

California Environmental Protection Agency



Vapor Recovery Test Procedure

TP - 201.1A

**DETERMINATION OF EFFICIENCY OF
PHASE I VAPOR RECOVERY SYSTEMS OF
DISPENSING FACILITIES WITH
ASSIST PROCESSORS**

Adopted: April 12, 1996
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**California Environmental Protection Agency
Air Resources Board
Vapor Recovery Test Procedure**

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**Determination of Efficiency of
Phase I Vapor Recovery Systems of
Dispensing Facilities with
Assist Processors**

1 APPLICABILITY

Definitions common to all certification and test procedures are in:

**D-200 Definitions for
Certification Procedures and
Test Procedures for
Vapor Recovery Systems**

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.

This procedure applies when the operation of an assist processor precludes the application of TP-201.1.

2 PRINCIPLE AND SUMMARY OF TEST PROCEDURE

This is a mass balance test procedure. TP-201.1 is a volumetric test procedure.

During a fuel delivery, the volume of gasoline delivered from the tank truck to the underground tank is recorded and the concentration of gasoline vapor returning to the tank truck is measured. The weight of gasoline vapor discharged from the vent of the underground tank and, if applicable, from the vent of the vacuum assisted secondary processing unit during the same period is determined. The efficiency of control is calculated from these determinations.

3 BIASES AND INTERFERENCES

3.1 Bulk Delivery Vapor Leaks

Any vapor leak exceeding 21,000 ppm (as propane), during the gasoline bulk delivery, precludes the use of this method.

3.2 Cargo Tank Performance

Gasoline cargo tanks exceeding the allowable daily performance standards preclude the use of this method.

4 SENSITIVITY, RANGE, AND PRECISION

The minimum readability of the pressure gauges shall be 0.1 inches of water column.

The minimum accuracy of the pressure gauges shall be 2 % of full scale.

5 EQUIPMENT AND SUPPLIES

(1) For each vent, including restricted vents and vents of any processing units, a positive displacement meter equipped with an automatic data gathering system that can differentiate direction of flow and records volume vented in such a manner that this data can be correlated with simultaneously recorded hydrocarbon concentration data and a manifold for meter outlet with taps for an HC analyzer, a thermocouple, and a pressure sensor.

Use rotary type positive displacement meter(s) with a back pressure limit (BPL) less than:

1.10 inches water column at a flowrate of 3,000 CFH down to
0.05 inches water column at a flowrate of 30.0 CFH.

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

- (1) taps on the inlet side for
 - (a) a thermocouple with a range of 0 to 150 °F and
 - (b) a pressure gauge with a range providing absolute pressure readings within 10 to 90% of the range (more than one gauge shall be used, if necessary) and
- (2) taps on the inlet and outlet sides for a differential pressure gauge with a range of 0 to < 2x BPL (i.e. full scale shall be less than twice the back pressure limit).

Wherever in this procedure the use of a "thermocouple" is specified, another

equally effective temperature sensing device may alternatively be used.

- (3) Coupling for the vent vapor line to connect the gas meter. Coupling to be sized for a minimum pressure drop.
- (4) Coupling for the vent of the vacuum assisted secondary processing unit to connect the gas meter. Coupling to be sized so as to create no significant additional pressure drop on the system.
- (5) Coupling for tank truck vapor return line with thermocouple, manometer, and HC analyzer taps. Coupling to be the same diameter as the vapor return line.

Wherever in this procedure the use of a "manometer" is specified, another equally effective pressure sensing device may alternatively be used.

- (6) Coupling for tank truck fuel drop line with thermocouple tap. Coupling to be the same diameter as the fuel line.
- (7) Two (2) hydrocarbon analyzers (FID or equivalent approved by the ARB Executive Officer) with recorders and with a capability of measuring total gasoline vapor concentration of 100 percent as propane. Both analyzers to be of same make and model.
- (8) Three (3) flexible thermocouples or thermistors (0-150°F) with a recorder system.
- (9) Explosimeter
- (10) Barometer
- (11) Three manometers or other pressure sensing devices capable of measuring zero to ten inches of water.
- (12) Thermometer
- (13) Analyzers for CO and CO₂ as needed for performance of incinerator procedures per § 13.2.

6 CALIBRATION PROCEDURE

A record of all calibrations shall be maintained.

