

(i) For laboratory testing, you generally 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 (or powers) that an engine must follow. If the standard-setting part allows it, you may also simulate field testing with an engine dynamometer in a laboratory or other environment.

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

(2) The type of testing may also affect what test equipment may be used. You may use “lab-grade” test equipment for any testing. The term “lab-grade” refers to equipment that fully conforms to the applicable specifications of this part. For some testing you may alternatively use “field-grade” equipment. The term “field-grade” refers to equipment that fully conforms to the applicable specifications of subpart J of this part, but does not fully conform to other specifications of this part. You may use “field-grade” equipment for field testing. We also specify in this part and in the standard-setting parts certain cases in which you may use “field-grade” equipment for testing in a laboratory-type environment. (NOTE: Although “field-grade” equipment is generally more portable than “lab-grade” test equipment, portability is not relevant to whether equipment is considered to be “field-grade” or “lab-grade”.)

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**§ 1065.20 Units of measure and overview of calculations.**

(a) *System of units.* The procedures in this part generally follow the International System of Units (SI), as detailed in NIST Special Publication 811, which we incorporate by reference in § 1065.1010. The following exceptions apply:

(1) We designate angular speed,  $f_n$ , of an engine’s crankshaft in revolutions per minute (r/min), rather than the SI unit of radians per second (rad/s). This is based on the commonplace use of r/min in many engine dynamometer laboratories.

(2) We designate brake-specific emissions in grams per kilowatt-hour (g/(kW · hr)), rather than the SI unit of grams per megajoule (g/MJ). In addition, we use the symbol hr to identify hour, rather than the SI convention of using h. This is based on the fact that engines are generally subject to emission standards expressed in g/kW · hr. If we specify engine standards in grams per horsepower · hour (g/(hp · hr)) in the standard-setting part, convert units as specified in paragraph (d) of this section.

(3) We generally designate temperatures in units of degrees Celsius (°C) unless a calculation requires an absolute temperature. In that case, we designate temperatures in units of Kelvin (K). For conversion purposes throughout this part, 0 °C equals 273.15 K. Unless specified otherwise, always use absolute temperature values for multiplying or dividing by temperature.

(b) *Concentrations.* This part does not rely on amounts expressed in parts per million. Rather, we express such amounts in the following SI units:

(1) For ideal gases,  $\mu\text{mol/mol}$ , formerly ppm (volume).

(2) For all substances,  $\text{cm}^3/\text{m}^3$ , formerly ppm (volume).

(3) For all substances, mg/kg, formerly ppm (mass).

(c) *Absolute pressure.* Measure absolute pressure directly or calculate it as the sum of atmospheric pressure plus a differential pressure that is referenced to atmospheric pressure. Always use absolute pressure values for multiplying or dividing by pressure.

(d) *Units conversion.* Use the following conventions to convert units:

(1) *Testing.* You may record values and perform calculations with other units. For testing with equipment that involves other units, use the conversion factors from NIST Special Publication 811, as described in paragraph (a) of this section.

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(2) *Humidity.* In this part, we identify humidity levels by specifying dew-point, which is the temperature at which pure water begins to condense out of air. Use humidity conversions as described in §1065.645.

(3) *Emission standards.* If your standard is in g/(hp · hr) units, convert kW to hp before any rounding by using the conversion factor of 1 hp (550 ft · lbf/s) = 0.7456999 kW. Round the final value for comparison to the applicable standard.

(e) *Rounding.* You are required to round certain final values, such as final emission values. You may round intermediate values when transferring data as long as you maintain at least six significant digits (which requires more than six decimal places for values less than 0.1), or all significant digits if fewer than six digits are available. Unless the standard-setting part specifies otherwise, do not round other intermediate values. Round values to the number of significant digits necessary to match the number of decimal places of the applicable standard or specification as described in this paragraph (e). Note that specifications expressed as percentages have infinite precision (as described in paragraph (e)(7) of this section). Use the following rounding convention, which is consistent with ASTM E29 and NIST SP 811:

(1) If the first (left-most) digit to be removed is less than five, remove all the appropriate digits without changing the digits that remain. For example, 3.141593 rounded to the second decimal place is 3.14.

