

collected for determination of formaldehyde background for methanol-fueled vehicles.

(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 CFV-CVS.

[54 FR 14500, Apr. 11, 1989]

§ 86.109-94 Exhaust gas sampling system; Otto-cycle vehicles not requiring particulate emission measurements.

(a)(1) *General.* The exhaust gas sampling system described in this paragraph is designed to measure the true mass of gaseous emissions in the exhaust of either Otto-cycle light-duty vehicles or light-duty trucks which are waived from requirements for the measurement of particulate emissions. 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 total 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 250 °F (121 °C); 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 250 °F (121 °C), prior to the test and during the 10 minute hot soak segment 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 vehicle tailpipe exit.

(3) *Positive displacement pump.* The Positive Displacement Pump-Constant Volume Sampler (PDP-CVS), Figure B94-1 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 for the bag sample, and for methanol-fueled vehicles, the methanol sample (Figure B94-2) and the formaldehyde sample (Figure B94-3), are achieved by sampling at a constant flow rate. For methanol-fueled vehicles, the sample lines for the methanol and formaldehyde samples are heated to prevent condensation. The temperature of the sample lines shall be more than 5 °F (3 °C) above the maximum dew point of the sample, but below 250 °F (121 °C). (Note: For 1990 through 1994 model year methanol-fueled vehicles, methanol and formaldehyde sampling may be omitted provided the bag sample (hydrocarbons and methanol) is analyzed using a HFID calibrated with methanol.)

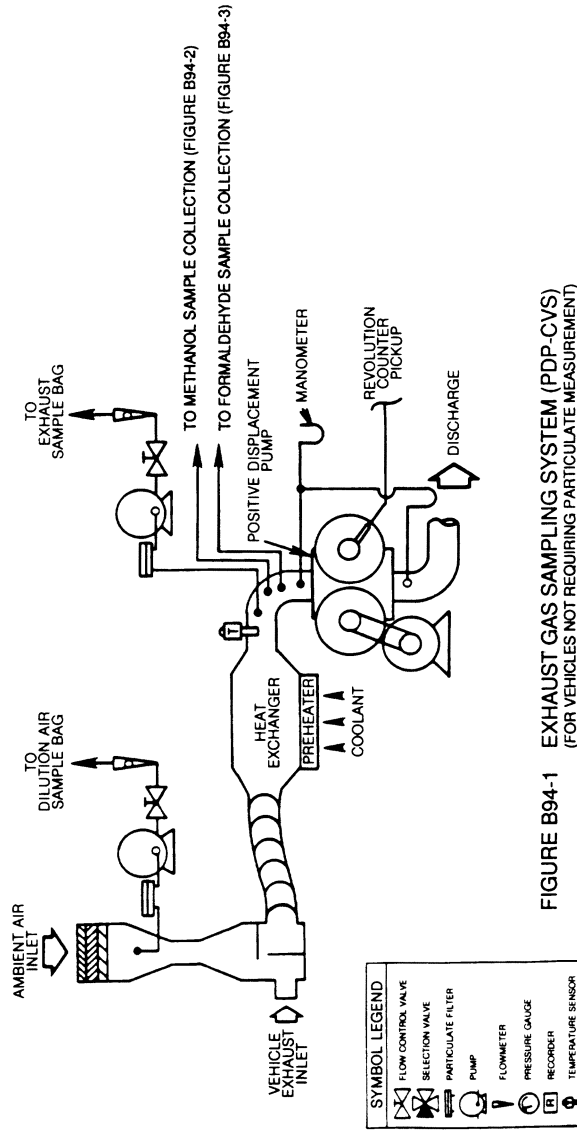


FIGURE B94-1 EXHAUST GAS SAMPLING SYSTEM (PDP-CVS)
(FOR VEHICLES NOT REQUIRING PARTICULATE MEASUREMENT)