6.1 Analyzers

Follow the manufacturer's instructions concerning warm-up time and adjustments. On each test day prior to testing, zero the analyzer with a zero gas and span with a known concentration of calibration gas at a level near the highest concentration expected. Perform an intermediate zero and span calibration approximately 2 hours after the initial calibration and at any time a calibration drift is evident. Check for zero and span calibration drift at the end of the test period. All calibrations and adjustments shall be documented.

6.2 Volume Meters

Meters shall be calibrated on an annual basis.

6.3 Pressure Transducers

Calibrate pressure transducers prior to testing and immediately following the test period with a static pressure calibrator for a range of -3 to +3 inches water or appropriate range of operation.

6.4 Temperature Transducers

Calibrate temperature transducers every six months using ambient air, the temperature of which is determined by a NIST traceable mercury-glass thermometer.

7 PRE-TEST PROTOCOL

7.1 Location of Test Site

Prototype systems will be located within 100 miles of Sacramento for testing. Other locations may be accepted at the discretion of the ARB Executive Officer.

7.2 Specification of Test, Challenge, and Failure Modes

The specification of test, challenge, and failure modes such as the number of liquid transfer episodes, volume and volumetric rate of liquid transfer, storage tank volumes, etc. shall be done according to the principles of CP-201 § 5 for the testing and evaluation of vapor recovery equipment.

7.3 System and Facility Preparation

System equipment and components shall be completely operational and any storage tanks involved in the test shall be filled to the appropriate volume a minimum of 24 hours prior to the scheduled test.

8 TEST PROCEDURE

The facility and system shall be prepared to operate according to any specified test, challenge, and failure modes.

In this section, the term "vent" and the specified procedures for testing vents shall also apply to any assist processor with which such procedures are compatible. Procedures are 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.

8.1 Test Locations

8.1.1 Test Point 1 (Vapor Return) and Test Point 2 (Vent and/or Assist Processor)

- (1) The test for underground fueling will be conducted under, as closely as feasible, normal conditions for the station. Normal conditions will include delivery time and station operating conditions.
- (2) Connect manifold to outlet of positive displacement meter and resulting to system vent of underground tank using the coupler or if the vent has a restriction, remove the restriction and connect the coupler, manifold and the meter system to the vent and connect restrictor to manifold outlet. If appropriate, connect another manifold and meter to the vent of the vacuum assisted secondary processing unit, or, if appropriate, use E.P.A. methods cross-referenced in D-200. Use the test procedures set forth in § 13.2 for determination of incinerator emissions.
- (3) Connect the HC analyzer with recorder, thermocouple and manometer to the vent manifold. Calibrate the equipment in accordance with § 6.
- (4) Connect the couplers to the tank truck fuel and vapor return lines.
- (5) Connect an HC analyzer with a recorder, a manometer and a thermocouple to the taps on the coupler on the vapor return line. Connect thermocouple to the tap on the coupler on the fuel line.

- (6) Connect tank truck fuel and vapor return lines to appropriate underground tank lines in accordance with written procedure for the system.
- (7) Check the tank truck and all vapor return line connections for a tight seal before and during the test with the explosimeter.
- (8) Record the initial reading of gas meter(s).
- (9) Start fueling of the underground tank in accordance with manufacturers' established normal procedure.
- (10) Hydrocarbon concentrations, temperature and pressure measurements shall be recorded using stripchart recorders within the first 15 seconds of the unloading period. The gas meter reading is to be taken at 60 second intervals.
- (11) Record at the start and the end of the test barometric pressure and ambient temperature.
- (12) At the end of the drop, disconnect the tank truck from the underground tank in accordance with manufacturers' instructions (normal procedure). Leave the underground tank vent instrumentation in place.
- (13) Continue recording hydrocarbon concentrations, temperatures, pressure and gas meter readings at the underground tank vent and/or the exhaust of any processing unit at 20-minute intervals. Do this for one hour or until the system returns to normal conditions as specified by the manufacturer for secondary systems.
- (14) Disconnect instrumentation from the vent(s).
- (15) Record volume of gasoline that is delivered.
- (16) Record final reading of gas meter.

8.1.2 Test Point 3 (Vapor Incinerator)

Specific procedures are provided below for testing incinerators due to the complexity of such testing. Other types of assist processors, e.g. adsorbers and condensers, are tested by the more conventional hydrocarbon sampling and analytical procedures specified in other sections.

