# California Environmental Protection Agency

# ⊜≡ Air Resources Board

**Vapor Recovery Test Procedure**

## TP-201.1A

## Emission Factor For
## Phase I Systems at Dispensing Facilities

**Adopted:  April 12, 1996**
**Amended:  March 17, 1999**
**Amended:  February 1, 2001**

**Note: This procedure is being amended.  For ease of viewing this method is shown as adopted text and the March 17, 1999 text is shown as repealed text.  Because all the text is affected, for ease of viewing, the underline is omitted as allowed by title 1, California Code of Regulations, section 8.**

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**Phase I Systems at Dispensing Facilities**


Definitions common to all certification and test procedures are in:

**D-200  Definitions for Vapor Recovery Procedures**

For the purpose of this procedure, the term "ARB" refers to the State of California Air Resources Board, and the term "ARB Executive Officer" refers to the Executive Officer of the ARB or his or her authorized representative or designate.


## 1.  PURPOSE AND APPLICABILITY

1.1   This procedure applies when it is necessary to determine a mass emission factor for the Phase I System rather than the volumetric efficiency determined by the application of TP–201.1.  The operation of a vapor processor or vapor incinerator typically precludes the application of TP-201.1.

1.2   The purpose of this test procedure, TP-201.1A, is to determine the emission factor (in units of pounds of hydrocarbon emitted per 1000 gallons of gasoline transferred from cargo tank to storage tank, lb/kgal) for installations of  Phase I vapor recovery systems (VRS) at gasoline dispensing facilities (GDFs).

## 2.  PRINCIPLE AND SUMMARY OF TEST PROCEDURE

During a fuel delivery, the volume of gasoline transferred from the cargo tank to the storage tank is determined.  The mass of any gasoline vapors discharged from the vent(s) of the storage tank(s) and, if present, from the exhaust of the vapor processor or vapor incinerator unit is determined.  The mass emission factor for the fuel transfer event is calculated from these determinations.

As required to determine an emission related parameter and except where otherwise specified, the equipment and procedures specified in the following test methods shall be used.

EPA Method 2A   Direct Measurement of Gas Volume Through Pipes and Small Ducts

EPA Method 2B   Determination of Exhaust Gas Volume Flow Rate From Gasoline Vapor Incinerators

EPA Method 25A  Determination of Total Gaseous Organic Compound Emissions Using a
Flame Ionization Detector

EPA Method 25B  Determination of Total Gaseous Organic Compound Emissions Using a
Nondispersive Infrared Analyzer

## 3.  BIASES AND INTERFERENCES

3.1  Bulk Delivery Vapor Leaks

Any vapor leak exceeding the LEL (2.1 volume % as propane), during the gasoline
bulk delivery, precludes the use of this method.  Vapor concentration is determined at
a distance of 1 inch from any potential vapor leak source.  Measurements are made
using the equipment and procedures specified in EPA Method 21 (40 CFR Part 60,
App. A).

3.2  Cargo Tank Performance

Gasoline transfers performed using cargo tanks which do not meet the year round
(daily) performance standards required by ARB Certification Procedure "CP-204,
Certification Procedure for Vapor Recovery Systems of Cargo Tanks" preclude the use
of this method.

## 4.  SENSITIVITY, RANGE, AND PRECISION

The measurements of concentration and volumetric parameters required by TP-201.2 are
well within the limits of sensitivity, range, and precision of the specified equipment.

## 5.  EQUIPMENT AND SUPPLIES

5.1  Volume Meters

A volume measuring device (meter) is required at each vent, including those equipped
with pressure-vacuum relief valves and the exhaust of any vapor processor or vapor
incinerator.  The meter should be equipped with an automatic data gathering system
that can differentiate direction of flow and record the volume vented in such a manner
that this data can be correlated with contemporaneous data on the meter temperature
and pressure and the hydrocarbon concentration of vapors passing through the meter.
A sampling manifold shall be connected to the meter with taps for hydrocarbon (HC)
concentration sampling, a thermocouple, and a pressure sensor connection.

Use a calibrated positive displacement  meter or a turbine meter for measurement of
volumetric flow.  The error of the meter shall be less than 2% of the true volume over
the entire range of flow rates for which the meter will be used.

Any volume meter that is installed in the vapor recovery system plumbing shall
demonstrate conformance with the back pressure limit (BPL), specified below:

Meters with a manufacturer specified maximum flow rating of greater than
or equal to 1000 CFH shall demonstrate:

BPL ≤ 1.10 inches water column at a flow rate of 3,000 CFH or the maximum flow rating specified by the manufacturer, whichever is less, and BPL ≤ 0.05 inches water column at a flow rate of 30 CFH.

Meters with a manufacturer specified maximum flow rating of less than 1000 CFH shall demonstrate:

BPL ≤ 0.70 inches water column at a flow rate of 800 CFH and BPL ≤ 0.04 inches water column at a flow rate of 16 CFH.

Meter(s) shall be equipped with the following equipment:

(1) taps on the inlet and outlet sides for a differential pressure gauge with a full scale range of less than or equal to four times the back pressure limit to allow detection of a pressure drop greater than the BPL.

(2) Couplings required to connect meters to the VRS at the tank vent lines, the exhaust of the vapor processor or the inlet of the vapor incinerator. Couplings shall be sized and constructed such that the test apparatus does not cause any significant increase in the pressure drop associated with flow through the systems tested.

5.2    Pressure Measurement Device for Volume Meters

Use a pressure measuring device (e.g. transducer, liquid manometer or Magnahelic gauge) with a range selected to ensure that the pressure measured by the device are within 10 to 90% of the full scale range. More than one gauge shall be used, if necessary. Pressure measurement shall be conducted at the sample coupling attached to the inlet of each volume meter. The error of the pressure measuring device shall be no greater than 3% of the true pressure over the entire range of pressures to be measured by the device.

5.3    Temperature Measurement Device

Use a temperature measuring device (e.g. thermocouple, thermometer) with a design range suitable for the temperature being measured. Typically, a range of 0 to 200 $^\circ$ F is suitable for use in this test procedure. Temperature measurement shall be conducted at the sample coupling attached to the inlet of each volume meter. The ambient temperature is also measured and recorded during the Phase I gasoline transfer. The error in the temperature measuring device shall be no greater than 4 degrees Fahrenheit.

5.4    Hydrocarbon Analyzer(s)

Depending on the test point location of the HC measurement, the HC analyzer shall be capable of continuously measuring HC concentrations as follows:

100 ppm to 80 percent by volume using propane as a calibration gas, or
75 ppm to 60 percent by volume using butane as a calibration gas.

5.5     Carbon Dioxide ($CO_2$) Analyzer at Vapor Incinerator Exhaust

Use a carbon dioxide analyzer as specified in ARB Method 100 (title 17, CCR, section 94114) or USEPA Method 3A, "Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources (Instrumental Analyzer Procedure)", 40 CFR Part 60, App. A.

