

**§ 86.509-90 Exhaust gas sampling system.**

(a)(1) *General.* The exhaust gas sampling system is designed to measure the true mass emissions of vehicle exhaust. In the CVS concept of measuring mass emissions, two conditions must be satisfied: the total volume of the mixture of exhaust and dilution air must be measured and a continuously proportioned volume of sample must be collected for analysis. Mass emissions are determined from the sample concentration and totalized flow over the test period.

(2) *Vehicle tailpipe to CVS duct.* For methanol fueled vehicles, cooling of the exhaust gases in the duct connecting the vehicle tailpipe to the CVS shall be minimized. This may be accomplished by:

(i) Using a duct of unrestricted length maintained at a temperature above the maximum dew point of the exhaust, but below 121 °C (250 °F); heating and possibly cooling capabilities are required; or

(ii) Using a short duct (up to 12 feet long) constructed of smooth wall pipe with a minimum of flexible sections, maintained at a temperature above the maximum dew point of the exhaust, but below 121 °C (250 °F), prior to the test and during any breaks in the test and uninsulated during the test (insulation may remain in place and/or

heating may occur during testing provided maximum temperature is not exceeded); or

(iii) Using smooth wall duct less than five feet long with no required heating. A maximum of two short flexible connectors are allowed under this option; or

(iv) Omitting the duct and performing the exhaust gas dilution function at the motorcycle tailpipe exit.

(3) *Positive displacement pump.* The Positive Displacement Pump-Constant Volume Sampler (PDP-CVS), Figure F90-1 satisfies the first condition by metering at a constant temperature and pressure through the pump. The total volume is measured by counting the revolutions made by the calibrated positive displacement pump. The proportional samples are achieved by sampling at a constant flow rate. For methanol-fueled motorcycle sample lines for the methanol and formaldehyde samples are heated to prevent condensation. The temperature of the sample lines shall be more than 3 °C (5 °F) above the maximum dew point of the sample, but below 121 °C (250 °F). (Note: For 1990 through 1994 model year methanol-fueled motorcycles, methanol and formaldehyde sampling may be omitted provided the bag sample (hydrocarbons and methanol) is analyzed using a HFID calibrated with methanol.)

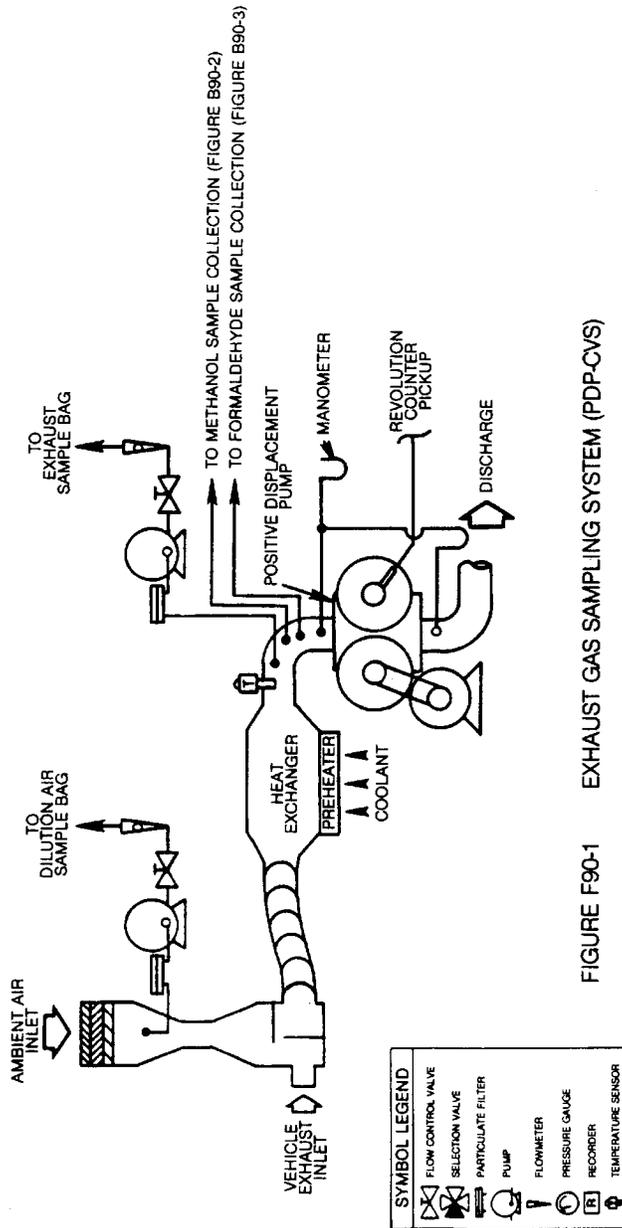


FIGURE F90-1 EXHAUST GAS SAMPLING SYSTEM (PDP-CVS)

