California Environmental Protection Agency

# Air Resources Board

**Vapor Recovery Test Procedure**

**TP - 201.2J**

**PRESSURE DROP BENCH TESTING OF VAPOR RECOVERY COMPONENTS**



Adopted: October 8, 2003

**Amended: October XX, 2010**

**California Environmental Protection Agency**
**Air Resources Board**

# TP-201.2J

## Pressure Drop Bench Testing of Vapor Recovery Components



Definitions common to all certification and test procedures is in:

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

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

## 1. APPLICABILITY AND PURPOSE

This procedure applies to Phase II vapor recovery components installed at dispensing facilities. The purpose of this test procedure is to determine the pressure drop of components in vapor recovery systems at a fixed flow rate for compliance with pressure drop performance standards specified in Certification Procedure 201 (CP-201) and applicable Executive Order for specific components. This procedure is used during certification.

## 2. PRINCIPLE AND SUMMARY OF TEST PROCEDURE

The pressure drop across a vapor recovery component is determined by measuring the differential pressure. Test points are located immediately upstream and downstream from the component. The test is conducted while passing a known flow of nitrogen gas through the component.

Figures 1 illustrates typical components that undergo testing. Figure 2 illustrates an example of a pressure drop test bench.

## 3. BIASES AND INTERFERENCES

Equipment tested for certification must be representative of the equipment used in actual installations of vapor recovery systems.

## 4. SENSITIVITY, RANGE, AND PRECISION

This procedure can measure pressure drops in the range of 0.001 to 2 inches $H_2O$ at a flow of 60 cubic feet per hour (CFH) with a precision estimated at $\pm$ 0.002 inch $H_2O$.

## 5. EQUIPMENT

**5.1** Differential Low Pressure Transmitter and Meter. This test procedure utilizes two electronic differential low-pressure transmitters to measure pressure drops for components and systems. The instrument used for measuring individual components has a range of 0.000 to ~~0.100~~ **0.250** inches $H_2O$ and an accuracy of zero point two five percent (0.25%) of full scale with a resolution of 0.001. ~~The instrument used for measuring components connected in series has a range of 0.000 to 2 inches H2O and an accuracy of zero point zero six percent (0.06%) of full scale with a resolution of 0.001 inch H2O. Repeatability is point zero five percent (0.05%) of full-scale.~~

**5.2** Mass Flow Meter. This test procedure utilizes a mass flow meter (MFM) to measure the flow rate. Since the volume flow specification in CP-201 for determining pressure drop that references this test procedure is 60 CFH or 28.3 liters per minute (LPM), the range of the mass flow meter used to measure flow is 0.0 to 30.0 LPM. The accuracy of the MFM is plus or minus 0.3 LPM of full scale with a resolution of 0.1 LPM. Repeatability is point two percent (0.2%) of full-scale.

**5.3** Nitrogen ($N_2$). This procedure uses commercial grade nitrogen in a high-pressure cylinder, equipped with a two-stage pressure regulator.

**5.4** Orifice Plate. A flat metal plate with a sharp edged hole accurately machined to 0.5 inch in diameter.

**5.5** Pipe. Two 24-inch sections of 1 ½-inch diameter **rigid piping with smooth bore.** ~~schedule 40 PVC pipe.~~

**5.6** Digital Manometer. A digital manometer with a range of 0 to 19.99 inches $H_2O$ is used to check the pressure integrity of the system while performing a leak test.



## 6. CALIBRATION PROCEDURE

The MFM used in this test procedure is certified to a primary standard on an annual basis. To get an initial certification, the correlation coefficient from seven multi-point calibrations must be at least 0.9999. After the initial calibration, the annual MFM certification must be within one percent (1.0%) of the previously certified slope and intercept.

Pressure measurement devices are calibrated in accordance with manufacturer's specifications at an outside laboratory. To be considered, the outside laboratory must use NIST traceable standards to perform calibrations. The certification results in a slope and intercept from a five-point calibration to a known standard.