5.6     Carbon Monoxide (CO) Analyzer at Vapor Incinerator Exhaust

Use a carbon monoxide analyzer as specified in ARB Method 100 (title 17, CCR, section 94114) or USEPA Method 10, "Determination of Carbon Monoxide Emissions From Stationary Sources", 40 CFR Part 60, App. A.

5.7     Combustible Gas Detector

Use a combustible gas detector or explosimeter meeting the specifications required by EPA Method 21 "Determination of Volatile Organic Compounds Leaks", 40 CFR Part 60, App. A or ARB test procedure "TP-204.3, Determination of Leak(s)", to quantify any vapor leaks occurring during the Phase I gasoline transfer.

5.8     Barometer

Use a mercury, aneroid, or equivalent barometer accurate to within 5 millimeters of mercury ( 0.2 inches of mercury ) to determine ambient pressure during the Phase I gasoline transfer.

5.9     In-line Plumbing

Design goals for plumbing arrangements, regardless of GDF, are:

(1)     Minimize length of additional test piping installed at any sample points within the VRS.

(2)     Minimize pressure drop across in-line plumbing and the volume meter.

(3)     Return the entire volume of any sample extracted from the vapor return line to prevent a negative bias in the VRS pressure and the mass of pressure driven fugitive emissions.

(4)     Test apparatus plumbing shall be designed for easy adaptability to GDF configurations which may be encountered.  Ball valves may be installed at the inlet and exhaust of volume meters in order to isolate the meter from the VRS in the event that the meter requires servicing during the test.  Such ball valves shall be sized to match the size of the vapor return line and test apparatus plumbing.

5.10    Cargo Tank Fill Line and Vapor Return Line Couplers

The temperature and/or pressure or hydrocarbon concentration of the fluids in the cargo tank fill and vapor return lines is not necessary for determination of the mass

emission factor for which this procedure is used. However, if deemed necessary, the volume of the vapor returned to the cargo tank may be estimated based on the volume of gasoline delivered to the storage tank(s). If this volume is to be corrected to standard conditions of temperature and pressure the following equipment will be required to accommodate temperature and pressure measuring devices.

(1)     Coupling for tank truck vapor return line with thermocouple and manometer, taps. Coupling to be the same diameter as the vapor return line.

(2)     Coupling for tank truck fuel drop line with thermocouple tap. Coupling to be the same diameter as the fuel line.

5.11  Calibration Gases

Cylinders of certified, or NIST traceable, calibration gases using propane (or butane) in nitrogen capable of providing calibration for the analyzer ranges recommended. Each range requires three calibration gases:

(1) High-Range Gas: Concentration between 80 and 100% of range.
(2) Mid-Range Gas: Concentration between 40 and 60% of range.
(3) Zero Gas: Nitrogen with a hydrocarbon concentration less than 0.25% of range.

5.12  Gas Dilution System

A gas dilution system which meets the requirements of EPA Method 205, Verification of Gas Dilution Systems for Field Instrument Calibrations, CFR 40, Part 51, Appendix M, may be used to provide low-level calibration gases from a high-level calibration gas. The calibration gas used with a gas dilution system shall be an EPA Protocol gas. A gas dilution system which meets the requirements of EPA Method 205 may be used for all analyzer calibrations and sampling system bias checks. If a diluter is used, it must be included in the calibration of the analyzer(s).

5.13  Data Acquisition System/Data Recorder

Provide a permanent record of hydrocarbon analyzer data using a strip chart recorder. A datalogger or another electronic data acquisition is also recommended. Data shall be collected at intervals not to exceed one second. Any electronic data acquisition system must be capable of integration at a ten-second interval. The strip chart, as well as the data acquisition system, must have a resolution of 0.5 percent of the analyzer range.


# 6.  CALIBRATIONS

All measurement devices shall be calibrated as described below. A record of all calibrations shall be maintained.

6.1 Analyzers: Calibration curves shall be produced no longer than six months before testing using ARB's SOP 054, "Standard Operating Procedure for the Multilevel Calibrations of Pollutant Gas Analyzers" September 1, 1997. Field calibrations during testing shall be conducted as described in Section 8.1.1.

6.2 Calibration Gases:

    6.2.1 Certification. The calibration gases must be certified according to one of the following options:

        6.2.1.1 The EPA Traceability Protocol for Assay and Certification of Gaseous Calibration Standards (40 CFR Ch.1, Part 75, App. H), or

        6.2.1.2 To an analytical accuracy of $\pm$ 2% percent, traceable to a reference material approved by the National Institute of Standards and Technology (NIST) and recertified annually.

    6.2.2 Documentation. Information on calibration gas cylinders shall be entered into a log identifying each cylinder by serial number. Sufficient information shall be maintained to allow a determination of the certification status of each calibration gas and shall include: (1) the data put in service, (2) assay result, (3) the dates the assay was performed, (4) the organization and specific personnel who performed the assay, and (5) the date taken out of service.

6.3 Volume Meters: All volume meter calibrations shall be NIST traceable. Volume meters shall be calibrated on an annual basis against a bell type spirometer at flow rates representing 1, 10, 30, 60, and 90% of the meter capacity. The accuracy of the meter shall be 5% of the true volume measured over the range of flow rates encountered in application of this test procedure. Alternatively, the field volume meter may be calibrated against a transfer meter. The transfer meter shall be calibrated against the bell type spirometer or wet test meter and may not be used in the field as a working meter.

6.4 Pressure Measuring Device: Calibrate pressure measurement devices prior to and immediately following the test period with a static pressure calibrator at five points over a range of – 10 to +10 inches water or appropriate range of operation. The accuracy of the device shall be 5%. Alternatively, pressure measurement devices may be calibrated in accordance with manufacturer's specifications with a documentation of the specifications and the calibrations in the certification test report.

6.5 Temperature Measuring Device: Temperature measurement devices shall be checked semi-annually using an ice bath, ambient air, and boiling water. This temperature check shall be performed by comparison to a NIST traceable measurement device.

## 7. PRE-TEST REQUIREMENTS

7.1 System and Facility Preparation

Vapor recovery system equipment and components shall be completely operational and no deliveries to any storage tanks involved in the test shall have occurred within the preceding 36 hours.

The evaluation performed by the ARB Executive Officer shall specify the final requirements for facility preparation. The guiding principle is that testing activities shall not significantly alter GDF or VRS operating conditions. The installation of test equipment can alter facility and system values for critical parameters (e.g. the release of pressure caused by opening the VRS plumbing to install test equipment at the tank vent or vapor processor or incinerator inlet). Therefore, final preparation procedures are specified herein. Alternate procedures may be used if approved in writing by the ARB Executive Officer.

