California Environmental Protection Agency

Air Resources Board

Vapor Recovery Test Procedure

TP-201.5

Determination (by Volume Meter) of
Air to Liquid Volume Ratio of
Vapor Recovery Systems of
Dispensing Facilities

Adopted: April 12, 1996

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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 test procedure can be used to quantify the air to liquid volume ratio (A/L) of a vapor recovery system. This test procedure is particularly well suited to dispensing facility vapor recovery systems which use bootless nozzles with circumferential holes near the front of their spouts; but it may be adapted for other systems.

This test procedure can be used to determine the performance specification for air to liquid volume ratio of a vapor recovery system during the certification process and subsequently to determine compliance with that performance specification for any installations of such a system.

When this test procedure is used to set a performance specification for a system, any deviations from the use of the equipment and procedures specified below shall be written into the certification report for such system if it is certified. Any compliance testing of a system shall be done according to this procedure, with appropriate adjustments for such deviations.

2 PRINCIPLE AND SUMMARY OF TEST PROCEDURE

The air to liquid volume ratio (A/L) of a vapor recovery system is, for a given dispensing episode, the quotient of the volume of air collected by a nozzle and the volume of liquid dispensed by that nozzle. In principle, any equipment and procedure which provides for the simultaneous measurement of air volume collected and liquid volume dispensed, from the same system, is a basis for determination of A/L for that system.

TP-201.5 measures A/L rather than the volume ratio of vapor (mixed with air) to liquid (V/L), because doing so is much more consistent, repeatable, and less expensive. A/L testing can be coordinated with efficiency testing to yield A/L performance specifications for compliance testing.

3 BIASES AND INTERFERENCES

There are no known biases or interferences inherent to the equipment and procedures specified; however several system parameters must be monitored and controlled so that this procedure can serve its intened purpose.

3.1 Non-Repeatable or Non-Representative Test Conditions

It is possible that system components could operate during testing in such a way that results are non-repeatable or are non-representative of subsequent installations of the system. To minimize such effects, the ARB test monitor shall note any relevant operating parameters for inclusion in the certification process as conditions on certification at a particular A/L ratio.

3.1.1 Non-Repeatable Test Conditions

For example, the liquid dispensing rate can introduce bias if it is non-repeatable; for many systems, the A/L performance varies with liquid flow rate.

In the procedures below, a maximum repeatable flow rate of liquid is required. If A/L performance varies with liquid flow rate for some system, it is necessary to place an upper limit on liquid flow rate in the ARB Executive Order.

(1) **(Liquid) Fuel Pumps**

To achieve repeatability, it is necessary to control the number of simultaneous dispensing episodes from a common liquid pump during certification testing. Such number shall be a performance specification in the ARB Executive Order so that subsequent installations of the system can be consistently tested.

(2) **(Air and Vapor) Assist Pumps**

To achieve repeatability, it is necessary to control the number of simultaneous dispensing episodes served by a common assist pump during certification testing. Such number shall be a performance specification in the ARB Executive Order so that subsequent installations of the system can be consistently tested.

3.1.2 Non-Representative Test Conditions

For example, nozzle quantities, qualities, and interactions can introduce bias if they are non-representative; for many systems, the A/L performance varies with such parameters.

In the procedures below, if more than one nozzle is served by the same assist pump, precautions are required to eliminate nozzle interactions which yield non-representative A/L performance. Within a system subject to certification testing, nozzle qualities must be representative of the nozzle qualities within subsequent installations.

To achieve representativeness, it may be necessary to control the nozzle quantities, qualities, and interactions during certification testing and subsequently by inclusion of specific requirements in the ARB Executive Order.

3.2 Condensation, Evaporation, and Other Factors

Different systems have different tendencies to condense and evaporate liquid in vapor lines. This and other factors can cause different A/L values in different modes of system operation. In consideration of such factors, the ARB Executive Officer may determine a different data collection protocol and a different data reduction protocol than the examples given in §§ 8 and 11.

4 SENSITIVITY, RANGE, AND PRECISION

The values of the determinations required by this test procedure are well within the limits of sensitivity, range, and precision of the specified equipment.

5 EQUIPMENT

Some of the equipment for testing a bootless nozzle is shown in:

Figure 1
A/L Volumetric Test Meter and

Figure 2
A/L Test Tank.

5.1 Air Volume Meter and Plumbing Hardware

The plumbing hardware shall connect the nozzle spout to a positive displacement air volume meter (e.g. Roots® meter) so that the air volume pulled into the collection holes in the spout can be measured with minimal pressure drop.

Use a calibrated positive displacement gas volume meter (e.g. a Roots meter) for measurement of volumetric flow rate through the sleeve.

