California Environmental Protection Agency

Air Resources Board

Vapor Recovery Test Procedure

TP - 201.2C

DETERMINATION OF SPILLAGE OF
PHASE II VAPOR RECOVERY SYSTEMS OF
DISPENSING FACILITIES

Adopted: April 12, 1996

The method is being amended. For ease of viewing, the method is shown as repealed text and proposed text.

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Determination of Spillage of Phase II Vapor Recovery Systems of Dispensing Facilities

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.

The procedure can be used for the determination of liquid spill frequencies and quantities at dispensing facilities. This procedure can be adapted for use at other facilities.

2 PRINCIPLE AND SUMMARY OF TEST PROCEDURE

After the vapor recovery nozzles are inspected and determined to be in good working order, as specified in CCR 94006, a pre-survey calibration of pours is performed. This calibration will determine the areas of 1 mL, 5 mL, and 25 mL pours at the location of the test. When the calibration is completed, vehicle fuelings are observed, and measurements are made to quantify any observed spills.

In principle, it is possible to perform a cross-calibration between gasoline and some less hazardous liquid, such as water. If this can be demonstrated in practice, to the satisfaction of the ARB Executive Officer, then water may be used for spill calibration at a test site.

3 BIASES AND INTERFERENCES

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3.1 Different pavements can cause different results.

A calibration of pours shall be conducted at each test site. The gasoline shall be poured on an area of the pavement which is representative of the pavement where the majority of vehicle spills occur so that the results of the calibration of pour volume to area can be representative for each site.

3.2 The tester could subjectively select certain vehicles over others.

A consistent method of vehicle selection is described in the test procedure. The tester must choose the first vehicle that appears in his/her field of view, for which the fueling episode has not yet begun.

4 SENSITIVITY, RANGE, AND PRECISION

4.1 Sensitivity

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4.1.1 Excluding Determination of Spillage < 1 mL per Episode

Quantification of spill area is tedious and arduous for spill volumes less than 1 mL. Research and development (R&D) by the American Petroleum Institute (API) showed that:

(1) By count, spill episodes less than 1 mL account for 83% of all spill episodes.

(2) By volume, spill episodes less than 1 mL account for 3% of all spill volumes.

Therefore, the ARB Executive Officer can exclude quantification of any spill which has an area corresponding to less than 1 mL on the calibration curve. The calculated result for recorded spill data shall be divided by (97%) to obtain a final result which is adjusted for quantification of excluded spills < 1mL.

4.1.2 Including Determination of Spillage < 1 mL per Episode

The ARB Executive Officer can include quantification of any spill which has an area corresponding to less than 1 mL on the calibration curve. With additional resources devoted to calibration and data collection, quantification can be extended to lower volumes.

Further sensitivity and precision can be obtained by observing dripping episodes and recording data using, as an approximation, 20 drops = 1 mL.

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Cost-effectiveness calculations for this option can interpolate from the following estimate for the annual significance, in California, of an error of 1 drop of spillage for every 10 gallons dispensed:

4.2 Range

Calibration linearity depends upon pavement characteristics. During procedure development, the area of a 25 mL pour was chosen as a maximum calibration area because of the following findings:

(1) Larger pour areas could be measured as the sum of smaller areas by the application of analytical geometry.

(2) Calibration linearity is excellent (typically $r^2 = 0.999+$), allowing confident extrapolation for even the largest spills reported in the API study.

(3) A set of calibration pours (with a maximum of 25 mL/pour) adds only 0.4% to the estimated typical monthly spill volume at a dispensing facility with a throughput of 100,000 gallons per month.

4.3 Precision

The typical 95% confidence interval for the mean of seven replicated calibration pour areas during procedure development was ±7%.

5 EQUIPMENT

(1) Data sheets (test calibration form, test data form), indelible pen, and clipboard.

(2) Graduated cylinders (10 mL, 25 mL, and 100 mL).

(3) Tape measure.

(4) Gas can.