8.1.2.1 Incinerator Performance Specifications

Incinerator emissions shall be determined using the procedures of EPA M-2B, as outlined in this procedure, including any additional requirements provided below.

Any incinerator shall be evaluated and tested to establish:

- (1) a performance specification for carbon monoxide (CO) emissions and
- (2) performance specifications for other critical incinerator operating parameters per CP-201 § 3 which requires, in part:

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

- (1) the identification of such critical system operating parameters,
- (2) the performance specifications for such critical system operating parameters, and
- (3) the specification of requirements for indicating gauges, detection devices, and alarms.

Challenge and failure mode testing shall be performed to establish system sensitivity to and performance specifications for the following variables:

- (1) storage tank ullage at start of liquid transfer
- (2) volume and volumetric rate of liquid transfer
- (3) number of nozzles in simultaneous use and
- (4) individual nozzle dispensing rates.

Compliance with the incinerator performance specifications shall be determined per CP-201, as applicable.

8.1.2.2 Incinerator Sampling Parameters

A preliminary evaluation of incinerator operation shall be conducted to determine data collection intervals for time and parameter magnitude for each parameter. Such intervals shall be chosen to provide calculated estimates of incinerator mass emissions factors which differ by no more than $\pm 10\%$ from actual, based on engineering judgment.

Data for each parameter shall be collected on such intervals.

Collect and record incinerator data for all of the parameters required to make a determination per EPA M-2B, with additional requirements for auxiliary fuel to expand the applicability of EPA M-2B:

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

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

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

V_{out} = vapor incinerator outlet volume (SCF)

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

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

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

$[HC]_{out}$ = vapor incinerator outlet hydrocarbon concentration (ppm)

$[CO_2]$ = vapor incinerator outlet carbon dioxide concentration (ppm)

$[CO]$ = vapor incinerator outlet carbon monoxide concentration (ppm)

Based on an engineering evaluation of a subject incinerator, the ARB Executive Officer may allow simplifying assumptions to be used in place of actual data collection. For example, for auxiliary fuel, it is often possible to use data from the fuel supplier.

8.1.2.3 Incinerator Visual Inspection

Visual Inspection. Any visible emissions except for steam, from vapor incinerators are an indication of poor combustion. An incinerator shall not emit air contaminants (not including moisture) in such a manner that the opacity of the emission is greater than 10 percent for a period or periods aggregating more than one minute in any 60 consecutive minutes; or greater than 40 percent opacity at any time. Should such visible emissions from the exhaust be detected, the control system is unacceptable and the problem must be corrected and an application made to the ARB Executive Officer for reconsideration for certification.

8.1.2.4 Incinerator Exhaust Sample Location

The vapor incinerator exhaust sample must be taken from the exhaust stack downstream of the burner far enough to permit complete mixing of the combustion gases. For most sources, this point is at least eight stack diameters downstream of any interference and two diameters upstream of the stack exit. There are many cases where these conditions cannot be met. The sample point shall be no less than one stack diameter from the stack exit and one stack diameter above the high point of the flame and be at a point of maximum velocity head. Vapor incinerator emissions shall be monitored for a 24 hour period beginning at the time of the first dispensing period.

8.1.2.5 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. Unaltered sample shall be returned to the sample manifold.

8.2 General Sampling Parameters

The test team shall collect and record frequent periodic or continuous measurements of the following sample gas variables ~~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

9 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

Calibration Gases

Calibration gases are classified into three types:

(1) Standard Reference Materials

These are primary standards to which all other standards shall be traceable. For any substance for which no standard reference material is obtainable, a calibration gas of the highest level of accuracy and precision obtainable shall qualify as a standard reference material, subject to approval by the ARB Executive Officer.

A standard reference material, which normally is kept at a main laboratory, qualifies as an intermediate standard and as a working standard, too.

(2) Intermediate Standards

These are secondary standards which shall be assayed versus the corresponding NIST-SRM once every six months with a concentration difference which is no more than one percent of the results for the NIST-SRM. An intermediate standard container which does not meet its assay requirement shall be taken out of service. To re-enter service, the intermediate standard container shall be recharged and meet its assay requirement.

An intermediate standard, which normally is kept at a branch laboratory or a shop, qualifies as a working standard, too.

(3) Working Standards

These are tertiary standards which shall be assayed versus the corresponding intermediate standard before every test with a concentration difference which is no more than one percent of the results for the intermediate standard. A working standard container which does not meet its assay requirement shall be taken out of service. To re-enter service, the working standard container shall be recharged and meet its assay requirement.