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 CFH for a meter with a rating over 1000 CFH and
>
> 0.70 inches water column at a flowrate of 800 CFH down to
> 0.04 inches water column at a flowrate of 16 CFH for a meter with a rating of or under 1000 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 ^{o}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) or any other range appropriate to allow detection of a pressure drop greater than the BPL.

5.2 Liquid Volume Meter

Use the meter on the liquid dispenser.

5.3 Portable Liquid Tank

A portable tank shall be used to receive dispensed liquid. The tank shall have sufficient volume so that 7.5 gallons can be received without triggering a premature shutoff. In the development of this procedure, a 25 gallon tank was adequate for two dispensing episodes between emptyings. The tank shall be on a wheeled cart and plumbed so that liquid received by the tank can be returned to the appropriate storage tank.

Figure 2, for example, shows an optional carbon scrubber arrangement which provides personnel protection from hazardous vapors and reduces emissions due to the performance of this test procedure.

5.4 Stop Watch

Use a stop watch accurate and precise to within 0.2 seconds.

6 CALIBRATION PROCEDURE

Follow the appropriate calibration procedures from TP-201.2.

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.

8 TEST PROCEDURE

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

The procedures below are for testing a bootless nozzle; with appropriate changes, these procedures can be used on other equipment. The procedure below shall be performed by at least two people familiar with the safety and mechanical principles of liquid dispensing equipment, especially for dispensing gasoline and other hazardous liquids.

8.1 General A/L Test Instructions

(1) Assemble the equipment shown in Figures 1 and 2, for example,. If more than one nozzle is served by the same assist pump, all nozzles other than the test nozzle shall be sealed vapor tight with, e.g., plastic bags and tape or rubber bands.

(2) Read and record the initial value on the air volume meter. Do not depend on using the terminal reading from a prior dispensing episode. The pressure drop across an appropriate volume meter is so low that a light breeze can change this value.

(3) Set the liquid meter and stopwatch to zero.

(4) Fully engage the dispensing lever and hold for the maximum repeatable flow rate of liquid. For most systems, there will be a brief pause before the liquid flows and is registered by the liquid meter.

(5) Start the stop watch when the liquid meter indicates liquid flow.

(6) Attempt to dispense 7.48 gallons (one cubic foot) of liquid and simultaneously:

(a) shut off liquid flow and

(b) stop the stop watch.

Read and record the liquid volume dispensed and the elapsed time.

(7) Read and record the final value on the air volume meter.

8.2 Certification Test Instructions

Different systems have different tendencies to condense and evaporate liquid in vapor lines. This and other factors can cause different A/L values in different modes of system operation. In consideration of such factors, the ARB Executive Officer may determine a different data collection protocol and a different data reduction protocol than the examples below. However, instructions must be determined before collection of final certification test data.

(1) Collect three sets of A/L test data per nozzle:

(a) from any nozzle (or nozzles) on any dispenser (or dispensers) used by the applicant for certification efficiency testing and

(b) at three flow rates (e.g. repeatable minimum, average of repeatable minimum and repeatable maximum, and repeatable maximum.

(2) Calculate the performance specification as an allowed range of A/L values according to one of the alternatives provided in § 11.

8.3 Compliance Test Instructions

Different systems have different tendencies to condense and evaporate liquid in vapor lines. This and other factors can cause different A/L values in different modes of system operation. In consideration of such factors, the ARB Executive Officer may determine a different data collection protocol and a different data reduction protocol than the examples below. However, instructions may not be changed after certification.

(1) Collect one set of A/L test data per nozzle:

(2) Compare the resulting A/L value with the allowed range of A/L values given as a performance specification in the ARB EXecutive Order for the tested system.

(a) If the resulting value is in the allowed range of A/L values, the system complies.

(b) If the resulting value is not in the allowed range of A/L values, collect two more sets of A/L test data and calculate the average A/L for all three sets.

(i) If the resulting value is in the allowed range of A/L values, the system complies.

(ii) If the resulting value is not in the allowed range of A/L values, the system does not comply.

9 QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

This section is reserved for future specification.

10 RECORDING DATA

This section is reserved for future specification.

11 CALCULATING RESULTS

Different systems have different tendencies to condense and evaporate liquid in vapor lines. This and other factors can cause different A/L values in different modes of system operation. In consideration of such factors, the ARB Executive Officer may determine a different data reduction protocol than the examples below. However, all calculation protocols must be determined before collection of final certification test data.

11.1 **A/L Values**

Calculate A/L for each test of a dispensing episode:

$$A/L = \frac{\text{(volume of air collected)}}{\text{(volume of liquid dispensed)}}$$

11.2 **Performance Specification**

The performance specification shall be expressed as an allowed range of A/L values. The performance specification range shall be the mean value of A/L ±10% of the mean.