7.1.1 Facility Preparation Procedures

(1) Install all required testing apparatus on the tank vent line(s),and if present,the vapor processor exhaust and vapor incinerator inlet lines and wait at least 16 hours before testing. Until then, provide conditions which minimally disturb facility and system operations due to the presence of such equipment for such time; or

(2) install all equipment and wait until system parameters that are perturbed by the installation of test equipment, such as pressure and hydrocabon concentration have returned to within the normal operating range established by the preliminary evaluation of the VRS. Until then, provide conditions which minimally disturb facility and system operations due to the presence of such equipment.

## 8. DAILY PRE-TEST PROCEDURES

8.1 Field Calibration

8.1.1 Hydrocarbon Analyzers: Follow manufacturer's instructions concerning warm-up time and adjustments. On each test day, prior to data collection, zero the analyzer with a zero gas and span with known concentrations of calibration gases at levels which are 40 to 60% and 80 to 100% of the concentration ranges to be used for the test.

Conduct the analyzer calibration error check by sequentially introducing the three calibration gases (high-range, mid-range and zero gas) and recording the analyzer response to each calibration gas. Make no adjustments to the sampling/analysis system except those necessary to achieve the proper calibration gas flowrate. The analyzer calibration error for any calibration gas shall not exceed ±2 percent of the range. If needed, take corrective action until acceptable performance is achieved.

Perform a leak check on the vacuum side of the assembly at the maximum pump vacuum. Correct any leaks found and repeat the leak check and correction procedure until no leak is detected.

8.1.2 CO and $CO_2$ Analyzers: Repeat instructions in 8.1.1 for CO and $CO_2$ analyzers if applicable.

8.1.3 Pressure Measurement Device: Prior to and immediately following each day of testing, record the pressure measuring device(s) response to the pressure generated by a static pressure calibrator at 0, 40, and 80% of the specified range of operation. If pressure differs more than 10%, recalibrate the device. Document instrument response before and after adjustment.

8.1.4 Temperature Measurement Device. Check the accuracy of the temperature measurement device(s) against an NIST traceable mercury-glass thermometer at ambient temperature prior to and immediately following each day of testing. If necessary, adjust the temperature read-out in accordance with manufacturer's instructions. Provide a copy of these instructions and document the instrument response before and after adjustment in the test report.

8.2 Sampling System Bias Checks: Check sampling set-up by introducing a known hydrocarbon concentration as close to the sample point as possible. If the difference between the analyzer field calibration and the sample system bias check exceeds +5% of the range for the high-level calibration gas, the system fails the bias check and corrective action must be taken. Calculate bias using Equation 8.3. All sampling points must pass the bias check before the test can proceed.

$$Bias = \left[ \frac{(C_a - C_b)}{R} \right] x100$$

where:

$C_a$ = analyzer response for calibration gas for field calibration

$C_b$ = analyzer response for calibration gas for sampling system bias check

$R$ = analyzer range

8.3 Initiate Test Documentation:

8.3.1 Photographs shall be taken at each test point to document the equipment set-up. Any changes in configuration during the test shall also be documented by photographs, along with the date and time of the modification. A video demonstrating emission measurement during a fuel delivery is recommended.

8.3.2 Testers shall maintain a test log which shall consist of a narrative documenting activities at the test site, such as Phase I fuelings, modifications

to equipment and the reasons for testing decisions.  The tester shall update the test log at least twice a day.

8.4 RVP Sample: If required by the ARB Executive Officer, collect gasoline samples of each grade as described in title 13, CCR, Section 2296.

## 9.  TEST PROCEDURE

9.1 Test Point 1 (Tank Vents) and / or Test Point 2 (Vapor Processor Exhaust)

In this section, the term "vent" and the specified procedures for testing vents shall also apply to any vapor processor with which such procedures are compatible.  Any assist processor that is incompatible with the application of these procedures shall not be certified until the compatibility requirements of the certification procedures are met.  Separate equipment and test procedures are specified elsewhere for vapor incinerators.

(1) Remove any PV valve(s) that is (are) installed on the vent(s).  Then install the coupler, volume meter and sample manifold and reinstall the PV Valve at the outlet of the sample manifold.  Figures 4 and 5 depict the final installation.  In these figures, elbows have been use to orient the meter in a horizontal flow direction.  This is done to minimize the chance of contamination falling into the outlet of the meter and jamming the meter.  A jammed meter can be detected by higher than normal pressure drop through the meter at normal volumetric flow rates.  The differential pressure gauge installed across the meter is used for this purpose.  Horizontal orientation is recommended but not required.

If a vapor processor is present, connect an additional coupler, meter and sample manifold to the exhaust of the vapor processor.  Additional guidance on the direct measurement of flow through ducts which may be applicable to the vapor processor exhaust, can be found in EPA Method 2A.

(2) Connect the temperature and pressure measuring devices and the HC analyzer sample lines and, if required, the sample return lines to the vent sampling manifold. Calibrate the measurement devices in accordance with section 6.

(3) If required, connect the couplers to the tank truck fuel and vapor return lines and connect the temperature and pressure measuring devices to these couplers. Calibrate the measurement devices in accordance with section 6.

(4) Request that the cargo tank operator identify the volume of gasoline to be transferred from the cargo tank using shipping manifests, load rack receipts, etc.  Instruct the cargo tank operator to gauge the storage tank(s) and confirm that adequate storage tank ullage is available to accept the full volume to be transferred from the cargo tank.  Individually record the initial gasoline inventory volumes in each storage tank.

(5) Instruct the cargo tank operator to connect tank truck fill and vapor return lines to the appropriate underground tank connections in accordance with the written procedure for the Phase I VRS.  Ensure that there is no conflict between the normal delivery procedures established by the cargo tank owner/operator and those established by the applicant for Phase I VRS certification.

(6) Check the cargo tank dome hatches, pressure relief valves and vapor return line connections with the combustible gas detector before and during the gasoline transfer.  Record any measurements above 100 % of the LEL (2.1 % as propane).

(7) Record the initial readings of all volume measuring devices installed for this test procedure.

(8) Begin the transfer of gasoline from the cargo tank to the GDF storage tank in accordance with cargo tank owner/operator established normal procedure.  Ensure that there is no conflict between the normal delivery procedures established by the cargo tank owner/operator and those established by the applicant for Phase I VRS certification.

(9) Hydrocarbon concentrations and temperature and pressure measurements shall be recorded using strip chart recorders for the entire time period of the gasoline transfer operation.  The volume measuring device readings are to be recorded at a minimum frequency of once every 15 seconds during the transfer.

(10) Record the barometric pressure and ambient temperature at the start and the end of the test.

(11) At the end of the gasoline transfer, disconnect the tank truck from the underground tank in accordance with manufacturers' instructions (normal procedure).  Instruct the cargo tank operator to gauge the tank and record the reading.  Individually record the gross volume of gasoline delivered to each storage tank.  This may be determined by the cargo tank operators shipping papers or from the pre- and post- delivery tank inventories determined by manual or automated tank gauging.