A working standard normally serves for field calibration and testing.

All calibrations shall be performed with a calibration gas of at least working standard quality. Any cylinder is to be recharged or taken out of service when the cylinder pressure drops to 10 percent of the original pressure.

Information on calibration gas containers shall be entered into a permanent log identifying each container by serial number. Sufficient information shall be maintained to allow a determination of the compliance status of each calibration gas per these requirements; such information shall include for each container, but not be limited to each:

- (1) date put in service,
- (2) assay result, and
- (3) date taken out of service.

10 RECORDING DATA

This section is reserved for future specification.

11 CALCULATING RESULTS

Note: In addition to other required calculations, vapor recovery system test results shall be calculated in units of pounds of hydrocarbon emitted per thousand gallons of fuel transferred for any results which are expressible in such units.

Calculate all efficiency results to the nearest 0.1%.

In this section, the term "vent" and the specified procedures for calculating results from vent data shall also apply to any assist processor 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 General Nomenclature

11.1.1 Parameters

General parameters are listed below, other parameters are defined in the calculations or alternative procedures:

[HC] = hydrocarbon concentration (volume fraction),

V_m = measured volume of gases and vapors,

P = pressure, and

T = temperature.

For any dispensing episode:

D = volume of liquid dispensed, and

Δt = elapsed time of dispensing.

11.1.2 Subscripts

Subscripts shall be used to distinguish parameters and modes of measurement, e.g.:

$P_{(s,e,t)}$ = value of parameter "P" for subinterval "s" of dispensing episode "e" at test point "t".

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

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

P_t = value of parameter "P" for an entire test at test point "t".

11.2 Standardization and Calibration of Parameters

Volume Standardization

Directly measured volumes (such as those directly measured for Test Points 2 and 3) shall be standardized as follows:

$$V = V_m \left(\frac{528}{T} \right) \left(\frac{P_b + \left(\frac{P}{13.6} \right)}{29.92} \right)$$

where:

V = volume corrected to standard conditions (ft³).

V_m = measured volume (ft³).

P_b = barometric pressure (in. Hg).

P = differential pressure in sample line (in. water gauge).

T = temperature of gas stream (°R).

11.2.2 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. % or ppm).

11.2.3 Mass

Masses shall be calculated from calibration data and measurements as follows:

$$m = \left(\frac{MW}{385} \right) \times [HC] \times V$$

where:

m = mass (lb_m)

MW = molecular weight of calibration gas (lb_m/lb-mole)

385 = standard volume of one lb-mole at 528°R and 29.92 in. Hg

Note for manual data reduction: In general, [HC]_(e,t) will stabilize to a steady value during a dispensing interval. If this is not the case, break V_(e,t) into "s" subintervals and calculate:

$$m_{(e,t)} = \left(\frac{MW}{385} \right) \times \sum_1^s ([HC]_{(s,e,t)} \times V_{(s,e,t)})$$

11.3 Volume Calculations

11.3.1 Volume for Test Point 1 (Vapor Return)

The volume for Test Point 1 is not directly measured and shall be calculated as follows:

$$V_1 = (0.1337 \text{ G}) \left(\frac{528}{T} \right) \left(\frac{P_b + \left(\frac{P}{13.6} \right)}{29.92} \right)$$

where:

V₁ = volume corrected to standard conditions.

G = gallons of gasoline loaded.

P_b = barometric pressure (in. Hg).

P = final pressure in storage or delivery tank (in. water gauge).

T = temperature of gas stream (°R).

11.3.2 Volume for Test Point 2 (Vent and/or Assist Processor)

This volume is directly measured and shall be standardized per § 11.2.1.

11.3.3 Volume for Test Point 3 (Incinerator)

Note the possibility for simplifying assumptions described in § 8.1.2.2.

11.3.3.1 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

Any inlet volume from the facility vapor space entering the vapor incinerator is directly measured and shall be standardized per § 11.2.1.

(2) inlet volume of auxiliary fuel

Any inlet volume from auxiliary fuel entering the vapor incinerator is directly measured and shall be standardized per § 11.2.1.