11.3 **Alternative Performance Specification**

This performance specification may be used after an engineering evaluation by the ARB Executive Officer has determined that it is necessary to statistically account for the variance of A/L values for a system.

The performance specification shall be expressed as an allowed range of A/L values. The performance specification shall be the same as the 95% confidence interval for the expectation value of a single observation of A/L.

For example, assume that a nozzle was tested with the following results for A/L:

observation number	A/L
1	1.02
2	0.99
3	1.02

(1) Find the mean value of A/L.

$$\bar{x} = \frac{1.02 + 0.99 + 1.02}{3} = 1.01$$

(2) Find the sample standard deviation of the mean value of A/L.

$$s = \sqrt{\frac{(1.02 - \bar{x})^2 + (0.99 - \bar{x})^2 + (1.02 - \bar{x})^2}{(3 - 1)}} = 0.0173$$

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

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.

$$95\%\ \text{c.i.} = \bar{x} \pm (t\, s) = 1.01 \pm 0.075$$

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
30	2.045

12 REPORTING RESULTS

12.1 Certification Report

12.1.1 Performance Specification

Report:

(1) the mean value of A/L,

(2) 10% of the mean value of A/L, and

(3) the mean value of A/L± 10% of the mean.

Report (3) as the performance specification which is the allowed range of A/L values for subsequent installations of the system.

12.1.2 Alternative Performance Specification

Report:

(1) the mean value of A/L,

(2) the variance of the mean value of A/L, and

(3) the 95% confidence interval for the expectation value of a single observation of A/L using Student's t Statistic and assuming a normal distribution of A/L values for all system nozzles.

Report (3) as the performance specification which is the allowed range of A/L values for subsequent installations of the system.

12.2 Compliance Test Report

Report:

(1) the number of nozzles at the dispensing facility which do not meet the performance specification and

(2) the total number of nozzles at the dispensing facility.

Report any other system operating parameters technically pertinent to the A/L performance specification as required by the certification procedure.

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

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
A/L Volumetric Test Equipment