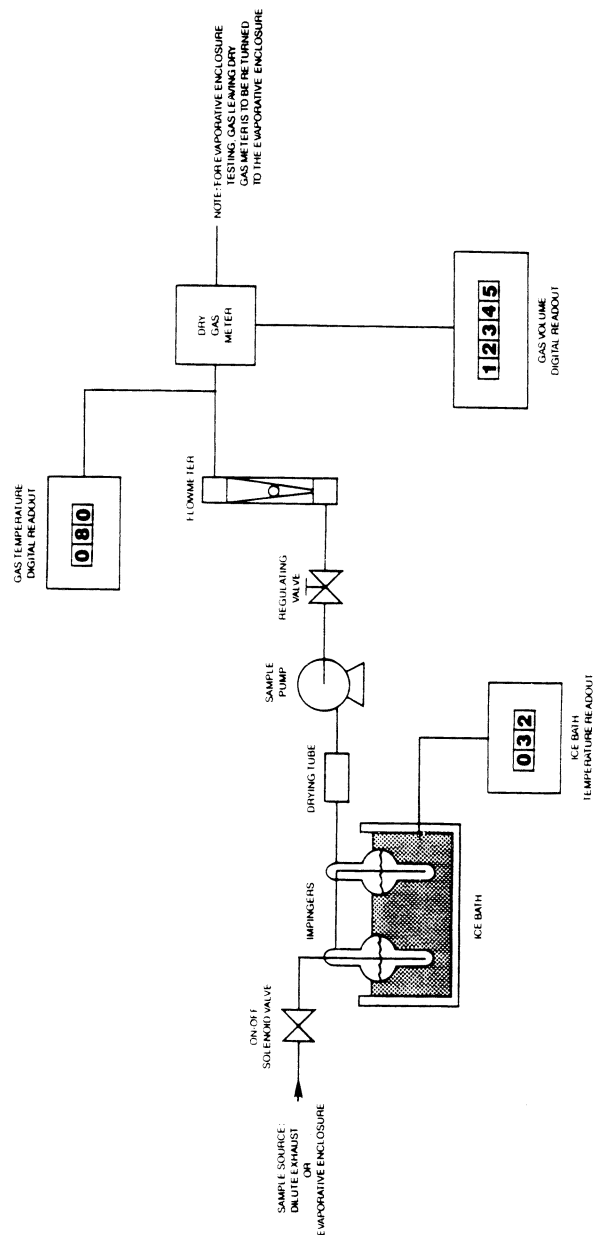


FIGURE B04-2 METHANOL SAMPLE COLLECTION FLOW SCHEMATIC

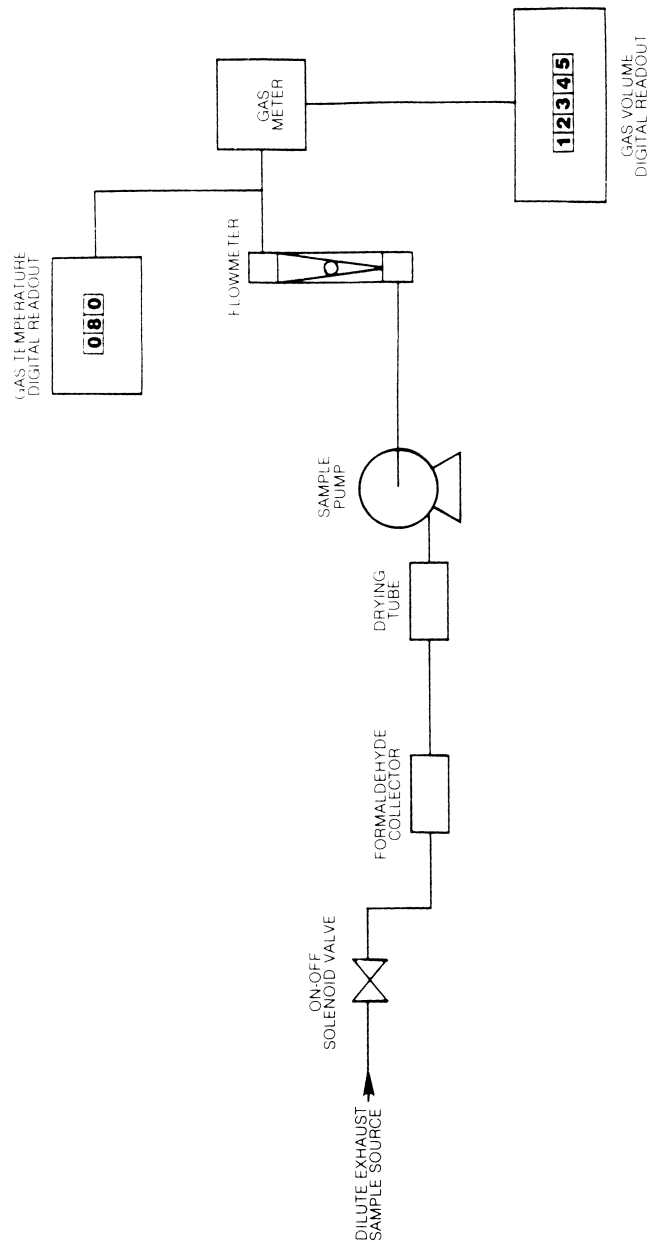


FIGURE B94-3 FORMALDEHYDE SAMPLE COLLECTION FLOW SCHEMATIC

(4) *Critical flow venturi.* The operation of the Critical Flow Venturi-Constant Volume Sampler (CFV-CVS) sample system, Figure B94-4, 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 (for methanol-fueled vehicles, one line supplies sample for the bag sample, another line supplies sample for the methanol sample, and a third line supplies sample for the formaldehyde sample.) The methanol and formaldehyde sample lines are heated to prevent condensation. The temperature of the sample lines shall be more than 5 °F (3 °C) above the maximum dew point of the sample, but below 250 °F (121 °C). Care should be taken to ensure that the CFVs of the sample probes are not heated since heating of the CFVs would cause loss of