(5) Absorbent substance (and safe, vapor tight disposal container).

(6) Dust pan.

(7) Whisk broom.

6 CALIBRATION PROCEDURE

In principle, it is possible to perform a cross-calibration between gasoline and some less hazardous liquid, such as water. If this can be demonstrated in practice, to the satisfaction of the ARB Executive

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Officer, then water may be used for spill calibration at a test site.

6.1 Summary

6.1.1 Standard Calibration Procedure

(1) For every dispensing facility, select spill observation locations.

(2) For a each spill observation location, measure three 1 mL pours, three 5 mL pours and three 25 mL pours.

(3) Construct a calibration curve for each spill observation location.

6.1.2 Lower Emission Calibration Procedure

(1) For every dispensing facility, select spill observation locations.

(2) For a representative spill observation location, measure three 1 mL pours, three 5 mL pours and three 25 mL pours.

(3) Construct a calibration curve for the representative spill observation location.

(4) Calculate the 95% confidence interval for one 5 mL pour observation assuming a Gaussian distribution and applicability of Student's t Statistic. Call this interval the "pour interval". See § 11 for statistical calculation procedures.

(5) Measure one 5 mL pour for each of the other spill observation locations.

(a) If the result is outside the pour interval for any of the other spill observation locations, construct another calibration curve for use at such location.

(b) If the result is inside the pour interval for any of the other spill observation locations, employ the calibration curve from the representative spill observation location for use at such location.

6.2 Pouring Procedure

(1) As required in the summary above, pour 1 mL, 5 mL, or 25 mL of gasoline (from the 100 mL graduated cylinder) into the appropriate graduated cylinder. (For the 1 mL and 5 mL pours, use the 10 mL graduated cylinder, and for the 25 mL pours, use the 25 mL graduated cylinder.)

(2) Choose a spot on the pavement where the majority of vehicle spills occur, or a spot that is very similar (in smoothness, porosity, amount of gasoline stains, exposure to sun) to the pavement where the majority of vehicle spills occur.

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(3) Using the tape measure, locate a point 30 inches above the pavement.

(4) Carefully pour the gasoline from the 30 inch height onto one spot. Note that the pour shall be as close to a circular or elliptical shape as possible.

6.3 Measuring Procedure

(1) In order to measure the area of the pour accurately and consistently, the tester must recognize the four phases of a pour:

(a) The pour will spread, increasing in area at a relatively rapid speed.

(b) The rate of spread will decrease.

(c) The area will stabilize.

(d) Evaporation will cause the pour to shrink.

(2) The measurement shall occur at phase 3, the point at which the area of the pour is no longer increasing, but not yet decreasing:

(a) Using the tape measure, measure the major axis or height (A) and minor axis or width (B) of the pour.

(b) Record the dimensions on the Calibration Form, an example of which is provided in Figure 2. If the pour is in the shape of an ellipse or a circle, use the geometric formula for an ellipse (A x B x 0.785) to calculate the area. If the pour does not resemble an ellipse or circle, abort the procedure and pour again.

(c) For the 5 mL and 25 mL pours, use absorbent substance (and safe, vapor tight disposal container) to absorb the gasoline and clean it up with the whisk broom and dust pan.

(d) Repeat the procedure until the required data has been collected for up to three 1 mL pours, three 5 mL pours, and three 25 mL pours.

6.4 Calculating Areas

(1) Calculate the average area of the up to three 1 mL pours by adding the areas and dividing that sum by the appropriate number.

(2) Enter this amount in the appropriate space on the Calibration Form.

(3) Repeat this procedure for the 5 mL pours and the 25 mL pours.

7 PRE-TEST PROTOCOL

Inspect all the vapor recovery equipment that shall be used in the test. Verify that the equipment is in

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good working order, is free from tears, slits, leaks or any other defects which would substantially impair the effectiveness of the system, as specified in Section 94006, Title 17 of the California Code of Regulations.

