

an estimate based on the vessel pressure and temperature. Use good engineering judgment to estimate the H<sub>2</sub>O content. For example, you may use previous direct measurements of H<sub>2</sub>O content to verify the vessel's level of saturation.

(5) If a sample dryer is not used in this verification test, use good engineering judgment to prevent condensation in the transfer lines, fittings, or valves from the point where  $x_{\text{H}_2\text{O}}$  is measured to the analyzer. We recommend that you design your system so the wall temperatures in the transfer lines, fittings, and valves from the point where  $x_{\text{H}_2\text{O}}$  is measured to the analyzer are at least 5 °C above the local sample gas dewpoint.

(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 30 seconds of sampled data. Calculate the arithmetic mean of this data. The analyzer meets the interference verification if this value is within (0.0 ±0.4) mmol/mol.

(e) *Exceptions.* The following exceptions apply:

(1) You may omit this verification if you can show by engineering analysis that for your CO<sub>2</sub> sampling system and your emission-calculation procedures, the H<sub>2</sub>O interference for your CO<sub>2</sub> NDIR analyzer always affects your brake-specific emission results within ±0.5% of each of the applicable standards. This specification also applies for vehicle testing, except that it relates to emission results in g/mile or g/kilometer.

(2) You may use a CO<sub>2</sub> NDIR analyzer 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.

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#### § 1065.355 H<sub>2</sub>O and CO<sub>2</sub> interference verification for CO NDIR analyzers.

(a) *Scope and frequency.* If you measure CO using an NDIR analyzer, verify the amount of H<sub>2</sub>O and CO<sub>2</sub> interference after initial analyzer installation and after major maintenance.

(b) *Measurement principles.* H<sub>2</sub>O and CO<sub>2</sub> can positively interfere with an NDIR analyzer by causing a response similar to CO. If the NDIR analyzer uses compensation algorithms that utilize measurements of other gases to meet this interference verification, simultaneously conduct these other measurements to test the compensation algorithms during the analyzer interference verification.

(c) *System requirements.* A CO NDIR analyzer must have combined H<sub>2</sub>O and CO<sub>2</sub> interference that is within ±2 % of the flow-weighted mean concentration of CO expected at the standard, though we strongly recommend a lower interference that is within ±1%.

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

(1) Start, operate, zero, and span the CO NDIR analyzer as you would before an emission test. If the sample is passed through a dryer during emission testing, you may run this verification test with the dryer if it meets the requirements of §1065.342. Operate the dryer at the same conditions as you will for an emission test. You may also run this verification test without the sample dryer.

(2) Create a humidified CO<sub>2</sub> test gas by bubbling a CO<sub>2</sub> span gas that meets the specifications in §1065.750 through distilled H<sub>2</sub>O in a sealed vessel. If the sample is not passed through a dryer during emission testing, control the vessel temperature to generate an H<sub>2</sub>O level at least as high as the maximum expected during emission testing. If the sample is passed through a dryer during emission testing, control the vessel temperature to generate an H<sub>2</sub>O level at least as high as the level determined in §1065.145(e)(2) for that dryer. Use a CO<sub>2</sub> span gas concentration at least as high as the maximum expected during testing.

(3) Introduce the humidified CO<sub>2</sub> test gas into the sample system. You may introduce it downstream of any sample dryer, if one is used during testing.

(4) If the sample is not passed through a dryer during this verification test, measure the H<sub>2</sub>O mole fraction,  $x_{\text{H}_2\text{O}}$ , of the humidified CO<sub>2</sub> test gas as close as possible to the inlet of the analyzer. For example, measure dewpoint,  $T_{\text{dew}}$ , and absolute pressure,  $p_{\text{total}}$ , to calculate  $x_{\text{H}_2\text{O}}$ . Verify that the H<sub>2</sub>O content meets the requirement in paragraph (d)(2) of this section. If the sample is passed through a dryer during this verification test, you must verify that the H<sub>2</sub>O content of the humidified test gas downstream of the vessel meets the requirement in paragraph (d)(2) of this section based on either direct measurement of the H<sub>2</sub>O content (e.g., dewpoint and pressure) or an estimate based on the vessel pressure and temperature. Use good engineering judgment to estimate the H<sub>2</sub>O content. For example, you may use previous direct measurements of H<sub>2</sub>O content to verify the vessel's level of saturation.

(5) If a sample dryer is not used in this verification test, use good engineering judgment to prevent condensation in the transfer lines, fittings, or valves from the point where  $x_{\text{H}_2\text{O}}$  is measured to the analyzer. We recommend that you design your system so that the wall temperatures in the transfer lines, fittings, and valves from the point where  $x_{\text{H}_2\text{O}}$  is measured to the analyzer are at least 5 °C above the local sample gas dewpoint.

(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) The analyzer meets the interference verification if the result of paragraph (d)(7) of this section meets the tolerance in paragraph (c) of this section.

(9) You may also run interference procedures for CO<sub>2</sub> and H<sub>2</sub>O separately. If the CO<sub>2</sub> and H<sub>2</sub>O levels used are higher than the maximum levels expected during testing, you may scale down each observed interference value by multiplying the observed interference by the ratio of the maximum expected

concentration value to the actual value used during this procedure. You may run separate interference concentrations of H<sub>2</sub>O (down to 0.025 mol/mol H<sub>2</sub>O content) that are lower than the maximum levels expected during testing, but you must scale up the observed H<sub>2</sub>O interference by multiplying the observed interference by the ratio of the maximum expected H<sub>2</sub>O concentration value to the actual value used during this procedure. The sum of the two scaled interference values must meet the tolerance in paragraph (c) of this section.

(e) *Exceptions.* The following exceptions apply:

(1) You may omit this verification if you can show by engineering analysis that for your CO sampling system and your emission-calculation procedures, the combined CO<sub>2</sub> and H<sub>2</sub>O interference for your CO NDIR analyzer always affects your brake-specific CO emission results within ±0.5% of the applicable CO standard.

(2) You may use a CO NDIR analyzer 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.

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#### HYDROCARBON MEASUREMENTS

#### § 1065.360 FID optimization and verification.

(a) *Scope and frequency.* For all FID analyzers, 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:

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

(2) Determine the methane (CH<sub>4</sub>) response factor after initial analyzer installation and after major maintenance as described in paragraph (d) of this section.