(3) total inlet volume entering vapor incinerator

$$V_{in} = V_{facility} + V_{fuel}$$

where:

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

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

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

(4) inlet hydrocarbon concentration

$$[HC]_{in} = \frac{(N [HC]_{facility} V_{facility}) + (N [HC]_{fuel} V_{fuel})}{V_{in}}$$

where:

$$[HC]_{in} = \text{inlet hydrocarbon concentration entering vapor incinerator (ppm)}$$

- N = number of carbon atoms in each molecule of calibration gas
- [HC]_{facility} = hydrocarbon concentration of inlet volume from the facility vapor space (volume fraction)
- [HC]_{fuel} = hydrocarbon concentration of auxiliary fuel (volume fraction)

11.3.3.2 Final Incinerator Outlet Volume Calculations

Calculate any vapor incinerator outlet volume using the following equation:

$$V_{\text{out}} = V_{\text{in}} \left(\frac{[\text{HC}]_{\text{in}}}{N [\text{HC}]_{\text{out}} + [\text{CO}_2] + [\text{CO}] - 300} \right)$$

where:

- V_{out} = vapor incinerator outlet volume (SCF)
- N = number of carbon atoms in each molecule of calibration gas
- [HC]_{out} = vapor incinerator outlet hydrocarbon concentration (ppm)
- [CO₂] = vapor incinerator outlet carbon dioxide concentration (ppm)
- [CO] = vapor incinerator outlet carbon monoxide concentration (ppm)
- 300 = assumed background concentration (ppm) of CO₂

11.4 Efficiency

The efficiency is based on the vapor mass flux through three significant areas:

- m₍₁₎ = the mass flux through the vapor return line;
- m₍₂₎ = the mass flux through the vent and/or assist processor; and
- m₍₃₎ = the mass flux through the vapor incinerator.

The percent vapor recovery efficiency is calculated as follows:

$$\% \text{ vapor recovery efficiency} = \frac{m_{(1)} - [m_{(2)} + m_{(3)}]}{m_{(1)}} \times 100\%$$

12 REPORTING RESULTS

Note: In addition to other required results, vapor recovery system test results shall be reported in units of pounds of hydrocarbon emitted per thousand gallons of fuel transferred for any results which are expressible in such units.

This section is reserved for future specification.

13 ALTERNATIVE TEST PROCEDURES

Test procedures, other than specified above, shall only be used if prior written approval is obtained from the ARB Executive Officer. In order to secure the ARB Executive Officer's approval of an alternative test procedure, the applicant is responsible for demonstrating to the ARB Executive Officer's satisfaction that the alternative test procedure is equivalent to this test procedure.

- (1) Such approval shall be granted on a case-by-case basis only. Because of the evolving nature of technology and procedures for vapor recovery systems, such approval shall not be granted in subsequent cases without a new request for approval and a new demonstration of equivalency.
- (2) Documentation of any such approvals, demonstrations, and approvals shall be maintained in the ARB Executive Officer's files and shall be made available upon request.

14 REFERENCES

This section is reserved for future specification.

15 EXAMPLE FIGURES AND FORMS

15.1 Figures

Each figure provides an illustration of an implementation which conforms to the requirements of this test procedure; other implementations 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.

Figure 1

Test Locations

Figure 2 Storage Tank Test Point 1 Storage Tank Pressure Assembly

Note:

