data, as measured from the engine's primary output shaft.
- (2) Transform normalized duty cycles into reference duty cycles for your engine by using an engine map.
- (3) Prepare your engine, equipment, and measurement instruments for an emission test.
- (4) Perform pre-test procedures to verify proper operation of certain equipment and analyzers.
- (5) Record pre-test data.
- (6) Start or restart the engine and sampling systems.
- (7) Sample emissions throughout the duty cycle.
- (8) Record post-test data.
- (9) Perform post-test procedures to verify proper operation of certain equipment and analyzers.
- (10) Weigh PM samples.

(b) An ~~laboratory~~ emission test generally consists of measuring emissions and other parameters while an engine follows one or more duty cycles that are specified in the standard-setting part. There are two general types of duty cycles:

(1) Transient cycles. Transient duty cycles are typically specified in the standard-setting part as a second-by-second sequence of speed commands and torque (or power) commands. Operate an engine over a transient cycle such that the speed and torque of the engine's primary output shaft follows the target values. Proportionally sample emissions and other parameters and use the calculations in subpart G of this part to calculate emissions. Start a transient test according to the standard-setting part, as follows:

Formatted: Underline

(i) A cold-start transient cycle where you start to measure emissions just before starting ~~a cold engine~~ 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) Steady-state cycles. Steady-state duty cycles are typically specified in the standard-setting part as a list of discrete operating points (modes or notches), where each operating point and has one value of a speed command and one value of a torque (or power) command. Ramped-modal cycles for steady-state testing also list test times for each

Formatted: Underline

mode and ramps of speed and torque to follow between modes. Start a steady-state cycle as a hot running test, where you start to measure emissions after an engine is started, warmed up and running. You may run a steady-state duty cycle as a discrete-mode cycle or a ramped-modal cycle, as follows:

(i) Discrete-mode cycles. Before emission sampling, stabilize an engine at the first discrete mode. Sample emissions and other parameters for that mode and then stop emission sampling. Record mean values for that mode, and then stabilize the engine at the next mode. Continue to sample each mode discretely and calculate weighted emission results according to the standard-setting part.

Formatted: Underline

(ii) Ramped-modal cycles. Perform ramped-modal cycles similar to the way you would perform transient cycles, except that ramped-modal cycles involve mostly steady-state engine operation. Perform a ramped-modal cycle as a sequence of second-by-second speed commands and torque (or power) commands. Proportionally sample emissions and other parameters during the cycle and use the calculations in subpart G of this part to calculate emissions.

Formatted: Underline

(c) Other subparts in this part identify how to select and prepare an engine for testing (subpart E), how to perform the required engine service accumulation (subpart E), and how to calculate emission results (subpart G).

(d) Subpart J of this part describes how to perform field testing.

3. Section 1065.510 is revised to read as follows:

§1065.510 Engine mapping.

Formatted: Font: Bold

(a) Applicability, scope, and frequency. An engine map is a data set that consists of a series of paired data points that represent the maximum brake torque versus engine speed, measured at the engine's primary output shaft. Map your engine if the standard-setting part requires engine mapping to generate a duty cycle for your engine configuration.

Formatted: Underline

Map your engine while it is connected to a dynamometer or other device that can absorb work output from the engine's primary output shaft according to §1065.110. Configure any auxiliary work inputs and outputs such as hybrid, turbo-compounding, or thermoelectric systems to represent their in-use configurations, and use the same configuration for emission testing. See Figure 1 of §1065.210. This may involve configuring initial states of charge and rates and times of auxiliary-work inputs and outputs. We recommend that you contact the Designated Compliance Officer before testing to determine how you should configure any auxiliary-work inputs and outputs. Use the most recent engine map to transform a normalized duty cycle from the standard-setting part to a reference duty cycle specific to your engine. Normalized duty cycles are specified in the standard-setting part. You may update an engine map at any time by repeating the engine-mapping procedure. You must map or re-map an engine before a test if any of the following apply:

Formatted: Underline

(1) If you have not performed an initial engine map.

(2) If the atmospheric pressure near the engine's air inlet is not within ± 5 kPa of the atmospheric pressure recorded at the time of the last engine map.

(3) If the engine or emission-control system has undergone changes that might affect maximum torque performance. This includes changing the configuration of auxiliary work inputs and outputs.

(4) If you capture an incomplete map on your first attempt or you do not complete a map within the specified time tolerance. You may repeat mapping as often as necessary to capture a complete map within the specified time.

(b) Mapping variable-speed engines. Map variable-speed engines as follows:

Formatted: Underline

(1) Record the atmospheric pressure.

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

(3) Operate the engine at its warm idle speed, within manufacturer tolerances, if specified. Apply a representative amount of torque to the engine's primary output shaft if nonzero torque at idle speed is representative of its in-use operation. For example output torque at idle speed might normally occur if the engine is always coupled to a device such as a pump or hydrostatic drive that always applies some amount of nonzero torque at idle. Record at least 30 values of speed and use the mean of those values as measured idle speed for cycle generation.

(4) Set operator demand to maximum and control engine speed at (95 ± 1) % of its warm idle speed for at least 15 seconds. For engines with reference duty cycles whose lowest speed is greater than warm idle speed, you may start the map at (95 ± 1) % of the lowest reference speed.

(5) Perform one of the following:

(i) For any engine subject only to steady-state duty cycles (i.e., discrete-mode or ramped-modal), you may perform an engine map by using discrete speeds. Select at least 20 evenly spaced setpoints between warm idle and the highest speed above maximum mapped power at which (50 to 75) % of maximum power occurs. If this highest speed is unsafe or unrepresentative (e.g, for ungoverned engines), use good engineering judgment to map up to the maximum safe speed or the maximum representative speed. At each setpoint, stabilize speed and allow torque to stabilize. Record the mean speed and torque at each setpoint. We recommend that you stabilize an engine for at least 15 seconds at each setpoint and record the mean feedback speed and torque of the last (4 to 6) seconds. Use linear interpolation to determine intermediate speeds and torques. Use this series of speeds and torques to generate the power map as described in paragraph (e) of this section.

(ii) For any variable-speed engine, you may perform an engine map by using a continuous sweep of speed by continuing to record the mean feedback speed and torque at 1 Hz or more frequently and increasing speed at a constant rate such that it takes (4 to 6) min to sweep from 95 % of warm idle to the highest speed above maximum power at which (50 to 75) % of maximum power occurs. If this highest speed is unsafe or unrepresentative (e.g, for ungoverned engines), use good engineering judgment to map up to the maximum safe speed or the maximum representative speed. Stop recording after you complete the sweep. From the series of mean speed and maximum torque values, use linear interpolation to determine intermediate values. Use this series of speeds and torques to generate the power map as described in paragraph (e) of this section.

(c) Negative torque mapping. If your engine is subject to a reference duty cycle that specifies negative torque values (i.e., engine motoring), generate a motoring map by any of the following procedures:

Formatted: Underline

- (1) Multiply the positive torques from your map by -40 %. Use linear interpolation to determine intermediate values.
- (2) Map the amount of negative torque required to motor the engine by repeating paragraph (b) of this section with minimum operator demand.
- (3) Determine the amount of negative torque required to motor the engine at the following two points: at warm idle and at the highest speed above maximum power at which (50 to 75) % of maximum power occurs. If this highest speed is unsafe or unrepresentative (e.g, for ungoverned engines), use good engineering judgment to map up to the maximum safe speed or the maximum representative speed. Operate the engine at these two points at minimum operator demand. Use linear interpolation to determine intermediate values.

(d) Mapping constant-speed engines. For constant-speed engines, generate a map as follows:

Formatted: Underline

- (1) Record the atmospheric pressure.
- (2) Warm up the engine by operating it. We recommend operating the engine at approximately 75 % of the engine's expected maximum power. Continue the warm-up until ~~either~~ the engine coolant, block, or head absolute temperature is within ± 2 % of its mean value for at least 2 min or until the engine thermostat controls engine temperature.
- (3) You may operate the engine with a production constant-speed governor or simulate a constant-speed governor by controlling engine speed with an operator demand control system described in §1065.110. Use either isochronous or speed-droop governor operation, as appropriate.
- (4) With the governor or simulated governor controlling speed using operator demand, operate the engine at no-load governed speed (at high speed, not low idle) for at least 15 seconds.
- (5) Record at 1 Hz the mean of feedback speed and torque. Use the dynamometer to increase torque at a constant rate. Unless the standard-setting part specifies otherwise, complete the map such that it takes (2 to 4) min to sweep from no-load governed speed to the lowest speed below maximum mapped power at which the engine develops (85-95) % of maximum mapped power. You may map your engine to lower speeds. Stop recording after you complete the sweep. Use this series of speeds and torques to generate the power map as described in paragraph (e) of this section.

(e) Power mapping. For all engines, create a power-versus-speed map by transforming torque and speed values to corresponding power values. Use the mean values from the recorded map data. Do not use any interpolated values. Multiply each torque by its corresponding speed and apply the appropriate conversion factors to arrive at units of power (kW). Interpolate intermediate power values between these power values, which were calculated from the recorded map data.

