(b) Use good engineering judgment to measure other oxygenated compounds in the exhaust.

### § 1065.810 Calculations.

(a) *THCE emissions.* (1) Calculate THCE emissions as the sum of the mass of the nonoxygenated hydrocarbons in the exhaust and the carbon-equivalent mass of each measured oxygenated species in the exhaust.

(2) Calculate carbon-equivalent mass of each measured oxygenated species from the following equation:

$$\text{Carbon equivalent} = 13.8756 \times \text{MOC}/\text{MWPC}$$

Where:

MOC is the mass of the oxygenated compound in the exhaust, and MWPC is the molecular weight of compound per carbon atom of compound.

(b) *NMHCE emissions.* Calculate NMHCE emissions as either:

(1) The sum of the mass of the nonoxygenated nonmethane hydrocarbons in the exhaust and the carbon-equivalent mass of each measured oxygenated species in the exhaust.

(2) THCE minus the mass of methane in the exhaust.

(c) *Sample calculation.* (1) Assume the following emissions for a test: 40.00 grams of nonoxygenated hydrocarbons, 100.00 grams of ethanol, and 10.00 grams of acetaldehyde, and 1.00 gram of formaldehyde.

(2) The carbon-equivalent of the masses of oxygenated compounds are:

(i) $13.8756 \times 100.00/(46.068/2) = 60.24$ grams of ethanol.

(ii) $13.8756 \times 10.00/(44.052/2) = 6.30$ grams of acetaldehyde.

(iii) $13.8756 \times 1.00/(30.026) = 0.46$ grams of formaldehyde.

(3) THCE = 40.00 + 60.24 + 6.30 + 0.46 = 107.00 grams per test.

## Subpart J—Field Testing

### § 1065.901 Applicability.

(a) The test procedures in this subpart measure brake-specific emissions from engines while they remain installed in vehicles or equipment in the field.

(b) These test procedures apply to your engines as specified in the standard-setting part. For example, part 1048 of this chapter specifies emission standard to be used for in-use tests conducted in accordance with the provisions of this part. Unless this subpart is specifically mentioned in the standard-setting part, compliance with the provisions of this subpart is not required.

### § 1065.905 General provisions.

(a) Unless the standard-setting part specifies deviations from the provisions of this subpart, testing conducted under this subpart must conform to all of the provisions of this subpart.

(b) Testing conducted under this subpart may include any normal in-use operation of the engine.

### § 1065.910 Measurement accuracy and precision.

(a) Measurement systems used for in-use testing must be accurate to within ±5 percent compared to engine dynamometer testing conducted according to the test procedures of this part that are applicable for your engine. These systems must also have a precision of ±5 percent or better. Determine accuracy and precision of an in-use system by simultaneously measuring emissions using the engine-dynamometer test procedures of this part and the in-use system. To have a statistically valid sample, measure emissions during at least 3 tests each for at least 3 different engines. You must conduct these verification tests using the test cycle specified in the standard-setting part, unless we approve a different test cycle.

(1) A system must meet the following conditions to be considered sufficiently accurate:

(i) The correlation coefficient (r) for a least-squares linear fit that includes the origin must be 0.95 or higher.

(ii) The average ratio (for all tests) of the emission rate from the in-use system divided by the emission rate from the dynamometer procedure must be 0.97 to 1.05.

(2) For a system to be considered sufficiently precise, the average coefficient of variance for all engines must be 5 percent or less for each pollutant.

NOTE: Increasing the length of the sampling period may be an effective way to improve precision.

(b) Measurement systems that conform to the provisions of §§ 1065.915 through 1065.950 are considered to be in compliance with the accuracy and precision requirements of paragraph (a) of this section.

EFFECTIVE DATE NOTE: At 69 FR 39262, June 29, 2004, § 1065.910 was revised, effective Aug. 30, 2004. For the convenience of the user, the revised text is set forth as follows:

**§ 1065.910 Measurement accuracy and precision.**

Measurement systems used for field testing have accuracy and precision comparable to those of dynamometer testing. Measurement systems that conform to the provisions of §§ 1065.915 through 1065.950 are deemed to be in compliance with the accuracy and precision requirements of paragraph of this section. If you use other field testing measurement systems you need to have documentation indicating that it is comparable to a dynamometer system.

(a) The two systems must be calibrated independently to NIST traceable standards or equivalent national standards for this comparison. We may approve the use of other standards. Calculations of emissions results for this test should be consistent with the field testing data reduction scheme for both the in-use equipment and the dynamometer equipment, and each complete test cycle will be considered one "summing interval", Si as defined in the field-testing data reduction scheme.