(2) If the first digit to be removed is greater than five, remove all the appropriate digits and increase the lowest-

value remaining digit by one. For example, 3.141593 rounded to the fourth decimal place is 3.1416.

(3) If the first digit to be removed is five with at least one additional non-zero digit following the five, remove all the appropriate digits and increase the lowest-value remaining digit by one. For example, 3.141593 rounded to the third decimal place is 3.142.

(4) If the first digit to be removed is five with no additional non-zero digits following the five, remove all the appropriate digits, increase the lowest-value remaining digit by one if it is odd and leave it unchanged if it is even. For example, 1.75 and 1.750 rounded to the first decimal place are 1.8; while 1.85 and 1.850 rounded to the first decimal place are also 1.8. Note that this rounding procedure will always result in an even number for the lowest-value digit.

(5) This paragraph (e)(5) applies if the regulation specifies rounding to an increment other than decimal places or powers of ten (to the nearest 0.01, 0.1, 1, 10, 100, etc.). To round numbers for these special cases, divide the quantity by the specified rounding increment. Round the result to the nearest whole number as described in paragraphs (e)(1) through (4) of this section. Multiply the rounded number by the specified rounding increment. This value is the desired result. For example, to round 0.90 to the nearest 0.2, divide 0.90 by 0.2 to get a result of 4.5, which rounds to 4. Multiplying 4 by 0.2 gives 0.8, which is the result of rounding 0.90 to the nearest 0.2.

(6) The following tables further illustrate the rounding procedures specified in this paragraph (e):

Quantity	Rounding increment			
	10	1	0.1	0.01
3.141593 .....	0	3	3.1	3.14
123,456.789 .....	123,460	123,457	123,456.8	123,456.79
5.500 .....	10	6	5.5	5.50
4.500 .....	0	4	4.5	4.50

Quantity	Rounding increment			
	25	3	0.5	0.02
229.267 .....	225	228	229.5	229.26
62.500 .....	50	63	62.5	62.50
87.500 .....	100	87	87.5	87.50
7.500 .....	0	6	7.5	7.50

(7) This paragraph (e)(7) applies where we specify a limit or tolerance as some percentage of another value (such as  $\pm 2\%$  of a maximum concentration). You may show compliance with such specifications either by applying the percentage to the total value to calculate an absolute limit, or by converting the absolute value to a percentage by dividing it by the total value.

(i) Do not round either value (the absolute limit or the calculated percentage), except as specified in paragraph (e)(7)(ii) of this section. For example, assume we specify that an analyzer must have a repeatability of  $\pm 1\%$  of the maximum concentration or better, the maximum concentration is 1059 ppm, and you determine repeatability to be  $\pm 6.3$  ppm. In this example, you could calculate an absolute limit of  $\pm 10.59$  ppm ( $1059 \text{ ppm} \times 0.01$ ) or calculate that the 6.3 ppm repeatability is equivalent to a repeatability of 0.5949008498584%.

(ii) Prior to July 1, 2013, you may treat tolerances (and equivalent specifications) specified in percentages as having fixed rather than infinite precision. For example, 2% would be equivalent to 1.51% to 2.50% and 2.0% would be equivalent to 1.951% to 2.050%. Note that this allowance applies whether or not the percentage is explicitly specified as a percentage of another value.

(8) You may use measurement devices that incorporate internal rounding, consistent with the provisions of this paragraph (e)(8). You may use devices that use any rounding convention if they report six or more significant digits. You may use devices that report fewer than six digits, consistent with good engineering judgment and the accuracy, repeatability, and noise specifications of this part. Note that this provision does not necessarily require you to perform engineering analysis or keep records.

(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 (such as  $X \pm Y$ ), target the associated

control point to that single value (X). Examples of this type of range include “ $\pm 10\%$  of maximum pressure”, or “(30  $\pm 10$ ) kPa”. In these examples, you would target the maximum pressure or 30 kPa, respectively.

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

(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 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 (dry-to-wet corrected, if applicable) 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.

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#### § 1065.25 Recordkeeping.

(a) The procedures in this part include various requirements to record