(4) *Critical flow venturi.* The operation of the Critical Flow Venturi—Constant Volume Sampler (CFV-CVS) sample system, Figure F90-2, is based upon the

principles of fluid dynamics associated with critical flow. Proportional sampling throughout temperature excursions is maintained by use of small

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CFVs in the sample lines, which respond to the varying temperatures in the same manner as the main CFV. For methanol-fueled motorcycles, the methanol and formaldehyde sample lines are heated to prevent condensation. The temperature of the sample lines shall be more than 3 °C (5 °F) above the maximum dew point of the sample, but below 121 °C (250 °F). Care must be taken to ensure that the CFVs of the sample probes are not heated since heating of the CFVs would cause

loss of proportionality. (Note: For 1990 through 1994 model year methanol-fueled motorcycles, methanol and formaldehyde sampling may be omitted provided the bag sample (hydrocarbons and methanol) is analyzed using a HFID calibrated with methanol.) Total flow per test is determined by continuously computing and integrating instantaneous flow. A low response time temperature sensor is necessary for accurate flow calculation.

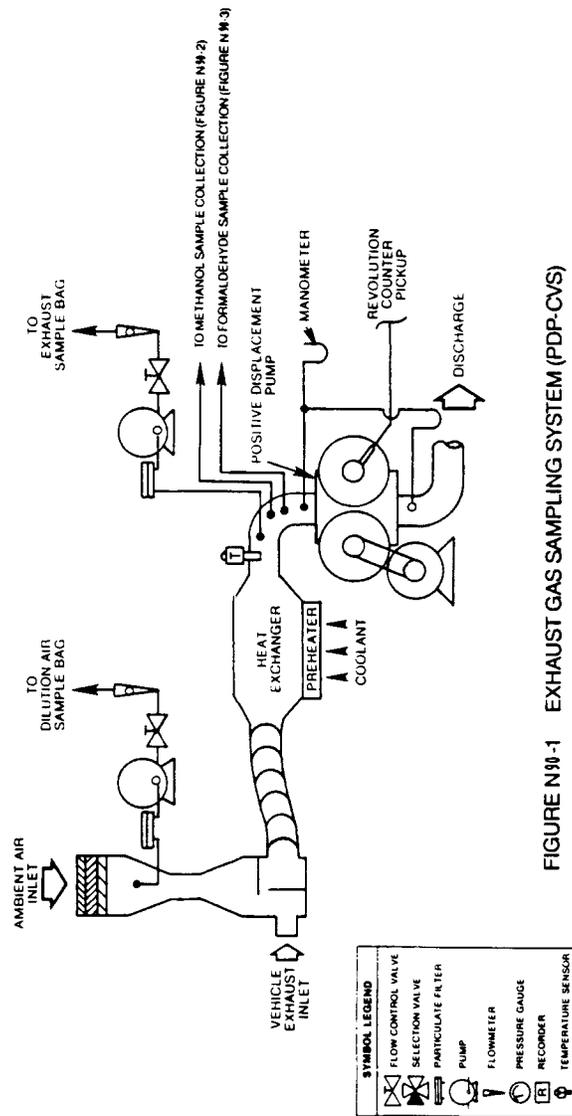


FIGURE N11-1 EXHAUST GAS SAMPLING SYSTEM (PDP-CVS)