Temperature Measurement Devices: Temperature measurement devices shall be checked semi-annually using an ice bath, ambient air, and boiling water.  This accuracy check shall be conducted by comparison to a NIST traceable measurement device.

## 7. PRE-TEST PROTOCOL

Ensure that the test equipment has been calibrated within the last year.

Turn on test equipment and allow it to stabilize for 30 minutes.

Perform a single-point-response check of the test equipment using an orifice plate. The observed response of differential low-pressure meter must be within three percent (3%) of the expected response as calculated under Section 9 below.

## 8. TEST PROCEDURE



Figure 1 shows examples of equipment to be tested, depending upon the application of the certification procedure.

Figure 2 shows an example of a test bench.

**8.1** Measuring Barometric Pressure and Flow Temperature

8.1.1 Insure that the electronic test equipment has operated for 30 minutes.

8.1.2 Uncap the end of the schedule-40 PVC pipe.

8.1.3 Slowly establish a stable flow rate by slowly adjusting the needle valves shown in Figure 2 until the display of MFM reads 28.3 LPM.

8.1.4 Allow a few seconds for the system to reach equilibrium.

8.1.5 Record the downstream flow temperature and ambient barometric pressure readings on the Vapor Recovery Component Pressure Drop Bench Test Data Form.

**8.2** Calculate the Correct MFM Display to Obtain a Flow of 28.3 LPM

Calculate the MFM display that corresponds to a flow rate of 28.3 LPM using the MFM calibration slope and intercept along with the barometric pressure and flow temperature as described in Attachment 1.

**8.3** Establishing a Stable Test Flow

Slowly establish a stable flow rate of 28.3 LPM by slowly adjusting the needle valves shown in Figure 2 until the display of MFM reads the value calculated in Section 8.3.1.

**8.4** Measuring the Test Bench Pressure Drop

8.4.1 Perform this measurement once prior to testing vapor recovery components.

8.4.2 Couple the upstream and downstream test bench flanges together.

8.4.3 Uncap the end of the schedule 40 pipe.

8.4.4 Slowly establish a stable test flow rate of 28.3 LPM by slowly adjusting the needle valves until the display of MFM reads the value as calculated in Section 8.3.1.

8.4.5 After a stable test flow is obtained, record the pressure drop reading from the differential low-pressure meter. Record the reading on the Vapor Recovery Component Pressure Drop Bench Test Data Form.

**8.5** Leak Test.

8.5.1 Insure that the liquid paths of the component to be tested are blocked to prevent $N_2$ from flowing through them.

8.5.2 Connect the test item with a leak-tight connector to the test bench flanges as shown in Figure 2.

8.5.3 Cap the end of the schedule-40 PVC pipe to obtain a leak-tight seal.

8.5.4 Visually and manually check all fittings for proper assembly.

8.5.5 Slowly establish a stable gauge pressure of approximately 2 inches $H_2O$.

8.5.6 Monitor the system for five minutes. If the pressure does not fall by more than 0.1 inch $H_2O$, the system is leak tight. If the pressure drops by more than 0.1 inch $H_2O$ over the monitoring period the system may be leaking.

8.5.7 If the pressure check is unable to verify a seal, check for leaks by applying soap solution around all fittings and/or by observing the pressure meter.

8.5.8 If soap bubbles grow around fittings or if the pressure continues to drop, repeat subsections 8.1.1 through 8.1.5. It may be necessary to provide an isothermal environment for the pressurized ballast tank to minimize pressure changes caused by temperature fluctuations.

**8.6** Recording Component Pressure Drops

8.6.1 After performing a leak check, uncap the end of the test pipe.

8.6.2 Obtain a stable test flow as specified in subsection 8.4.5.

8.6.3 Record the differential pressure drop and stop the flow momentarily. Re-establish a stable flow, take a second reading, and stop the flow momentarily. Re-establish a stable flow and take a third reading. Record the readings on the Vapor Recovery Component Pressure Drop Bench Test Data Form (Form 1).