Formatted: Underline

(f) Measured and declared test speeds and torques. You may use test speeds and torques that you declare instead of measured speeds and torques if ~~you declare them before engine mapping and~~ they meet the criteria in this paragraph (f). Otherwise, you must use ~~measured speeds~~ and torques derived from the engine map.

Formatted: Underline

(1) Measured speeds and torques. Determine the applicable ~~measured~~ speeds and torques according to §1065.610:

- (i) Measured maximum test speed for variable-speed engines.
- (ii) Measured maximum test torque for constant-speed engines.
- (iii) Measured “A”, “B”, and “C” speeds for steady-state tests.
- (iv) Measured intermediate speed for steady-state tests.

(2) Required declared speeds. You must declare the following speeds:

Formatted: Underline

(i) Warmed-up, low-idle speed for variable-speed engines. Declare this speed in a way that is representative of in-use operation. For example, if your engine is typically connected to an automatic transmission or a hydrostatic transmission, declare this speed at the idle speed at which your engine operates when the transmission is engaged.

(ii) Warmed-up, no-load, high-idle speed for constant-speed engines.

(3) Optional declared speeds. You may declare an enhanced idle speed according to §1065.610. You may use a declared value for any of the following as long as the declared value is within (97.5 to 102.5) % of its corresponding measured value:

Formatted: Underline

(i) Measured maximum test speed for variable-speed engines.

(ii) Measured intermediate speed for steady-state tests.

(iii) Measured “A”, “B”, and “C” speeds for steady-state tests.

(4) Declared torques. You may declare an enhanced idle torque according to §1065.610.

Formatted: Underline

You may declare maximum test torque as long as it is within (95 to 100) % of the measured value.

(g) Other mapping procedures. You may use other mapping procedures if you believe the procedures specified in this section are unsafe or unrepresentative for your engine.

Formatted: Underline

Any alternate techniques you use must satisfy the intent of the specified mapping procedures, which is to determine the maximum available torque at all engine speeds that occur during a duty cycle. ~~Report-Identify~~ any deviations from this section’s mapping procedures when you submit data to us.

4. Section 1065.512 is revised to read as follows:

§1065.512 Duty cycle generation.

Formatted: Font: Bold

(a) Generate duty cycles according to this section if the standard-setting part requires engine mapping to generate a duty cycle for your engine configuration. The standard-setting part generally defines applicable duty cycles in a normalized format. A normalized duty cycle consists of a sequence of paired values for speed and torque or for speed and power.

(b) Transform normalized values of speed, torque, and power using the following conventions:

(1) Engine speed for variable-speed engines. For variable-speed engines, normalized speed may be expressed as a percentage between idle speed and maximum test speed, f_{ntest} , or speed may be expressed by referring to a defined speed by name, such as “warm idle,” “intermediate speed,” or “A,” “B,” or “C” speed. Section 1065.610 describes how to transform these normalized values into a sequence of reference speeds, f_{nref} . Note that the cycle-validation criteria in §1065.514 allow an engine to govern itself at its in-use idle speed. This allowance permits you to test engines with enhanced-idle devices and to simulate the effects of transmissions such as automatic transmissions. For example, an

enhanced-idle device might be an idle speed value that is normally commanded only under cold-start conditions to quickly warm up the engine and aftertreatment devices.

(2) Engine torque for variable-speed engines. For variable-speed engines, normalized torque is expressed as a percentage of the mapped torque at the corresponding reference speed. Section 1065.610 describes how to transform normalized torques into a sequence of reference torques, T_{ref} . Section 1065.610 also describes under what conditions you may command T_{ref} greater than the reference torque you calculated from a normalized duty cycle. This provision permits you to command T_{ref} values representing curb-idle transmission torque (CITT). For any negative torque commands, command minimum operator demand and use the dynamometer to control engine speed to the reference speed. Note that the cycle-validation criteria in §1065.514 allow an engine to pass cycle statistics for torque for any data points recorded during negative torque commands. Also, use the maximum recorded torque at the minimum mapped speed as the maximum torque for any reference speed at or below the minimum mapped speed.

(3) Engine torque for constant-speed engines. For constant-speed engines, normalized torque is expressed as a percentage of maximum test torque, T_{test} . Section 1065.610 describes how to transform normalized torques into a sequence of reference torques, T_{ref} . Section 1065.610 also describes under what conditions you may command T_{ref} greater than 0 N·m when a normalized duty cycle specifies a 0 % torque command.

(4) Engine power. For all engines, normalized power is expressed as a percentage of mapped power at maximum test speed, f_{ntest} . Section 1065.610 describes how to transform these normalized values into a sequence of reference powers, P_{ref} . ~~You may~~ eConvert these reference powers to reference speeds and torques for operator demand and dynamometer control.

(c) For variable-speed engines, command reference speeds and torques sequentially to perform a duty cycle. Issue speed and torque commands at a frequency of at least 5 Hz for transient cycles and at least 1 Hz for steady-state cycles (i.e., discrete-mode and ramped-modal). ~~For transient cycles, l~~inearly interpolate between the 1 Hz reference values specified in the standard-setting part to determine the 5 Hz more frequently issued reference speeds and torques. During an emission test, record the 1 Hz mean values of the reference speeds and torques and the feedback speeds and torques at the same frequency. Use these recorded values to calculate cycle-validation statistics and total work.

(d) For constant-speed engines, operate the engine with the same production governor you used to map the engine in §1065.525510 or simulate the in-use operation of a governor the same way you simulated it to map the engine in §1065.525510. Command reference torque values sequentially to perform a duty cycle. Issue torque commands at a frequency of at least 5 Hz for transient cycles and at least 1 Hz for steady-state cycles (i.e., discrete-mode, ramped-modal). ~~For transient cycles, l~~inearly interpolate between the 1 Hz reference values specified in the standard-setting part to determine the 5 Hz more frequently issued reference torque values. During an emission test, record the 1 Hz mean values of the reference torques and the feedback speeds and torques at the same frequency. Use these recorded values to calculate cycle-validation statistics and total work.

(e) You may perform practice duty cycles with the test engine to optimize operator demand and dynamometer controls to meet the cycle-validation criteria specified in §1065.514.

5. Section 1065.514 is revised to read as follows:

§1065.514 Cycle-validation criteria for operation over specified duty cycles.

Validate the execution of your duty cycle according to this section unless the standard-setting part specifies otherwise. This section describes how to determine if the engine's operation during the test adequately matched the reference duty cycle. This section applies only to speed, torque, and power from the engine's primary output shaft. Other work inputs and outputs are not subject to cycle-validation criteria. For any data required in this section, use the duty cycle reference and feedback values that you recorded during a test interval.

- Formatted: Font: Bold
- Formatted: Font: Bold
- Formatted: Font: Bold
- Formatted: Font: Bold
- Formatted: Not Highlight
- Formatted: Not Highlight

(a) Testing performed by EPA. Our tests must meet the specifications of paragraph (g) of this section, unless we determine that failing to meet the specifications is related to engine performance rather than to shortcomings of the dynamometer or other laboratory equipment.

Formatted: Underline

(b) Testing performed by manufacturers. Emission tests that meet the specifications of paragraph (g) of this section satisfy the standard-setting part's requirements for duty cycles. You may ask to use a dynamometer or other laboratory equipment that cannot meet those specifications. We will approve your request as long as using the alternate equipment does not adversely affect your ability to show compliance with the applicable emission standards.

Formatted: Underline

(c) Time-alignment. Because time lag between feedback values and the reference values may bias cycle-validation results, you may advance or delay the entire sequence of feedback engine speed and/or torque pairs to synchronize them with the reference sequence.

