

California Environmental Protection Agency



Vapor Recovery Test Procedure

TP-203.1

Determination of Emission Factor of
Vapor Recovery Systems of
Terminals

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**California Environmental Protection Agency
Air Resources Board**

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Vapor Recovery Systems of
Terminals**

1 APPLICABILITY

A set of definitions common to all certification and test procedures is 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.

The following test procedures shall be for determining the efficiency of vapor recovery systems controlling gasoline vapors emitted during the filling of fixed roof gasoline storage tanks and during the loading of cargo tanks at terminals.

2 PRINCIPLE AND SUMMARY OF TEST PROCEDURE

2.1 Principle

At a terminal (during loadings of cargo tanks and filling of fixed roof storage tanks connected to the vapor recovery system), all probable and practically accessible points of emission shall be checked for vapor leaks. The volume of gasoline delivered from the terminal storage tanks to the cargo tanks is recorded, the volume of gasoline delivered to any fixed roof storage tank(s) is recorded (as required), and the mass of the hydrocarbon vapors emitted from the system are measured. The mass emission of hydrocarbons is calculated from these determinations and is expressed in units of pounds per 1,000 gallons.

2.2 Summary

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

EPA Method 2A

EPA Method 2B

EPA Method 18

EPA Method 25A

EPA Method 25B

2.3 Special Considerations

2.3.1 With prior written approval of the ARB Executive officer, careful visual reading and manual recording of data is acceptable in lieu of automatic sensing and recording procedures.

2.3.2 If a determination is required for the fractional concentration of non-methane hydrocarbons or if a special molecular weight determination is required, integrated bag sampling and GC/FID analysis using EPA Method 18 shall be included in the procedures. The bag sample shall be obtained by continuous sampling at a fixed rate over (an) operating cycle(s) of the processing unit such that the sample bag is not completely filled at the end of the sample period(s).

If only the fractional concentration of non-methane hydrocarbons is required, then a NDIR calibrated to provide separate methane and non-methane values can be used.

2.3.3 Venting shall only be allowed during testing if all emissions of hydrocarbons from absolutely every vent source can be reliably quantified and included in emissions calculations; otherwise:

(1) If the vapor recovery system includes an incinerator-type processing unit, then that unit's exhaust is the only allowable emissions point.

(2) Processing units which do not utilize an incinerator may have more than one exhaust. If so, each exhaust must be equipped so that mass emissions can be quantified. Any such exhaust(s) then become the only allowable emission point(s).

3 BIASES AND INTERFERENCES

This section is reserved for future specification.

4 SENSITIVITY, RANGE, AND PRECISION

This section is reserved for future specification.

5 EQUIPMENT

5.1 Transfer to Cargo Tank from Terminal

- 5.1.1 Positive displacement gas meter(s) or turbine meters shall be sized to avoid adverse effects on the vapor recovery system.

Use rotary type positive displacement meter(s) or turbine meter(s), meeting the requirements of EPA Method 2A, and 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 accomodating 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 appropriate to allow detection of a pressure drop greater than the BPL.

- 5.1.2 Coupler for attaching the flowmeter to the exhaust(s) of the processing unit(s) with the thermocouple, pressure, and HC analyzer taps.

- 5.1.3 Coupler for the vapor vent line (when no processor is present) to accommodate the gas meter with thermocouple, pressure taps, and hydrocarbon analyzer sample and sample return taps. Coupler is to be sized for a minimum pressure drop.

- 5.1.4 Appropriate hydrocarbon analyzer(s) (either FID, NDIR, GC/FID with recorder.

Recorder strip charts shall be a minimum of 10 inches wide and be ruled with a minimum of 10 chart divisions per inch. Data loggers may only be used with prior approval of the ARB Executive Officer, who may require simultaneous use of strip chart recorders to cross check the validity of data recorded by the data loggers.