## 9. QUALITY ASSURANCE / QUALITY CONTROL (QA/QC)

**9.1** Equipment Certification. All test equipment (mass flow meter, differential low-pressure transmitter, temperature transducer, and barometric pressure transducer) is certified against a primary standard traceable to the NIST annually.

**9.2** Single Point Response Check. The test equipment used to measure pressure drop is challenged with an orifice plate prior to testing vapor recovery components. The orifice plate will generate a known pressure drop for a given flow based on its dimensions and the dimensions of the test pipe. The measured pressure drop across the orifice plate must be within three percent (3%) of the predicted pressure drop for a flow rate of 28.3 LPM using the following equation:

Orifice Plate Pressure Drop: $$p = \frac{}{2}(1 - \frac{A_2^2}{A_1^2})(\frac{Q}{C_d A_2})^2$$

Where:

$p_1$ = Pressure one laminar pipe diameter before orifice
$p_2$ = Pressure one half laminar pipe diameter after orifice
$v_1$ = Velocity of fluid in laminar pipe leading to orifice
$v_2$ = Velocity of fluid in orifice
$\rho$ = Density of test fluid (Nitrogen = 1.16 kg/m$^3$ @ 20ºC)
$A_1$ = Cross sectional area of laminar pipe leading to orifice

$A_2$ = Cross sectional area of square edged orifice
$Q$ = Flow in laminar pipe leading to orifice
$C_d$ = Orifice discharge coefficient

## 10. RECORDING DATA

Data are recorded on the Vapor Recovery Component Pressure Drop Bench Test Data Form (Form 1).

## 11. CALCULATING RESULTS

Differential pressure drop readings from three runs are averaged. This average is then compared with the applicable component requirement to determine compliance.



## 12. ALTERNATIVE TEST PROCEDURES

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

## 13. EXAMPLE FIGURES AND FORMS

**13.1** Form 1 - Vapor Recovery Component Pressure Drop Bench Test Data Form

**13.2** Figures

Each figure provides an illustration of an implementation that conforms to the requirements of this test procedure; other implementations that so conform are acceptable too.

13.2.1 Figure 1: Examples of Equipment to Be Tested

13.2.2 Figure 2: Example of a Bench Test

**Form 1**

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## Vapor Recovery Component Pressure Drop Bench Test Data Form

**Manufacturer:** ________________________________ **Model #** __________________________

**Performance Type: Nozzle** ! **Hose** ! **Breakaway** ! **Dispenser** ! **Swivel** !

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Barometric Pressure:________mmHg Flow Temp:________ºCelsius

Mass Flow Meter (MFM) Reading: ______ MFM Slope: _________ MFM Intercept: ____

$Q_{STD}$ = MFM Display*MFM Slope + MFM Intercept = __________L/Min

$$Q_{Actual} = Q_{STD} * (\frac{FlowTemp + 273.15}{298.15}) * (\frac{760}{Barometric\,Pressure})$$

$Q_{Actual}$ = _____L/Min

$$MFMDisplay = \frac{((\frac{28.3}{(\frac{FlowTemp + 273.15}{298.15}) * (\frac{760}{Baro\,Pressure})}) - MFMInt)}{MFMSlope}$$

| | | inches $H_2O$ | Temp | MFM Display |
|---|---|---|---|---|
| Serial # ____________ | Run #1 Pressure Drop: | ______ | | |
| | Run #2 Pressure Drop: | | | |
| | Run #3 Pressure Drop: | ______ | ______ | ___________ |
| | Average: | ______ | | |
| | Test Bench Drop: | ______ | | |
| | Average – Bench Drop: | ______ | | |
| | Requirement: | ______ | | |

**Average Pressure Drop – Test Bench Drop ≤ Requirement? Pass** ! **Fail** !

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| ***Performance Type*** | ***Requirement*** |
|---|---|
| **Nozzle Pressure Drop** | ΔP at 28.3 LPM of $N_2 \leq$ 0.08 inches $H_2O$ |
| **Hose Pressure Drop** | ΔP at 28.3 LPM of $N_2 \leq$ 0.09 inches $H_2O$ |
| **Breakaway Pressure Drop** | ΔP at 28.3 LPM of $N_2 \leq$ 0.04 inches $H_2O$ |
| **Dispenser Pressure Drop** | ΔP at 28.3 LPM of $N_2 \leq$ 0.08 inches $H_2O$ |
| **Swivel Pressure Drop** | ΔP at 28.3 LPM of $N_2 \leq$ 0.01 inches $H_2O$ |