(12) Leave the storage tank vent, and if present, vapor processor (or vapor incinerator) testing apparatus in place.  Continue recording hydrocarbon concentrations, temperatures, pressure and gas meter readings at the storage tank vent and/or the exhaust of any vapor processor or vapor incinerator at a minimum frequency of once per 5-minute interval.  Continue recording data at this frequency for one hour after completion of the gasoline transfer or until the system returns to the conditions of pressure, HC concentration, and vapor processor (incinerator) and storage tank vent volumetric flow rates that were present just prior to the start of Phase I delivery operations.

(13) At the end of the post delivery monitoring period record final reading of each volume measuring device installed for this test procedure.

(14) Disconnect instrumentation from the vent(s) and if present, the vapor incinerator.

9.2 Test Point 2a (Vapor Incinerator inlet) and 2b (Vapor Incinerator exhaust)

9.2.1 General Sampling Parameters for Vapor Incinerators

Specific procedures are provided below for testing gasoline vapor incinerators due to the unique test procedure (EPA Method 2B, 40 CFR, Part 60, App.A) used to determine the exhaust volume for the vapor incinerator.

Other types of assist processors, e.g. carbon adsorption beds, refrigerated condensers, and chemically selective permeation membranes are tested by the more conventional hydrocarbon sampling and analytical procedures specified in previous sections.

During TP-201.1A testing continuous measurements shall be recorded for the following system parameters shown in hexagon outlines in Figure 1:

HC = Hydrocarbon Concentration at inlet and exhaust test points

CO = Carbon Monoxide Concentration at exhaust test point

$CO_2$ = Carbon Dioxide Concentration at exhaust test point

V = Volume at inlet test point

P = Pressure in meter at inlet test point

T = Temperature in meter at inlet test point

### 9.2.2 Incinerator Sampling Parameters

An evaluation of incinerator design and operating parameters shall be conducted to determine specific testing protocols. The evaluation shall include specifications for appropriate data collection time intervals and appropriate ranges or capacities for devices used to determine temperature, pressure, concentrations, and volume. The time intervals specified for data averaging or intermediate mass emission calculations shall be chosen to provide calculated estimates of incinerator mass emissions factors which can be shown to be accurate to $\pm$ 10% of the true emission factor, based on sound scientific and engineering principles. The concentration and volume measurements made at the incinerator inlet must be contemporaneous with the measurements of concentration made at the incinerator exhaust to produce an accurate result for the calculated exhaust volume. This is especially important during time periods when concentrations or volumetric flow rate are changing rapidly (e.g. cold start ups). The influence of instrument response times on the testers ability to identify contemporaneous data at the inlet and exhaust test points must also be evaluated.

Data for each parameter shall be collected and recorded for the appropriate time intervals determined as specified above. Collect and record incinerator data for all of the parameters required to make a determination of the incinerator exhaust volume as required by EPA Method 2B, 40 CFR, Part 60, App.A.

This test procedure also includes additional monitoring requirements for auxiliary fuel (if present) to expand the applicability of EPA Method 2B. Some vapor incinerators may use auxiliary fuel (typically natural gas, propane, or LPG) to accomplish faster ignition and more complete combustion of the gasoline vapors controlled by the incinerator. In this case it is necessary to quantify the additional incinerator exhaust volume

associated with the combustion of the auxiliary fuel. The parameters that must be monitored are defined below:

| | | |
|---|---|---|
| $V_{in}$ | = | total inlet volume processed by vapor incinerator (SCF) |
| $V_{fvs}$ | = | inlet volume of gasoline vapors from the facility vapor space, storage tanks and vapor recovery system (SCF) |
| $V_{af}$ | = | inlet volume of auxiliary fuel (SCF) |
| $V_{exh}$ | = | vapor incinerator exhaust volume (SCF) |
| $N$ | = | number of carbon atoms in each molecule of calibration gas for analyzers used to determine concentration of gasoline vapors at the incinerator inlet and exhaust (normally propane, $N = 3$) |
| $N_{af}$ | = | number of carbon atoms in each molecule of calibration gas for analyzers used to determine concentration of auxiliary fuel at the incinerator inlet |
| $[HC]_{fvs}$ | = | hydrocarbon concentration of inlet volume from the facility vapor space (volume fraction = volume % / $10^2$) |
| $[HC]_{af}$ | = | hydrocarbon concentration of auxiliary fuel (volume fraction = volume % / $10^2$) |
| $[HC]_{exh}$ | = | vapor incinerator outlet hydrocarbon concentration (volume fraction = ppm / $10^6$) |
| $[CO_2]$ | = | vapor incinerator outlet carbon dioxide concentration (volume fraction = ppm / $10^6$) |
| $[CO]$ | = | vapor incinerator outlet carbon monoxide concentration (volume fraction = ppm / $10^6$) |

9.2.3  Incinerator Inlet Sample Location

The vapor incinerator inlet sample and temperature and pressure measurements must be taken from a sample manifold attached to the inlet side of the volume meter which has been inserted at a break in the inlet line. The installation of test equipment shall not interfere with the normal operation of the vapor incinerator. The total volume of sample taken from the incinerator inlet for the purpose of hydrocarbon concentration measurement must be returned, unaltered, to the sample manifold. This is necessary in order to avoid the risk of any bias in the system pressure or incinerator mass emission caused by application of this test procedure.

9.2.4  Incinerator Exhaust Sample Location

The vapor incinerator exhaust sample must be taken from the exhaust stack down-stream of the burner far enough to permit complete mixing of the combustion gases. A sampling point which is at least eight stack diameters downstream of any flow disturbance, and two diameter upstream of any flow disturbance is desirable. Flow disturbances of concern include a bend, expansion, or contraction in the stack, the stack exhaust point, and the location of a visible flame.

If the "8 and 2 criteria" cannot be met, a sampling point which is at least two stack diameters downstream of any flow disturbance and one diameter upstream of any flow disturbance may be used. Any alternative sampling locations which do not meet these minimum criteria must be approved by the ARB Executive Officer on the basis of adequate justification, submitted by the applicant. This justification shall include analysis based on sound scientific and engineering principals, to demonstrate that an incinerator stack with sampling ports which meet the minimum criteria are not feasible for GDF installations of the certified VRS. In any event, the sample point shall be no less than one half diameter from the stack exit and one stack diameter above the high point of the visible flame and be at a point of maximum velocity head, normally the center or the stack.

(Further guidance on sampling locations for gaseous pollutant concentration measurement can be found in 40 CFR Pt.60 App. A, Meth. 1 and App. B, Spec. 2.)

Note that any use of temporary stack extensions or other apparatus installed solely for the purpose of source testing shall not be allowed if there is evidence indicating that the quantity or chemical structure of the incinerator emissions will be altered by the presence of such apparatus.