8 TEST PROCEDURE

8.1 Spill (Pour) Calibration

A calibration shall be performed for each spill observation location which has characteristics which, in the judgment of the ARB Executive Officer, require a separate calibration for that location.

8.2 Spill Quantification

Measure and record the dimensions of all observed spills that occur during each episode of dispensing liquid into a vehicle. For the purpose of this procedure, a dispensing episode includes:

(1) Removal of the nozzle from the pump.

(a) Spill or
(b) no spill.

(2) Dispensing of liquid into the vehicle.

(a) Spill or

(b) no spill.

(3) Removal of nozzle from the vehicle and return of the nozzle to the pump.

(a) Spill or

(b) no spill.

8.2.1 Select a vehicle for observation.

Choose the next vehicle that appears, for which the fueling episode is about to begin.

8.2.2 Measure any spill(s).

The measurement shall occur at the point at which the area of the spill is no longer increasing, but not yet decreasing.

8.2.2.1 Spills on the Pavement

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Apply the principles of analytical geometry to measure appropriate lengths and calculate the area for each spill, e.g.:

(1) If the spill resembles an ellipse, measure and record the major and minor axes (A & B; A = B for a circle.).

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(2) If the spill resembles a rectangle, measure and record the distances between sides (W & H; W = H for a square.).

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(3) If the spill does not resemble an ellipse or a rectangle, apply the appropriate principles of analytical geometry for the shape the spill most resembles (e.g. trapezoid, polygon, etc.).

(4) As a last resort, apply mensuration to parallel thin strips of equal width which are imagined to lie over the spill. For each strip, measure the length between the two points on the perimeter of the spill which are on the mid-line of each strip. The area of each strip is calculated as a rectangular area. The area of the spill is then the sum of the areas of the strips.

(5) If the area of the spill less than 1 mL according to the calibration line, ignore it.

8.2.2.2 Spills on a Vehicle

Record any spills that land on a vehicle. All such spills shall be presumed to have an average volume of 2 mL.

8.2.3 Record the spill(s).

Record the spill dimensions on a Data Form, an example of which is provided in Figure 1, and make a note of the shape of the spill.

8.2.4 Complete measurement, calculation, and recording.

Do not initiate the next observation until all data has been recorded from the previous observation.

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8.3 Ancillary Data for each Vehicle Fueling Episode

If time permits, after completing spill quantification:

(1) Record the time (hours:minutes) that dispensing of gasoline begins; i.e. when the nozzle is removed from the pump and inserted into the vehicle fill pipe.

(2) Record the make, model, and estimated year of the vehicle.

(4) Record the time that dispensing of gasoline ends; i.e. when the nozzle is removed from the vehicle fill pipe and returned to the pump.

(5) Record the number of gallons dispensed and:

(a) whether a fill-up occurred,

(b) whether a top-off occured, and

(c) the number of shut-off clicks.

(6) Record the spillage type.

(a) Pre-dispensing

(b) Dispensing

(c) Post-dispensing

(7) Record other comments.

9 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

To ensure accurate estimations of volume/area for each spill, the calibration shall include three (3) pours for each volume calibrated (1 mL, 5 mL, and 25 ml) and shall be performed as appropriate for each spill observation location at a test station.

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10 RECORDING DATA

Record calibration data as indicated on the Calibration Form. Record observations as indicated on the Data Form. Record average volumes on the Calibration Graph, an example of which is provided in Figure 3.

Record any unusual aspects of any spill which could qualify such spill as resulting from inappropriate use of the system equipment. If the ARB Executive Officer determines that a spill resulted from inappropriate use of the system equipment, then exclude the results of that spill from calculations below.

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.

11.1 Complete the Calibration Graph.

(1) Find the average volumes of 1 mL, 5 mL, and 25 mL pours on the Calibration Form.

(2) Calculate the natural logarithms of the average volumes of 1 mL, 5 mL, and 25 mL pours.

(3) Plot the natural logarithms of these average areas against the natural logs of the volumes on the Calibration Form.