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Test Performed By: _________________________________ Date:_________________

**Figure 1**
**Examples of Equipment to Be Tested**

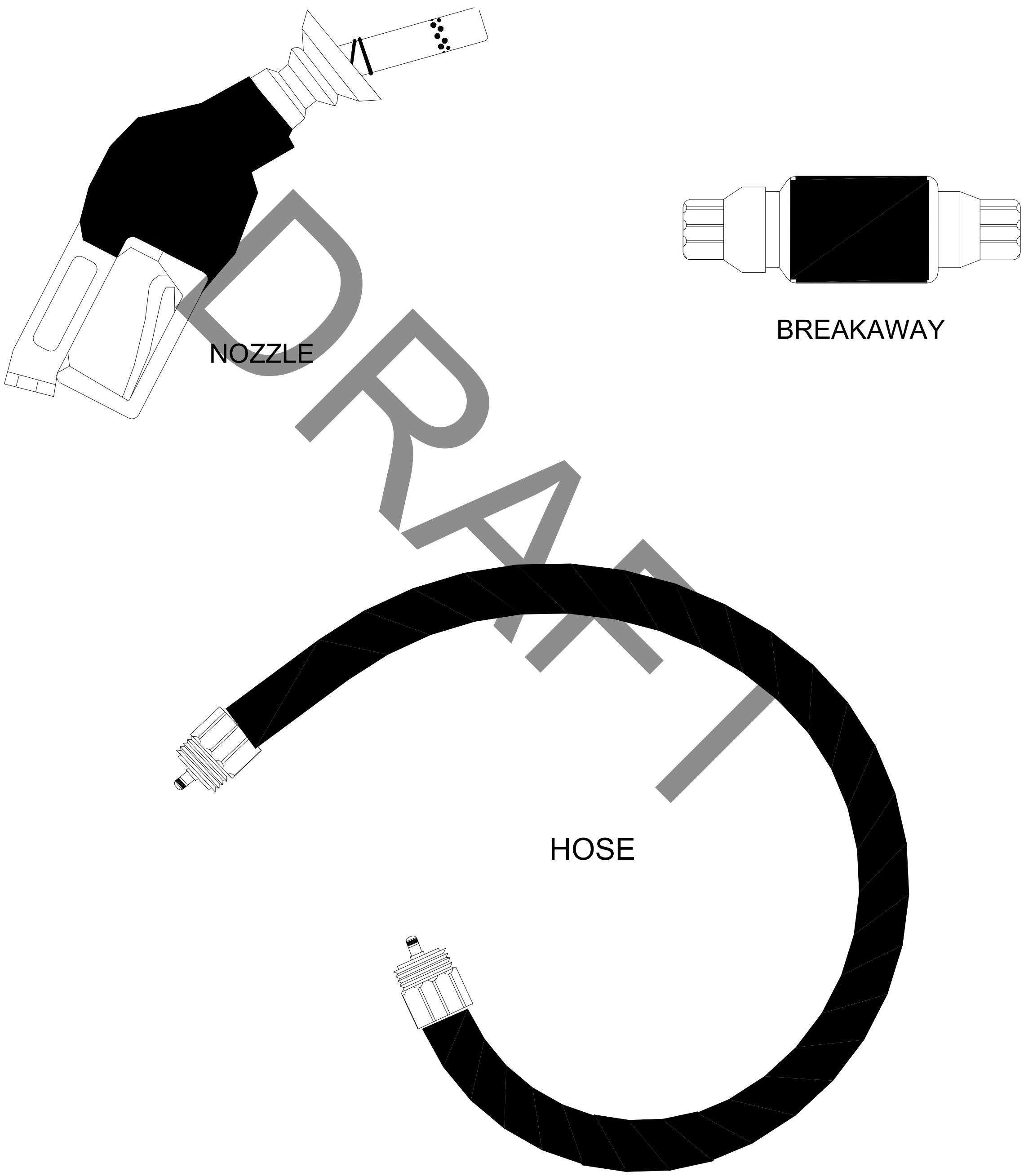
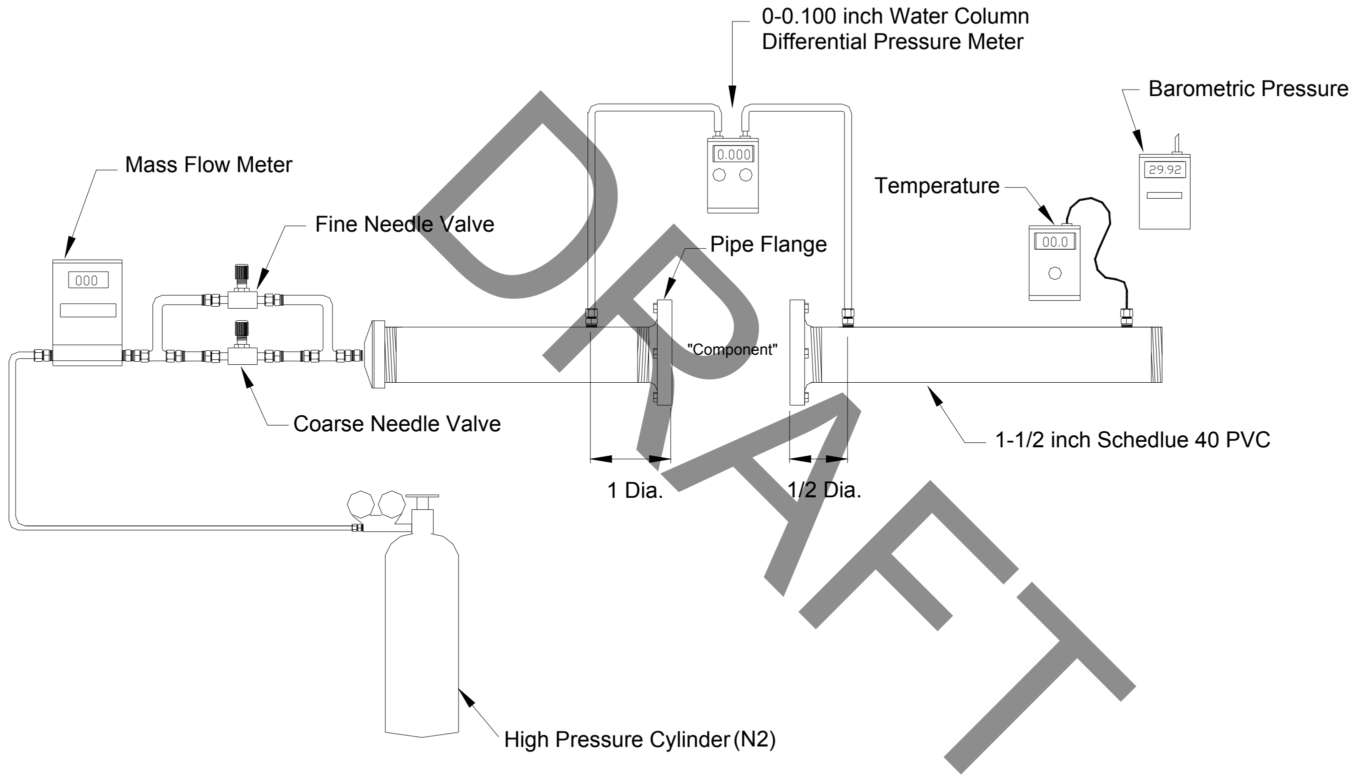


**Figure 2**
**Example of a Bench Test**




Notes: Three tube configurations are required to measure different components. Each configuration requires a uniquely designed orifice plate, flange, couplings, and male & female interfacing adapters.