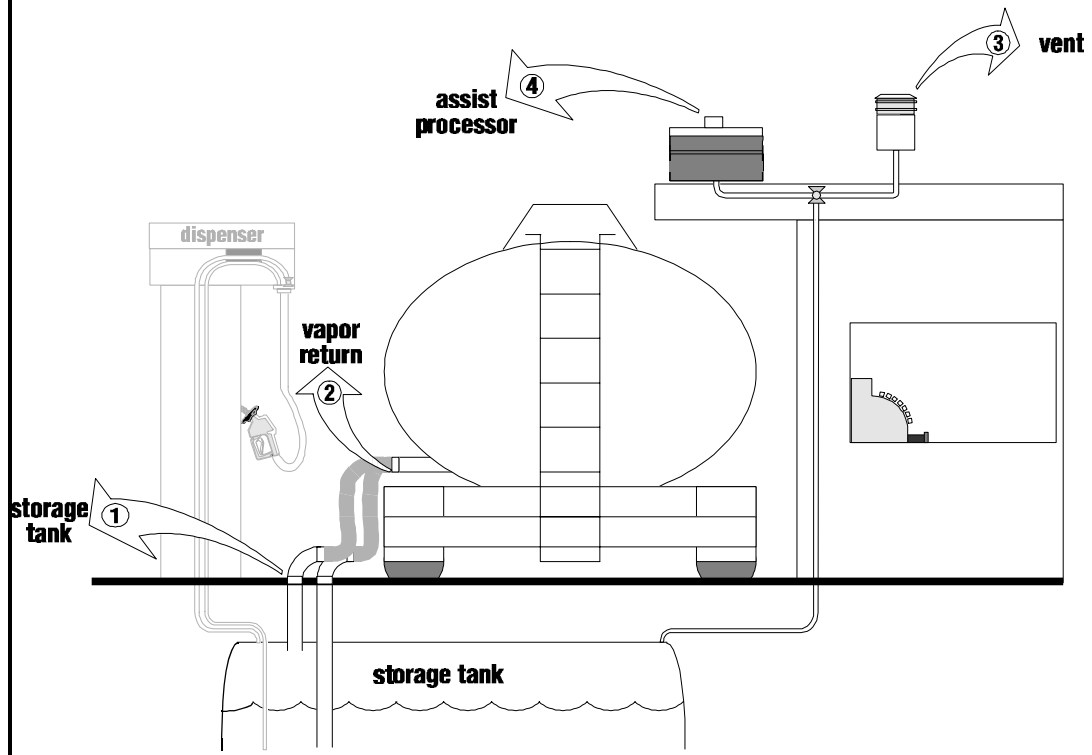
The following figures focus on volume measurements. Further details regarding hydrocarbon concentration measurements are provided in the figures for Phase II testing in TP-201.2; which can be viewed as if appropriate modifications, in consideration of the differences between Phase I and Phase II testing, have been made.

Figure 3 Vapor Return Test Point 2 Cargo Tank Pressure Assembly

Figure 4 Vent Test Point 3 Single Vent (Volume Measurement)

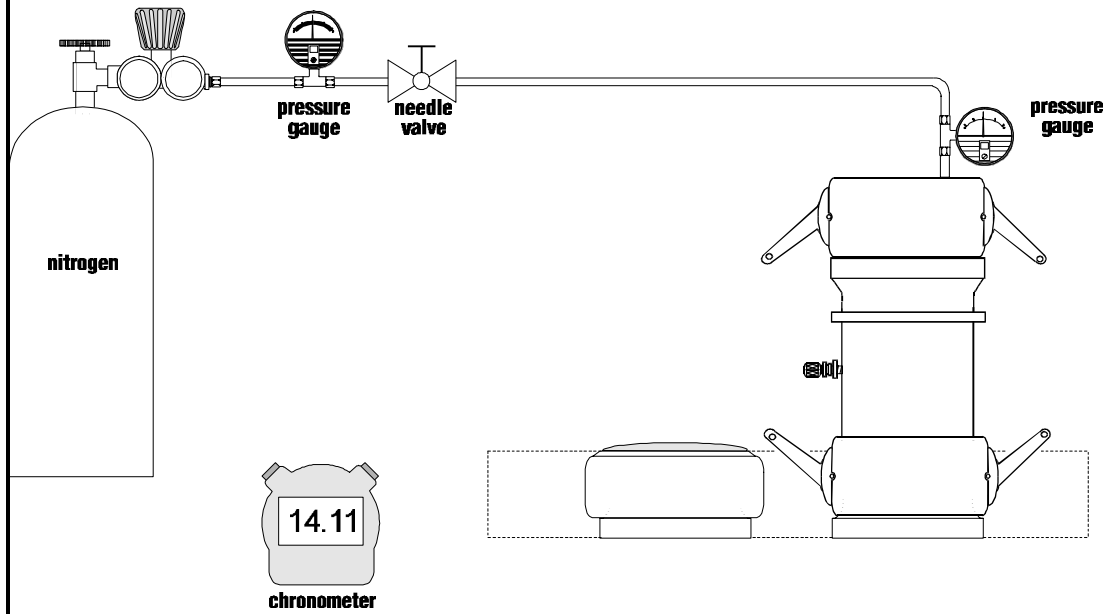
Figure 5 Vent Test Point 3 Manifolded Vents (Volume Measurement)