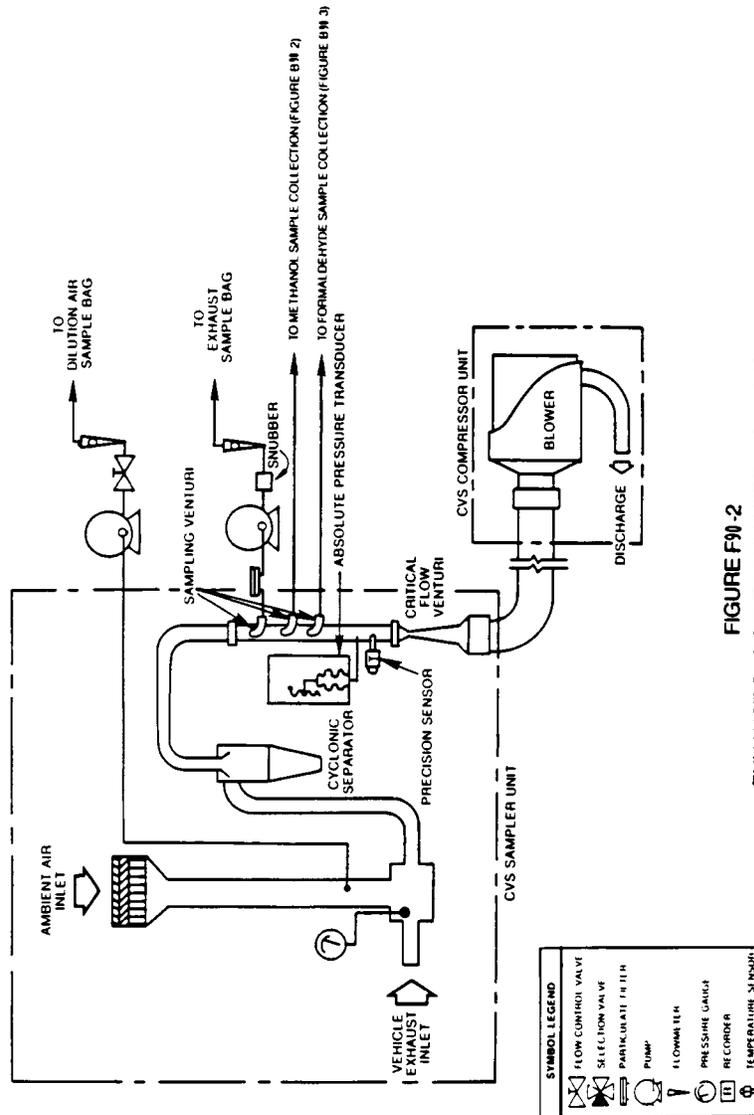


FIGURE F90-2  
EXHAUST GAS SAMPLING SYSTEM (CFV/ CVS)

(5) *Electronic Flow Control.* The Critical Flow Venturi—Electronic Flow Control—Constant Volume Sampler (CFV-EFC-CVS) system is identical to the CFV-CVS system described in paragraphs (a)(4) and (c) of this section, except that it maintains proportional sampling for methanol and formaldehyde by measuring the CVS flow rate,

and electronically controlling sample flow rates. It is recommended that sample volumes be measured by separate flow meters. For methanol-fueled motorcycles, the samples lines for the methanol and formaldehyde samples are heated to prevent condensation. The temperature of the sample lines shall be more than 20 °F (11 °C) above

the maximum dew point of the sample, but below 121 °C (250 °F).

(6) *Other systems.* Other sampling systems may be used if shown to yield equivalent results, and if approved in advance by the Administrator (e.g., a heat exchanger with the CFV-CVS or an electronic flow integrator without a heat exchanger, with the PDP-CVS).

(b) *Component description, PDP-CVS.* The PDP-CVS, Figure F90-1, consists of a dilution air filter and mixing assembly, heat exchanger, positive displacement pump, sampling systems including, probes and sampling lines which, in the case of the methanol-fueled motorcycles, are heated to prevent condensation (heating of the sample lines may be omitted, provided the methanol and formaldehyde sample collection systems are close coupled to the probes thereby preventing loss of sample due to cooling and resulting condensation in the sample lines), and associated valves, pressure and temperature sensors. The PDP-CVS shall conform to the following requirements:

(1) Static pressure variations at the tailpipe(s) of the vehicle shall remain within  $\pm 1.25$  kPa ( $\pm 5.02$  in H<sub>2</sub>O) of the static pressure variations measured during a dynamometer driving cycle with no connection to the tailpipe(s). (Sampling systems capable of maintaining the static pressure to within  $\pm 0.25$  kPa ( $\pm 1.00$  in. H<sub>2</sub>O) will be used by the Administrator if a written request substantiates the need for this closer tolerance.)

(2) The gas mixture temperature, measured at a point immediately ahead of the positive displacement pump, shall be within  $\pm 5$  °C (9 °F) of the designed operating temperature at the start of the test. The gas mixture temperature variation from its value at the start of the test shall be limited to  $\pm 5$  °C (9 °F) during the entire test. The temperature measuring system shall have an accuracy and precision of  $\pm 1$  °C (1.8 °F).