(b) While other statistical analyses may be acceptable, we recommend that the comparison be based on a minimum of seven (7) repeats of colocated and simultaneous tests. Perform this comparison over the applicable steady-state and transient test cycles using an engine that is fully warmed up such that its coolant temperature is thermostatically controlled. If there is no applicable transient test cycle, use the applicable steady-state cycle. Anyone who intends to submit an alternative comparison is encouraged to first contact EPA Office of Transportation and Air Quality, Assessment and Standards Division to discuss the applicant's intended statistical analysis. The Division may provide further guidance specific to the appropriate statistical analysis for the respective application.

(c) The following statistical tests are suggested. If the comparison is paired, it must demonstrate that the alternate system passes a two-sided, paired t-test. If the test is unpaired, it must demonstrate that the alternate system passes a two-sided, unpaired t-test. The average of these tests for the reference system must return results less than or equal to the applicable emissions standard. The t-test is performed as follows, where "n" equals the number of tests:

(1) Calculate the average of the in-use system results; this is Iavg.

(2) Calculate the average of the results of the system to which the in-use system was Referenced; this is Ravg.

(3) Calculate the "n-1" standard deviations for the in-use and reference averages; these are Isd and Rsd respectively. Form the F ratio: F = (Isd/Rsd) 2. F must be less than the critical F value, Fcrit at a 95% confidence interval for "n-1" degrees of freedom. Table 1 of this section lists 95% confidence interval Fcrit values for n-1 degrees of freedom. Note that $n_A$ represents the number of alternate system samples, while $n_R$ represents the number of reference system samples.

(4) For an unpaired comparison, calculate the t-value:

$$t_{unpaired} = (I_{avg} - R_{avg})/((I_{sd}^2 + R_{sd}^2)/n)^{1/2}$$

(5) For a paired comparison, calculate the "n-1" standard deviation (squared) of the differences, $d_i$, between the paired results, where "i" represents the $i^{th}$ test of n number of tests:

$$S_D^2 = (Sd_i^2 - ((Sd_i)^2/n))/(n-1)$$

(6) For a paired comparison, calculate the t-value:

$$t_{paired} = (I_{avg} - R_{avg})/(S_D^2/n)^{1/2}$$

(d) The absolute value of t must be less than the critical t value, $t_{crit}$ at a 95% confidence interval for "n-1" degrees of freedom.

TABLE 1 OF § 1065.910—95% CONFIDENCE INTERVAL CRITICAL F VALUES FOR F-TEST

| nR–1 | nI–1 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | | 4.284 | 4.207 | 4.147 | 4.099 | 4.06 | 4.027 | 4 | 3.976 | 3.956 | 3.938 | 3.922 | 3.908 | 3.896 | 3.884 | 3.874 |
| 7 | | 3.866 | 3.787 | 3.726 | 3.677 | 3.637 | 3.603 | 3.575 | 3.55 | 3.529 | 3.511 | 3.494 | 3.48 | 3.467 | 3.455 | 3.445 |
| 8 | | 3.581 | 3.5 | 3.438 | 3.388 | 3.347 | 3.313 | 3.284 | 3.259 | 3.237 | 3.218 | 3.202 | 3.187 | 3.173 | 3.161 | 3.15 |
| 9 | | 3.374 | 3.293 | 3.23 | 3.179 | 3.137 | 3.102 | 3.073 | 3.048 | 3.025 | 3.006 | 2.989 | 2.974 | 2.96 | 2.948 | 2.936 |
| 10 | | 3.217 | 3.135 | 3.072 | 3.02 | 2.978 | 2.943 | 2.913 | 2.887 | 2.865 | 2.845 | 2.828 | 2.812 | 2.798 | 2.785 | 2.774 |
| 11 | | 3.095 | 3.012 | 2.948 | 2.896 | 2.854 | 2.818 | 2.788 | 2.761 | 2.739 | 2.719 | 2.701 | 2.685 | 2.671 | 2.658 | 2.646 |
| 12 | | 2.996 | 2.913 | 2.849 | 2.796 | 2.753 | 2.717 | 2.687 | 2.66 | 2.637 | 2.617 | 2.599 | 2.583 | 2.568 | 2.555 | 2.544 |
| 13 | | 2.915 | 2.832 | 2.767 | 2.714 | 2.671 | 2.635 | 2.604 | 2.577 | 2.554 | 2.533 | 2.515 | 2.499 | 2.484 | 2.471 | 2.459 |
| 14 | | 2.848 | 2.764 | 2.699 | 2.646 | 2.602 | 2.565 | 2.534 | 2.507 | 2.484 | 2.463 | 2.445 | 2.428 | 2.413 | 2.4 | 2.388 |
| 15 | | 2.79 | 2.707 | 2.641 | 2.588 | 2.544 | 2.507 | 2.475 | 2.448 | 2.424 | 2.403 | 2.385 | 2.368 | 2.353 | 2.34 | 2.328 |
| 16 | | 2.741 | 2.657 | 2.591 | 2.538 | 2.494 | 2.456 | 2.425 | 2.397 | 2.373 | 2.352 | 2.333 | 2.317 | 2.302 | 2.288 | 2.276 |
| 17 | | 2.699 | 2.614 | 2.548 | 2.494 | 2.45 | 2.413 | 2.381 | 2.353 | 2.329 | 2.308 | 2.289 | 2.272 | 2.257 | 2.243 | 2.23 |
| 18 | | 2.661 | 2.577 | 2.51 | 2.456 | 2.412 | 2.374 | 2.342 | 2.314 | 2.29 | 2.269 | 2.25 | 2.233 | 2.217 | 2.203 | 2.191 |
| 19 | | 2.628 | 2.544 | 2.477 | 2.423 | 2.378 | 2.34 | 2.308 | 2.28 | 2.256 | 2.234 | 2.215 | 2.198 | 2.182 | 2.168 | 2.155 |
| 20 | | 2.599 | 2.514 | 2.447 | 2.393 | 2.348 | 2.31 | 2.278 | 2.25 | 2.225 | 2.203 | 2.184 | 2.167 | 2.151 | 2.137 | 2.124 |