Formatted: Underline

~~(d) Calculating work. Before calculating work values, omit any points recorded during engine cranking and starting. Cranking and starting includes any time when an engine starter is engaged, any time when the engine is motored with a dynamometer for the sole purpose of starting the engine, and any time during operation before reaching idle speed. See §1065.525(a) and (b) for more information about engine cranking. After omitting points recorded during engine cranking and starting, but before omitting any points under paragraph (e) of this section, calculate total work, W , based on the feedback values and reference work, W_{ref} , based on the reference values, as described in §1065.650.~~

(ed) Omitting additional points. Besides engine cranking, you may omit additional points from cycle-validation statistics as described in the following table:

Formatted: Underline

Table 1 of §1065.514—

Permissible criteria for omitting points from duty-cycle regression statistics

| For reference duty cycles that are specified in terms of speed and torque (f_{ref} , T_{ref}) | | |
|---|------------------|--|
| When operator demand is at its... | you may omit... | if... |
| minimum | power and torque | $T_{ref} < 0$ % (motoring) |
| minimum | power and speed | $f_{ref} = 0$ % (idle <u>speed</u>) and $T_{ref} = 0$ % (idle <u>torque</u>) and |

| | | |
|--|----------------------------------|--|
| | | $T_{\text{ref}} - (2\% \cdot T_{\text{max mapped}}) < T < T_{\text{ref}} + (2\% \cdot T_{\text{max mapped}})$ |
| minimum | power and either torque or speed | $f_n > f_{\text{nref}}$ or $T > T_{\text{ref}}$ but not if $f_n > f_{\text{nref}}$ and $T > T_{\text{ref}}$ |
| maximum | power and either torque or speed | $f_n < f_{\text{nref}}$ or $T < T_{\text{ref}}$ but not if $f_n < f_{\text{nref}}$ and $T < T_{\text{ref}}$ |
| For reference duty cycles that are specified in terms of speed and power ($f_{\text{nref}}, P_{\text{ref}}$) | | |
| When operator demand is at its... | you may omit... | if... |
| minimum | power and torque | $P_{\text{ref}} < 0\%$ (motoring) |
| minimum | power and speed | $f_{\text{nref}} = 0\%$ (idle speed) and $P_{\text{ref}} = 0\%$ (idle power) and $P_{\text{ref}} - (2\% \cdot P_{\text{max mapped}}) < P < P_{\text{ref}} + (2\% \cdot P_{\text{max mapped}})$ |
| minimum | power and either torque or speed | $f_n > f_{\text{nref}}$ or $P > P_{\text{ref}}$ but not if $f_n > f_{\text{nref}}$ and $P > P_{\text{ref}}$ |
| maximum | power and either torque or speed | $f_n < f_{\text{nref}}$ or $P < P_{\text{ref}}$ but not if $f_n < f_{\text{nref}}$ and $P < P_{\text{ref}}$ |

(fe) Statistical parameters. Use the remaining points to calculate regression statistics described in §1065.602. Round calculated regression statistics to the same number of significant digits as the criteria to which they are compared. Refer to Table 2 of §1065.514 for the default criteria and refer to the standard-setting part to determine if there are other criteria for your engine. Calculate the following regression statistics:

Formatted: Underline

- (1) Slopes for feedback speed, a_{1f_n} , feedback torque, a_{1T} , and feedback power a_{1P} .
- (2) Intercepts for feedback speed, a_{0f_n} , feedback torque, a_{0T} , and feedback power a_{0P} .
- (3) Standard estimates of error for feedback speed, SEE_{f_n} , feedback torque, SEE_T , and feedback power SEE_P .
- (4) Coefficients of determination for feedback speed, $r^2_{f_n}$, feedback torque, r^2_T , and feedback power r^2_P .

(ef) Cycle-validation criteria. Unless the standard-setting part specifies otherwise, use the following criteria to validate a duty cycle:

Formatted: Underline

- (1) For variable-speed engines, apply all the statistical criteria in Table 2 of this section.
- (2) For constant-speed engines, apply only the statistical criteria for torque in ~~the~~ Table 2 of this section.

Table 2 of §1065.514—Default statistical criteria for validating duty cycles

| Parameter | Speed | Torque | Power |
|--------------------------------------|------------------------------------|---------------------------------------|--------------------------------------|
| Slope, a_1 | $0.950 \leq a_1 \leq 1.030$ | $0.830 \leq a_1 \leq 1.030$ | $0.830 \leq a_1 \leq 1.030$ |
| Absolute value of intercept, $ a_0 $ | $\leq 10\%$ of warm idle | $\leq 2.0\%$ of maximum mapped torque | $\leq 2.0\%$ of maximum mapped power |
| Standard error of estimate, SEE | $\leq 5.0\%$ of maximum test speed | $\leq 10\%$ of maximum mapped torque | $\leq 10\%$ of maximum mapped power |
| Coefficient of determination, r^2 | ≥ 0.970 | ≥ 0.850 | ≥ 0.910 |

6. Section 1065.520 is amended by revising paragraphs (b), (f)(1), (g) introductory text, and (g)(7)(iii) to read as follows:

§1065.520 Pre-test verification procedures and pre-test data collection.

Formatted: Font: Bold

* * * * *

(b) Unless the standard-setting part specifies different tolerances, verify that ambient conditions are within the following tolerances before the test:

(1) Ambient temperature of (20 to 30) °C.

(2) Intake air temperature of (20 to 30) °C upstream of all engine components.

~~(3)~~ Atmospheric pressure of (80.000 to 103.325) kPa and within ±5 % of the value recorded at the time of the last engine map.

~~(4)~~ Dilution air conditions as specified in §1065.140~~(b)~~.

* * * * *

(f) * * *

(1) Start the engine and use good engineering judgment to bring it to one of the following:

(i) 100 % torque at any speed above its peak-torque speed.

(ii) 100% operator demand.

* * * * *

(g) After the last practice or preconditioning cycle before an emission test, verify the amount of nonmethane contamination in the exhaust and background HC-sampling systems. You may omit verifying the contamination of a background HC sampling system if its contamination was verified within ten days before testing. For any NMHC measurement system that involves separately measuring methane and subtracting it from a THC measurement, verify the amount of HC contamination using only the THC analyzer response. There is no need to operate any separate methane analyzer for this verification. Perform this verification as follows: * * *

(7) * * *

~~(iii) For any compression-ignition engines, any two-stroke spark ignition engines, or 4-stroke spark-ignition engines that are less than 19 kW, 2 µmol/mol.~~

* * * * *

7. Section 1065.525 is revised to read as follows:

§1065.525 Engine starting, restarting, optional repeating of void discrete modes and shutdown.

Formatted: Font: Bold

Formatted: Font: Bold

(a) Start the engine using one of the following methods:

(1) Start the engine as recommended in the owners manual using a production starter motor or air-start system and either an adequately charged battery, ~~or a~~ suitable power supply, or a suitable compressed air source.

(2) Use the dynamometer to start the engine. To do this, motor the engine within ±25 % of its typical in-use cranking speed. Stop cranking within 1 second of starting the engine.

(b) If the engine does not start after 15 seconds of cranking, stop cranking and determine why the engine failed to start, unless the owners manual or the service-repair manual describes the longer cranking time as normal.

(c) Respond to engine stalling with the following steps:

- (1) If the engine stalls during warm-up before emission sampling begins, restart the engine and continue warm-up.
- (2) If the engine stalls during preconditioning before emission sampling begins, restart the engine and restart the preconditioning sequence.
- (3) If the engine stalls at any time after emission sampling begins for a transient test or ramped-modal cycle test, the test is void.
- (4) ~~Except as described in paragraph (d) of this section, void the test if~~ the engine stalls at any time after emission sampling begins. ~~for a discrete mode in a discrete mode duty cycle test, void the test or perform the following steps to continue the test:~~
(d) If emission sampling is interrupted during one of the modes of a discrete-mode test, you may void the results only for that individual mode and perform the following steps to continue the test:
 - (i) ~~If the engine has stalled, r~~Restart the engine.
 - (ii) Use good engineering judgment to restart the test sequence using the appropriate steps in §1065.530(b).
 - (iii) Precondition the engine by operating at the previous ~~discrete~~ mode for approximately the same amount of time it operated at that mode for the last emission measurement. a similar amount of time compared with how long it was initially run.
 - (iv) Advance to the mode at which the engine stalled and continue with the duty cycle as specified in the standard-setting part.
 - (v) Complete the remainder of the test according to the requirements in this subpart.
- (~~e~~) Shut down the engine according to the manufacturer's specifications.

Formatted: Not Highlight

8. Section 1065.530 is revised to read as follows:

§1065.530 Emission test sequence.

Formatted: Font: Bold

- (a) Time the start of testing as follows:
 - (1) Perform one of the following if you precondition sampling systems as described in §1065.520(f):
 - (i) For cold-start duty cycles, shut down the engine. Unless the standard-setting part specifies that you may only perform a natural engine cooldown, you may perform a forced engine cooldown. Use good engineering judgment to set up systems to send cooling air across the engine, to send cool oil through the engine lubrication system, to remove heat from coolant through the engine cooling system, and to remove heat from any exhaust aftertreatment systems. In the case of a forced aftertreatment cooldown, good engineering judgment would indicate that you not start flowing cooling air until the aftertreatment system has cooled below its catalytic activation temperature. For platinum-group metal catalysts, this temperature is about 200 °C. Once the aftertreatment system has naturally cooled below its catalytic activation temperature, good engineering judgment would indicate that you use clean air with a temperature of at least 15 °C, and direct the air through the aftertreatment system in the normal direction of exhaust flow. Do not use any cooling procedure that results in unrepresentative emissions (see §1065.10(c)(1)). You may start a cold-start duty cycle when the temperatures of an engine's lubricant, coolant, and aftertreatment systems are all between (20 and 30) °C.
 - (ii) For hot-start emission measurements, shut down the engine. Start ~~a the~~ hot-start duty cycle as specified in the standard-setting part. within 20 min of engine shutdown.

(iii) For testing that involves hot-stabilized emission measurements, such as any steady-state testing, you may continue to operate the engine at ~~fnest-maximum test speed~~ and 100 % torque if that is the first operating point. Otherwise, operate the engine at warm-idle or the first operating point of the duty cycle. In any case, start the emission test within 10 min after you complete the preconditioning procedure.