Figure 2
A/L Test Tank

FIGURE 1

A/L Test Equipment for Bootless Nozzles

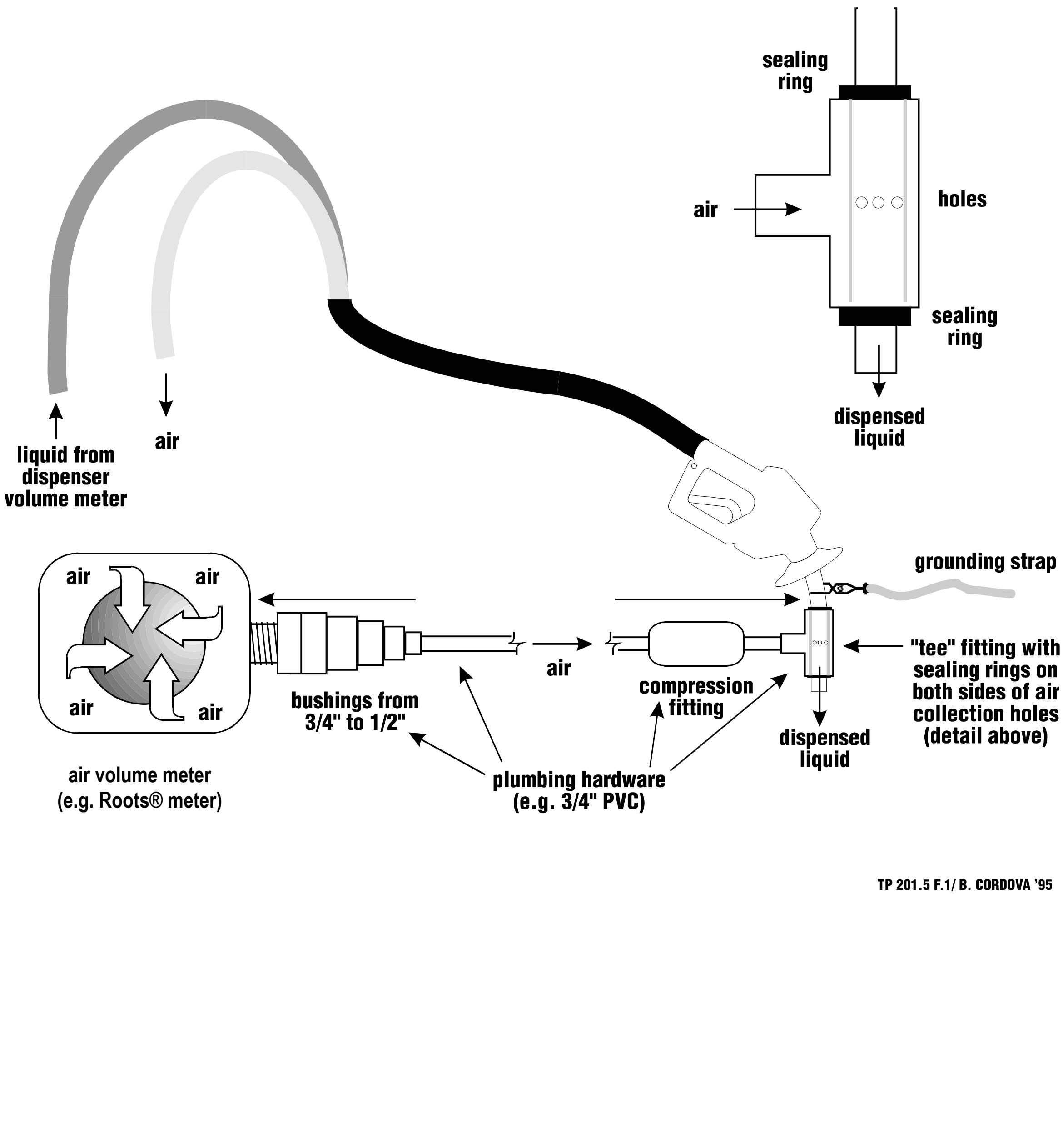
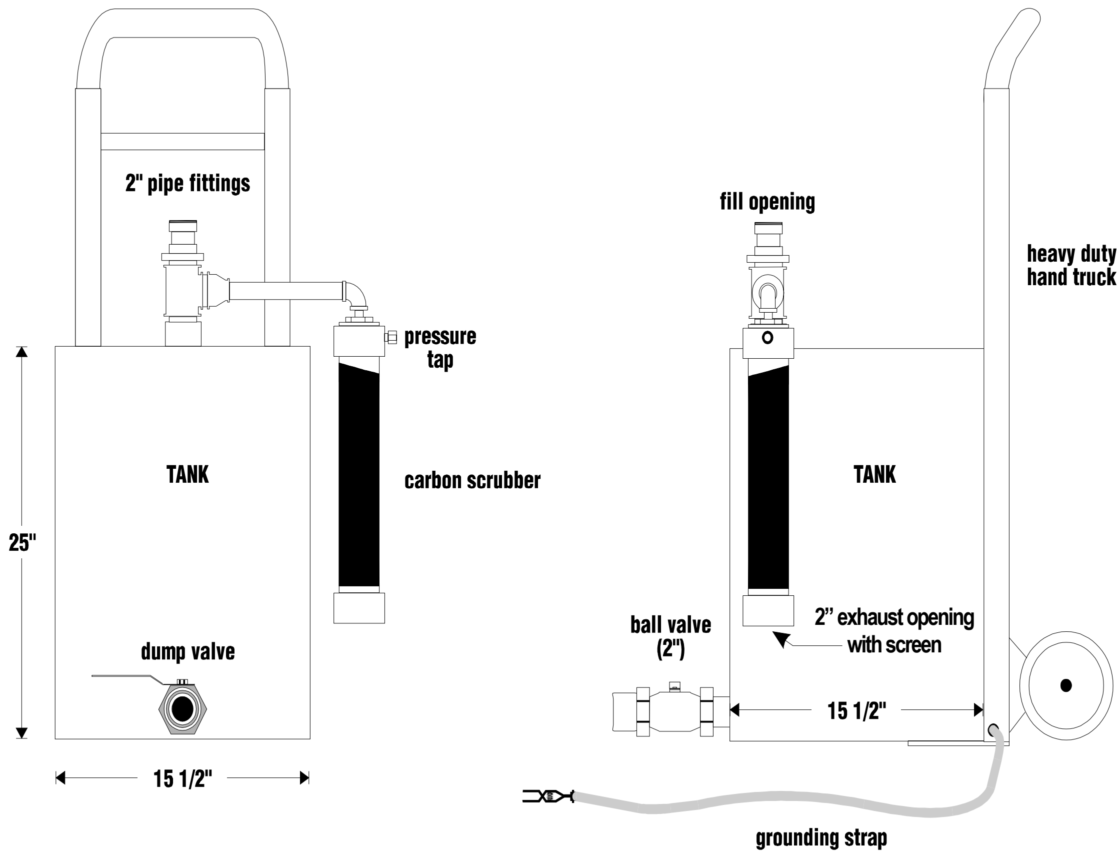


FIGURE 2
A/L Testing Tank



This design can meet the performance specifications of this procedure, any other design which meets such specifications is acceptable.