TABLE 2 OF § 1065.910.—95% CONFIDENCE INTERVAL CRITICAL T VALUES FOR T-TEST

| n-1 | $t_{crit}$ |
|---|---|
| 6 | 2.45 |
| 7 | 2.36 |
| 8 | 2.31 |
| 9 | 2.26 |
| 10 | 2.23 |
| 11 | 2.20 |
| 12 | 2.18 |
| 13 | 2.16 |
| 14 | 2.14 |
| 15 | 2.13 |
| 16 | 2.12 |
| 17 | 2.11 |
| 18 | 2.10 |
| 19 | 2.09 |
| 20 | 2.09 |

**§ 1065.915 Equipment specifications for SI engines.**

This section describes equipment you may use to measure in-use emissions. You may use other equipment and measurement systems that conform to the requirements of §§ 1065.905 and 1065.910.

(a) The primary components of the in-use measurement system are a mass air flow sensor, a portable FID, a zirconia-based $NO_X$ sensor, a zirconia-based air/fuel ratio sensor, and a portable NDIR analyzer.

(1) The mass air flow sensor must meet the requirements of § 1065.930.

(2) The portable FID must meet the requirements of § 1065.935.

(3) The $NO_X$ and air/fuel sensors must meet the requirements of § 1065.940

(4) The NDIR analyzer must meet the requirements of § 1065.945.

(b) You must measure the following parameters continuously at a rate of 3 Hz or higher and store the data electronically:

(1) THC, $NO_X$, CO concentrations.

(2) Mass air-fuel ratio.

(3) Intake air flow rate.

(4) Engine speed.

(5) Parameters used to calculate torque.

(c) You must minimize sample line length for any analyzers that require a physical sample be drawn from the exhaust to the analyzer (*i.e.*, THC and CO analyzers). You must draw these samples at a constant flow rate. In no case may you use any combination of sample line length and sample flow rate that would require more than 10 seconds for the analyzer to reach 90 percent of its final response after a step change to the input concentration at the opening of the sample probe. For residence time delays between 1 and 10 seconds, you must correct the measurements to be consistent with the data for engine speed, torque, and air intake. You may also correct other measurements with less than delays less than 1 second.

(d) You may insert the sample probes and sensors into the exhaust pipe, or mount them in an exhaust extension that is connected to the exhaust pipe with negligible leaking. Place the sample probes and sensors close enough to the center line of the exhaust pipe to minimize boundary layer effects from the wall.

**§ 1065.920 Equipment setup and test run for SI engines.**

This section describes how to set up the equipment specified in § 1065.915, and how to use it to measure in-use emissions from SI engines.

(a) Inspect the vehicle or equipment to determine whether it meets any applicable requirements of the standard-setting part. This may include requirements related to model year, accumulated hours of operation, fuel specifications, maintenance history, engine temperatures, etc.

(b) Perform calibrations as specified in this subpart. In the field, this generally will require only zeroing and spanning the instruments. However, each instrument must have been fully calibrated according to the instrument manufacturer's specifications. Non-linear calibrations generated previously from the full calibration may be used after zeroing and spanning the instruments. Spanning can be performed using a single gas bottle, consistent with good engineering practice, and provided that stability of the span mixture has been demonstrated.

(c) Connect the data recorder (with any necessary signal interpreters or converters) to the engine's electronic control module.

(d) Disconnect the air intake system, as necessary, to attach the mass air flow sensor. Reconnect the system after attaching the mass air flow sensor.