(2) ~~If you do not precondition sampling systems, For all other testing,~~ perform one of the following:

(i) For cold-start duty cycles, prepare the engine according to paragraph (a)(1)(i) of this section.

(ii) For hot-start emission measurements, first operate the engine at any speed above peak-torque speed and at (65 to 85) % of maximum mapped power until either the engine coolant, block, or head absolute temperature is within ± 2 % of its mean value for at least 2 min or until the engine thermostat controls engine temperature. Shut down the engine. Start the duty cycle within 20 min of engine shutdown.

(iii) For testing that involves hot-stabilized emission measurements, bring the engine either to warm idle or the first operating point of the duty cycle. Start the test within 10 min of achieving temperature stability. Determine temperature stability either as the point at which the engine coolant, block, or head absolute temperature is within ± 2 % of its mean value for at least 2 min, or as the point at which the engine thermostat controls engine temperature.

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

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

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

(3) Start dilution systems, sample pumps, cooling fans, 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 §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 ~~use analyzers that~~ 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 analyzers using NIST-traceable gases that meet the specifications of §1065.750. Span FID analyzers on a carbon number basis of one (1), C₁. For example, if you use a C₃H₈ span gas of concentration 200 μmol/mol, span the FID to respond with a value of 600 μmol/mol. Span FID analyzers consistently with the determination of their respective response factors, *RF*, and penetration fractions, *PF*, according to §1065.365.

(11) We recommend that you verify gas analyzer responses after zeroing and spanning by flowing-sampling a calibration gas that has a concentration near one-half of the span gas

Formatted: Font: Italic

Formatted: Font: Italic

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 engine exhaust constituents, start measuring and recording background concentrations.

(13) Drain any condensate from the intake air system and close any intake air condensate drains that are not normally open during in-use operation.

(c) Start testing as follows:

(1) If an engine is already running and warmed up, and starting is not part of the duty cycle, perform the following for the various duty cycles:

(i) Transient and steady-state ramped-modal cycles. Simultaneously start running the duty cycle, sampling exhaust gases, recording data, and integrating measured values.

(ii) Steady-state discrete-mode cycles. Control the engine operation speed and torque to match the first mode in the test cycle. This will require controlling engine speed and load, engine load, or other operator demand settings, as specified in the standard-setting part.

Follow the instructions in the standard-setting part to determine how long to stabilize engine operation at each mode and, how long to sample emissions at each mode, and how to transition between modes.

(2) If engine starting is part of the duty cycle, initiate data logging, sampling of exhaust gases, and integrating measured values before attempting to start the engine. Initiate the duty cycle when the engine starts.

(d) At the end of the each test interval, continue to operate all sampling and dilution systems to allow the sampling system's response time to elapse. Then stop all sampling and recording, including the recording of background samples. Finally, stop any integrating devices and indicate the end of the duty cycle in the recorded data.

(e) Shut down the engine if you have completed testing or if it is part of the duty cycle.

(f) If testing involves another duty cycle after a soak period with the engine off, start a timer when the engine shuts down, and repeat the steps in paragraphs (b) through (e) of this section as needed.

(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 §1065.545. Void any samples that did not maintain proportional sampling according to §1065.545.

(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 §1065.595.

(3) As soon as practical after the duty cycle is complete but no later than 30 minutes after the duty cycle is complete, perform the following:

(i) Zero and span all batch gas analyzers.

(ii) Analyze any gaseous batch samples, including background samples.

(4) 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 and correct for drift as described in §1065.550.

(h) Unless the standard-setting part specifies otherwise, determine whether or not the test meets the cycle-validation criteria in §1065.514.

Formatted: Not Highlight

(1) If the criteria void the test, you may retest using the same denormalized duty cycle, or you may re-map the engine, denormalize the reference duty cycle based on the new map and retest the engine using the new denormalized duty cycle.

(2) If the criteria void the test for a constant-speed engine only during commands of maximum test torque, you may do the following:

(i) Determine the first and last feedback speeds at which maximum test torque was commanded.

(ii) If the last speed is greater than or equal to 90 % of the first speed, the test is void. You may retest using the same denormalized duty cycle, or you may re-map the engine, denormalize the reference duty cycle based on the new map and retest the engine using the new denormalized duty cycle.

(iii) If the last speed is less than 90 % of the first speed, reduce maximum test torque by 5 %, and proceed as follows:

(A) Denormalize the entire duty cycle based on the reduced maximum test torque according to §1065.512.

(B) Retest the engine using the denormalized test cycle that is based on the reduced maximum test torque.

(C) If your engine still fails the cycle criteria, reduce the maximum test torque by another 5 % of the original maximum test torque.

(D) If your engine fails after repeating this procedure four times, such that your engine still fails after you have reduced the maximum test torque by 20 % of the original maximum test torque, notify us and we will consider specifying a more appropriate duty cycle for your engine under the provisions of §1065.10(c).

9. Section 1065.545 is amended by revising paragraph (b)(2) to read as follows:

§1065.545 Validation of proportional flow control for batch sampling.

Formatted: Font: Bold

* * * * *

(b) * * *

(2) Positive-displacement pump option. You may use the 1 Hz (or more frequently) recorded pump-inlet conditions. Demonstrate that the flow density at the pump inlet was constant within ± 2.5 % of the mean or target density over each test interval. For a CVS pump, you may demonstrate this by showing that the absolute temperature at the pump inlet was constant within ± 2 % of the mean or target absolute temperature over each test interval.

Formatted: Underline

* * * * *

10. Section 1065.550 is revised to read as follows:

§1065.550 Gas analyzer range validation, drift validation, and drift correction.

Formatted: Font: Bold

(a) Range validation. If an analyzer operated above 100 % of its range at any time during the test, perform the following steps:

Formatted: Underline

(1) 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, ~~for the entire test.~~

(2) 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 always operates at less than 100 % of its range ~~for the entire test.~~

(b) Drift validation and drift correction. Calculate two sets of brake-specific emission results. Calculate one set using the data before drift correction and calculate the other set after correcting all the data for drift according to §1065.672. Use the two sets of brake-specific emission results as follows:

Formatted: Underline

(1) If the difference between the corrected and uncorrected brake-specific emissions are within ± 4 % of the uncorrected results or within ± 4 % of the applicable standard for all regulated emissions, the test is validated for drift. If not, the entire test is void.

(2) If the test is validated for drift, you must use only the drift-corrected emission results when reporting emissions, unless you demonstrate to us that using the drift-corrected results adversely affects your ability to demonstrate ~~whether or not that~~ your engine complies with the applicable standards.

11. Section 1065.590 is amended by revising paragraph (j)(9) to read as follows:

§1065.590 PM sample preconditioning and tare weighing.

* * * * *

(j) * * *

(9) Once weighing is completed, Follow the instructions given in paragraphs (g) through (i) of this section.

Formatted: Font: Bold

12. Section 1065.595 is amended by revising paragraph (e) to read as follows:

§1065.595 PM sample post-conditioning and total weighing.

* * * * *

(e) To stabilize PM samples, place them in one or more containers that are open to the PM-stabilization environment, which is described in §1065.190. A PM sample is stabilized as long as it has been in the PM-stabilization environment for one of the following durations, during which the stabilization environment has been within the specifications of §1065.190:

(1) If you expect that a filter's total surface concentration of PM will be greater than about 0.5473 $\mu\text{mg}/\text{mm}^2$, expose the filter to the stabilization environment for at least 60 minutes before weighing.

Formatted: Font: Symbol

(2) If you expect that a filter's total surface concentration of PM will be less than about 0.5473 $\mu\text{mg}/\text{mm}^2$, expose the filter to the stabilization environment for at least 30 minutes before weighing.

Formatted: Font: Symbol

(3) If you are unsure of a filter's total surface concentration of PM, expose the filter to the stabilization environment for at least 60 minutes before weighing.

(4) Note that 0.5 $\mu\text{g}/\text{mm}^2$ is approximately equal to 567 μg of net PM mass on a PM filter with a 38 mm diameter stain area. It is also an approximate surface concentration at 0.07

g/kWh for a hot-start test with compression-ignition engines tested according to 40 CFR part 86, subpart N, or 50 mg/mile for a light-duty vehicle tested according to 40 CFR part 86, subpart B.

* * * * *

Subpart G—[Amended]

1. Section 1065.610 is amended by revising paragraph (b)(1) before the equation to read as follows:

§1065.610 Duty cycle generation.

* * * * *

(b) Maximum test torque, T_{test} . For constant-speed engines, determine the measured T_{test} from the power-versus-speed map, generated according to §1065.510, as follows:

(1) Based on the map, determine maximum power, P_{max} , and the speed at which maximum power occurs, f_{nPmax} . Divide every recorded power by P_{max} and divide every recorded speed by f_{nPmax} . The result is a normalized power-versus-speed map. Your measured T_{test} is the **speed torque** at which the sum of the squares of normalized speed and power is maximum, as follows:

* * * * *

2. Section 1065.642 is amended as follows:

- a. By revising the reference “Eq. 1065.640-4” to read “Eq. 1065.640-5”.
- b. By revising the reference “Eq. 1065.640-5” to read “Eq. 1065.640-6”.
- c. By revising the reference “Eq. 1065.640-6” to read “Eq. 1065.640-7”.