- 5.1.5 One (1) flexible thermocouple or thermistor (0-250°F) with a recorder system.
- 5.1.6 Appropriate pressure sensing device(s) (transducer(s) or equivalent).
- 5.1.7 Coupler with pressure tap for use between pressure-vacuum (PV) relief valve and fixed roof storage tank vent.
- 5.1.8 Coupler with pressure tap for use between PV valve and vent on vapor holder tank.
- 5.1.9 Explosimeter.
- 5.1.10 Barometer.

5.2 Transfer to Fixed Roof Storage Tanks

Use the same equipment as specified in the section, "Transfer to Cargo Tank from Terminal."

5.3 Emissions from Incinerator

This section applies whenever a vapor recovery system includes an incinerator-type processing unit.

Equipment Summary per EPA Methods 2A, 2B, 25A, and 25B

- 5.3.1 Volume Meter
- 5.3.2 Two Organic Analyzers (Inlet and Outlet)
- 5.3.3 CO Analyzer
- 5.3.4 CO₂ Analyzer

6 CALIBRATION PROCEDURE

6.1 Flow Meters

Standard methods and equipment shall be used to calibrate the flow meters.

6.2 Temperature Recording Instruments

Follow manufacturer's instructions.

6.3 Pressure Recording Instruments

Follow manufacturer's instructions.

6.4 Hydrocarbon Analyzer

Follow the manufacturer's instructions concerning warm-up time and adjustments. On each test day prior to testing and at the end of the day's testing, zero the analyzer and calibrate and span with appropriate calibration gases. Perform an intermediate zero and span calibration approximately 2 hours after the initial calibration and at any time a calibration drift is evident.

6.5 A record of all calibrations made shall be maintained.

7 PRE-TEST PROTOCOL

The processing unit may be tested for a series of 24 consecutive 1-hour periods and pressures in the vapor holder and any fixed roof gasoline storage tanks may be monitored for 30 consecutive days. The ARB Executive Officer shall have the discretion of testing for longer or shorter periods as may be necessary for properly evaluating any system's compliance with performance standards or performance specifications. During the test of the processing unit, the pressure during the loading of a number of cargo tanks will be monitored. As close as possible, the system shall be tested under normal operating conditions (dispensing rates shall be at the maximum rate possible consistent with safe and normal operating practices; simultaneous use of more than one dispenser during transfer operations shall occur to the extent that such would normally occur, and the processing unit shall be operated in accordance with the manufacturer's established parameters), and shall be operated in accordance with the owner's or operator's established operating procedures.

To ensure consistency with U.S. EPA regulations, the test duration will be a minimum of six (6) hours and the test shall be conducted with a minimum gasoline transfer of 80,000 gallons.

7.1 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-203 § 5 for the testing and evaluation of vapor recovery equipment.

A minimum volume of gasoline transferred to cargo tanks shall be 100,000 gallons. An engineering evaluation shall be conducted to determine if a throughput higher than the minimum is necessary to adequately evaluate system performance. (Examples: Carbon bed performance can degrade during continuous periods of high loading and refrigeration units can show lower performance during required defrost cycles which may occur only once in a 24 hour period.)

7.2 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.

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

The required preliminary evaluation shall set the final requirements for facility preparation. The dominant principle shall be that testing activities minimally alter facility and system conditions.

Install all equipment and wait until a cargo tank arrives. Until then, provide conditions which minimally disturb facility and system operations due to the presence of such equipment for such time.

8 TEST PROCEDURE

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

The use of bags to seal the vents, so that volume of out-breathing into the bags can be observed, shall be used as the primary procedure for monitoring out-breathing. Any other procedure shall be used only after approval by the ARB Executive Officer.

For systems with multiple vents all system vents shall be monitored. Alternatively, if system vents are manifolded, then one vent may be monitored while the others are sealed with plastic bags. Attempt to monitor the vent with the least resistance to atmospheric emissions.

When bagging valves, do not seal vacuum valves or the vacuum side of pressure/vacuum valves. On any vacuum valves, use a combustible gas detector according to EPA Method 21 calibrated to the lower explosive limit for methane (21,000 ppm).