proportionality. The variable mixture flow rate is maintained at sonic velocity, is inversely proportional to the square root of the gas temperature, and is computed continuously. Since the pressure and temperature are the same at all venturi inlets, the sample volume is proportional to the total volume. (Note: For 1990 through 1994 model year methanol-fueled vehicles, methanol and formaldehyde sampling may be omitted provided the bag sample (hydrocarbons and methanol) is analyzed using a HFID calibrated with methanol.)

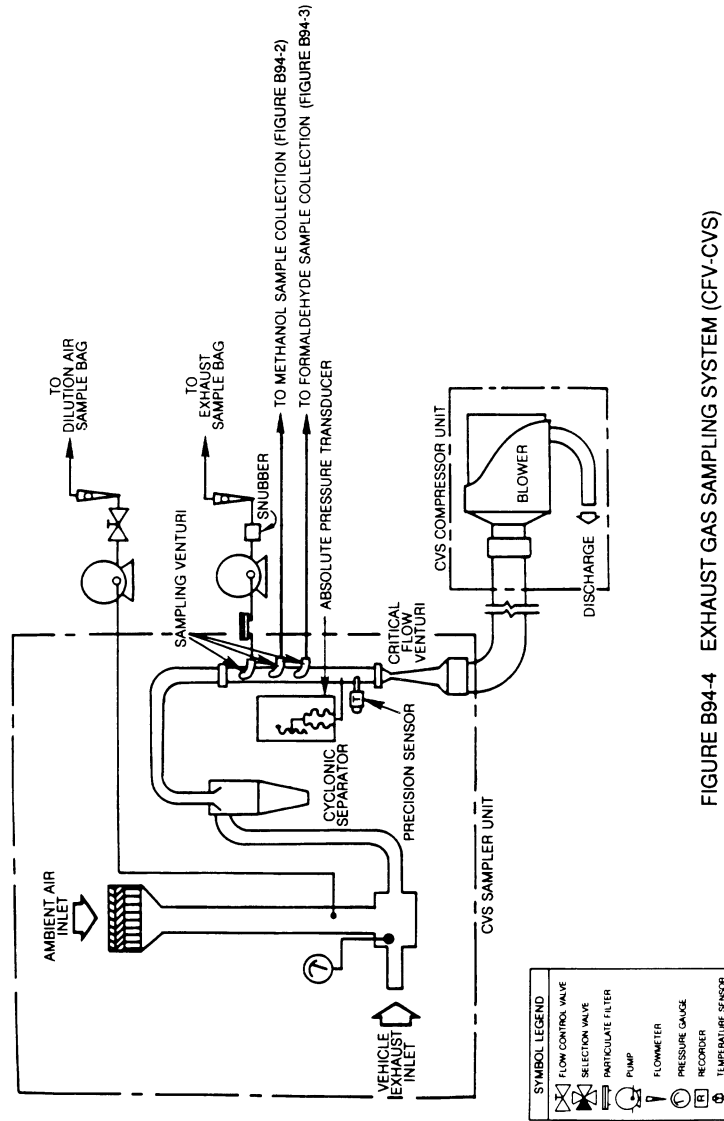


FIGURE B94-4 EXHAUST GAS SAMPLING SYSTEM (CFV-CVS)

(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. For methanol-fueled vehicles, the samples lines for the methanol and formaldehyde samples are heated to prevent condensation. The temperature of the sample lines shall be more than 5 °F (3 °C) above the maximum dew

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

(6) *Other systems.* Other sampling systems may be used if shown to yield equivalent or superior results, and if approved in advance by the Administrator.