9.2.5    Incinerator Performance Specifications

The vapor incinerator shall be evaluated and tested to determine any performance specifications that are deemed necessary by the ARB Executive Officer to ensure that GDF installation of the certified VRS are operated in a manner consistent with the operation of the vapor incinerator during certification testing following TP-201.1A. The following performance specifications may warrant evaluation:

(1) a performance specification for time averaged hydrocarbon concentration (as propane) in the incinerator exhaust stream and

(2) a performance specification for time averaged carbon monoxide (CO) concentration in the incinerator exhaust stream and

(3) performance specifications for other critical incinerator operating parameters such as: maximum and minimum volumetric vapor processing rates, exhaust stack temperatures, vapor feed blower fan speed and inlet pressure etc.

The results of evaluation and testing of the system shall be documented in the certification test report and shall include:

(1) the identification of the critical incinerator operating parameters,

(2) the performance specifications for the critical incinerator operating parameters, and

(3) the specification of any necessary monitoring and alarm requirements for temperature, pressure, hydrocarbon and/or carbon monoxide concentration, feed blower operating parameters, and other critical incinerator operating parameters, indicating gauges, detection devices, and alarms.

9.3     Cargo Tank Fill and Vapor Return Line Test Points

These additional test points are not necessay to determine the emission factor test result using this test procedure.  However, the information may be deemed necessary by the ARB Executive Officer for the purpose of evaluating other aspects of the Phase I VRS.  The temperature and pressure of vapors in the return line are used to estimate the standard volume of vapors returned to the cargo tank based on the volume of gasoline transferred to the storage tank.  This estimation assumes a 1 to 1 volume ratio for the volume of vapor displaced from the storage tank to the volume of liquid transferrred to the storage tank (i.e. there is no significant change in vapor volume due to  vapor condensation or liquid evaporation during the transfer).

(1) If required, connect the couplers to the tank truck fuel and vapor return lines and connect the temperature and pressure measuring devices to these couplers. Calibrate the measurement devices in accordance with section 6.

(2) Temperature and pressure measurements shall be continuously recorded using strip chart recorders or manually recording at a minimum frequency of once each minute during the entire time period of the gasoline transfer operation.

9.4     General Sampling Parameters

During TP-201.1A testing periodic or continuous measurements shall be recorded for the following system parameters shown in hexagon outlines in Figure 1:

HC =   Hydrocarbon Concentration

CO =   Carbon Monoxide Concentration

$CO_2$    =   Carbon Dioxide Concentration

V       =   Volume

P       =   Pressure

T       =   Temperature

## 10. END OF TEST DAY PROCEDURES

These procedures are required at the end of each test day.

10.1 System Bias Checks: Conduct for all analyzers used that test day. Perform the sampling system bias check by alternately introducing zero gas and the calibration gas at the probe. Operate the system at the normal sampling rate and make no adjustments to the measurement system other than those necessary to achieve proper calibration gas flow rates through the sampling system to the gas analyzer.

The test run shall be considered invalid if the difference of zero or calibration gas measured for the bias check in section 10.1 and the zero or calibration gas bias check measured in section 8.3 exceeds ±5% of the range, as determined by equation 10.1.

$$\text{Bias} = \frac{(C_a - C_{fb})}{R} x100$$

Where:

$C_{fb}$ = analyzer response for the zero or upscale calibration gas for post run sampling system bias check

$C_a$ = analyzer response for the zero or upscale calibration for initial analyzer calibration

$R$ = analyzer range

## 11. CALCULATING RESULTS

Calculate mass emission factor results to the nearest 0.001 lb/kgal.

In this section, the term "vent" and the specified procedures for calculating results from vent data shall also apply to any assist processor exhaust with which such procedures are compatible. Procedures are also specified for incinerator type assist processors. Any assist processor which is incompatible with the application of these procedures shall not be certified until the compatibility requirements of the certification procedures are met.

11.1 Parameters

Figure 1 illustrates some parameters specified in the calculations. General parameters are listed below, other parameters are defined in the calculations or alternative procedures:

[HC]  =  hydrocarbon concentration
(volume fraction, i.e. ppm$_v$ / $10^6$ or Volume % / $10^2$)

V$_m$  =  metered volume of gases and vapors,

P  =  meter pressure, and

T  =  meter temperature.

For each Phase I gasoline transfer episode:

G  =  volume of gasoline transferred, and

t  =  elapsed time during gasoline transfer.

11.2  Subscripts

Subscripts shall be used to distinguish parameters and modes of measurement.

Subscripts are used to distinguish values for the same general parameter at differing test locations and times, e.g.:

P$_{(t,e,s)}$  =  value of parameter "P" at test point "t" for transfer episode "e" during the time interval "s".

Any or all of these subscripts may modify a parameter, and for consistency, subscripts will appear in the order (t,e,s) given above, e.g.:

P$_{(t,e)}$  =  value of parameter "P" at test point "t"; for transfer episode "e" and

P$_t$  =  value of parameter "P" at test point "t" for the entire test period.

11.3  Volume at Standard Conditions of Temperature and Pressure

Directly measured volumes (such as those directly measured for Test points 1, 2, and 2a) shall be standardized as follows:

$$V = V_m \times \left(\frac{528}{T}\right) \times \left[\frac{P_{bar} + \left(\frac{P}{13.6}\right)}{29.92}\right]$$

where:

$V$ = volume corrected to standard conditions ($ft^3$).

$V_m$ = measured volume ($ft^3$).

$P_{bar}$ = barometric pressure (in. Hg).

$P$ = meter pressure (in. water gauge).

$T$ = meter temperature ($^oR$).

## 11.4 Concentration

Each measured concentration of gas and vapor shall be corrected for any analyzer zero and/or span drifts and shall be expressed as a volume fraction (i.e. volume % / $10^2$ or ppm / $10^6$).

## 11.5 Mass

HC mass emissions are calculated as the product of a volume (std. cu. ft.), a HC volume fraction (cu. ft. HC / cu. ft.), and a mass density (Lb. HC / std. cu. ft. HC). If the volumetric flow rate at the test point does not vary significantly with time then the time averaged HC concentration can be multiplied by the total volume for the time period to obtain an accurate total hydrocarbon mass for the time period. However, if the volumetric flow rate at the test point varies significantly with time, then incremental masses must be calculated from incremental volume and time averaged concentrations for subintervals of short enough duration that the flow rate is essentially constant for the subinterval. The incremental masses calculated in this manner for each subinterval must then be summed over the entire time period for which the total mass is to be determined. This is most readily accomplished through the use of electronic data acquisition and manipulation to calculate and sum incremental masses representing time periods on the order of several seconds.

Masses are calculated using the following equation:

$$m_t = V_t \times [HC]_t \times \left[ \frac{MW}{385} \right]$$

where:

$m_t$ = mass determined at test point t (lb)

$V_t$ = volume determined at test point t corrected to standard conditions ($ft^3$).