8.1 Transfer to Cargo Tank from Terminal

- 8.1.1 Connect appropriate coupler to exhaust of processing unit and connect flowmeter.
- 8.1.2 Connect HC analyzer (with recorder) to appropriate tap on coupler on processing unit exhaust.
- 8.1.3 Connect thermocouple with recorder to appropriate tap on coupler on processing unit exhaust, and connect pressure sensing device to appropriate tap on processing unit exhaust coupler.
- 8.1.4 Connect coupler between PV valve and vent of vapor holder tank and connect pressure sensing device (with recorder) to coupler. Bag vent line and P/V valve on vapor holder.
- 8.1.5 Connect coupler between PV valve and fixed roof storage tank and connect pressure sensing device (with recorder) to coupler. Bag vent line and P/V valve on fixed roof tank.

8.2 Transfer to Fixed Roof Storage Tanks

- 8.2.1 Connect appropriate coupler to exhaust of processing unit and connect flowmeter.
- 8.2.2 Connect HC analyzer (with recorder) to appropriate tap on coupler on processing unit exhaust.
- 8.2.3 Connect thermocouple with recorder to appropriate tap on coupler on processing unit exhaust, and connect pressure sensing device to appropriate tap on processing unit exhaust coupler.
- 8.2.4 Connect coupler between PV valve and vent of vapor holder tank and connect pressure sensing device (with recorder) to coupler. Bag vent line and P/V valve on vapor holder.
- 8.2.5 Connect coupler between PV valve and fixed roof storage tank and connect pressure sensing device (with recorder) to coupler. Bag vent line and P/V valve on fixed roof tank.
- 8.2.6 Record the pressure on the bulk storage tank for the required period. Observe the bag placed over the P/V valve on the bulk storage tanks.
- 8.2.7 Record the pressure on the vapor-holder tank for the required period. Observe the bag placed over the P/V valve on the vapor holder tank.

- 8.2.8 Record the HC concentration, temperature, pressure, and exhaust gas flowrate from the processor exhaust for the required period.
- 8.2.9 At the end of the specified times, disconnect all instrumentation and couplings from the vapor recovery systems.
- 8.2.10 Record the volume of gasoline that is delivered during the specified testing times.
- 8.2.11 Pressure monitoring of cargo tank is to be performed, as appropriate, in accordance with § 8.1.

8.3 Test Procedures for Determining Incinerator Emissions

Performance Specifications for Incinerators

Any incinerator shall be evaluated and tested to establish:

- (1) a performance specification for hydrocarbon (HC) emissions and
- (2) performance specifications for other critical incinerator operating parameters:

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.

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

- (1) number of loading arms in simultaneous use and
- (2) individual loading arm transfer rates. Challenge and failure mode testing on individual loading arm transfer rates shall only be required if the system is designed to operate at widely variable transfer rates.

Compliance with the incinerator performance specifications shall be determined per CP-203.

Parameters for Incinerator Data Collection

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, the volumetric flow rate of auxiliary fuel can often be established from specifications provided by the incinerator manufacturer and the concentration of auxiliary fuel from data available from the fuel supplier.

Resolution for Incinerator Data Collection

A preliminary evaluation of incinerator operation shall be conducted to assess the rate of change of the magnitude of measured parameters. An appropriate time interval for data recording shall be determined. 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.

9 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

9.1 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 **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.

(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

These subsections outline calculations for separate tests, one in which there are transfers to cargo tanks and one in which there are transfers to fixed roof tanks. During normal terminal operations both types of transfers may occur simultaneously therefore it is not possible to separate the mass emissions from each operation. The procedures shall be used to calculate total mass emissions divided by the total volume transferred to cargo tanks and fixed roof tanks.

11.1 Transfer to Cargo Tank from Terminal

11.1.1 **Review pressures** recorded during the loading of cargo tanks to determine if any equalled or exceeded 18 inches H₂O gauge pressure. Record and report such instances.