(b) *Component description, PDP-CVS.* The PDP-CVS, Figure B94-1, consists of a dilution air filter and mixing assembly, heat exchanger, positive displacement pump, sampling systems (see Figure B94-2 for methanol sampling system and Figure B94-3 for formaldehyde sampling system) sampling lines which are heated to a temperature that is more than 5 °F (3 °C) above the maximum dew point of the sample, but below 250 °F (121 °C) in the case of the 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), 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 ± 5 inches of water (1.2 kPa) 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 ± 1 inch of water (0.25 kPa) 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 ± 10 °F (± 5.6 °C) 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 ± 10 °F (± 5.6 °C) during the entire test. The temperature measuring system shall have an accuracy and precision of ± 2 °F (1.1 °C).

(3) The pressure gauges shall have an accuracy and precision of ± 1.6 inches of water (0.4 kPa).

(4) The flow capacity of the CVS shall be large enough to completely elimi-

nate water condensation in the dilution and sampling systems. (300 to 350 cfm (0.142 to 0.165 m³/s) is sufficient for most petroleum-fueled vehicles. Higher flow rates are required for methanol-fueled vehicles and may be required for natural gas-fueled 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.) (Copies may be obtained from U.S. Department of Commerce, NTIS, Springfield, Virginia 22161; order \pm PB 84104702.) 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 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 vehicles).

(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 vehicle emitted the maximum allowable level of methanol (based on all applicable standards) during the first phase of the test, 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. Sampling systems for all phases shall be identical.

(ii) The formaldehyde system shall be designed such that, if a test vehicle emitted formaldehyde at a rate equal to twenty percent of the maximum allowable level of NMHCE (i.e., 0.05 g/mi for a 0.25 g/mi NMHCE standard), or the maximum formaldehyde level allowed by a specific formaldehyde standard, whichever is less, during the first phase of the test, 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. Sampling systems for all phases shall be identical.

(iii) The methanol and formaldehyde impinger 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 B94-4, 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 a temperature that is more than 5 °F (3 °C) above the maximum dew point of the sample, but below 250 °F (121 °C) 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 ± 5 inches of water (1.2 kPa) 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 ± 1 inch of water (0.25 kPa) 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 ± 2 °F (1.1 °C) and a response time of 0.100 seconds 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 ± 1.6 inches of water (0.4 kPa).

(4) The flow capacity of the CVS shall be large enough to completely eliminate water condensation in the dilution and sampling systems. (300 to 350 cfm (0.142 to 0.165 m³/s) is sufficient for most petroleum-fueled vehicles. Higher flow rates are required for methanol-fueled vehicles and may be required for natural gas-fueled 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 (121 °C).

(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 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 vehicles).

(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 vehicle emitted the maximum allowable level of methanol (based on all applicable standards) during the first phase of the test, 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. Sampling systems for all phases shall be identical.

(ii) The formaldehyde system shall be designed such that, if a test vehicle emitted formaldehyde at a rate equal to twenty percent of the maximum allowable level of NMHCE (i.e., 0.05 g/mi for a 0.25 g/mi NMHCE standard), or the maximum formaldehyde level allowed by a specific formaldehyde standard, whichever is less, during the first phase of the test, 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. Sampling systems for all phases shall be identical.

(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. The EFC sample system shall conform to all of the requirements listed in paragraph (c), except that the methanol and formaldehyde samples must both be drawn from a static probe. It also must comply with the following additional requirements:

(1) The ratio of the CVS mass flow rate to the sample mass flow rate shall not deviate from the design ratio by more than ± 5 percent. (The volumetric sample flow rate shall be varied inversely with the square root of the bulk stream temperature.)

(2) Flow meters to totalize sample volumes for methanol and/or formaldehyde samples shall meet the accuracy specifications of § 86.120. Total sample volumes may be obtained from the flow controllers, provided that the controllers meet the accuracy specifications of § 86.120.

[56 FR 25760, June 5, 1991, as amended at 59 FR 48505, Sept. 21, 1994; 60 FR 34336, June 30, 1995]

§ 86.110-90 Exhaust gas sampling system; diesel vehicles.

(a) *General.* The exhaust gas sampling system described in this paragraph is designed to measure the true mass of both gaseous and particulate emissions in the exhaust of either diesel light-duty vehicles and light-duty trucks. This system utilizes the CVS concept (described in § 86.109) of measuring mass emissions. The mass of gaseous emissions is determined from the sample concentration and total flow over the test period. The mass of particulate emissions is determined from a proportional mass sample collected on a filter and from the total flow over the test period. General requirements are as follows:

(1) This sampling system requires the use of a PDP-CVS or a CFV sample system with heat exchanger connected to a dilution tunnel. Figure B90-5 is a schematic drawing of the PDP system. Figure B90-6 is a schematic drawing of the CFV system (methanol-fueled Otto-cycle vehicles may be tested using this test equipment.)