(3) The pressure gauges shall have an accuracy and precision of  $\pm 0.4$  kPa ( $\pm 3$  mm Hg).

(4) The location of the dilution air inlet shall be placed so as to use test-cell air for dilution and the flow capacity of the CVS shall be large enough to completely eliminate water condensa-

tion in the dilution and sampling systems. Control of water condensation with methanol-fueled vehicles is critical. Additional care may also be required to eliminate water condensation when testing natural gas and liquefied petroleum gas-fueled vehicles. (Procedures for determining CVS flow rates are detailed in "Calculation of Emissions and Fuel Economy When Using Alternative Fuels," EPA 460/3-83-009.) Dehumidifying the dilution air before entering the CVS is allowed. Heating the dilution air is also allowed, provided:

(i) The air (or air plus exhaust gas) temperature does not exceed 121 °C (250 °F).

(ii) Calculation of the CVS flow rate necessary to prevent water condensation is based on the lowest temperature encountered in the CVS prior to sampling. (It is recommended that the CVS system be insulated when heated dilution air is used.)

(iii) The dilution ratio is sufficiently high to prevent condensation in bag samples as they cool to room temperature.

(5) Sample collection bags for dilution air and exhaust samples (hydrocarbons and carbon monoxide) shall be of sufficient size so as not to impede sample flow. A single dilution air sample, covering the total test period, may be collected for the determination of methanol and formaldehyde background (methanol-fueled motorcycles).

(6) The methanol sample collection system and the formaldehyde sample collection system shall each be of sufficient capacity so as to collect samples of adequate size for analysis without significant impact on the volume of dilute exhaust passing through the PDP. The systems shall also comply with the following requirements that apply to the design of the systems, not to individual tests:

(i) The methanol system shall be designed such that if a test motorcycle continuously emitted the maximum allowable level of methanol (based on all applicable standards) the measured concentration in the primary impinger would exceed either 25 mg/l or a concentration equal to 25 times the limit of detection for the GC analyzer.

(ii) The formaldehyde system shall be designed such that if a test motorcycle continuously emitted formaldehyde at a rate equal to twenty percent of the maximum allowable level of THCE (*i.e.*, 1.0 g/km for a 5.0 g/km standard), or the maximum formaldehyde level allowed by a specific formaldehyde standard, whichever is less, the concentration of formaldehyde in the DNPH solution of the primary impinger, or solution resulting from the extraction of the DNPH cartridge, shall exceed either 2.5 mg/l or a concentration equal to 25 times the limit of detection for the HPLC analyzer.

(iii) The methanol and formaldehyde systems shall be designed such that the primary impinger collects at least 90 percent of the analyte in the samples. The remaining analyte shall be collected by the secondary impinger. This requirement does not apply to dilution air samples, since they do not require secondary impingers, or to samples in which the concentrations approach the limit of detection.

(c) *Component description, CFV-CVS.* The CFV-CVS sample system, Figure F90-2, consists of a dilution air filter and mixing assembly, a cyclone particulate separator, unheated sampling venturies for the bag samples, and for the methanol and formaldehyde samples from methanol-fueled vehicles, samples lines heated to prevent condensation for the methanol and formaldehyde samples from methanol fueled vehicles (heating of the sample lines may be omitted provided, the methanol and formaldehyde sample collection systems are close coupled to the probes thereby preventing loss of sample due to cooling and resulting condensation in the sample lines), a critical flow venturi, and assorted valves, and pressure and temperature sensors. The CFV sample system shall conform to the following requirements:

(1) Static pressure variations at the tailpipe(s) of the vehicle shall remain within  $\pm 1.25$  kPa (5.02 in H<sub>2</sub>O) of the static pressure variations measured during a dynamometer driving cycle with no connection to the tailpipe(s). (Sampling systems capable of maintaining the static pressure to within  $\pm 0.25$  kPa (1.00 in H<sub>2</sub>O) will be used by the Administrator if a written request

substantiates the need for this closer tolerance.)

(2) The temperature measuring system shall have an accuracy and precision of  $\pm 1$  °C (1.8 °F) and a response time of 0.100 second to 62.5 percent of a temperature change (as measured in hot silicone oil).

(3) The pressure measuring system shall have an accuracy and precision of  $\pm 0.4$  kPa ( $\pm 3$  mm Hg).