§ 1065.642 SSV, CFV, and PDP molar flow rate calculations.

* * * * *

Using Eq. 1065.640-~~67~~,
 $f_{ssv} = 0.997$

Using Eq. 1065.640-~~56~~,
 $C_f = 0.274$

Using Eq. 1065.640-~~45~~,
 $C_d = 0.990$

* * * * *

3. Section 1065.650 is amended by revising the reference to “1065.650-5” in paragraph (e)(4) to be “Eq. 1065.650-5” and adding Equation 1065.650-5 after Equation 1065.650-4 in paragraph (b)(2)(i) to read as follows:

§1065.650 Emission calculations.

* * * * *

- (b)
 - (2)
 - (i) * * *

Where:
 $\Delta t = 1/f_{record}$ Eq. 1065.650-5

Formatted: Subscript

* * * * *

(e) * * * * *
Using Eq. 1065.650-5,
 $\Delta t = 0.2$ s

* * * * *

4. Section 1065.655 is amended by revising paragraphs (c) introductory text and (d)(1)(ii) to read as follows:

§1065.655 Chemical balances of fuel, intake air, and exhaust.

* * * * *

(c) Chemical balance procedure. The calculations for a chemical balance involve a system of equations that require iteration. We recommend using a computer to solve this system of equations. You must guess the initial values of up to three quantities: the amount of water in the measured flow, x_{H_2O} , fraction of dilution air in diluted exhaust, x_{dil} , and the amount of products on a C_1 basis per dry mole of dry measured flow, $x_{C_{prod}dry}$. For each emission concentration, x , and amount of water, x_{H_2O} , you must determine their completely dry concentrations, x_{dry} and x_{H_2Odry} . You must also use your fuel's atomic hydrogen-to-carbon ratio, α , and oxygen-to-carbon ratio, β . For your fuel, you may measure α and β or you may use the default values in Table 1 of §1065.650. Use the following steps to complete a chemical balance:

* * * * *

(d) * * * * *
(1) * * * * *

(ii) During emission testing you route open crankcase flow to the exhaust according to §1065.130(~~g~~**i**).

* * * * *

Subpart H— [Amended]

Formatted: Font: Bold

Formatted: Font: Bold

- Section 1065.701 is amended by revising paragraphs (c) introductory text and (e) to read as follows:

§1065.701 General requirements for test fuels.

Formatted: Font: Bold

(c) Fuels not specified in this subpart. If you produce engines that run on a type of fuel (or mixture of fuels) that we do not specify in this subpart, you must get our written approval to establish the appropriate test fuel. See the standard-setting part for provisions related to fuels not specified in this subpart. We will generally allow you to use the fuel if you ~~You must~~ show us all the following things are true before we can specify a different test fuel for your engines:

Formatted: Underline

- Show that this type of fuel is commercially available.
- Show that your engines will use only the designated fuel in service.
- Show that operating the engines on the fuel we specify would unrepresentatively increase emissions or decrease durability.

* * * * *

(e) Service accumulation and field testing fuels. If we do not specify a service-accumulation or field-testing fuel in the standard-setting part, use an appropriate commercially available fuel such as those meeting minimum ~~ASTM~~ specifications from the following table:

Formatted: Underline

Table 1 of §1065.701—~~Specifications for~~ Examples of service-accumulation and field-testing fuels.

| Fuel category type | Subcategory | ASTM specification Reference procedure ¹ |
|---------------------------------------|--|--|
| Diesel | Light distillate and light blends with residual | ASTM D975-04c |
| | Middle distillate | ASTM D6751-03a |
| | Biodiesel (B100) | ASTM D6985-04a |
| <u>Intermediate and residual fuel</u> | <u>All</u> | <u>See §1065.705</u> |
| Gasoline | Motor vehicle gasoline and minor oxygenate blends | ASTM D4814-04b |
| | Minor oxygenated gasoline blends | ASTM D4814-04b |
| | Ethanol (E75-85) Methanol (M70-M85) | ASTM D5798-99 ASTM D5797-96 |
| <u>Alcohol</u> | <u>Ethanol (E75-85)</u> | <u>ASTM D5798-99</u> |
| | <u>Methanol (M70-M85)</u> | <u>ASTM D5797-96</u> |
| Aviation fuel | Aviation gasoline | ASTM D910-04a |
| | Gas turbine | ASTM D1655-04a |
| | Jet B wide cut | ASTM D6615-04a |
| Gas turbine fuel | General | ASTM D2880-03 |

¹All ASTM specifications are incorporated by reference in §1065.1010.

- Section 1065.703 is amended by revising Table 1 to read as follows:

§1065.703 Distillate diesel fuel.

Formatted: Font: Bold

* * * * *

Table 1 of §1065.703—Test fuel specifications for distillate diesel fuel

| Item | Units | Ultra Low Sulfur | Low Sulfur | High Sulfur | Reference Procedure ¹ |
|------|-------|------------------|------------|-------------|----------------------------------|
|------|-------|------------------|------------|-------------|----------------------------------|

| | | | | | |
|--|-------|-----------|-----------|-------------|----------------|
| Cetane Number | — | 40 - 50 | 40 - 50 | 40 - 50 | ASTM D 613-03b |
| Distillation range: | C | | | | ASTM D 86-04b |
| Initial boiling point | | 171 - 204 | 171 - 204 | 171 - 204 | |
| 10 pct. point | | 204 - 238 | 204 - 238 | 204 - 238 | |
| 50 pct. point | | 243 - 282 | 243 - 282 | 243 - 282 | |
| 90 pct. point | | 293 - 332 | 293 - 332 | 293 - 332 | |
| Endpoint | | 321 - 366 | 321 - 366 | 321 - 366 | |
| Gravity | API | 32 - 37 | 32 - 37 | 32 - 37 | ASTM D 287-92 |
| Total sulfur | mg/kg | 7 - 15 | 300 - 500 | 2000 - 4000 | ASTM D 2622-03 |
| Aromatics, minimum. (Remainder shall be paraffins, naphthalenes, and olefins) | g/kg | 100 | 100 | 100 | ASTM D 5186-03 |
| Flashpoint, min. | C | 54 | 54 | 54 | ASTM D 93-02a |
| Kinematic Viscosity | cSt | 2.0 - 3.2 | 2.0 - 3.2 | 2.0 - 3.2 | ASTM D 445-04 |
| ¹ ASTM procedures are incorporated by reference in §1065.1010. See §1065.701(d) for other allowed procedures. | | | | | |

3. Section 1065.705 is revised to read as follows:

§1065.705 Residual and intermediate residual fuel. ~~[Reserved]~~

This section describes the specifications for fuels meeting the definition of residual fuel in 40 CFR 80.2, including fuels marketed as intermediate fuel. Residual fuels for service accumulation and any testing must meet the following specifications:

- (a) The fuel must be a commercially available fuel that is representative of the fuel that will be used by the engine in actual use.
- (b) The fuel must meet the specifications for one of the categories in the following table:

Formatted: Font: Bold

Formatted: Font: Bold

Formatted: Bullets and Numbering

Table 1 of §1065.705–Service accumulation and test fuel specifications for residual fuel.

