

your ability to show that engines comply with all applicable emission standards.

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

(a) *Scope and frequency.* If you measure CO using an NDIR analyzer, verify the amount of H₂O and CO₂ interference after initial analyzer installation and after major maintenance.

(b) *Measurement principles.* H₂O and CO₂ 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 H₂O and CO₂ interference that is within $\pm 2\%$ of the flow-weighted mean concentration of CO expected at the standard, though we strongly recommend a lower interference that is within $\pm 1\%$.

(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.

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

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

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

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

(6) Multiply this mean value 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 mul-

tiple this ratio by the mean value recorded during this verification.

(7) The analyzer meets the interference verification if the result of paragraph (d)(6) of this section is within $\pm 2\%$ of the flow-weighted mean concentration of CO expected at the standard.

(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 calculations procedures, the combined CO₂ and H₂O interference for your CO NDIR analyzer always affects your brake-specific CO emission results within $\pm 0.5\%$ 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.

HYDROCARBON MEASUREMENTS

§ 1065.360 FID optimization and verification.

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

(1) Calibrate a FID upon initial installation. Repeat the calibration as needed using good engineering judgment.

(2) Optimize a FID's response to various hydrocarbons after initial analyzer installation and after major maintenance.

(3) Determine a FID's methane (CH₄) response factor after initial analyzer installation and after major maintenance.

(4) Verify methane (CH₄) response within 185 days before testing.

(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. Calibrate using C₃H₈ 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.

(c) *FID response optimization.* 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.

(d) *CH₄ response factor determination.* Since FID analyzers generally have a different response to CH₄ versus C₃H₈, determine each 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:

(1) Select a C₃H₈ span gas that meets the specifications of § 1065.750. Record the C₃H₈ concentration of the gas.

(2) Select a CH₄ span gas 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) *FID methane (CH₄) response verification.* 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 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%.

(1) 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. Determine a new RF_{CH_4} as described in paragraph (d) of this section.

(2) If RF_{CH_4} is 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.

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

(a) *Scope and frequency.* If you use FID analyzers for raw exhaust measurements from engines that operate in a non-stoichiometric mode of combustion (e.g., compression-ignition, lean-burn), verify the amount of FID O₂ interference upon initial installation and after major maintenance.

(b) *Measurement principles.* Changes in O₂ concentration in raw exhaust can affect FID response by changing FID flame temperature. Optimize FID fuel, burner air, and sample flow to meet this verification. Verify FID performance with the compensation algorithms for FID O₂ interference that you have active during an emission test.

(c) *System requirements.* Any FID analyzer used during testing must meet the FID O₂ interference verification according to the procedure in this section.

(d) *Procedure.* Determine FID O₂ interference as follows:

(1) Select two span reference gases that meet the specifications in § 1065.750 and contain C₃H₈ near 100% of span for HC. 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 span gas used 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; otherwise perform one or more of the following to address the deficiency:

(i) Select zero and span gases for emission testing that contain higher or lower O₂ concentrations.

(ii) Adjust FID burner air, fuel, and sample flow rates. Note that if you adjust these flow rates to meet the O₂ interference verification, you must re-verify with the adjusted flow rates that the FID meets the CH₄ response factor verification according to § 1065.360.

(iii) Repair or replace the FID.