11.2 Statistical Calculation Procedures

The 95% confidence interval is the range of values expected 95% of the time for a single observation.

For example, assume that a observation location was tested with 5 mL spills with the following results for spill area (SA):

observation number	SA (square inches)
1	3.72
2	3.64
3	3.85

(1) Find the mean value of SA.

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(2) Find the sample standard deviation of the mean value of SA.

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(3) Find the 95% confidence interval for the expectation value of a single observation of SA using Student's t Statistic and assuming a normal distribution of SA values for all observations.

Note that for three observations, there are two degrees of freedom and the Student's t Statistic is 4.303 for a 95% confidence interval.

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Other values of t are provided below for convenience:

number of observations	t
4	3.182
5	2.776
6	2.571
7	2.447
8	2.365
9	2.306
10	2.262
15	2.145

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30	2.045

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11.3 Calculate the total gallons of gasoline dispensed.

(1) Find the sum of the gallons dispensed, for each data form.

(2) Add the Gallons Dispensed column; this sum = X.

(3) Calculate total pounds of gasoline spatback or spilled, for each data sheet.

(a) Convert the spill areas to volumes using the Calibration Graph.

(b) Calculate the sum of the volumes (of spills) in milliliters = alpha.

(c) Convert alpha to grams by dividing it by 0.8; this amount = beta.

(d) Convert beta to pounds by dividing it by 454. This amount = Y, and represents the total pounds of gasoline spatback and spilled.

(4) Adjust for spillage less than 1 mL per episode: $Y_a = Y/(0.97)$

11.4 Calculate pounds of gasoline spatback and spilled per 1000 gallons of gasoline dispensed.

(1) Gallons dispensed = X

(2) Pounds gasoline spatback and spilled = Y_a.

(3) Calculate $(1{,}000)(Y_a/X)$

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.

Report the calculated result, pounds of gasoline spatback and spilled per 1000 gallons of gasoline dispensed.

Report the number of spills (>1 mL) per 100 dispensing episodes.

13 ALTERNATIVE TEST PROCEDURES

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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

"A Survey and Analysis of Liquid Gasoline Released to the Environment During Vehicle Refueling at Service Stations"
API (American Petroleum Institute) Publication No. 4498
Health and Environmental Sciences Department
June 1989.

15 EXAMPLE FIGURES AND FORMS

Each figure or form 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 or forms 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
Data Form

Figure 2
Calibration Form

Use one form for each spill observation location.

The area calculation provided assumes an ellipse.

Figure 3
Calibration Graph

Typical results from development of this procedure are provided.

An actual working calibration graph for field use shall have axis divisions about ten times finer than this

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display graph.

After calibration, a line from the natural logarithm of an area observation is constructed horizontally from the vertical axis to determine an intersection with the calibration line; from which point a vertical line is constructed to an intersection with the horizontal axis. The intersection with the horizontal axis is the natural logarithm of the volume which corresponds to the area observation. The inverse natural logarithm of the value of this intersection is the volume of the observed spill.

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Figure 1
Data Form

CAR	TIME of FUELING		VOLUME	SPILL DIMENSIONS		SPILL AREA
(make, model, & year)	(start)	(finish)	(gal)	(inches)	(inches)	(sq. in.)

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Figure 2

Calibration Form

Station Name	Date
Address	
Equipment Tested	
ARB Test Monitor	
Tester	

SPILL CALIBRATION				
SPILL VOLUME	SPILL DIMENSIONS		SPILL AREA	AVERAGE SPILL AREA
(mL)	A (inches)	B (inches)	AB x 0.785 (sq. in.)	(sq. in.)
# 1 1mL				
# 2 1mL				
# 3 1mL				
# 4 1mL				
# 5 1mL				
# 1 5mL				
# 2 5mL				
# 3 5mL				
# 4 5mL				
# 5 5mL				

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# 1 25mL				
# 2 25mL				
# 3 25mL				
# 4 25mL				
# 5 25mL				