Comment [MWS1]: New Table

| Characteristic | Unit | Category ISO-F- | | | | | | | | | | Test method reference ¹ |
|--|-------------------------------------|---|-----------|-----------|------------|------------|------------|------------|------------|------------|------------|--|
| | | RMA 30 | RMB 30 | RMD 80 | RME 180 | RMF 180 | RMG 380 | RMH 380 | RMK 380 | RMH 700 | RMK 700 | |
| Density at 15 °C, max. | kg/m ³ | 960.0 | 975.0 | 980.0 | 991.0 | | 991.0 | | 1010.0 | 991.0 | 1010.0 | ISO 3675 or ISO 12185: 1996/Cor 1:2001 (see also ISO 8217:2005(E) 7.1) |
| Kinematic viscosity at 50 °C, max. | cSt | 30.0 | | 80.0 | 180.0 | | 380.0 | | 700.0 | | | ISO 3104:1994/Cor 1:1997 |
| Flash point, min. | °C | 60 | | 60 | 60 | | 60 | | 60 | | | ISO 2719 (see also ISO 8217:2005(E) 7.2) |
| Pour point (upper) Winter quality, max. Summer quality, max. | °C | 0 6 | 24 24 | 30 30 | 30 30 | | 30 30 | | 30 30 | | | ISO 3016 ISO 3016 |
| Carbon residue, max. | (kg/kg) % | 10 | | 14 | 15 | 20 | 18 | 22 | 22 | | | ISO 10370:1993/Cor 1:1996 |
| Ash, max. | (kg/kg) % | 0.10 | | 0.10 | 0.10 | 0.15 | 0.15 | | 0.15 | | | ISO 6245 |
| Water, max. | (m ³ /m ³) % | 0.5 | | 0.5 | 0.5 | | 0.5 | | 0.5 | | | ISO 3733 |
| Sulfur, max. | (kg/kg) % | 3.50 | | 4.00 | 4.50 | | 4.50 | | 4.50 | | | ISO 8754 or ISO 14596: 1998/Cor 1:1999 (see also ISO 8217:2005(E) 7.3) |
| Vanadium, max. | mg/kg | 150 | | 350 | 200 | 500 | 300 | 600 | 600 | | | ISO 14597 or IP 501 or IP 470 (see also ISO 8217:2005(E) 7.8) |
| Total sediment potential, max. | (kg/kg) % | 0.10 | | 0.10 | 0.10 | | 0.10 | | 0.10 | | | ISO 10307-2 (see also ISO 8217:2005(E) 7.6) |
| Aluminium plus silicon, max. | mg/kg | 80 | | 80 | 80 | | 80 | | 80 | | | ISO 10478 or IP 501 or IP 470 (see also ISO 8217:2005(E) 7.9) |
| Used lubricating oil (ULO), max. | mg/kg | Fuel shall be free of ULO. We consider a fuel to be free of ULO if one or more of the elements zinc, phosphorus, or calcium is at or below the specified limits. We consider a fuel to contain ULO if all three elements exceed the specified limits. | | | | | | | | | | IP 501 or IP 470 (see ISO 8217:2005(E) 7.7) IP 501 or IP 500 (see ISO 8217:2005(E) 7.7) IP 501 or IP 470 (see ISO 8217:2005(E) 7.7) |
| Zinc | | 15 | | | | | | | | | | |
| Phosphorus | | 15 | | | | | | | | | | |
| Calcium | | 30 | | | | | | | | | | |

¹ ISO procedures are incorporated by reference in §1065.1010. See §1065.701(d) for other allowed procedures.

4. Section 1065.710 is amended by revising Table 1 to read as follows:

§1065.710 Gasoline.

* * * * *

Formatted: Font: Bold

Table 1 of §1065.710—Test fuel specifications for gasoline

| Item | Units | General Testing | Low-Temperature Testing | Reference Procedure ¹ |
|--|--------------------------------|---|---|----------------------------------|
| Distillation Range: Initial boiling point 10% point 50% point 90% point End point | C | 24 - 35.2 49 - 57 93 - 110 149 - 163 Maximum, 213 | 24 - 36 37 - 48 82 - 101 158 - 174 Maximum, 212 | ASTM D 86-04b |
| Hydrocarbon composition: Olefins Aromatics Saturates | m ³ /m ³ | Maximum, 100,0000.10 Maximum, 350,0000.35 Remainder | Maximum, 0,475,000175 Maximum, 0,304,000304 Remainder | ASTM D 1319-03 |
| Lead (organic) | g/liter | Maximum, 0.013 | Maximum, 0.013 | ASTM D 3237-02 |
| Phosphorous | g/liter | Maximum, 0.0013 | Maximum, 0.005 | ASTM D 3231-02 |
| Total sulfur | mg/kg | Maximum, 80 | Maximum, 80 | ASTM D 1266-98 |
| Volatility (Reid Vapor Pressure) | kPa | 60.0 - 63.4 ^{2,3} | 77.2 - 81.4 | ASTM D 323-99a |

¹All ASTM procedures are incorporated by reference in §1065.1010. See §1065.701(d) for other allowed procedures.
²For testing at altitudes above 1 219 m, the specified volatility range is (52.0 to 55.2) kPa and the specified initial boiling point range is (23.9 to 40.6) C.
³For testing unrelated to evaporative emissions, the specified range is (55.2 to 63.4) kPa.

Formatted Table

5. Section 1065.715 is revised to read as follows:

§1065.715 Natural gas.

(a) Except as specified in paragraph (b) of this section, natural gas for testing must meet the specifications in the following table:

Formatted: Font: Bold

Table 1 of §1065.715—Test fuel specifications for natural gas

| Item | Value ¹ |
|--|-------------------------|
| Methane, CH ₄ | Minimum, 0.87 mol/mol |
| Ethane, C ₂ H ₆ | Maximum, 0.055 mol/mol |
| Propane, C ₃ H ₈ | Maximum, 0.012 mol/mol |
| Butane, C ₄ H ₁₀ | Maximum, 0.0035 mol/mol |
| Pentane, C ₅ H ₁₂ | Maximum, 0.0013 mol/mol |
| C ₆ and higher | Maximum, 0.001 mol/mol |
| Oxygen | Maximum, 0.001 mol/mol |
| Inert gases (sum of CO ₂ and N ₂) | Maximum, 0.051 mol/mol |

¹All parameters are based on the reference procedures in ASTM D 1945-03 (incorporated by reference in §1065.1010). See §1065.701(d) for other allowed procedures.

(b) In certain cases you may use test fuel not meeting the specifications in paragraph (a) of this section, as follows:

Formatted: Not Highlight

- (1) You may use fuel that your in-use engines normally use, such as pipeline natural gas.
- (2) You may use fuel meeting alternate specifications if the standard-setting part allows it.
- (3) You may ask for approval to use fuel that does not meet the specifications in paragraph (a) of this section, but only if using the fuel would not adversely affect your ability to demonstrate compliance with the applicable standards.
- (c) When we conduct testing using natural gas, we will use fuel that meets the specifications in paragraph (a) of this section.
- (~~b~~d) At ambient conditions, natural gas must have a distinctive odor detectable down to a concentration in air not more than one-fifth the lower flammable limit.

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Not Highlight

Formatted: Font: Bold

6. Section 1065.720 is revised to read as follows:

§1065.720 Liquefied petroleum gas.

(a) Except as specified in paragraph (b) of this section, liquefied petroleum gas for testing must meet the specifications in the following table:

Table 1 of §1065.720—Test fuel specifications for liquefied petroleum gas

| Item | Value | Reference Procedure ¹ |
|---|---|--|
| Propane, C ₃ H ₈ | Minimum, 0.85 m ³ /m ³ | ASTM D 2163-91 |
| Vapor pressure at 38 °C | Maximum, 1400 kPa | ASTM D 1267-02 or 2598-02 ² |
| Volatility residue (evaporated temperature, 35 °C) | Maximum, -38 °C | ASTM D 1837-02a |
| Butanes | Maximum, 0.05 m ³ /m ³ | ASTM D 2163-91 |
| Butenes | Maximum, 0.02 m ³ /m ³ | ASTM D 2163-91 |
| Pentenes and heavier | Maximum, 0.005 m ³ /m ³ | ASTM D 2163-91 |
| Propene | Maximum, 0.1 m ³ /m ³ | ASTM D 2163-91 |
| Residual matter (residue on evap. of 100) ml oil stain observ.) | Maximum, 0.05 ml pass ³ | ASTM D 2158-04 |
| Corrosion, copper strip | Maximum, No. 1 | ASTM D 1838-03 |
| Sulfur | Maximum, 80 mg/kg | ASTM D 2784-98 |
| Moisture content | pass | ASTM D 2713-91 |

¹ASTM procedures are incorporated by reference in §1065.1010. See §1065.701(d) for other allowed procedures.

²If these two test methods yield different results, use the results from ASTM D 1267-02.

³The test fuel must not yield a persistent oil ring when you add 0.3 ml of solvent residue mixture to a filter paper in 0.1 ml increments and examine it in daylight after two minutes.

(b) In certain cases you may use test fuel not meeting the specifications in paragraph (a) of this section, as follows:

- (1) You may use fuel that your in-use engines normally use, such as commercial-quality liquefied petroleum gas.
- (2) You may use fuel meeting alternate specifications if the standard-setting part allows it.
- (3) You may ask for approval to use fuel that does not meet the specifications in paragraph (a) of this section, but only if using the fuel would not adversely affect your ability to demonstrate compliance with the applicable standards.

(c) When we conduct testing using liquefied petroleum gas, we will use fuel that meets the specifications in paragraph (a) of this section.

(~~b~~d) At ambient conditions, liquefied petroleum gas must have a distinctive odor detectable down to a concentration in air not more than one-fifth the lower flammable limit.

7. Section 1065.750 is amended by revising paragraphs (a)(2), (a)(3), and (a)(4) to read as follows:

§1065.750 Analytical Gases.

Formatted: Font: Bold

* * * * *

(a) * * * *

(2) Use the following gases with a FID analyzer:

(i) FID fuel. Use FID fuel with ~~an~~ a stated H₂ concentration of (0.400 ±0.004) mol/mol, balance He, and a stated total hydrocarbon concentration of ~~— Make sure the mixture contains no more than~~ 0.05 μmol/mol THC or less.

Formatted: Underline

(ii) FID burner air. Use FID burner air that meets the specifications of purified air in paragraph (a)(1) of this section. For field testing, you may use ambient air.