**FIGURE 1
Test Locations**



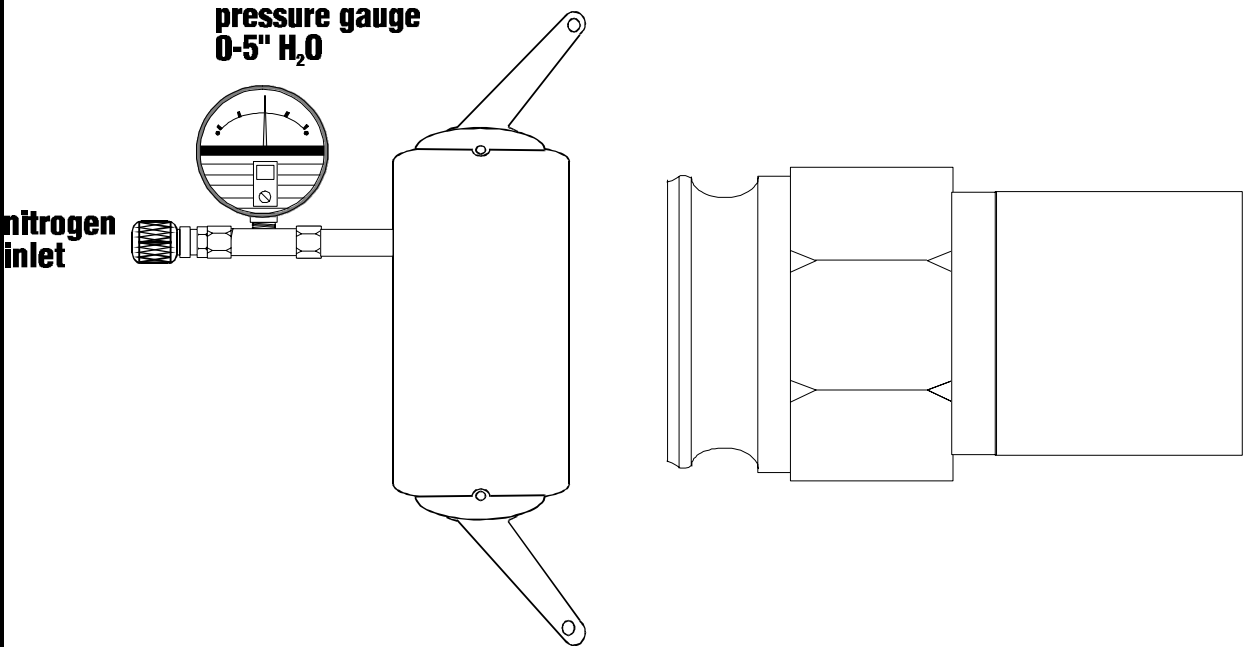
TP 201.1A F.1/B. CORDOVA '95

FIGURE 2
Storage Tank Test Location 1
Storage Tank Pressure Assembly



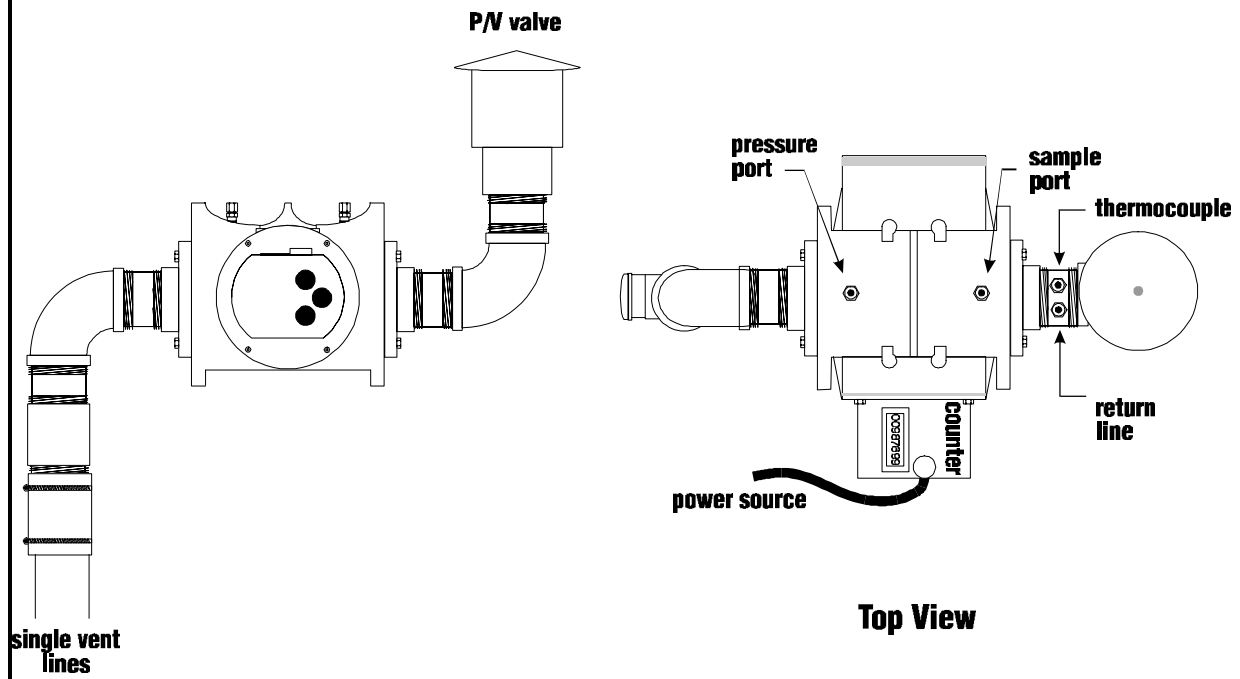
TP 201.1A F.2/B. CORDOVA '95

FIGURE 3
Vapor Return Test Location 2