$[HC]_t$ = hydrocarbon concentration of auxiliary fuel
(volume fraction = volume % / $10^2$ or ppm / $10^6$)

MW = molecular weight of HC analyzer calibration gas, e.g. 44 for propane (lb/lb-mole)

385 = standard volume (ft$^3$) of one lb-mole of ideal gas at standard temperature and pressure (528$^o$R and 29.92 in. Hg)

11.6 Volume Calculations

11.6.1 Volume for Test Points 1 and 2 (Vents and/or Assist Processor Exhaust)

This volume is directly measured and shall be standardized per section 11.2

11.6.2 Volume for Test Point 2b (Vapor Incinerator Exhaust)

The incinerator exhaust volume is calculated per EPA Method 2B, 40 CFR, Part 60, App.A. Note the possibility for simplifying assumptions described in Section 8.1.5.3

11.6.2.1 Preliminary Incinerator Outlet Volume Calculations

Before calculating the vapor incinerator outlet volume, calculate the following preliminary values:

(1) inlet volume from the facility vapor space (test point 4b)

Any inlet volume from the facility vapor space entering the vapor incinerator is directly measured and shall be standardized per Section 11.2.

(2) inlet volume of auxiliary fuel

If directly measured the inlet volume of auxiliary fuel entering the vapor incinerator shall be standardized per Section 11.2

(3) total inlet volume entering vapor incinerator

$$V_{in} = V_{fvs} + V_{af}$$

where:

$V_{in}$ = total inlet volume entering vapor incinerator (SCF)

$V_{fvs}$ = inlet volume from the facility vapor space (SCF)

$V_{af}$ = inlet volume of auxiliary fuel (SCF)

11.6.2.2 Inlet Hydrocarbon Concentration

The combined inlet hydrocarbon concentration of gasoline vapors and auxiliary fuel shall be calculated using the following equation

$$[HC]_{in} = \frac{\left[ \left( N_{fvs} \times [HC]_{fvs} \times V_{fvs} \right) + \left( N_{af} \times [HC]_{af} \times V_{af} \right) \right]}{V_{in}}$$

where:

$V_{in}$     =     total inlet volume entering vapor incinerator (SCF)

$[HC]_{in}$     =     combined hydrocarbon concentration at the vapor incinerator inlet (volume fraction)

$N$     =     number of carbon atoms in each molecule of calibration gas

$[HC]_{fvs}$     =     hydrocarbon concentration of vapors from the facility vapor space at the vapor incinerator inlet (volume fraction)

$[HC]_{af}$     =     hydrocarbon concentration of auxiliary fuel (volume fraction)

Note 1:
The equation presented above for the combined hydrocarbon concentration at the vapor incinerator inlet, $[HC]_{in,}$ is used when the hydrocarbon concentration of the auxiliary fuel, $[HC]_{af}$ ,is determined during certification testing using a hydrocarbon analyzer.  Simplifying assumptions, which produce acceptable accuracy for the incinerator exhaust mass, can be made when standard auxiliary fuels such as natural gas, propane or liquefied petroleum gas, are used.  The simplification involves the substitution of the carbon concentration of the auxiliary fuel for the terms $N_{af}$ x $[HC]_{af}$ in the equation above.  The carbon concentration (i.e. 1 x $[CH_4]$ + 2 x $[C_2H_6]$ + 3 x $[C_3H_8]$ + . . . ) can be determined from a chemical analysis of the auxiliary fuel which may be available from the auxiliary fuel supplier.

Note 2:
If no auxiliary fuel is used by the incinerator the equation for the inlet hydrocarbon concentration reduces to:

$$[HC]_{in} = N_{fvs} \times [HC]_{fvs}$$

11.6.2.3  Final Incinerator Exhaust Volume Calculations

Calculate the vapor incinerator exhaust volume using the following equation:

$$V_{exh} = \frac{V_{in} \times [HC]_{in}}{\left( N_{exh} \times [HC]_{exh} \right) + [CO_2] + [CO] - 0.0003}$$

where:

$V_{exh}$   =   vapor incinerator outlet volume (SCF)

$V_{in}$   =   total inlet volume entering vapor incinerator (SCF)

$[HC]_{in}$ =    combined hydrocarbon concentration at the vapor incinerator inlet
(volume fraction = % by volume $/10^2$)

$N_{exh}$   =   number of carbon atoms in each molecule of calibration gas for
the incinerator exhaust HC analyzer

$[HC]_{exh}$ =    vapor incinerator exhaust hydrocarbon concentration
(volume fraction = ppm $/10^6$)

$[CO_2]$   =   vapor incinerator outlet carbon dioxide concentration
(volume fraction = % by volume $/10^2$)

$[CO]$   =   vapor incinerator outlet carbon monoxide concentration
(volume fraction = ppm $/10^6$)

$0.0003$ =    assumed background concentration of $CO_2$
(volume fraction = ppm $/10^6$)

11.7  Mass Emission Factor

The mass emission factor is calculated from the total volume of gasoline transferred
from the cargo tank to the storage tank(s) and the HC mass emissions determined at
the tank vent(s) and if present at the vapor processor or vapor incinerator exhaust.
The calculation is performed as follows:

$$EF = \frac{(m_1 + m_2) \times 1000}{G}$$

where:

$EF$   =   the Phase I VRS mass emission factor determined during the test
(units of pound HC per thousand gallons of gasoline transferred)

$G$   =   the total volume of gasoline delivered to the storage tank(s) during the test
(units of gross gallons)

$m_1$   =   the mass emissions through the tank vent(s)
(units of pounds HC as propane)

$m_2$   =   the mass emissions through the vapor processor or vapor incinerator exhaust
(units of pounds HC as propane)

11.8 Volume of Vapor Returned to Cargo Tank Through Phase I Vapor Return Line

The volume for the vapor return line test point is not necessary for the emission factor determination for which this test procedure is designed. Further discussion on the determination of this parameter is included in TP-201.1.

The volume for the vapor return line test point is not directly measured and shall be calculated as follows:

$$V_{vr} = \left[ \left( \frac{G}{7.481} \right) \times \left( \frac{528}{T} \right) \times \left( \frac{P_{bar} + \dfrac{P_m}{13.6}}{29.92} \right) \right] - V_1 - V_{2\,or\,2a}$$

where:

$V_{vr}$ = vapor return line volume corrected to standard conditions.

$V_1$ = vent line volume corrected to standard conditions.

$V_{2\,or\,2a}$ = volume entering vapor processor or vapor incinerator corrected to standard conditions. (Note: The inlet volume to a vapor processor is not necessary to determine the emission factor for which this test procedure is applicable. Procedures for measuring or estimating the inlet volume to a vapor processor are not presented in this test procedure. An air mass balance based on the volume of air exiting the processor and the concentration of HC in the processor inlet and exhaust streams may provide an adequate estimate of the vapor processor inlet volume.)