(4) The location of the dilution air inlet shall be placed so as to use test-cell air for dilution and the flow capacity of the CVS shall be large enough to completely eliminate water condensation in the dilution and sampling systems. Control of water condensation with methanol-fueled vehicles is critical. Additional care may also be required to eliminate water condensation when testing natural gas and liquefied petroleum gas-fueled vehicles. (Procedures for determining CVS flow rates are detailed in "Calculation of Emissions and Fuel Economy When Using Alternative Fuels," EPA 460/3-83-009.) Dehumidifying the dilution air before entering the CVS is allowed. Heating the dilution air is also allowed, provided:

(i) The air (or air plus exhaust gas) temperature does not exceed 250 °F.

(ii) Calculation of the CVS flow rate necessary to prevent water condensation is based on the lowest temperature encountered in the CVS prior to sampling. (It is recommended that the CVS system be insulated when heated dilution air is used.)

(iii) The dilution ratio is sufficiently high to prevent condensation in bag samples as they cool to room temperature.

(5) Sample collection bags for dilution air and exhaust samples (hydrocarbons and carbon monoxide) shall be of sufficient size so as not to impede sample flow. A single dilution air sample, covering the total test period, may be collected for the determination of methanol and formaldehyde background (methanol-fueled motorcycles).

(6) The methanol sample collection system and the formaldehyde sample collection system shall each be of sufficient capacity so as to collect samples of adequate size for analysis without

significant impact on the volume of dilute exhaust passing through the CVS. The systems shall also comply with the following requirements that apply to the design of the systems, not to individual tests:

(i) The methanol system shall be designed such that if a test motorcycle continuously emitted the maximum allowable level of methanol (based on all applicable standards) the measured concentration in the primary impinger would exceed either 25 mg/l or a concentration equal to 25 times the limit of detection for the GC analyzer.

(ii) The formaldehyde system shall be designed such that if a test motorcycle continuously emitted formaldehyde at a rate equal to twenty percent of the maximum allowable level of THCE (*i.e.*, 1.0 g/km for a 5.0 g/km standard), or the maximum formaldehyde level allowed by a specific formaldehyde standard, whichever is less, the concentration of formaldehyde in the DNPH solution of the primary impinger, or solution resulting from the extraction of the DNPH cartridge, shall exceed either 2.5 mg/l or a concentration equal to 25 times the limit of detection for the HPLC analyzer.

(iii) The methanol and formaldehyde systems shall be designed such that the primary impinger collects at least 90 percent of the analyte in the samples. The remaining analyte shall be collected by the secondary impinger. This requirement does not apply to dilution air samples, since they do not require secondary impingers, or to samples in which the concentrations approach the limit of detection.

(d) *Component description, CFV-EFC- CVS.* The CVS sample system is identical to the system described in paragraph (c) of this section, plus includes a means of electronically measuring the CVS flow rate, and electronic mass

flow controllers for the methanol and formaldehyde sample lines, and separate flow meters to totalize sample flow volumes (optional). The EFC sample system shall conform to all of the requirements listed in paragraph (c) of this section, except that the methanol and formaldehyde samples may both be drawn from a single static probe. It also must comply with the following additional requirements:

(1) The ratio of the CVS flow rate to the sample flow rate shall not deviate from the ratio at the start of the test by more than  $\pm 5$  percent. (The volumetric sample flow rate shall be varied inversely with the square root of the bulk stream temperature.)

(2) Flow totalizers for methanol and/or formaldehyde samples shall have an accuracy of  $\pm 2$  percent. Total sample volumes may be obtained from the flow controllers, with the advance approval of the administrator, provided that the controllers can be shown to have an accuracy of  $\pm 2$  percent.

[54 FR 14539, Apr. 11, 1989, as amended at 59 FR 48512, Sept. 21, 1994; 60 FR 34351, June 30, 1995]

**§ 86.511-90 Exhaust gas analytical system.**

(a) *Schematic drawings.* Figure F90-3 is a schematic drawing of the exhaust gas analytical system for analysis of hydrocarbons (HC) (hydrocarbons plus methanol in the case of methanol-fueled motorcycles), carbon monoxide (CO), carbon dioxide (CO<sub>2</sub>), and oxides of nitrogen (NO<sub>x</sub>). Since various configurations can produce accurate results, exact conformance with the drawing is not required. Additional components such as instruments, valves, solenoids, pumps and switches may be used to provide additional information and coordinate the functions of the component systems