Cargo Tank Pressure Assembly



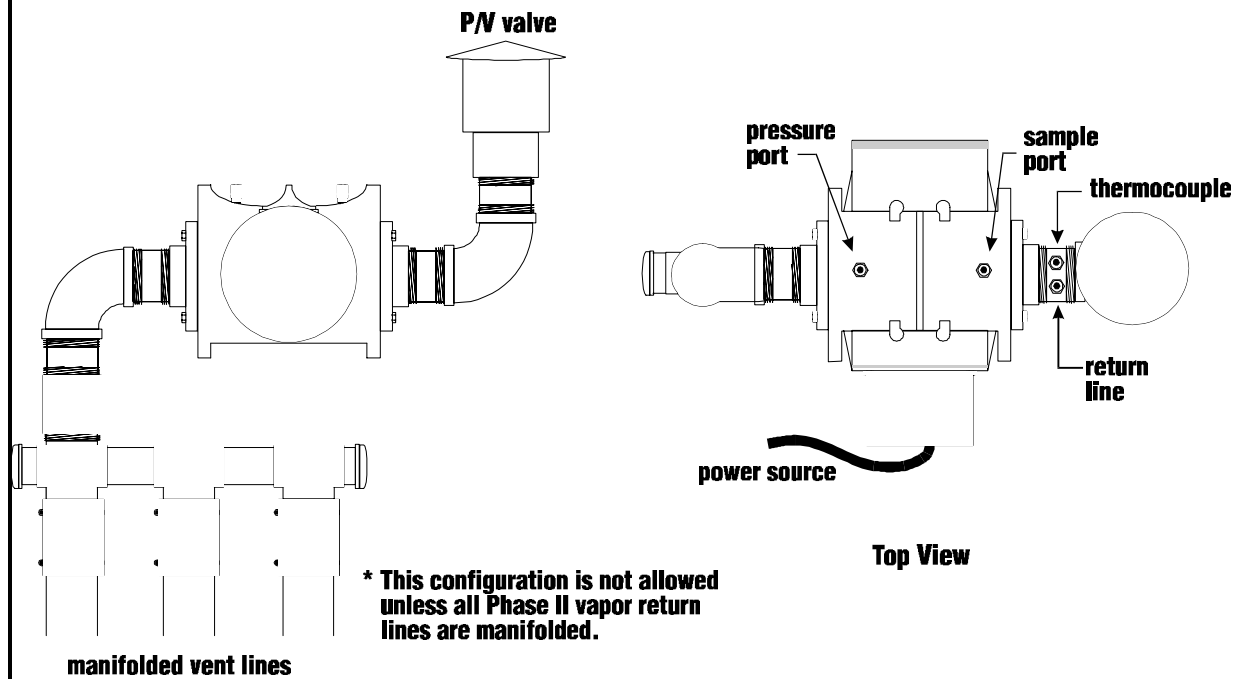
TP 201.1A F.3/ B. CORDOVA '95

FIGURE 4
Vent Test Location 3
Single Vent (Volume Measurement)



TP 201.1A F4/ B. CORDOVA '95

FIGURE 5
Vent Test Location 3
Manifolded Vents (Volume Measurement)



TP 201.1A F.5/ B. CORDOVA '95