Formatted: Underline

(iii) FID zero gas. Zero flame-ionization detectors with purified gas that meets the specifications in paragraph (a)(1) of this section, except that the purified gas O₂ concentration may be any value. Note that FID zero balance gases may be any combination of purified air and purified nitrogen. We recommend FID analyzer zero gases that contain approximately the flow-weighted mean concentration of O₂ expected during testing.

Formatted: Underline

(iv) FID propane span gas. Span and calibrate THC FID with span concentrations of propane, C₃H₈. Calibrate on a carbon number basis of one (C₁). For example, if you use a C₃H₈ span gas of concentration 200 μmol/mol, span a FID to respond with a value of 600 μmol/mol. Note that FID span balance gases may be any combination of purified air and purified nitrogen. We recommend FID analyzer span gases that contain approximately the flow-weighted mean concentration of O₂ expected during testing. If the expected exhaust O₂ concentration is zero, we recommend using a balance gas of purified nitrogen.

Formatted: Underline

(v) FID methane span gas. If you always span and calibrate a CH₄ FID with a nonmethane cutter, then span and calibrate the FID with span concentrations of methane, CH₄. Calibrate on a carbon number basis of one (C₁). For example, if you use a CH₄ span gas of concentration 200 μmol/mol, span a FID to respond with a value of 200 μmol/mol. Note that FID span balance gases may be any combination of purified air and purified nitrogen. We recommend FID analyzer span gases that contain approximately the flow-weighted mean concentration of O₂ expected during testing. If the expected exhaust O₂ concentration is zero, we recommend using a balance gas of purified nitrogen.

Formatted: Underline

(3) Use the following gas mixtures, with gases traceable within ±1.0 % of the ~~NIST~~ NIST accepted value or other gas standards we approve:

- (i) CH₄, balance purified synthetic air and/or N₂ (as applicable).
- (ii) C₂H₆, balance purified synthetic air and/or N₂ (as applicable).
- (iii) C₃H₈, balance purified synthetic air and/or N₂ (as applicable).
- (iv) CO, balance purified N₂.
- (v) CO₂, balance purified N₂.
- (vi) NO, balance purified N₂.
- (vii) NO₂, balance purified synthetic air~~N₂~~.
- (viii) O₂, balance purified N₂.
- (ix) C₃H₈, CO, CO₂, NO, balance purified N₂.
- (x) C₃H₈, CH₄, CO, CO₂, NO, balance purified N₂.

(4) You may use gases for species other than those listed in paragraph (a)(3) of this section (such as methanol in air, which you may use to determine response factors), as long as they are traceable to within $\pm 1.0\%$ of the ~~NIST true~~NIST accepted value or other similar standards we approve, and meet the stability requirements of paragraph (b) of this section.

* * * * *

Subpart I— [Amended]

1. Section 1065.805 is amended by revising paragraph (a) to read as follows:

§1065.805 Sampling system.

(a) Proportionally dilute engine exhaust, and use batch sampling to collect flow-weighted dilute samples of the applicable alcohols and carbonyls at a constant flow rate. You may not use raw sampling for alcohols and carbonyls.

* * * * *

Subpart J—[Amended]

1. Section 1065.901 is amended by revising paragraph (b) introductory text to read as follows:

§1065.901 Applicability.

* * * * *

Formatted: Font: Bold

(b) Laboratory testing. You may use PEMS for any testing in a laboratory or similar environment without restriction or prior approval if the PEMS meets all the specifications for the laboratory equipment that it replaces. You may ~~also optionally~~ use PEMS for any ~~laboratory testing~~ testing in a laboratory or similar environment if we approve it in advance, ~~as long as the standard setting part does not prohibit it for certain types of laboratory testing,~~ subject to the following provisions:

* * * * *

Formatted: Underline

2. Section 1065.905 is amended by revising paragraph (e) introductory text to read as follows:

§1065.905 General provisions.

* * * * *

Formatted: Font: Bold

(e) Laboratory testing using PEMS. You may use PEMS for testing in a laboratory as described in §1065.901(b). Use the following procedures and specifications when using PEMS for laboratory testing:

* * * * *

Formatted: Underline

3. Section 1065.910 is revised to read as follows:

§1065.910 PEMS auxiliary equipment for field testing.

For field testing you may use various types of auxiliary equipment to attach PEMS to a vehicle or engine and to power PEMS.

Formatted: Font: Bold

(a) When you use PEMS, you ~~will likely may~~ route engine intake air or exhaust ~~to a raw exhaust through a flow meter and sample probes.~~ Route the engine intake air or exhaust as follows:

(1) Flexible connections. Use short flexible connectors at the end of the engine's exhaust pipe where necessary.

Formatted: Underline

(i) You may use flexible connectors to enlarge or reduce the ~~exhaust~~ pipe diameters to match that of your test equipment.

(ii) Use flexible connectors that do not exceed a length of three times their largest inside diameter.

(iii) Use four-ply silicone-fiberglass fabric with a temperature rating of at least 315 °C for flexible connectors. You may use connectors with a spring-steel wire helix for support and you may use Nomex™ coverings or linings for durability. You may also use any other nonreactive material with equivalent permeation-resistance and durability, as long as it seals tightly ~~around tailpipes and does not react with exhaust.~~

(iv) Use stainless-steel hose clamps to seal flexible connectors ~~to the outside diameter of tailpipes,~~ or use clamps that seal equivalently.

(v) You may use additional flexible connectors to connect to flow meters ~~and sample probe locations.~~

(2) ~~Raw exhaust tubing~~. Use rigid 300 series stainless steel tubing to connect between flexible connectors. Tubing may be straight or bent to accommodate vehicle geometry. You may use “T” or “Y” fittings made of 300 series stainless steel tubing to join ~~exhaust from multiple tailpipes connections~~, or you may cap or plug redundant ~~tailpipes-flow paths~~ if the engine manufacturer recommends it.

Formatted: Underline

(3) ~~Exhaust back pressure~~Flow restriction. Use ~~flowmeters, connectors,~~ and tubing that do not increase ~~back-pressure~~flow restriction so much that it exceeds the manufacturer’s maximum specified ~~exhaust-restriction~~value. You may verify this at the maximum exhaust flow rate by measuring ~~back-pressure~~ at the manufacturer-specified location with your system connected. You may also perform an engineering analysis to verify ~~proper back-pressure~~an acceptable configuration, taking into account the maximum exhaust flow rate expected, the field test system’s flexible connectors, and the tubing’s characteristics for pressure drops versus flow.

Formatted: Underline

(b) For vehicles or other motive equipment, we recommend installing PEMS in the same location where a passenger might sit. Follow PEMS manufacturer instructions for installing PEMS in ~~vehicle-cargo spaces, vehicle-trailers, engine spaces,~~ or externally such that PEMS is directly exposed to the outside environment. Locate PEMS where it will be subject to minimal sources of the following parameters:

- (1) Ambient temperature changes.
- (2) Ambient pressure changes.
- (3) Electromagnetic radiation.
- (4) Mechanical shock and vibration.
- (5) Ambient hydrocarbons—if using a FID analyzer that uses ambient air as FID burner air.

(c) ~~Mounting hardware~~.—Use mounting hardware as required for securing flexible connectors, ~~exhaust tubing,~~ ambient sensors, and other equipment. Use structurally sound mounting points such as vehicle frames, trailer hitch receivers, ~~walkspaces,~~ and payload tie-down fittings. We recommend mounting hardware such as clamps, suction cups, and magnets that are specifically designed for ~~vehicle-your~~ applications. We also recommend considering mounting hardware such as commercially available bicycle racks, trailer hitches, and luggage racks ~~where applicable~~.

(d) ~~Electrical power~~.—Field testing may require portable electrical power to run your test equipment. Power your equipment, as follows:

- (1) You may use electrical power from the vehicle, ~~equipment, or vessel,~~ up to the highest power level, such that all the following are true:
 - (i) The ~~vehicle~~-power system is capable of safely supplying ~~your~~-power, such that ~~your the power~~ demand ~~for testing~~ does not overload the ~~vehicle’s~~ power system.
 - (ii) The engine emissions do not change significantly ~~as a result the power demand for testing when you use vehicle power~~.
 - (iii) The power ~~you~~-demand ~~for testing~~ does not increase output from the engine by more than 1 % of its maximum power.
- (2) You may install your own portable power supply. For example, you may use batteries, fuel cells, a portable generator, or any other power supply to supplement or replace your use of vehicle power. However, you must not supply power to the vehicle, ~~vessel, or equipment’s-s~~ power system under any circumstances.

4. Section 1065.915 is amended by revising paragraph (a) before the table and paragraphs (d)(1) and (d)(5)(iii)(B) to read as follows:

§1065.915 PEMS instruments.