$G$ = gallons of gasoline transfered.

$P_{bar}$ = barometric pressure (in. Hg).

$P_m$ = final pressure in vapor return line (in. water gauge).

$T$ = average temperature of gas stream in vapor return line ($^o$R).

## 12. REPORTING RESULTS

Written data records must be kept during testing and persons in control of such data must be documented in a chain of custody record. Written data records must contain all information used to calculate and report final results. All results must be written and submitted on acceptable media as specified by the the ARB Executive Officer on a case-by-case basis for each report.

In cases of conflict between hard copy and electronic format, the hard copy shall be presumed correct, unless the ARB Executive Officer specifies otherwise in writting.

## 13. ALTERNATIVE TEST PROCEDURES

This procedure shall be conducted as specified. Modifications to this test procedure shall not be used to determine compliance unless prior written approval has been obtained from the ARB Executive Officer, pursuant to Section 14 of Certification Procedure CP-201.

## 14. REFERENCES

This section is reserved for future specification.

## 15. EXAMPLE FIGURES AND FORMS

15.1  Figures

Each figure provides an illustration of test implements which conform to the requirements of this test procedure; other test implements which so conform are acceptable, too. Any specifications or dimensions provided in the figures are for example only, unless such specifications or dimensions are provided as requirements in the text of this or some other required test procedure.

Figures depicting the test apparatus used at the Phase I vapor return line are presented in TP-201.1

**Note:**
The following figures focus on volume measurements. Further details regarding hydrocarbon concentration measurements are provided in the figures for Phase II testing in TP-201.2; which may be appropriate if necessary modifications are made to address the differences between Phase I and Phase II testing procedures.