11.1.2 **Volume of gas** discharged through the processing unit exhaust or any vent

See § 11.3 for calculation of volume from an incinerator.

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

Where:

- V = Volume of gas discharged, ft³, through processor exhaust, corrected to 68°F and 29.92 "Hg;
- P_b = Barometric pressure, "Hg.
- P = Gauge pressure at exhaust coupler, "WC.
- V_p = Volume of gas determined by flowmeter on the processing exhaust, corrected for amount of vapor removed for the hydrocarbon analysis, ft³.

T_p = Average temperature in the processing exhaust line, °R.

11.1.3 Weight of hydrocarbons discharged through the processing exhaust or any vent per 1000 gallons of gasoline loaded into the cargo tanks.

$$W = \frac{(C)(V)(M)}{385(G)}$$

where:

W = Weight of hydrocarbons discharged through the processor exhaust per 1000 gallons of gasoline loaded into cargo tanks, lb_m .

C = Average fractional concentration of hydrocarbons at exhaust (decimal fraction). This may be adjusted to represent non-methane hydrocarbons if the procedure includes a methane/non-methane hydrocarbon determination by integrated bag sampling and GC/FID analysis.

V = From (11.1.2) above.

M = Molecular weight of exhaust hydrocarbons which shall be assumed equal to that of the gas(es) used to calibrate the organic analyzer unless the procedure includes a molecular weight determination by integrated bag sampling and GC/FID analysis, ($lb_m/lb\text{-mole}$).

385 = Molar volume, ($ft^3/lb\text{-mole}$), at standard conditions

G = Total quantity of gasoline loaded into cargo tanks, (total gallons loaded/1000).

11.2 Transfer to Fixed Roof Storage Tanks

11.2.1 Volume of gas discharged through the processing unit exhaust or any vent.

See § 11.3 for calculation of volume from an incinerator.

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

where:

- V = Volume of gas discharged ft, through processor exhaust, corrected to 68°F and 29.92 "Hg;
- P_b = Barometric pressure, "Hg.
- P = Gauge pressure at exhaust coupler, "WC.
- V_p = Volume of gas determined by flowmeter on the processing exhaust, corrected for amount of vapor removed for the hydrocarbon analysis, ft.³
- T_p = Average temperature in the processing exhaust line, °R.

11.2.2 Weight of hydrocarbons discharged through the processing exhaust or any vent per 1000 gallons of gasoline loaded into the storage tanks.

$$W = \frac{(C)(V)(M)}{385(G)}$$

where:

- W = Weight of hydrocarbons discharged through the processor exhaust per 1000 gallons of gasoline loaded into cargo tanks, lb_m.
- C = Average concentration of hydrocarbons at exhaust (decimal fraction). This may be adjusted to represent non-methane hydrocarbons if the procedure includes a methane/non-methane hydrocarbon determination by integrated bag sampling and GC/FID analysis.
- V = From (11.1.2) above.
- M = Molecular weight of exhaust hydrocarbons which shall be assumed equal to that of the gas(es) used to calibrate the organic analyzer unless the procedure includes a molecular weight determination by integrated bag sampling and GC/FID analysis, (lb-mole).
- 385 = Molar volume, (ft³/lb-mole), at standard conditions
- G = Total quantity of gasoline loaded into storage tanks, (total gallons loaded/1000).

11.3 Volume from Incinerator

Note the possibility for simplifying assumptions described in § 8.3.

11.3.1 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 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:

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

$$N = \text{number of carbon atoms in each molecule of calibration gas}$$

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

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

11.3.2 Final Incinerator Outlet Volume Calculations

Calculate any vapor incinerator outlet volume using the following equation:

$$V_{\text{out}} = V_{\text{in}} \left(\frac{[HC]_{\text{in}}}{N[HC]_{\text{out}} + [CO_2] + [CO] - 300} \right)$$

where:

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

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

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

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

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

300 = assumed background concentration (ppm) of CO_2

12 REPORTING RESULTS

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 FIGURES

This section is reserved for future specification.