(a) Instrument specifications. We recommend that you use PEMS that meet the specifications of subpart C of this part. For unrestricted use of PEMS in a laboratory or similar environment, use a PEMS that meets the same specifications as each lab instrument it replaces. For field testing ~~or~~ for ~~laboratory~~ testing with PEMS in a laboratory or similar environment, under the provisions of §1065.905(b), the specifications in the following table apply instead of the specifications in Table 1 of §1065.205.

| | | | | |
|-----|---|---|---|---|
| * | * | * | * | * |
| (d) | * | * | * | * |

(1) Recording ECM signals. If your ECM updates a broadcast signal more or less frequently than 1 Hz, process data as follows: take one of the following steps:

(i) If your ECM updates a broadcast signal more frequently than 1 Hz, use PEMS to sample and record the signal's value more frequently—up to 5 Hz maximum. Calculate and record the 1 Hz mean of the more frequently updated data.

(ii) If your ECM updates a broadcast signal less frequently than 1 Hz, use PEMS to sample and record the signal's value at the most frequent rate. Linearly interpolate between recorded values and record the interpolated values at 1 Hz.

(iii) Optionally, you may use PEMS to electronically filter the ECM signals to meet the rise time and fall time specifications in Table 1 of this section. Record the filtered signal at 1 Hz.

| | | | | |
|-------|---|---|---|---|
| * | * | * | * | * |
| (5) | * | * | * | * |
| (iii) | * | * | * | * |

(B) Use a single BSFC value that approximates the BSFC value over a test interval (as defined in subpart K of this part). This value may be a nominal BSFC value for all engine operation determined over one or more laboratory duty cycles, or it may be any other BSFC that ~~we approve you determine~~. If you use a nominal BSFC, we recommend that you select a value based on the BSFC measured over laboratory duty cycles that best represent the range of engine operation that defines a test interval for field-testing. You may use the methods of this paragraph (d)(5)(iii)(B) only if it does not adversely affect your ability to demonstrate compliance with applicable standards.

| | | | | |
|---|---|---|---|---|
| * | * | * | * | * |
|---|---|---|---|---|

5. Section 1065.920 is amended by revising paragraphs (a) and (b)(7) introductory text to read as follows:

§1065.920 PEMS Calibrations and verifications.

(a) Subsystem calibrations and verifications. Use all the applicable calibrations and verifications in subpart D of this part, including the linearity verifications in §1065.307, to calibrate and verify PEMS. Note that a PEMS does not have to meet the system-response specifications of §1065.308 if it meets the overall verification described in paragraph (b) of this section. This section does not apply to ECM signals.

(b) * * *

(7) ~~If for each constituent, t~~The PEMS passes this verification if any one of the following are true for each constituent:

* * * * *

6. Section 1065.925 is amended by revising paragraph (h)(8) to read as follows:

§1065.925 PEMS preparation for field testing.

* * * * *

(h) * * *

(8) If corrective action does not resolve the deficiency, you may use a contaminated HC system if it does not prevent you from demonstrating compliance with the applicable emission standards.

Formatted: Font: Bold

7. Section 1065.935 is amended by revising paragraph (e)(1) to read as follows:

§1065.935 Emission test sequence for field testing.

* * * * *

(e) * * *

(1) Continue sampling as needed to get an appropriate amount of emission measurement, according to the standard setting part. If the standard-setting part does not describe when to stop sampling, develop a written protocol before you start testing to establish how you will stop sampling. You may not determine when to stop testing based on ~~measured~~ emission results.

* * * * *

Formatted: Font: Bold

Subpart K— [Amended]

1. Section 1065.1001 is amended by revising the definitions for “Regression statistics” and “Tolerance” and adding definitions in alphabetical order for “Mode”, “NIST accepted”, and “Recommend” to read as follows:

§1065.1001 Definitions.

* * * * *

Mode means one of the following:

- (1) A distinct combination of engine speed and load for steady-state testing.
- (2) A continuous combination of speeds and load specifying a transition during a ramped-modal test.
- (3) A distinct operator demand setting, such as would occur when testing locomotives or constant-speed engines.

NIST accepted means relating to a value that has been assigned or named by NIST.

* * * * *

Recommend has the meaning given in §1065.201.

Regression statistics means any of the ~~set of regression~~ statistics specified in §1065.602 through (l).

* * * * *

Tolerance means the interval in which 95 % of a set of recorded values of a certain quantity must lie, with the remaining 5% of the recorded values deviating from the tolerance interval ~~only due to measurement variability~~. Use the specified recording frequencies and time intervals to determine if a quantity is within the applicable tolerance. ~~For parameters not subject to measurement variability, tolerance means an absolute allowable range.~~

* * * * *

Formatted: Font: 12 pt

Formatted: Underline

2. Section 1065.1005 is amended by revising paragraph (g) to add defined acronyms for “CITT” and “FEL” in the table to read as follows:

§1065.1005 Symbols, abbreviations, acronyms, and units of measure.

* * * * *

(g) * * *

| | |
|-------------|--------------------------------------|
| ***** | |
| <u>CITT</u> | <u>Curb Idle Transmission Torque</u> |
| ***** | |
| <u>FEL</u> | <u>Family Emission Limit</u> |
| ***** | |

3. Section 1065.1010 is amended by revising paragraph (b) and adding paragraph (f) to read as follows:

§1065.1010 Reference materials.

* * * * *

(b) ISO material. Table 2 of this section lists material from the International Organization for Standardization that we have incorporated by reference. The first column lists the number and name of the material. The second column lists the section of

this part where we reference it. Anyone may purchase copies of these materials from the International Organization for Standardization, Case Postale 56, CH-1211 Geneva 20, Switzerland or www.iso.org. Table 2 follows:

Table 2 of §1065.1010–ISO materials

Comment [MWS1]: Updated Table

| Document number and name | Part 1065 reference |
|---|---------------------|
| ISO 14644-1, Cleanrooms and associated controlled environments | 1065.190 |
| ISO 8217:2005, Petroleum products -- Fuels (class F) -- Specifications of marine fuels | 1065.705 |
| ISO 3675:1998, Crude petroleum and liquid petroleum products -- Laboratory determination of density -- Hydrometer method | 1065.705 |
| ISO 12185:1996/Cor 1:2001, Crude petroleum and petroleum products -- Determination of density -- Oscillating U-tube method | 1065.705 |
| ISO 3104:1994/Cor 1:1997, Petroleum products -- Transparent and opaque liquids -- Determination of kinematic viscosity and calculation of dynamic viscosity | 1065.705 |
| ISO 2719:2002, Determination of flash point -- Pensky-Martens closed cup method | 1065.705 |
| ISO 3016:1994, Petroleum products -- Determination of pour point | 1065.705 |
| ISO 10370:1993/Cor 1:1996, Petroleum products -- Determination of carbon residue -- Micro method | 1065.705 |
| ISO 6245:2001, Petroleum products -- Determination of ash | 1065.705 |
| ISO 3733:1999, Petroleum products and bituminous materials -- Determination of water -- Distillation method | 1065.705 |
| ISO 8754:2003, Petroleum products -- Determination of sulfur content -- Energy-dispersive X-ray fluorescence spectrometry | 1065.705 |
| ISO 14596:1998/Cor 1:1999, Petroleum products -- Determination of sulfur content -- Wavelength-dispersive X-ray fluorescence spectrometry | 1065.705 |
| ISO 14597:1997, Petroleum products -- Determination of vanadium and nickel content -- Wavelength-dispersive X-ray fluorescence spectrometry | 1065.705 |
| ISO 10307-2:1993, Petroleum products -- Total sediment in residual fuel oils -- Part 2: Determination using standard procedures for ageing | 1065.705 |
| ISO 10478:1994, Petroleum products -- Determination of aluminium and silicon in fuel oils -- Inductively coupled plasma emission and atomic absorption spectroscopy methods | 1065.705 |
| IP-470, Aluminium, silicon, vanadium, nickel, iron, calcium, zinc and sodium in residual fuels, by AAS finish | 1065.705 |
| IP-500 Phosphorus content of residual fuels by ultra-violet spectrometry | 1065.705 |
| IP-501 Aluminium, silicon, vanadium, nickel, iron, sodium, calcium, zinc and phosphorus in residual fuel oil, by ICP finish | 1065.705 |

* * * * *

(f) Institute of Petroleum material. Table 6 of this section lists the Institute of Petroleum standard test methods material from the Energy Institute that we have incorporated by reference. The first column lists the number and name of the material. The second column lists the section of this part where we reference it. Anyone may purchase copies of these materials from the Energy Institute, 61 New Cavendish Street, London, W1G 7AR, UK, +44 (0)20 7467 7100 or www.energyinst.org.uk. Table 6 follows:

Table 6 of §1065.1010–Institute of Petroleum materials

| Document number and name | Part 1065 reference |
|--|---------------------|
| <u>IP-470, Aluminium, silicon, vanadium, nickel, iron, calcium, zinc and sodium in residual fuels, by AAS finish</u> | <u>1065.705</u> |
| <u>IP-500 Phosphorus content of residual fuels by ultra-violet spectrometry</u> | <u>1065.705</u> |
| <u>IP-501 Aluminium, silicon, vanadium, nickel, iron, sodium, calcium, zinc and phosphorus in residual fuel oil, by ICP finish</u> | <u>1065.705</u> |