**Figure 1**
**Test Locations**

**Figure 2**
**Vent Test Point 3**
**Single Vent (Volume Measurement)**

**Figure 3**
**Vent Test Point 3**
**Vents Connected by Manifold (Volume Measurement)**
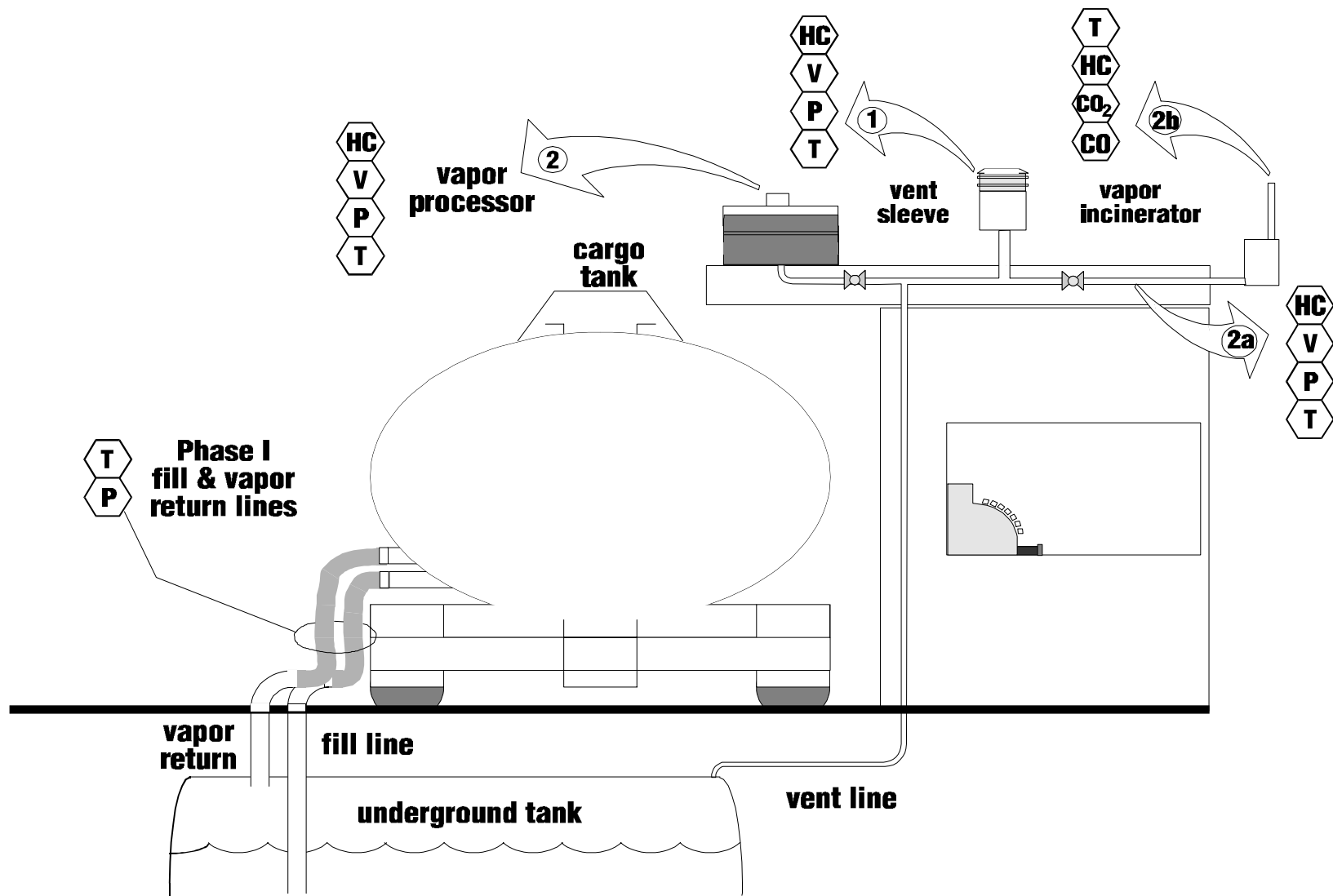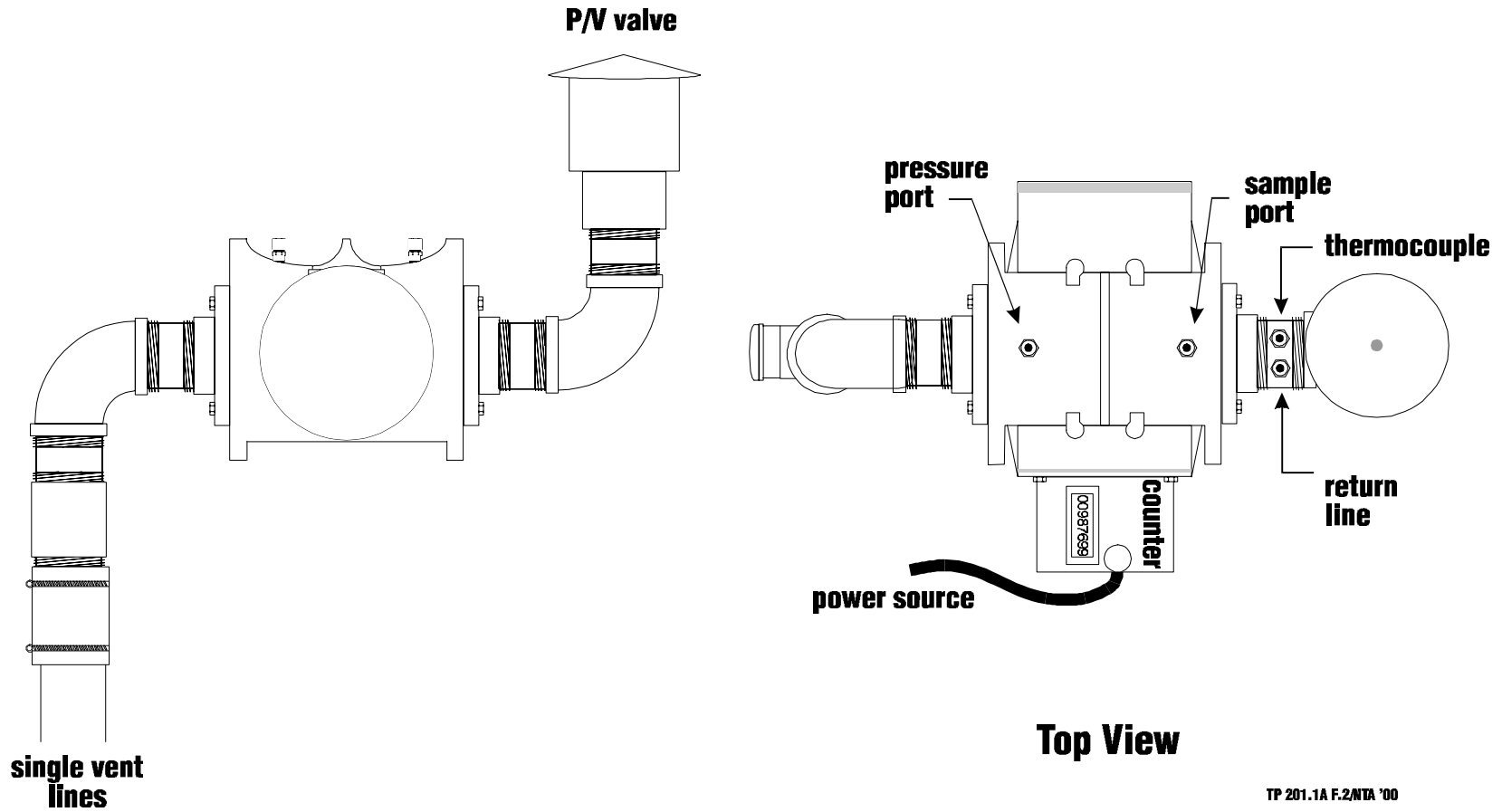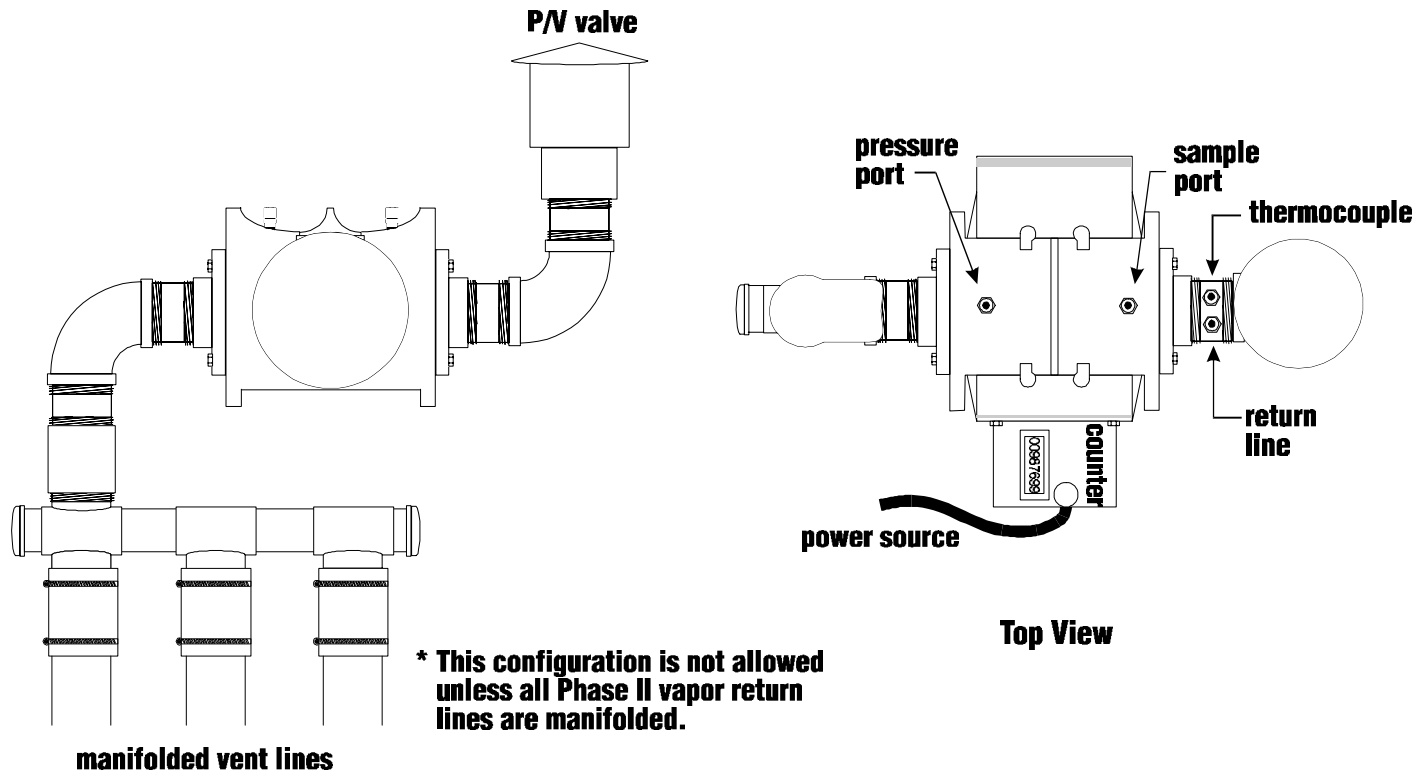
# Figure 1
# Test Locations

**Figure 2**
**Test Point 3, Single Vent (Volume Measurement)**



P/V valve

pressure
port

sample
port

thermocouple

counter

00987699

return
line

power source

single vent
lines

**Top View**

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# Figure 3
## Test Point 3, Vents Connected by Manifold (Volume Measurement)

**P/V valve**

**manifolded vent lines**

\* This configuration is not allowed unless all Phase II vapor return lines are manifolded.

**pressure port**

**sample port**

**thermocouple**

**return line**

**counter**

**power source**

**Top View**

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